APPENDIX A

STATUS OF PC CONDITIONS IN 2016

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Climate	1	N/A	Annually	In progress	GPS/tidal gauge monitoring of sea levels and storm surges
	2	58	As needed	Not applicable in 2016	Validation and update of climate change impacts of the project on the LSA and RSA.
	3	63	Annually	In progress	Exploring and implementing steps to reduce GHGs.
	4		As needed	Not applicable in 2016	Engage Inuit in climate change related research and studies.
	5	59	As needed	Complete	Reasonable measures to ensure that Project-site weather related information is publically available.
	6		As needed	Complete	Provide results of SO2, NOX, and GHG emissions calculations using fuel consumption or other relevant criteria.
Air Quality	7	57, 61, 62	Prior to construction	In progress	Update AQ and noise abatement plan to include continuous SO2 and NO2 monitoring at port sites to capture operations phase ship-generated emissions for several seasons.
	8	61	Annually	In progress	Demonstrate through SO2 and NO2 monitoring at the mine site and ports that emissions remain within predicted levels. Provide rationale and mitigation measures for exceedances.
	9	57	Annually	Complete	Provide calculations of GHG emissions at the port sites and other Project sources including Project associated aircraft.
	10	2, 57	Prior to construction	Complete	Update to dust management plan to include monitoring and management plans
	11	57	Prior to construction	Complete	Develop and implement Incineration Management Plan.
	12		As needed	Complete	Conduct at least one stack test immediately following commissioning new incinerators.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Noise and Vibration	13		As needed	Complete	Work with Fisheries and Oceans Canada to select overpressure threshold applied to explosives for the protection of fish and aquatic life.
	14	32	Annually	In progress	Conduct noise and vibration monitoring at Project accommodations in summer and winter during all phases of the project.
	14a	32	As needed	Not applicable in 2016	Demonstrate appropriate adaptive management practices during construction for activities with the potential to disrupt marine mammals.
	14b	32	Annually	Complete	Demonstrate appropriate adaptive management practices for project activities with the potential to disrupt terrestrial wildlife and Project site users.
	15	32	Annually	Complete	Collaborate with the QIA and local Hamlets when undertaking consultation with communities regarding railway, tote road and marine shipping operations. Provide visuals and discuss safety considerations.
Hydrology and Hydrogeology	16		As needed	Complete	Ensure that water related infrastructure is consistent with FEIS and FEIS addendum.
	17	6	As needed	Complete	Develop and implement measures to ensure that all effluent satisfies discharge criteria established by relevant regulatory authorities.
	18	42	As needed	Not applicable in 2016	Confirm and update, as needed, the approximate fill time of the mine lake pit identified in the FEIS.
	19	57	As needed	Complete	Develop and implement adequate water infrastructure monitoring to ensure that natural water flow is not significantly hindered. Monitor and report water withdrawal rates and water use for domestic and industrial purposes.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Groundwater and Surface Waters	20	57, 65	As needed	Complete	Monitor the effects of explosive residue and by-products from Project related blasting. Implement measures to ensure explosives do not negatively effect the surrounding area.
	21	2	As needed	Complete	Ensure that the scope of the AEMP is consistent with the requirements in the condition.
	22	57	Prior to construction	Complete	Develop a Sediment and Erosion Management Plan.
	23	57	Prior to construction	In progress	Develop and implement Groundwater Monitoring and Management Plan.
	24	6	As needed	Complete	Ensure that effluent discharge conditions are met all times
	25		Prior to construction	Complete	Identify sensitive landforms and develop and implement measures to minimize Project impacts on identified landforms.
	26	57	Prior to construction	Complete	Develop and Implement Erosion Management Plan.
	27		Annually	Complete	Record notes on impacts to the aesthetic value of the Project area heard in public consultations.
	28		As needed	Complete	Monitor Project effects on permafrost and ensure its integrity.
	29		As needed	Complete	Provide construction design and drawings for review and acceptance by relevant authorities. Provide as-built drawings to authorities following construction.
	30	65	As needed	Complete	Develop site-specific quarry operation and management plans before the development of any potential quarry site or borrow pit.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Vegetation	31		As needed	Complete	Ensure that Project activities are planned and conducted to minimize the Project footprint.
	32		As needed	Ongoing	Ensure that all supplies brought to site are clean of soil that could contain plant seeds not naturally occurring in the area. Inspect vehicle tires prior to initial use in Project area.
	33	57	Annually	Complete	Include relevant monitoring and management plans within the TEMMP.
	34		As needed	Complete	Conduct soil sampling to determine levels of metals in soils where berry producing plants are, near any potential development area prior to commencing operations.
	35		Prior to construction	Not applicable in 2016	Monitor baseline metal levels in organ tissue of caribou harvested with the local study area, prior to commencing operations.
	36	67	Annually	Complete	Establish an on-going monitoring program of vegetation used as caribou forage near project development areas, prior to commencing operations.
	37	43, 68	As needed	Not applicable in 2016	Incorporate methods to evaluate the potential introduction of invasive plant species into the Terrestrial Environment and Monitoring Plan. Report non-indigenous plant species to the Government of Nunavut.
	38		Annually	Complete	Review and adjust all monitoring information and management plans annually and adjust as needed to prevent/reduce adverse project effects on vegetation.
	39	39	Prior to construction	Complete	Develop a progressive revegetation program for disturbed areas no longer in use.
	40		As needed	Complete	Include revegetation plans in the Site Reclamation Plan that promotes progressive reclamation compatible with the surrounding environment.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Freshwater Environment	41	64	As needed	Complete	Maintain a 100-m naturally vegetated buffer between the high water mark of any fish-bearing water bodies and permanent quarries with the potential for acid rock drainage, unless otherwise approved.
	42		As needed	Complete	Maintain a 30-m naturally vegetated buffer between the mining operation and adjacent water bodies.
	43		Prior to construction	Complete	Submission of a Site Drainage and Silt Control Plan to the relevant authorities prior to the start of construction.
	44		As needed	Not applicable in 2016	Meet or exceed guidelines for blasting thresholds set by Fisheries and Oceans Canada for the protection of fish and fish habitat.
	45		As needed	Complete	Adherence to the No-Net-Loss principle at all phases of the Project.
	46	64	As needed	Complete	Ensure runoff from fuel storage and maintenance facility areas, sewage and wastewater other facilities generating liquid effluent and runoff meet discharge requirements.
	47		As needed	Complete	Design and construct all Project infrastructure so as they do not prevent or limit the movement of water in fish bearing streams.
	48		As needed	Complete	Engage with Fisheries and Oceans Canada and the QIA to explore Project specific thresholds for blasting that would exceed guidelines.
	48(a)		Annually	Complete	Conduct additional surveys for the presence of arctic char in freshwater bodies and ongoing monitoring of arctic char health where applicable, within watersheds proximal to the mine, tote road and Milne Inlet Port project development areas, including but not limited to, Phillips Creek, Tugaat and Qurluktuk. Consult with MHTO re: the design, timing, and location of proposed surveys and ongoing monitoring.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Terrestrial Environment	49	46, 47, 49, 50	As needed	Complete	Establish a Terrestrial Environment Working group to serve as an advisory body.
	50	70	As needed	Complete	Develop and implement a Project specific terrestrial monitoring plan.
	51	58	As needed	Complete	Consider and, where appropriate, cooperate with relevant regional and/or community-based monitoring initiatives that raise issues or produce information pertinent to mitigating project-induced impacts. Give special consideration for supporting regional studies of population health and harvest programs for North Baffin caribou.
	52		As needed	Not applicable in 2016	Initiate and develop a timeline to test and implement deterrence mechanisms for caribou near hazardous areas, within 3 months of issuances of the project certificate. Report information back to the Terrestrial working group.
	53	15, 71, 73	Annually	Complete	Proponent shall demonstrate all measures outlined in the condition to mitigate impacts to caribou.
	54	101	Prior to construction	Complete	Provide an updated Terrestrial Environment Monitoring Plan which includes all aspects included in the condition.
	55	57, 74	As needed	Not applicable in 2016	Develop an adaptive management plan applicable to wolves and wolf habitats in collaboration with the Government of Nunavut.
	56		As needed	In progress	Develop a progressive strategy for the recovery of terrestrial wildlife habitat that is consistent with the Nunavut Wildlife Act.
	57		Annually	Complete	Report annually on terrestrial environment monitoring efforts including information included in the condition.
	58	60	Annually	Complete	Incorporate a review section in the NIRB annual report including the information outlined in the condition.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Terrestrial Environment	59		Annually	In progress	Ensure that aircraft maintain, whenever possible altitudes outlined in the condition. Develop measures to ensure all employees and subcontractors providing aircraft services are respectful of wildlife and Inuit harvesting that may occur in the Project development area.
	60		Prior to construction	Complete	Develop a blasting program to minimize the effects of blasting on terrestrial wildlife, prior to construction.
	61		As needed	Complete	Implement a stop work policy when wildlife in the area may be endangered by Project work, whenever practical and not causing human safety concerns.
	62		As needed	Complete	Prohibit Project employees from transporting firearms to site and from operating firearms in the Project area for the purpose of wildlife harvest.
	63		Annually	Complete	Liaise with local Hunters and Trappers Organizations in advance of carrying out terrestrial wildlife surveys. Meet with the organizations annually to discuss wildlife monitoring.
	64		As needed	Complete	Ensure the environment protection plan incorporates waste management provisions to ensure carnivores are not attracted to Project site(s).
Birds	65		As needed	Complete	Ensure all employees at site receive bird awareness training (avoidance of nests and large concentrations of foraging and moulting birds).
	66	75	As needed	Complete	Avoid bird Species at Risk and their nests; establish avoidance zones as per TEMMP.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Birds	67	75	As needed	Complete	Ensure mitigation and monitoring strategies for bird Species at Risk are updated for consistency with applicable status reports, recovery strategies, action plans and management plans.
	68		As needed	Complete	Install flashing red, red strobe or white strobe lights and guy-wire deterrents on communications towers. Consider reducing lighting when possible in areas where it may serve as an attractant to birds or other wildlife.
	69		As needed	Complete	Prior to bird migrations and nesting, identify and install nesting deterrents (e.g. flagging) to discourage birds from nesting that will be disturbed by construction/clearing activities.
	70		As needed	Complete	Protect any nests found (or indicated nests) with a buffer zone as per setback distances outlined in the TEMMP.
	71		Annually	In progress	Subject to safety requirements, the Proponent shall require all project related aircraft to maintain a cruising altitude of at least: a. 650 m during point to point travel when in areas likely to have migratory birds b. 1100 m vertical and 1500 m horizontal distance from observed concentrations of migratory birds c. 1100 m over the area identified as a key site for moulting snow geese during the moulting period (July-August), and if maintaining this altitude is not possible, maintain a lateral distance of at least at least 1500 m from the boundary of this site

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Birds	72		Annually	In progress	Ensure that pilots are informed of minimum cruising altitude guidelines and that a daily log or record of flight paths is maintained and available for regulatory authorities.
	73	77	As needed	Complete	Develop detailed and robust mitigation and monitoring plans for migratory birds taking into consideration input from relevant organizations.
	74	57, 77	Prior to construction	Complete	Develop and update relevant monitoring plans for migratory birds prior to construction including the key indicators included in the condition.
	75	77	Annually	Complete	Report annually on terrestrial habitat loss due to the Project to verify impact predictions and project footprint.
Marine Environment	76	79	As needed	Complete	Develop a comprehensive environmental effect monitoring program to address concerns and identify potential impacts on the marine environment.
	77 (revised)	46, 49, 51	As needed	Complete	Establish a Marine Environment Working Group.
	78		Annually	Complete	Update baseline information for landfast ice using a long term data-set and with inter-annual variation.
	79		As needed	Complete	Provide the Canadian Hydrographic Services with bathymetric data and other information in support of Project shipping where possible.
	80		Prior to construction	Deferred	Prior to commercial shipping of iron ore, a detailed risk assessment is to be conducted for Project related shipping accidents.
	81	84	As needed	Not applicable in 2016	Reassess the potential for ship wake impacts to cause coastal change following changes to the proposed shipping route.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Environment	82		As needed	Not applicable in 2016	Encouraged to have ore carriers to subjected to sea trials to measure wake characteristics at various speeds.
	83		As needed	In progress	Install tidal gauges at Steensby and Milne Ports to monitor sea levels and storm surges.
	83 (a)		Annually	Complete	Identify potential for and conduct monitoring to identify effects of sediment redistribution associated with construction and operation at Milne Port
	84		As needed	Not applicable in 2016	Update sediment redistribution modelling once ship design has been completed and sampling should be undertaken to validate the model and inform sampling sites and the monitoring plan.
	85	84	As needed	Not applicable in 2016	Develop a monitoring plan to verify Project impact predictions associated with sediment redistribution resulting from propeller was in shallow water locations along the shipping route. Additional mitigation measures are required if monitoring detects negative impacts.
	86	85	Prior to construction	Complete	Prior to commercial shipping of iron ore, use more detailed bathymetry collected from Steensby and Milne Inlets to model anticipated ballast water discharges from ore carriers. This information should be used to update ballast water discharge impact predictions and sampling should be conducted to validate the model.
	87	85	Annually	Complete	Develop a detailed monitoring program at a number of sites over the long term to evaluate changes to marine habitat and organisms and to monitor for non-native introductions resulting from Project-related shipping. Initiate program several years prior to any ballast water discharge at Steensby or Milne Inlets.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Environment	88	85, 86	Prior to construction	Complete	Prior to commercial shipping of iron ore, provide update risk analysis regarding ballast water discharge to assess the adequacy of treatment and implications on the receiving environment.
	89	57, 87	As needed	In progress	Develop and implement a ballast water management program that may include the treatment and monitoring of ballast water discharges in a manner consistent with or exceeds applicable regulations. The management program should reflect all inclusions outlined in the condition.
	90	57	As needed	Complete	Incorporate into the Project Shipping and Marine Wildlife Management Plan provisions to achieve compliance with the requirements under the International Convention for the Control and Management of Ships Ballast Water and Sediment (2004) or its replacement regulation as amended.
	91		As needed	In progress	Develop a detailed monitoring plan for Steensby and Milne Inlets for fouling that complies with all applicable regulatory requirements and guidelines issued by Transport Canada.
	92	10, 108, 110	Annually	Complete	Ensure that the Proponent maintains the necessary equipment and trained personnel to respond to all sizes of potential spills in a self sufficient manner.
	93		Prior to construction	Not applicable in 2016	Prior to construction, based on vessel selection, reassess the risk analysis of using vessel -based fuel storage with the inclusions outlined in the condition.
	94	106	As needed	Deferred	Consult directly with affected communities regarding its plans for over-wintering of fuel in Steensby Inlet.
	95	8	As needed	Deferred	Meet or exceed all regulatory regulations and requirements to the practice of overwintering of a fuel vessel at Steensby Inlet with reporting to NIRB and Transport Canada.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Environment	96	8	Deferred	Deferred	Update the NIRB on the results of all compliance monitoring and site inspections undertaken by government agencies for the overwintering of a fuel vessel at Steensby Inlet.
	97		Prior to construction	Complete	Prior to commercial shipping of iron ore, conduct fuel spill dispersion modelling that minimally includes those items outlined in the condition.
	98	11, 106	As needed	Complete	Incorporate the results of revised fuel dispersion modelling into its impact predictions for the marine environment and the spill response and emergency preparedness plans.
Marine Wildlife	99	81	As needed	Not applicable in 2016	With the Marine Environment Working Group, consider and identify priorities for conducting supplemental baseline assessments for the items outlined in the condition.
	100	57	Deferred	Not applicable in 2016	Update the Project Shipping and Marine Wildlife Management plan to include avoidance of polynyas and mitigation measures designed for potential fuel spills along the shipping lane during the winter months.
	101		Annually	Applicable items are complete for 2016. Some items are Not applicable in 2016.	Incorporate all items outlined in the condition into the appropriate monitoring plans.
	102	30, 36	Annually	Complete	Ensure that routing of project vessels is tracked and recorded for both the southern and northern shipping routes, with data made real-time available to communities in Nunavut and Nunavik.
	103		Annually	Complete	Report annually to the NIRB regarding project related ship track and sea-ice information including all items outlined in the condition.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Wildlife	104		Annually	Complete	Plan shipping routes to Steensby Port in accordance with the items outlined in the condition. Summarize all incidences of significant deviations from the nominal shipping route presented in the FEIS to/from Milne and Steensby Ports.
	105		Prior to construction	In progress	Ensure that measures to reduce the potential for interaction with marine mammals particularly in Hudson Strait and Milne Inlet area identified and implemented prior to commencement of shipping operations.
	106		As needed	In progress	Ensure that shipboard observers are employed during seasons where shipping occurs and provided with the means to effectively carry out the duties. The role of shipboard observers should be taken into consideration in the design of any Project purpose built ships.
	107		As needed	In progress	Revise the proposed 'surveillance monitoring' to improve the likelihood of detecting strong marine mammal, seabird or seaduck responses occurring too far ahead of the ship to be detectable by observers aboard the ore carriers.
	108		As needed	Not applicable in 2016	Ensure that data produced by the surveillance monitoring program is analysed by experienced analysts (in addition to being discussed as proposed in the FEIS) to maximize effectiveness in providing baseline information and/or detecting potential effects. Data from the long term monitoring should be treated with the same rigor.
	109		As needed	Complete	Conduct a monitoring program to confirm the predictions in the FEIS with respect to disturbance effects from ships noise on the distribution and occurrence of marine mammals.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Wildlife	110	84	As needed	In progress	Immediately develop a monitoring protocol that includes acoustical monitoring to assess short, long term and cumulative effects of vessel noise on marine mammals. Work with the MEWG to identify appropriate early warning indicators that will ensure rapid identification of negative impacts along southern and northern shipping routes.
	111		As needed	In progress	Develop clear thresholds for determining if negative impacts as a result of vessel noise is occurring.
	112		Prior to construction	In progress	Prior to commercial shipping of iron ore, in conjunction with the MEWG, develop a monitoring protocol that includes acoustical monitoring that provides an assessment of the negative effects of vessel noise on marine mammals. Consideration of early warning indicators and thresholds of impacts should be included.
	113		Annually	Complete	Conduct monitoring of marine fish and fish habitat including monitoring for Arctic Char stock size and health condition in Steensby and Milne Inlets, as recommended by the MEWG.
	114		As needed	Not applicable in 2016	In the event of the development of a commercial fishery in Steensby Inlet or Milne Inlet areas, in conjunction with the MEWG, shall update the monitoring program for fish and fish habitat to ensure that the ability to identify Arctic Char stock(s) and any changes in stock size and structure of affected stocks and fish health is maintained to address any monitoring issues relating to the commercial stock fishery.
	115		As needed	Complete	Continue to explore off-setting options in both the freshwater and marine environment to offset serious hard to fish which will result from the construction and infrastructure associated with the project.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Wildlife	116		Prior to construction	Not applicable in 2016	Prior to construction, develop mitigation measures to minimize the effects of blasting on marine fish and fish habitat, marine water quality and wildlife that includes compliance with the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters.
	117		As needed	Not applicable in 2016	Ensure that blasting in, and near, marine water shall only occur during periods of open water. Blasting in, and near, fish-bearing freshwater should occur to the greatest degree possible in open water. Blasting during ice-covered periods must meet requirements established by Fisheries and Oceans Canada.
	118		Prior to construction	Complete	Prior to construction, incorporate into the appropriate mitigation plan, thresholds for the use of specific mitigation measures meant to prevent or limit marine wildlife disturbance.
	119		Prior to construction	Not applicable in 2016	In conjunction with the MEWG, monitor ringed seal birth lair abundance and distribution for at least two years prior to the start of ice-breaking to develop a baseline, with continue monitoring over the life-time of the project.
	120		Annually	Complete	Ensure, subject to vessel and human safety, that all Project shipping adhere to mitigation measures outlined in the condition for the protection of marine wildlife.
	121	80, 83	As needed	In progress	Immediately report any accidental contact by Project vessels with marine mammals or seabird colonies to Fisheries and Oceans Canada and Environment Canada, respectively.
	122		Annually	Complete	Summarize and report annually to the NIRB regarding accidental contact by Project vessels with marine mammals or seabird colonies through the applicable monitoring report.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Wildlife	123		As needed	Not applicable in 2016 (discontinued)	Provide sufficient marine mammal observer coverage on Project vessels to ensure that collisions with marine mammals and seabird colonies are observed and reported throughout the lifecycle of the Project. The marine wildlife observer protocol should include those items outlined in the condition.
	124		As needed	Complete	Prohibit all Project employees from recreational boating, fishing and harvesting of marine wildlife in Project areas, including Steensby and Milne Inlets.
	125	41	Prior to construction	Not applicable in 2016	Prior to the use of acoustic deterrent devices, carry out consultations with communities along the shipping routes and nearest to Steensby and Milne Inlet Ports to assess acceptability of the devices. Feedback from consultation should be incorporated into the mitigation plan.
	125(a)	35	Annually	Complete	Consult with potentially affected communities and groups, particularly the Hunters and Trappers Organizations regarding the identification of Project vessel anchor sites and potential areas of temporary refuge for Project vessels along the shipping routes within the Nunavut Settlement Area. Feedback from the consultation should be incorporated.
	126		As needed	Complete	Design monitoring programs to ensure that local users of the marine area in communities along the shipping route have opportunity o be engaged throughout the life of the Project in assisting with monitoring and evaluating potential Project-induced impacts and changes in marine mammal distributions.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Marine Wildlife	127	27, 28	Annually	Complete	Ensure that communities and groups in Nunavik are kept informed of Project shipping activities and are provided with opportunity to participate in the continued development and refinement of shipping related monitoring and mitigation plans.
	128	27, 28	As needed	Complete	Consult with local communities as fish habitat off-setting options are being considered and demonstrate incorporation of this input in the design of the Fish Habitat Off-Setting Plan.
Population Demographics	129	45, 46	Annually	Complete	Encouraged to engage in the work of the Qikiqtaaluk Socio-Economic Monitoring Committee along with other agencies and affected communities, endeavoring to identify areas of mutual interest into a collaborative monitoring framework that includes socio-economic priorities related to the Project, communities and the North Baffin region as a whole.
	130	46	As needed	Complete	Consider establishing and coordinating with smaller socio-economic working groups to meet Project specific monitoring requirements throughout the life of the Project.
	131	45	As needed	Complete	The Qikiqtaaluk Socio-Economic Monitoring committee is encouraged to engage in monitoring of demographic changes including the movement of people into and out of the North Baffin communities and the territory as a whole.
	132		As needed	Complete	Encouraged to partner with other agencies in the North Baffin region, the Municipal Training Organization and the Government of Nunavut in developing/implementing programs which encourage Inuit to remain living in their home communities while seeking ongoing and progressive training and development.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Population Demographics	133	41	Annually	Complete	Encouraged to work with the Qikiqtaaluk Socio-Economic Monitoring committee and with the Government of Nunavut and other relevant stakeholders to design and implement a voluntary survey to be completed by its employees on an annual basis in order to track housing status and migration intentions. Non-confidential findings are to be reported to the Government of Nunavut and the NIRB.
	134		Annually	Complete	Provide in the annual report to the NIRB a summary of employee origin information including information outlined in the condition.
Education and Training	135	93	As needed	Complete	Encouraged to consider offering additional options for work/study programs available to Project employees.
	136	92, 94	As needed	Complete	Encouraged to work with training organizations and/or government departments offering mine-related or other training in order to provide additional training opportunities for employees which are transferable and meaningful.
	137	92	Annually	Complete	Prior to construction, develop an easy referenced listing of formal certificates and licences that may be acquired via on-site training or training during employment at Mary River. Listing to be updated on an annual basis, provided to the NIRB upon completion and whenever it is revised.
	138	92	As needed	Complete	Encouraged to work with the Qikiqtani Inuit Association to ensure timely development of effective Inuit training and work-ready programs.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Education and Training	139		Prior to construction	Complete	Prior to construction, undertake and provide results of a detailed labour market analysis which provides quantitative predictions on the number of employees to be sourced from southern Canada and foreign markets. Within 90 days of receipt of the Project Certificate, submission of an updated labour market analysis must be submitted.
	140		Annually	Complete	Encouraged to survey Nunavummiut employees as they are hired and specifically note the level of education obtained and whether the incoming employee resigned or left an educational institute to take up employment with the Project.
	141	92	As needed	Complete	Prior to construction, encouraged to work with the Qikiqtani Inuit Association in order to prioritize the provision of training of Inuit to serve as employees in monitoring or other such capacities.
Livelihood and Employment	142	105	As needed	Complete	Encouraged to address the potential direct and indirect effects that may result from Project employees on-site use of various Inuktitut dialects as well as other spoken languages.
	143		As needed	Complete	Encouraged to consider the use of both existing and innovative technologies as a way to ensure Project employees are able to contact their family and friends.
	144		As needed	Complete	Encouraged to make requirements for employment clear in its work-readiness and other programs and documentation.
	145	45	As needed	Complete	Encouraged to work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring committee to monitor the barriers to employment for women.
	146		As needed	Complete	The Government of Nunavut and the Qikiqtani Inuit Association are encouraged to investigate the possibility for Project revenue streams to support initiatives or programs which offset or subsidize child care for Project employees.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Livelihood and Employment	147	17	As needed	Complete	Encouraged to work with the Government of Nunavut and the Nunavut Housing Corporation to investigate options and incentives which might enable and provide incentive for employees living in social housing to maintain employment as well as to negotiate for an obtain manageable rental rates.
Economic Development	148	45	As needed	Complete	Encouraged to undertake collaborative monitoring in conjunction with the Qikiqtaaluk Socio-economic Monitoring committee's monitoring program which addresses Project harvesting interactions and food security and broad indicators of dietary habits.
	149		Prior to construction	Complete	Prior to operations, required to undertake an analysis of the risk of temporary mine closure giving consideration to the affects of such to the North Baffin region.
	150	34	Prior to construction	Complete	Ensure that specific conditions are met in regard to Sirmilik National Park, as outlined in the condition.
	151		As needed	Complete	Encouraged to investigate measures and programs designed to assist Project employees with home ownership or access to affordable housing options.
	152		As needed	Not a Baffinland condition	The Qikiqtani Inuit Association is encouraged to provide the Board and the Qikiqtaalik Socio-Economic Monitoring committee which information regarding the effectiveness of any provisions within the Inuit Impact Benefit Agreement which may require that larger contracts are broken into smaller contracts.
Human Health and Wellbeing	153	96	As needed	Complete	Encouraged to employ a mental health professional to provide counselling to Inuit and non-Inuit employees in order to positively contribute toward employee health and well-being.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Human Health and Wellbeing	154	45	As needed	Complete	Work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic committee to monitor potential indirect effects of the projects.
	155		Prior to construction	Complete	Encouraged to provide the NIRB with an updated report on its development of mitigation measures and plans to deal with potential cultural conflicts which may occur at site.
	156		As needed	Complete	Encouraged to assist with the provision and/or support of recreation programs and opportunities within the potentially affected communities in order to mitigate potential impacts of employees' absence from home and community life.
	157	96	As needed	Complete	Consider providing counselling and access to treatment programs for addictions, domestic parenting, and marital issues that affect employees and/or their families.
Community Infrastructure	158		As needed	Complete	Encouraged to work with the Government of Nunavut and other relevant parties to develop a Human Health Working Group.
	159	45	As needed	Complete	Encouraged to work with the Government of Nunavut to develop an effects monitoring program that captures increases to community based and airport infrastructure in the local study area and Iqaluit.
	160		As needed	Complete	The Government of Nunavut and the Qikiqtani Inuit Association are encouraged to cooperate to ensure that benefits are in a broad sense distributed across impacted communities and demographic groups that best offsets Project related impacts to infrastructure or services.
	161		As needed	Complete	The Government of Nunavut should be prepared for the potential need for increased policing to handle on-going Project related demographic changes in subsequent crime prevention.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Culture Resources and Land Use	162	97	As needed	Complete	Make all reasonable efforts to engage Elders and community members of the North Baffin communities for input into monitoring programs and mitigative measures to ensure that they are informed by traditional activities, cultural resources and land-use.
	163		As needed	Complete	Continue to engage and consult with the communities of the North Baffin region to ensure that Nunavummiut are kept informed about Project activities.
	164	30, 34	As needed	Complete	Provide notification to communities regarding scheduled ship transits throughout the Regional Study Area including Eclipse Sound and Milne Inlet. Real-time data should be made available. Changes to proposed shipping routes should be provided to the MEWG, the community of Pond Inlet and communities in the region.
	165	14	As needed	Complete	Encouraged to provide buildings along the rail line and Tote Road for emergency shelter purposes to be made available for employees and land users of the area.
	166	30	As needed	Complete	Ensure through consultation efforts and public awareness campaigns that the public has access to shipping operations personnel for transits into and out of Steensby and Milne ports via telephone or internet contact to ensure information regarding ice conditions and ship movements can be shared.
Benefits, Royalties and Taxation	167		As needed	Not applicable in 2016	Encouraged to enter into negotiations for a Development Partnership Agreement with the Government of Nunavut.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Governance and Leadership	168	45	As needed	Complete	Include the aspects outlined in the condition into the monitoring program adopted by the Qikiqtani Socio-Economic Monitoring committee.
	169		Annually	Complete	Provide an annual monitoring summary to the NIRB on the monitoring data collected related to the regional and cumulative economic effects associated with the Project and any proposed mitigation measures.
Accidents and Malfunctions	170		As needed	Deferred	Include an updated Terrestrial Wildlife Management and Monitoring Plan plans for increased caribou monitoring efforts including weekly winter track surveys and bi-monthly surveys in the summer and fall.
	171		As needed	Complete	Include within the updated Terrestrial Wildlife Management and Monitoring Plan, a commitment to establish deterrents along the railway and Tote road embankments at any areas where the movement of caribou presents a likelihood of mortality to occur.
	172	8	Prior to construction	Not applicable in 2016	Encouraged to provide the Government of Nunavut with evidence that the vessel intended for use for the overwintering of fuel has been designed and certified for use under the operational conditions. Proof of vessel owners insurance policies are required.
	173	9	As needed	Complete	Employ best practices and meet all regulatory requirements during ship to shore and other marine based fuel transfer events.
	174	108, 110	As needed	Complete	Provide, as well as the Canadian Coast Guard, spill response equipment and annual training to Nunavut communities along the shipping route.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Accidents and Malfunctions	175	34, 57	Deferred	Deferred	In coordination with the Qikiqtani Inuit Association and the Hunters and Trappers Organizations of the North Baffin communities and Coral Harbour, provide updates to the Shipping and Marine Wildlife Management Plan to include adaptive management measures to take should the placement of route markers along the ships track during ice breaking not prove to feasible for marking the route.
	176		Prior to construction	Deferred	Required to revise its spill planning to include additional trajectory modelling for Hudson Strait, where walrus concentrate, as well as Milne Inlet, Eclipse Sound and Pond Inlet during winter conditions.
	177	13, 37	As needed	Complete	Enroll any foreign flagged vessels commissioned for Project-related shipping within Canadian waters into the relevant foreign program, equivalent to Transport Canada's Marine Safety Delegated Statutory Inspection Program.
Alternatives Analysis	178		As needed	Deferred	Subject to safety requirements, require all Project vessels to maintain a route to the south of Mill Island to prevent disturbances to walrus and walrus habitat.
Operational Variability	179	4	Deferred	Deferred	Not to exceed 20 ore carrier transits to Steensby Port per month during the open water season (242 transits per year).
	179a	4	Annually	Complete	The total volume of ore shipped via Milne Inlet shall not exceed 4.2 million tonnes.
	179b	4	Annually	Complete	The total volume of ore transported by truck on the Tote road shall not exceed 4.2 million tonnes per year.
Transboundary Effects	180		As needed	Complete	The Marine Environment Working Group shall invite a representative from Makivik Corporation to be a member of the group.
	181		Annually	Complete	Regardless of whether Makivik Corporation participates as a member of the Marine Environment Working Group, the group will provide Makivik with regular updates throughout the life cycle of the project.

Subject Area	PC Condition No.	Proponent Commitment[1]	Reporting Requirement [1]	2016 Condition Status [2]	Summary of Condition Requirement
Transboundary Effects	182		As needed	Complete	Make available any ship route deviation routes provided to the NIRB to Makivik Corporation.

NOTES:

1. Reporting Requirements are generally grouped as follows:

Annually - Condition is reported on in the Annual Report.

As needed - Condition is reported on based on changes to the Project or specific timelines and as the Condition dictates.

Prior to construction - Condition is reported on prior to the construction phase and generally includes the timelines "prior to operation" and "prior to shipping".

Deferred - Condition is specific to an aspect of the Project which is not yet viable and will be reported on when said aspect does become viable and as the Condition dictates.

2. 2016 Condition Statuses are generally grouped as follows:

Complete - Condition requirement(s) has/have been met.

In progress - Baffinland is in the process of meeting the Condition requirement(s). Details are provided in the appropriate section of the Annual Report.

Not applicable in 2016 - Generally applies only to "As needed" Reporting Requirements where no changes to the Project nor specific timelines triggered an update to the Condition.

Deferred - Condition is specific to an aspect of the Project which is not yet viable and will be reported on when said aspect does become viable and as the Condition dictates.

APPENDIX B

COMMUNITY SURVEY RESULTS (SEPT 2016)

Project Report
Date: 3/31/17

Mary River Project Community Survey Report

1. Background

Baffinland carried out a community survey within the five North Baffin communities that are the most likely to be affected by the Mary River Project (the Project). The survey consisted of a series of high level questions that asked about how the project may potentially be affecting the communities, the environment, and the overall way of life in North Baffin Island. The survey was also used to gather information about the overall relationship between Baffinland and the North Baffin communities. The survey was a mechanism for community residents to have their voices heard, and for Baffinland to foster its positive relationships with the communities.

2. Purpose

Baffinland believes in engaging with local stakeholders to have a better understanding of how to approach its mining operations to maximize local benefits and to minimize adverse impacts upon communities. . To do this, Baffinland decided to reach out to the communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet by distributing surveys that would help the company identify and respond to the concerns raised by the stakeholders. In return, Baffinland can provide data to the communities to show the company understands their concerns and will take those concerns into account in the execution of the Project. The survey will also provide reference for future communications with local stakeholders.

3. Methodology

3.1 Role of BCLOs

The company has offices in all five communities. The Baffinland Community Liaison Officers (BCLOs) reside in the communities and act as a bridge between the company and the communities. The BCLOs were tasked with carrying out the surveys on behalf of Baffinland. Their role for the community surveys was to implement the surveys on behalf of Baffinland, assist participants if they have any questions about the survey, gather the completed surveys up and send them back to Baffinland headquarters for the data to be analyzed.

3.2 Survey Development

The survey was developed by Baffinland in collaboration with the BCLOs. The contents of the survey were intended to help Baffinland understand community values and priorities and how the Project may be affecting community members. There were general questions for the purpose of gathering information on the demographics of the participants and for Baffinland to understand survey coverage. Another set of questions were open-ended, to ensure that questions were not leading in any way. It also gave participants the freedom to elaborate on any ideas, thoughts, or concerns. The questions asked how the Project may have affected the bio-physical or social environment.

4. Survey Implementation

The community survey was conducted between September 12th and September 30th of 2016. In order to maximize the number of community members who completed the surveys, fliers, posters, and radio announcements were used to promote the surveys within the communities. To incentivize people to participate in the survey, a draw prize was also offered in each community, and all participants were added to a grand prize raffle draw.

Community members were given the opportunity to complete the survey online using Survey Monkey. Hard copy surveys were also available, and the local BCLOs were available at the Co-op, Northern Stores or at the BCLO offices to help participants complete the survey and answer any questions. All surveys were translated into Inuktitut to ensure equal access for all community members.

Participation in the surveys was voluntary, and participants identity was kept anonymous; Participant names and contact information was not included as part of the survey.

4.1 Survey Format

The survey was divided into three categories: General Questions, Project-Related Questions, and Ongoing Communication.

4.1.1 General Information

This section requested information about each participant's demographics, including: age, gender, where they live, and if they were or are currently employed by Baffinland, which allowed Baffinland to ensure that responses reflected both Baffinland employees and non-employees.

4.1.2 Questions about the Project

This section was designed to assist Baffinland in understanding how the Project may be affecting communities. The questions were open-ended and consisted of questions related to the bio-physical environment and the communities, including positives and negatives about the Project, and suggestions for improvements. Responses were intended to provide Baffinland with feedback, ideas, and opportunities to improve processes and procedures.

4.1.3 Ongoing Communication

The survey question pertaining to ongoing communication was designed to ensure that Baffinland's approach to communicating communities was reflective of *how* communities wanted to receive Project-related information.

4.2 Data Analysis

Once the surveys were completed, the data was compiled for all communities. The BCLOs were responsible for taking hard copy surveys and uploading them to the online platform (Survey Monkey). The names of the respondents were not included in the data uploaded to Survey Monkey. All data from Survey Monkey was downloaded to excel and each response was categorized into environmental and community topic areas. The categorized responses were then analyzed and interpreted using Excel software. The categorized responses were then uploaded to StakeTracker, which is Baffinland's online stakeholder tracking and mapping tool. During the upload to StakeTracker all responses were assigned categories and topics which relate to either the bio-physical or the socio-economic environment. This allows Baffinland to track information systematically.

5. Results

Five BCLOs implemented the survey in the span of two weeks, with the total of 205 people participating (Figure 1). Out of those participants, 49 had either previously or currently worked for the Mary River Project. 29 of those were contractors while 20 were employees of Baffinland. One participant chose not to answer the question.

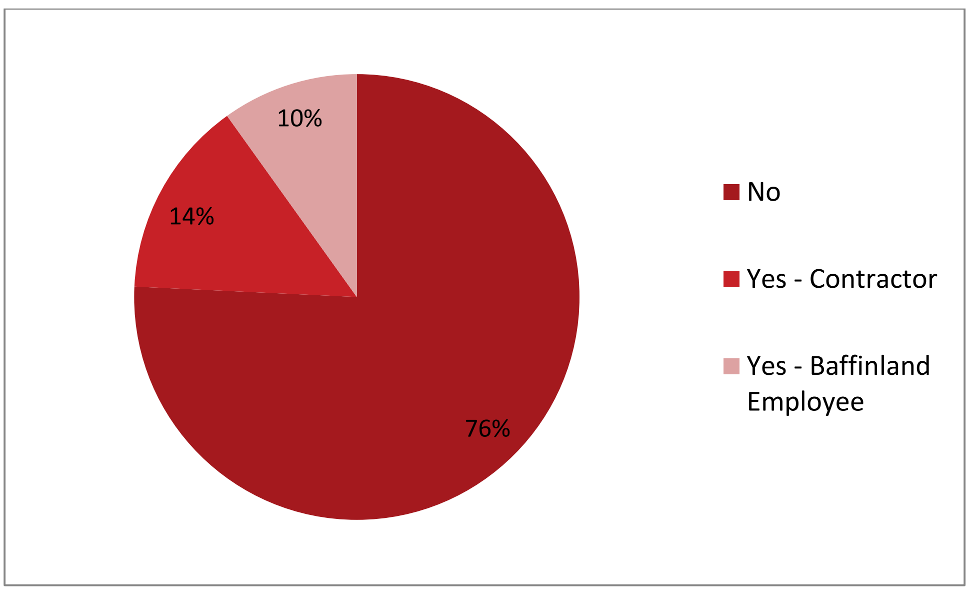


Figure 1: The Number of Participants that Worked for Baffinland

5.1 General Questions

There was nearly equal participation from all communities (Figure 2), with Pond Inlet showing the lowest participation (16.1 percent) and Hall Beach and Igloolik showing the highest participation (22 percent).

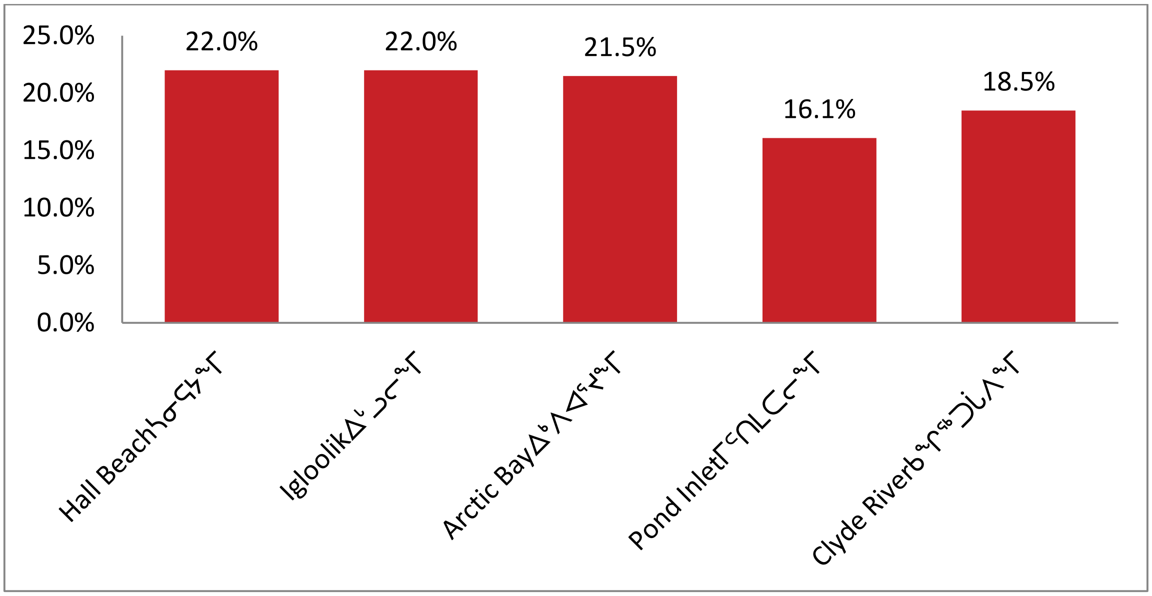


Figure 2: Survey Distribution by Community

In terms of respondent demographics, there were more male respondents (58%) compared to female (42%), and there was representation from all age categories, as shown in Figure 3. The single largest age group of the participants was in the 24-34 age groups.

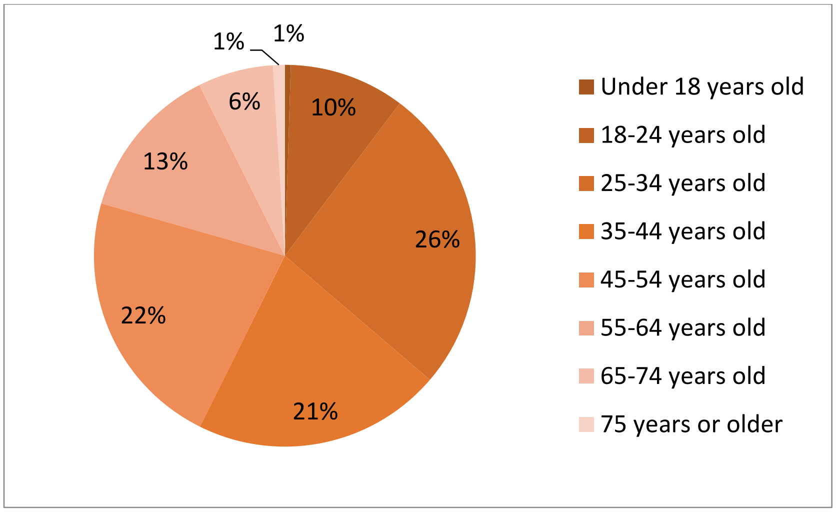


Figure 3: Age Category Distribution

5.2 Questions about the Project

5.2.1 Has the Project Made a Difference in the Community?

Based on the survey results, 57 percent of participants indicated that the Project has had a positive effect on the community, ten percent indicated that it has resulted in negative effect, and 35 percent said they have seen no change as a result of the Project (Figure 4). The most frequent response to the question about whether the Project has made a difference in the community was regarding provision of jobs to local Inuit and youth, providing income and work benefits for families and communities, educating the locals through jobs and life skills, and ensuring good communication with the communities and Baffinland.

Comments regarding negative effects of the Project included the long separation between families and employees affecting family stability, the ongoing challenges associated with substance abuse in communities, the need for improvements between Baffinland and community communication, the need for ongoing environmental protection, and that not enough Inuit are being hired by Mary River. Survey respondents also talked about the need for continued focus on worker safety and equity in providing community support.

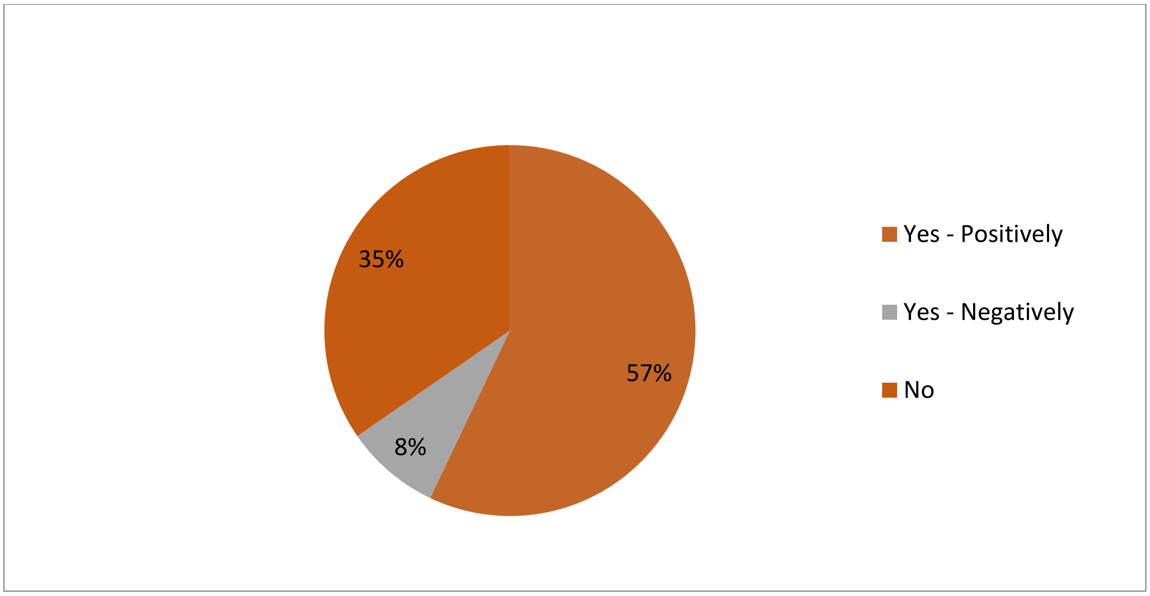


Figure 4: Community Results for Whether the Project has made a Difference in the Community

5.2.2 What are the Things Baffinland is Doing Well?

Most survey respondents (54 percent) answered that local employment is the aspect of the Project that is being well executed by Baffinland (Figure 5). Communities also acknowledged improvements in the quality of life for community members, such as bringing in income for families; good communication with Baffinland; work related training to locals; and providing stability and economic growth to the community.

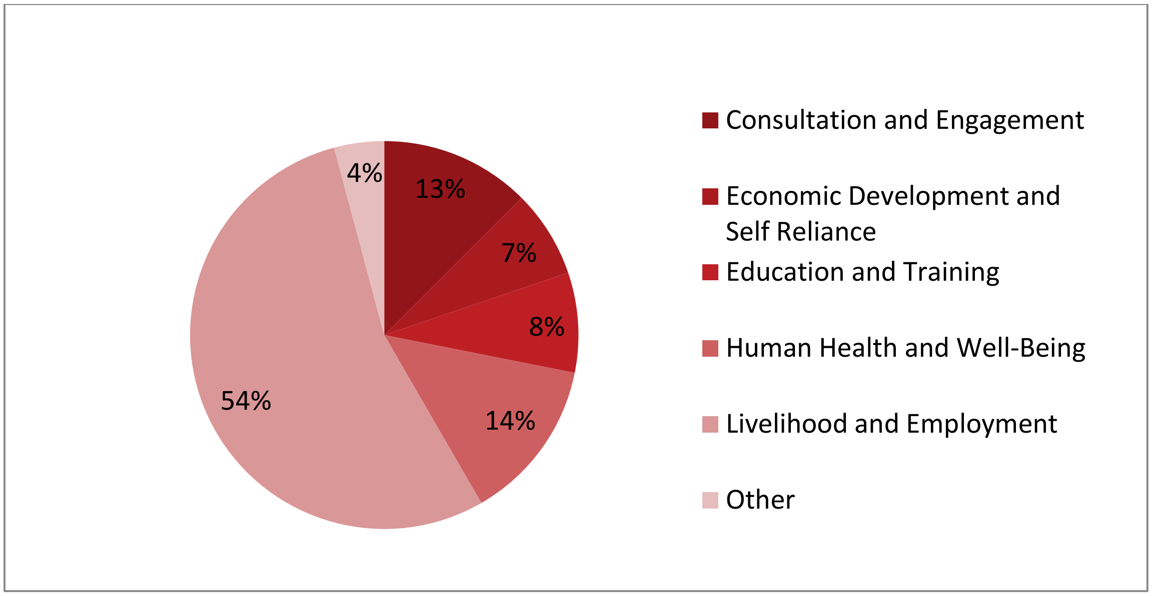


Figure 5: Community Results for What Baffinland is Doing Well

5.2.3 Are You Concerned about how the Project is Affecting the Community and the Environment?

When asked about what concerns people might have about how the Project is affecting the community or the environment, the majority of respondents (65 percent) did not have any concerns (Figure 6). Those who did express concerns about the environment (18 percent) talked about the mine affecting terrestrial and marine wildlife and wildlife habitat due to dust, changes in water quality, shipping and blasting noises. Concerns about how the Project is affecting the community (17 percent) referred to the need for more Inuit employment, concerns about substance abuse in communities, and the difficulties due to family separation from employees, and the effects on harvesting activities.

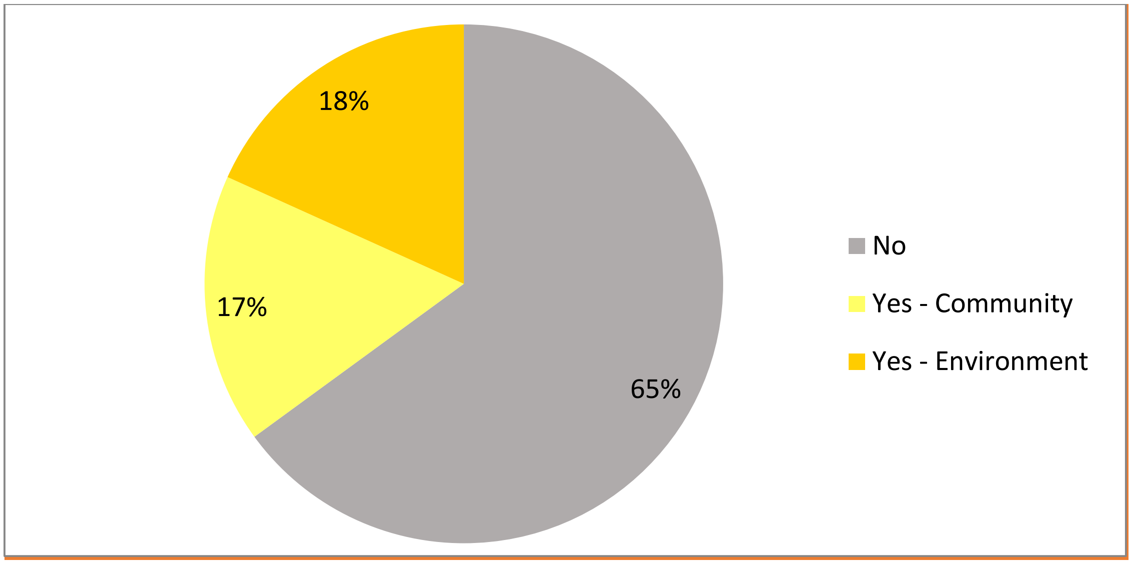


Figure 6: Number of respondents that indicated a concern about how the Project was affecting the environment or community

5.3 Ongoing Communication

5.3.1 How Would You Like to Receive Future Information about the Project?

Most survey respondents (59 percent) indicated that they are satisfied with Baffinland's current community engagement efforts. The breakdown of respondent's preference for communication between Baffinland and the communities is provided in Figure 7. Communication requests using open houses, radio, community meetings, and in person meetings with Baffinland representatives were the most frequent.

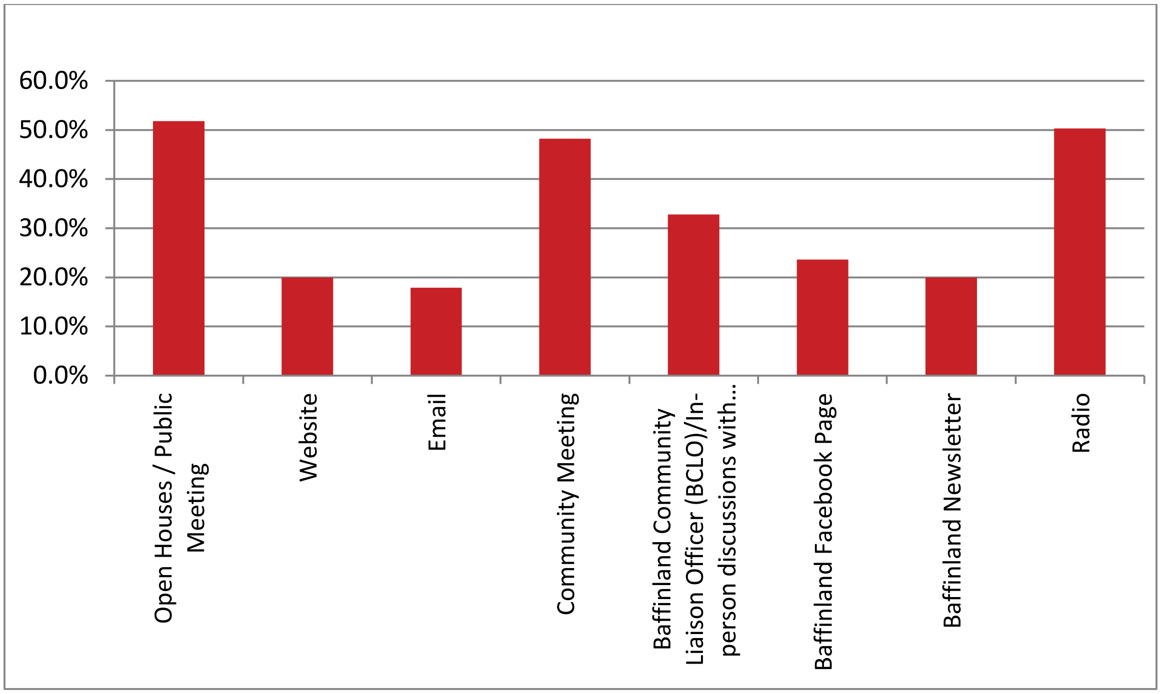


Figure 7: Breakdown of Preferred Communication Methods

5.4 Key Topics Raised

A summary of the frequency that all topics were raised by respondents is provided in Figure 8.

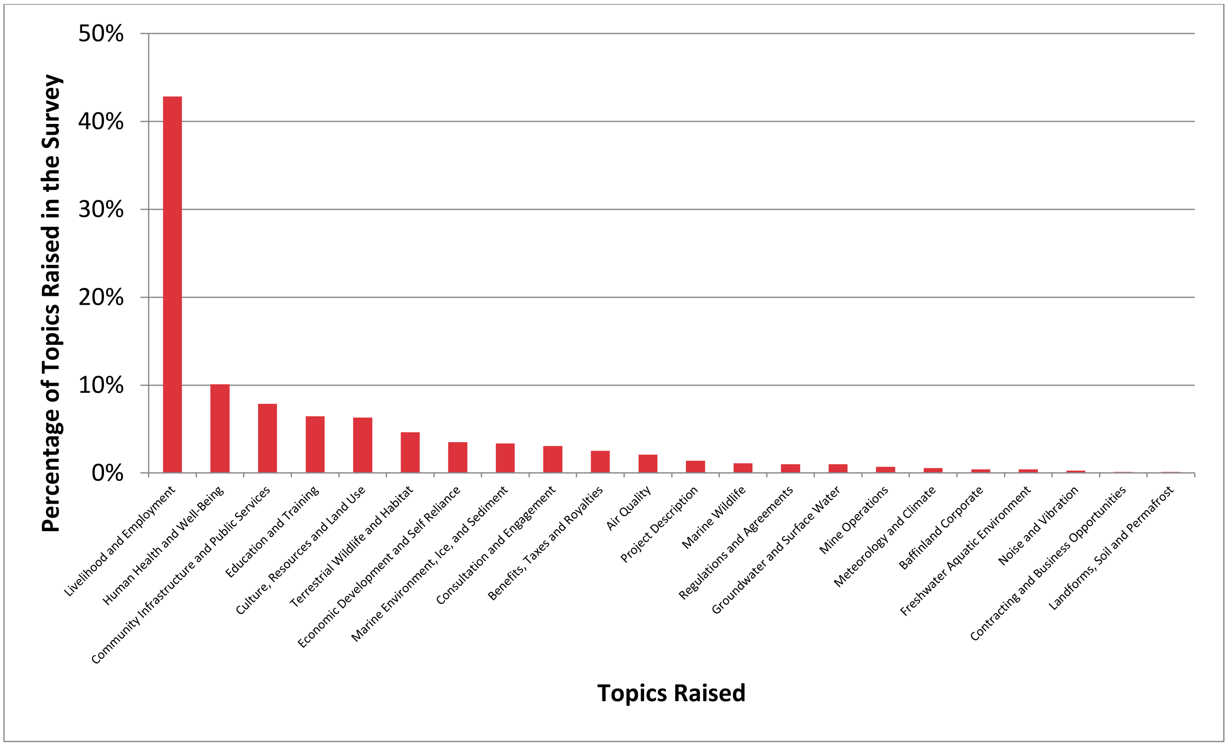


Figure 8: Frequency of Topics Raised During Community Survey

The data for the top five topics raised during the community survey are shown in Figure 9, and are further discussed below.

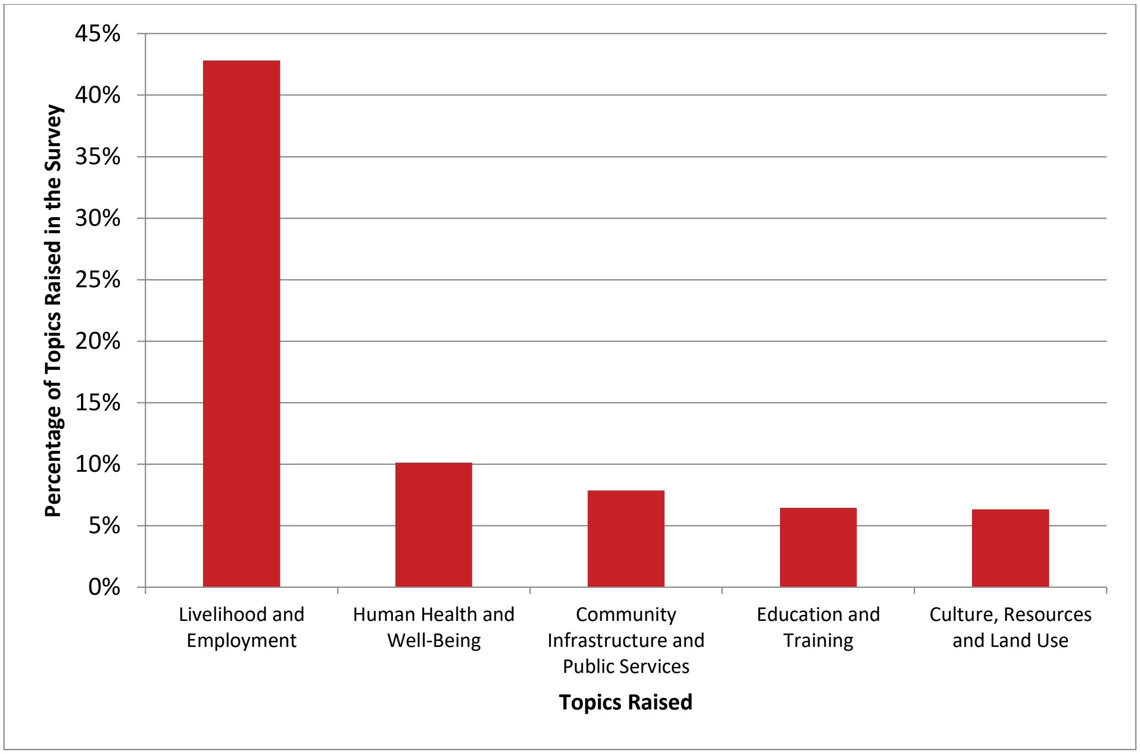


Figure 9: The Five Most Frequent Topics Raised for all Communities

5.4.1 Livelihood and Employment

Livelihood and employment was the most cited topic in the community survey, and represents 43 percent of all survey responses. Overall, comments regarding employment were positive, as locals look favourably on the fact that Baffinland is providing communities with a source of income. This is seen to result in better quality of life, and more stability for the families and the communities. However, some respondents stated that there is room to improve employment and human resources practices, with notable examples including: hiring more Inuit over southerners, hiring local youth, better advertisements of job openings, and improved job retention and career progression.

5.4.2 Human Health and Well-Being

The community responses regarding human health and well-being represents 10 percent of all survey responses. The comments included a number of topics related to local life. In the community, there is a general approval for Baffinland providing a source of income, education, and providing social support, especially with addressing challenges associated with substance abuse. However, respondents were concerned that the mine would affect local wildlife, and in turn, affect their harvesting season. Within the family unit, respondents indicated that although the communities are better off with more income, there is stress placed on families of employees due to the long distance between the communities and the mine, which is seen to have a negative effect on family stability. In the workplace, respondents indicated that Inuit workers have faced discrimination at the mine. Respondents also requested that more amenities be made available at the mine, most notably a shop to purchase popular items.

5.4.3 Community Infrastructure and Public Services

Community survey responses regarding community infrastructure and public services represent eight percent of all survey responses. Overall, respondents commented on improvements that are needed to the local infrastructure, including roads, harbours and airstrips. There were also a number of comments regarding transportation between the communities and the airports, and some of the challenges employees face when they do not have access to a vehicle to transport them to the airport.

5.4.4 Education and Training

Comments regarding education and training represented eight percent of all survey responses. Respondents commented on the need to train local Inuit community members in order to improve the benefits realized by the communities. Education initiatives such as heavy equipment operator training, college education, and work ready programs have been successful in helping locals achieve these goals. However, respondents indicated that more of this training is needed. Responses also requested additional support for youth, in order for that workforce to be considered employable by local businesses and the mine.

5.4.5 Culture, Resources and Land Use

Culture, resources and land use represent six percent of all survey responses. The majority of comments regarding cultural resources and land use mentioned how the mine is or would potentially affect the Inuit lifestyles and tradition. Respondents requested that Baffinland do more to invest in community programs, especially ones that help promote family values, as well as building community centres that promote sports. In addition, respondents requested assurance from Baffinland that the mine's activities – such as generating noise and dust – would not interfere with local harvesting of wildlife.

5.4.6 Other

Two other topics of significance that were raised in the community survey responses were:

Terrestrial Wildlife and Habitat

Some respondents are concerned that the mine changes in the bio-physical environment – such as air emissions, dust, noise, and water quality – may have an effect on the local wildlife, most notably caribou. Concerns about effects to terrestrial wildlife and habitat also extended to the effect that would have on Inuit traditional practices such as hunting and gathering activities.

Marine Environment, Ice and Sediment

Survey respondents expressed concerns that the mine would affect the marine environment, including marine mammals, marine migration patterns, and Inuit traditional practices and lifestyle. Survey responses included concerns about how shipping routes may affect the marine environment, including both fishing and hunting of the local wildlife. In particular, respondents mentioned the effect that ships may have on the fishing areas, and on narwhal calving grounds. Respondents also mentioned that shipping should not continue during periods of sea ice as this would affect hunting and wildlife migration. Safety issues were also raised regarding shipping during the winter season.

5.5 Key Topics Raised by Each Community

5.5.1 Arctic Bay

The five topics most frequently raised by survey respondents in Arctic Bay were:

1. Livelihood and employment;
2. Human health and well-being;
3. Community infrastructure and public services;
4. Education and training; and
5. Culture, resources and land use.

Livelihood and employment was the most frequent topic raised in Arctic Bay, making up 39 percent of the responses (Figure 10). The responses primarily related to Inuit employment, with the majority of comments indicating that the mine has provided positive opportunities in the form of employment and economic benefits for the community. However, other respondents also indicated a need for improved work related training for the locals and the need to hire more Inuit.

The second most frequently raised topic was human health and well-being, which makes up 16 percent of comments from Arctic Bay. The respondents stated that the long distance relationship between the mine workers and their families has affected the overall stability of the family unit. Responses included allowing more time for workers to spend with their families, and providing benefits to help out families, such as daycare.

Community infrastructure and services was the next most frequently raised topic, which was 12 percent of all community responses for Arctic Bay. Respondents indicated that community access from Arctic Bay to the airport needs to be improved, and ideas for improvement included providing a shuttlebus for Baffinland employees and improving roads infrastructure for safe travel.

Education and training was the fourth most frequently raised topic (11 percent). Comments indicated a need for improved work related training, including heavy equipment operator training, mine related training, financial education, youth training. Respondents also mentioned the need for a community learning centre and the need for financial support so that people can access training programs.

Culture, resources, and land use, made up five percent of the responses in Arctic Bay. Respondent comments included protection of Inuit lifestyles and traditions, such as hunting, Inuit crafts and protection of local wildlife.

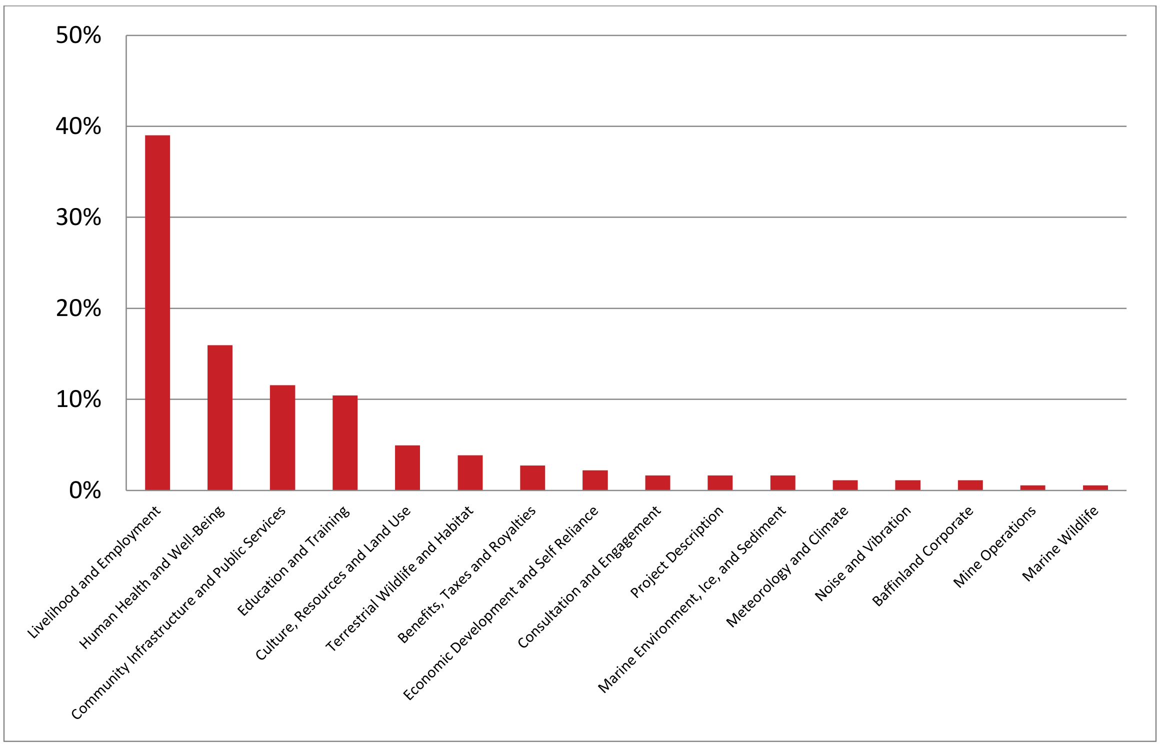


Figure 10: Breakdown of Topics Raised for Arctic Bay

5.5.2 Clyde River

The five topics most frequently raised by survey respondents in Clyde River were:

1. Livelihood and employment;
2. Human health and well-being;
3. Community infrastructure and public services;
4. Economic Development and Self Reliance; and
5. Terrestrial Wildlife and Habitat.

Livelihood and employment makes up 48 percent of the responses from Clyde River community respondents (Figure 11). The responses relate to livelihood and employment, with the majority of comments indicating that the mine has provided positive opportunities to the community in the form of jobs and economic benefits for the community. However, other respondents also indicated the need for a healthy workplace for Inuit workers, to hire more Inuit and youth, and more advertising for job openings.

Human health and well-being is the second most frequent response, making up 8 percent of the responses. Family separation was noted as a challenge in the community. Similar to Arctic Bay, there are concerns about family stability in Clyde River. Respondents also indicated the need to improve training at the mine needs and ensure an ongoing focus on safety measures.

The third most frequent response (seven percent) from Clyde River was from the following categories:

- **Community infrastructure and public services:** Respondents indicated that community access from Clyde River to the airport needs to be improved, and ideas for improvement included providing a shuttlebus for Baffinland employees and improving roads infrastructure for safe travel.
- **Economic development and self-reliance:** Certain respondents requested access to soapstone from the mine for traditional carving activities. There was positive feedback from respondents regarding Baffinland providing economic development opportunities to the community.
- **Terrestrial wildlife and habitat:** Respondents indicated some concerns that the Project may change wildlife migration patterns, especially caribou, and that traditional hunting grounds may be affected.

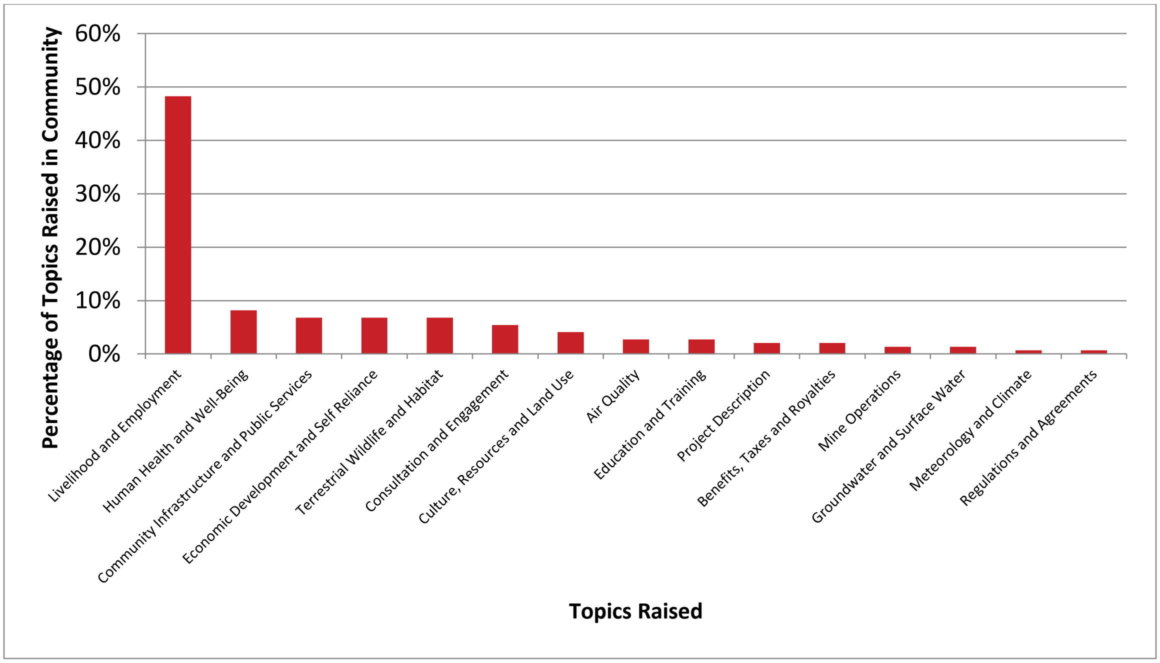


Figure 11: Breakdown of Topics Raised for Clyde River

5.5.3 Hall Beach

The five topics most frequently raised by survey respondents in Hall Beach were:

1. Livelihood and employment;
2. Culture, resources and land use;
3. Education and training;
4. Community infrastructure and public services; and
5. Human health and well-being;

Livelihood and employment is the most frequent topic raised in Hall Beach, representing 44 percent of responses (Figure 12). Community responses relate to Inuit employment, with the majority of comments indicating that the mine has provided positive opportunities to the community in the form of employment and economic benefits for the community. However, other respondents noted that there is a need for improved work related training for Inuit, and to hire more Inuit and youth. Job progression and retention is also an issue mentioned by survey respondents.

The second most frequent topic relates to culture, resources, and land use, making up 9 percent of the responses. There were no significant concerns raised by survey respondents, and overall the comments were positive. Responses were also positive regarding Baffinland's respect for

Inuit values. However, respondents did provide comments regarding protection of the local wildlife, which is considered vital for the community.

Education and training makes up 9 percent of the topics raised by community respondents in Hall Beach. Comments indicated a need for improved work related training, including heavy equipment operator training, mine related training, financial education, and youth training.

The fourth most frequent response (seven percent) from Hall Beach was from the following categories:

- **Community infrastructure and public services:** Respondents indicated that community access from Hall Beach to the airport needs to be improved. Responses also mentioned that some building projects should be implemented to improve the community infrastructure, most notably daycare.
- **Human health and well-being:** Family separation was noted as a challenge in the community, including concerns about family stability and ongoing challenges with substance abuse.

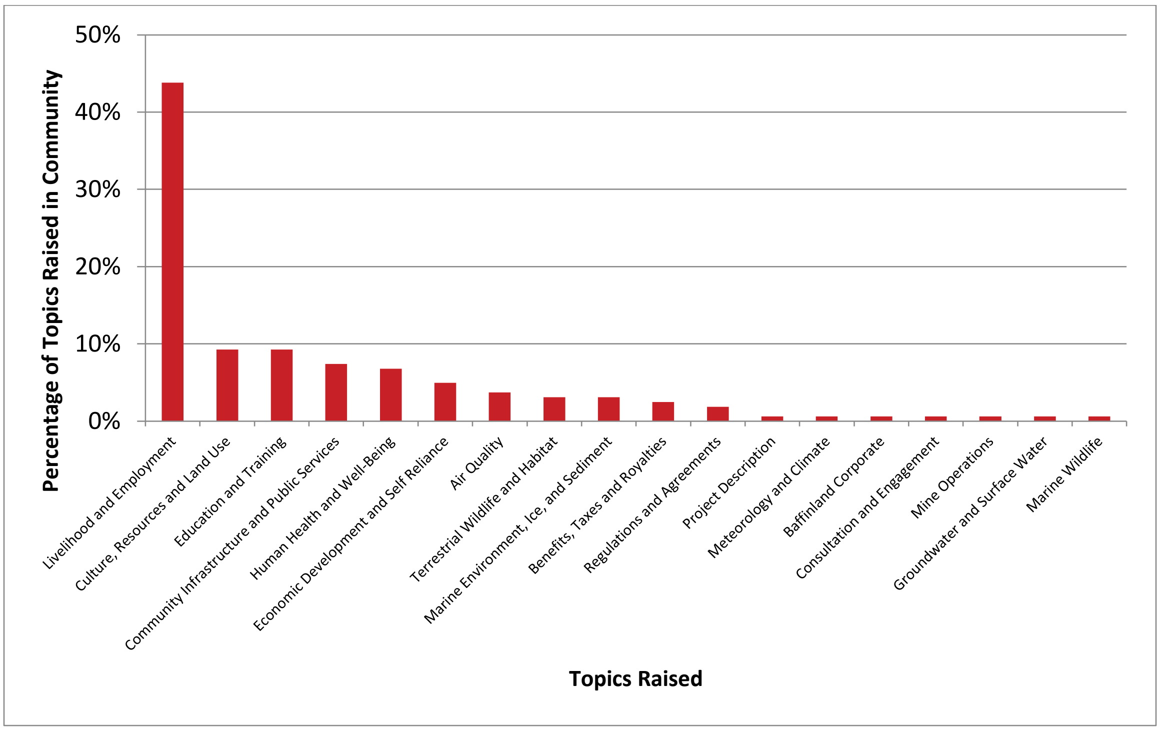


Figure 12: Breakdown of Topics Raised for Hall Beach

5.5.4 Igloolik

The five topics most frequently raised by survey respondents in Igloolik were:

1. Livelihood and employment;
2. Culture, resources and land use;
3. Education and training;
4. Human health and well-being; and
5. Terrestrial and Wildlife Habitat.

Livelihood and employment makes up 49 percent of the overall topics raised in Igloolik (Figure 13). Survey responses related to employment including opportunities the mine has provided in the form of Inuit and youth. However, some responses noted that not enough Inuit were being hired or were only employed for a very short period of time. Respondents also indicated a need for training to ensure that better jobs are obtained both at Baffinland and in the community.

The second most frequent topic is culture, resources and land use, making up 9 percent of the responses. Some respondents were concerned that changes to the bio-physical environmental and noise from the mine would change the wildlife migration patterns and hunting grounds. There was also a comment that employees are not permitted to hunt while working at the mine site.

The third most frequent response (seven percent) from Igloolik was from the following categories:

- **Education and training:** Comments indicated a need for improved work related training, especially for the youth.
- **Human health and well-being:** The comments from community respondents were primarily regarding the need for improved housing in the community and the need for more country food.

Terrestrial wildlife and habitat makes up 5 percent of the responses from Igloolik. Respondents raised concerns that changes in the bio-physical environment may change wildlife migration patterns, especially for caribou.

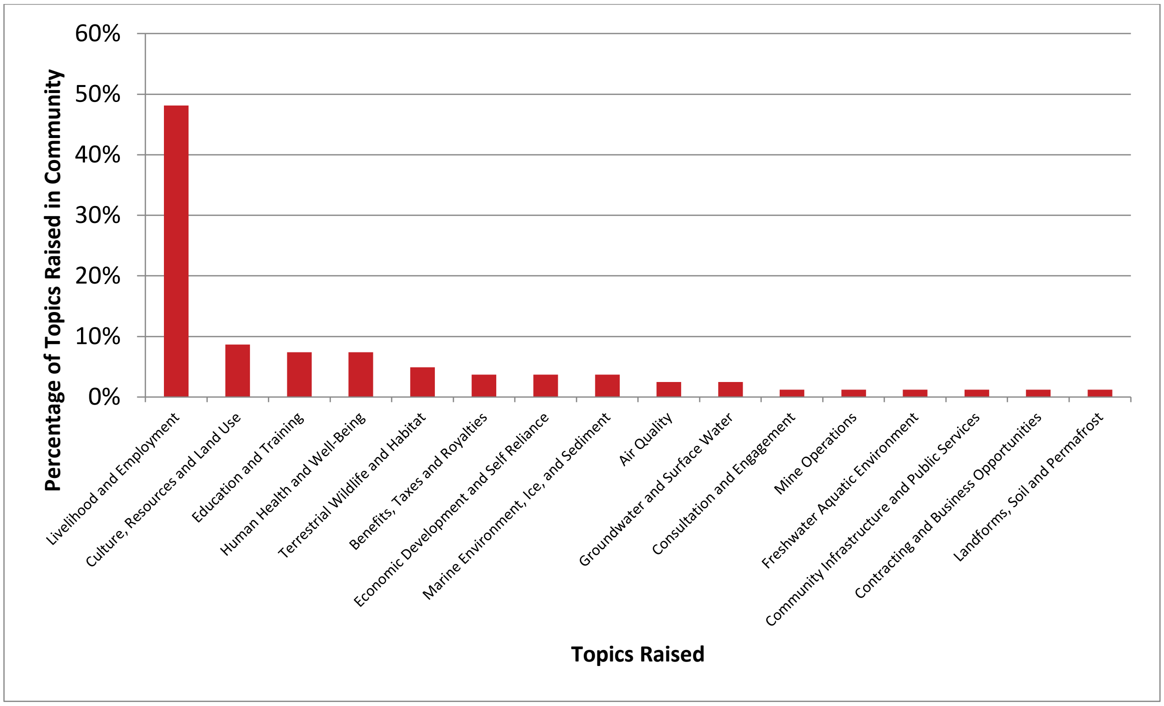


Figure 13: Breakdown of Topics Raised for Igloolik

5.5.5 Pond Inlet

The five topics most frequently raised by survey respondents in Pond Inlet were:

1. Livelihood and employment;
2. Human health and well-being;
3. Marine environment, ice and sediment;
4. Community infrastructure and public services; and
5. Consultation and engagement.

The most frequent topic raised by survey respondents in Pond Inlet relates to livelihood and employment, which represents 38 percent of all responses (Figure 14). The responses relate to Inuit employment, with the majority of comments indicating that the mine has positive provided opportunities to the community of Pond Inlet. The community responses indicate a need to improve local Inuit employment. There were also questions raised about salaries, vacation time, and job security for employees. Survey respondents also indicated the need for ongoing efforts around workplace inclusion and cultural sensitivity training

The second most frequent topic raised in Pond Inlet was regarding human health and well-being, which represents 10 percent of responses. The comments included family stability and difficulties associated with families being separated from mine employees.

The third most frequent response (nine percent) from Pond Inlet was regarding marine environment, ice and sediment: The most common responses was regarding the potential effects that ships may have on fishing and hunting grounds, which may affect harvesting. Respondents suggested that Baffinland not ship during the ice season, and minimize the number of ships.

Community infrastructure and public services makes up eight percent of the comments. Respondents indicated that local infrastructure such as the roads, the airstrip, and the harbor need to be upgraded.

Consultation and engagement makes up six percent of the responses. The survey participants responded that ongoing engagement is needed with Pond Inlet residents regarding concerns around Inuit lifestyle and traditions.

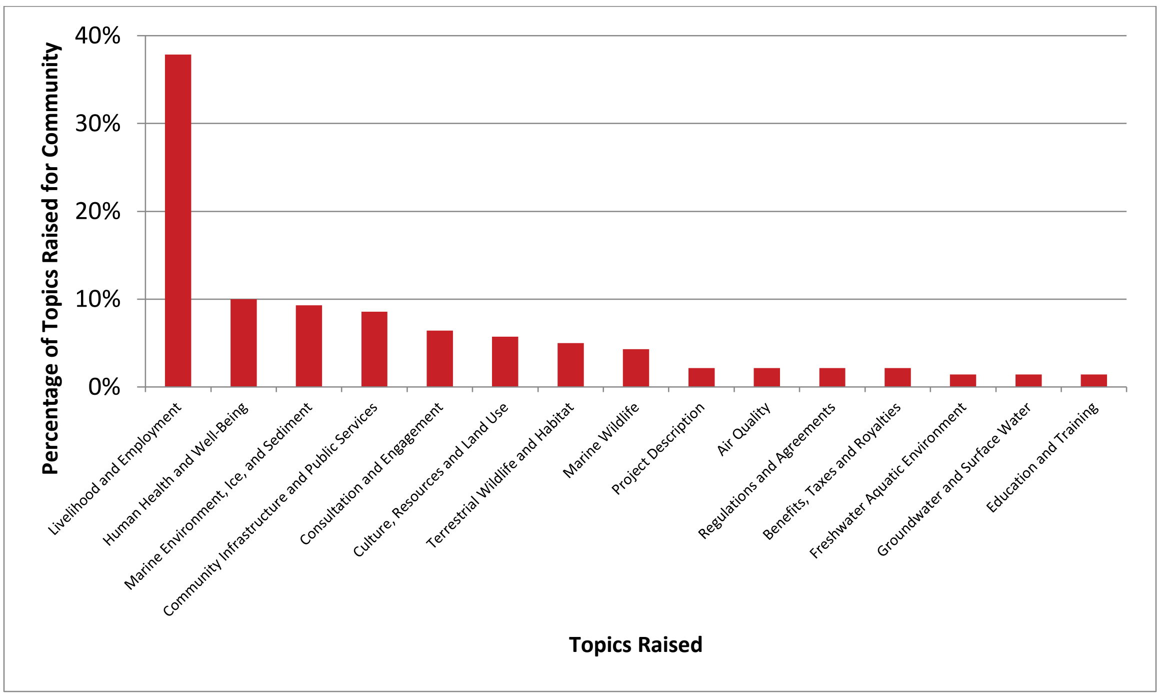


Figure 14: Breakdown of Topics Raised for Pond Inlet

6. Lessons Learned

Some lessons learned from implementing the community survey include:

1. **Overall Participation:** initial participation in the survey was low, despite BCLOs making significant efforts to encourage community participation. Offering incentives to each community member that participates may improve involvement in the future.

2. **Participation of Pond Inlet:** Although Pond Inlet is potentially one of the most affected communities surveyed, it showed the lowest participation rate. Future surveys should look for opportunities to focus on improving participation from this particular community.

3. **Clarity of Responses:** interpretation of some responses was sometimes difficult. Additional training of BCLOs on how to clarify responses will help to understand any underlying issues or concerns that community members may be trying to express.

4. **Alignment with EIS Guidelines:** some responses were not easily categorized with the EIS guidelines. Training of BCLOs on the guidelines, would help to ensure that responses can be more easily categorized and aligned with EIS guidelines.

7. Conclusions

Overall implementation of the community survey was successful, and the results have been valuable in forming Baffinland's understanding of key benefits the project is providing, and the issues and concerns that each of the five North Baffin Communities has about the Project.

The level of participation was similar between the five communities, and in general, there was strong participation from both men and women in the communities. Most survey participants were not Baffinland employees, nor had they previously worked at Mary River. There was participation from a broad range of age demographics, with nearly 70 percent of respondents being between the ages of 25-54 years old.

Most respondents (57 percent) of respondents indicated that the Project has made a positive difference in the community, 35 percent responded that they have not seen any difference, and eight percent indicated that the project has had a negative effect in the community.

When asked whether community members were concerned about how the project is affecting the community or the environment, most respondents indicated that they had no concerns.

Of all the responses received, the most frequently raised topic was regarding livelihood and employment, which represents 43 percent of responses. Overall, comments regarding employment were positive, as respondents look favourably on the fact that Baffinland is providing communities with a source of income. This is seen to result in better quality of life, and more stability for the families and the communities. However, some respondents stated that there is room to improve employment and human resource practices, with notable examples including: hiring more Inuit over southerners, hiring local youth, better advertisements of job openings, and improved job retention and career progression.

The next most frequently raised topics were: human health and well-being (10 percent), community infrastructure and public services (eight percent), education and training (eight percent), and culture, resources and land use (six percent).

Baffinland

Baffinland Iron Mines Corporation

Appendix

Survey

Mary River Project – Survey

ᒪᓕᔫᓐᓂ ᐱᓕᕆᓂᖅ – ᐊᐱᖅᓲᑦ

This survey's purpose is to collect community feedback on the Mary River Project (the Project). This is an opportunity for residents of the North Baffin region to tell the company what they think about the Project's operations to-date.

ᑖᓐ ᓇ ᐊᐱᖅᓲᑦ ᐋᑐᑎᖃᖅᑐᖅ ᓄᓇᓕᖕᒥ ᐅᓂᑦ ᑐᓴᕋᓲ ᑕᐅᓗᓂ ᒪᓕᔫᓐᓂ ᐱᓕᕆᓂᕐ ᒧᑦ (ᐱᓕᕆᓂᖅ) ᐃᓱᒪᒋᔭ ᐅᔪᓂᒃ. ᐱᕕᒃ ᓴᕆᔭ ᐅᔪᖅ ᐃᓄᖏ ᓄᑦ ᕿᑭᖅᑖᓘᑉ ᐅᐊᖕ ᓇᖕᖏᓂᕐ ᒥᐅᓄᑦ ᐅᖃᕈᓐ ᓇᕐ ᕕᐅᓪ ᓗᓂ ᐹᕕᓐ ᓵᓐ ᑯᓐ ᓄᑦ ᖃᓄᖅ ᐃᓱᒪᒋᔭᕐ ᒥᓂᒃ ᐊᐅᓚᓂᖕᒫ ᐱᓕᕆᐊᖑᐃᒪᓂᖕᒪᓄᑦ ᒫᓐ ᓇᒧᑦ.

This survey is completely voluntary and all individuals who agree to participate will remain confidential. The results of this survey will be used by Baffinland to help improve the Project and its community engagement program, and may be presented publically (e.g. in reports or presentations). Survey participants will be compensated by a draw for a prize.

ᑖᓐ ᓇ ᐊᐱᖅᓲᑦ ᐃᓱᒪᖅᓱᑎᑦ ᑎᐊᖑᔪᖅ ᐃᓚᐅᔪᒪᔪᓕᒫ ᓗ ᐊᐱᖅᓱᒻ ᒧᑦ ᖃᐅᔨᒪᓇᖅᑎᑕᐅᕝ ᔫᓐ ᖕᕋᓪ ᑭᓇᐅᓂᖕᒋ ᓂᒃ. ᑖᒃ ᑯᐊ ᖃᐅᔨ ᔭ ᐅᔪᑦ ᐊᐱᖅᓲᑎᒃ ᑯᑦ ᐋᑐᖅᑕᐅᓂᐊᖅᑐᑦ ᐸᕝᕕᓐ ᓵᓐ ᑯᓐ ᓂᑦ ᐋᖅᑭᑎᐊᕐᑯᓪ ᓗᒍ ᐱᓕᕆᓂᖕᒋᑦ ᓄᓇᓕᖕ ᓄᓪ ᓗ ᐃᓚᐅᖃᑕᐅᓂᕐ ᓄᑦ ᐱᕆᓂᕆᖕᒋᑦ, ᓴ ᖅᑭ ᑕᐅᑐᐃᓐ ᓇᕆᐊᖃᕐ ᓗᓂᓗ ᐃᓄᓕᒫ ᓄᑦ (ᓱᕐ ᓗ ᐅᓂᒃ ᑳᓂ ᑕᕐ ᕆᔭ ᐅᑎᑎᒍᓪ ᓘᓃᑦ ᐅᓂᒃ ᑳᓂ). ᐃᓚᐅᖃᑕᐅᔪᑦ ᐊᐱᖅᓲᑎᓄᑦ ᐊᒧᔭᒃ ᓴᙳᖃᑦ ᑕᕐ ᓂᐊᖅᑐᑦ ᓵᓚᒃ ᓴᐅᓯ ᐊᕈᓐ ᓇᕐ ᓗᑎᒃ.

General Questions
ᐊᐱᖅᑯᓯᑦ ᖃᓄᐃᓐ ᓇᖅ

1. Basic respondent information:
ᐊᐱᖅᓱᖅᑕᐅᔫᑉ ᒥᒃ ᓵᓄᑦ:

a) Community:
ᓄᓇᓕᐅᑉ ᐊᑎᖓ

- ☐ Hall Beach - ᓴᓂᕌᔭᖕᒥ
- ☐ Igloolik - ᐃᒡᓗᓕᖕᒥ
- ☐ Arctic Bay - ᐃᒃᐱᐊᕐᔪᖕᒥ
- ☐ Pond Inlet - ᒥᑦᑎᒪᑕᓕᖕᒥ

- ☐ Clyde River - ᑲᖏᖅᑐᒐᐱᖕᒥ
- ☐ Iqaluit - ᐃᖃᓗᐃᑦ

b) Sex:
ᐊᖑᑕᐅᕚ ᐊᕐ ᓇᐅᕙᓘᓃᑦ :

☐ Male - ᐊᖑᑎ ☐ Female - ᐊᕐ ᓇᖅ

c) Age:
ᐊᕐ ᕌᒎᖕᒋᑦ :

- ☐ Under 18 years old
  ᐊᕐ ᕌᒍᑦ 18 ᑐᖕᒑᓂ
- ☐ 18-24 years old
  18-24 ᐊᕐ ᕌᒍᓖᑦ
- ☐ 25-34 years old
  25-34 ᐊᕐ ᕌᒍᓖᑦ
- ☐ 35-44 years old
  35-44 ᐊᕐ ᕌᒍᓖᑦ
- ☐ 45-54 years old
  45-54 ᐊᕐ ᕌᒍᓖᑦ
- ☐ 55-64 years old
  55-64 ᐊᕐ ᕌᒍᓖᑦ
- ☐ 65-74 years old
  65-74 ᐊᕐ ᕌᒍᓖᑦ
- ☐ 75 years or older
  75 ᐊᕐᕌᒍᓖᑦ ᐅᖓᑖᓂᓘᓃᑦ

d) Do you work at the Mary River Project?
ᐃᖅᑲᓇᐃᔭᖅᐱᑦ ᓅᔾᔨᖕᓂ ᐱᓕᕆᐊᓂ?

- ☐ Yes - Baffinland Employee
  ᐄ- ᐹᕚᓐᓚᓐᑯᓐᓄᑦ ᐃᖅᑲᓇᐃᔭᖅᑎ
- ☐ Yes - Contractor
  ᐄ- ᑳᓐᑐᕌᒃᑎ
- ☐ No - ᐋᒃ ᑲ

e) Have you previously worked at the Mary River Project?
ᓅᔾᔨᖕᓂ ᐃᖅᑲᓇᐃᔭᓚᐅᖅᓯᒪᕕᑦ

- ☐ Yes - Baffinland Employee
  ᐄ - ᐹᕚᓐᓚᓐᑯᓐᓄᑦ ᐃᖅᑲᓇᐃᔭᖅᑎ
- ☐ Yes - Contractor
  ᐄ - ᑳᓐᑐᕋᒃᑎ

☐ No - ᐋᒃᑲ

Project-Related Questions
ᐱᓕᕆᓂᕐ ᒧᑦ ᑐᕌᖓᔪᑦ ᐊᐱᖅᑯᑏᑦ

1. Has the Project made a difference in your community?
ᐱᓕᕆᓂᖅ ᐊᓯᔾ ᔫᓯᒪᕙ ᓄᓇᒋᔭᕐ ᓯᓐ ᓂ?

- ☐ Yes - Positive

  ᐄ - ᐱᐅᔪᒥᒃ

- ☐ Yes - Negative

  ᐄ - ᐱᐅᖏᑦᑐᒥᒃ

- ☐ No

  ᐋᒃ ᑲ

If yes, in what way?
ᐊᖏᕈᕕᑦ, ᖃᓄᖅ ᐊᒃ ᑐᐃᕙ?

____

____

2. Are you concerned about how the Project is affecting the community (e.g. cultural activities, harvesting, family life etc.)?
ᐃᓱᒫᓘᑎᕚᐅᒃ ᐱᓕᕆᓂᐅᑉ ᐊᒃ ᑐᐃᓂᖓ ᓄᓇᓕᖕ ᒥᐅᓂᒃ (ᓈᕐ ᓗ ᐃᓅᓯ ᑐᖃᒃ ᑯᑦ ᐱᓕᕆᓃᑦ, ᐊᖑᓇᓱᖕ ᓃᑦ, ᐃᓚᒌ ᓅᓗᑦ ᐃᓅᓯᖅ ᐊᓯᖕᖏᓪᓗ)?

- ☐ Yes - ᐄ
- ☐ No - ᐋᒃ ᑲ

a) If yes, what are you concerned about?
ᐊᖏᕈᕕᑦ, ᑭᓱᓂᒃ ᐃᓱᒫᓘᑎᖃᖅᐱᑦ?

____

____

b) If yes, do you have any suggestions on what Baffinland can do about it?
ᐊᖏᕈᕕᑦ ᐃᓱᒪᒋᔭᖃᖅᐱᑦ ᐸᕝᕙᓐ ᓚᓐ ᑯᓐ ᓄᑦ ᐋᖅᑭᒋᐊᕈᑎᒋᔪᓐ ᓇᖅᑐᓂᒃ ᑕᒪᑐᒧᖓ?

____

____

Baffinland

Baffinland Iron Mines Corporation

3. **Are you concerned about how the Project is affecting the environment (e.g. air quality, water quality, noise, wildlife, fish)?**
   ᐃᓱᒫᓘᒃ ᐲᑦ ᐱᓕᕆᓂᕐᒃ ᐊᑐᐃᓇᓱᒋᓪᓗᒍ ᐊᕙᑎᒃ (ᓰᕐ ᓗᓯᑕᐹ ᐱᐅᓂᖓᑦ, ᐃᒥᐹ ᐱᐅᓂᖓᑦ, ᓂᐸᕿᓐᓂᒃ ᑯᑦ, ᓂᕐ ᔪᕆᓪᓗᑦ, ᐃᖃᓘᒃ ᑎᒍᑦ)?

   - ☐ Yes - ᐄ
   - ☐ No - ᐋᒃ ᑲ

a) If yes, what are you concerned about?

ᐊᖏᕈᕕᑦ, ᑭᓱ ᓂᒃ ᐃᓱᒫ ᓘᑎᖃᖅᐱᑦ ?

____

____

b) If yes, do you have any suggestions on what Baffinland can do about it?
ᐊᖏᕈᕕᑦ ᐃᓱᒪᒋᔭᖃᖅᐲᑦ ᐹᕙᓐ ᓚᓐ ᑯᓐ ᓄᑦ ᐋᖅ ᑭ ᒋ ᐊᕈ ᑎᒋ ᔪᓐ ᓇᖅ ᑐᓂᒃ ᑕᒪ ᑐᒧᖕᖓ

____

____

4. **What else can the Project be doing for the community?**
   ᖃᓄᒃ ᑲᓐ ᓂᖅ ᐱᓕᕆᔪᓐ ᓇᖅᐸᑦ ᐱᓕᕆᔪᑦ ᓄᓇᓕᖕ ᒥ ᐅᓄᑦ ᐃᑲᔫᑎᖃᕈᓐ ᓇᖅᑐᓂᒃ ?

____

____

5. **Do you have any other questions, comments, or suggestions you would like to share with us?**
   ᐊᐱᖅ ᑯᑎᒃ ᓴᖅᐲᑦ, ᐅᖃᐅᓯᒃ ᓴᖅᐲᑦ, ᖃᓄᐃᒋᐊᑲᓐ ᓂᕆᑎᒃ ᓴᓂᒃ ᐃᓱᒪᒋᔭᖅᐲᑦ ᐅᖁᑎᓐ ᓄᑦ ᑐᓴ ᐅᒪᔭ ᐅᖁᔭᔅ ᓯᓐ ᓂᒃ ?

____

____

Baffinland
Baffinland Iron Mines Corporation

Ongoing Communication
ᑲᔪᓰᓇᖅᑐᒃ ᑯᑦ ᑐᓴᐅᒪᖃᑎᒌᖕᓂᖅ

1. **How would you like to receive future information about the Project? (Check the most applicable boxes)**
ᑐᓴᖅᑎᑦ ᑎᔾ ᔪᑎᓂᒃ ᑭᓱᓂᒃ ᑐᓴᐅᒪᔾ ᔪᑎᖃᒃ ᑲᓐ ᓂᕈᒪᕕᑦ ᓱᕗᓂᑦ ᑎᓐ ᓂ ᐱᓕᕆᓂᓕᕆᔪᓂᒃ ?
(ᓂᕈᐊᕐ ᓱᒋᑦ ᐱᐅᓂᖅᐹᖕᖑᔫ ᒋᔭᑎᑦ ᓇᓗᓇᐃᔭᕋᖕᒍᑦ)

- ☐ Open Houses / Public Meeting
ᑐᑭ ᓯ ᕚᓪ ᓚᕿᑎᒃ ᓴᐅᓪ ᓗᖕᒋᑲ ᑎᒪ ᑎᑦ ᑎᓃᑦ / ᐃᓄᓚᒫ ᖅᑎᑦ ᑎᓃᑦ
- ☐ Website
ᖃᕋᓯ ᐅᔭ ᑎᒍ ᑦ ᐱᔪ ᒥ ᓇᖅ ᓯ ᐅᑎᑎᒍ ᑦ
- ☐ Email
ᖃᕋᓯ ᐅᔭ ᑎᒍ ᑦ ᑎᑎᕋ ᖃᑦ ᑕᐅᑎᓗᑦ
- ☐ Community Meeting
ᓄᓇᓕᖕ ᓂ ᑲ ᑎᒪ ᔪ ᓂ
- ☐ Baffinland Community Liaison Officer (BCLO) / in-person discussions with Bafflinland representatives
ᐹᕕᓐ ᓛᓐ ᑯᓐ ᓂ ᓄᓇᓕᖕ ᓂ ᑎᑎᕋ ᖅ ᑎᖏᓐᓂᑦ /
ᓇᔪ ᖅ ᑎᓰ ᒡ ᓗᓂ ᐅᖃᖃᑎᒌ ᖕ ᓂᒃ ᑯ ᑦ ᐹᕚᓐ ᓛᓐ ᑯ ᑦ ᑭ ᒡ ᒐ ᖅ ᑐᖅ ᑎᖏ ᓄᑦ
- ☐ Baffinland Facebook Page
ᕚᐃᔅ ᐳᒃ ᑯ ᑦ
- ☐ Baffinland Newsletter
ᐸᐃᑉ ᐹᑎᒍ ᑦ ᐱᕙᓪ ᓚᐊᔪ ᑎᒍ ᑦ
- ☐ Radio
ᓈᓚᐅᑎᒃ ᑯ ᑦ
- ☐ Other: _________________
ᐊᓯ ᐊᒍ ᑦ

2. **Do you think enough community engagement has been done by Baffinland?**
   ᐹᕙᓐ ᓛᓐ ᑯᑦ ᓄᓇᓕᖕ ᓂᒃ ᐃᓚᐅᑎᑦ ᑎᖃᑦ ᑕᕐ ᓂᖕᒋᕐ ᓈᒻ ᒪᒃ ᐹ?
   - ☐ Yes - ᐄ
   - ☐ No - ᐋᒃ ᑲ

3. **Are there things Baffinland is doing well? If yes, what are they?**
   ᐹᕚᓐ ᓛᓐ ᑯᑦ ᐱᓕᕆᑦ ᑎᐊᓂᖅᑲᖅ ᐹᑦ ? ᐊᖏᕈᕕᑦ , ᑭᓃ ᕙᑦ ᐱᓕᕆᐊᕆᑦ ᑎᐊᖅ ᑕᖏᓐ ?

____

____

4. **Are there things Baffinland is not doing well? If yes, what are they?**
   ᐹᕙᓐ ᓛᓐ ᑯᑦ ᐱᓕᕆᓂᖔᖅ ᑭ ᑦ ᑎᐊᖅ ᓯ ᒪ ᖏᓐ ᓂᖅᑲᖅ ᐹ? ᐊᖏᕈᕕᑦ , ᑭ ᓃ ᕙᑦ
ᐋᖅ ᑭ ᑦ ᑎᐊᖅ ᓯ ᒪ ᖏᓐ ᑐᑦ ?

____

____

5. **Do you have any suggestions on how Baffinland can improve its community engagement activities?**
   ᐃᓱᒪᒋᔭᖅᑲᖅ ᐲᑦ ᖃᓄᖅ ᐹᕙᓐ ᓛᓐ ᑯᑦ ᐱᐅᓯ ᑎᑦ ᑎᒃ ᑲ ᓂᕈ ᓇᕐ ᒪᖔᑕ ᓄᓇᓕᖕ ᒥᐅᓂᒃ
ᐃᓚᐅᑎᑦ ᑎᑦ ᑎᐊᕐ ᓂᕐ ᒥᒃ ?

____

____

6. **Baffinland is considering the use of community surveys on a regular (e.g. annual) basis to monitor community views on the Project. Would you be supportive of this?**
   ᐹᕙᓐ ᓛᓐ ᑯ ᓂᑦ ᐃᓱᒪᒃ ᓴᖅᓯ ᐅᕈᑕᐅᖕ ᒪᑦ ᓄᓇᓕᖕ ᓂᑦ ᐊᐱᕉ ᑏᑦ
ᐊᑐᖅ ᑕᐅᖏᓐ ᓇᕐ ᓂᐊᓕᕐ ᒪᖔᑕ (ᕉ ᕐ ᓗ
   ᐊᕐ ᖀᒍᑕᓛ ᑦ) ᖃᐅᔮ ᓴ ᐅᑕᐅᕙᓪ ᓗᑎᒃ ᓄᓇᓕᖕ ᒥ ᐅᑦ ᐃᓱᒪᒋᔭ ᖏᓐ ᐱᓕᕆᓂᑎᒃ
ᖃᓄᐃᒋᔭᐅᖕ ᒪᖔᕐ . ᐊᐱᖅ ᕉ ᑎᓂᒃ ᐊᑐᖃᑦ ᑕᕐ ᓂᖅ ᐃᑲᔪ ᖅ ᑐᕿᔭ ᖅ ᐱᐅᒃ ?

   - ☐ Yes - ᐄ
   - ☐ No - ᐋᒃ ᑲ

Radio Announcement

English

Baffinland wants to hear from you!

Baffinland is conducting a community survey to hear more from you about the Mary River Project.

This is an opportunity for residents of <<Community Name Inserted Here>> to tell the company what they think about the Project's operations to-date.

Please stop by your local BCLO office anytime between September 12th and September 30th. Someone will be there during regular office hours, to help you with the survey.

If you have any questions about the survey, please contact your BCLO.

We encourage all residents to participate in this important event.

Inuktitut

ᐹᕙᓐᓛᓐᑯᑦ ᐃᓕᓯᓐᓂᑦ ᑐᓴᕈᒪᔪᑦ!

ᐹᕙᓐᓛᓐᑯᑦ ᐱᓕᕆᓂᐊᕐᒪᑕ ᓄᓇᓕᖕᓂ ᐊᐱᖅᓲᑎᒥᒃ ᐃᓕᓯᓐᓂᑦ ᑐᑭᓯᐊᒃᑲᓐᓂᕈᑎᒥᒃ ᓄᓘᔾᖕᓂ ᐱᓕᕆᓂᐅᑉ ᒥᒃᓵᓄᑦ.

ᑖᓐᓇ ᐱᕕᖃᕐᕕᒃᓴᐅᓂᐊᖅᐳᖅ ᐃᒡᓗᓕᖕᒥ ᓄᓇᖃᖅᑐᑦ ᖃᓄᖅ ᐃᓱᒪᖕᒪᖕᒑᑕ ᐱᓕᕆᓂᐅᑉ ᐊᐅᓚᓂᖓᓂᒃ ᒫᓐᓇᒧᑦ ᑎᑭᖦᖢᒍ.

ᐊᖅᑯᓵᕈᓐᓇᖅᐳᑎᑦ ᓄᓇᓕᖕᓂ ᐹᕙᓐᓛᓐᑯᑦ ᑐᓴᐅᒪᑎᑦᑎᔨᖕᒐᑕ ᑎᑎᕋᕐᕕᖕᒐᓄᑦ ᖃᖕᒐᑐᐃᓐᓇᖅ ᐊᑯᓐᓂᖕᒐᓂ ᓯᑎᐱᕆ 12 ᐊᒻᒪ ᓯᑎᐱᕆ 30 ᐃᖅᑲᓇᐃᔭᕐᓇᐅᑎᓪᓗᒍ, ᐊᐱᖅᓲᑎᒧᑦ ᐃᑲᔪᖅᑕᐅᓂᐊᕋᕕᑦ.

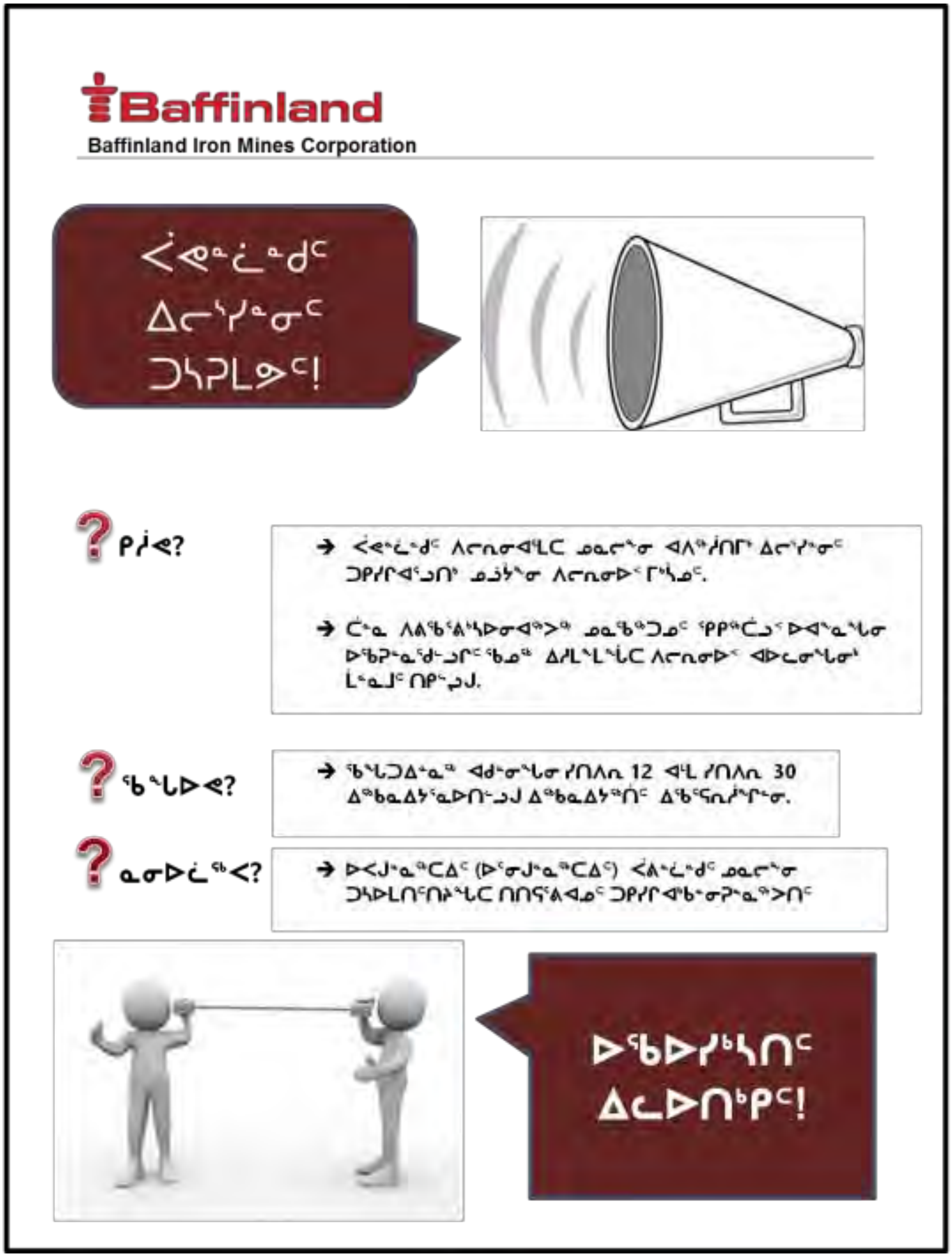
ᐊᐱᖅᑯᑎᒃᓴᖃᕋᔭᕐᓂᕈᕕᑦ ᑖᔅᓱᒧᖓ ᐊᐱᖅᓲᑕᐅᔪᒧᑦ, ᑐᑭᓯᐊᕐᕕᒋᓗᒃ ᓄᓇᓕᖕᓂ ᐹᕙᓐᓛᒃᑯᑦ ᑐᓴᐅᒪᑎᑦᑎᔨᖕᒐᑦ.

ᑲᔪᖕᒋᖅᓴᐃᕗᒍᑦ ᓄᓇᓕᖕᒥᐅᓕᒫᑦ ᐃᓚᐅᑦᑎᐊᕐᑯᓪᓗᒋᑦ ᑖᔅᓱᒧᖓ ᐱᓪᓚᕆᐅᔪᒧᑦ (ᐱᒻᒪᕆᐅᔪᒧᑦ) ᐊᐱᖅᓲᒻᒧᑦ.

Poster

English

Inuktitut


Baffinland
Baffinland Iron Mines Corporation
ᐹᕙᓛᒃᑯᑦ
ᐃᓕᔅᓯᒪᓂᑦ
ᑐᓴᕈᒪᕗᑦ!
ᑭᓲᕙ?
ᐸᕙᓛᒃᑯᑦ ᐱᓕᕆᓂᐊᕐᒪᑕ ᓄᓇᓕᖕᓂ ᐊᐱᖅᓱᕆᑎᒥᒃ ᐃᓕᔅᓯᒪᓂᑦ ᑐᑭᓯᒋᐊᕐᓗᑎᒃ ᓄᓘᔮᖕᓂ ᐱᓕᕆᓂᐅᑉ ᒥᒃᓵᓄᑦ.
ᑖᓐᓇ ᐱᕚᖅᑳᕐᕕᔅᓴᐅᓂᐊᖅᐳᖅ ᓄᓇᖃᖅᑐᓄᑦ ᕿᑭᖅᑖᓗᑉ ᐅᐊᓐᓇᖓᓂ ᐅᖃᕈᓐᓇᕐᓂᕆᓗᒋᑦ ᖃᓄᖅ ᐃᓱᒪᖕᒪᖔᑕ ᐱᓕᕆᓂᐅᑉ ᐊᐅᓚᓂᖓᓂᒃ ᒫᓐᓇᒧᑦ ᑎᑭᓪᓗᒍ.
ᖃᖓᐅᕙ?
ᖃᖓᑐᐃᓐᓇᖅ ᐊᑯᓐᓂᖓᓂ ᓯᑎᐱᕆ 12 ᐊᒻᒪ ᓯᑎᐱᕆ 30 ᐃᖅᑲᓇᐃᔭᕐᓇᐅᑎᓪᓗᒍ ᐃᖅᑲᓇᐃᔭᖅᑎᑦ ᐃᖅᑲᕐᕿᓇᓱᖕᒥᓂ.
ᓇᓂᐅᓛᖅᐸ?
ᐅᐸᒍᓐᓇᖅᑕᐃᑦ (ᐅᕐᓂᒍᓐᓇᖅᑕᐃᑦ) ᐹᕝᕙᓛᒃᑯᑦ ᓄᓇᓕᖕᓂ ᑐᓴᐅᒪᑎᑦᑎᔾᔪᑎᖏᓐᓂ ᑎᑎᕋᕐᕕᐊᓄᑦ ᑐᑭᓯᒋᐊᒃᑳᓂᕈᓐᓇᖅᐳᑎᑦ
ᐅᖃᐅᓯᒃᓴᑎᑦ
ᐃᓚᐅᑎᒃᑭᑦ!

APPENDIX C

COMMUNITY TOUR MEETING RECORDS (NOV 2016)

Baffinland Nov 2016 Community Meeting Results Summary

2/2/2017

Background

Between November 21st and 25th (2016), Baffinland initiated a tour of the five North Baffin communities that are the most likely to be affected by the Mary River Project. The tour consisted of public meetings, open houses, and face-to-face meetings with community leaders. In each community, a meeting was held with the Hamlet Council and in Pond Inlet and Arctic Bay separate meetings were held with the Hunter and Trapper Organizations (HTOs). The purpose of the meetings was to:

- Present an update on the current operations and plans for future expansion;
- Provide residents an opportunity to ask questions and voice any concerns they may have;
- Support ongoing engagement and relationship building between Baffinland and the North Baffin communities; and
- Understand what changes the communities have observed, since the start of mine operations.

Format of the Community Tour

For all communities, Baffinland staff attended a variety of face-to-face meetings with Hamlet Councils and in both Pond Inlet and Arctic Bay separate meetings were held with the HTOs. In each community, there was a public meeting and an open house to engage with as many affected and interested community members as possible.

In order to promote attendance at the events, Baffinland Community Liaison Officers (BCLOs) promoted the events in their respective communities, and organized face-to-face meetings with Hamlet Councils and HTOs (where possible). Regular radio announcements started two weeks before the event, posters were displayed in the local Co-op and Northern Stores, the schedule as was posted on Baffinland's website, and invitation letters were sent to community leadership and key stakeholders. Incentives, such as refreshments and prize draws, were announced to encourage attendance at the Open Houses.

In each community, Baffinland representatives attended face-to-face meetings with the local Hamlet Council, and in Pond Inlet and Arctic Bay separate meetings with HTOs were organized. Meetings were also held with other key stakeholders. A summary of the community tour events is as follows:

Event	Number	Notes
Hamlet Meetings	5	
HTO Meetings	2	There were also two Hamlet Council meetings (Igloolik and Clyde River) where HTO representative(s) were able to attend.
Public Meetings + Open Houses	5	
Other	3	Economic Development Officer, arctic researcher, Archivist.

An Open House and a Public Meeting was held between approximately 5:00pm and 10pm in each community. The Open House consisted of five information stations, which were organized as follows:

Station 1	Current Operations & Camp Life
Station 2	Results from Community Survey
Station 3	Environmental Monitoring
Station 4	Recruitment and Employment
Station 5	Expansion Project

Baffinland representatives were present at each of the stations to answer any questions that were raised and to record any issues or concerns that were raised by residents. The format of the Public Meeting included a 30 minute presentation, providing an update on Baffinland, which generally followed the content of the Open House stations. A question and answer session followed the presentation to respond to resident questions and concerns and to ensure that all issues were documented for follow-up, as required. During the event, community members were provided with comment forms, which provided an opportunity to give anonymous written feedback to Baffinland. All concerns or issues that required follow-up were documented and the names of residents were noted as appropriate. All data was uploaded to the StakeTracker database for analysis and follow-up.

The public meeting presentation was made in Inuktitut, and all written materials (presentations, comment forms, posters, etc.) were translated into Inuktitut. Whisper kits were available to all community residents, and simultaneous translation was available between English and Inuktitut for all events.

Schedule of Meetings and Events

Baffinland Iron Mines Participants

Joe Tigullaraq, Mary Hatherly, Parul Saxena, Megan Lord-Hoyle, Adam Gregorczyk, Joshua Arreak, Shiwley Paul, Richard Cook (Knight Piesold), Olivia Gamache (Hatch)

Community	Event Information
Clyde River - November 21st	**Hamlet with HTO representation** (Joe, Mary, Joshua, Megan) - 5:30-7:00pm **Open house and Public Meeting** (All BIM) - 5:30-6:00, 7:00-10:15pm

Community	Event Information
Pond Inlet - November 22nd	**Pond Inlet Archives** (Megan, Richard) **-** 11:00-11:30am **SmartIce** (Megan and Richard) - 11:45-12:30pm **HTO Meeting** (Joe, Mary, Joshua, Megan, Shiwley, Richard) -1:30-3:00pm **Hamlet Meeting with Mary River Community Group** (Joe, Mary, Joshua, Megan, Richard) - 3:30-5:45pm **Open House and Public Meeting** (All) - 4:30-6pm, 7-10:30pm
Arctic Bay - November 23rd	**HTO Meeting** (Joe, Mary, Joshua, Megan, Shiwley, Richard) - 11:00-12:15pm **Economic Development Officer (Heritage Centre)** (Megan and Richard) - 3:30-4:15pm **Hamlet Meeting** (Joe, Mary, Joshua, Megan, Richard) - 4:30-6:00pm **Open House and Public Meeting** (All) - 4:30-6:00pm, 7:00-11:00pm
Igloolik - November 24th	**Hamlet Meeting with HTO representation** (Joe, Mary, Joshua, Megan, Shiwley) – 2:00-4:15pm **Open House and Public Meeting (local media present)** (All) - 4:30-6:00pm, 7:00-9:30pm
Hall Beach - November 25th	**Hamlet Meeting** (Joe, Mary, Joshua, Megan, Shiwley) - 1:30-4:30pm **Open House and Public Meeting** (All) – 4:30pm-6:00pm, 7pm-10:30pm

Results

A total of 332 North Baffin residents attended the public meetings and open house events, which can be broken down as follows for each community:

Arctic Bay	Clyde River	Hall Beach	Igloolik	Pond Inlet
85	67	64	31	85

Summary of Topics Raised

The most common questions coming from the communities were about Inuit employment. Regarding Inuit employment, the issues that were raised during the community tour included challenges around job stability and progression, improving Inuit recruitment and retention, ensuring a positive working environment at the mine, and training and capacity building. Included in the tour was a human resources representative from Baffinland, who provided residents with an update of the programming that was put in place in 2016, and that will be rolled out in 2017.

A second focus of discussion was around the potential effects that shipping may be having in the North Baffin areas. A number of questions were asked about the shipping process and plans for the expansion project, such as the routes used, the fleet size, environmental emergency plans and management procedures, interactions with ships during the harvesting season, duration of the shipping season and ideas for improving communications regarding the shipping program. Details regarding the shipping program and the environmental monitoring programs were provided by Baffinland representatives.

Topics Raised

Arctic Bay

The topics raised by the community residents in Arctic Bay were primarily related to Inuit employment at Baffinland (Figure 1), including: establishing a positive work environment, training, job retention, and future work opportunities. Residents also talked about their Inuit way of life and about obtaining funding for their community and programs.

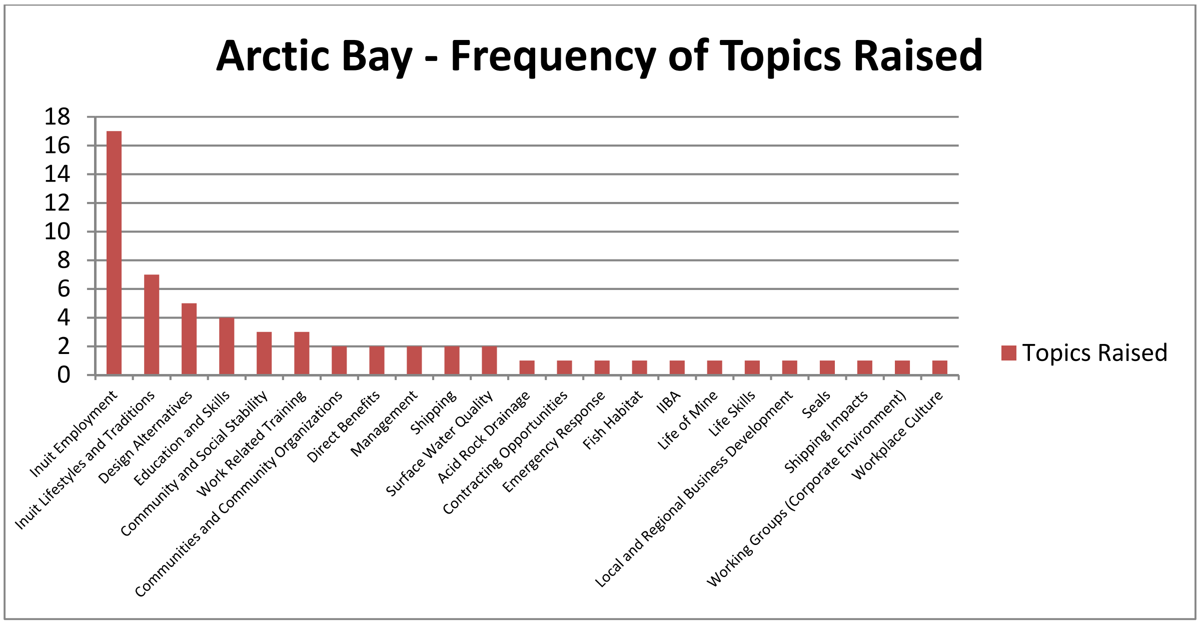


Figure 1: Topics Raised in Arctic Bay Open House

Clyde River

The residents of Clyde River were primarily concerned about how shipping activities may affect the Inuit way of life, including harvesting activities, and were interested in what environmental protection measures are being taken by Baffinland (Figure 2).

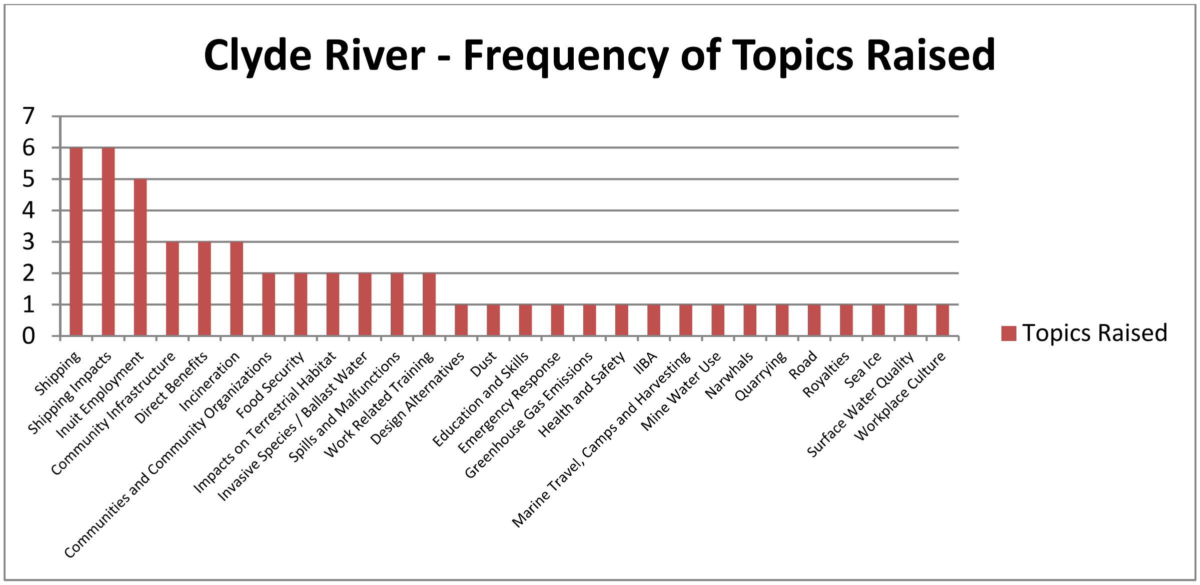


Figure 2: Topics Raised in Clyde River Open House

Hall Beach

Inuit employment was the primary focus for discussions with residents from the Hall Beach community. Similar to Arctic Bay, residents discussed creating a positive work environment at the site, training, job retention, and future work opportunities (Figure 3).

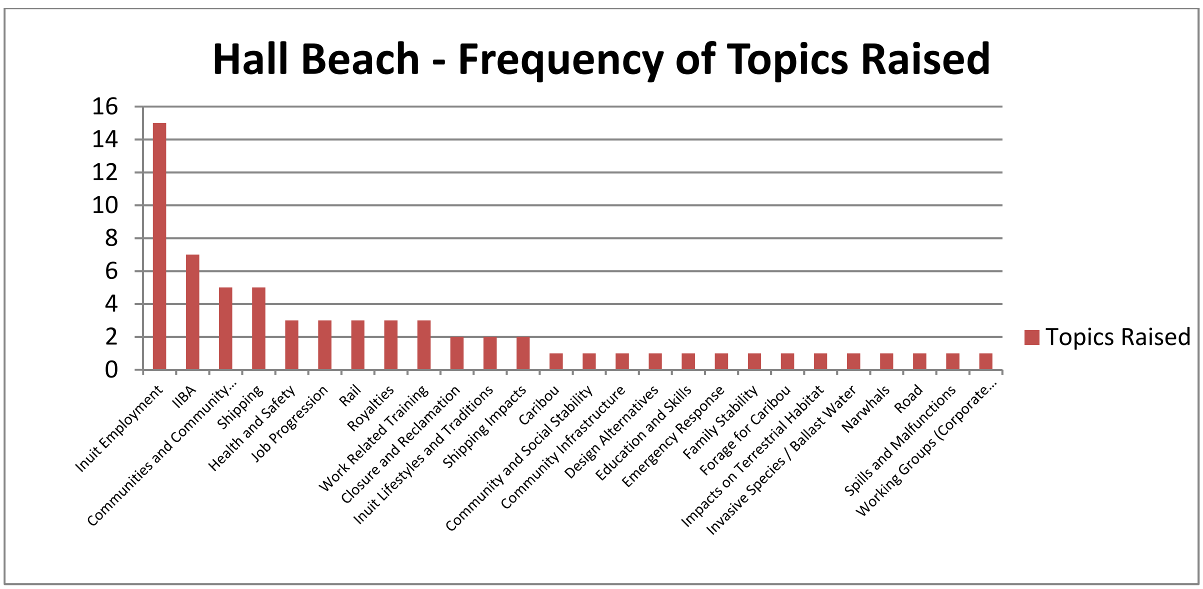


Figure 3: Topics Raised in Hall Beach Open House

Igloolik

Inuit employment was also the most frequent topic raised at the meetings in Igloolik. Residents inquired about job stability when working at Baffinland as well as training in the workplace. Meetings with the Hamlet also included discussions about optimizing the design for the expansion project and shipping routes (Figure 4).

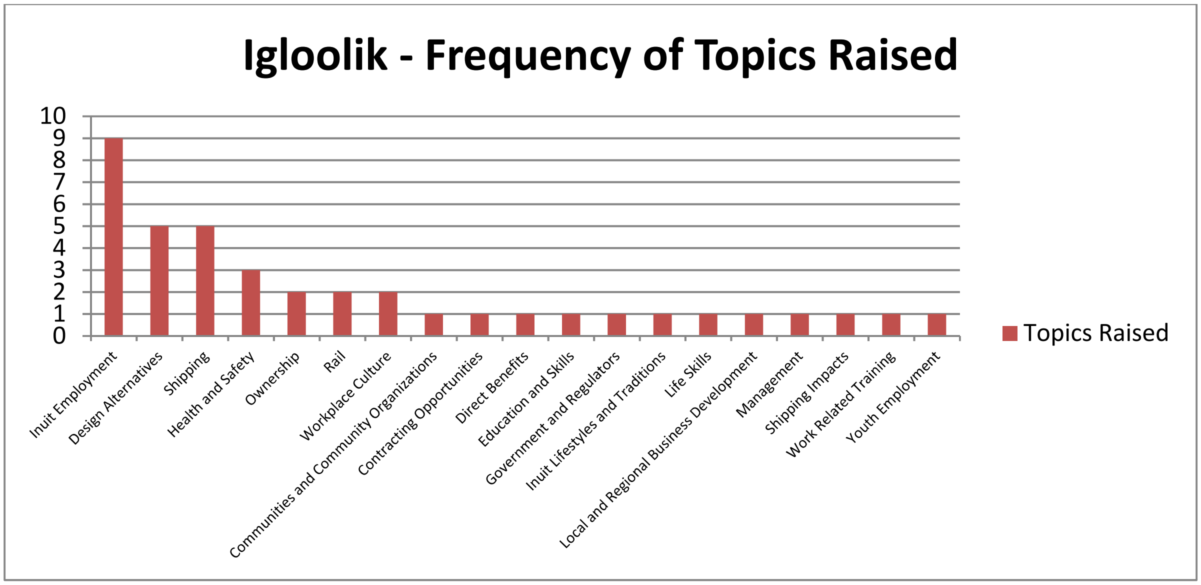


Figure 4: Topics Raised in Igloolik Open House

Pond Inlet

Residents in Pond Inlet were also focused on employment including creating a positive work environment, training, job retention, and future work opportunities. Residents also had a number of questions about the shipping program, and were interested in the expansion plans for the shipping routes and fleet size (Figure 5).

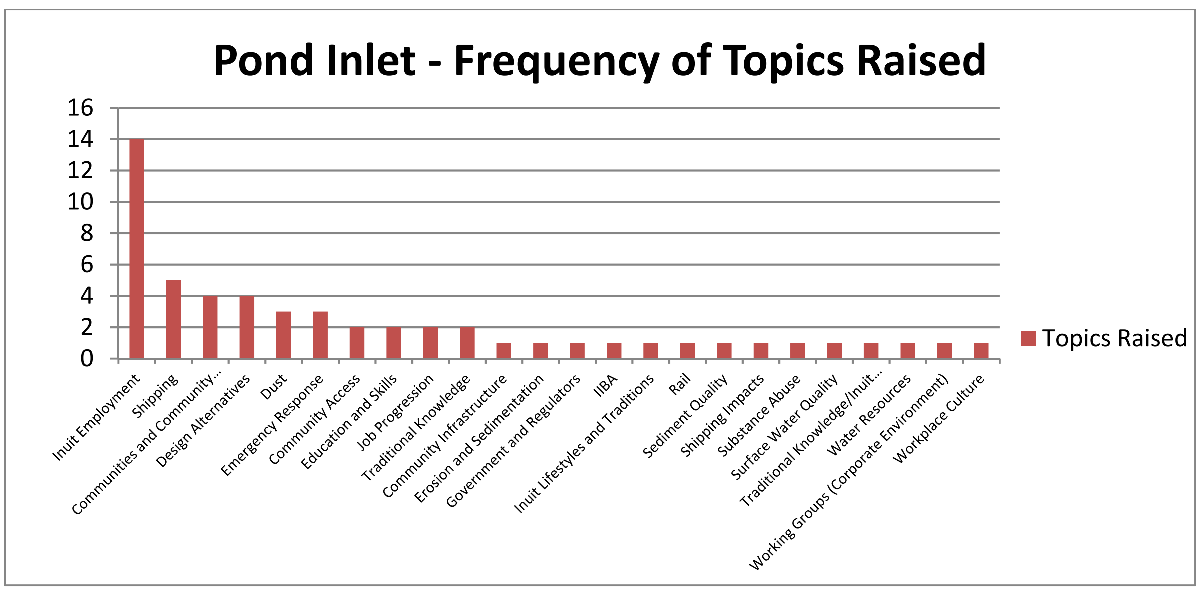


Figure 5: Topics Raised in Pond Inlet Open House

Community Topics Raised

With the exception of Igloolik, the number of topics raised for the communities is fairly close together with Hall Beach having the most topics raised during the meetings. Factors may include the overall attendance of the Open House (Figure 6).

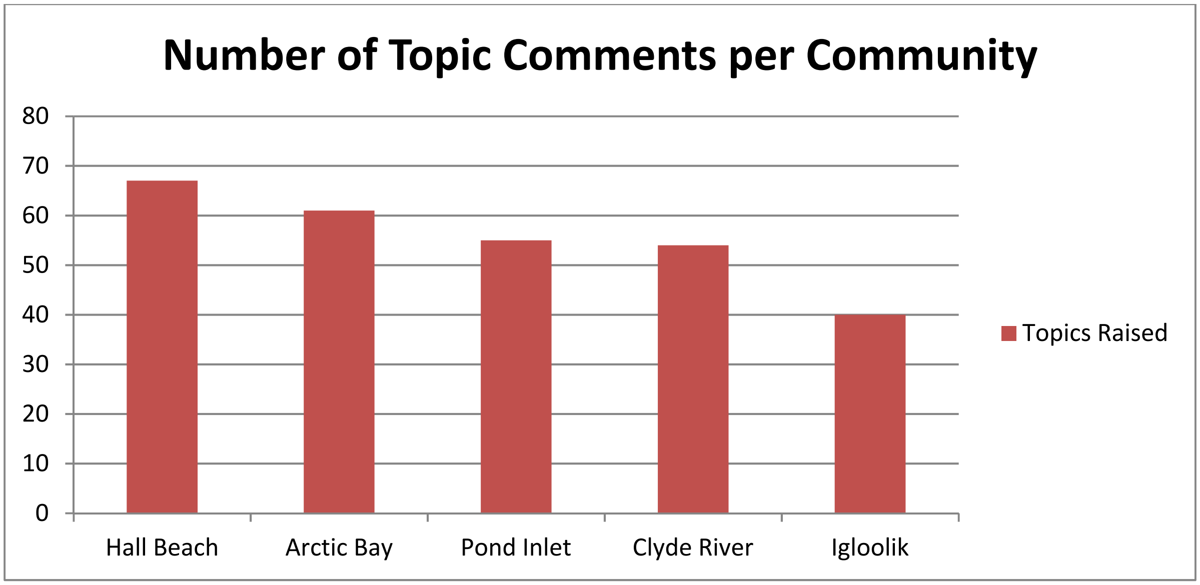


Figure 6: Number of Topic Comments per Community

Shipping and Sea Ice Comments

There were a total of 36 instances where shipping was raised during the community tour. Discussions about the potential effects of shipping focused on the following areas:

- Environmental effects from ballast water and waste;
- Effects of shipping routes on the local wildlife and sea ice formation;
- Details regarding expansion of the ship fleet and frequency of shipping activities;
- Duration of the shipping season;
- Community safety;
- Ability to respond to emergency situations (e.g. spills); and
- Mechanisms to keep residents informed about the shipping program.

A more comprehensive summary of the comments is provided in Appendix A.

Conclusions

Based on feedback from community members during the community tour, the most pressing concern for residents is Inuit employment at Baffinland. Regarding shipping, residents were most concerned about ensuring that processes and procedures are in place to protect the environment.

Appendix A: Specific Comments on Ship, Ice, and Marine Travel

Communication title	Communication date	Communication method	Event name	Individual/group name	Communication summary
2016-11-21 In-Person / Face-To-Face with Clyde River about Spills and Malfunctions, Emergency Response, Shipping Impacts	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Question about the emergency response plan that will be in place for a spill at sea. Baffinland responded that this will be required, as per regulations.
2016-11-21 In-Person / Face-To-Face with Clyde River about Invasive Species / Ballast Water, Shipping Impacts	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Concern about whether ballast water will cause environmental harm in the arctic. Baffinland responded that UV is used to kill microorganisms.
2016-11-21 In-Person / Face-To-Face with Clyde River about Invasive Species / Ballast Water, Shipping Impacts	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Question about how ballast water will be managed. Baffinland responded that some ballast water is released as the boat approaches the arctic, however there is an environmental procedure that is followed.
2016-11-22 In-Person / Face-To-Face with Unidentified stakeholders, about Shipping Impacts	Nov 22, 2016	In-Person / Face-To-Face	2016-11-22 - Pond Inlet - Public Forum/Meeting	Unidentified stakeholder	Shipping route opposition
2016-11-23 In-Person / Face-To-Face with Arctic Bay about Design Alternatives, Shipping Impacts	Nov 23, 2016	In-Person / Face-To-Face	2016-11-23 - Arctic Bay - Public Forum/Meeting	Arctic Bay	Question about: approvals process for expansion; monitoring programs on board ships that were stopped; Inuit participation in working groups and committees; Inuit employment requirements under the IIBA. Concerns about: effects of shipping on marine environment. Response: overview of approvals process. Response: overview of onboard ship monitoring program & current status. Response: overview of employment programs, and conditions under IIBA.
2016-11-24 In-Person / Face-To-Face with about Design Alternatives, Shipping, Shipping Impacts	Nov 24, 2016	In-Person / Face-To-Face	2016-11-24 - Igloolik - Public Forum/Meeting	Igloolik	Question: can the ship activity be publicized so communities know when ships are moving. Response: summary of notification process for shipping.
2016-11-25 In-Person / Face-To-Face with Hall Beach about Shipping, Shipping Impacts	Nov 25, 2016	In-Person / Face-To-Face	2016-11-25 - Hall Beach - Public Forum/Meeting	Hall Beach	Question: environmental effects of shipping. Concern: effects of the project on wildlife. Response: overview of environmental monitoring programs (water, air, terrestrial)
2016-11-25 In-Person / Face-To-Face with Hall Beach about Shipping, Shipping Impacts	Nov 25, 2016	In-Person / Face-To-Face	2016-11-25 - Hall Beach - Public Forum/Meeting	Hall Beach	Question: frequency of shipping for expansion. Response: overview of expansion project, including current shipping plans.
2016-11-21 In-Person / Face-To-Face with Clyde River about Design Alternatives, Shipping, Sea Ice, Shipping Impacts	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Question about when the expansion will be approved. Question about whether there will be shipping during the winter season. Baffinland responded that the project description will be submitted on Nov. 30th. The project is going to minimize shipping through ice to the extent possible.
2016-11-21 In-Person / Face-To-Face with Clyde River about Shipping	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Question about whether waste is contaminating the environment. Baffinland responded that only wood and metal is landfilled. Hazardous materials are removed from site by ship.
2016-11-21 In-Person / Face-To-Face with Clyde River about Shipping, Shipping Impacts	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Question about how many ships there will be. Baffinland responded that there were 38 ships in 2016. There will be more ships as part of the expansion.
2016-11-21 In-Person / Face-To-Face with Clyde River about Shipping	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Hamlet Meeting	Clyde River	Comment that tourist ships should be compensating the communities. Baffinland responded that ships travelling fast through the area has been noted as a concern.

2016-11-21 In-Person / Face-To-Face with about Shipping, Marine Travel, Camps and Harvesting, Shipping Impacts	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Public Forum/Meeting	Clyde River	Concerned about: changing the current shipping route; shipping through ice; impacts on sea mammals; impacts on hunting (on land and on ice). Positive feedback included: employment opportunities; environmental monitoring (especially of the sea bed at Milne Inlet); Narwhal monitoring station; Baffinland's responses to community concerns; availability of clinic to treat community members; Baffinland's support for the people and how it helps hunters. Baffinland responded that only the approved shipping route is being used. If a new route is used for the expansion project, it will need to be approved by the Government. The monitoring program is ongoing, and to date there have not been any increase or decrease in Narwhal populations. Narwhals are not scared away by the Baffinland ships.
2016-11-21 In-Person / Face-To-Face with Unidentified stakeholders, about Shipping	Nov 21, 2016	In-Person / Face-To-Face	2016-11-21 - Clyde River - Public Forum/Meeting	Unidentified stakeholder	Ship sizes
2016-11-22 In-Person / Face-To-Face with Hamlet of Pond Inlet about Communities and Community Organizations, Shipping	Nov 22, 2016	In-Person / Face-To-Face	2016-11-22 - Pond Inlet - Hamlet Meeting	Hamlet of Pond Inlet	Question about: plans for winter shipping. Response: Community approval is being sought for shipping plans.
2016-11-22 In-Person / Face-To-Face with Hamlet of Pond Inlet about Design Alternatives, Shipping	Nov 22, 2016	In-Person / Face-To-Face	2016-11-22 - Pond Inlet - Hamlet Meeting	Hamlet of Pond Inlet	Question about: number of ships, and shipping seasons Response: shipping to be limited to open water season, to the extent possible.
2016-11-22 In-Person / Face-To-Face with Hamlet of Pond Inlet about Design Alternatives, Shipping	Nov 22, 2016	In-Person / Face-To-Face	2016-11-22 - Pond Inlet - Hamlet Meeting	Hamlet of Pond Inlet	Question about: plans for winter shipping; plans for consultation for expansion project. Response: Overview of consultation process for the expansion provided. Response: winter shipping to be avoided to the extent possible.
2016-11-22 In-Person / Face-To-Face with Hamlet of Pond Inlet about Shipping	Nov 22, 2016	In-Person / Face-To-Face	2016-11-22 - Pond Inlet - Hamlet Meeting	Hamlet of Pond Inlet	Question about: name of jet that goes to Milne Inlet. Response: Nolinor
2016-11-22 In-Person / Face-To-Face with Hamlet of Pond Inlet about Shipping	Nov 22, 2016	In-Person / Face-To-Face	2016-11-22 - Pond Inlet - Hamlet Meeting	Hamlet of Pond Inlet	Question about: plans to bring an ice breaker to Pond Inlet; whether old vehicles from Baffinland can be sent to Pond Inlet. Response: overview of shipping during winter provided. Will consider process for providing benefits to communities in upcoming IIBA review.
2016-11-23 In-Person / Face-To-Face with Design Alternatives, Shipping	Nov 23, 2016	In-Person / Face-To-Face	2016-11-23 - Arctic Bay - Public Forum/Meeting	Arctic Bay	Question about: trans-shipping Response: more information will be in the project description submitted Nov. 30.
2016-11-23 In-Person / Face-To-Face with Arctic Bay about Design Alternatives, Shipping	Nov 23, 2016	In-Person / Face-To-Face	2016-11-23 - Arctic Bay - Public Forum/Meeting	Arctic Bay	Question about: approvals process for expansion; shipping over the last year; shipping numbers for expansion project. Response: overview of proposed expansion project, including approvals.
2016-11-24 In-Person / Face-To-Face with Igloolik about Rail, Shipping	Nov 24, 2016	In-Person / Face-To-Face	2016-11-24 - Igloolik - Public Forum/Meeting	Igloolik	Question: what will happen to Steensby option. Response: overview of expansion project currently under consideration.
2016-11-24 In-Person / Face-To-Face with Igloolik about Shipping	Nov 24, 2016	In-Person / Face-To-Face	2016-11-24 - Igloolik - Public Forum/Meeting	Igloolik	Question: shipping frequency for 4.2Mtpa. Response: overview of current operations
2016-11-24 In-Person / Face-To-Face Design Alternatives, Shipping, Shipping Impacts	Nov 24, 2016	In-Person / Face-To-Face	2016-11-24 - Igloolik - Public Forum/Meeting	Igloolik	Question: can the ship activity be publicized so communities know when ships are moving. Response: summary of notification process for shipping.
2016-11-24 In-Person / Face-To-Face with Hamlet of Igloolik about Shipping	Nov 24, 2016	In-Person / Face-To-Face	2016-11-24 - Igloolik - Public Forum/Meeting	Hamlet of Igloolik	Question: plans to meet 4.2Mtpa capacity. Response: overview of current operations, and plans to improve production capacity.
2016-11-24 In-Person / Face-To-Face with Igloolik about Design Alternatives, Shipping	Nov 24, 2016	In-Person / Face-To-Face	2016-11-24 - Igloolik - Public Forum/Meeting	Igloolik	Question: timing and frequency of shipping. Response: overview of current shipping program; summary of expansion plans for increasing production and shipping.
2016-11-25 In-Person / Face-To-Face with Hall Beach about Shipping	Nov 25, 2016	In-Person / Face-To-Face	2016-11-25 - Hall Beach - Public Forum/Meeting	Hall Beach	Question: what to people of Pond Inlet think about bigger ships? Response: summary of consultations; will be back in 2017 to discuss further.
2016-11-25 In-Person / Face-To-Face with Hall Beach about Shipping, Narwhals	Nov 25, 2016	In-Person / Face-To-Face	2016-11-25 - Hall Beach - Public Forum/Meeting	Hall Beach	Comment: ice breaker ships may be able to free Narwhals that get stuck inland when the inlet freezes. Response: Thank you for comment.
2016-11-25 In-Person / Face-To-Face with Hall Beach about Shipping, Spills and Malfunctions, Emergency Response	Nov 25, 2016	In-Person / Face-To-Face	2016-11-25 - Hall Beach - Public Forum/Meeting	Hall Beach	Question: emergency response planning and spill management for ships. Response: Clarification about plans for shipping in open water to the extent possible. Overview of environmental management system for shipping.

APPENDIX D

WORKING GROUP MEETING NOTES

Appendix D1	TEWG Meeting Notes
Appendix D2	MEWG Meeting Notes
Appendix D3	SEMWG Meeting Notes
Appendix D4	MRCG Meeting Notes
Appendix D5	Pond Inlet Youth Council Meeting Notes

APPENDIX D1

TEWG MEETING NOTES

Terrestrial Environment Working Group Meeting 9 Meeting Minutes

Date: November 30, 2016

Location: 1084 Aeroplex Building,
Executive and Intergovernmental Affairs Boardroom
Remote: 1 866 969-8429 ID: 5084494

Participants		
Member Organization	**Attendees**	
Baffinland Iron Mines (Baffinland)	Wayne McPhee (WM)	I
	Joe Tigullaraq	N
	Megan Lord-Hoyle (MLH)	I
	Jim Millard	P
Qikiqtani Inuit Association (QIA)	Kim Poole (KP)	P
	David Qamaniq (DQ)	I
	Luc Brisebois (LB)	I
	Jeff Higdon (JH)	I
Environment and Climate Change Canada (ECCC)	Jean Francois Dufour	P
	Paul Smith (PS)	I
Government of Nunavut (GN)	Brad Pirie (BP)	I
	Jacques LaCroix	P
	Amy Robinson	N
Mittimatalik Hunters and Trappers Organization (MHTO)	Mathias Qaunaq (MQ)	I
	Elijah Panipakoocho (EP)	I
Observer Organization		
World Wildlife Fund – Canada (WWF)	Andrew Dumbrille	N
	Amanda Hanson Main (AHM)	I
Baffinland Consultants		
Environmental Dynamics Inc. (EDI)	Mike Setterington (MS)	I
Additional Recipients		
Qikiqtani Inuit Association (QIA)	Stephen Williamson Bathory	

I – In person, P-phone in participation, N- Not attending

Agenda	
1.	Welcome and introductions (Wayne McPhee, All)
2.	Summary of 2016 Mary River site activities (Megan Lord-Hoyle)
3.	Baffinland update and organizational changes (Wayne McPhee)
Health Break (10:30am)	
4.	Workshop (led by Wayne McPhee): Working group mandate and revisions to the Terms of Reference
Lunch (provided)	
5.	2016 Terrestrial Environmental Monitoring Program (Mike Setterington)

Agenda	
Health Break	
6.	Workshop (led by Wayne McPhee): Roundtable updates on relevant research projects - ECCC – PRISM and Red Knot Monitoring (Paul Smith) - QIA – Community Based Monitoring (Luc Brisebois) Next Steps
Reference Material	

Comments	
2. + 3.	MLH: Provided an overview of the presentations made in the communities between Nov 21-25, 2016) and an overview of the Mary River Project. WM: Provided an update on Baffinland activities and organizational changes. Provided the group with the draft construction lay outs of the Mine and Port site for the Phase 2 project update submitted to NIRB that day. **Socio-economic Comments:** DQ: Asked about safety on site and if all signs are translated across the site. MLH/WM: Signs on the Tote Road are in English. Other signs across the site are in both languages. We will continue to work on translating all signage for safety. MQ: Expressed communication issues with the Baffinland community liaison (BCLO) officer in Pond Inlet. The BCLO was away on medical leave for a period making communications difficult. Also expressed that ground transportation availability in the communities makes it difficult to get to the airstrip for the site charter. WM: There was a short time where the BCLO in Pond Inlet was unavailable, we had hired a backfill until the permanent BCLO returned. Transportation issues have been raised in the community survey as well. Baffinland is considering options to help with this. MQ: Clarified restrictions and safety concerns around harvesting soapstone near the quarries on site. JM: If it can be planned in advance, Baffinland will assist in any way possible. Megan to send MQ JMs contact info. **Comments on the Phase 2 project description:** AHM: Questions about considerations for phase 2. Optimizing open water shipping, does that mean that winter shipping is off the table? WM: Shipping season proposed at 6 months – July to December. Intent is to get as much out in the open water as possible. **General:** MQ: Should have mentioned yesterday for marine, where dock is being built, I have a fairly large boat. I had to get away from wind. When I made it to Milne Inlet, HTO shelter cabin. I went to check on my boat, I saw many dead animals on the beach, including Greenland shark. When I went for coffee, they told me they had to do seismic work for the dock. Trying to put up my net. When I was stringing my net, I saw white spots on the ocean. When I pulled my net, I had so many sculpin. I did not catch a single arctic char. I did relay that to someone I'm sure. I wish I had collected digital images.

	In the spring I went caribou hunting along the same route. For two days I was sheltering in the HTO cabin. There is a river nearby where we get water. I went to retrieve ice. I saw reddish colouration in the ice, it was fairly deep. I had to go a good distance. A fox came by, and the fur was all discoloured, reddish. As I followed the river, I saw a rabbit with reddish fur. Is there any way that we can do something to contain the iron ore deposits so animals have no access to it? Ragged Island, where ships congregate where they're waiting for their next load, that's on our transportation route to hunting grounds. We saw the boats, even though I know they were instructed not to discard, that they are supposed to exchange ballast prior to coming to the inlet. Some ships waited for up to two weeks to get their load. The next bay from Ragged Island, it was obvious there was some discharge from those ships. Is there anything in this working group we can do? I know not every boat is like this, is there something we can do about this. I'd like to seek some direction so I can go back to my membership, especially around the seismic testing, and I know that there has been some done in the past. With the current situation in Clyde River, is there something we can provide to the people of Pond Inlet about seismic testing. I'd like more information about the seismic testing used for the building of the dock. JM: A Greenland shark was found dead on shore. JM to provide the date and reason for death to MQ. The shark discussed by JM was decomposed when found, MQ referenced a recently dead shark. JH: The noise monitoring from the dock construction was included in the 2015 NIRB report. I will be reviewing on behalf of the QIA and can provide a summary to the HTO.
4.	WM: Suggestions for changes to ToR have been made by NIRB and noted in previous meeting minutes, no recommendations to date on what exactly to change. Baffinland requested input into revisions to the ToR. Discussions of the revisions were completed on November 29, 2016 at the Marine Environment Working Group with the same organizations. The revisions listed below reflect the discussions held with the Marine group. Comments made by this group are italicized. **Revisions to the Terms of Reference (ToR)** All revisions will be made to the March 6, 2013 version. Clarification that the group is an advisory body not a decision making group. Legal Review: WM: Requested feedback on the need for lawyers input on the revisions to the ToR. LB: QIA doesn't see a need for lawyers to be involved in the revisions. No parties voiced the need for legal review. Chair of Meetings: WM: Suggested that the ToR be amended to reflect Baffinland as the permanent chair. No groups had opposition to Baffinland remaining as the chair but generally felt that having the option to rotate was a good idea. WM: Clarified that holding the working groups was a project certificate condition and that Baffinland needs the ability to ensure that the meetings take place. *A clause could be added to the ToR regarding triggers for a formal review or timelines for review.* Format and Frequency of Meetings: WM: Suggestion for two face to face meetings with two conference calls in between or three face to face meetings. Group: Requested a meeting to be held on-site. Baffinland to look into the logistics and timing. *KP: Liked the addition of a third meeting. Conference calls work for quick changes and discussions. Requested a tour of the site or to hold a meeting on site.*

	JH: The groups should take advantage of smaller sub-group meetings focused on specific topics as outlined in the ToR. These meetings can happen at any time throughout the year. General revisions: LB: QIA proposed that the HTO be accepted as members and that the MHTO costs be covered by Baffinland. Baffinland is in full agreement. The representatives of the MHTO are in agreement. No parties opposed. MQ and EP to check with their local board for approval. WM: The ToR will be amended to include their participation and reflect that Baffinland will cover the costs for participation. Simultaneous translation will be available at meetings to allow for full participation of all members. *Discussion around NIRBs participation in the meetings. Noted that a letter will be sent to NIRB requesting clarification on their participation. Also noted that NIRB monitoring offices may be consulted by members of the working groups.* *Clarification on member status. Makivik was included on the draft agenda in error. The group confirmed that adding the MHTO and the WWF as a member and observer respectively was agreed to.* Inuktitut Translation: Simultaneous translators to be present at all meetings where required. Only the executive summary of technical documents will be translated. Meeting minutes will be translated. The North Baffin dialect will be used for translations. *Consider two interpreters for in-person meetings. Consider how to translate for conference calls.* Timelines for distribution of documents to the TEWG were agreed upon as follows: • Meeting minutes to be translated and distributed to the group within three weeks of a meeting • Comments on meeting minutes to be provided to Baffinland within three weeks. If no comments are received, Baffinland will assume acceptance of the minutes. Baffinland to finalize minutes within two weeks. • Technical reports, including but not limited to the Annual Terrestrial Monitoring report, will be provided to the working group by January 15th at the latest, comments to be sent to Baffinland within one month of receipt of the report.* • *Draft technical reports will be provided 10 days before meetings.* • Conference call in late February, final technical reports posted to Baffinland web portal (under development) by March 31. *As Baffinland has changed the structure for reporting in late 2016, reports may not be submitted by Jan 15, 2016. In following years reports will be submitted by this date. **NIRB Annual Reporting Process:** WM: We have discussed changes to the annual reporting process. NIRB is looking for documents which are more streamlined, reflect cumulative effects and are useful for the communities. AHM: How does Baffinland respond to comments on reports? WM: Detailed responses to every comment may not be made. The intention to have an earlier review of documents and request comments within one month of receipt should help to eliminate the comments made after submission in the annual report, and allow for the spring meeting to focus on the upcoming field season rather than last year's comments. Group: Suggestion to have a meeting in the summer of 2017 to discuss the 2016 submissions comments.

	EP: We do not see reports very often. WM: In the future a summary of the technical reports will be developed and translated for community access. GG (ECCC): The distillation of scientific information into a communicable way is important. A template was developed for reporting of field summary reports with and for the HTOs. GG to distribute. **General:** MLH: To distribute list of participants and designates to be confirmed and/or identified by each organization. Baffinland to draft and distribute updated ToR by December 23, 2016. Comments to be received by the working groups by January 15th. *The date was moved, following the meeting, to January 20th to reflect the break around the holiday season.
5.	MS: Presented the results of the draft Terrestrial Annual Monitoring Report. PS: What is the timeframe to revisit programs and power analysis? AHM: Questioned the triggers for re-evaluation of program frequencies using the example of carnivore programs being discontinued until increases in natural abundance are observed. Is it the parties around the table responsibility to trigger this? Sought clarification from the GN on the need to conduct den surveys. MS: All programs can be revisited at any time as new science becomes available or the group feels there is a need. The Terrestrial Environmental Effects Monitoring Plan shows the long term plan for all programs. Not all programs require annual monitoring. I would look to the parties at the table for triggers to re-evaluate the programs. If the GN feels that carnivore abundance is increasing (as a result of increased caribou abundance in the area) we would re-visit the program. BP: The GNs wildlife division is responsible for this. I can provide an update. EP: Hunters find foxes and wolves nuisances. Not worried about studying wolves because they eat the caribou population. LB: Commented that revisions to programs and adaptive management strategies are made two years after the issues is raised. MS: These groups provide instantaneous feedback. WM: It is the intention that the changes to the annual reporting format will address this. AHM: Clarification on the histogram showing vehicle traffic per day on the Tote Road. MS: They are stacked histograms, the total is the sum of the grey and blue bars. DQ: Questions why vehicular traffic is low in May. JM: Traffic is restricted during freshet. DQ: Discussion on truck weights. JM: Scales are located going into the crusher area. The trucks are not carrying much more than 100 tonnes. **Dust:** JH: In regards to the dust sampling program, asked if this could incorporate some community based monitoring. JM: The samples are required to be sent to a certified lab. If one was available in a North Baffin community that would be very beneficial. AHM: Noted that Arctic College in Iqaluit has a laboratory but not sure on the accreditation. Discussion on the isopleths created for dust monitoring. The prevailing wind direction was taken into consideration in the development of the isopleths. There is continuous climatic monitoring

	which is reported annually and compared to the baseline in the Final Environmental Impact Statement. Discussion on dust suppressants. Ca-Cl cannot be applied to the airstrip. There are other chemicals approved for use in Nunavut other than Ca-Cl and the need for a chemical suppressant on the road is being considered. DQ: Commented that when you mix seal skin with salt, the skin shrinks and suggested staying away from Ca-Cl. JM: It was noted that further dust suppression was needed and there was a suggestion to present dust suppression locations along the Tote Road in the annual report using a figure. WM: The rail line will alleviate dust from the Tote Road, it was noted that this will have no impact on the dust created at the port. Dust suppression methods around the port are being considered. EP: Shared his experience of dust on the Tote Road. Explained that the weight of the trucks on the Tote Road creates the most dust. The loaded trucks would create an imprint on the road and create the most dust in comparison to unloaded trucks. Felt that the majority of dust was from traffic on the road. **Vegetation:** MS: Monitoring exclosures will remain in place even in years where monitoring is not occurring. It was noted that this detailed level of plant surveying is rare. PS suggested that if data can be provided to a remote sensing specialist it might be possible to link the field data to remote sensing analyses and therefore reduce the costs and time for field work. **Flight Height:** Discussion around non-compliance to flight height guidelines. Focussed discussion on how tracking non-compliance as it happens would help to mitigate occurrences and provide a better understanding of why the non-compliances were occurring. JM to confirm that the GPS coordinates the pilots are using are the correct files. EP: Provided insight into flying while conducting caribou population studies. It is preferred to fly low for caribou surveys. Caribou are found to the east of Mary River and the most sightings were to the south east of the project. They were migrating north. When we sight them with a helicopter survey we have to fly at the right height - too high or too low and it will scare them away. We don't want to harass them with the noise levels. For the past five years we have done a survey every summer. This past summer was the worst weather and we flew for three days only. But we also sighted more over the last summer. When there is a population explosion they are braver and don't run away as easily. **Mammals:** MS: There is local involvement in the snow track and height of land survey programs, but they lack local leadership. It would be very beneficial to have EP or someone like him work with the younger people to provide guidance and training. It could help to re-design the programs if needed. AHM: Program design - I see that the project certificate focuses on calving periods. Since you mentioned this is not a labour intensive event (height of land surveys), could you add another event during the migratory event for example? Perhaps the time of year could be reconsidered as well. Maybe it would be easier to see caribou when the land is snow covered. EP: When we go caribou hunting we are at the height of land and we check the top of the land masses, during mosquito season you look high. Another trick is to go to rough terrain, and if you are serious about locating a caribou, in hilly country they will go to the tops of the hill. When there is snow

	cover it is easier to see them. In late autumn and fall their fur turns whiter and that is easier to see. In the dead of summer they are brown and very hard to find. Especially if you are trying to do a population survey by helicopter. MS: It is true it is not labour intensive but it is a focused effort to get people out there. These are not migratory caribou. So there is no other time to look for them other than when it is snow covered or when their fur changes colour. There is also continuous monitoring from every truck driver moving along the tote road. They will report back if anything is seen and this would be a trigger to re-evaluate monitoring. MQ: We are familiar with caribous behaviour – by August the animals go more inland, in the spring they move to shore. MS: No one has seen caribou in the project area. MQ: There was a high population of caribou in the 90's and they would come into the community. When they left the community it seemed like they took other herds. We are starting to see a slight increase in caribou again. EP: Is there a consistent study with the geese? Because they are high in our diet. Also rabbits and ptarmigan. The wolves/carnivores are not so much in our diet in our community. Gyrfalcon aren't on our list of diet. Including loons - the meat eaters are not in our diet so much. The murres and ducks are more common in our diet as well. We are not too worried about the meat eating birds because they are not in our diet. The owl, they are some of our favorite animals because they protect the geese eggs. They keep the foxes away. The geese prefer to nest close to the owls. Owls can stand up to some of the dogs around, maybe even wolves. Many animals are intimated by the talons. For that reason to our people the owls are some of our favorite animals. MS/PS: We focus on peregrine falcon because from an effects perspective, these birds are very site specific. They occupy the same sites for multiple years, are an excellent indicator species and if something is happening at the top of the food chain something must be happening down below. The waterfowl roadside survey is not species specific. Goose monitoring is done range wide across the Arctic by ECCC. Things like taking photos from airplanes, banding of birds to see how many are shot in the south. In addition, BIM is monitoring thick billed murres as well by supporting ECCC's work. **General:** KP: Expressed concerns about some of the terminology in the report related to productivity and nest success metrics. Requesting clarification. MS: Please correspond in writing.
6.	PS: Presented on ECCC Red Knot Monitoring Programs and PRISM JH: Is there an opportunity for community involvement in the program or does it require an experienced birder? PS: An experienced birder is needed to identify the birds, others can assist in other aspects of the program. DQ: Questioned studies of jaeger and Arctic tern as these are species at risk. PS: Clarified that they are not species at risk, but that they are declining. EP: Shared observations of the decline in shorebird populations around Pond Inlet. Gyrfalcon go after the shorebirds and songbirds. The focus of these programs should be on controlling gyrfalcons in support of the smaller shorebirds. Similar to wolves and caribou. Shorebirds aren't high in our diet but it is interesting to know why they are declining. It's like with polar bears, as their population increases, there is a decrease in seal populations. PS: Scientists are concerned with the decline in shorebirds because there was a decline in meat eating birds in the 60s/70s, now the meat eating bird population is increasing and songbirds are decreasing. JH (noted in

	review of minutes): Scientists are concerned with shorebird declines in general. Increases in raptor numbers may be a contributing factor in the declines of some shorebird species, but it isn't the proximate reason driving research interest. DQ: Regarding caribou populations: noted that he has heard that once a population gets too big they will have a giant decline. EP: Our knowledge holders see that this is true, when the population swells a die off will follow. QIA did not present the community based monitoring presentation again because of limited time and the majority of the room was the same as the Nov. 29 meeting.

	Action Items	**Action By**	**Date Completed**
1.	MLH to send MQ JMs contact info	Baffinland	Dec 21, 2016
2.	JM to send information about Greenland shark death to MQ	Baffinland	
3.	JH to provide review of the Construction Noise Monitoring report to the MHTO	JH	
4.	BP to provide guidance on the need to conduct den surveys	BP	
5.	JM to confirm GPS coordinates site pilots are using for flight height compliance	JM	
6.	GG to provide field summary reports	GG	Nov 30, 2016

Baffinland

APPENDIX D2

MEWG MEETING NOTES

MEMO

To: Marine Environment Working Group (MEWG)

From: Todd Burlingame, Vice-President Sustainable Development

cc: Wayne McPhee, Director Sustainable Development

Date: July 6, 2016

Re: 2016 Marine Mammal Aerial Survey

Baffinland fully recognize the importance of monitoring the effects of Baffinland's shipping activities on narwhals as well as meeting the Nunavut Impact Review Boards' Project Certificate condition requirements for marine mammals. In 2016, Baffinland is funding the fourth year of Bruce Head shore-based monitoring study of narwhals as well as investing in additional analyses of acoustic data on shipping and narwhal vocalizations and integrating these results more fully with shore-based observations and aerial survey data collected in 2015. This information will provide further insight into how shipping and other human activities in Milne Inlet influence narwhal distribution and abundance as well as narwhal behaviour.

The cost for the Aerial Survey proposed for 2016 has been estimated at approximately $650,000. This cost represents the largest single expenditure for the Sustainable Development activities planned in 2016. In December 2015, Baffinland determined that the Bruce Head Survey was the priority activity for monitoring shipping activity effects on Narwhals and that the Aerial Survey component would be deferred until an analysis of the data could be completed to determine the effectiveness of the program.

We recognize the importance of aerial surveys in providing a more regional approach to monitoring narwhal response to shipping and are seeking opportunities to utilize UAVs (drones) to collect additional aerial data while at the same time managing costs. We are encountering complications in initiating this program including the ability to get authorization to operate UAVs beyond line of site. Should we be successful in getting approvals we intend to try using UAVs to conduct aerial surveys this year.

If you have any questions or concerns about our decision to defer the aerial surveys this year, please feel free to contact myself or Wayne McPhee, Director Sustainable Development.

Thank you, Todd

MINUTES

To: Marine Environment Working Group (MEWG)

From: Wayne McPhee, Director Sustainable Development

Cc: Todd Burlingame, Vice-President Sustainable Development

Date: August 17, 2016

Re: Final Minutes from the
MEWG Conference Call – August 4th, 2016

Attendance:

Todd Burlingame (Baffinland)	Stephen Williamson Bathory (QIA)
Wayne McPhee (Baffinland)	Jeff Higdon (QIA)
Val Moulton (LGL, consultant to Baffinland)	Bruce Stewart (QIA)
Rolph Davis (LGL, consultant to Baffinland)	Brad Pirie (GN)
Mike Setterington (EDI, consultant to Baffinland)	Amy Robinson (GN)
Francine Mercier (Parks Canada)	Veronique D'Amours-Gauthier (DFO)
Andrew Dumbrille (WWF-Canada)	Julie Marentette (DFO)
Kristin Westdal (ON)	Steve Ferguson (DFO)
Gregor Gilbert (Makivik)	
Natasha Mablick (HTO, Pond Inlet)	

Invited but not in attendance

Tara Arko (NIRB)	Elizabeth Patreau (DFO)
Denise Baikie (GN)	Luc Brisebois (QIA)
Anne Wilson (ECCC)	Chris Debicki (ON)
Jean-Francois Dufour (ECCC)	
Grant Gilchrist (ECCC)	

Introduction of New Members:

- Wayne McPhee, new Director Sustainable Development replacing Oliver Curran at Baffinland.
- Veronique D'Amours-Gauthier, replacing Georgina Williston at DFO.
- Bruce Stewart with QIA is joining the group.

Update on 2016 Monitoring:

Bruce Head Shore-Based Marine Mammal Monitoring

- Val (LGL) provided a quick summary of the 2016 program. The work plan is the same as for the 2015 season. There were weather delays but the team is on site and the 2016 program is underway.
- No comments or questions were raised about the Bruce Head program.

Aerial Survey

- Todd (Baffinland) related that the 2016 Aerial Survey program had been deferred by Baffinland in December 2015 but recognized that this decision had been poorly communicated to the MEWG.
- Todd described the cooperation with DFO where Baffinland will provide data from the 2013, 2014 and 2015 surveys to DFO and that DFO will provide data from their 2016 aerial survey.
- Steve (DFO) indicated that DFO was looking at narwhal stocks in the study area.
- Todd indicted that DFO would be using the same transects that were used by Baffinland in previous surveys.
- Rolph (LGL) confirmed that the DFO survey was the same as the Extensive Survey that was completed by LGL in previous years, except that LGL flew a second duplicate flight instead of just the one planned by DFO, and that the same data would be collected.
- Todd asked for questions.
- Jeff (QIA) asked if the DFO survey lines were the same as the 2013 DFO survey.
- Steve (DFO) replied that the lines are different but better aligned with the study area.
- Jeff (QIA) asked if Baffinland was looking at a Before, During and After survey.
- Todd (Baffinland) replied that we were looking at options. One option was to use a helicopter to do surveys but safety concerns need to be managed. A second option is to add a Before, During and After survey at the end of the DFO survey.
- Steve (DFO) confirmed that Before, During and After survey may be possible depending on the timing.
- Andrew (WWF) asked what DFO's purpose was for the 2016 survey.
- Steve (DFO) replied that the communities have asked for a survey of narwhal stocks in Admiralty Inlet vs Eclipse Sound.
- Andrew (WWF) asked if the communities have raised concerns about shipping impacting narwhal populations.
- Steve (DFO) replied that there had been no mention of shipping concerns from the community.
- Jeff (QIA) asked if DFO was using one flight crew or two crews.
- Steve (DFO) replied that they were using just one crew that would fly both areas that are being investigated.

- Someone asked how many ships were transiting so far in 2016.
- Todd and Wayne (Baffinland) indicated that approximately 10 ships had arrived and 6 ships had left the port so far in 2016.
- Kristin (ON) asked what would be done if there were no ships in the water during the DFO survey.
- Todd (Baffinland) indicated that Baffinland is expecting a steady flow of ships and if this occurs, it will be discussed with MEWG.

Acoustic Survey

- Todd (Baffinland) asked the group for information about concerns with the Acoustic Survey.
- Andrew (WWF) indicated that WWF thinks that acoustic data should be collected every year and that an integration report should be developed.
- Val (LGL) indicated that LGL was waiting for budget approval from Baffinland to start the Integration Report.
- Todd (Baffinland) confirmed that Baffinland would review the plans for the integration report and get the work started so that an update could be provided to the MEWG at the next meeting.

Shipboard monitors

- Todd (Baffinland) discussed that the MEWG has discussed cancelling the shipboard monitoring program and asked the group for confirmation.
- Jeff (QIA) indicated that the shipboard monitoring program had been deferred for 2016 but not cancelled.
- Todd (Baffinland) raised a concern about the communication of the decision to defer the program and whether the decision by the MEWG was being communicated back to parent organizations.
- Stephen (QIA) acknowledged that the deferral of the shipboard monitoring program had been communicated to QIA. Stephen indicated that deferral was conditional on finding other monitoring programs. Stephen indicated that he would follow-up off-line with Baffinland.

Community-Based Monitoring discussion

- Todd (Baffinland) indicated that Baffinland was a big supporter of Community-Based Monitoring (CBM) programs but that Baffinland wasn't seeing any suggestions or alternatives that can be explored. Todd asked if anyone had a better CBM alternative.
- There were no answers from the group.
- Todd suggested that we revisit this discussion during the next in-person meeting.

Update Members and contacts

- Todd (Baffinland) indicated that Baffinland did not have an up to date membership list for the MEWG and requested that everyone send an email to Wayne (Baffinland) with the primary and secondary contacts.

Communications

- Todd (Baffinland) asked for clarification on how participants connect to their parent organizations specifically, what is the process for communicating back to the parent organization and whether Baffinland needed to provide a formal communication back to each organization.
- Jeff (QIA) indicated that he provides a summary report of MEWG meetings back to QIA. Jeff also indicated that MEWG minutes should be posted on the NIRB web site and also indicated that a final version of the minutes were often not completed.
- Todd (Baffinland) indicated that Baffinland would commit to improving performance, providing minutes to the group and following up with NIRB about posting working group minutes.
- Andrew (WWF) indicated that he hopes that each member is communicating with their parent organizations and that Baffinland should not be expected to provide duplicate communication. MEWG members should have the responsibility for communication within their organization.

Comments/Concerns

- Todd (Baffinland) asked if there were any additional comments or concerns.
- Jeff (QIA) indicated that the Integration Report was very important and should be a priority.
- Stephen (QIA) indicated that a NIRB officer should attend the working groups including MEWG.
- Todd (Baffinland) asked for the source of the interest in having NIRB attend the MEWG meetings.
- Stephen (QIA) indicated that under the Nunavut Lands Claim agreement that NIRB has a responsibility to monitor the project and that NIRB receiving only the Annual Report is not enough to provide adequate monitoring.
- Todd (Baffinland) asked the group for their thoughts.
- Mike (EDI) indicated that NIRB was invited as an observer in the past and had always declined. Mike added that NIRB had been invited to attend this conference call.
- Todd (Baffinland) indicated that NIRB would be copied on minutes which would provide them with more frequent information.
- Andrew (WWF) indicated that WWF is very supportive of NIRB's participation and volunteered to phone NIRB to discuss.
- Todd (Baffinland) suggested that we table this discussion until the next meeting.
- Stephen (QIA) agreed that this was fair.
- Kristin (ON) requested an update on the status of the DFO aerial survey.
- Steve (DFO) confirmed that update reports from the field could be provided to the group.

Next meeting

- Todd (Baffinland) indicated that next meeting was planned to be in Iqaluit.
- Date to be set for November 2016

Actions:

- Attendance: Everyone was requested to send an e-mail to Wayne (Baffinland) to confirm who was on the call and who would be the primary and secondary contacts for the MEWG;
- Updates on Aerial Survey: progress will be provided by DFO and circulated by Baffinland;
- MEWG membership and alternate list: Baffinland will update and circulate;
- Integration report: Baffinland to follow up with LGL and communicate a plan for the report;
- NIRB participation: Baffinland will add to the agenda for the next meeting;
- Meeting Minutes: Baffinland to circulate and, when finalized look at getting posted to the NIRB website;
- Baffinland will review the minutes from the April 2016 meeting to clarify that the shipboard monitoring program was Deferred and not Cancelled.

Marine Environment Working Group Meeting 9 Meeting Minutes

Date: November 29, 2016

Location: Fisheries and Oceans Canada, Qamutiq Building – 4th Floor Boardroom, 630 Mivvik St, Iqaluit NU

Remote: 1-866-251-3220 ID: 6861183#

Participants		
Member Organization	**Attendees**	
Baffinland Iron Mines (Baffinland)	Wayne McPhee (WM)	I
	Joe Tigullaraq	N
	Megan Lord-Hoyle (MLH)	I
	Jim Millard	N
Qikiqtani Inuit Association (QIA)	Jeff Higdon (JH)	I
	David Qamaniq (DQ)	I
	Luc Brisebois (LB)	I
	Lily Maniapik (LM)	I
Department of Fisheries and Oceans (DFO)	Veronique D'Amours-Gauthier (VDG)	I
	Kim Howland (KH)	I
Environment and Climate Change Canada (ECCC)	Grant Gilchrist (GG)	P
	Paul Smith (PS)	I (1pm)
Government of Nunavut (GN)	Brad Pirie (BP)	I
	Amy Robinson	N
Parks Canada (PC)	Francine Mercier	N
	Diane Blanchard	N
Makivik	Gregor Gilbert	N
Mittimatalik Hunters and Trappers Organization (MHTO)	Mathias Qaunaq (MQ)	I
	Elijah Panipakoocho (EP)	I
Observer Organization		
Oceans North (ON)	Kristin Westdal (KW)	P
	Trevor Taylor	N
World Wildlife Fund – Canada (WWF)	Andrew Dumbrille	N
	Amanda Hanson Main (AHM)	I
Baffinland Consultants		
Golder	Andrea Locke (AL)	I
Environmental Dynamics Inc. (EDI)	Mike Setterington (MS)	I
Additional Recipients		
Qikiqtani Inuit Association (QIA)	Stephen Williamson Bathory	

I – In person, P-phone in participation, N- Not attending

Agenda	
1.	Welcome and introductions (Wayne McPhee, All)
2.	Summary of 2016 Mary River site activities (Megan Lord-Hoyle)
3.	Baffinland update and organizational changes (Wayne McPhee)
Health Break (10:30am)	
4.	Workshop (led by Wayne McPhee): Working group mandate and revisions to the Terms of Reference Objectives of marine monitoring
Lunch (provided) (12:20-1:00pm)	
5.	Third Party Peer Review of 2015 Aerial Survey Report (Andrea Locke)
	Marine Monitoring Programs Integration Report (Andrea Locke)
Health Break	
6.	Workshop (led by Wayne McPhee): Roundtable updates on relevant research projects - DFO – invasive species monitoring (Kim Howland) - ECCC – seabird program (Grant Gilchrist) - QIA – Community Based Monitoring (Luc Brisebois) Next Steps
Reference Material	
Presentation 1 Project Update Pres… / Presentation 2 Baffinland Update - / Presentation 3 Integration Report f… / MEWG Nov 2016_ Howland compresse… / 161124-QIA-CBM-WG Presentation-Fina…	

Comments	
2. + 3.	MLH: Provided an overview of the presentations made in the communities between Nov 21-25, 2016) and an overview of the Mary River Project. WM: Provided an update on Baffinland activities and organizational changes. **Socio-economic Comments:** LB: Is the survey information available by community? MLH: The data is available but we haven't prepared a report in that format yet. DQ: There doesn't seem to be anything about hunters being affected on that list (referring to a summary list of concerns about the project from the survey). MLH: The list reflects just the top five concerns, not a thorough list. EP: Has a study been conducted to determine which communities are affected the most? MLH: I can't provide a thorough answer, but based on what I heard from the messaging at the recent community tour (last week), it seems that all communities are on "equal footing" – under the IIBA agreement. Currently, I think, since the majority of activities are occurring near Pond Inlet, Pond Inlet is seen as the most impacted community. EP Follow- up for QIA: How do you determine which communities have the biggest impacts? LB: In the original proposal, it was assumed that the more southern communities would be more impacted. In the current phase, when we did our community engagement tour last year, we heard that Pond Inlet is the only impacted community and we didn't hear from the other communities that there were any impacts. We did hear that there were decreasing narwhal in eclipse sound, we heard this from

	more than one source including the HTO. This might be just a one year thing but it is of concern to us. EP: Questioned if and why the employment levels are decreasing? WM/LB: We don't have the data on why Inuit employment rates are dropping. We have conducted an employee survey to help understand the reasons and we are working with the QIA. EP follow-up directed at the QIA: We have to find out why employment and retention is decreasing. Are you trying to move the targets and make sure they are met? LB: Our target with Baffinland is 25% which is lower than what we were thinking. It was 20% at the beginning of the year, and what we are seeing is problems with retention not recruitment. We are doing a number of programs to increase employment to Inuit firms who can provide services to the project and who can contribute to the MIEG. There is now a strategy in place and this is something Baffinland is working on and it is their responsibility. We are providing an oversight role only. LM: The project referred to by LB is under the Baffin Inuit Labour Gap Analysis (BILUGA). The results have been shared with the community and Baffinland. There is now a designated Inuit firm list. DQ: Expressed concerns that the QIA has heard that the staff of Baffinland are unhappy – there is limited progression and the beneficiaries are unable to speak their language over the radio, although French is spoken. WM: English is the only language accepted over the radio for safety reasons. JH: Are you seeing high turnover only in the North Baffin communities or in the south as well? WM: Both. The rotation lifestyle can be difficult. DQ: asked about training opportunities for Inuit for railroad positions. WM responded that Baffinland training will be required for railway maintenance, engineering, etc. **Comments on the Phase 2 project description:** KH: To accommodate the 12 mtpa, how many vessels are needed? WM: Roughly 1 cape size vessel and 1 panamax per day. JH: Will the existing panamax dock remain and additional dock for the cape be added? WM: Yes. EP: What will the start date of the project be? WM: Assuming permits are in place, north railway construction will begin in 2018. JH: Will EIS alternatives assessment include keeping the Tote road option and winter shipping as options? WM: Yes EP: Expressed concerns about the impacts to the environment if larger boats are needed. Commented that hunters have noted that the tugs are very noisy and have an impact on whales. WM: Bigger boats are somewhat noisier, but there will be fewer large boats than smaller boats. More tugs will be needed but I had not heard that the noise from tugs was of concern. MQ: Expressed that he is not opposed to the project. Noted that once the project began, narwhals migrate in a different pattern. Noted that the community is harvesting fewer narwhal. The effects on Narwhal is not just Baffinland, it's a combination, including cruise ships. Second point… commented on the need to focus on the effects of the noise and vibration of ships on land when they pass the community. Noted that cabins were shaking when ships come up from Milne Inlet. EP: If there was a building, the cruise ship would have been over 100 ft high, like a

	floating island. WM: Was it an ore ship that made the vibrations, or the cruise ship? MQ: It was a Baffinland boat. WM: Requested that MQ and EP show the locations of the cabins during the break. JH: Noted that the terms and conditions related to noise and vibration are related to the mine site and the port area only. AHM: Is the switch from road to rail a complete switch? Or does the road supplement the rail. What is the timeline for the EIS? WM: Once the rail is operational, all iron ore will go by rail. Road will be used for the movement of people and equipment. We are targeting end of March for the EIS. DQ: Requested clarification around the process for the Phase 2 approvals and if Baffinland has to go back to the Nunavut Land Use Planning Commission. WM: The exemption provided by the Minister of INAC was questioned with the switch from road to rail. NIRB asked if this was a significant change under the Nunavut land use planning commission. The Minister has put it back to NIRB to determine if Baffinland has to go back to the commission. DQ/JH/LB: Will Navy Board Inlet be used with increased shipping? Is trans-shipping included in the project update? Will the original proposal of 18 mtpa remain? WM: The plan includes only use of Eclipse sound and no trans-shipping is included. The original proposal will remain, the new proposal increases approval to ship up to 12 mtpa through the northern route. KH: Requested a copy of the Annual project review forum presentation given in Igloolik last year? WM: The information would be different than our current proposal, but we can find and send.
4.	WM: Suggestions for changes to ToR have been made by NIRB and noted in previous meeting minutes, no recommendations to date on what exactly to change. Baffinland requested input into revisions to the ToR. **Revisions to the Terms of Reference (ToR)** All revisions will be made to the March 6, 2013 version. Clarification that the group is an advisory body not a decision making group. Legal Review: WM: Requested feedback on the need for lawyers input on the revisions to the ToR. LB: QIA doesn't see a need for lawyers to be involved in the revisions. No parties voiced the need for legal review. Chair of Meetings: WM: Suggested that the ToR be amended to reflect Baffinland as the permanent chair. No groups had opposition to Baffinland remaining as the chair but generally felt that having the option to rotate was a good idea. WM: Clarified that holding the working groups was a Project Certificate condition and that Baffinland needs the ability to ensure that the meetings take place. Format and Frequency of Meetings: WM: Suggestion for two face to face meetings with two conference calls in between or three face to face meetings. Group: Requested a meeting to be held on-site. Baffinland to look into the logistics and timing.

	General revisions: LB: QIA proposed that the HTO be accepted as members and that the MHTO costs be covered by Baffinland. Baffinland is in full agreement. The representatives of the MHTO are in agreement. No parties opposed. MQ and EP to check with their local board for approval. The upcoming HTO elections could delay approval and change who attends the meetings. WM: The ToR will be amended to include their participation and reflect that Baffinland will cover the costs for participation. Simultaneous translation will be available at meetings to allow for full participation of all members. AHM: some issues with communication in the past, minutes not being posted to registry, etc. JH: MEWG members not even receiving final minutes for some meetings. WM: Acknowledged, communications will be improved Inuktitut Translation: Simultaneous translators to be present at all meetings where required. Only the executive summary of technical documents will be translated. Meeting minutes will be translated. The North Baffin dialect will be used for translations. Timelines for distribution of documents were agreed upon as follows: • Meeting minutes to be translated and distributed to the group within three weeks of a meeting • Comments on meeting minutes to be provided to Baffinland within two weeks. If no comments are received, Baffinland will assume acceptance of the minutes. Baffinland to finalize minutes within two weeks. • Technical reports, will be provided to the working group by January 15th at the latest, comments to be sent to Baffinland within one month of receipt of the report.* • *Draft technical reports will be provided 10 days before meetings.* • Conference call in late February, final technical reports posted to Baffinland web portal (under development) by March 31. *As Baffinland has changed the structure for reporting in late 2016, reports may not be submitted by Jan 15, 2016. In following years reports will be submitted by this date. **NIRB Annual Reporting Process:** WM: We have discussed changes to the annual reporting process. NIRB is looking for documents which are more streamlined, reflect cumulative effects and are useful for the communities. AHM: How does Baffinland respond to comments on reports? WM: Detailed responses to every comment may not be made. The intention to have an earlier review of documents and request comments within one month of receipt should help to eliminate the comments made after submission in the annual report, and allow for the spring meeting to focus on the upcoming field season rather than last year's comments. Group: Suggestion to have a meeting in the summer of 2017 to discuss the 2016 submissions comments. AHM: commented that the NIRB requirement to have a monitoring framework as an Appendix to the Project Certificate that included details on what Baffinland will report on, formatting etc. has not been completed. This is to be developed by NIRB. EP: We do not see reports very often. WM: In the future a summary of the technical reports will be developed and translated for community access. GG: The distillation of scientific information

	into a communicable way is important. A template was developed for reporting EC fieldwork activities with and for the HTOs. GG to distribute. **General:** JH: Requested how Baffinland plans to address recommendation no. 16 in the November 4th letter addressed to Baffinland from NIRB. WM: Part of the discussion today is meant to be focused around how we meet these requirements. For example, the MHTO had not previously been present at working group meetings but Baffinland would like to invite them to participate in all meetings going forward. Their participation is a requirement under the Project Certificate and we are now meeting this condition. LB: Questioned why NIRB does not participate in the meetings? AHM: Requested that a letter be sent to NIRB on the working groups behalf to clarify their involvement and role. WM: Clarified that Baffinland has discussed this with NIRB in the past and that all meeting minutes are provided to NIRB. Baffinland can draft a letter asking for clarification on NIRBs role in the working groups. WM: Our intention is to revise the Shipping and Marine Wildlife Management plan once we have consensus on the 2017 plan. The plan will be drafted by Baffinland and circulated to the group for input. DQ: Questioned the cancellation of the ship board observers program. WM: The program is on hold right now for safety reasons. We are asking the group for input into other viable options to replace the program. We want to focus on scientifically valid community based monitoring programs and are looking for collaborations and ideas. Group: Baseline data needs to be strengthened for Phase 2. Positive feedback on community monitoring approach. JH: at the April 2016 meeting it was decided that Baffinland would prepare a report for QIA on ways to improve the MMO program, this is reflected in the April minutes. WH: Will look into it. MLH: The distribution list of participants and designates to be confirmed and/or identified by each organization.
5.	WM: AL will present on the integration report of the marine mammal work since 2013 and the collaboration with DFO on the aerial survey in 2016. The intent is to redraft the shipping and marine wildlife management plan. AL: Presents two presentations (peer review of the LGL marine mammal aerial surveys and the integration report). AHM: Will Baffinland continue to consider drone surveys? WM: We'll continue to consider option, but nothing we could do this year. MQ: Expressed concerns about garbage, oil spills and a reddish colour sediment on the water around Ragged Island where boats are mooring before being loaded at the port. WM: This is the first I have heard about these concerns. We can look into options to have more observers in the area. LB: What are policies that Baffinland has in place to enforce policies on the commercial ships? WM: There is a procedure and plan that we use with the boats, we give them instructions on requirements for working in the area.

	Various: General, but not specific baseline requirements for Phase 2 project submission. AHM: Given that previous three years of monitoring is useless for determining project effects (based on review of integration report), it is more important to continue with baseline data collection and updated monitoring programs. WM: The studies to date have not been wasted effort but have not detected effects. The purpose of the integration report was to consolidate existing information for future planning. DQ: Expressed concerns about the aerial surveys not capturing all whales (i.e. those below surface)? AL: Provided a technical answer to help account for this but there is the presumption that we do not see all whales present. DQ: Expressed that whales make many different sounds when they call and questioned what sounds are captured? AL: They record a range of sounds that a narwhal can make. DQ: Did you ever get elders to listen to the calls, or just scientists? AL: Elders have likely not been involved in listening to the recordings. LB: Are you going to include other marine mammals in effects monitoring? WM: We are here to discuss. MAS: We discussed broadening the species of interest in the terrestrial work as well. There are problems associated with this and including the need for a sufficient sample size to detect an effect. MQ: Expressed concerns over seeing something put in the water that the narwhal swam away from. I don't know if it was DFO that did this, in 2007 possibly. DQ (to MQ): Did you see the gadget, what size was it? Maybe 7 ft plus long. WM: We can try to find out what this was. JH: various devices have been deployed over the years, current profilers, CTD sensors, etc. EP: Described work at Bruce Head study. We have the highest population of Arctic char and they stay in the ocean, that's why you see so many narwhal in the area. Bruce Head observations. Every hour we were looking at each of these areas, they are identified with numbers. We looked not just for narwhal, but also the weather and to see if when the ships went by if the narwhal behaviour changed. We had to make notes on our observations. Adult, male or female, any characteristic we could identify was recorded. This is one of the most effective way to observe the patterns and the migrations. You aren't bothering them, you observe them in the natural environment. 750m uphill you can even observe narwhals under water, you can see when the ship passes how the behaviours change. In my experience this was one of the best methods to be studying narwhals and in addition, it was harder to tell about the seals. The seals would swim to shore when the ship passes, but the narwhals all they have to do is dive deep when a ship comes. This is the difference between narwhals and seals when the ship passes. The binoculars are so strong you can identify a person on the shore behind the ship. AL: When we put people on ships for surveys in other areas, we give them those types of binoculars, but with the system that was used in Pond, that would not be possible. Being able to use these binoculars may help. MQ: Whenever you do any research it is best to consolidate with IQ to cover both sides. That would be my very high recommendation. We are always trying to harvest them and we do get to know their behaviour. August is the best time to do the population estimates and then the fall season (windy season) comes in and interferes with your study.

	MQ: Whenever you do research, the best thing you can do is consult with IQ – that's my recommendation. We're always close to harvesting. We get to know the behavior. August is the best time for population estimates. The windy/fall season interferes with the study. The study needs to continue into the inlets. This is where the whales are because this is where the fish are found in the dead of the summer. EP: Discussed depth sounders that make a noise that seals and narwhals react to. Hunters in Pond Inlet used up tags for narwhal and then switch to hunting seals in August. Noted that narwhal respond to hunting. We can tell if the narwhal are feeding, wounded or hunting. DQ: Asked if the different sounds from vessels effect narwhal. EP: Describes marine mammal behavior. Seal response to ships. Mammals react to sound, esp. when shot at in calm water. Now we have so many ship traffic, the narwhal response isn't as acute. They're getting used to the sound. They used to respond even to the supply ship and would swim up to shore to avoid it. Sound was foreign to them. It's not so common to see that anymore. We saw this in the 1950s. When narwhal are feeding, they're not so easily spooked. Last summer we had lots of cod and capelin. KH: Presents work on invasive species monitoring. EP: Asked if ballast water is exchanged before the ships come into Baffin Island waters. KH: The ballast waters are exchanged in accordance with international regulations in the middle of the ocean. Concerns with exchanging at the port are related to water quality and changes in salinity. There is a report on emergency exchange zones. KH to provide report. GG: Sent seabird reports to MEWG. If anyone has any questions, contact him. LB: Presented on community-based monitoring. Study goals address community concerns or interests. Compliments all project work above and beyond adhering to just the terms and conditions as a bonus. JH: In all programs there is a retention problem. Because of the nature of the work, you can hire great people for two months, but they can't wait around for the next season. Goal towards involvement of technicians in multiple programs and phase out southern consultants in the future.

	Action Items	**Action By**	**Date Completed**
1.	Include analysis of tug boat noise levels in monitoring	Baffinland/Golder	
2.	Evaluate the need to include noise and vibration monitoring in Pond Inlet	Baffinland/Golder	
3.	Provide a copy of the Annual Project review forum presentation to KH	Baffinland	
4.	Prepare Draft ToR revisions	Baffinland Dec 23,2016	Dec 22, 2016
5.	Draft letter to NIRB requesting clarification on their role	Baffinland	
6.	Distribute list of participants for review by organizations	Baffinland	Dec 22, 2016
7.	Schedule winter conference call	Baffinland	

8.	Distribute ECCC reporting template developed with the HTOs	GG	Nov 30,2016
9.	Consider options for observers/inspections around ragged island	Baffinland	
10.	Look into any devices placed in the water around the port area	Baffinland	
11.	Send emergency ballast water exchange zones report	KH	
12.	Look into MMO report to be prepared for QIA	Baffinland	

APPENDIX D3

SEMWG MEETING NOTES

Mary River Socio-Economic Monitoring Working Group
Meeting Agenda

Date: July 19, 2016
Time: 14:30
Location: Baffinland Office, Iqaluit, NU
Organizations: BIMC, GN, INAC, QIA

1. BIMC
    a. Review 2015 Mary River Socio-Economic Monitoring Program report
    b. Changes from the 2013 and 2014 reports
    c. Proposed indicators for future reports
        i. Overlapping indicators with other SEMPs in Nunavut

2. GN and INAC
    a. Project Certificate term and condition responsibilities of the Q-SEMC
        i. 129, 130, 131, 133, 145, 148, 154, 168
    b. TC 133 – Voluntary Housing Survey
        i. Best way forward?
    c. TC 140 – Voluntary Employee Survey
        i. Incorporate potential Q-SEMC questions into existing survey?

3. QIA
    a. Update on projects?

4. General updates
    a. Adult Learning Program at Mary River?
    b. Mary River Experience report?

Qikiqtaaluk
Socio-Economic Monitoring Committee

2016 Annual Meeting Report

Iqaluit, Nunavut: July 20-21, 2016

The community of Iqaluit, Nunavut

4/4/2016

Produced by the Government of Nunavut

EXECUTIVE SUMMARY

The Qikiqtaaluk Socio-Economic Monitoring Committee (SEMC, or 'the committee') gathered in Iqaluit for its annual meeting on July 20-21, 2016 to collectively monitor regional resource development activity and discuss any subsequent socio-economic changes in Qikiqtaaluk communities. Representatives from 10 hamlets were in attendance, in addition to representatives from the Qikiqtani Inuit Association (QIA), Indigenous and Northern Affairs Canada (INAC), Baffinland Iron Mines Corporation (BIMC or Baffinland), and the Government of Nunavut (GN).

The meeting began with a roundtable introduction and presentations from government agencies. The conversation touched on some of the different services and opportunities offered throughout the region with emphasis on education and training. The Nunavut Bureau of Statistics (NBS) then provided a high-level regional overview of the socio-economic environment with a presentation containing government-collected statistical data. This was followed by a community roundtable to gain further insight from community representatives on the local social, economic, and cultural environments in the region. The day concluded with an presentation from Baffinland that included activity updates on the Mary River project as well as a detailed review of the 2015 Mary River Socio-Economic Monitoring Program (SEMP). Baffinland shared data and information on employment and training, and discussed some the company's expected plans moving forward to maximize Inuit participation at the Mary River mine. Baffinland also presented proposed changes to the Mary River SEMP for future reports that will enable the committee to better monitor potential impacts and benefits identified by the company in their final environmental impact statement (EIS).

On the second day of the meeting, participants discussed several monitoring requirements in the Mary River project certificate which require indicator data to monitor effectively and quantitatively. The experiences and opinions shared by community representatives will continue to be discussed at future SEMC meetings until indicators are developed. Further, the added perspectives from communities will contribute to analyses in the Mary River SEMP.

Common issues raised throughout the meeting were current Inuit employment, training, and retention levels. Community representatives would like to see these numbers increase from 2015 levels. Baffinland representatives outlined some of their strategies to achieve the Minimum Inuit Employment Goal that was recently negotiated with QIA. The committee will continue to monitor the implementation of these strategies over the next year and at the next Qikiqtaaluk SEMC meeting, tentatively scheduled for the first week of May 2017 in Arctic Bay.

TABLE OF CONTENTS

LIST OF ACRONYMS

- **AEM**: Agnico-Eagle Mines, owner and operator of the Meadowbank Mine in the Kivalliq region.
- **BIMC**: Baffinland Iron Mines Corporation, owner and operator of the Mary River Mine in the Qikiqtaaluk region.
- **EDT/ED&T**: GN Department of Economic Development and Transportation, the GN Department responsible for holding SEMCs.
- **EDU**: GN Department of Education.
- **EDO**: Economic Development Officer.
- **EIA**: Environmental Impact Assessment, the permitting/regulatory process that major projects have to go through before construction is allowed to take place.
- **EIS**: Environmental Impact Statement, a comprehensive review of anticipated impacts of proposed projects, project design, and predicted operations.
- **FS**: GN Department of Family Services.
- **GN**: Government of Nunavut.
- **H**: Department of Health.
- **HTO**: Hunter and Trapper's Organization.
- **IAU**: Innusiup Asijjiqpallianinganik Ujjiqsurniq, socio-economic monitoring research project of the Qikiqtani Inuit Association
- **IIBA**: Inuit Impact and Benefit Agreement, a private agreement signed between a project proponent and a Designated Inuit Organization (such as QIA, KvIA, and KtIA) to ensure that Inuit interests are addressed as compensation for the impacts of a proposed project.
- **Indicator**: A measurable "thing" that indicates the state, level, or rate of something. E.g. an indication of population growth is the total population of a city over time.
- **INAC**: Indigenous and Northern Affairs Canada, previously AANDC (Aboriginal Affairs and Northern Development Canada)
- **IOL**: Inuit Owned Lands.
- **IQ**: Inuit Qaujimajatuqangit, or Inuit Traditional Knowledge.
- **KIA**: Kitikmeot or Kivalliq Inuit Association (usually referred to as KtIA/KitIA and KvIA/KivIA, respectively).
- **LHO**: Local Housing Organization.
- **LSA**: Local Study Area
- **NBS**: Nunavut Bureau of Statistics.
- **NGMP**: Nunavut General Monitoring Plan, AANDC's monitoring obligation under the NLCA.
- **NHC**: Nunavut Housing Corporation.

- **NIRB**: Nunavut Impact Review Board, an Institute of Public Governance created under the NLCA to review the proposal and development of major projects.
- **NLCA**: Nunavut Land Claims Agreement.
- **NPC**: Nunavut Planning Commission.
- **NTI**: Nunavut Tunngavik Incorporated.
- **QIA**: Qikiqtani Inuit Association.
- **RCMP**: Royal Canadian Mounted Police.
- **SAO**: Senior Administrative Officer, each Hamlet has one.
- **SEMC**: Socio-Economic Monitoring Committee. Nunavut has three Committees, one per region. These Committees meet once a year in each region to monitor the impacts of major projects.
- **SEMP**: Socio-Economic Monitoring Program. Developed to monitor project-specific socio-economic impacts and benefits of operating mines.
- **VSEC**: Valued Socio-Economic Component.

REPORT FORMAT

This report is divided into three chapters. The first chapter introduces the Qikiqtaaluk Socio-Economic Monitoring Committee (SEMC) and provides the background and purpose of the committee. Chapter two summarizes the proceedings of the 2016 annual Qikiqtaaluk SEMC meeting in Iqaluit on July 20-21, 2016. This chapter includes the meeting agenda, participant list, and summaries of presentations and discussions. It also provides a summary of the Mary River-specific meeting that took place prior to the SEMC meeting on July 19. Lastly, chapter three provides some discussion on common topics that were raised during the meeting and some points for further consideration.

LETTER FROM THE CHAIRPERSON

I am pleased to present the Qikiqtaaluk Socio-Economic Monitoring Committee report on the proceedings of the meeting that took place July 20-21, 2016, in Iqaluit.

Baffinland Iron Mines Corporation provided an informative summary of all 2015 activities as well as planned upcoming operations for the Mary River Project. With the issuance of a Project Certificate in 2012 (later amended in 2014), the Qikiqtaaluk Socio-Economic Monitoring Committee has been actively monitoring the socio-economic benefits and impacts in North Baffin communities and the Qikiqtaaluk region. Through collection and dissemination of data information, and shared discussion amongst committee members, the Qikiqtaaluk Socio-Economic Monitoring Committee continued to fulfill its responsibilities set out in the Mary River Project Certificate.

There was general discussion at the 2016 Qikiqtani SEMC and requests for input from the community representatives on the impacts – good or bad – that they see in their communities. Several comments were made around hiring practices, staff turnover, and creating a working relationship to resolve some of these discussions.

The Qikiqtaaluk SEMC is a valuable forum for community members and other participants to share information on how development activities impact the region and their communities. Sharing information between hamlet representatives, the Qikiqtani Inuit Association, territorial and federal governments, industry, and other stakeholders, provides for a collaborative effort to work together in promoting and protecting the existing and future well-being of residents and communities in the region.

I thank all the participants that attended for committing to the important work being facilitated by the Government of Nunavut to monitor the socio-economic benefits and impacts of major development projects. It is vital to the committee and the monitoring effort to ensure that all parties do participate in the meetings and attend regularly to ensure continuity and the building of knowledge. Working together enables us to see all perspectives and learn from each other's experiences. I am very pleased with the kinds of questions and comments that came from the community representatives.

Sincerely,

Rhoda Katsak

Chairperson, Qikiqtaaluk Socio-Economic Monitoring Committee

1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE OF THE SEMC

Environmental assessment in Nunavut falls under the regulatory purview of the Nunavut Impact Review Board (NIRB), an Institution of Public Government created under the Nunavut Land Claims Agreement (NLCA) to administer environmental assessment and follow-up processes. At the culmination of the NIRB's assessment process, a project can be approved, approved with conditions, or rejected. A project certificate is issued for approved projects and may contain terms and conditions that "provide for the establishment of a monitoring program for that project which may specify responsibilities for the proponent, NIRB or Government" (NLCA 12.7.1). Monitoring major projects is also a responsibility of the NIRB (NLCA 12.2.2e). Monitoring is necessary to identify whether predicted changes are taking place, to determine if unpredicted impacts are occurring, and to ensure that companies are mitigating any negative effects as required by the project certificate and any relevant licenses or permits.

Since 2007, SEMCs have addressed project certificate requirements for project-specific monitoring programs. Through a regional approach, three SEMCs create a discussion forum and information sharing hub that supports impacted communities and interested stakeholders to take part in monitoring efforts. This approach also provides monitoring efficiency and consistency within the territory.

The Department of Economic Development & Transportation (EDT, 'the department') has been the GN's lead on the SEMCs. As such, the department has been responsible for collecting socio-economic data from across GN departments and other sources, consolidating this information, and disseminating it to the committees and other interested parties, primarily through reports such as this. Each of the three SEMCs are chaired by the appropriate EDT regional director of community operations, and coordinated by the regional socio-economic coordinator to ensure efforts are consistent, traceable, and comparable, and that they feed into other programs such as the Nunavut General Monitoring Plan (NGMP).

1.1.1 SEMC OBJECTIVES

Considering the above, SEMCs have the following objectives:

1. To ensure that major development projects comply with their permits by meeting their socio-economic monitoring requirements during the environmental

assessment, approval, and monitoring processes as required by the NIRB and the Nunavut Land Claims Agreement;

2. To bring together communities, governments, Designated Inuit Organizations, and resource development companies in a unique forum that encourages open and engaged discussions and information-sharing among all parties; and,
3. To collect and share regional socio-economic data with impacted stakeholders that is validated by local and traditional knowledge.

1.1.2 STATUS AND NEXT STEPS

Regional SEMCs were established in 2007, and have since met annually in each region. The meeting in Iqaluit was the first regional SEMC meeting of the 2016-2017 fiscal year. Two more regional meetings are scheduled to take place in the Kivalliq and Kitikmeot regions later this fall.

Regional SEMC reports from the 2012-2013 fiscal year were the first to provide comprehensive, standardized reporting on nine standard salued socio-economic components (VSECs; e.g. demographics, health and well-being, education, etc.), and over 40 different indicators. These numbers exclude VSECs and indicators that are project-specific. These reports are available for download on our website, http://nunavutsemc.com/, which was launched in 2012 to more effectively communicate socio-economic information with Nunavummiut and other interested groups.

The reporting approach was further modified in 2014 to better serve the committees. The reports for 2012-2013 were composed largely of tables and graphs containing statistical figures for the region, making these reports large and potentially difficult to read. The statistical data has been removed from the main report and attached as an appendix (Appendix B of this report) so that readers can still have a reference point when looking at trends. In addition, an interactive database has been created to visually display over 40 different socio-economic indicators. This database can be accessed on the SEMC website.

The following goals were set for the 2016-2017 fiscal year:

- Maintain the momentum of SEMCs by continuing to hold at least one meeting in each region annually;
- Augment and align GN-wide participation, especially through regional office support, and consistent participation of other organizations;
- Report on project-specific indicators in a more comprehensive manner; and
- Improve the delivery of information at the meetings.

The SEMCs continued to maintain momentum by holding one annual meeting in each region in 2015. GN-wide participation has increased in most regions, and committee members have continued to work with proponents (e.g. TMAC Resources Ltd., Agnico Eagle Mines Ltd., and Baffinland Iron Mines Corp., etc.) in order to ensure compliance with NIRB socio-economic monitoring requirements, and have continued to improve the delivery of information at regional meetings.

Goals for this fiscal year are to continue to standardize project-specific socio-economic monitoring programs for all operating projects, further consolidate currently available data from different sources into one place to allow for monitoring continuity, directly address issues raised at meetings with concrete, accurate, and relevant data, and continue to develop action plans that reflect the priorities of each region and assist Nunavummiut to respond to socio-economic change.

2. 2016 ANNUAL QIKIQTAALUK SEMC MEETING, IQALUIT

The annual Qikiqtaaluk SEMC meeting was held in Iqaluit on July 20-21, 2016. Representatives from 10 hamlets were in attendance to share experiences and information regarding socio-economic changes experienced in their home communities. Participants also heard from Government of Nunavut regional staff, the Government of Canada, Qikiqtani Inuit Association, and Baffinland. In addition to the regional SEMC, the project-specific Baffinland Socio-Economic Monitoring Working Group (SEWG) met on July 19, 2016 to review the 2015 Mary River Socio-Economic Monitoring Program (SEMP) report in accordance with project certificate term and condition no. 130.

2.1 AGENDA AND PARTICIPANTS

This section reflects the intention of the meeting and the agenda that was sent out to participants. It also lists those who were in attendance. The proceedings of the meeting are reported in section 2.2.

Dates:

Wednesday July 20, 2016
Thursday July 21, 2016

Location: Hotel Arctic – Iqaluit, NU

Chair: Rhoda Katsak, Director of Community Operations, Qikiqtaaluk (GN-EDT)

Schedule:

DAY 1 – JULY 20, 2016

Morning session
9:00 AM – 11:45 AM

1. General Opening	
Government of Nunavut • Rhoda Katsak	Opening Remarks by the Chairperson
All	Participant introductions
Government of Nunavut • Clayton Lloyd	Purpose of the SEMC and objectives of this meeting • Review Agenda • Mining highlights in Nunavut

Government of Canada • Tamara Fast	• Qikiqtaaluk SEMC overview and meeting objectives • Mary River Socio-Economic Monitoring Working Group
2. Socio-Economic Monitoring	
Government Roundtable • Education • Family Services • Health • Housing	Updates from Regional GN departments and government agencies • Relevant programs • General observations
Qikiqtani Inuit Association • Hagar Idlout-Sudlovenick	Community-based research • Project updates
Community Roundtable • Hamlet representatives	Open floor discussion to introduce communities • Benefits and impacts of current major development projects • General observations
Nunavut Bureau of Statistics • Meeka Mearns	Socio-economic indicators of well-being • Statistics and analysis
Discussion	• Are the results as expected? • Interesting or unexpected trends?

Afternoon session
1:15 PM – 4:30 PM

3. Proponent Updates	
Baffinland Iron Mines • Jason Prno Lisa Parker	Mary River Iron Mine • Updates on 2015 Project activities • Results from the Socio-Economic Monitoring Program • Planned work for 2016
Discussion	• Are the results as expected? • Interesting or unexpected trends?

End of Day 1

DAY 2 – July 21, 2016

Morning session
9:00 AM – 11:45 AM

4. Qikiqtaaluk SEMC Priorities	
Qikiqtaaluk SEMC	Discussion of SEMC priorities • Review Day 1 and review SEMC objectives • Discuss Mary River Socio-Economic Monitoring Program
Government of Nunavut • Clayton Lloyd Qikiqtaaluk SEMC • All	Mary River Project Certificate monitoring • Discussion of Terms and Conditions related to: o Population movement o Barriers to employment of women o Substance abuse, gambling, marital problems

End of meeting

Participants of the 2016 Qikiqtaaluk Socio-Economic Monitoring Committee

July 20-21, 2016, Iqaluit

Group	Organization	Name	Position	Community
GN	EDT	Rhoda Katsak	Director, Qikqtaaluk Community Operations	Pond Inlet
	NBS	Meeka Mearns	Information Officer/Analyst	Pangnirtung
	H	Deborah Arnold	Public Health Officer	Iqaluit
	EDU	Trudy Pettigrew	Executive Director – Qikiqtani School Operations	Pond Inlet
	FS	Melissa Alexander	Labour Market Information Coordinator	Iqaluit
	NHC	Arielle Stockdale	Senior Policy Analyst	Iqaluit
	EDT	Clayton Lloyd Erika Zell	Regional Socio-Economic Coordinator Environmental Assessment Coordinator	Iqaluit
Industry	Baffinland	Jason Prno	Consultant	-
	Baffinland	Lisa Parker	Head of Human Resources	-
GoC	AANDC	Tamara Fast	Regional Socio-Economic Analyst	Iqaluit
Hamlets	Arctic Bay	Geela Arnauyumayuq	Mayor	Arctic Bay
	Cape Dorset	-	-	-
	Clyde River	-	-	-
	Grise Fiord	Meeka Kigutak	Mayor	Grise Fiord
	Hall Beach	Reena Irqittuq	Second deputy	Hall Beach
	Igloolik	Erasmus Ivvalu	Council member	Igloolik
	Iqaluit	Joamie Eeejeesiak	Community Economic Development Officer	Iqaluit
	Iqaluit	Elizabeth Kingston	Council member	Iqaluit
	Kimmirut	Maliktu Lyta	Council member	Kimmirut
	Pangnirtung	Moses Qappik	Mayor	Pangnirtung

	Pond Inlet	Abraham Kublu	Council member	Pond Inlet
	-	-	-	-
	Sanikiluaq	Johnny Manning	Assistant SAO	Sanikiluaq
	Qikiqtarjuaq	Mary Killiktee	Mayor	Qikiqtarjuaq
RIA	QIA	Hagar Idlout-Sudlovenick	Director, Social Policy	Iqaluit
Observer	Research	Andrew Hodgkins	University of Alberta	Edmonton

2.2 SUMMARY OF MEETINGS

The Government of Nunavut provided an overview of current resource development activities in Nunavut as well as a background of the SEMC and multi-stakeholder socio-economic monitoring. The departments of Education, Family Services, Health, and the Nunavut Housing Corporation (NHC) then presented information on their respective roles in socio-economic monitoring in Nunavut. Indigenous and Northern Affairs Canada (INAC) added with an explanation of funding opportunities through the Nunavut General Monitoring Plan (NGMP). This introduction provided context for committee members to assist with discussion topics over the course of the meeting.

The Nunavut Bureau of Statistics (NBS) shared socio-economic monitoring information from the five north Baffin communities and Iqaluit. These six communities are of significant interest as they make up the Mary River Local Study Area (LSA). The committee looked at statistics on population, education, health, income, crime, and food prices, and discussed some of the similarities and differences between what the statistics portray and what is commonly observed and experienced in the communities. Some highlighted trends include: A noticeable increase of training hours completed amongst Inuit (1,283 hours in 2013, 3,596 hours in 2014 and 4,530 hours in 2015); an increase of the value of Procurement with Inuit Owned Businesses and JVs (from $64 million in 2014 to $103.5 million in 2015); and an increase in population demographics in the LSA with an ongoing gradual decrease of non-Inuit residents.

QIA presented on their Innusiup Asijjiqpallianinganik Ujjiqsurniq (IAU) program, a community-based research project in four Qikiqtaaluk communities designed to monitor socio-economic change at the community level. Baseline data collection is currently in progress and will hopefully be completed near the end of summer. QIA has yet to determine the frequency of any follow-up studies.

The community roundtable discussion offered insight into the socio-economic changes experienced since the commencement of the Mary River project. The economic benefits of employment and contracts to local businesses have been interpreted as largely positive in the LSA. Still, many communities expressed their desire to see higher Inuit employment levels and greater access to training at Mary River. Communities outside of the LSA talked about the negative impacts of limited employment opportunities for residents.

Baffinland provided updates on 2015 activities and presented results and analysis from its 2015 SEMP report. This included monitoring information on migration in and out of north Baffin, education and training, employment, contracting opportunities, and results from a voluntary employee survey. The company also responded to the concerns expressed by community representatives regarding reduced employment and training opportunties, and suggested that the lower numbers are likely a result of the project transitioning from construction to operation. Baffinland representatives confirmed that the company intends to implement appropriate measures to achieve the Minimum Inuit Employment Goal negotiated with the Qikiqtani Inuit Association (QIA) and expects these immediate concerns to be addressed in time.

Subsection 2.2.1 of this report summarizes the presentations and discussions that took place during the two-day SEMC meeting in Iqaluit. Subsection 2.2.2 briefly provides an overview of the project-specific Mary River Socio-Economic Monitoring Working Group meeting that took place on July 19, 2016.

2.2.1 PRESENTATIONS AND DISCUSSION

GOVERNMENT ROUNDTABLE

Department of Economic Development and Transportation, presented by Clayton Lloyd – Regional Socio-Economic Monitoring Coordinator

The GN provided an introduction to the committee that summarized the overall purpose and goals of the SEMC as well as the importance of meeting. This served as a refresher for participants who had previously attended the Qikiqtaaluk SEMC as well as a brief overview of the committee for those who had not. The presentation offered an overview of the legal obligation and purpose of socio-economic monitoring in Nunavut and highlighted the roles and responsibilities of interested stakeholders at the SEMC. A review of regional resource development activities from the past year was also provided to give participants some background information ahead of the meeting's discussions.

Department of Education, presented by Trudy Pettigrew – Executive Director, Qikiqtani

The Department of Education (EDU) continues to work on realigning departmental priorities to better support school needs in Nunavut. Concentrated efforts to realign priorities will have a positive impact in the long term but have resulted in some immediate challenges including limited program funding and prolonged vacant staffing positions. One of the department's priorities is literacy. EDU has been working with consultants to develop books in Inuktitut to improve the reading and writing abilities of students. Another priority of EDU is consistency between the regional boards. EDU is currently reviewing the *Education Act* and held consultation sessions across the territory during the summer of 2016. Lastly, EDU is placing more emphasis on increasing parental engagement to support students outside of the classroom.

Nunavut Housing Corporation, presented by Arielle Stockdale – Senior Policy Analyst

NHC briefly explained changes to the Rent Scale system that were implemented in 2014 to reduce disincentives to work and encourage saving. Programs offered through NHC to encourage homeownership include the Nunavut Downpayment Assistance Program (NDAP) and the Tenant to Owner Program (TOP). NDAP offers Nunavummiut a second mortgage that is forgivable over a 10-year period, while TOP allows public housing tenants to purchase the public housing unit they are renting, or another public housing unit that may be available for sale. The Nunavut Housing Corporation is currently developing a Blueprint for Action which will outline a strategic approach to provide affordable housing and improve the local workforce.

Department of Family Services Career Development, presented by Melissa Alexander – Labour Market Information Coordinator

The Family Services (FS) career development section facilitates labour market participation and connects Nunavummiut with jobs through the promotion of education and training. Achieving this requires routine consolidation of information on labour supply and labour demand to create occupational forecasting models. Many programs are available to assist with skills development. Of particular interest to the Qikiqtaaluk SEMC are the following:

Labour Market Information: Labour market funding agreements with the Government of Canada support the suite of programs and services offered in Nunavut. These agreements help the GN better understand labour needs in communities so that the right programs can be developed and delivered. It allows for a greater number of Nunavummiut to access training and education than would be possible with GN funding alone. It also assists Nunavummiut to further their employment goals and overcome barriers to participation in the labour market.

Labour Market Programming: Programs such as Adult Learning and Training Supports (ALTS) and Training on the Job are designed to develop the skills required to successfully participate in the labour force. Training on the Job provides an incentive to employers by subsidizing the registered employee's wages.

Financial Assistance for Nunavut Students (FANS): FANS is designed to ensure that financial need is not a barrier to higher education by offsetting some of the costs of post-secondary education. It is for students attending designated post-secondary and academic programs.

Apprenticeships and Trades Occupations Certification: The Apprenticeship Unit supports skilled workers and apprentices on their way to becoming journeypersons either with or without their Interprovincial Standards Red Seal certification. The Apprenticeship Unit also certifies eligible trade occupations.

More information can be accessed on the Department of Family Services website or from a local career development officer.

Department of Health, presented by Deborah Arnold – Public Health Officer

The Department of Health is an active member of the GN's Socio-Economic Assessment Committee (SEAC) to review and monitor the impacts of resource development projects on individuals. Areas of concern include communicable diseases and mental health. The Department of Health has made changes to the communicable diseases report to improve the delivery and access of information. Additionally, the mental health division is looking to bring more experts into the territory to achieve greater success in suicide prevention.

REGIONAL SOCIO-ECONOMIC MONITORING

Nunavut Bureau of Statistics, presented by Meeka Mearns – Information Officer

To assist with monitoring regional socio-economic change, the Nunavut Bureau of Statistics presented on GN socio-economic data. With the focus primarily on the North Baffin and the Mary River Project, NBS provided data on the five North Baffin communities. A more complete and comprehensive overview of socio-economic statistics of all Nunavut communities can be found attached to this report (Appendix B). Below is a brief overview of the indicators discussed with the committee:

Population:
Each of the five North Baffin communities has experienced annual population growth since 2012. The largest increases have taken place in Igloolik and Pond Inlet, while smaller increases have occurred in Arctic Bay, Clyde River, and Hall Beach.

Education:
Public school enrolment numbers remained stable or increased in all North Baffin communities in 2015. The Qikiqtani regional graduation rate (28.4%) increased slightly from 2014 but remains lower than the 2013 and 2012 rates.

Health:
The total number of health centre visits and health centre visits per capita increased most significantly in Pond Inlet. Igloolik and Arctic Bay also experienced increases in 2014, while

Hall Beach and Clyde River saw decreases from 2013. Hall Beach and Igloolik have the lowest health centre visits per capita in the North Baffin region with 6.7 and 7.9 visits per year, respectively.

Crime:

The number of actual violations in 2014 increased slightly from 2013 in Arctic Bay, Clyde River, Igloolik, and Hall Beach. Clyde River experienced the most significant annual increase with 91 more violations in 2014 compared to 2013. When adjusted to the number of violations per 100,000 persons, Hall Beach and Igloolik, as in 2013, had the lowest rate of violations in the North Baffin in 2014.

Suicide:

One half of Nunavut's 32 recorded suicides in 2015 happened in the Qikiqtaaluk region. The total number of suicides in Qikiqtaaluk, Kivalliq, and Kitikmeot in 2015 was 16, 9, and 7, respectively.

Food Price Survey:

The average cost of 24 selected food items increased in each Qikiqtaaluk community in 2015 with the exception of Hall Beach where those same items decreased in price by 4.5%. The largest price increases happened in Resolute (17.3%), Iqaluit (12.9%), and Sanikiluaq (10.9%).

COMMUNITY ROUNDTABLE

After discussing government-collected quantitative socio-economic data, the Qikiqtaaluk SEMC proceeded to a community roundtable discussion. Hamlet representative were provided the opportunity to share with the rest of the committee information regarding the social, economic, and cultural environments in their home communities. This served to provide additional context to the statistical information previously presented by NBS. The transcripts below have been paraphrased from the meeting.

Pond Inlet:

"Baffinland and the Mary River Project have certainly impacted the socio-economic environment in Pond Inlet. The new money from has been nice for those who are employed but not everyone is seeing those benefits. We feel that training efforts of our residents have been scaled back and those who have completed training, even the heavy equipment operator training, are not being offered full-time work."

Igloolik:

"The Co-op and Northmart have been running out of money because not enough of our residents have bank accounts. The economic impacts of Mary River have been positive. Training opportunities and Inuit priority hiring has helped as well but we hope this can be improved to how it was in the first few years of construction. The community is concerned there are not enough extra-curricular activities for the youth – especially culturally appropriate activities."

Pangnirtung:

"Summer students have been hired by the hamlet to clean up the community, which has been mutually positive for the community and students. The youth centre was almost shutdown because of a lack of funding but fortunately it was able to stay open."

Kimmirut:

"Our residents were more involved in the Mary River project early on when there was an impact assessment in the community, but people now are wondering if the southern shipping route will be used or not. Other types of shipping have been very active around town. One approach the community has taken to reduce small crimes is with After Midnight Monitoring. We feel it has helped to have a few volunteers to have a presence and walk around town after midnight when small crimes typically occur."

Sanikiluaq:

"It is great to see Inuit actively involved in the Mary River project but our community has not seen any of those benefits. The benefits look good on paper but our residents are desperate for more job opportunities."

Hall Beach:

"Baffinland was very inviting during the environmental assessment stage and our community was excited for the employment and training opportunities. But a few years into the Mary River Project and we are now dealing some of the impacts that were not expected. Employees moving to new communities and breaking up families has been something that is happening. Too many of the Inuit employees are stuck in housekeeping and dishwasher positions with not enough opportunity to progress to higher pay and responsibility. Hall Beach would appreciate more public meetings and information sessions with Baffinland to hear our concerns."

Arctic Bay:

"The employee who died at site last year impacted our community greatly. The new laptop computers that Baffinland gives high school graduates is a program we very much appreciate.

Stories of racism on site really concern us because that should never be tolerated. An Inuit goal of 25% is still too low. There are many people ready to work in Nunavut and the North Baffin."

Grise Fiord:

"We try to encourage our high school graduates to seek employment at Mary River but they don't want to leave home. The travel to site is still quite far and they worry of homesickness. Alcohol and bootlegging is becoming an increasing concern in our community. The hamlet is working with the RCMP to keep crime down. The Arctic Fisheries Alliance has greatly helped us get affordable meat products from Newfoundland. This has helped our residents offset the high costs of living."

Qikiqtarjuaq:

"There is no connection between our community and Mary River. Although we were consulted early on, we do not see any hires from here since the beginning of construction and operations. Our community has been actively applying for funding from federal agencies to improve the socio-economic environment on things like access roads to hunting grounds, clean up contaminants near DEW Line sites, and training programs to strengthen the labour pool. Not all applications have been accepted but we are getting a bit of money here and there to help out. We would like to be more involved in the Mary River Project. We have qualified heavy equipment operators ready to work but we're at a disadvantage not being a point-of-hire community. Lastly, our community would like to be considered for a deep water port. We are located in a great location geographically and it would be wise to invest in infrastructure now to set ourselves up for the future. A deep water port would greatly benefit our community and the region."

INDUSTRY UPDATE

Peregrine Diamonds, Chidliak Exploration Project

Representatives from Peregrine Diamonds were unable to attend the Qikiqtaaluk SEMC meeting. A brief project overview and recent project developments have been included in the report at their request.

"The Chidliak project is located 120 kilometres northeast of Iqaluit, the capital of Nunavut, on Canada's Baffin Island. The project consists of 506 Chidliak claims and 71 adjacent Qilaq claims, covering a total of 564,396 hectares. Since July of 2008, 71 kimberlites have been discovered at Chidliak and three at Qilaq. Representative samples of 50 of the 74 kimberlites have been submitted for industry-standard microdiamond assay at the

Saskatchewan Research Council (“SRC”) in Saskatoon. Peregrine’s news releases record the diamond-positive results obtained for 45 kimberlites and barren results for five kimberlites. Diamond testing of the remaining 24 kimberlites has been deferred based on low diamond and/or low tonnage potential assessments by the experienced Peregrine technical team. The CH-1, CH-6, CH-7, CH-28, CH-31, CH-44, CH-45, and CH-46 kimberlites have tonnage potential and coarse diamond size distributions that are considered to represent economic diamond mining potential.

The 2016 Inferred Mineral Resources for the CH-6 and CH-7 kimberlites formed the foundation of the Preliminary Economic Assessment (PEA) for the Phase One Chidliak Development, which was announced in a July 7, 2016 news release. Highlights of the 2016 Chidliak Phase One Diamond Development PEA base case are:

- Pre-tax Net Present Value (NPV) of C$ 743.7 million, at a 7.5% discount rate and a pre-tax Internal Rate of Return (IRR) of 38.1%.
- After-tax NPV of C$ 471.2 million, at a 7.5% discount rate and an after-tax IRR of 29.8%.
- Total Life of Mine (LOM) pre-tax Free Cash Flow of C$ 1.31 billion.
- Pre-tax average annual Free Cash Flow of C$ 131 million per annum.
- After-tax payback period of two years, LOM of 10 years.
- Operating margin of 72%.
- LOM average production rate of 1.2 million carats per annum, peaking at 1.8 million carats per year.
- LOM average mining head grade of 1.67 carats per tonne.
- Estimated pre-production capital requirement of approximately C$ 434.9 million, including C$ 56.7 million in contingency.
- Pre-production capital includes the construction of a 160-kilometre all-weather road to connect to Iqaluit, the capital of Nunavut.”

Baffinland Iron Mines Corporation, presented by Lisa Parker – Head of Human Resources, and Jason Prno – Consultant

The presentation began with an overview of the Mary River Project followed by 2015 project milestones. Mining and hauling activities continued from the mine site to the Milne Inlet Port to permitted quantities. The first commercial shipping season occurred during the open water season between July and October 2015. Baffinland spoke briefly about the proposal for the Early Revenue Phase (ERP) Phase II, which would expand the total annual ore tonnage by 7.8 Million tonnes over an increased shipping season. Baffinland expects to submit an EIS for Phase II in the near future, although no specific date was given. Phase II studies, analyses, and community consultations are ongoing.

Baffinland then presented results from the 2015 Mary River Socio-Economic Monitoring Program report. This included a description of predicted residual effects and impacts, project certificate conditions, data, and analyses. The full 2015 Mary River SEMP report can be accessed on the Nunavut Impact Review Board and Nunavut SEMC websites. A summary of results is provided below.

Population Demographics:

Based on population data, there do not appear to be any project-induced demographic changes in and out of the North Baffin region at this time. Baffinland is able to monitor migration of current employees in and out of the North Baffin. Results indicate that five Inuit employees migrated out of North Baffin LSA communities in 2015, while five Inuit employees also migrated into the region.

Education and Training:

Although the total number of training hours offered to Baffinland employees decreased in 2015, the total hours of training to Inuit employees increased. The highest numbers of training hours were delivered for Heavy Equipment Operator and Ore Truck (B-Train) drivers. No project-related trends in secondary school graduations can be identified at this time as data displays much variability. Monitoring will continue to identify any potential trends in the future.

Livelihood and Employment:

The number of regular full-time Inuit employees decreased by seven over the last year for a total of 92 in 2015. The reduction in Inuit employees may have been caused by the 2015 staff hiring freeze. The communities with the most employees on December 31, 2015 were Arctic Bay (20), Pond inlet (18), and Clyde River (14). Twenty-one Inuit employees were either promoted to a new position or secured a permanent position from a fixed-term contract. Although Inuit employee departures decreased from 45 in 2014 to 41 in 2015, this remains a priority for Baffinland to better understand reasons for high turnover and adjust management plans accordingly. With regards to female employment rates, the percentage of hours worked by Inuit women compared to Inuit men on the Mary River

Project (approximately 27.5%) was much higher than non-Inuit women compare to non-Inuit men in 2015.

Contracting and Business Opportunities:

The total number of contracts with Inuit-owned businesses and joint-ventures decreased from 19 in 2014 to 12 in 2015. However, the total value of those contracts increased significantly from $64 million to $103.5 million, respectively. Further, the total number of contracts to Inuit-owned businesses and joint-ventures in the LSA increased from three to five in 2015. The total employee payroll in 2015 was highest in Arctic Bay ($1,915,734), followed by Pond Inlet ($1,822,996), then Iqaluit ($1,434,422).

Following the presentation of 2015 Mary River SEMP results, Baffinland discussed its proposed changes to the reporting format in upcoming reports. The proposed changes are intended to better serve the committee by improving the delivery of information and to ensure that monitoring of each final EIS predicted impact is occurring. Baffinland will incorporate additional indicators in future reports to monitor the effects on human health and well-being, as well as community infrastructure and public services. Data for these proposed indicators will be collected by Baffinland, the Nunavut Bureau of Statistics, and Statistics Canada.

A comprehensive assessment of the benefits and impacts of the Mary River Project on the socio-economic environment can be found in the final version of the Mary River SEMP annual report, which was submitted to the NIRB in March 2016 and can be uploaded from www.NunavutSEMC.com

QIKIQTAALUK SEMC MARY RIVER PROJECT CERTIFICATE MONITORING

Impacted stakeholders of the Qikiqtaaluk SEMC provide valuable input into the socio-economic monitoring process that assist with the analyses of Mary River Project effects. When specific indicators do not exist, this input becomes all the more important.

Baffinland and the other members of the Qikiqtaaluk SEMC are responsible for monitoring Project effects on population movement between communities (Condition 131), employment barriers for women (Condition 145), and substance abuse, gambling, and marital issues (Condition 154). Baffinland has made efforts to monitor the impacts in these areas of concern but have acknowledged that their assessment of impacts could benefit from additional discussion with the Qikiqtaaluk SEMC.

Population Movement Between Communities:

The movement of employees was raised as a concern in Hall Beach. It has been observed that one or more employees have left their spouse for a new relationship and moved to a new community or to southern Canada. The subsequent impacts on the employee's family are major. It was requested that Baffinland require their employees to be dropped off after their shift in the same community they were pick up to eliminate this impact. Baffinland responded to this request with an explanation that the company cannot enforce their employee's right to move to a new community.

Baffinland was also asked by other community members if they are able to monitor population patterns of former employees who no longer work at Mary River as this could provide added insight into the Project's effects. Baffinland replied that they could do a better job at this through communication with the Baffinland Community Liaison Officers.

Employment Barriers for Women:

One community representative expressed concern that women, even if properly trained as heavy equipment operators, are primarily gaining employment as kitchen staff or janitors. Some women who are interested in working at Mary River are intimidated by mining culture. Another representative asked the committee if there are any ideas on how to better support women at Mary River. Baffinland provided some additional context to the heavy equipment and B-Train hiring process and explain that they receive many applications for these positions. Baffinland prioritizes Inuit hires but need to hire the most qualified candidate with experience therefore cannot necessarily select one gender over the other.

Substance Abuse, Gambling, and Marital Issues:

Several communities including Arctic Bay, Hall beach, Grise Fiord, and Pond Inlet cited alcohol and drug abuse as concerns in their communities. However, there was no direct link to an increase in substance abuse issues since the beginning of Mary River. Community representatives explained that this has been an ongoing concern and that the hamlets have been working closely with the RCMP to reduce and eliminate the prevalent use and consumption of drugs and alcohol.

2.2.2 MARY RIVER SOCIO-ECONOMIC MONITORING WORKING GROUP

Baffinland received its project certificate for the Mary River Early Revenue Phase project on April 28, 2014. Within this project certificate are a series of conditions that relate to socio-economic monitoring. Conditions of particular importance to the SEMC are as follows:

Condition Number	Mary River Project Certificate Terms and Conditions
129	The Proponent is strongly encouraged to engage in the work of the Qikiqtaaluk Socio-Economic Monitoring Committee along with other agencies and affected communities, and it should endeavor to identify areas of mutual interest and priorities for inclusion into a collaborative monitoring framework that includes socio-economic priorities related to the Project, communities, and the North Baffin region as a whole.
130	The Proponent should consider establishing and coordinating with smaller socio-economic working groups to meet Project specific monitoring requirements throughout the life of the Project.
131	The Qikiqtaaluk Socio-Economic Monitoring Committee is encouraged to engage in the monitoring of demographic changes including the movement of people into and out of the North Baffin communities and the territory as a whole. This information may be used in conjunction with monitoring data obtained by the Proponent from recent hires and/or out-going employees in order to assess the potential effect the Project has on migration.
133	The Proponent is encouraged to work with the Qikiqtaaluk Socio-Economic Monitoring Committee and in collaboration with the Government of Nunavut's Department of Health and Social Services, the Nunavut Housing Corporation and other relevant stakeholders, design and implement a voluntary survey to be completed by its employees on an annual basis in order to identify changes of address, housing status (i.e. public/social, privately owned/rented, government, etc.), and migration intentions while respecting confidentiality of all persons involved. The survey should be designed in collaboration with the Government of Nunavut's Department of Health and Social Services, the Nunavut Housing Corporation and other relevant stakeholders. Non-confidential results of the survey are to be reported to the Government of Nunavut and the NIRB.
145	The Proponent is encouraged to work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring Committee to monitor the barriers to employment for women, specifically with respect to childcare availability and costs.
148	The Proponent is encouraged to undertake collaborative monitoring in conjunction with the Qikiqtaaluk Socio-Economic Monitoring Committee's monitoring program which addresses Project harvesting interactions and

	food security and which includes broad indicators of dietary habits.
154	The Proponent shall work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring Committee to monitor potential indirect effects of the Project, including indicators such as the prevalence of substance abuse, gambling issues, family violence, marital problems, rates of sexually transmitted infections and other communicable diseases, rates of teenage pregnancy, high school completion rates, and others as deemed appropriate.
168	The specific socioeconomic variables as set out in Section 8 of the Board's Report, including data regarding population movement into and out of the North Baffin Communities and Nunavut as a whole, barriers to employment for women, project harvesting interactions and food security, and indirect Project effects such as substance abuse, gambling, rates of domestic violence, and education rates that are relevant to the Project, be included in the monitoring program adopted by the Qikiqtaaluk Socio-Economic Monitoring Committee.

In accordance with the Mary River Socio-Economic Monitoring Working Group (MRSEMWG or 'Working Group') Terms of Reference[1], there was a technical meeting on July 19, 2016 in Iqaluit with representatives from Baffinland, the GN, INAC, and QIA. The 2015 SEMP report on the Mary River Project was Baffinland's third annual submission to the Working Group and the Nunavut Impact Review Board.

The 2015 report was re-organized from its predecessor 2013 and 2014 reports to provide a more streamlined monitoring format. The new report focuses on final EIS prediction, residual effects, data, and analysis. Baffinland presented the 2015 Mary River SEMP results to the Working Group then outlined proposed changes to further modify the Mary River SEMP in future reports.

The Working Group also discussed government-collected indicators to be incorporated into future reports. The GN presented Baffinland and the Working Group with a table of proposed new indicators to be added and current indicators to be removed. The purpose of these suggestions is to develop greater consistency across all project SEMPs in Nunavut. The Doris North, Meadowbank, and Mary River SEMPs were all developed at different periods of time and do not contain all of the same indicators, thus making reviewing and

[1] The Mary River Socio-Economic Monitoring Working Group Terms of Reference can be found on the SEMC website. http://nunavutsemc.com/wp-content/uploads/2014/12/Dec-3_2012_MRSEMP_ToR_Final-clean.pdf

assessing the socio-economic effects of each project challenging. The indicators proposed by the GN will be considered by Baffinland for inclusion into future reports.

The Working Group then developed a strategy to monitor Project Certificate requirements where no official data currently exists. It was decided that until proper indicators are developed to collect data on population movement between communities (Condition 131), employment barriers for women (Condition 145), and substance abuse, gambling, and marital issues (Condition 154), the most appropriate way to monitor these effects will be through discussion with the Qikiqtaaluk SEMC. This will provide a temporary series of qualitative data for the Working Group's considerations and analyses of Mary River Project effects.

Lastly, the Working Group discussed how to best approach the voluntary housing survey as outlined in Project Certificate Condition 133. Baffinland is encouraged to work with the Qikiqtaaluk SEMC, Nunavut Housing Corporation, and the Department of Health and Social Services to design and implement a voluntary housing survey to be completed by employees to identify project effects on housing (change of address, housing status, etc.). Baffinland has agreed to work with the appropriate GN departments to either add housing questions to their existing voluntary employee survey, or, create a new voluntary survey. The GN intends to begin work with Baffinland on this survey later this year.

2.2.3 QIKIQTAALUK SEMC ACTION ITEM WORK PLAN

The following table highlights specific items that were discussed throughout the Qikiqtaaluk SEMC and Mary River Working Group meetings that require follow up. This provides a way to track commitments made by SEMC members during the two day meeting. Any outstanding items should be reviewed at the next meeting in order to discuss solutions or plans moving forward.

Item	Organization(s)	Timeframe
If possible, include more detailed employment data that may exist in the Inuit Impact and Benefit Agreement report to the Qikiqtaaluk SEMC	Baffinland QIA	Next Qikiqtaaluk SEMC
Update the Qikiqtaaluk SEMC with new strategies to reduce Inuit turnover	Baffinland	Next Qikiqtaaluk SEMC

GN departmental staff to contact Baffinland representatives when prepared to begin developing a voluntary housing survey for employees	GN – NHC Baffinland	December, 2016

3. DISCUSSION

This section briefly summarizes the main topics of discussion at the annual Qikiqtaaluk SEMC meeting in Iqaluit.

3.1 QIKIQTAALUK SEMC AND PROJECT-SPECIFIC MONITORING

Discussions during the annual Qikiqtaaluk SEMC meeting largely focused on the socio-economic environment and potential links to the Mary River Project. The committee reviewed the 2015 Mary River Socio-Economic Monitoring Program (SEMP) to gain a more comprehensive understanding of the socio-economic changes that have occurred since the mine began construction in 2013. The Mary River SEMP currently tracks four Valued Socio-Economic Components that relate to several project certificate socio-economic monitoring terms and conditions.

The meeting facilitated open discussions between the North Baffin community representatives and Baffinland personnel regarding concerns and dialogue surrounding socio-economic impacts and benefits. The total number of regular full-time Inuit employees decreased by seven from 2014 for a total of 92 in 2015. A contributing factor in this decrease is the transition of the Mary River Project from construction to operations and Baffinland predicts that this will stabilize over time once the transition has been completed. The decrease is likely also due to the 2015 staff hiring freeze. Although there was a small decrease of employees, the total hours of training to Inuit employees increased from 2014 to 2015, mostly in Heavy Equipment Operator and Ore Truck driver training.

Inuit turnover rate was another issue discussed at the Qikiqtaaluk SEMC. Although the turnover rate for Inuit employees in 2015 was higher than it was for non-Inuit employees, it still remains lower than what was predicted in the FEIS. Communities voiced that the Inuit turnover rate have been evident since the beginning of the project,although the exact reasons are unknown to them. Baffinland's 2015 Socio-Economic Monitoring Report cites family/personal issues at home (childcare not suitable for rotational work, frustration with job - rotation, salary, length of shift) and obtaining jobs in their home community for resigning. For turnover due to dismissals the most cited reasons were absenteeism and poor job performance.. Baffinland has committed to updating the Qikiqtaaluk SEMC with new strategies to reduce Inuit turnover. These strategies will be presented at the 2017 Qikiqtaaluk SEMC meeting.

In addition to turnover rates, barriers to women gaining employment at the project were discussed in the meeting. One potential issue identified is that female applicants are primarily employed as kitchen staff or janitors and not heavy equipment operators or other positions, even when the appropriate qualifications are held. Baffinland explained that although they prioritize Inuit hires, they must hire the candidates most qualified for the position. Discussions then took place regarding observed increases in substance abuse, gambling and marital issues in Qikiqtaaluk communities. Communities are concerned with the relation between working at Mary River and an increase in substance and gambling abuse issues. Community representatives explained that this is an ongoing issue not directly related to Mary River and that hamlets are working with the RCMP in an attempt to reduce and eliminate substance abuse. Baffinland will continue to monitor the impacts in these areas of concern, but have acknowledged that their assessment of impacts could benefit from additional discussion with the Qikiqtaaluk SEMC.

The quantitative assessment of the SEMP together with the qualitative analysis of the committee's discussions provides a thorough understanding of the benefits and impacts associated with the Mary River mine. The committee is encouraged by the positive employment and training numbers at Mary River but reiterated their desire to see these numbers continue to increase. Baffinland shares this sentiment and expressed their commitment to improve the delivery of programs to create lasting benefits for its employees. The annual SEMC meeting is an optimal venue for impacted stakeholders to raise concerns and voice suggestions to AEM so that the company can look to modify programs in a way that best meets the needs of Qikiqtaalukmiut.

The Working Group also discussed government-collected indicator data to be incorporated into future reports. The GN presented Baffinland and the Working Group with a table of proposed new indicators to be added and current indicators to be removed. The purpose of these suggestions is to develop greater consistency across all project SEMPs in Nunavut. The indicators proposed by the GN will be considered by Baffinland for inclusion into future reports. Along with the adjustment of these indicators, Baffinland is encouraged to work with the Qikiqtaaluk SEMC, Nunavut Housing Corporation, and the Department of Health and Social Services to design and implement a voluntary housing survey to be completed by employees to identify project effects on housing (change of address, housing status, etc.). This will either be added to the existing Mary River voluntary employee survey, or, a new voluntary survey will be created.

APPENDIX A: PRESENTATIONS

Appendix A is a separate document that contains the Power Point slide presentations discussed within this report in the order they were presented and scheduled in the agenda:

1. Government of Nunavut
2. Nunavut Bureau of Statistics
3. Baffinland Iron Mines Corporation

APPENDIX B: STATISTICS

Appendix B is a separate document that contains statistical information on the following valued socio-economic components and associated indicators:

Demographics

Population estimates

Population estimates by region and community

Population estimates by age group, region and community

Population mobility

Aboriginal identity

Health and well-being

Life expectancy

Infant mortality

Teenage pregnancy

Birth weight

Perception of drug and alcohol abuse

Tobacco addiction

Alcohol addiction

Suicide

Number of visits to community health centres

Children and social services: Number of children receiving services

Food security

Hunger

Consumer price index

Cost of northern food basket

Nutrition North: Subsidy amount and weight per community

Education

Public school enrolment by grades

Secondary school graduation rate

Attendance by grades

Housing

Total dwellings and household size

Total rented and public/private-owned dwellings

Crowding

Public housing wait list

Crime

Actual violations

Rate of police-reported incidents

Criminal violations by type

Economic activity

Gross domestic product

Retail trade

Building permits

Employment

Labour force characteristics

Persons receiving employment insurance

Percentage of households receiving income support

Taxfilers with employment income, and median employment income

Social Assistance caseload

Social Assistance expenditures

Inuit languages

Population by mother tongue

Language most spoken at home

Traditional activities and skills

Population that hunted, fished, gathered, and/or trapped in the past 12 months

Time spent with elders (youth)

Baffinland

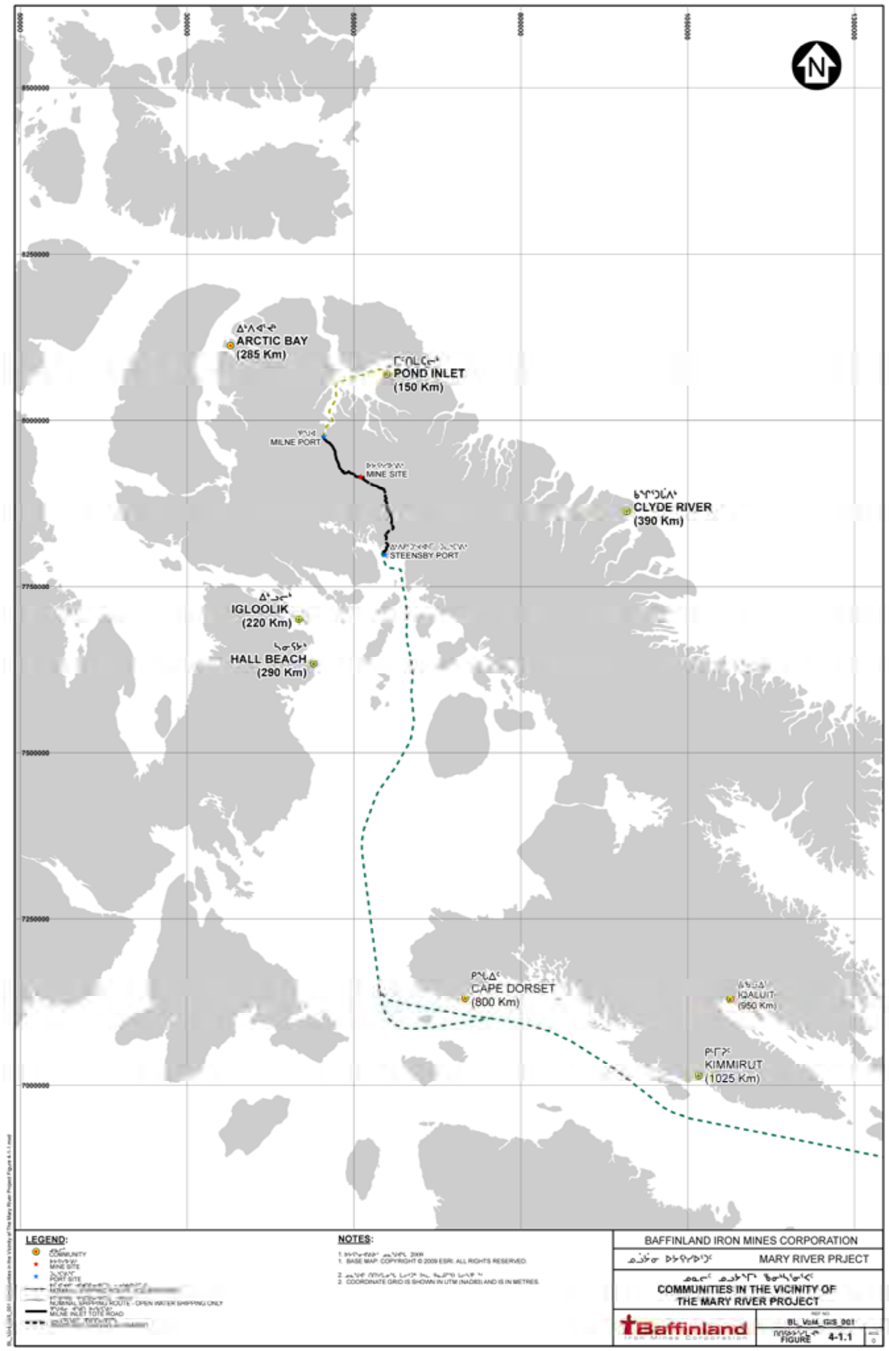
Qikiqtaaluk Socio-Economic Monitoring Committee & Mary River Socio-Economic Monitoring Working Group Meetings
July 2016

Mary River Project Overview & Update

Mary River Project Overview

- Operating open pit iron ore mine with associated project components owned and operated by Baffinland Iron Mines Corporation. Located approximately 160 km south of Pond Inlet and 1,000 km north of Iqaluit.
- Consists of three currently active main project locations: Mine Site, 100 km long Milne Inlet Tote Road, and Milne Port. Also includes a proposed railway and Steensby Port, both located to the south of the mine site.
- Initial project approved by the NIRB in 2012. Early Revenue Phase (ERP) operation approved by the NIRB in 2014, including additional production of up to 4.2 Mt/a of iron ore, ore haulage over the Milne Inlet Tote Road, and open water shipping of ore from Milne Port.
- Baffinland now permitted for future development of 18 Mt/a railway and total combined production rate of 22.2 Mt/a.

Mary River Project: Regional Overview



Baffinland

Mary River Project: Global Overview

Baffinland

Mary River Project Update

2015 Milestones

- Mining and hauling activities from the Mine Site to the Milne Inlet Port Site and ongoing 'ramp-up' of operations to permitted quantities
- First commercial shipping season occurred between July and October
- Mine construction, initiated in 2013, continued through 2015
- Ongoing monitoring and mitigation for environmental compliance

Other Developments

- In 2014, Baffinland announced a proposal for ERP Phase II. Phase II would expand the 4.2 Mt/a ERP operation by 7.8 Mt/a to 12 Mt/a of ore transported to Milne Port over an expanded shipping season. Project description submitted to NIRB and NPC in October 2014.
- Baffinland expects to submit an Environmental Impact Statement (EIS) for Phase II in the near future. The EIS will include an analysis of transport of ore by trucks and rail.
- Phase II studies, analyses, and community consultations are ongoing

2015
Socio-Economic Monitoring Report

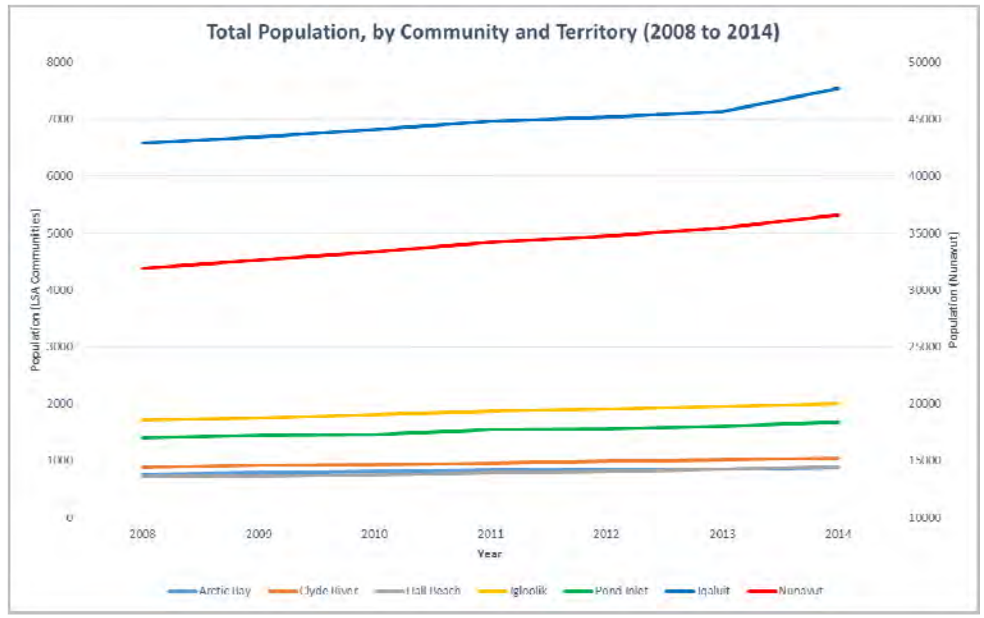
2015 Socio-Economic Monitoring Report Overview

- Project-related socio-economic monitoring requirements originate from the Nunavut Land Claims Agreement (NLCA) and NIRB Project Certificate No. 005. The Mary River SEMWG Terms of Reference also provides guidance.
- Structure and content of 2015 report has been re-organized since previous reports. For each selected VSEC the report now clearly presents:
  - Descriptions of predicted residual effects/mitigation measures or relevant Project Certificate conditions
  - Indicator data
  - Analyses
- 2015 report presents information on the four VSECs Baffinland was best able to provide information on:
  - Population demographics
  - Education and skills
  - Livelihood and employment
  - Contracting and business opportunities
- 2016 and future reports will present information on all remaining VSECs. Indicators require stakeholder feedback before finalization.

1. VSEC - Population Demographics

Demographic Change
(Project Certificate Condition)

- Populations of the North Baffin Local Study Area (LSA) communities, Iqaluit, and Nunavut continued to expand at high rates. Percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities remains high, although an ongoing gradual decrease is apparent. Territorial migration trends for Nunavut show variability.
- No Project-induced demographic changes apparent at this time



1. VSEC - Population Demographics

In-migration of Non-Inuit Project Employees into the North Baffin LSA & Out-migration of Inuit Residents from the North Baffin LSA (Predicted Effects)

- FEIS predicted <5% of the non-Inuit baseline population could in-migrate and 1% to <5% of the total population could out-migrate
- Available migration data indicates no unanticipated negative effects (thus supporting the FEIS predictions)
- Additional data and future analyses could provide additional insight

Known Migrations of Project Employees and Contractors in the North Baffin LSA (2015)				
Type of Migration	**Inuit Employee**	**Non-Inuit Employee**	**Inuit Contractor**	**Non-Inuit Contractor**
Number of Individuals Migrating Into North Baffin LSA Communities	4	—	1	—
Number of Individuals Migrating Out of North Baffin LSA Communities	5	—	—	—

Source: Baffinland records

1. VSEC - Population Demographics

Employee Residence, Housing, and Migration Status and Intentions (Project Certificate Condition)

- No indicator data were available for this topic in 2015. Should relevant data become available, Baffinland will consider integrating it into future socio-economic monitoring reports.

1. VSEC - Population Demographics

Employee Origin
(Project Certificate Condition)

- High number of Inuit employees from the LSA a likely reflection of Inuit hiring commitments
- Non-Inuit employees originate primarily from outside Nunavut, likely providing skills not available in-territory
- Total employee numbers increased in 2015 but the number of Inuit employees decreased by a small amount. May be due to 2015 staff reduction measures/hiring freeze or calculation changes.

Baffinland Employees (Regular Full-Time) On Staff at the End of December 2015, by Origin and Beneficiary Status

Origin		Baffinland Employees	
		Inuit	Non-Inuit
Nunavut	Arctic Bay	20	2
	Clyde River	14	1
	Hall Beach	9	3
	Igloolik	11	2
	Pond Inlet	18	0
	Iqaluit	10	2
Other Canadian Provinces and Territories	Alberta	0	10
	British Columbia	0	27
	Manitoba	0	11
	New Brunswick	1	22
	Newfoundland	1	44
	Northwest Territories	0	3
	Nova Scotia	1	38
	Ontario	7	274
	Prince Edward Island	0	2
	Quebec	0	18
	Saskatchewan	0	4
	Yukon	0	1
International	Other	0	1
Total		**92**	**465**

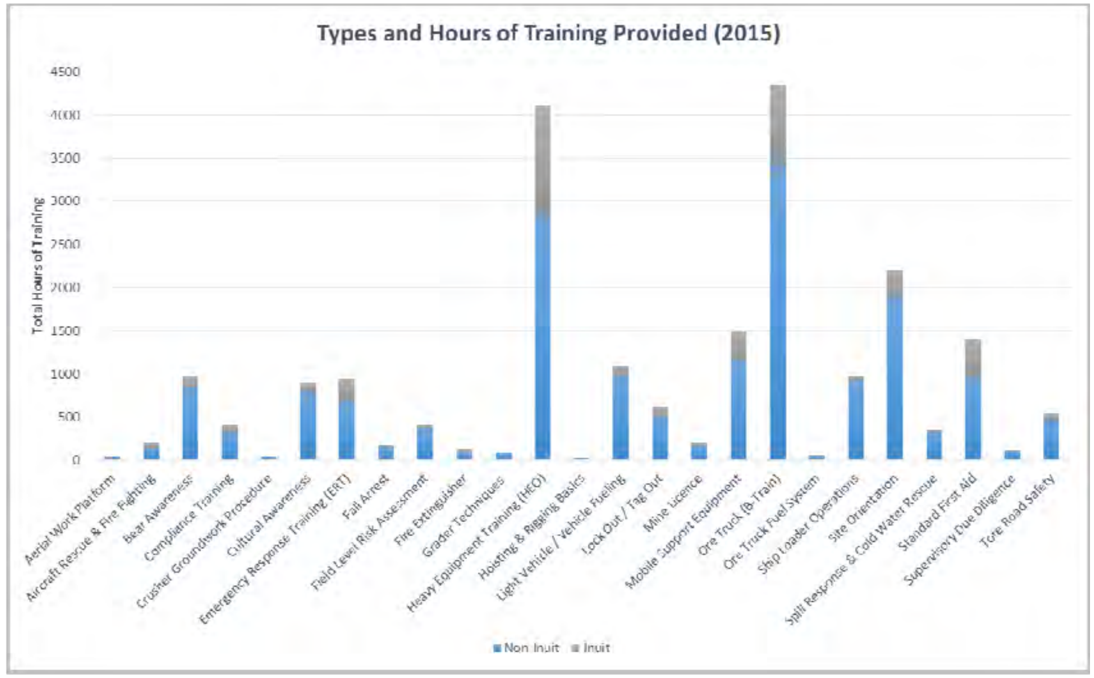
Source: Baffinland records
Notes: This table excludes contractors but includes Baffinland community-based and corporate head office positions.

Baffinland

2. VSEC - Education and Training

Improved Life Skills Amongst Young Adults (Predicted Effect)

- FEIS predicted positive effects on life skills development amongst young adults in the LSA
- Indications that positive effects continue to result from Project (e.g. as a result of employment, pre-employment training, and on-the-job training; access to EFAP and on-site Elders)

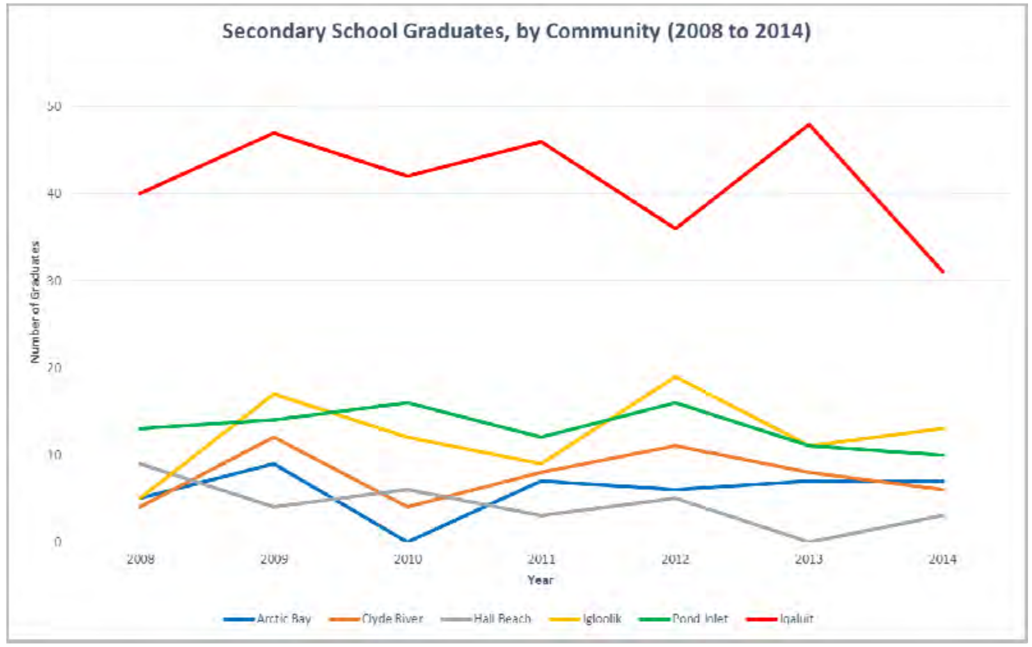


Baffinland

2. VSEC - Education and Training

Incentives Related to School Attendance and Success (Predicted Effect)

- FEIS predicted a positive effect on education and skills development in the LSA due to incentives related to school attendance and success
- Baffinland continued to support various educational and training initiatives through its donations program and IIBA in 2015.
- Existing data displays variability and/or shows no Project-correlated trends. Future monitoring may provide additional insight.



Baffinland

2. VSEC – Education and Training

Opportunities to Gain Skills (Predicted Effect)

- FEIS predicted a positive effect on education and skills development, due to Project-related opportunities for training and skills acquisition amongst LSA residents
- In 2015, Baffinland continued to provide a substantial number of training and skills development opportunities to its Inuit employees, thus confirming the positive effect

Hours of Training Completed			
Beneficiary Status	**2013**	**2014**	**2015**
Inuit	1,283	3,596	4,530
Non-Inuit	4,555	20,271	17,352
Total	**5,838**	**23,867**	**21,882**

Source: Baffinland records

2. VSEC – Education and Training

Education and Employment Status Prior to Project Employment (Project Certificate Condition)

- Employee Information Survey administered to Inuit employees/contractors in early 2016
- Survey respondents have varied educational and pre-employment backgrounds. However, more survey respondents have a high school and/or tertiary education (76.3%) than do Nunavut residents overall (53.9%).
- Baffinland will continue to track the education and employment status of its Inuit employees prior to Project employment to see if any future trends emerge

Baffinland Inuit Employee/Contractor Level of Education Obtained (January/February 2016 Survey Results)

Level of Education	Number of Individuals (76 Surveys Received)
Less than High School	17
High School	39
College/Trade School	19
University	0
Unknown	1

Source: Baffinland records

Baffinland Inuit Employee/Contractor Pre-Employment Status (January/February 2016 Survey Results)

Pre-Employment Status	Number of Individuals (76 Surveys Received)
Unemployed	35
Full-Time Employment	22
Part-Time Employment	6
Casual Employment	9
Employed, Status Unknown	1
Unknown	3

Source: Baffinland records

3. VSEC - Livelihood and Employment

Creation of Jobs in the LSA (Predicted Effect)

- FEIS predicted a positive effect on wage employment in the LSA. Annual labour demand predicted to be 0.9 million hours during ERP operations, 2.9 million hours during the 18 Mt/a phase, and 4.1 million hours during the construction phase (peaking at 7.3 million hours).
- FEIS prediction exceeded in 2015, positive effect confirmed
- However, a small decrease in hours of labour performed in Nunavut occurred in 2015, likely due to 2014 being a major construction year on-site and the staff reduction measures/hiring freeze enacted in 2015. Baffinland anticipates returning to normal hiring practices once conditions improve.

Total Hours of Project Labour Performed in Nunavut		
2013	**2014**	**2015**
863,177	1,867,882	1,844,081

Source: Baffinland records

3. VSEC - Livelihood and Employment

Employment of LSA Residents (Predicted Effect)

- FEIS predicted a positive effect on wage employment in the LSA. An estimated 342,000 hours of labour are predicted to be provided each year to LSA residents, 230,000 hours of which will be provided by North Baffin LSA residents.
- Predictions were met in 2014. In 2015, the Project continued to make positive LSA employment contributions.
- However, employment numbers were slightly lower than predicted in 2015. 307,570 hours were worked by LSA residents (16.7% of total hours worked) and 213,392 hours were worked by North Baffin LSA residents (11.6% of total hours worked). This reduction was likely due to the staff reduction measures/hiring freeze enacted in 2015. Baffinland anticipates returning to normal hiring practices once conditions improve.

3. VSEC - Livelihood and Employment

New Career Paths (Predicted Effect)

- FEIS predicted the Project would have a positive effect on the ability of LSA residents to progress in their jobs and careers
- In 2015, a substantial number of Inuit were employed by the Project and many were promoted to new positions. Career opportunities introduced to the region represent a positive effect and are a likely result of mitigation measures Baffinland has developed.
- However, there were a number of Baffinland Inuit employee departures in 2015. Baffinland will continue to monitor employee turnover causes and outcomes, and the success of career advancement programs.

Baffinland Inuit Employee Promotions

Type of Promotion	Year	
	2014	2015
Fixed Term to Permanent	9	7
Promotion	9	14
Total	**18**	**21**

Source: Baffinland records

Number of Baffinland Inuit Employee Departures

2013	2014	2015
9	45	41

Source: Baffinland records

Notes: 2013 and 2014 numbers are for indeterminate employees only. 2015 numbers include determinate and indeterminate employees.

Baffinland

3. VSEC - Livelihood and Employment

Barriers to Employment for Women (Project Certificate Condition)

- Women worked considerably fewer hours on the Project (approximately 9.1% of the total) than their male counterparts in 2015
- Women remain under-represented in the Canadian mining sector as a whole
- Percentage of hours worked by Inuit women compared to Inuit men on the Project (approximately 27.5% of this total) was much higher than non-Inuit women compared to non-Inuit men in 2015

Hours Worked by Project Employees and Contractors, by Gender and Beneficiary Status

Beneficiary Status & Gender		2013		2014		Q4 2015[1]	
		Hours Worked	% of total (863,177)	Hours Worked	% of total (1,867,882)	Hours Worked	% of total (430,244)
Inuit	Male	124,754	14.5%	267,169	14.3%	54,794	12.7%
	Female	49,611	5.8%	112,437	6.0%	20,732	4.8%
Non-Inuit	Male	639,468	74.1%	1,394,204	74.6%	336,124	78.1%
	Female	49,200	5.7%	94,072	5.0%	18,594	4.3%
TOTAL		**863,177**	—	**1,867,882**	—	**430,244**	—

Source: Baffinland records

[1] In 2015, gender data related to hours worked was only available for Q4

4. VSEC - Contracting and Business Opportunities

Expanded Market for Business Services to the Project (Predicted Effect)

- FEIS predicted the Project would have a positive effect on creating market opportunities for businesses in the LSA and RSA, through the supply of goods and services to the Project
- Baffinland procurement data suggests the Project has had a positive effect on creating market opportunities for businesses in the LSA and RSA to supply goods and services to the Project, as was predicted in the FEIS

Procurement with Inuit-Owned Businesses and Joint Ventures			
Procurement Details	**Year**		
	2013	2014	2015
Value of Procurement with Inuit-Owned Businesses and JVs	$200 million	$64 million	$103.5 million
Total Number of Contracts with Inuit-Owned Businesses and JVs	13	19	12
Number of Contracts with Inuit-Owned Businesses and JVs in the LSA	6	3	5

Source: Baffinland records

Baffinland

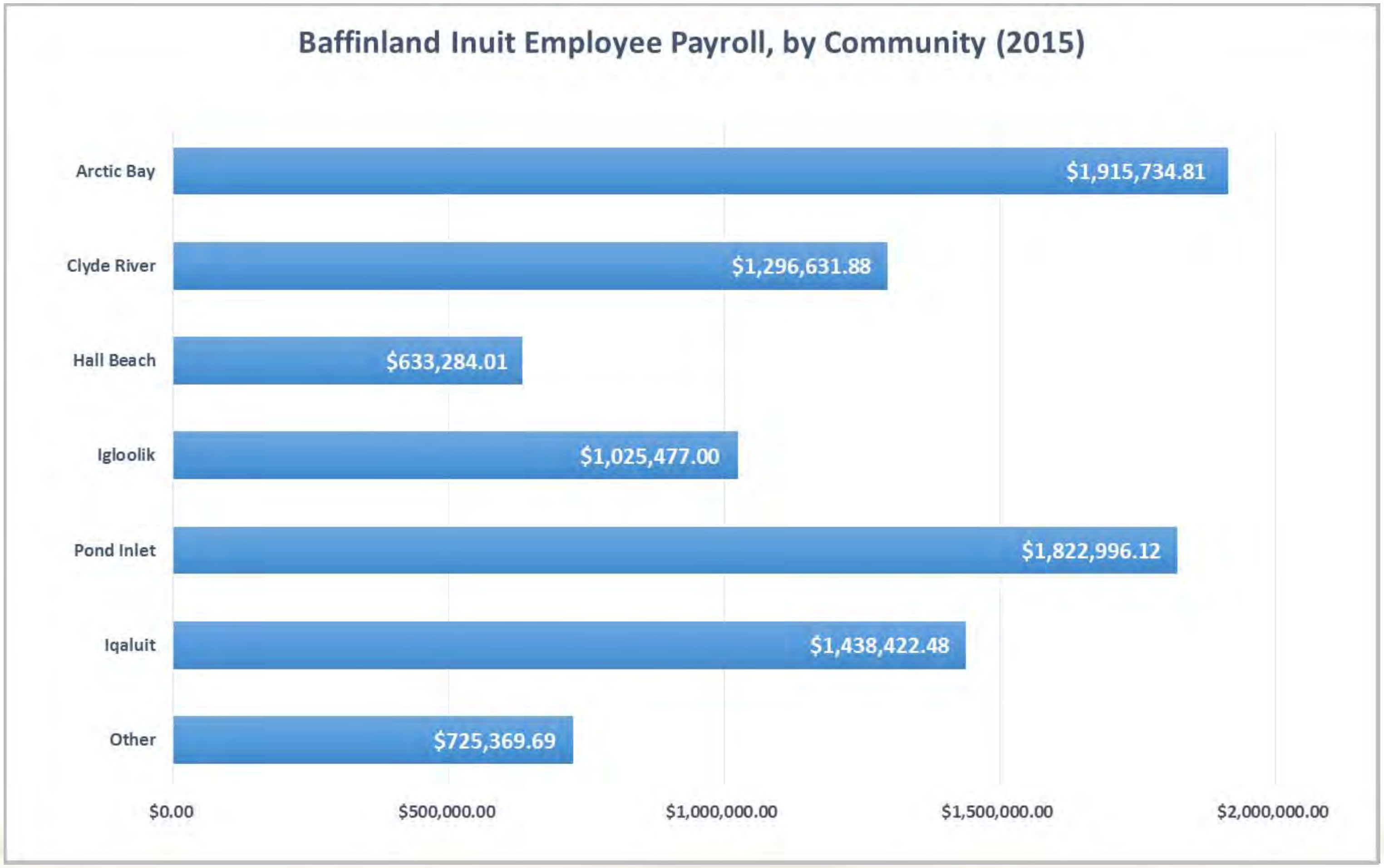
4. VSEC - Contracting and Business Opportunities

Expanded Market for Consumer Goods and Services (Predicted Effect)

- FEIS predicted an expanded market for consumer (i.e. non-Project related) goods and services across the LSA
- Considerable amounts spent on Inuit payroll (approx. $8.9 million) and contracting with Inuit-owned businesses and joint ventures (approx. $103.5 million) in 2015. These new contributions to the Nunavut economy are a direct result of Project development and represent a positive effect.
- The number of NTI registered Inuit firms in the LSA have increased by 11 since 2013
- LSA residents now have a greater capacity to purchase local goods and services as a result of the Project. Increased Project-related incomes can also can act to stimulate further business growth.

4. VSEC - Contracting and Business Opportunities

Expanded Market for Consumer Goods and Services (Predicted Effect)



Baffinland

5. Summary of Regional and Cumulative Effects

- The Project continued to make positive contributions to the Nunavut economy in 2015. No negative regional or cumulative economic effects associated with the Project were identified.
- In 2014, there were a total of 14,860 jobs held in Nunavut and 26,221,000 total hours worked, with average weekly earnings of $1,236.44 per employee. Hours worked by Baffinland's employees and contractors in Nunavut in 2014 represent 7.1% of the Nunavut total. Average weekly earnings of Baffinland's Inuit employees in 2014 were higher than the Nunavut average, at $1,618.59.
- '*Mining, quarrying, and oil and gas extraction*' was responsible for contributing $345.2 million to Nunavut's real GDP, while '*construction'* was responsible for $285.1 million. The Mary River Project has been an important contributor to these amounts.
- Mining in Canada, generally, contributed $57 billion to the country's GDP in 2014, or 3.5% of total Canadian GDP. The industry also employs 375,000 individuals and remains the largest proportional private sector employer of Aboriginal peoples in the country.

Potential Indicators for 2016 and Future Reports

VSEC - Economic Development and Self-Reliance

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	Increased pressure on the land	N/A – As noted in the FEIS, monitoring is already conducted through other VECs/VSECs
	Changes to land-based economy	
	Increased opportunities for youth	
	Education and training opportunities	
	Increased wealth and well-being	
	Increased wealth in community	
	Rotational absence of residents	
	Increased local business opportunities	
	Expanded economic activity, flows, and opportunities	
Project Certificate Condition	Project harvesting interactions and food security, which includes broad indicators of dietary habits	Should indicators be required, they will be selected in consultation with the Mary River SEMWG

Baffinland

VSEC – Human Health and Well-Being

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	Changes in parenting	Number of children receiving welfare services, by region (GNDFS)
		Total number of youth charged and not charged, by community (StatCan)
	Household income and food security	Proportion of taxfilers with employment income and median employment income, by community (NBS)
		Percentage of population receiving social assistance, by community (NBS)
	Overall effects on children	N/A – Monitoring will already be conducted through other 'human health and well-being' indicators
	Transport of substances through Project site	Number of contraband infractions at Project sites (Baffinland)

Baffinland

VSEC – Human Health and Well-Being

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	Affordability of substances	Number of impaired driving violations, by community (NBS)
		Number of drug violations, by community (NBS)
	Attitudes towards substances and addictions	N/A – Monitoring will already be conducted through other ‘human health and well-being’ indicators
	Absence from the community during work rotation	No indicator(s) proposed, although this issue will continue to be tracked through QSEMC meetings and community engagement
Project Certificate Condition	Prevalence of substance abuse	N/A – Monitoring will already be conducted through other ‘human health and well-being’ indicators
	Prevalence of gambling issues	Should indicators be required, they will be selected in consultation with the Mary River SEMWG

VSEC – Human Health and Well-Being

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Project Certificate Condition	Prevalence of family violence	Rate of police-reported family violence in Nunavut (StatCan)
	Prevalence of marital problems	Percent of Nunavut residents separated or divorced (NBS)
	Rates of sexually transmitted infections and other communicable diseases	Percent of health centre visits related to infectious diseases, by community and territory (NBS)
	Rates of teenage pregnancy	Nunavut live birth rate, by mothers under the age of 20 (NBS)
	High school completion rates	N/A – Monitoring will already be conducted through other 'education and training' indicators

Baffinland

VSEC - Community Infrastructure and Public Services

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	Competition for skilled workers	Number of new Project employees leaving hamlet positions (Baffinland)
	Labour Force Capacity	Training and experience generated by the Project (Baffinland)
		Employee turnover (Baffinland)
Project Certificate Condition	Pressures on existing health and social services provided by GN that may be impacted by Project-related in-migration of employees	Should indicators be required, they will be selected in consultation with the Mary River SEMWG
	Project-related pressures on community infrastructure	Should indicators be required, they will be selected in consultation with the Mary River SEMWG
	Project-related pressures on community airport infrastructure	Number of annual Project flights to community airports in Nunavut (Baffinland)

Baffinland

VSEC - Cultural Resources

- Monitoring will already be conducted through annual archaeology reports and will not appear in annual socio-economic monitoring reports.

VSEC - Resources and Land Use

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	Quantity of caribou harvested per level of effort	N/A – Potential effects on caribou will continue to be tracked through Baffinland's terrestrial wildlife monitoring program
	Safe travel around Eclipse Sound and Pond Inlet	Number of recorded land user visits to Project sites (Baffinland) Number of reported land user safety incidents and/or complaints (Baffinland)
	Safe travel through Milne Port	
	Emissions and noise disruption at camps	
	Sensory disturbances and safety along Milne Inlet Tote Road	
	Detour around mine site for safety and travel	
	Difficulty and safety relating to railway crossing	
	Detour around Steensby Port	

VSEC - Resources and Land Use

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	HTO cabin closures	N/A – No monitoring required. Effects are permanent for life of Project.
	Restriction of camping locations around Steensby Port	N/A – No monitoring required. Effects are permanent for life of Project.

VSEC - Cultural Well-Being

- No monitoring and/or indicators proposed, as no residual effects were identified in the FEIS

VSEC - Benefits, Royalty, and Taxation

Residual Effect or Project Certificate Condition	Topic	Potential Indicator
Residual Effect	Payments of payroll and corporate taxes to territorial government	Total annual payroll and corporate taxes paid by Baffinland to the territorial government (Baffinland)

Baffinland

VSEC - Governance and Leadership

- No monitoring and/or indicators proposed, as no residual effects were identified in the FEIS

Concluding Remarks

Concluding Remarks

- 2015 monitoring report supports many FEIS predictions (for selected VSECs) and identifies a number of positive effects the Project has had. Various Project Certificate conditions were also reported on.
- LSA employment is one area where Project activities didn't fully match FEIS predictions in 2015. Baffinland anticipates returning to normal hiring practices once conditions improve.
- There were a number of Baffinland Inuit employee departures in 2015. Baffinland will continue to monitor employee turnover causes and outcomes, and the success of Baffinland Inuit employment programs.
- In some cases, additional data and monitoring will be necessary before FEIS predictions can be fully verified.
- 2015 monitoring report presents a draft socio-economic monitoring plan, describing proposed indicators and data sources for all VSECs assessed in the FEIS, and for information that has been requested through the Project Certificate. Baffinland anticipates working with the Mary River SEMWG in 2016 to finalize this plan.

Meeting Notes
Mary River Socio-Economic Monitoring Working Group (SEMWG) Meeting
February 2, 2017 (300pm – 445pm)
By Teleconference

Attendees:

Baffinland Iron Mines Corporation (Baffinland):
Mary Hatherly
Adam Grzegorczyk
Jason Prno (consultant)
Richard Cook (consultant)

Government of Nunavut (GN):
Lou Kamermans
Chantelle Masson
Erika Zell
Arielle Stockdale

Qikiqtani Inuit Association (QIA):
Rebecca Mearns
Shane Cameron (consultant)

Indigenous and Northern Affairs Canada (INAC)
David Abernethy
Rachel Theoret-Gosselin

Other Information:

Jason Prno facilitated the meeting. Richard Cook took meeting notes.

Meeting Notes:

1. **Introductions (All)**
2. **Update on the 2016 Socio-Economic Monitoring Report (Baffinland)**
    a. In preparation, to be submitted with NIRB Annual Report
    b. Similar in structure and content to 2015 report, which was a significant departure from previous reports. Now much more comprehensive, with additional indicators added.

This was done to bring the report better in line with EIS indicators and PC conditions. The report has been improved further for 2016.

c. 2015 report – Issued in draft to get feedback from the SEMWG, so we've taken that feedback and have incorporated it into the 2016 report.
d. A new addition to the 2016 report – Revamp of employee information survey. This will be an addition to the 2016 report.
e. Baffinland is considering the inclusion of a trends analysis in the 2016 report; similar to the NWT Communities and Diamonds report and more recently the Meadowbank monitoring report. Looking forward to obtaining SEMWG feedback on the approach, when people review the 2016 report.
f. Currently have most of the government data we need for the 2016 report, just waiting on company data for 2016.
g. Inuit employment was lower than Baffinland would like in 2016, and Inuit turnover was higher than they would like. Baffinland is taking active steps to address this. An Inuit HR Strategy and Inuit Procurement Strategy are in the final stages of preparation.
h. Baffinland will table the draft Inuit HR Strategy with QIA for discussion. It includes high level commitments which are intended to assist Baffinland/contractors in meeting or exceeding the MIEG. First goal is to strengthen stakeholder engagement and collaboration. Second goal is to strengthen data collection processes. Want to see employee skills and match that with upcoming needs, to be able to identify training initiatives required. Want to roll out a revamped Work Readiness Program, which will be run as a pilot in 2017 with the intention to deliver 2x/year in each community in subsequent years.
i. Want to improve recruitment, and develop a process to catch issues in first 8 weeks following site employment to identify and address employee concerns. A number of initiatives are being looked at with regards to youth fairs, scholarships, and developing programs for youth and women to gain experience/exposure on-site. What has been lacking is a process of monitoring and an evaluation framework. Some initiatives to discuss with QIA in the future include joint training for BCLOs/CLOs, HR career information tour, and an on-site apprenticeship program. New instructions to contractors are also envisioned (want to improve contractor reporting of Inuit employment), with incentive and penalty schemes attached. Baffinland is revising its onboarding and retention programs. Baffinland would like to create a mechanism to track employee concerns, including complaints/grievances. Voluntary employee survey is also being looked at.
j. Inuit HR Strategy is a companion piece to Inuit Procurement Strategy.
k. Company takes Inuit employment very seriously, and we acknowledge Baffinland has not met targets. Want to encourage Inuit employment but equally important is retention and advancement of Inuit through the workforce. Baffinland will be developing 3 to 5 year goals to address training, recruitment, advancement and retention.
l. RE: 2016 monitoring program data - Some data remains only available at the territorial level. Where data is lacking, Baffinland will continue to track issues through the QSEMC process and Baffinland's community engagement program.

Questions and comments on 2016 Socio-Economic Monitoring Report (All)

LK – Will we follow the same process as last year of circulating a draft to the SEMWG before the annual report?

JP - Won't be able to get a draft report out before annual report, because of when data becomes available. The purpose of the draft last year was to provide an opportunity to get comments on the new reporting format.

LK – It's a practice we advocate for. Meadowbank has provided early drafts, but has latency in their reporting. TMAC has provided us with a draft before. Maybe we can have communication with Baffinland before the annual report is submitted so we don't have to go through NIRB process with formal comments.

JP – That's what we were looking at, and part of why we wanted to have this call, because one face-to-face meeting a year makes continuity difficult. Perhaps more regular teleconferences with the SEMG would address this concern.

RM – We can be available more often for these types of calls.

JP – Richard is taking notes and we'll circulate them to the SEMWG.

DA – How will the trends analysis be different from what you are already doing?

JP – This is something we looking at for 2016, but wanted to talk to the group before moving too much farther ahead. We haven't done this before, but are considering analyzing trends before/after development and year over year. We're interested in a dashboard approach.

DA - Will this be presented in bar charts, etc.?

JP – To be determined. But, It would be nice to agree on common indicators so we can compare projects across the territory.

DA – We'll wait and see what you produce; we're looking forward to seeing what is done.

AG – We are still a young project and therefore have only ~2 years of operational data. So, we are just now getting to the point where we can do trends analyses. It will depend on available data and length of the dataset.

3. Obtain working group feedback on the new Baffinland Employee Information Survey

JP – Baffinland decided to revamp is survey to achieve PC condition requirements. A draft of the survey documents were distributed to the SEMWG members prior to this call. One PC condition specifically asked us to work with QSEMC in developing the survey, so this is why we asked this group (which is a subset of the QSEMC) for feedback. Baffinland will issue the survey to all new employees as part of the onboarding process. Survey will be voluntary. Inuit employees living within and outside of Nunavut will be asked to complete the survey, in addition to non-Inuit employees living in Nunavut. Wouldn't be administered to contractors. One of the PC conditions focuses on migration, and we have tailored our questions as such. We are hoping to generate initial data in Q1-2017 for the 2016 monitoring report. Afterward, survey results will be reported by calendar year. Hope to get information out for the 2016 report, but results may need to be presented at a later date if this is not possible. Feedback on the survey from the SEMWG is requested.

AS – We added a number of suggested questions on the survey. Does everyone have them with track changes?

JP – They were only issued to Baffinland.

AS – There were two subsets of questions we added. The first were questions on respondents' current housing situation. Overcrowding is a very important topic. For the people finding employment, what is their current situation, and will employment affect their housing situation? The majority of Nunavummiut live in public housing. With increased income, will different options be available to them? We want to take advantage of employment by bringing people out of public housing, if it is possible. If the survey is for incoming employees only, the data we collect may be more limited. Or is it for outgoing employees too?

JP – The survey is planned to be administered only during the onboarding of new employees.

AS – So it may be premature to ask about home ownership, since new employees might not know what employment will mean for their housing. So maybe asking questions on their current housing situation is sufficient.

LK – The PC condition states an annual survey will be conducted.

JP – Survey results would be reported annually for new hires. Baffinland really struggled with obtaining survey responses before when on-site HR staff tried to survey employees. They received lots of push back. We thought best way to get feedback year after year was by integrating the survey into the new employee onboarding process.

LK – Voluntary surveys are hard to do. But seeing changes over time will be difficult if you're surveying each employee only once.

JP – Good point. We can talk about this further. But the poor reception of survey last year is why we are proposing what we are now.

LK – Getting that information right away is critical, but it needs to be followed up on to see changes over time.

JP – Comparability diminishes if a given employee fills it out once, and then doesn't fill it out, for example, until 5 years later, or never fills it out again. So the GN would prefer to have survey administered voluntarily every year?

LK/AS – From housing perspective, it would be difficult to figure out impact of the project over time otherwise. I like the idea that the survey can be anonymous, but it could be useful to analyze cohorts (e.g. what is the housing situation for new employees vs. employees after 5 years, etc.?). The data is a lot less valuable when it is not collected annually.

AG – From the proponent's perspective it is our preference to collect this data, but we had a strong pushback from our employees when we last tried. We can't make people do the survey, so that's why we proposed the approach we did.

JP – There is another point that we want to discuss – There are a number of housing questions added by the GN that divert from the essence of the PC condition. We want a survey that is focused on what is required to be collected, is simple and easy to complete, and reduces barrier to having people complete it.

LK – We took the approach that we weren't necessarily limited to what was specified in the PC. NIRB doesn't always incorporate all comments made by reviewing parties into their PCs. We ultimately want to know if the projects provide a benefit. I don't think the questions we added change the direction of the survey. The GN can provide more information / comments on why the questions are needed, if you like? Or could Baffinland highlight those that are not applicable?

JP – We can send you our comments if you like. Did INAC or QIA have any comments on the survey?

RM – We've looked at the survey and share concerns with the GN re: only conducting the survey on new employees. Is there way to look at trends? We do have some comments/suggestions we can provide in writing. We also have an upcoming JMC meeting in Oakville. One thing on the agenda for some time has been the development of a workplace conditions survey. This would be done with current employees at Baffinland, as a requirement of the IIBA. We have been discussing with Baffinland a survey with employees or employment coordinators. Is there a way to integrate the workplace conditions survey with this survey? And could you use Inuit employment coordinators to get participation? It's not clear how the previous survey was rolled out and communicated – It's worth looking into. Getting respondents to fill out a survey can be difficult. It's important to explain why the survey is being conducted and how it will benefit things.

JP – I wasn't aware of this other survey; it's worth considering combining them both.

MH – It's on the agenda for the JMC for next week, so we can talk about it then?

RM – Yes, combining the surveys would be much better, if possible. We will send comments on re-wording questions or with follow up questions. Is there a need to include the employee's names on the survey? Or can they remain anonymous?
RC – Have other companies conducted such surveys?

LK – Meadowbank conducted a survey several years back, and found it very helpful. I will look into whether or not the Meadowbank survey is shareable.

DA – Re: survey question 9 on community location – Are you trying to see what community they would want to relocate to?

JP – Community employment location would be specific to BCLOs or Baffinland Iqaluit staff.

DA – Regarding the need to complete the survey annually, I agree with the GN's interpretation of the Project Certificate.

[Unrecorded comments]

RTG – My comments on survey were already brought up. Re: confidentiality - Make it clear their name is optional as it currently appears mandatory. We need to read up PC Condition No. 133 and what its actual intention was. You should find a way to monitor change of status. Could you survey 1-year, 3-year, and 5-year employees?

4. **Discuss Baffinland's plans for addressing the socio-economic impact assessment portion of the Phase 2 EIS.**

[RC provided an update on the status of the Phase 2 review and EIS]

JP – For the Phase 2 baseline, the goal is to draw on and reference the considerable amount of baseline work that has already been prepared for the Project. The intention is not to present an updated baseline report. Plenty of monitoring data has been generated since the FEIS. We want to focus on what we're already monitoring and what's already been determined to be important to monitor. For the impact assessment, we want to focus only on the residual effects assessed in the FEIS (largely leaving aside subjects of note and other topics and information). We will discuss and provide summary information on how each of the residual effects will or will not change due to the Phase 2 Proposal. If any of these effects are expected to change significantly, a more detailed effects assessment discussion will be provided.

LK – From reviewing the ERP, it was very hard to see what was being studied and what numbers we were working with, because the document was flipping between the FEIS and ERP addendum. Nailing down how we are going to refer to the project, as it now includes the southern rail line, will be important.

[RC – Defined the 4 stages of Phase 2]

EZ – When will the proposal go to NPC?

AG – In the next couple of days.

RTG – Have you discussed with NIRB if there would be a screening phase?

RC – Baffinland already has amended guidelines, so the best case is that they proceed right to review. But we don't know what NIRB will decide in terms of next steps.

AG - Yes, we will be meeting with NIRB next week.

5. Other Matters

LK – The GN is contemplating a territorial socio-economic monitoring workshop, an idea which was borne out of the Kitikmeot SEMC. Realizing we will likely have projects in each region soon, we don't currently get a full perspective of how the industry is affecting the territory. We would like to see aggregated territorial reports. The workshop would bring industry and other players together to discuss indicators, processes, and how to approach socio-economic monitoring in the near future. We also want regional Inuit organization attendance and input, so will send details to you shortly. If we're all on the same page, we will start into the planning, logistics, and development of materials. We were at one point thinking April would be the best time for the workshop, but the earliest now is May.

[Meeting adjourned at 4:45 pm]

APPENDIX D4

MRCG MEETING NOTES

Baffinland Iron Mines Corporation
Mary River Project

Mary River Community Group Meeting
- Meeting Notes -

Participants:

Enookie Inuarak (MRCG)
Joshua Arreak (MRCG)
Paniloo Sangoya (MRCG)
Timothy Aksarjuk (MRCG)
Jimmy Pitseolak (MRCG)
Joanna (MRCG)
Tom Paddon (Baffinland)
Joe Tigullaraq (Baffinland)
Jennifer St. Paul Butler (Baffinland)
Jason Prno (Jason Prno Consulting Services Ltd.)
Mike Setterington (EDI)
Peter Autut (QIA)

Date and Location:

May 11, 2016 (9:00 am)
Hotel Meeting Room, Pond Inlet, Nunavut

Notes:

- Were the students and women's representative notified of this meeting? I wasn't notified.
- I like how our sessions have been going. We need to work through the decisions we need to make. This won't be the last meeting. Even if Baffinland isn't here, you can inform QIA and we can meet. These meetings are just the beginning. There is more that needs to be done. The railroad is not set in stone and will need to be discussed. We are not here just to say 'no'. We're not necessarily completely traditional Inuit any more, but in some ways our culture cannot change. We can't live our old lifestyle any more, but our culture and food remain important. We need to get along and work closely together.
- We don't always know what to do in this group if we aren't delegated items in advance. We have met without Baffinland but we like it when Baffinland is in attendance.
- What's the plan for this summer? How many ships?
- Trans-shipment site #3 is not really an option for Pond Inlet, because we use that area.
- It would be interesting to see the end product of Mary River iron ore [steel]. Pictures, even.
- Will you submit to NIRB in September?
- We [the MRCG] would definitely like to meet more. This group can in turn inform the community about Mary River. I am very concerned about the additional 7.8 million tonnes per year. We've heard that Baffinland hasn't been able to keep up with its shipping and quotas [in 2015]. This summer may give us a better idea of what Baffinland can do.

- My concern is you have ‘June – March’ listed [on the shipping slide]. It should read ‘end of June to March’, like you say verbally. I would oppose the project if the other wording is used.
- When we become too divided in our community, communication becomes harder. Communication is the most important thing. When people are not informed they tend to get mad. We need to remain well-informed. Communication to me is the most important thing.
- This past summer the community would not be informed of issues at Milne Inlet and of ships not being loaded in time, and being backed up as a result. The Mary River Community Group should be informed about these types of issues and we can let the community know. We would like to be informed of any problems that develop.
- If you had VHF, you could inform us using that.
- Joe K. [Baffinland’s BCLO in Pond Inlet] could be used to share information with the Mary River Community Group when Baffinland is not in town.
- We like to see updates and hear of improvements in your activities.
- It’s difficult for us to report back to Baffinland on what we’ve discussed in previous meetings [where Baffinland was not present] because we no longer have a secretary.
- During our last meeting we discussed the project update, the Baffinland letter to NIRB, and the NIRB letter to INAC, and then we went on the radio to discuss these. There were a couple of responses from the community, but we didn’t answer anything. We let the community know we were only informing them.
- When we had the radio show, we were listening to the people’s comments on air. It sounded like people still didn’t understand Baffinland’s plans. It would be helpful for you to host a town hall meeting or radio show to inform the community of your plans. Some people still have no idea of what’s happening. When the weather is good, in June, when people are travelling and camping, is not a good time to host a meeting. July is better because people are trapped in the community. Mid-July would be best. Please meet with the HTO and Hamlet before September. People understand that Phase 2 is necessary for Baffinland, but don’t understand the details.

APPENDIX D5

POND INLET YOUTH COUNCIL MEETING NOTES

Baffinland Iron Mines Corporation
Mary River Project

Pond Inlet Youth Council Meeting
- Meeting Notes -

Participants:

Approximately 14 representatives of the Pond Inlet Youth Council
Tom Paddon (Baffinland)
Joe Tigullaraq (Baffinland)
Jennifer St. Paul Butler (Baffinland)
Jason Prno (Jason Prno Consulting Services Ltd.)
Mike Setterington (EDI)
Peter Autut (QIA)

Date and Location:

May 10, 2016 (7:00 – 9:30 pm)
Hotel Meeting Room, Pond Inlet, Nunavut

Other Information:

Baffinland provided an overview presentation of the Mary River Project and Phase 2 proposal, and showed a number of videos. Meeting participants were generally interested in learning more about Baffinland's current operations and plans for Phase 2, posed a number of questions to Baffinland, raised concerns, and made various suggestions.

Notes:

- What's a biologist?
- Is the caribou population going down?
- Is mining like recycling?
- How come when we burn plastic it doesn't turn into oil?
- Do the trucks go that slow? Or is that [video] in slow motion?
- When did they build that stuff in the video?
- Where did the equipment come from?
- Did you build the road too?
- Do they melt the rock?
- There's a job at the mine site where you just push a button and blast the rock apart?
- How do you pay for the trucks and equipment?
- Before you place the explosives, will you use a blueprint?
- What's the open pit going to look like after mining? So you're making a cliff?
- How many people are working at Mary River?
- It's like a community there?
- If you work 12 hours, when do you sleep?
- Is it really strict at the mine?

- Did you have to do calculating in your old human resources job at the mine?
- What's going to happen to the equipment and trucks when all the iron ore is gone?
- How much iron ore have you mined so far?
- Tonnes? What would a tonne look like in oranges?
- That's one person's job? To drive the truck?
- So the stockpile will stay there until the summer?
- If there's going to be a train, what would happen to the trucks?
- Are you planning to build the railway?
- How are the environmental impacts identified and how is the environmental assessment done?
- Re: monitoring. How long does it take to make sure there isn't any impact?
- Would you mind sharing the monitoring information with us?
- How do you get gas and fuel to the mine?
- After all the years of Inuit telling you there are animals along the shipping route, why do you continue to use the shipping route?
- Have you ever brought any iron ore products from Mary River back to Nunavut?
- Do you support and donate to WWF?
- Is the IIBA like the land claims agreement?
- A few years ago there was discussion on shipping; was that ever approved?
- Are you thinking of shipping in the winter time?
- Will you use ice breakers for shipping in the winter?
- You will be shipping in winter where people hunt seals?
- Did you hear in your workshops that you shouldn't ship in the winter time?
- You're damn right we're concerned [about shipping through ice].
- How many ships will you use?
- How many ships would you need in the open water season to make the project profitable?
- Are you going to create more thick [EIS] binders for Phase 2?
- I get stuck thinking about ships going through Milne Inlet in the winter. It kills my mind. People camp in the spring. People go fishing.
- You should only start ice breaking in June when the ice starts breaking up.
- But that will mean more shipping in the open water.
- Jimmy said it takes four hours to set up the bridge [that crosses the ship track in Nain].
- Do the bridges float?
- What if you get stuck [with your ice breaker]? Their ice [in Labrador] is thinner than here.
- Do you work with Smart Ice?
- There was a video we saw where the ice breaker got stuck. I'm really concerned.
- Are you thinking of shipping ore by plane? Or just by ship?
- What happens when a ship needs to pass by those bridges? Do they remove them?
- Do people die at mines? At Milne Inlet?
- What was the cause [of Baffinland's recent fatality]?
- Was the death investigated?
- Did the police come by plane?
- What solutions came from the investigation? What changes did you make?
- Was it an accident or murder?
- Will QIA do a 'yes' or 'no' poll in communities for the project?
- How many recommendations from NIRB do you listen to?
- Who pays for the bridge? How is the money made at the mine and by local companies?

- How much iron ore do you need to produce a ton of steel?
- I've been feeling hopeless with submitting proposals for funding for the youth council.
- What are you doing to support the families who have a husband or wife working at Mary River? They might not be able to hunt or provide for their family.
- The class you mentioned [work readiness]; is that an optional class?
- Could you offer community-based jobs to people in the community?
- It would be useful to have a local employee that people can come up to and ask questions, someone they know and can speak Inuktitut to.
- Someone younger than Joe K. [Baffinland's current BCLO in Pond Inlet] would be good, someone the youth know.
- Would you rather hire loner people at the mine?
- You don't sell cigarettes at the mine?
- Is there hazardous stuff at the mine?
- How did the Mary River Project begin? How was it discovered?
- How long does the fuel last? How big is your storage?
- So right now there is no money being made at Mary River? You're only spending it?
- What's going to happen to Mary River once the mining is done?
- Right now there are lots of potential buyers for iron ore in Europe?
- Is Mary River the only iron ore mine?
- What's so special about Mary River?
- Do you listen to the communities, or the government and QIA when you gather your information on wildlife?
- How much of what you submit to the government is accepted?
- I heard it was impossible to stay in the same ship's track?
- Is it dangerous to stand beside the ice breaker as it passes by?
- What is the steam/smoke coming out the side of the ship [in the video]?
- Would your ships have that?
- Would your ships go as slow as they are in the video?
- What if the bridge falls apart?
- How is the bridge connected?
- Was the bridge company in Labrador formed before the ice breakers started coming in?
- How does the company [that operates the ship track crossing bridges in Labrador] make money?
- Do they have one bridge or several [in Labrador]? If you had bridges here you would probably need to use many of them.
- The youth aren't informed in this community. The Hamlet doesn't inform us.
- I think bringing the youth to the mine site would be really helpful.

APPENDIX E

2016 PHOTO ESSAY

OPERATIONS AND SITES

Photo 1 - Mary River Mine Site Deposit 1 and Mine Haul Road, July 2016

Photo 2 - Prepping for blast at Deposit #1

Photo 3 - Mary River Mine Site Open Pit Bench, July 2016

Photo 4 - Loading Mary River Ore at Nuluujaak Pit, March 2016

Photo 5 - Milne Port Tote Road and ore hauler, April 2016

Photo 6 - Refueling ore carrier

Photo 7 - Haul Truck travelling the Tote Road

Photo 8 - Mary River Mine Site accommodations complex, crusher and maintenance yard, July 2016

Photo 9 - Mary River Exploration Camp and Waste Settling Ponds, July 2016

Photo 10 - Mary River Mine Site Landfill, July 2016

Photo 11 - Maintenance shop

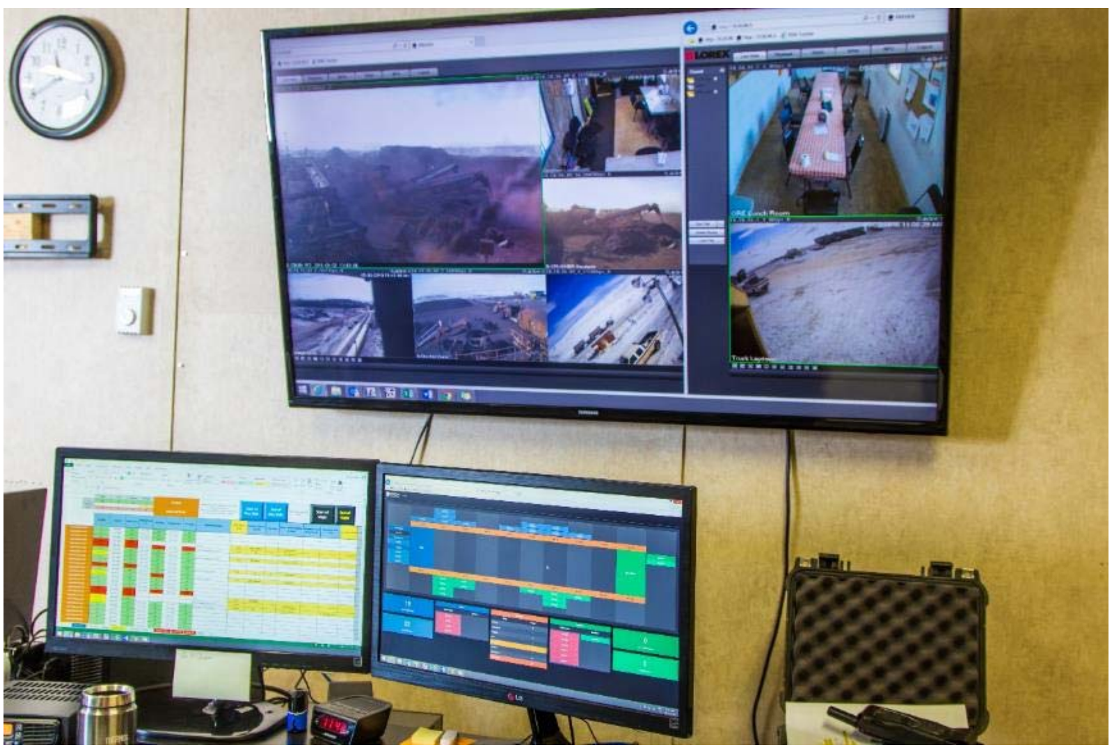


Photo 12 - Site Security Monitors Areas on site to ensure the safety of Baffinland Employees and Site Visitors

Photo 13 - Equipment simulation training area

Photo 14 - Milne Port infrastructure, September 2016

Photo 15 - Milne Port Ship loader and Ore Dock, August 2016

Photo 16 - Milne Port Ship loader conveyor and stockpile, 2016

Photo 17 - Aerial view of Milne Port Site and Ore Stockpile, July 2016

Photo 18 - Aerial view of Steensby Port before backhaul August 2016

Photo 19 - Aerial view of Steensby Port after Backhaul, August 2016

Photo 20 - Snow fence snow drift trial, March 2016

Photo 21 - Excavator armoring the Mine Haul Road embankment, May 2016

Photo 22 - Milne Port Tote Road Km 90 ditch and culvert repair and armoring, June 2016

Photo 23 - Siltation mitigation measures at the toe of the Crusher Pad, July 2016

Photo 24 - Mary River Mine Site Waste Rock Stockpile and Waste Rock Sedimentation Pond, July 2016

Photo 25 - Mary River Mine Site Crusher Pad Ore Stockpile and Engineered Drainage Ditch and Sedimentation Pond, July 2016

Photo 26 - Seacan Bridge removed at Km 62, November 2016

Photo 27 - Tires stacked inside a sea can using a forklift, numbered for easy tracking

Photo 28 - Location of seacan for tire disposal at the Mine Site (north of the incinerator building)

MONITORING AND TRAINING

Photo 29 - Observation platform on Bruce Head, North of Milne Port, August 2016

Photo 30 - Campsite on Bruce Head, North of Milne Port, August 2016

Photo 31 - 2016 Bruce Head Camp Study Team, September 2016

Photo 32 - Milne Port dust fall sampling station, September 2016

Photo 33 - Caribou height of land monitoring, 2016

Photo 34 - Deploying a hydrocarbon skimming unit during the marine spill response training July 2016

COMMUNITY ENGAGEMENT

Photo 35 - November community tour - Clyde River

Photo 36 - November community tour - Pond Inlet

Photo 37 - November community tour - Pond Inlet

Photo 38 - November community tour - Arctic Bay

Photo 39 - November community tour - Arctic Bay

Photo 40 - November community tour - Igloolik

Photo 41 - November community tour - Pond Inlet

Photo 42 - Phase 2 Workshop - Baffinland and their consultants worked with the communities of Pond Inlet and Arctic Bay to gain valuable traditional knowledge

Photo 43 - Phase 2 Workshop - Mapping seasonal movements by humans and caribou

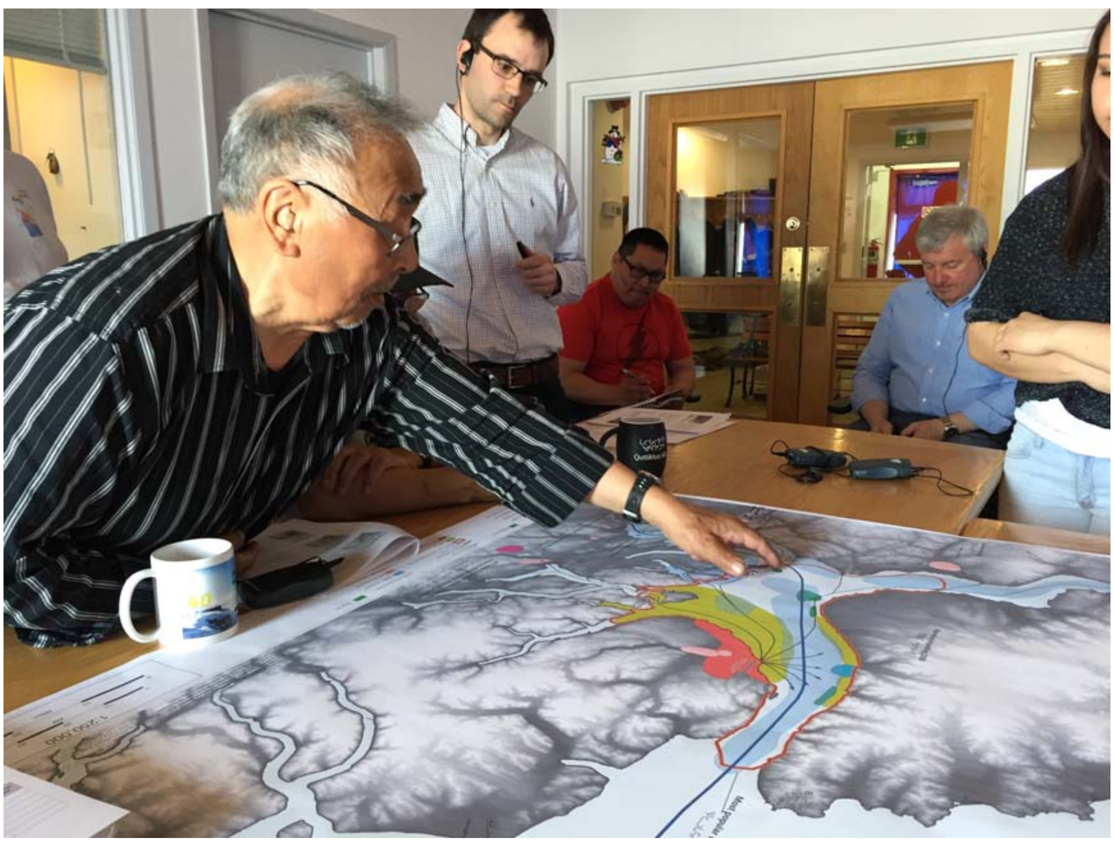


Photo 44 - Phase 2 Workshop - discussing shipping routes

Photo 45 - Phase 2 Workshop - Gathering input on shipping routes

APPENDIX F

UPDATED MANAGEMENT PLANS

Appendix F1	Environmental Protection Plan
Appendix F2	Aquatic Effects Monitoring Plan

APPENDIX F1

ENVIRONMENTAL PROTECTION PLAN

Baffinland Iron Mines Corporation

Environmental Protection Plan

BAF-PH1-830-P16-0008

Rev 1

Prepared By: Lea Willemse
Department: Environment
Title: Environmental Coordinator
Date: August 30, 2016
Signature: L. Willemse

Approved By: Jim Millard
Department: Environment
Title: Environmental Manager
Date: August 30, 2016
Signature: Allan Knight On behalf of Jim Millard

DOCUMENT REVISION RECORD

Issue Date MM/DD/YY	Revision	Prepared By	Approved By	Issue Purpose
07/15/14	0	AV	JM	Issued for Use (Supersedes Doc. No. H349000-1000-07-126-0001 rev. 1)
08/30/16	1	LW	JM	Issued for Use

0 CONTENTS AND REVISION CONTROL

The Environmental Protection Plan (EPP) is a living document and is subject to on-going updates. The Contents and Revision Control Operational Standard presented, herein, outlines the contents of the EPP and provides a Contents List with the most recent revision date for each Operational Environment Standard (OES). The Contents List will be updated and re-issued when any OES is revised or added.

SECTION 0			
0	Contents and Revision Control		
SECTION 1			
1.1	Purpose of the Environmental Protection Plan		
1.2	Organization of the Environmental Protection Plan		
1.3	Environmental Commitments		
1.4	Environmental Approvals		
1.5	Responsibilities		
SECTION 2	OPERATIONAL ENVIRONMENTAL STANDARDS	REV #	REVISION DATE
2.1	Cultural Heritage and Archaeological Resources	H	May 10, 2016
2.2	Avoiding Disturbance to Local Land Users	F	May 10, 2016
2.3	Land Disturbance	F	May 10, 2016
2.4	Water Use	G	May 10, 2016
2.5	Geotechnical Drilling Operations	F	July 15, 2014
2.6	Equipment Operations & Mobilization	F	May 10, 2016
2.7	Fuel Storage and Handling	G	May 10, 2016
2.8	Aircraft Flights	G	May 10, 2016
2.9	Sediment and Erosion Control	F	May 10, 2016
2.10	Polar Bear Encounters	F	May 10, 2016
2.11	Fox and Wolf Encounters	E	May 10, 2016

2.12	Caribou Protection Measures	F	May 10, 2016
2.13	Bird Protection Measures	G	May 10, 2016
2.14	Solid Waste Management	F	May 10, 2016
2.15	Wastewater Treatment	H	May 10, 2016
2.16	Hazardous Material and Hazardous Waste Management	F	May 10, 2016
2.17	Road Construction and Borrow Development	G	May 10, 2016
2.18	Tote Road Watercourse Crossing Installation	G	July 15, 2014
2.19	Road Traffic Management	G	May 10, 2016
2.20	Drilling, Blasting and Crushing	G	May 10, 2016
2.21	Exploration Drilling Operations	F	May 10, 2016
2.22	Water Sampling for On-Ice Drilling	D	July 15, 2014
2.23	Wildlife Log Instructions	C	May 10, 2016
2.24	Blasting in Water	C	July 15, 2014
2.25	Quarry and Barrow Pit Operation	C	July 15, 2014
2.26	Concrete Production	C	July 15, 2014
2.27	Excavations and Foundations	C	July 15, 2014
2.28	Air Quality, Noise and Vibration	C	May 10, 2016
2.29	Post-Construction Activities	C	May 10, 2016
2.30	Protection of the Marine Environment and Wildlife	C	May 10, 2016
2.31	Freshet Management	B	May 10, 2016
2.32	Compliance Inspections	B	May 10, 2016
2.33	Spill Control Measures and Reporting	B	May 10, 2016
SECTION 3			
3.0	Documentation Logs and Forms	D	July 15, 2014
3.1	Cultural Heritage Change Find Discovery Form	B	July 15, 2014
3.2	Human Use Log	B	July 15, 2014
3.3	Mary River Visitor Access Routes	A	February 12, 2015
3.4	Water Collection Log	A	July 15, 2014
3.5	Drill Inspection Forms	B	July 15, 2014
3.6	NT-NU Spill Report Form	A	July 15, 2014
3.7	Daily Tank Farm Inspection Checklist	A	July 15, 2014
3.8	Fuel Tank Dipping Form	A	July 15, 2014
3.9	Polar Bear Readiness Audit Form	A	May 10, 2016
3.10	Wildlife Log	C	July 15, 2014
3.11	Active Migratory Bird Nest Search Form	A	May 10, 2016
3.12	Off-site Waste Disposal Log	C	July 15, 2014
3.13	Wastewater Log	A	July 15, 2014
3.14	Watercourse Crossing Data Monitoring Form	A	July 15, 2014
3.15	Turbidity Monitoring Data Form	A	July 15, 2014
3.16	Environmental Inspection Forms	A	May 10, 2016
SECTION 4			
4.0	Request for Revision to an Operational Standard	C	July 15, 2014

TABLE OF CONTENTS

List of Appendix

1 INTRODUCTION

1.1 PURPOSE

The purpose of the Environment Protection Plan is to ensure that a high level of importance is placed on the protection of the environment by Project Personnel throughout the lifecycle of Baffinland Iron Mines Corporation's (Baffinland's) Mary River Project (Project). This document provides Operational Environmental Standards (OESs) to identify and address Project environmental issues and concerns and to provide guidance and control measures (which may be field fit as required), to avoid potential negative impacts to the environment and/or minimize or mitigated these impacts to the greatest extent practicable. The OESs are not comprehensive and are intended to be used in conjunction with relevant documents such as Environmental Management Plans (EMPs), Standard Operating Procedures, Environmental Permits, Licences, and Regulation, etc. The EPP will be updated as required to reflect current management reviews, incident investigations, regulatory changes, or other Project-related process modifications. The EPP is an integral part of the Project's Environmental Management System implemented for the Project to allow for the integration of environmental issues and regulations into the design/engineering and operation of the Project through the implementation and evolution of the OESs presented in this document.

The EPP provides a practical way to facilitate field implementation of environmental regulations, practices, and measures required to eliminate or reduce potential adverse environmental effects. It is a working document for use by Project Personnel, as well as at the Baffinland corporate level for ensuring commitments made in policy statements are implemented and monitored. The EPP provides a quick reference for Project Personnel to monitor for compliance and to make suggestions for improvements. This EPP provides the general protection measures for routine and unplanned activities associated with the Project. The EPP is developed in recognition of applicable permits, authorizations, approvals and Inuit Knowledge. As well, the plan provides operational measures that comply with aforementioned permits, approvals, etc., and provides reference to other associated and relevant documents such as Environmental Management Plans and Standard Operating Procedures.

The specific purposes of the EPP are as follows:

- Provide a reference document to ensure that commitments to minimize adverse environmental effects will be met.
- Document and identify environmental concerns and ensure appropriate protection measures are implemented.
- Provide concise guidance to Project Personnel regarding the implementation of appropriate standards for protecting the environment and minimizing adverse environmental effects.

- Provide a reference and training document for Project Personnel when planning and/or conducting specific activities and working in specific areas.
- Communicate changes in the program through the revision process.
- Provide a reference to related applicable documents such as legislative requirements, guidelines, permits, Environmental Management Plans, Standard Operating Procedures, etc.

The EPP provides documentation of environmental protection measures against which the environmental performance of Project Personnel can be readily measured and corrective actions developed and implemented where required. Project Personnel are expected to understand and implement the environmental protection measures provided within the EPP. If, at any time, Project Personnel do not understand or are unclear regarding how or when to implement an environmental protection measure the Environment Department must be contacted to obtain clarification.

1.2 ORGANIZATION OF THE ENVIRONMENTAL PROTECTION PLAN

The EPP provides directions to ensure Project Personnel understand and implement environmental protection standards for both routine activities and unplanned events associated with Project activities. The format of the EPP is intended to enable its practical use by Project Personnel, especially supervisors, in the workplace. Its function is a support document to impart an understanding by Project Personnel of Baffinland's approach to environmental protection planning and the specific requirements in various permits, approvals, authorizations, Environmental Management Plans, etc., issued for specific project components and activities.

Sustainable Development and Human Rights Policy

At Baffinland Iron Mines Corporation (Baffinland), we are committed to conducting all aspects of our business in accordance with the principles of sustainable development & corporate responsibility and always with the needs of future generations in mind. Baffinland conducts its business in accordance with the Universal Declaration of Human Rights and ArcelorMittal's Human Rights Policy which applies to all employees and affiliates globally.

Everything we do is underpinned by our responsibility to protect the environment, to operate safely and fiscally responsibly and with utmost respect for the cultural values and legal rights of Inuit. We expect each and every employee, contractor, and visitor to demonstrate courageous leadership in personally committing to this policy through their actions. The Sustainable Development and Human Rights Policy is communicated to the public, all employees and contractors and it will be reviewed and revised as necessary on a regular basis. These four pillars form the foundation of our corporate responsibility strategy:

1. Health and Safety
2. Environment
3. Upholding Human Rights of Stakeholders
4. Transparent Governance

1.0 HEALTH AND SAFETY

- We strive to achieve the safest workplace for our employees and contractors; free from occupational injury and illness, where everyone goes home safe everyday of their working life. Why? Because our people are our greatest asset. Nothing is as important as their health and safety. Our motto is "Safety First, Always".
- We report, manage and learn from injuries, illnesses and high potential incidents to foster a workplace culture focused on safety and the prevention of incidents.
- We foster and maintain a positive culture of shared responsibility based on participation, behaviour, awareness and promoting active courageous leadership. We allow our employees and contractors the right to stop any work if and when they see something that is not safe.

2.0 ENVIRONMENT

- Baffinland employs a balance of the best scientific and traditional Inuit knowledge to safeguard the environment.
- Baffinland applies the principles of pollution prevention, waste reduction and continuous improvement to minimize ecosystem impacts, and facilitate biodiversity conservation.

- We continuously seek to use energy, raw materials and natural resources more efficiently and effectively. We strive to develop more sustainable practices.
- Baffinland ensures that an effective closure strategy is in place at all stages of project development to ensure reclamation objectives are met.

3.0 UPHOLDING HUMAN RIGHTS OF STAKEHOLDERS

- We respect human rights, the dignity of others and the diversity in our workforce. Baffinland honours and respects the unique cultural values and traditions of Inuit.
- Baffinland does not tolerate discrimination against individuals on the basis of race, colour, gender, religion, political opinion, nationality or social origin, or harassment of individuals freely employed.
- Baffinland contributes to the social, cultural and economic development of sustainable communities in the North Baffin Region.
- We honour our commitments by being sensitive to local needs and priorities through engagement with local communities, governments, employees and the public. We work in active partnership to create a shared understanding of relevant social, economic and environmental issues, and take their views into consideration when making decisions.
- We expect our employees and contractors, as well as community members, to bring human rights concerns to our attention through our external grievance mechanism and internal human resources channels. Baffinland is committed to engaging with our communities of interest on our human rights impacts and to reporting on our performance.

4.0 TRANSPARENT GOVERNANCE

- Baffinland will take steps to understand, evaluate and manage risks on a continuing basis, including those that may impact the environment, employees, contractors, local communities, customers and shareholders.
- Baffinland endeavours to ensure that adequate resources are available and that systems are in place to implement risk-based management systems, including defined standards and objectives for continuous improvement.
- We measure and review performance with respect to our safety, health, environmental, socio-economic commitments and set annual targets and objectives.
- Baffinland conducts all activities in compliance with the highest applicable legal & regulatory requirements and internal standards.
- We strive to employ our shareholder's capital effectively and efficiently and demonstrate honesty and integrity by applying the highest standards of ethical conduct.

Brian Penney
Chief Executive Officer
February 2016

1.3 ENVIRONMENT APPROVALS

Table 1-1 provides a list of Baffinland's issued Environmental Approvals.

TABLE 1-1: ENVIRONMENTAL APPROVALS ISSUED TO BAFFINLAND

Permit ID	Licence Name	Status Update for 2015	Expiry
Nunavut Impact Review Board			
No. 005	Amended Project Certificate	All works and activities proposed have been screened by the NIRB and have been considered in the amended Project Certificate issued by the NIRB in May 2014. A NIRB Annual Report is submitted by March 31 of each year summarizes the status of the Project relative to the conditions outlined in the Project Certificate.	N/A
Nunavut Water Board Licences			
2AM-MRY1325 Amendment No. 1	Type A Water Licence	An application to amend the Type A Water Licence to account for activities approved for the Early Revenue Phase was submitted to the NWB on July 16, 2014. Final hearings took place in April, 2015 and was approved on July 31, 2015.	June 30, 2025
2BE-MRY1421	Type B Water Licence	In good standing; no amendments from previous year.	April 16, 2021
8BC-MRY1416	Type B Water Licence	The activities therein are now covered by the amended Type A. As such, the licence was cancelled by the NWB on February 25, 2016.	Cancelled
Crown Land Use Permits and Quarry Permits			
47H16-1-2	Foreshore Area for Milne Port Ore Dock Lease	In good standing; no changes from previous year. Will be renewed.	June 30, 2035
N2014Q0016	Tote Road and Borrow Area Land Use Permit	In good standing; no changes from previous year. Will be renewed.	June 30, 2016
N2014C0013	Steensby Camp Land Use Permit	In good standing, no changes from previous year. Will be renewed.	June 30, 2016
N2014J0011	Bruce Head Land Use Permit	In good standing, no changes from previous year. Will be renewed.	June 30, 2016
Authorizations under the Fisheries Act			

Permit ID	Licence Name	Status Update for 2015	Expiry
06-HCAA-CA7-0084	Crossings along the Milne Inlet Tote Road Authorization	The authorization remains valid and has been amended over the years. Monitoring and reporting to DFO occurs annually. Baffinland made a request to have the following sea can crossing; STA17 (CV 128), STA 62 (BG50) and STA 80 (CV 217) remain in place until no later than December 31, 2016. This request was approved by DFO on September 30, 2015.	December 31, 2016
NU-07-0050	Upgrades to Tote Road Crossings Letter of Advice	The construction summary report was provided in the 2014 Annual Report to NIRB.	N/A
14-HCAA-00525	Authorization	A monitoring report for the construction of the ore dock was submitted to DFO on January 4, 2016.	December 31, 2020
Approvals under the Navigable Waters Protection Act			
BG50, CV128, CV217, and CV223	Construction of Watercourse Crossings (Bridges and Culverts)	In good standing, no changes from previous year.	Until complete
4306-2-6- P/B	Occasional-Use Marine Facility	The Milne Inlet Marine Facility Security Plan was approved by Transport Canada on June 5, 2015.	June 30, 2018
Approvals under Nunavut Mine Health and Safety Act			
-	-	In good standing, no changes from previous year.	-
Licence under the Explosives Act			
F76068	Division 1 Factor Licence	Held by explosives contractor for the Project.	-
Leases under the Nunavut Land Claims Agreement			
Q13C301	Inuit Owned Land Commercial Lease	Compliance with the lease is outlined in the *2015 Annual Report to QIA and NWB*.	December 31, 2043

The terms and conditions of these approvals have been incorporated into the OESs provided in this document. Project Personnel are directed to the applicable approvals. Should discrepancies exist between the OES and approvals provided in Table 1-1, the approvals govern. Official copies of the approvals are maintained on site by the Baffinland Document Controller.

1.4 RESPONSIBILITIES

Vice-President of Sustainable Development

- Provide corporate resources and overall direction to the implementation of the EPP.

Environmental Manager

- Provide technical guidance and final review and approval of revised versions of EPP.
- Ensure EPP is properly communicated to departmental Site Managers and ensure adequate training is in place for all site Supervisors.

Environmental Superintendents and Coordinators

- Conduct a review and revision of the EPP on an as needed basis to determine if updates are required, or at the request of the Environmental Manager.
- Review revisions to the EPP.
- Ensure revisions are distributed to managers and supervisors.
- Perform document controls.
- Ensure that managers, supervisors and their staff are familiar with the EPP and its protection measures.
- Obtain approvals from management.

Site Managers (including Contractors)

- Implement the EPP in daily operations.
- Maintain a current copy of each relevant OES and the Contents and Revision Control List (Section 0).
- Provide training and support to ensure successful implementation of the EPP.
- Initiate changes to improve and update the plan as needed.

Site Personnel

- Familiarization with the relevant sections of the EPP.
- Have knowledge of reporting procedures.

Environmental Consultants

- Provide technical support to EPP development and ongoing revisions.
- Provide audits of EPP implementation, as requested by the VP Sustainable Development.

2 OPERATIONAL ENVIRONMENT STANDARDS

2.1 CULTURAL HERITAGE AND ARCHAEOLOGICAL RESOURCES

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.1	Cultural Heritage and Archaeological Resources	H	May 10, 2016

A number of cultural heritage and archaeological sites have been identified across the Project Area. The Environment Department will provide information regarding the location of these sites relative to potential work areas. The potential exists to encounter undiscovered cultural heritage or archaeological resources (Chance Finds) when conducting construction activities such as excavating and site clearing.

2.1.1 ENVIRONMENTAL CONCERN

The Mary River Project area has been occupied by humans for over 4,000 years. Archaeological sites are very common throughout the region, mostly consisting of stone structures that usually represent tent rings and shelters, caches, traps, hunting blinds, cairns and *inukshuks*. Stone tool making sites are also present. These types of archaeological sites and features are often difficult to recognize. All archaeological sites are valuable, non-renewable sources of information about local people's history and provide crucial data for scientists studying Northern ways of life throughout the past. It is against territorial law to disturb known or suspected archaeological sites, punishable by fine or imprisonment. Many areas of the Project have not been surveyed by a qualified archaeologist; therefore Project Personnel must obtain approval from the Environment Department before traveling off of existing roads or disturbing ground surfaces.

Milne Port, the Tote Road, and Mary River sites have been identified as having high overall archaeological potential. While surveys have been completed throughout project areas, they are ongoing. The locations of identified archeological finds have been provided to Baffinland.

2.1.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures will be implemented to minimize the potential for impacting an archaeological site:

- Project Personnel shall not deviate from already disturbed areas or established routes (existing roads and camp areas).
- Cultural resources discovered during project activities (Chance Finds) shall be reported to the Environment Department who will develop a course of action in consultation with the Project Archaeologist
- Upon a discovery, a Cultural Heritage Chance Find Discovery Report (Section 3.1) must be completed and submitted to the Environment Department.
- Human remains and funerary objects shall be treated with dignity and respect at all times, regardless of ethnic origins, cultural backgrounds or religious affiliations.

- Artifacts shall be left where they are found. If artifacts are disturbed or removed, their location shall be reported to the Environment Department
- Archaeological site locations shall be kept confidential to prevent unauthorized collection or disturbance of artifacts.
- Known sites near Project activities will be marked by stakes, flagging and/or yellow rope at approximately 30 metres away from each site.
- All Project Personnel shall avoid and remain more than 30 m away from all known or suspected archaeological sites, staying well away from any temporary protection measures such as flagging, stakes and/or yellow rope fencing.
- Existing inukshuks shall not be modified or disturbed. New inukshuks or rock piles shall not be constructed since building new rock piles may clutter the archaeological record and/or result in unknowingly using rocks from existing archaeology sites.
- Known archaeological sites shall be avoided by re-routing roads and establishing borrow excavations at locations approved for use by the Project Archaeologist. Sites that can't be avoided will be mitigated by the archaeology team prior to construction activities.
- If suspected archaeological or human remains (structures, artifacts or bones) are unearthed during work operations, stop work immediately and notify the Environment Department. The Environment Department will in turn contact the Project Archaeologist and the appropriate lands inspector and the Government of Nunavut, as required by law. The Project Archaeologist shall complete an archaeological review of all proposed Project Areas as they are finalized to identify areas with possible conflicts and areas where Project activities may proceed.

2.1.3 FORMS

- Baffinland EPP - Cultural Heritage Chance Find Discovery Report (Section 3.1)

2.1.4 RELATED DOCUMENTS

- Baffinland – Cultural Heritage Resource Protection Plan (BAP-PH1-830-P16-0006)

2.2 AVOIDING DISTURBANCE TO LOCAL LAND USERS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.2	Avoiding Disturbance to Local Land Users	F	May 10, 2016

2.2.1 ENVIRONMENTAL CONCERN

Land and resource use in the Project Area includes hunting, fishing, trapping and tourism. Potential impacts to existing land use will include the interruption of camping, hunting, tourism and marine activities in and around Milne Port, the Tote Road and Mary River. During open water, it is common for Pond Inlet residents to travel by boat to Milne Port. During fall, winter and spring, hunters travel to Project Areas to hunt seals on the sea ice and caribou inland. Baffinland is committed to minimize disturbance to land users to the extent possible.

2.2.2 ENVIRONMENTAL PROTECTION PROCEDURE

Measures will be implemented to minimize disturbance to existing land use patterns for the duration of the Project. These measures include:

- Advanced notification of shipping schedules to the community of Pond Inlet and to Nunavut Tourism. This will allow other land users (e.g. hunters, tourist operators) to re-schedule or modify travel plans, if preferred.
- Limit activities at Milne Port to the western portion of the beach near camp and do not operate equipment along the eastern half of the beach or off existing roads.
- Aircraft will fly in accordance with guidelines outlined in the Aircraft Flights Operational Environment Standard (Section 2.8).
- Road traffic will operate in accordance with guidelines outlined in the Road Traffic Management Operational Environment Standard (Section 2.19).
- Pilots and others will record the presence of other land users in the Human Use Log (Section 3.2) posted at each site, and will notify the Environment Department of any sightings.
- Land users are encouraged to record their presence using the Human Use Log (Section 3.2) posted at each Project Site.
- Any disruptions to land use will be documented so that this information can be considered in subsequent phases of project development.
- Baffinland has developed a Hunter and Visitor Site Access Procedure (BAF-PH1-830-PRO-0002), which provides safe access routes to and instructions upon arrival for Hunters and Visitors visiting Project sites.

2.2.3 FORMS

- Baffinland EPP - Human Use Log (Section 3.2)
- Baffinland EPP – Visitor Access Routes – Mary River and Milne Port (Section 3.3)

2.2.4 RELATED DOCUMENTS

- Baffinland EPP - Aircraft Flights (Section 2.8)
- Baffinland EPP – Road Traffic Management (Section 2.19)
- Baffinland Hunter and Visitor Site Access Procedure (BAF-PH1-830-PRO-0002)

2.3 LAND DISTURBANCE

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.3	Ground Disturbance	F	May 10, 2016

Ongoing development of Project areas require ground disturbances, including camp and road construction, quarrying and mobile vehicle operation.

2.3.1 ENVIRONMENTAL CONCERN

The Arctic is a fragile environment where the recovery of vegetation within this region is slow. Ground disturbance shall be minimized to protect archaeological resources, wildlife habitats, sensitive landforms, such as ice-rich permafrost features, and prevent erosion and the movement of sediment into watercourses and water bodies. Conditions provided in Baffinland's permits, licences and authorizations address ground disturbances and outline the necessary protection measures that are required to minimize impact to the environment.

2.3.2 ENVIRONMENTAL PROTECTION PROCEDURE

The following measures shall be implemented to minimize potential ground disturbances:

- Project Personnel and equipment shall remain on only existing roads and trails.
- Modifications to any design/engineering drawings must be approved by the Environment Department before any Work on the modification may be started.
- Rutting (furrow creation) shall be minimized on ground surfaces when possible.
- All camps and equipment storage areas shall be located on gravel, sand and/or other durable land.
- No materials shall be stored on the surface ice of streams.
- No material shall be removed from below the ordinary High Water Mark of any stream or water body.
- Greywater sumps must be located at distance of at least 31 metres above the ordinary High Water Mark of any water body.
- Equipment and supplies brought to Project sites shall be clean and free of soils that could contain plant seeds not naturally occurring in the area. Vehicle tires and treads in particular must be inspected prior to initial use in Project Areas.
- Prior to construction activities, a site drainage drawing must be submitted to the Environment Department for approval.
- The limits for all clearing, grubbing and topsoil overburden removal shall be identified on the "Issued for Construction" drawings and staked in the field prior to the commencement of any Work.
- Areas to be cleared shall have sediment and erosion control measures implemented prior to the initiation of any clearing activities. The sediment and erosion control measures shall be adapted

to suit the field conditions associated with the specific construction activities as construction proceeds.

- No debris or any other construction material shall be allowed to enter any water body.
- New equipment entering the site will be examined for invasive species.
- A Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005) will be completed for all non-approved land disturbances.

2.3.3 FORMS

- Baffinland - Incident Investigation Form (BAF-PH1-810-FOR-0005)

2.3.4 RELATED DOCUMENTS

- Baffinland EPP – Cultural Heritage and Archaeological Resources (Section 2.1)
- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- Baffinland EPP – Road Construction and Borrow Development (Section 2.17)
- Baffinland EPP – Quarry and Borrow Pit Management (Section 2.25)
- Baffinland EPP – Excavation and Foundations (Section 2.27)
- Baffinland – Roads Management Plan (BAF-PH1-830-P16-0023)
- Baffinland – Borrow Pit and Quarry Management Plan (BAF-PH1-830-P16-0004)

2.4 WATER USE

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.4	Water Use	G	May 10, 2016

2.4.1 ENVIRONMENTAL CONCERN

Water is an important resource that must be protected. The use of water by Baffinland for the Project is currently governed by the Type A Water Licence (2AM-MRY1325, Amendment No. 1) and Type B Water Licences (2BE-MRY1421) issued to the Company by the Nunavut Water Board (NWB). In addition to regulating water usage, Baffinland's water licences regulate many aspects of the Company's waste management practices, construction and operation activities, aquatic effects monitoring, emergency response planning and the abandonment, reclamation and closure of the Project.

This Operational Environment Standard highlights the key terms and conditions of Baffinland's water licences and other approvals governing water use.

2.4.2 ENVIRONMENTAL PROTECTION MEASURES

CAMP WATER SUPPLY

- Only approved water sources shall be used for Project activities.
- The Mary River Mine Site will obtain water from Camp Lake.
- The Milne Port Camp is approved to obtain water from Phillips Creek during the summer (open water) and km 32 lake or another approved source during the winter.
- Water supply facilities are to be maintained to the satisfaction of the AANDC Inspector.
- Total volumes of water withdrawn from any water body by Baffinland will be recorded and provided to the Environment Department upon request using the Water Collection Log (Section 3.4).
- Daily water usages volumes for Project Sites shall not exceed volumes outlined in Baffinland's Type A Water Licence (2AM-MRY1325, Amendment No. 1), as shown below in TABLE 2.4- 1

TABLE 2.4- 1: WATER USE FOR DOMESTIC AND INDUSTRIAL PURPOSES DURING THE CONSTRUCTION PHASE

Project Site	Maximum Daily Water Usage (m^3 per day)
Mine Site (Mary River)	657.5
Milne Port	68.5
Steensby Exploration Camp	435.8
Mid-Rail Exploration Camp	79.5

- Streams cannot be used as a water source unless authorized and approved by the Nunavut Water Board.
- If water is required from a source that may be drawn down (small lake or stream), Baffinland shall submit a request for approval to the Board 15 days prior to withdrawing the water.
- Work shall be performed in such a way as to ensure that materials such as sediment, fuel or any other hazardous material do not enter watercourses and waterbodies through the implementation of sediment control measures and proper hazardous materials management practices. In the event of a release to the environment, a spills contingency plan shall be implemented.
- All water intake hoses shall be equipped with a screen of an appropriate mesh size (as approved by the DFO) to ensure that fish are not entrained. Additionally, operators will ensure the water intake hoses withdraw water at such a rate that fish do not become impinged on the screen.
- Measures shall be provided to prevent and control erosion on banks of any body of water.
- Equipment shall not be washed in any watercourse or waterbody.
- No fuelling and/or servicing of equipment shall occur within 31 metres of any water body.

For water use associated with drilling programs, see Operational Environment Standards: Geotechnical Drilling Operations (Section 2.5) and Exploration Drilling Operations (Section 2.21).

2.4.3 FORMS

- Baffinland EPP – Water Collection Log (Section 3.4)

2.4.4 RELATED DOCUMENTS

- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- NWB - Type A Water Licence (2AM-MRY1325 Amendment No. 1)
- NWB - Type B Water Licence (2BE-MRY1421)
- Baffinland – Freshwater Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0026)

2.5 GEOTECHNICAL DRILLING OPERATIONS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.5	Geotechnical Drilling Operations	F	July 15, 2014

Geotechnical drilling may be required to obtain soil and rock samples necessary for engineering and designing the Project facilities and infrastructure.

2.5.1 ENVIRONMENTAL CONCERN

Environmental concerns associated with drilling include surface disturbances, drilling fluid and cutting disposal, impacts on dust, noise, water quality, and habitat encroachment. The use of water for drilling purposes is subject to the conditions outlined in Baffinland's Type B Water Licence (2BE-MRY1421).

2.5.2 ENVIRONMENTAL PROTECTION MEASURES

The following protection measures for geotechnical drilling management shall be implemented:

- Pre-Drilling Preparation and Acceptable Drill Locations:
  - A Pre-Drilling Inspection Report (see Section 3.5) shall be completed by the acting supervisor before drilling activities commence.
  - Additional geotechnical investigations shall be undertaken to identify sensitive landforms, modify engineering design for Project infrastructure, develop and implement preventative and/or mitigation and monitoring measures to minimize the impacts of the Project's activities and infrastructure on sensitive landforms.
  - Geotechnical drilling activities may be carried out within 31 m of the ordinary High Water Mark of waterbodies as long as the drilling location has been approved by the Nunavut Water Board. Please confirm all geotechnical drill locations with the Environment Department before drill mobilization.
  - Archaeology clearance shall be obtained from the Environmental Department for all geotechnical drill locations (see Section 2.1).
  - Conduct a wildlife inspection immediately prior to movement of the drill, involving aerial and ground survey of the new site. For details on drilling restrictions associated with wildlife interactions, see Operational Environment Standards: Polar Bear Encounters (Section 2.10), Fox and Wolf Encounters (Section 2.11), Caribou Protection Measures (Section 2.12) and Bird Protection Measures (Section 2.13).
  - Implement sediment and erosion control measures prior to drilling operations and maintain these during the operation to minimize transport of sediment into adjacent water bodies. Prior to the commencement of drilling for each hole, establish a dedicated sump location where collected "dirty" drill water and cuttings are to be disposed. The location shall be a minimum of 31 m from surface water bodies and located such that any flow toward a surface water body is minimized (sump shall be in a bowl, depression or be on a flat surface).

- Drill Operation and Movements:
  - Material shall not be stored on the surface of frozen streams or lakes, including immediate banks, except materials that are for immediate use.
  - All drill waste, including water, chips, muds and salts ($CaCl_2$) from land based drilling shall be disposed in a properly constructed sump or natural depression located at least 31 m above the High Water Mark of any water body.
  - All activities, including the overland transport of workers, shall be conducted in such a way to minimize ground disturbance.
  - All waste, such as food and packaging, shall be collected for disposal at the camp.
  - Feeding of all wildlife is prohibited.
  - Equipment or vehicles shall not be moved unless the ground surface is in a state capable of fully supporting the equipment or vehicles without rutting or gouging.
  - Daily inspections for fuel/hydraulic leaks, equipment condition, sediment and erosion control, and water intakes shall be conducted prior to commencing Work activities at the start and end of each work shift/day. All leaks shall be immediately repaired.
  - All drill rigs shall be equipped with spill kits in the event of leaks and spills. All operators should be trained in spill response and be familiar the use of spill kits.
  - In case the bottom of the permafrost is broken through by the drill, the depth of the bottom and location shall be reported immediately to the Environment Department who shall in turn report to the Nunavut Water Board.
  - Equipment shall not obstruct any stream.
  - Equipment storage holding areas will be located on gravel, sand or other durable land 31 m above the ordinary High Water Mark of any waterbody in order to minimize impacts on surface drainage and water quality.
  - Establish water quality conditions prior to and upon completion of any on-ice drilling program See Operational Environment Standard: Water Sampling for On-Ice Drilling (Section 2.22) for more details.
  - Contain and re-circulate drill water to the fullest extent possible in order to reduce water usage. Utilize silt fences and natural depressions to prevent water from running into nearby watercourses and water bodies.
  - Separate clean water from “dirty” water streams whenever possible, (by means of hose extensions and snow berms or other means that direct and keep discharge away from the immediate area of the drill hole) to prevent migration and expansion of a “dirty” water plume.
  - Work shall be performed in such a way as to ensure that materials such as sediment, fuel and/or any other hazardous material does not enter watercourses and waterbodies through the implementation of sediment control measures and proper hazardous materials management practices. In the event of a release to the environment, the approved Spills Contingency Plan shall be implemented.

- To maximize drill return water recirculation, casing is to be frozen into the ground to a depth of 3 to 6 m below grade. The specific depth of casing to be frozen into each hole and length of time to allow for freezing will be specified by the acting Supervisor.
- The drill water and cuttings spillage footprint shall be minimized through the use of berms, silt fences and/or other means of containment.
- Dispose of drill water into a properly constructed sump, or a naturally occurring contained depression. Drill water shall not be released directly to a nearby water course or to the ground.
- Use portable containment sumps (bins), for drill water and cuttings where containment in the ground is impractical. The bins shall not overflow and shall be dumped by means of helicopter or pump, to the location identified for disposal of dirty drill water and cuttings.
- Drilling waste must not be allowed to spread to the surrounding land or water bodies; the footprint of any spillage must be minimized to the greatest degree practicable.
- In case of an artesian flow occurrence, drill holes shall be immediately plugged and permanently sealed to prevent induced contamination of groundwater or salinization of surface waters. Report the artesian flow occurrence as soon as possible to the Environment Department who in turn will report the occurrence to the Nunavut Water Board.
- For on-ice drilling, returned water released must be nontoxic, and not result in an increase in Total Suspended Solids (TSS) in the immediate receiving water above the CCME guidelines for the protection of Fresh Water Aquatic Life (i.e., 10 mg/L for lakes with background levels under 100 mg/L or 10% for those above 100 mg/L).

- Drill Hole Abandonment:
  - Materials such as debris and/or drill cuttings shall not be left on the ice when there is potential for that material to enter a water body.
  - Restore, contour and stabilize constructed drill sumps, and other disturbed areas, to the pre-disturbed state immediately upon completion of drilling.
  - Return all combustible waste and petroleum products to camp for proper management and disposal.
  - Plug all drill holes upon completion, and where possible return drills cuttings at the surface to the drill hole at all land-based drilling locations.
  - Contour and stabilize all other disturbed areas upon completion of work and restore these areas to a pre-disturbed state.
  - Upon completion of a hole in rock, the casing will be removed. If the casing cannot be removed it will be cut off to be flush with surface and backfilled.
  - Remove all non-combustible garbage and debris from the land use area to an approved disposal site.
  - A Post-Drilling Inspection Report (see Section 3. – Drill Inspection Forms - Pre-Drilling, Daily and Post Drillings) will be filled out at the completion of each drill hole.

- Ensure a copy of all Pre-Drilling, Post-Drilling and Daily Drill Inspection Reports for all drill holes are submitted to the Environment Department at the completion of each drilling program.

2.5.3 FORMS

- Baffinland EPP – Drill Inspection Forms: Pre-Drilling, Daily and Post Drilling (Section 3.5)

2.5.4 RELATED DOCUMENTS

- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- Baffinland EPP - Polar Bear Encounters (Section 2.10)
- Baffinland EPP - Fox and Wolf Encounters (Section 2.11),
- Baffinland EPP - Caribou Protection Measures (Section 2.12)
- Baffinland EPP - Bird Protection Measures (Section 2.13)
- Baffinland EPP – Exploration Drilling Operations (Section 2.21)
- Baffinland EPP – Water Sampling for On-Ice Drilling (Section 2.22)
- Baffinland – Freshwater Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0010)
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- NWB - Type B Water Licence – 2BE-MRY1421
- Exploration Spill Contingency Plan (BAF-PH1-830-P16-0037)
- Emergency Response Plan (BAF-PH1-830-P16-0007)

2.6 EQUIPMENT OPERATION AND MOBILIZATION

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.6	Equipment Operations & Mobilization	F	May 10, 2016

2.6.1 ENVIRONMENTAL CONCERNS

Mobile equipment emits noise and air emissions, are potential sources of leaks and spills and can cause rutting and land disturbances, as well as disturbance of archaeological sites if necessary clearances have not been obtained.

Noise associated with equipment use and mobilization may negatively affect neighbours. Air emissions may have air quality implications. Accidental leaks or spills of fuel or other hazardous materials may affect soils, water quality, fish and fish habitat, and wildlife.

2.6.2 ENVIRONMENTAL PROTECTION MEASURES

- Damage to archaeology sites will be avoided by following the protection measures outlined in the Operational Environment Standard: Cultural Heritage and Archaeology Resources (Section 2.1).
- Rutting and land disturbance will be minimized by following the protection measures outlined in the Operational Environment Standard: Land Disturbance (Section 2.3).
- All equipment will be equipped with properly functioning mufflers.
- All spills involving equipment shall be reported to the Environment Department immediately and documented by submitting the necessary documentation within 12 hours of the spill using the Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005) and NT-NU Spill Report Form (Section 3.6). See Operational Environment Standard: Spill Control Measures and Reporting (Section 2.33) for more details on spill reporting.
- Daily pre-operation inspections will be made on all equipment using the Pre-Op Inspection Form. Pre-Op Inspection Forms should be given to the Maintenance Department at the end of day. If problems are identified the Maintenance Department should be notified and the equipment will be taken out of service and repaired.
- Equipment operators will be trained and licenced to operate their particular equipment; training will be provided for operators before operating any new equipment.
- Equipment and vehicles that will remain parked for extended periods of time or that are prone to leaks will have spill trays placed underneath them to contain any fluid leaks.

2.6.3 FORMS

- Baffinland – Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005)
- Baffinland – NT-NU Spill Report Form (Section 3.6)
- Baffinland – Pre-Op Inspection Form

2.6.4 RELATED DOCUMENTS

- Baffinland EPP – Cultural Heritage and Archaeological Resources (Section 2.1)
- Baffinland EPP – Land Disturbance (Section 2.3)
- Baffinland EPP – Spill Control Measures and Reporting (Section 2.33)
- Baffinland –Air Quality and Noise Abatement Management Plan (BAF-PH1-830-P16-0002)

2.7 FUEL STORAGE AND HANDLING

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.7	Fuel Storage and Handling	G	May 10, 2016

Permanent and temporary fuel storage facilities have been constructed at Project Sites. At Milne Port and the Mary River Mine Site, fuel is stored in bulk storage facilities consisting of steel fuel tanks and bladders located within lined containment berms. Small quantities of fuel are being stored in barrels and double walled ISO tanks within constructed containment berms at the Steensby and Mid-Rail Exploration Camps.

2.7.1 ENVIRONMENTAL CONCERNS

Accidental and uncontrolled leaks, releases and spills of fuel may occur due to improper storage, poor handling procedures or equipment malfunction. Fuel releases to the environment have the potential to negatively affect worker health and safety as well as soil quality, aquatic life and wildlife. The potential for fuel spills is addressed through the Company's Emergency Response and Spill Contingency Management Plans

2.7.2 ENVIRONMENTAL PROTECTION MEASURES

The following environmental protection measures shall be used for all storage and handling of fuels at the Project:

- Project personnel refuelling equipment or vehicles will supervise re-fuelling at all times and will not leave fuel transfer operations unattended.
- Avoiding ship-to-shore transfer of fuel during freeze-up or break-up periods.
- Undertake fuel transfer from vessels to shore under good weather conditions.
- Transfer of fuel to storage tanks or to vehicles shall be conducted by a fully-trained and qualified person.
- Exposed pipelines shall be protected from damage by vehicular collision through the installation of guard rails or barriers.
- Hoses and pipes used for fuel transfer shall be equipped with properly functioning and approved check valves that are spaced to prevent backflow of fuel in the case of failures.
- All spills shall be reported to the Environment Department immediately and documented by submitting the necessary documentation within 12 hours of the spill to using the Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005) and NT-NU Spill Report Form (Section 3.6). See Operational Environment Standard: Spill Control Measures and Reporting (Section 2.33) for more details on spill reporting.

- All fuel storage tanks will be inspected on a regular basis and will be in accordance with the requirements outlined in the Environmental Code of Practice for Aboveground Storage Tank Systems Containing Petroleum Products, issued by the Canadian Council of Ministers of the Environment.
- Daily inspections of the permanent fuel storage and dispensing facilities, located at Milne Port and the Mary River Mine Site, will be conducted by the Site Services Department using the Daily Tank Farm Inspection Checklist (Section 3.7).
- Fuel tanks at the permanent fuel storage and dispensing facilities, located at Milne Port and the Mary River Mine Site, will be dipped every 3 days by the Port & Logistics Department to confirm fuel levels and total fuel inventory using the Fuel Tank Dipping Form (Section 3.8).
- Fuel storage containers will be stored in secondary containment and shall not be placed within 31 m of ordinary High Water Mark of any water body.
- All mobile equipment will be serviced and fuelled on land at least 31 m above the ordinary High Water Mark of any water body No petroleum or chemical product will be allowed to spread to surrounding lands or into water bodies.
- All fuel containers shall be sealed and labelled with the name Baffinland Iron Mines Corporation.
- Waste oils, lubricants, and other used oil shall be placed in drums, labeled as waste materials, and stored in a contained area until removed from site for disposal at an approved, licenced waste management facility (Section 2.16 - Hazardous Material & Hazardous Waste Management).
- All fuel storage areas shall be inspected on a regular basis. See Operational Environment Standard: Compliance Inspections (Section 2.32). Examine all fuel storage containers in your work area for leaks at least once per day.
- Repair all leaks immediately.

2.7.3 FORMS

- Baffinland – Daily Fuel Tank Farm Inspection Checklist (Section 3.7)
- Baffinland – Fuel Tank Dipping Form (Section 3.8)
- Baffinland – Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005)
- Baffinland – NT-NU Spill Report (Section 3.6)

2.7.4 RELATED DOCUMENTS

- Baffinland EPP – Hazardous Material & Hazardous Waste Management (Section 2.16)
- Baffinland EPP – Spill Control Measures and Reporting (Section 2.33)
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- Baffinland – Emergency Response Plan (BAF-PH1-830-P16-0007)

- Baffinland – Spill Contingency Plan (BAF-PH1-830-P16-0036)
- Baffinland - Exploration Spill Contingency Plan (BAF-PH1-830-P16-0037)
- Baffinland – Milne Port Oil Pollution Emergency Plan (BAF-PH1-830-P16-0013)
- Baffinland – Bulk and Equipment Re-Fueling Procedure(BAF-PH1-350-PRO-0010)
- NWB – Type A Water Licence (2AM-MRY1325 Amendment No. 1)

2.8 AIRCRAFT FLIGHTS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.8	Aircraft Flights	G	May 10, 2016

The construction and operation phases of the Project involves air traffic consisting of flights made by helicopters, smaller twin-engine fixed wing aircraft and chartered flights by commercial jets. The high level of aircraft use requires pilots, and Project Personnel directing pilots, to be aware of the potential disturbances to wildlife and the requirements of the various permits and licences issued to Baffinland. Additionally, Inuit hunters may be moving through the Project Area at any time of the year, and Baffinland has committed to minimizing disturbance of local users to the extent possible. All Project Personnel are responsible for operating in accordance with the legal requirements and commitments outlined in this Operational Environment Standard. However, that being said, safety is the most critical aspect of aircraft operations and safety considerations supersede other concerns.

2.8.1 CONCERNS REGARDING WILDLIFE

Aircraft can cause disturbance to wildlife by interrupting their activities (i.e. feeding, calving, migration, etc.) and possibly causing the animals to leave an area and important habitats. Caribou, important to Inuit culture and diet, can be sensitive to aircraft noise. Disturbance of caribou has the greatest effect prior to, during and following calving (approximately mid-May to mid-July). Migratory birds are also disturbed by low-level overflights.

2.8.2 CONCERNS REGARDING INUIT LAND USE

Aircraft can disturb hunters or other land users (i.e. tourists) during low level flights that disturb the people and/or the wildlife they may be pursuing. Land users travel over land and ice from roughly November through late June/early July. August is particularly important for boats due to the short duration of open water. Land users may travel by boat and camp in Milne Inlet, and may travel inland hunting caribou by walking or using all-terrain vehicles. Remember that local land users were here first.

2.8.3 ENVIRONMENTAL PROTECTION MEASURES

- Minimize the number of flights to the extent possible.
- Subject to safety requirements, aircraft will maintain a cruising altitude of at least:
  - 650 m above ground level minimum, and;
  - 1,100 m vertical and 1,500 m horizontal from observed concentrations of migratory birds. If altitude is not possible, maintain a lateral distance of at least 1,500 m.
  - In July and August, either avoid travelling over, or use a minimum of 1,100 m vertical when travelling over the Snow Goose Area identified in Map 2


480000
505000
530000
555000
580000
605000
7920000
7895000
7870000
7845000
7820000
7795000
Milne Inlet Tote Road
Mary River Project
Angajurjualuk Lake
Proposed Rail Alignment
Nina Bang Lake
Erichsen Lake
Cockburn Lake
STEESNBY INLET
Steensby Port
LEGEND
Milne Tote Road
Potential Development Area
Environment Canada Area of Interest (Geese)
Environment Canada Area of Interest (Geese) 1500 m Buffer
The Mary River Project and the Snow Goose Area
NOTES
Updated PDA provided by Hatch (25 April 2013).
Snow goose area of interest (management area) provided by Environment Canada (2012).
Scale
0 5 10 20 30 40
Km
Map Scale: 1:800,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 UTM Zone 17N
Drawn: MP
Checked: MAS/DH
Date: 23/02/2016
MAP 2
Map Area
Mary River Project
Baffinland
EDI

- Ensure that certification of noise compliance is current, where compliance is applicable.
- Employees are responsible for reporting to the appropriate supervisor any improper flight practices.
- Avoid caribou calving sites between May 15 and July 15, as identified by Project biologists or observed by aircraft pilots.
- Pilots shall report to the Environment Department caribou movements and locations during calving and post-calving periods, so that these areas can be avoided.
- Avoid large concentrations of wildlife and take alternate routes.
- Plan routes that are likely to have least occurrences of wildlife.
- Hovering or circling may greatly increase disturbances and must be avoided when practical.
- Flights between Pond Inlet and Mary River will be routed so as to minimize interruption with community activities within the fiords between the site and the community.
- The Environment Department will inform pilots of wildlife sensitive area.
- For details on reporting wildlife sightings, refer to Operational Standard: Wildlife Log Instructions (Section 2.23)

2.8.4 EXCEPTIONS

- Low-level flights are required during slinging operations in the vicinity of the Mary River Mine Site Area and Steensby Camp, Milne Port and on occasion at other locations, or where short distances are involved.
- Low-level flights are permitted during wildlife surveys, as directed by the Project biologists in accordance with wildlife research permits.

2.8.5 FORMS

None

2.8.6 RELATED DOCUMENTS

- Baffinland EPP - Polar Bear Encounters (Section 2.10)
- Baffinland EPP - Fox and Wolf Encounters (Section 2.11)
- Baffinland EPP - Caribou Protection Measures (Section 2.12)
- Baffinland EPP - Bird Protection Measures (Section 2.13)
- Baffinland – Air Quality and Noise Abatement Management Plan (BAF-PH1-830-P16-0002)

2.9 SEDIMENT AND EROSION CONTROL

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.9	Sediment and Erosion Control	F	May 10, 2016

Land disturbances during road construction and operation, culvert installation and excavation of borrow locations and quarries have the potential to cause erosion and release sediment-laden runoff into nearby watercourses. Sediment and erosion control measures may include, but are not limited to, silt fencing, erosion control mats (fascines), sedimentation ponds, erosion blankets/geotextile lining, sand bags, terraces, benching, use of flocculants and riprap structures. Project Personnel are responsible for the implementation of erosion and sedimentation control measures prior to the initiation of construction activities and during ongoing mining Operations (i.e., clearing, grubbing, development of facilities, etc.) in each specific work area.

2.9.1 ENVIRONMENTAL CONCERN

The potential exists for the movement of soil (wind erosion), the unplanned release of sediment to watercourses/waterbodies and the slumping or change in landscape form associated with changes in the permafrost profile. Stormwater, which may include any surface runoff and flows resulting from precipitation, drainage or other sources, may contain suspended sediments, metals, petroleum hydrocarbons, and other substances. These materials may affect water clarity and, subsequently, aquatic life by reducing feeding success, fish egg and larval survival and fish habitat. Rapid runoff can degrade the quality of the receiving water by eroding stream beds and banks. Wind erosion is a key issue for the Project. The arid climate allows the wind to transport unprotected/disturbed soils from current locations. Improved road surfaces will increase potential runoff in downstream areas throughout the Project Area.

2.9.2 ENVIRONMENTAL PROTECTION MEASURES

As required, Project Personnel may be instructed to implement additional sediment and erosion control measures by the Project's Environment Department to ensure protection of the environment.

The following environmental protection procedures/measures will be taken to prevent or mitigate erosion and sediment-laden runoff impacts:

- The Surface Water and Aquatic Ecosystem Management Plan will be adopted to prevent and/or mitigate sediment loading into surface water within the Project Area.
- The size of the disturbed area and duration of soil exposure shall be limited as specified in the construction schedule and "Issued for Construction" drawings.
- Road embankments, watercourse crossing installations and borrow areas shall be constructed in accordance with approved plans and procedures.
- Temporary and permanent drainage installations shall be designed, constructed, and maintained to an appropriate standard.

- The topsoil/overburden stockpiles shall be contoured, where possible, with established drainage routes around the stockpiles, as specified by the Environment Department.
- Stream bank sections and slopes that contain loose or erodible materials shall be stabilized through the application of filter fabrics or geotextile in conjunction with riprap. Sediment control measures will be installed prior to watercourse crossing installations (Section 2.18 - Tote Road Watercourse Crossing Installation).
- Appropriate sediment and erosion control measures will include a combination of silt fences, silt (turbidity) curtains, sediment traps, settling ponds and gravel berms.
- Access and haul roads shall be constructed with gradients or surface treatment and drainage systems to limit the potential for run-off and erosion (Section 2.17 – Road Construction and Borrow Development).
- Borrow activities will be concentrated to the maximum extent possible to limit the area of disturbance.
- At borrow areas, drainage patterns will be re-established to near natural conditions.
- Turbidity monitoring will be conducted at watercourses by Environmental Monitors during and after construction activities when necessary.
- Project Personnel shall maintain, as required, all sediment and erosion control measures following rain or storm events to minimize further environmental damage. All repairs shall be undertaken under the direction and to the satisfaction of the Environment Department.

2.9.3 FORMS

None

2.9.4 RELATED DOCUMENTS

- Baffinland EPP – Road Construction and Borrow Development (Section 2.17)
- Baffinland EPP - Tote Road Watercourse Crossing Installation (Section 2.18)
- Baffinland - Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)

2.10 POLAR BEAR ENCOUNTERS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.10	Polar Bear Encounters	F	May 10, 2016

2.10.1 ENVIRONMENTAL CONCERN

Polar Bear encounters at the Mary River Project pose an immediate threat to life, health, safety, environment and property. Therefore, the Polar Bear Safety Plan (Plan) is to be used in conjunction with Baffinland's Emergency Response Plan (BAF-PH1-830-P16-0007) which provides the following guidance:

- Ensure the safety and well-being of personnel, the environment, and property
- Identify the types of emergencies that may occur and the procedures to respond, intervene, stop, or limit the emergency situation
- Ensure effective communication between personnel and the mine rescue team
- Ensure that personnel responding to emergencies are trained and have appropriate resources for the response

Polar bears are protected in Canada where they are legally hunted. Seasons, protected categories and quotas apply. The purpose of the Wildlife Act (statute of Nunavut) is to establish a comprehensive regime for the management of wildlife and habitat. The legislation provides that it is legal for anyone to attempt to deter, and if necessary destroy, a bear in defense of life or property. Any bear killed must be reported to the nearest conservation officer. It is an offense to allow the hide of a polar bear to spoil.

Site Personnel are required to comply with the requirements provided in the Polar Bear Protection Plan.

2.10.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures must be implemented to minimize the potential for bear-human encounters:

- Site and working areas will be kept clean of food scraps and garbage at all times. Effective waste management is paramount to reducing the likelihood of encounters.
- Do not attempt to chase, catch or follow polar bears under any circumstance.
- Polar bears that attempt to approach work sites or personnel must be actively deterred by shouting or use of noise makers such as bear bangers whenever possible.
- All polar bear sightings must be reported immediately to the Environmental Superintendent or his designate, regardless of the time of day.
- Bear monitors will be posted at coastal locations and will accompany remote field crews that do not have full-time air support.
- The Environmental Superintendent or his designate will authorize and coordinate the use of deterrent measures. A defence kill is to be used as an absolute last resort only when there is an imminent risk to human safety

- Helicopters may be used to haze/deter polar bears away from camps only under the authorization and direction of the Environmental Superintendent or his designate.
- Any defensive kills must be reported immediately to the Environmental Superintendent or his designate, who will notify the Qikiqtani Inuit Association (QIA), Hunters and Trappers Organization (HTO), wildlife officer and other stakeholders as required. The Inuit Impact Benefit Agreement (IIBA) outlines the protocol to be followed in the event of a defensive kill. The meat must not be allowed to spoil and the animal will need to be dressed immediately and the meat and pelt appropriately stored until transportation is available to the designated affected community, in accordance with the IIBA.
- Polar bear safety is a part of the Site Orientation Program.
- Please refer to the Polar Bear Safety Plan that has been developed for more information on mitigation measures and safety measures pertaining to polar bear encounters.
- Routine completion of a Polar Bear Readiness Audit to ensure that all Polar Bear incidents are documented and promptly reported to regulators and that all preparation and requirements regarding Polar Bear mortalities are in place.

2.10.3 FORMS

- Polar Bear Readiness Audit Form (Section 3.9)

2.10.4 RELATED DOCUMENTS

- Baffinland - Polar Bear Safety Plan (BAF-PH1-830-P16-0041)
- Inuit Impact Benefit Agreement
- QIA Directive 2013-1-17-2
- Polar Bear Readiness Procedure and Audit (Appendix A)

2.11 FOX AND WOLF ENCOUNTERS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.11	Fox and Wolf Encounters	E	May 10, 2016

2.11.1 ENVIRONMENTAL CONCERN

Foxes and wolves can become habituated to sites where they can access food and food waste. This situation can arise from intentional feeding by Project Personnel or improper waste management practices. Once such food conditioning has occurred, these animals lose their fear of humans and may approach Project Personnel in an aggressive fashion. Rabies is usually endemic in fox populations. Habituated foxes that act aggressively need to be dealt with immediately.

2.11.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures will be implemented to minimize potential impacts to foxes and wolves and the associated risk to the health and safety of Project Personnel:

- Site and working areas will be kept clean of food scraps and garbage. All waste will be disposed of in accordance with the Baffinland Waste Management Plan (BAF-PH1-830-P16-0028).
- Wildlife will not be intentionally fed under any circumstances. The consequences of such actions will lead to major disciplinary action.
- Solid carnivore proof skirting shall be installed on all kitchen and accommodation buildings to prevent foxes from venturing under buildings.
- Fox and wolf sightings should be recorded in the Wildlife Log (see Section 3.2) at camp. Wolf sightings should be reported to the Environment Department immediately.
- Wildlife attempting to approach personnel will be deterred by shouting, chasing and using noise makers, such as bear bangers. Should those deterrents not work, the site Environmental and Health & Safety Supervisors will be notified immediately for their assessment. Typically, wolves can be readily deterred by the above methods. Based on site experience, foxes are less responsive to deterrence. Due to the high incidence of rabies in foxes on Baffin Island, foxes that exhibit aggressive behaviour to humans, regardless of deterrence measures, are presumed to be rabid. The Environmental and Health & Safety Supervisors will assess the situation and make the recommendation for or against dispatching a likely rabid fox by lethal shot.
- In the rare situation where a lethal shot is necessary, approval to proceed will be provided by the Environment Supervisor for the location. Only personnel authorized and trained in the use of firearms will be used. This task will be executed so that Project Personnel, equipment and infrastructure are not endangered. If rabies is suspected, a body shot will be taken, and the carcass will be handled to avoid direct physical contact. The carcass will be incinerated immediately, and the Conservation Officer in Pond Inlet will be notified.

- Fox and wolf interactions with Project activities will be documented and included in the Wildlife Logs (see Section 3.2) and annual reports.
- No drilling activity should take place within 2 km of an active wolf den between mid-May and mid-August if direct line of sight and disturbance is noted. Contact on-site Environment staff to determine if a den is in the vicinity of operations.
- Qualified biologists will survey for carnivore (wolf and fox) dens, and an avoidance zone will be identified in consultation with the Project biologist. Den locations will be identified and Project Personnel advised accordingly. All Project personnel will adhere to wildlife and den avoidance guidelines during the denning season.

2.11.3 FORMS

- Baffinland EPP – Wildlife Log (Section 3.10)

2.11.4 RELATED DOCUMENTS

- Baffinland EPP – Wildlife Log Instructions (Section 2.23)
- Baffinland – Terrestrial Environment Mitigation and Monitoring (BAF-PH1-830-P16-0027)
- Baffinland - Waste Management Plan (BAF-PH1-830-P16-0028)

2.12 CARIBOU PROTECTION MEASURES

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.12	Caribou Protection Measures	F	May 10, 2016

2.12.1 ENVIRONMENTAL CONCERN

Caribou are currently present in relatively low numbers in the Project Area, but their numbers and encounter rates are expected to increase through the life of the Project. Caribou harvesting is important to local communities, so there is added importance to ensuring that the Project operates with minimal potential effects on caribou. The potential effects on caribou include those from disturbance, primarily due to noise and other sensory disturbances from project activities. The primary mitigation for caribou is avoidance followed by monitoring.

A Zone of Influence (ZOI) of 3 km from project activities has been defined for stationary activities such as camps, mining and drilling during the pre- to post-calving time period of May 15 to July 15. At other times of the year the caribou are less sensitive and a ZOI of less than 3 km is likely.

2.12.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures will be implemented to minimize disturbance to caribou:

- Employees that are not Nunavut Land Claim beneficiaries will not be permitted to hunt or fish on any land accessed from the Project. All personnel shall return home between shift rotations and shall not be permitted to stay in the area to hunt or fish as part of their shift rotations.
- Mobile equipment and vehicles shall yield the right-of-way to wildlife.
- Traffic is to slow down and keep distance from the animals as much as possible. If necessary, traffic will stop to enable crossings of groups or to allow groups of caribou paralleling the road to move into adjacent habitat. Caribou occurrence in the vicinity of the road and their responses to traffic will be monitored by on the ground behavioral observations, to determine if it is apparent that caribou are being disturbed or displaced by construction or traffic. Specific guidance is provided in the Caribou Encounter Decision Tree located in Appendix B.
- All caribou sightings will be reported to the Environment Department and they will keep geo-referenced records of caribou sightings. This will enable Project biologists to monitor caribou activity in relation to the Project.
- Active caribou calving sites (as identified by Project biologists or observed by aircraft pilots) will be avoided between May 15 and July 15, and where possible, there will be no increase in mine construction or operational activity within 3 km of the calving sites during this time period.

- If any females (one or more) are observed within 3 km of a planned project activity such as drilling or road construction from May 15 through to July 15, then the activity location will either be moved or the activity deferred as appropriate and if possible, until a later date when caribou are not present.
- Should a female caribou or a female with calves approach within 3 km of project activities (between May 15 and July 15), the animals will be observed on the ground. If it is obvious they are being disturbed, the activity will cease until they have moved at least 3 km away.
- If caribou approach a project activity site before work commences, the Environment Department shall be notified immediately and will determine the necessary measures that need to be taken to protect caribou activity.
- If caribou approach a project site while work is in progress, caribou will be observed for signs of disturbance.
- If the caribou are disturbed, the activity will be modified or cease until the caribou have moved away or they are guided away from the worksite.
- If caribou are observed within 3 km of a proposed new drill site and disturbance is noted, the drill should be moved to an alternative location and activity at the site deferred until after the caribou leave the area. If the drill is already in place and operating, and caribou move into the area, the animals should be monitored by the Project biologist or on-site Environmental personnel. If the caribou show no obvious signs of disturbance, drilling activities can continue. If the animals appear agitated, then activities must cease until the caribou leave.
- A wildlife monitor will be periodically present on site during the calving season to detect calving activities near the Tote Road, monitor cow/calf behavior in relation to traffic, designate a temporary no-stopping zone, guide traffic and document measures taken to reduce sensory disturbance to calving caribou.
- Monitoring and Mitigation measures will be implemented at points where the railway, roads, trails a flight paths pass through caribou calving areas, particularly during caribou calving times.
- Protocols will be implemented for documentation and reporting of all caribou collisions and mortalities as well as mechanisms for adaptive management responses designed to prevent further interactions.

2.12.3 FORMS

- Baffinland EPP – Wildlife Log (Section 3.10)

2.12.4 RELATED DOCUMENTS

- Baffinland –Terrestrial Environment Mitigation and Monitoring Plan (BAF-PH1-830-P16-0027)
- Baffinland - Caribou Encounter Decision Tree (Appendix B)

- Baffinland - Hunting and Fishing (Harvesting) Policy – On or Near Baffinland Leased Lands (BAF-PH1-820-POL-0001)

2.13 BIRD PROTECTION MEASURES

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.13	Bird Protection Measures	G	May 10, 2016

2.13.1 ENVIRONMENTAL CONCERN

Birds are generally widespread and often encountered in the Baffin region. Virtually all of these birds are migratory. The main concern with birds is that, the potential exists that some aspects of the project may disrupt nesting and migratory patterns. Birds are an important part of the food chain in the Arctic ecosystem and changes in their numbers and distribution will directly affect predators like raptors and foxes that rely on them as a readily available source of food. It is against the law to disturb or destroy an active migratory bird's nest (Migratory Bird Convention Act and regulations).

2.13.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures will be implemented to minimize disturbance to birds and bird nests:

- Project Personnel are not permitted to hunt birds.
- Inspections of each work area for nests will be conducted prior to commencement of project activity.
- On-ground inspections will be conducted for bird nest and eggs of each area prior to equipment placement or project activity. Active nest sites will be identified through observation of high densities of birds, nests, or birds exhibiting territorial behaviour indicating a nearby nest. Active nests must not be destroyed or disturbed.
- The inspections will be conducted based on method described in Appendix C of the EPP - Mary River Active Migratory Bird Surveys Protocol.
- Select new equipment placement location, at least 500 m from identified active nest sites, or as otherwise identified in the Mary River Terrestrial Environment Mitigation and Monitoring Plan.
- Precaution will be taken to avoid disrupting nest sites, if these are discovered.
- Songbirds, shorebirds, loons and waterfowl — If nests of these birds are found then drills, pumps and waterlines should be placed at least 500 metres from these nest sites and precaution should be taken to avoid disrupting them.
- Shoreline and waterline routes will be inspected for breeding birds, nests, and post-hatch young, before waterlines for drills are placed. Project Personnel should remain more than 100 m from these nest sites at all times and time spent on the hose alignment should be minimized to reduce disturbances in areas between water source and project activities.
- Active raptor (falcons, hawks and owls) nests will be avoided by relocation of project activities, if possible. Where possible or practical, Project activities will be relocated at least 500 m from

known active raptor nests during the breeding season, or the activity will be rescheduled to outside the breeding season (mid-April to mid-August). An individual nest protection plan will be produced by an avian biologist to direct activities within 500 m, or other appropriate distance, of the nest if it is not possible to relocate or delay the project activities.

- Bird sightings, particularly raptors or large concentrations of birds, should be recorded in the Wildlife Log (Section 3.10) at camp and reported to project biologists.
- If Species at Risk or their nests and eggs are encountered during Project activities, the primary mitigation will be avoidance. Project personnel shall establish clear zones of avoidance on the basis of the species-specific nest setback distances outlined in the Terrestrial Environment Mitigation and Monitoring Plan.
- Guy-wire deterrents will be used on communication towers established for the Project. Consideration will be given to reducing lighting when possible in areas where it may serve as an attractant to birds or other wildlife.
- Inspections of each work area for nests will be conducted prior to commencement of Project activity during the nesting season. Any nests found (or indicated nests) will be protected with a buffer zone determined by the setback distances outlined in the Terrestrial Environment Mitigation and Monitoring Plan until the young have fledged. If it is determined that observance of these setbacks is not feasible, nest-specific guidelines and procedures shall be developed to ensure the nests and their young are protected.
- Drills, pumps and waterlines should be placed at least 500 m from active bird nests and every precaution should be taken to avoid disrupting the nests. All Project Personnel must avoid active nest sites. Time spent on the hose alignment should be minimized to reduce disturbances in areas between the water source and Project activities. Active nests must not be destroyed.
- No drilling activity should take place within 500 m of an active raptor nest site during the breeding season (approximately mid-May to August); unless an individual nest protection plan has been prepared by an avian biologist in conjunction with the Baffinland Environment Department. Report all active nest sites to the Environmental Department.
- Whenever practical and not causing a human safety issue, a stop work policy shall be implemented when wildlife in the area may be endangered (at risk of immediate injury or death) by work being conducted.

2.13.3 FORMS

- Baffinland EPP – Wildlife Log (Section 3.10)
- Baffinland – Active Migratory Bird Nest Search Form (Section 3.11)

2.13.4 RELATED DOCUMENTS

- Baffinland –Terrestrial Environment Mitigation and Monitoring Plan (BAF-PH1-830-P16-0027)

- Baffinland - Active Migratory Bird Surveys Protocol (Appendix C)

2.14 SOLID WASTE MANAGEMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.14	Solid Waste Management	F	May 10, 2016

2.14.1 ENVIRONMENTAL CONCERN

Solid wastes are non-liquid, non-soluble materials including domestic garbage, food wastes, construction debris, commercial refuse, non-combustible and non-hazardous materials. Solid waste materials at site will be re-used and recycled wherever possible and feasible. Where it is not possible or feasible, the two main methods of solid waste treatment and/or disposal for the Project lifecycle will be incineration and landfilling. Solid waste, if not properly disposed of, may cause health and safety concerns to Project Personnel, attract wildlife, and could impair the aesthetics of the Project Areas. If unapproved wastes (i.e. hazardous or organic wastes) are placed in the landfill, poor quality landfill leachate may be generated and potentially affect nearby watercourses. This could also lead to attracting wildlife and increase wildlife interactions.

2.14.2 INCINERATION

Domestic wastes, including, that cannot feasibly be re-used or recycled, is incinerated at Project Sites. Combustible non-hazardous wastes (i.e., food scraps, oily rags, paper and small plastics, etc.) generated at Project sites is incinerated to minimize the negative impacts of attraction vectors to wildlife. Incinerator ash generated is analyzed and placed in the Mine Site Landfill after ensuring the ash meets regulatory requirements[1]. Waste oil and waste fuel may be burned when possible in the incinerator as a secondary source of fuel.

2.14.3 OPEN BURNING

Untreated, clean wood waste products including lumber, timber, and pallets as well as paper and cardboard packaging that cannot feasibly be re-used or recycled will be burned onsite at approved open-burn locations at Milne Port and Mary River. Any treated and/or painted waste wood products, including plywood or particle board, is not permitted for opening burning. Open burning shall strictly be operated in an open top sea container at an approved open-burning location as per the requirements provided in Baffinland's Open Burning of Untreated Wood, Cardboard and Paper Products Procedure (BAF-PH1-300-PRO-0001). Ash generated from open-burning will be analyzed and placed in the Mine Site Landfill after ensuring the ash meets regulatory requirements.

[1] Outlined in the Environmental Guidelines for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities provided by the Department of Environment of the Government of Nunavut.

2.14.4 INERT WASTE LANDFILL

Inert waste generated by Project activities will be disposed of as per the requirements provided in Baffinland's Landfill Maintenance and Operation Manual (BAF-PH1-320-0004). The Mary River Landfill Facility's used for disposal of inert, non-hazardous, bulky waste with little to no salvage value. This includes scrap metal, ash, rubber, concrete, plastics, and treated wood (including manufactured wood such as particle board and plywood). Landfill disposal of organic and hazardous wastes is prohibited.

2.14.5 ENVIRONMENTAL PROTECTION MEASURES

- Solid waste generated onsite will be segregated following Baffinland's Waste Management Plan (BAF-PH1-830-P16-0028). Waste streams generated at Project Sites are brought for incineration, disposed of at the Mary River Landfill Facility, approved open-burn locations, or backhauled offsite for proper disposal at a licenced waste facility (Section 2.16 – Hazardous Material and Hazardous Waste Management). Inert wastes such as scrap metal, discarded machinery parts, kegs, concrete, building materials, wood, rubber, and bulky plastics will be landfilled.
- Food wastes, packaging and paper will be incinerated on site. Kitchen grease will be shipped south for disposal.
- Untreated, clean wood waste products including lumber, timber, and pallets as well as paper and cardboard packaging that cannot feasibly be re-used or recycled will be burned onsite at an approved open-burn location at either Milne Port or the Mary River Mine Site.
- All wildlife attracting waste (i.e., food scraps, human waste) will be stored in sealed animal proof containers and incinerated as soon as practicable.
- All waste backhauled offsite will be manifested using the Off-Site Waste Disposal Log (Section 3.12) for tracking purposes (Section 2.16 – Hazardous Material and Hazardous Waste Management)
- Sewage sludge generated at the sewage treatment plants will be dewatered and incinerated onsite.
- Waste accumulated on site prior to disposal will be confined so that it does not pose health or environmental hazards.
- Time lapse between collection and disposal shall be minimized to the extent practical.
- All combustible waste and debris will be stored and covered until disposal.
- Additional training will be provided to the kitchen and accommodations staff on sorting camp domestic wastes.
- All Project Personnel are responsible for daily clean-up of the area in which their work activities are being conducted

2.14.6 FORMS

Baffinland EPP - Offsite Waste Disposal Log (Section 3.12)

2.14.7 RELATED DOCUMENTS

- Baffinland EPP – Hazardous Material and Hazardous Waste Management (Section 2.16)
- Baffinland – Waste Management Plan (BAF-PH1-830-P16-0028)
- Baffinland – Environmental Standard – Waste Sorting Guidelines (BAF-PH1-830-P25-0001)
- Baffinland - Open Burning of Untreated Wood, Cardboard and Paper Products Procedure (BAF-PH1-300-PRO-0001)
- GN - Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities

2.15 WASTEWATER TREATMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.15	Sewage Treatment	H	May 10, 2016

2.15.1 ENVIRONMENTAL CONCERN

Wastewater, such as sewage, grey water, and oily (contaminated) water will be generated throughout the lifecycle of the Project.

The quantity of treated effluent discharged from the Project Waste Water Treatment Plants (WWTP) and Oily Water Treatments Systems (OWTS) will be monitored and recorded using inline flow monitors. To fulfill the requirements of Baffinland's Type A Water Licence (as amended), routine water quality sampling of treatment effluent is completed at Project WWTPs by an accredited laboratory to confirm that effluent quality meets applicable discharge criteria and is acceptable for release into the receiving environment. Similarly, treated effluent from the Project's Oily Water Treatment Systems is adequately monitored when in operation using an accredited laboratory and by Baffinland's internal environment laboratory.

Uncontrolled or untreated releases of wastewater to the environment may impact drinking water, aquatic resources, wildlife and human health and should be reported immediately to the Environment Department (see Section 2.33 - Spill Control Measures and Reporting).

2.15.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures will be implemented to minimize the potential for accidental releases of wastewater on site:

- Operation of Project WWTPs and OWTSs is conducted in accordance with Baffinland's Type A Licence, in conjunction with Baffinland's Freshwater Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0010).
- Raw wastewater and final effluent quality will be sampled and tested according to the requirements of Baffinland's Type A Water Licence.
- All issues and/or concerns with Project WWTPs or OWTSs (i.e., improper operation, pipeline rupture, system breakdown, etc.), must be reported immediately to the Site Services and Environment Department.
- In the event of an accidental release of wastewater into the environment (i.e., pipeline rupture, etc.), immediate action is required to ensure that the release is contained and prevented from reaching any water body. Refer to Baffinland's Emergency Response Plan (BAF-PH1-840-P16-0002) and Spill Contingency Plan (BAF-PH1-830-P16-0036) for additional guidance. All sewage spills must be reported immediately to the Environment Department. For more information on spill reporting, see Operational Environment Standard: Spill Control Measures and Reporting (Section 2.33).

- Quantity of sewage treated will be documented continuously using in-line flow or vacuum truck counts. Vacuum truck counts will be tracked using the Wastewater Log (Section 3.13).
- Quantity of sludge generated by the Projects STPs will be recorded daily by the STP operators.
- Data will be reported as required by Baffinland's Water Type A Licence and other relevant approvals.
- The sludge generated by the Project WWTPs is dewatered using a filter press and incinerated on site. Sludge will be stored in an animal proof secure area until picked up for disposal.
- Conserve water use to reduce the amount of wastewater generated.
- Treated wastewater will only be released into the receiving environment at approved locations at both the Milne Port and the Mary River Mine Site. All wastewater discharges are monitored to ensure all discharged effluent meets the regulatory requirements outlined in Baffinland's Type A Water Licence.

2.15.3 FORMS

- Baffinland – Wastewater Log (Section 3.13)

2.15.4 RELATED DOCUMENTS

- Baffinland EPP – Spill Control Measures and Reporting (Section 2.33)
- Baffinland – Fresh Water Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0010)
- NWB – Type A Water Licence (2AM-MRY1325 Amendment No. 1)
- Baffinland - Emergency Response Plan (BAF-PH1-840-P16-0002)
- Baffinland - Spill Contingency Plan (BAF-PH1-830-P16-0036)

2.16 HAZARDOUS MATERIAL AND HAZARDOUS WASTE MANAGEMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.16	Hazardous Material & Hazardous Waste Management	F	May 10, 2016

2.16.1 ENVIRONMENTAL CONCERN

Hazardous materials (other than fuels) used throughout the lifecycle of the Project include; oils, greases, antifreeze, calcium chloride salt, ammonium nitrate, lead acid batteries, cleaners and other chemicals. Where the generation of the hazardous waste cannot be prevented, its management aims to prevent waste from resulting on a potential negative to the health and safety of Project Personnel and the environment.

Exposure to hazardous materials resulting from spills, leaks or releases cause potential human safety and health concerns. For more information refer to Baffinland's Hazardous Materials and Hazardous Waste Management Plan (BAF-PH1-830-P16-0011).

2.16.2 ENVIRONMENTAL PROTECTION MEASURES

Effective implementation of the following controls is required to ensure that hazardous materials and hazardous wastes are properly managed in order to minimize the potential for accidental releases to the environment:

- Hazardous materials and hazardous waste will be handled in accordance with Baffinland's Hazardous Materials and Hazardous Waste Management Plan EPP and will be stored within designated lined and contained areas or within shipping containers at the laydown area.
- Storage containers will be leak-proof and have content names and labels clearly visible.
- All drums shall be marked with the name Baffinland Iron Mines Corporation.
- Hazardous materials arriving by sealift will be temporarily stored in their original sea containers at laydown locations at Milne Port until transported to their final destination.
- Lubricating oils and antifreeze will be dispensed from drums or cubes using either fitted taps or pumps and will employ drip trays.
- Regular visual inspection for leaks, drips or indications of loss will be conducted at all storage areas for evidence of accidental releases and verification that wastes are properly labelled and stored.
- Waste storage sites will be monitored and sampled in accordance with Baffinland's Water Licences.

- All chemical spills must reported immediately to the Environment Department. The Emergency Response Plan and Spill Contingency Plan may be implemented, depending on the nature of the spill.
- Cleaning materials (i.e., rags, gloves, etc.) will be properly wrapped in sealed plastic bags and will be directed to disposal by incineration.
- All hazardous waste shall be clearly labelled and will not be combined with other solid non-hazardous waste.
- Smoking within 10 m of any hazardous waste storage location is prohibited.
- Baffinland shall itemize and maintain a tracking manifest for all hazardous materials to be used on-site. Environmental personnel shall conduct periodic inspections and audits to confirm the tracking manifest is up to date and accurate. Baffinland Departments and Contractors are responsible for maintaining the current Material Safety Data Sheets (MSDS) on-site for all hazardous materials pertaining to their activities.
- All hazardous material spills shall be reported to the Environment Department immediately and documented by submitting the necessary documentation within 12 hours of the spill using the Baffinland Incident Investigation Form and the NT-NU Spill Report Form (Section 3.6). All biological hazardous wastes generated at the medical clinic and first aid stations will be packaged, labeled and transported offsite for disposal at an appropriate licenced facility.
- Transportation and packaging of hazardous waste offsite shall be coordinated and supervised by fully-trained and qualified Project personnel or an appropriately licenced Contractor.

2.16.3 FORMS

- Baffinland – NT-NU Spill Report Form (Section 3.6)
- Baffinland – Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005)

2.16.4 RELATED DOCUMENTS

- Baffinland – Waste Management Plan (BAF-PH1-830-P16-0028)
- Baffinland – Hazardous Materials and Hazardous Waste Management Plan (BAF-PH1-830-P16-0011)
- Baffinland – Waste Sorting Guidelines (BAF-PH1-830-P25-0001)
- Baffinland - Spill Contingency Plan (BAF-PH1-830-P16-0036)
- Baffinland - Exploration Spill Contingency Plan (BAF-PH1-830-P16-0037)
- Baffinland - Emergency Response Plan (BAF-PH1-830-P16-0007)

2.17 ROAD CONSTRUCTION AND BORROW DEVELOPMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.17	Road Construction and Borrow Development	G	May 10, 2016

2.17.1 ENVIRONMENTAL CONCERN

Excavations disturb the ground surface and any vegetative cover that stabilizes the ground and reduces the potential for erosion. The excavation of sand and gravel from borrow areas, as well as the cut and fill technique that will occur during road construction throughout the lifecycle of the Project exposes soil, making it vulnerable to erosion.

These activities result in changes to the thermal regime of the ground (active layer and permafrost), as a new active layer is created. Modification to the thermal regime may induce melting of any ground ice present, resulting in thaw settlement and depressions caused by these settlements leading to erosion and possibly ponding of water.

2.17.2 ENVIRONMENTAL PROTECTION MEASURES

The ground surface will re-establish thermal equilibrium and will be suitable for re-colonization by natural vegetation over time. The following measures will be implemented to enhance this re-establishment of thermal equilibrium and minimize the effects of erosion, sedimentation and water ponding:

- Cut and fill areas will be stabilized by constructing gentle slopes less prone to erosion.
- Cut and fill areas are expected to be relatively small in horizontal and vertical extent. The side slopes of the borrow pits will be between 1H: 1V to 2H: 1V, slightly gentler than the slopes in the natural condition to reduce erosion.
- At low lying areas where roadbed fill is in the order of 1 m and the permafrost can be expected to rise to a meaningful degree, swales or culverts will be installed as part of road maintenance to prevent the ponding of water.
- At closure, swales will be left in place, or alternatively, the road bed will be breached to allow drainage.
- Borrow activities will occur only at approved locations and will be concentrated to limit the area of disturbance. Borrow pits will be located 31 metres away from the High Water Mark of the nearest water body or stream.
- Thawed layer removal will be done sequentially.
- Areas of unexpected settlement will be filled to re-establish the natural contours and eliminate ponding of water.
- Regular inspection of borrow locations will be completed and unstable slopes re-graded to eliminate depressions and re-establish natural drainage patterns.

2.17.3 FORMS

None

2.17.4 RELATED DOCUMENTS

- Baffinland EPP - Sediment and Erosion Control (Section 2.9)
- Baffinland EPP – Excavations and Foundations (Section 2.27)
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- Baffinland – Roads Management Plan (BAF-PH1-830-P16-0023)
- Baffinland – Borrow Pit and Quarry Management Plan (BAF-PH1-830-P16-0004)

2.18 TOTE ROAD WATERCOURSE CROSSINGS INSTALLATION

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.18	Tote Road Watercourse Crossings	G	July 15, 2014

Three major crossing types have been historically developed on the Tote Road as follows:

- Conventional single or multiple culverts crossings designed to pass select design flows.
- Culvert crossings (single or multiple) with an additional swale to accommodate increased flows during flood conditions
- Steel frame bridges (which may include culverts and/or swales).

2.18.1 ENVIRONMENTAL CONCERNS

Watercourse crossing installation has the potential to impact fisheries resources through the:

- Alteration of fish habitat or blockage of fish passage.
- Accidental releases of deleterious substances (i.e., fuel spills, sediment).

The construction of watercourse crossings has the potential to negatively affect fish and fish habitat from the construction of the crossing structures or the post-construction influence of the completed structures on fish habitat. Elevated levels of suspended sediment are the primary change in water quality that could result from work on or around water. Construction activities typically result in short-term effects, while long term effects can arise through erosion of ditches and slopes if not mitigated. Sediment sources related to construction activities include equipment crossings, excavation, blasting, and installation of bank protection measures (riprap), erosion from ditches and steep slopes, erosion from exposed areas on the right-of-way, and increased bed scour or bank erosion due to changes in downstream flow patterns.

There are four main groups of crossings with respect to fish habitat and the environmental protection measures required:

- Crossings with no fish habitat Small crossings with fish habitat, subject to the conditions of a DFO Letter of Advice (listed in Table 2.18-1).
- Crossings with fish habitat, subject to an authorization under Section 35(2) of the Fisheries Act (listed in Table 2.18-2).
- Fish habitat compensation sites – crossings where remedial work has be carried out to improve conditions for fish and expand potential fish habitat, as agreed upon as a condition of the above fisheries authorization

There are basic environmental protection measures that apply to all groups of crossings, and additional measures that apply to the crossings subject to the fisheries authorization.

2.18.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures will be implemented to minimize the potential impacts of stream crossing and installations:

- Culverts will be installed in accordance with approved plans.
- Work should be conducted during low flow conditions – avoid conducting work during large precipitation/runoff events.
- Sediment and erosion control measures shall be implemented prior to work and shall be left in place and maintained until all disturbed areas have been stabilized. For more information on sediment and erosion control measures see Operational Environment Standard: Sediment and Erosion Control (Section 2.9)
- Any stockpiled materials shall be stored and stabilized 31 metres away from the High Water Mark of any water body, unless for immediate use.
- All materials and equipment shall be operated and stored in a manner that prevents any deleterious substance (e.g. petroleum products, silt, debris, etc.) from entering the water. This includes checking that equipment is free of fluid leaks, and that grease and other debris is wiped or washed clean from the equipment, before entering the water.
- Re-fuelling and equipment maintenance is to be conducted 31 metres away from the High Water Mark of any water body.
- Install crossings at right angles to the watercourse so that the original direction of stream flow is not significantly altered.
- Minimize in-water work (get-in and get-out quickly).
- Water crossings will be backfilled with substrate (fill) material that is clean, competent, and consistent with the existing substrate size and texture found within the watercourse and will remain in/under the crossing.

2.18.3 ADDITIONAL ENVIRONMENTAL PROTECTION MEASURES - CROSSINGS SUBJECT TO "LETTER OF ADVICE"

- Water depth within the water crossing should be not be less than 20 cm or the same depth as the natural channel, especially during low flows.
- All disturbed areas shall be stabilized immediately upon completion of work and restored to a pre-disturbed state or better.

2.18.4 ADDITIONAL ENVIRONMENTAL PROTECTION MEASURES - CROSSINGS SUBJECT TO FISHERIES AUTHORIZATION AND FISH HABITAT COMPENSATION SITES

- An environmental inspector shall be on on-site to assess the crossings prior to the onset of construction to confirm the absence or presence of spawning sites at least 20 metres upstream or downstream of the crossing location, and whether spawning Arctic char are present in the vicinity (only applies to Table 2.18-2 crossings)

- For all crossings where fish may be present (Table 2.18-1, Table 2.18-2 and compensation sites), an environmental inspector shall be present to monitor construction activities and document turbidity levels upstream and downstream of the crossing under construction using the Turbidity Monitoring Data Form (Section 3.6) and the Watercourse Crossing Data Monitoring Form (Section 3.5).A qualified biologist or environmental inspector shall be on-site during all in-water construction, compensation and restoration works to ensure implementation of the designs, as intended in the Plan, and conditions of the fisheries authorization are being met.
- Construct new crossings at the existing crossing sites whenever practicable.
- If machinery is required to bring material or equipment to the opposite side of the watercourse, then it shall be restricted to a onetime event (over and back) and only if no other existing crossing can be used. If the stream bed and banks are highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation is likely to occur as a result of equipment crossing, then a temporary crossing structure or other practices shall be used to protect these areas.
- Machinery fording shall occur at least 20 metres upstream or downstream of location where fish and/or spawning sites are noted.

TABLE 2.18-1: CROSSING SUBJECT TO DFO LETTER OF ADVICE

Location Code	Road Location (km)	Easting (NAD 83)	Northing (NAD 83)	Catchment Area Size Reference
BG27	86.606	547,876	7,919,342	Small
BG29	84.805	546,229	7,919,877	Small
CV001	94.728	553,782	7,914,922	Small
CV030	77.503	540,123	7,921,310	Small
CV046	66.489	531,686	7,924,265	Small
CV057	60.714	528,379	7,928,657	Small
CV058	60.523	528,322	7,928,839	Small
CV059	59.960	528,102	7,929,356	Small
CV076	53.028	526,617	7,935,335	Small
CV082	49.656	525,254	7,938,131	Small
CV086	46.300	523,746	7,940,983	Small
CV102	36.029	521,934	7,950,591	Small
CV106	33.170	521,663	7,953,392	Small
CV112	31.446	521,033	7,954,935	Small
CV113	30.656	520,747	7,955,659	Small
CV115	27.686	519,222	7,958,135	Small
CV119	24.264	517,762	7,961,153	Small
CV120	23.510	517,294	7,961,707	Small

Location Code	Road Location (km)	Easting (NAD 83)	Northing (NAD 83)	Catchment Area Size Reference
CV125	20.448	515,296	7,963,841	Small
CV151	10.460	508,341	7,969,584	Small
CV152	10.282	508,201	7,969,684	Small
CV153	10.219	508,152	7,969,718	Small
CV154	9.570	507,620	7,970,076	Small
CV157	8.960	507,374	7,970,538	Small
CV166	6.055	505,538	7,972,370	Small
CV170	5.268	505,015	7,972,923	Small
CV176	2.637	503,834	7,975,057	Small
CV186	102.812	560,705	7,913,498	Small
CV187	103.078	560,957	7,913,414	Small
CV202	32.825	521,603	7,953,731	Small
CV203	34.150	521,782	7,952,435	Small
CV159	8.407	506,909	7,970,830	Extra Small
CV167	5.960	505,519	7,972,462	Extra Small
CV173	4.425	504,465	7,973,535	Extra Small

TABLE 2.18-2: CROSSING SUBJECT TO DFO FISHERIES AUTHORIZATION

Location Code	Road Location (km)	Easting (NAD 83)	Northing (NAD 83)
BG50	62.836	529,334	7,926,846
CV128	17.683	513,545	7,965,895
CV217	79.824	542,219	7,922,158
CV223	97.230	555,818	7,914,691
BG17	90.168	550,703	7,917,643
BG32	78.163	540,706	7,921,622
CV040	72.263	535,175	7,920,305
CV048	64.312	530,415	7,925,875
CV049	63.303	529,677	7,926,542
CV072	53.878	526,897	7,934,576
CV078	51.172	525,852	7,936,787
CV079	50.599	525,562	7,937,276
CV094	41.613	522,805	7,945,397
CV099	37.840	521,811	7,948,820
CV129	15.651	512,381	7,966,783
CV216	80.647	542,774	7,921,700
CV225	99.033	557,407	7,915,138
BG01	99.676	557,991	7,914,919

Location Code	Road Location (km)	Easting (NAD 83)	Northing (NAD 83)
BG04	94.148	553,250	7,915,113
BG24	87.710	548,766	7,918,878
CV060	58.853	527,622	7,930,342
CV104	33.794	521,732	7,952,788
CV111	31.991	521,355	7,954,524
CV114	29.648	520,278	7,956,528
CV224	97.758	556,238	7,915,044

2.18.5 FORMS

- Baffinland EPP - Watercourse Crossing Data Monitoring Form (Section 3.14)
- Baffinland EPP - Turbidity Monitoring Data Form (Section 3.15)

2.18.6 RELATED DOCUMENTS

- DFO Authorizations
- Transport Canada Navigable Waters Authorizations (various)
- Baffinland EPP - Sediment and Erosion Control (Section 2.9)
- Baffinland EPP – Excavations and Foundations (Section 2.27)
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- Baffinland – Roads Management Plan (BAF-PH1-830-P16-0023)

2.19 ROAD TRAFFIC MANAGEMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.19	Road Traffic Management	G	July 31, 2016

Project-related traffic will be managed to:

- Ensure smooth flow of road traffic during the Project's construction and operation.
- Ensure that adequate information is given to drivers and pedestrians in a timely manner to avoid accidents and holdups.
- Ensure assessment, monitoring and improvement of the existing road traffic site plans.

Over the life of the Project, there will be different levels of traffic flow. The peak flow periods of vehicles and equipment, and construction workers are expected to be during the day. Low flow periods will be during the night. However traffic flow will highly depend on operational planning or restrictions.

2.19.1 ENVIRONMENTAL CONCERN

- Traffic during construction and operation, if not properly managed, may cause disruption, accidents and interference in local community lifestyle.
- Project Traffic has the potential to affect traditional land based activities. i.e. hunting
- Improper traffic management may cause increased dust levels and higher environmental risks pertaining to hydrocarbon releases.

2.19.2 ENVIRONMENTAL PROTECTION MEASURES

- The Tote Road has an established right to public access, and therefore project-related traffic must share the road and be respectful of other users. Public road access and use should always be reported using the Baffinland. EPP –Human Use log (section 3.1)
- Traffic will be restricted to 50 km/hr, unless otherwise posted by dispatch. However, drivers must always drive to conditions. Traffic speed will be monitored by tracking the arrival times of trucks at the final destination, as well as by radar gun if necessary.
- Traffic shall yield the right of way to larger vehicles, giving priority to loaded haul trucks and snow plows.
- Vehicles are encouraged to carry spill supplies for immediate use if required
- Dust suppression shall be utilised on roads as required employing approved measures to reduce dust deposition on the road adjacent tundra. Baffinland - Air Quality and Noise Abatement Management Plan (BAF-PH1-830-P16-0002)

- Proper snow clearing measures will be employed to reduce snowbank drifting and facilitate proper road drainage come freshet- For more information refer to Baffinland's Site Snow Management Procedure (BAF-PH1-320-PRO-0050).
- Signposts will be established at every kilometre along road corridors and every vehicle is responsible to call out their location and direction at required posted areas (blind hills and corners).
- Radio towers will be established as required and with approval of the landowner. All vehicles will call out on the radio at designated areas (blinds corners, steep hills, etc.), their location, direction and type of vehicle for all other road users to hear along the Project's roadways (example: ore truck, loaded, kilometre 34, northbound).
- Community members will be encouraged not to discharge firearms within 1 km of Project roads, for the duration of the Project.
- Wildlife has the right-of-way and should be reported using the Baffinland EPP – Wildlife Log (Section 3.10). See Section 2.12 – Caribou Protection Methods for a description of what truck operators are to do when caribou are encountered within sight of the road.

2.19.3 FORMS

- Baffinland EPP – Wildlife Log (Section 3.10)

2.19.4 RELATED DOCUMENTS

- Baffinland EPP – Wildlife Log Instructions (Section 2.23)
- Baffinland - Roads Management Plan (BAF-PH1-830-P16-0023)
- Baffinland - Air Quality and Noise Abatement Management Plan (BAF-PH1-830-P16-0002)
- Baffinland - Site Snow Management Procedure (BAF-PH1-320-PRO-0050)
- QIA Commercial Lease
- AANDC Quarry and Land Use Permits

2.20 DRILLING, BLASTING AND CRUSHING

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.20	Drilling, Blasting and Crushing	G	May 10, 2016

Drilling and blasting will be conducted at all stages of the Project's lifecycle. Drilling and blasting activities will occur primarily at Deposit 1 at the Mary River Mine Site and rock quarries located throughout the Project Area. Throughout that life of the Project various blasting methods will be utilized. This will include the use of: high explosives, pre-packaged emulsions, ammonium nitrate fuel oil (ANFO), and emulsion produced on site. Although all of these explosives contain ammonium nitrate (AN) the chance of AN escaping and contaminating the surrounding area is extremely low when using emulsions or high explosives. Ammonia is toxic to aquatic life at certain concentrations; therefore, the proper handling of explosives during blasting operations is crucial in preventing spills from having an impact to nearby watercourses.

Crushing will occur at both the Mary River Mine Site and Milne Port and will generate air and noise emissions (Section 2.28 – Air Quality, Noise and Vibration). Air quality and noise levels will be monitored by the Environment and Health and Safety Departments.

2.20.1 ENVIRONMENTAL PROTECTION MEASURES

- Explosives use at the site, and worker safety around mining and crushing activities, is governed by Natural Resources Canada, and is detailed in the Company's Explosives Management Plan. Project Personnel using explosives shall have all required certifications including the blasters' certificates.
- All necessary precautions shall be taken to safely handle the explosives and to minimize spillage during blasting operations.
- All spills shall be reported to the Environment Department immediately and documented by submitting a report within 12 hours of the spill to the Environment Department using the Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005) and NT-NU Spill Report Form (Section 3.6).
- All drilling and blasting activities will be in accordance with the Company's site specific Quarry Management Plans (Section 2.25 – Quarry and Borrow Pit Management), the Explosives Management Plan.
- Environmental personnel will monitor water bodies and watercourses adjacent to blasting activities to ensure operational activities are not causing deleterious effects on aquatic resources, as stipulated in Baffinland's Type A Water Licence.

2.20.2 FORMS

- Baffinland - Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005)

- Baffinland EPP – NT-NU Spill Report Form (Section 3.6)

2.20.3 RELATED DOCUMENTS

- QIA Commercial Lease
- AANDC Quarry and Land Use Permits
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- Baffinland – Site Specific Quarry Management Plans (various)
- Baffinland – Borrow Pit and Quarry Management Plan (BAF-PH1-830-P16-0004)
- Baffinland – Roads Management Plan (BAF-PH1-830-P16-0023)
- Baffinland – Explosives Management Plan (E337697-PM407-50-126-0001)
- NWB – Type A Water Licence (2AM-MRY1325 Amended No. 1)

2.21 EXPLORATION DRILLING OPERATIONS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.21	Exploration Drilling Operations	E	July 15, 2014

Exploration drilling will be required to confirm, characterize and quantify new and already known deposits during the life of the Project.

2.21.1 ENVIRONMENTAL CONCERN

Environmental concerns with drilling include surface disturbances, drilling fluid and cutting disposal, impacts on dust, noise and water quality, and habitat encroachment.

All drilling muds and other additives must be approved by the Environment Department prior to being transported and used on site for any exploration drilling program. Data on drilling muds and other additives must be included as part of the Emergency Response and Spill Contingency Management Plans.

Use of water for drilling for the Project is subject to the conditions outlined in the Baffinland's Type B Water Licence (2BE-MRY1421).

2.21.2 ENVIRONMENTAL PROTECTION MEASURES

- Pre-drilling Preparation and Acceptable Drill Locations
    - Prior to drill placement, investigate site drainage to determine the proper downstream placement of the collection/settling sump(s), if warranted. Note that in most situations, sumps will be required; however, in some circumstances sumps may not be practical. In these cases, approval must be obtained by the Environmental Department.
    - Ensure sumps are of sufficient capacity based on a combination of proposed drill-hole length, water usage, and the potential residence time of the sumps.
    - Do not construct drill sites or drill sumps within 31 metres of the Normal High Water Mark of a water body unless specific approval is obtained by Baffinland from the Nunavut Water Board.
    - Ensure that the Pre-drilling Inspection Report (see Section 3.3) is completed prior to finalizing the drill site, sump locations, and silt fence locations.
    - Silt fences shall be placed immediately down-gradient of drill set-ups/sumps and up-gradient of any water body or stream. The selection of silt fence locations will be based on minimizing the transport distance of drill cuttings/mud and placing silt fences in optimal locations that will be functionally effective.
    - Archaeology clearance shall be obtained from the Environment Department for all exploration drill locations (Section 2.1 – Cultural Heritage and Archaeological Resources).

  - Conduct a wildlife inspection immediately prior to movement of the drill, involving aerial and ground survey of the new drill site. For details on drilling restrictions associated with wildlife interactions, see Operational Environment Standards: Polar Bear Encounters (Section 2.10), Fox and Wolf Encounters (Section 2.11), Caribou Protection Measures (Section 2.12) and Bird Protection Measures (Section 2.13).

- Drill Operations and Movements
  - Material shall not be stored on the surface of frozen streams or lakes, including immediate banks, except materials that are for immediate use.
  - Ensure that the drilling area is kept clean and tidy at all times. No littering is permitted - collect and package all waste for disposal at camp.
  - Feeding of all wildlife is prohibited.
  - All activities shall be conducted to minimize surface disturbance.
  - Minimize overland transportation for transport of workers off of approved roads and trails to reduce the potential for ground disturbance.
  - Do not use surface vehicles to move drill rigs or other equipment, without prior authorization by the Environment Department. The use of any vehicles off approved routes is prohibited.
  - Do not move equipment or vehicles unless the ground surface is in a state capable of fully supporting the equipment or vehicles without rutting or gouging.
  - Daily checks of active sumps will be conducted to ensure that any sump water spill-over occurs in a controlled manner. Sumps are to be constructed so that there is an overflow notch cut into the sump embankment to allow the sump water to decant from the sump in a controlled fashion.
  - Silt fences will be placed downstream of the sumps as described previously and will be checked daily.
  - Daily inspections for fuel/hydraulic leaks, equipment condition, sediment and erosion control, and water intakes shall be conducted prior to commencing work activities at the start and end of each work shift/day. All leaks shall be immediately repaired.
  - A Daily Drill Inspection Report (Section 3.5) will be filled out by the acting Supervisor for every day of drill operation.
  - All drill rigs shall be equipped with spill kits in the event of leaks and spill. All operators should be trained in spill response and be familiar the use of spill kits.

- If the bottom of the permafrost is broken through by the drill, the depth of the bottom of the permafrost and location shall be reported immediately to the Environment Department who followed by providing notification to the Nunavut Water Board.
- Equipment or material shall not obstruct any stream.
- Equipment storage holding areas will be located on gravel, sand or other durable land 31 metres above the ordinary High Water Mark of any water body in order to minimize impacts on surface drainage and water quality.

• Water Use, Brine and Drill Water Runoff

- Brine (calcium chloride salt mixed with water) used in exploration drilling is to be controlled to the maximum extent practicable. Drilling muds contained in drilling fluids must be settled out in sumps or by silt fences prior to entering any downstream water bodies or streams.
- Salt and water use for each drill is to be controlled by the use of brine mixing stations. The brine station operator will inspect his/her station daily and will be in continuous communication with each exploration drill. Brine conservation measures will be adopted which will include: shutting off the flow of brine to drills when brine is not required (i.e., when drills are temporarily shut down); eliminating all spillage in the vicinity of the brine stations; and minimizing to the greatest extent practicable the brine's salt concentrations.
- All water intake hoses shall be equipped with a screen of an appropriate mesh size (as approved by the DFO) to ensure that fish are not entrained. Additionally, operators will ensure the water intake hoses withdraw water at such a rate that fish do not become impinged on the screen.
- Measures shall be provided to prevent and control erosion on banks of any body of water.
- Streams cannot be used as a water source unless authorized and approved by the Nunavut Water Board.
- If water is required from a source that may be drawn down (small lake or stream), Baffinland shall submit a request for approval to the Board at least 15 days prior to withdrawing the water.
- Drill water shall be obtained from water sources(s) proximal to the drilling targets and shall not exceed a total of 250 m^3 per day for all drilling activities on the Project.
- Water use will be tracked using inline water metres on intake lines and recorded on the Daily Drilling Inspection Reports (Section 3.5).
- No material shall be removed from below the ordinary High Water Mark of any water body unless authorized.

- Contain and re-circulate drill water to the fullest extent possible in order to reduce water usage. Utilize silt fences and natural depressions to divert water from running into nearby watercourses and water bodies.
- Separate clean water from "dirty" water streams whenever possible, (by means of hose extensions and snow berms or other means that direct and keep discharge away from the immediate area of the drill hole) to prevent migration and expansion of a "dirty" water plume.
- Work shall be performed in such a way as to ensure that materials such as sediment, fuel and/or any other hazardous material does not enter watercourses and waterbodies through the implementation of sediment control measures and proper hazardous materials management practices . In the event of a release to the environment, a spills contingency plan shall be implemented.
- The drill water supply temperature should be monitored during drilling and kept to a temperature as low as possible (but not so low as to cause an imminent risk of frozen water lines).
- To maximize drill return water recirculation, casing is to be frozen into the ground to a depth of 3 to 6 m below grade. The specific depth of casing to be frozen into each hole and length of time to allow for freezing will be specified by the acting Supervisor.
- The drill water and cuttings spillage footprint shall be minimized through the use of berms, silt fences and/or other means of containment.
- Dispose of drill water into a properly constructed sump, or a naturally occurring contained depression. Drill water shall not be released directly to a nearby water course or to the ground.
- Use portable containment sumps (bins), for drill water and cuttings where containment in the ground is impractical. The bins shall not overflow and shall be dumped by means of helicopter or pump, to the location identified for disposal of dirty drill water and cuttings.
- Drilling waste must not be allowed to spread to the surrounding land or water bodies; the footprint of any spillage must be minimized to the greatest degree practicable.
- In case of an artesian flow occurrence, drill holes shall be immediately plugged and permanently sealed to prevent induced contamination of groundwater or salinization of surface waters. Report the artesian flow occurrence within 48 hrs to the Environment Department who in turn will report the occurrence to the Nunavut Water Board.
- For on-ice drilling, returned water released must be nontoxic, and not result in an increase in Total Suspended Solids (TSS) in the immediate receiving water above the CCME guidelines for the protection of Fresh Water Aquatic Life (i.e. .10 mg/L for lakes with background levels under 100 mg/L or 10% for those above 100 mg/L).

- Drill Hole Abandonment
  - Materials such as debris and/or drill cuttings shall not be left on the ice when there is potential for that material to enter a waterbody.
  - Restore, contour and stabilize al; constructed drill sumps, and other disturbed areas, to the pre-disturbed state immediately upon completion of drilling.
  - Return all combustible waste and petroleum products to camp for proper management and disposal.
  - Plug all drill holes upon completion, and where possible return drill cuttings at surface to the drill hole at all land-based drilling locations.
  - Contour and stabilize all other disturbed areas upon completion of work and restore these areas to a pre-disturbed state.
  - Upon completion of a hole in rock, the casing will be removed. If the casing cannot be removed it will be cut off to be flush with surface and backfilled.
  - Remove all non-combustible garbage and debris from the land use area to an approved disposal site.
  - Return all combustible waste and petroleum products to camp for proper management.
  - Ensure that a Post-Drilling Inspection Report (see Section 3.5 – Drill Inspection Form - Pre-Drilling, Daily and Post Drillings) is filled out at the completion of each drill hole.
  - Copies of all Pre-Drilling, Post-Drilling and Daily Drill Inspection Reports for all drill holes will be submitted to the Environment Department at the completion of each drilling program.

2.21.3 FORMS

- Baffinland EPP – Drill Inspection Forms: Pre-Drilling, Daily and Post Drilling (Section 3.5)

2.21.4 RELATED DOCUMENTS

- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- Baffinland EPP - Polar Bear Encounters (Section 2.10)
- Baffinland EPP - Fox and Wolf Encounters (Section 2.11)
- Baffinland EPP - Caribou Protection Measures (Section 2.12)
- Baffinland EPP - Bird Protection Measures (Section 2.13)
- Baffinland EPP – Exploration Drilling Operation (Section 2.21)
- Baffinland EPP – Water Sampling for On-Ice Drilling (Section 2.22)

- Baffinland – Freshwater Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0010)
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- NWB - Type B Water Licence (2BE-MRY1421)

2.22 WATER SAMPLING FOR ON ICE DRILLING

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.22	Water Sampling for On-Ice Drilling	D	July 15, 2014

2.22.1 ENVIRONMENTAL CONCERNS

On-ice drilling is critical for geotechnical investigations so that information for ports, bridges and other Project infrastructure may be collected for use in the infrastructure's design and engineering. Marine and lake environments are sensitive to disturbances, such as on-ice drilling. As such, overall water quality, including occurrence and concentrations of suspended solids and trace metals, must be monitored and protected. Water samples should be taken prior to on-ice drilling and after on-ice drilling to ensure appropriate water quality standards are maintained. Water sampling, for the purposes of water monitoring and detection of exceedances will ensure that the water quality is not compromised in the water bodies where on-ice drilling occurs.

2.22.2 ENVIRONMENTAL PROTECTION MEASURES

The following Measures will be followed to ensure that on-ice drilling (for both inland and marine environments) will not compromise the water quality of the underlying water body:

- A location not more than 30 m downstream (if applicable) from the proposed drill hole location will be selected for pre-drilling and post-drilling water samples.
- The pre-drilling water sample will be taken no more than four hours prior to drilling commencing at that location.
- The post-drilling water sample will be taken within four hours of the rods and casing being removed from the hole and the drill being decommissioned.
- The following methodology will be used to collect the water samples:

1. A hole will be augured through the ice and ice cuttings will be cleared from the hole.
2. A bailer will be used to obtain a representative water sample from the water column below the bottom of the ice.
3. The water sample will be transferred to sample bottles.
4. The same hole will be used to collect the pre-drilling and post-drilling water samples.

- Water samples will be tested to ensure that the total suspended solids (TSS) concentration does not increase by more than 10 mg/L for water bodies with background levels under 100 mg/L, or by more than 10% of the background level for water bodies with background levels above 100 mg/L.
- Before and after water samples will be tested in the field for TSS, pH and electrical conductivity.

- Before and after water samples will be submitted for laboratory testing to monitor total trace metals as determined by a standard ICP scan (to include at a minimum, the following elements: Al, Sb, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Sn, Sr, Tl, Ti, U, V, Zn), total arsenic and mercury.
- Drill water and cuttings reporting to surface from on-ice drilling will be discharged into a portable containment sump and removed from the ice. Water and cuttings will be stored in a pit at least 31 m above the High Water Mark of any water body, as specified by Baffinland.
- Operational Environment Standard protection measures outlined in the Operational Environment Standard: Geotechnical Drilling Operation (Section 2.5) will also be followed in conjunction with the protection measures listed above.

2.22.3 FORMS

None

2.22.4 RELATED DOCUMENTS

- Type B Water Licence – 2BE-MRY1421
- Baffinland EPP – Geotechnical Drilling Operation (Section 2.5)

2.23 WILDLIFE LOG INSTRUCTIONS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.23	Wildlife Log Instructions	C	May 10, 2016

Baffinland is required to keep a log of all wildlife sightings at the Project Sites as a requirement of its land use permits. A system of tracked wildlife log sheets has been set up by the Environment Department to monitor wildlife sightings.

Wildlife logs will be posted at all of the Project's operating camps. The information from these sheets will be regularly collected. Completed log forms are to be returned to the Environment Department for tracking wildlife log data.

Wildlife species potentially in the Project Area include caribou, wolf, wolverine, fox, arctic hare, lemmings, polar bear, walrus, seals, whales, raptors, loons, ducks, geese, songbirds and shorebirds. All on-site Project Personnel are required to record wildlife sightings on the posted Wildlife Log (Section 3.10) with the exception of caribou sightings, which should be reported to the Environment Department directly due to sensitive nature of these sightings. Identify the animal to the best of your knowledge. If you do not know the species, record a general group name, such as 'duck' or 'small bird'. If you are unsure, indicate this, such as 'fox or wolf?' Record tracks only if they are fresh.

All polar bear and wolf sightings are required to be reported to the Environment Department immediately. Refer to OESs: Polar Bear Encounters (Section 2.10) and Fox and Wolf Encounters (Section 2.11) for additional information on polar bear and wolf sightings. Refer to Caribou Protection Measures (Section 2.12) for additional information on caribou sightings.

2.23.1 WILDLIFE LOG INSTRUCTIONS

- Record your name and the date of the observation.
- Briefly describe the location, noting any significant landmarks, road kilometre marks, water bodies or other features. This is particularly important if Site Personnel are not equipped with a GPS.
- Record the GPS coordinates if possible. Ensure coordinates are recorded in latitude/longitude or UTM NAD83.
- Record the type of animal. Identify the species, if possible, or the general type or group.
- Record the number of animals observed and the life stage (juvenile or adult), if known.
- Record observations on the behaviour of the animal. What was it doing at the time you observed it? Was it making any sound? How did it react to your presence? How far away was it? Were you walking/driving/flying?

2.23.2 FORMS

- Baffinland EPP – Wildlife Log (Section 3.10)

2.23.3 RELATED DOCUMENTS

- Baffinland EPP – Polar Bear Encounters (Section 2.10)
- Baffinland EPP – Fox and Wolf Encounters (Section 2.11)
- Baffinland EPP – Caribou Protection Measures (Section 2.12)
- Baffinland EPP – Bird Protection Measures (Section 2.13)
- Baffinland –Terrestrial Environment Mitigation and Monitoring Plan (BAF-PH1-830-P16-0027)

2.24 BLASTING IN WATER

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.24	Blasting in Water	C	July 15, 2014

2.24.1 ENVIRONMENTAL CONCERN

Various blasting methods will be utilized throughout the lifecycle of the Project, including the use of high explosives and pre-packaged emulsions. Although these explosives contain ammonium nitrate (AN) the chance of AN escaping and contaminating the water is low. Ammonia is toxic to aquatic life at certain concentrations, therefore the proper handling and use of explosives during blasting operations is important to minimize potential impacts on the environment.

Blasting in or near water produces shock waves and vibrations that may have a potential impact on fish and marine mammals. Because of this, it is important that the appropriate and safe vibration limits are implemented to minimize the impact to the surrounding environment.

Potential silt and sediment production resulting from blasting activities may also have negative effects on fish and fish habitat. Silt and sediment can be transported in the water which may cause turbidity and a variety of other harmful effects on fish. Some of these negative effects include; clogging and abrasion of the gills of fish and other aquatic organisms, behavioral changes such as movement and migration, decreased resistance to disease, impairment of feeding, for example, turbidity interferes with feeding for visual feeders and poor egg and fry development. These are just a few of the potential harmful effects that silt, sediment and turbidity can have on the surrounding marine and freshwater environment so ensuring that the appropriate precautions are put in place when blasting is essential.

2.24.2 ENVIRONMENTAL PROTECTION MEASURES

- Explosives use at the site, and worker safety is governed by the NWT/Nunavut Occupational Health and Safety Act and Regulations.
- Project Personnel using explosives shall have all the required certifications including the blasters' certificates.
- Modern explosive materials and blasting will reduce the risk of ammonia contaminating the water.
- Best Management Practices will be used to ensure that blasting operations in water stay within 100kPa IPC threshold set forth by the DFO Guidelines for Use of Explosives In or Near Canadian Fisheries Waters.
- The production of silt in the water from the use of explosives will be minimized using Best Management Practices, including the installation of silt fences and turbidity curtains
- All necessary precautions shall be taken to safely handle the explosives and to minimize spillage during blasting operations.

- Adaptive Management will be implemented in all phases of the Project in order to ensure that all the precautionary measures are in place to reduce the environmental impact of the associated activities.
- Fisheries and Oceans Canada (DFO) has produced Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters to protect marine wildlife, including fish and marine mammals from underwater vibrations (DFO, 1998). Highlights of the guideline include the following:
  - No explosive is to be knowingly detonated within 500 m of any marine mammal (or no visual contact from an observer using 7 x 35 power binocular).
  - No explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (i.e. overpressure) greater than 100 kPa in the swim bladder of a fish.
  - No explosive is to be detonated that produces, or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during the period of egg incubation.
  - The guideline also presents tables of weight of explosive charge versus distance and other estimation methods to determine the potential impacts.
  - This guideline is relevant mostly for the Construction Phase of the Project with regards to port and river crossing construction.

2.24.3 FORMS

None

2.24.4 RELATED DOCUMENTS

- DFO – Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters
- DFO Fisheries Authorizations (various)
- Baffinland – Explosives Management Plan (E337697-PM407-50-126-0001)

2.25 QUARRY AND BORROW PIT MANAGEMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.25	Quarry and Borrow Pit Management	D	May 10, 2016

A number of rock quarries and borrow pits will be required throughout the Project's life cycle. The excavated aggregate and rock from borrow pits and quarries will be stockpiled until required for further processing or construction activities. During quarry development, overburden and soil will be removed and stockpiled to expose the bedrock. Waste rock from the Mine Area will also need to be handled and stockpiled separately in accordance with Baffinland's Waste Rock Management Plan.

2.25.1 ENVIRONMENTAL CONCERN

Quarrying and borrow pit operation may be responsible for a number of environmental impacts throughout the life of the Project. Potential impacts include: soil erosion, habitat loss, dust generation, permafrost degradation and water ponding. The water quality of waterbodies adjacent to these activities may also be impacted by means of sedimentation, fuel contamination and ammonia contamination from explosives residue.

2.25.2 ENVIRONMENTAL PROTECTION MEASURES

The following environmental protections measures for rock and aggregate excavation and management shall be implemented when developing all borrow pits and quarries:

- All Project Personnel involved in quarry and/or borrow pit development will be familiar with the conditions and environmental protection measures outlined in the Company's Borrow Pit and Quarry Management Plan as well as site specific Quarry Management Plans.
- The limits of the area to be excavated and the aggregate stockpile areas shall be clearly flagged/staked in the field prior to conducting any construction activities in the field.
- The borrow pits shall be designed to drain away from the face of the borrow pit to prevent water from ponding in borrow pits.
- A site specific Quarry Management Plan shall be developed for each of the Project's quarries.
- All quarry materials used shall be non-acid generating and non-metal leaching in chemical characteristics.
- When explosives are utilized Environmental personnel shall monitor the effects of explosives residue and related by-products from project-related blasting activities. In the event water licence criteria or other criteria established in the quarry or waste rock management plans are exceeded or close to being exceeded, Mine Operations personnel will work with Environment to develop and implement effective preventative and/or mitigation measures, including treatment, if necessary, to ensure that the effects associated with the manufacturing, storage, transportation and use of explosives do not negatively impact the Project and surrounding areas.

- Retain as much vegetation as practicable to the maintain slope stability.
- The side slopes of the borrow pits will be 1H:1V to 2H:1V, slightly gentler than natural slopes to reduce erosion.
- Maintain natural drainage patterns to the extent practicable.
- Maintain vegetation buffer zones to protect water bodies.
- Sources of in-pit water will be diverted away from the development area by constructing ditches and berms using rip-rap, geotextile and other sedimentation control measures. Ditching will be minimized to reduce land disturbance and will be approved by the Environment Department prior to construction.
- Organics and topsoil will be salvaged and stored for use in reclamation. Overburden material may be stored for reclamation or if the material is of acceptable quality, be used for construction.
- All material stockpiles, including aggregate, rock, waste rock and overburden, will be located at least 31 metres above the ordinary High Water Mark of any water body, unless for immediate use.
- Use rip-rap to reinforce drainage channel corners and water discharge points.
- Promote natural revegetation where required to stabilize slopes.
- Adequate sediment and erosion control measures, including silt fences, turbidity curtains, settling ponds and gravel berms, will be installed around the development area to protect adjacent watercourses and waterbodies from adverse impacts such as sedimentation and elevated turbidity levels (Section 2.9 – Sediment and Erosion Control).
- Use proper fuel containment and handling techniques, and have spill kits accessible.
- Use proper explosives handling techniques to minimize waste.
- Ice-rich material will be stockpiled 31 m above the ordinary High Water Mark of any water body and in a location where melt water will not re-enter the pit or have adverse impacts on adjacent aquatic resources.
- Dust shall be controlled as per the Air Quality and Noise Abatement Management Plan

2.25.3 FORMS

None

2.25.4 RELATED DOCUMENTS

- QIA Commercial Lease
- AANDC Quarry and Land Use Permits (various)
- Baffinland EPP – Land Disturbance (Section 2.3)

- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- Baffinland EPP – Road Construction and Borrow Pit Development (Section 2.17)
- Baffinland EPP – Drilling, Blasting and Crushing (Section 2.20)
- Baffinland – Life of Mine Waste Rock Management Plan (BAF-PH1-830-P16-0029)
- Baffinland – Borrow Pit and Quarry Management Plan (BAF-PH1-830-P16-0004)
- Baffinland – Site Specific Quarry Management Plans (various)

2.26 CONCRETE PRODUCTION

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.26	Concrete Production	C	July 15, 2014

2.26.1 ENVIRONMENTAL CONCERN

As required, during construction, concrete will be mixed at batching plants located at the construction laydown areas. Cement will be shipped via sea lift and mixed with water and aggregate to make the concrete. Waste concrete will arise from off-spec mixes, residual concrete at the end of pours, and from wash down of the equipment. It is important to ensure that there are no spills of waste cement or cement wash water runoff onsite as concrete is corrosive and waste runoff can impact the surrounding environment.

Another major concern is dust formation from the production of concrete. Dust will have a significant impact on the air quality on site so it is important that all precautionary measures, as outlined in the Air Quality and Noise Abatement Management Plan, are taken to contain and reduce the potential impact of dust generation.

2.26.2 ENVIRONMENTAL PROTECTION MEASURES

- To the greatest extent practicable, concrete production shall occur within the batch plant in order to ensure the dust is contained and Best Management Practices will be implemented to minimize the production and effects of dust onsite.
- Shipping of cement to site will be done using tote bags stored in sealed sea can containers which will reduce the likelihood of any spills occurring onsite.
- A purpose built concrete wash water pond shall be used to receive all wash water from concrete related activities in order to allow for the settling of solids, decant analysis and pH adjustment as required. Wash water will be recycled back into concrete production to the fullest extent possible in order to reduce water use and the quantity of wastewater generated by concrete production. All concrete product waste shall be disposed in the concrete wash pond or at other agreed to appropriate locations that pose not risk to the receiving environment.
- Lined containment areas will be used to wash concrete delivery trucks' drums and chutes on-site in order to minimize runoff of waste wash water.
- Waste hardened concrete will be used as either fill, or disposed of at the Mary River Mine Site Landfill.

2.26.3 FORMS

None

2.26.4 RELATED DOCUMENTS

- Baffinland – Air Quality and Noise Abatement Management Plan (BAF-PH1-830-P16-0002)
- Baffinland - Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)
- Baffinland – Fresh Water Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0010)

2.27 EXCAVATIONS AND FOUNDATIONS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.27	Excavation and Foundations	C	July 15, 2014

2.27.1 ENVIRONMENTAL CONCERN

Various activities requiring excavations and foundations will be undertaken throughout the life of the Project. Such activities include: driving pile foundations for buildings, excavating foundations for buildings and excavating abutments for bridges.

Excavations and foundations on site may have several environmental impacts that could potentially occur throughout the life of the Project. Possible environmental impacts that may occur include: loss of vegetation and wildlife habitat, effects on the stability and profile of permafrost, erosion, sedimentation, and the ponding of water.

2.27.2 ENVIRONMENTAL PROTECTION PROCEDURE

Measures that will be implemented to minimize the environmental impact of excavations and foundations throughout the Project include:

- Minimize vegetation disturbance as much as possible to enhance soil stability (see Section 2.3 – Land Disturbance).
- Ensure adequate drainage and maintain natural drainage patterns.
- Locate the development in a well-drained area whenever feasible.
- Ensure excavations are properly drained and that surface water drainage is diverted away from development areas whenever feasible.
- Adequate sediment and erosion control measures, including silt fences, turbidity curtains, settling ponds and gravel berms, will be installed around the development area to protect adjacent watercourses and waterbodies from adverse impacts such as sedimentation and elevated turbidity levels (see Section 2.9 – Sediment and Erosion Control).
- For more details on work activities related to water crossings (culverts, bridges), see Operational Environment Standard: Tote Road Watercourse Crossing Installation (Section 2.18).

2.27.3 FORMS

None

2.27.4 RELATED DOCUMENTS

- Baffinland EPP – Land Disturbance (Section 2.3)
- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- Baffinland EPP – Tote Road Watercourse Crossing Installation (Section 2.18)
- Baffinland – Borrow Pit and Quarry Management Plan (BAF-PH1-830-P16-0004)

2.28 AIR QUALITY, AND NOISE AND VIBRATION

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.28	Air Quality, Noise and Vibration	B	July 15, 2014

2.28.1 ENVIRONMENTAL CONCERN

Project related sources that may affect air quality include exhaust emissions from vehicles, aircraft, and other equipment, emissions from incinerators, and fugitive dust emissions from mining activities, borrow sources, road traffic and construction activities. Construction activities have the potential to generate emissions of airborne particulates that may result in short-lived periods of elevated particulate matter (PM10 and PM2.5) concentrations. Significant quantities of particulate matter during these periods may be transported by weather conditions to accommodation areas of the Project, resulting in potential health and safety issues for Project Personnel. Dust generated from vehicles and construction activities may potentially affect the health of vegetation, wildlife, Project Personnel and local communities as well as the safety of personnel and local residents around the site.

Noise and vibration is generated from construction activities such as the use of machinery, diesel generators, vehicles, drilling, excavation, crushing of aggregate, blasting, etc. When no control measures have been put in place, Project Personnel working with or near noisy equipment or processes may be affected by high direct or ambient noise which could potentially result in noise induced hearing loss. Noise and vibration may also affect wildlife in areas surrounding construction activities.

Please refer to the existing Air Quality and Noise Abatement Management Plan for more information on how to address any air quality and noise abatement concerns.

2.28.2 FORMS

None

2.28.3 RELATED DOCUMENTS

- Baffinland EPP – Blasting in Water (Section 2.24)
- Baffinland - Air Quality and Noise Abatement Management Plan (BAF-PH1-830-P16-0002)

2.29 POST-CONSTRUCTION ACTIVITIES

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.29	Post-Construction	B	May 10 , 2016

2.29.1 ENVIRONMENTAL CONCERN

Post-construction activities may include the re-contouring stockpiled soil and overburden, natural re-vegetation, restoring natural drainage patterns, equipment and waste removal etc., as required within the Project footprint in order to prepare for the Reclamation Phase of the Project and minimize environmental impacts.

The loss of terrestrial and aquatic habitat, erosion and slope failure, and the disturbance and/or destruction of historic resources are environmental concerns associated with the potential activities related to construction. With the proper post-construction activities in place, the physical environment shall be more readily restored and remediated to mitigate the potential impacts listed above.

Refer to the Preliminary Mine Closure and Reclamation Plan (FEIS, Appendix 10G) for more information on Post-Construction Activities and progressive reclamation.

2.29.2 FORMS

None

2.29.3 RELATED DOCUMENTS

- Baffinland – Final Environmental Impact Statement – Appendix 10G
- Baffinland – Interim Abandonment and Reclamation Plan (BAF-PH1-830-P16-0012)

2.30 PROTECTION OF THE MARINE ENVIRONMENT AND WILDLIFE

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.30	Protection of the Marine Environment and Wildlife	C	May 10, 2016

2.30.1 ENVIRONMENTAL CONCERN

Potential environmental impacts have been identified such as underwater and airborne noise, release of sediment into the water, and accidental introduction of hydrocarbons or other deleterious substances/materials into the marine environment. Should these potential impacts affect the marine habitat and wildlife, the appropriate protection and mitigation measures need to be implemented.

In 2015, Baffinland developed the Marine Environmental Effects Monitoring Plan (Appendix H of the Shipping and Marine Wildlife Management Plan, BAF-PH1-830-P16-0024). This plan is reviewed by the Marine Environment Working Group and submitted annually to the Nunavut Impact Review Board.

The objectives of the MEEMP are to:

- Address regulatory requirements, especially those listed in the amended NIRB Project Certificate No. 005.
- Develop a comprehensive and integrated environmental monitoring program that includes follow-up as required.
- Incorporate an ecosystem-based approach for monitoring and management of Project-related environmental effects.
- Coordinate all aspects of project-related marine environment effects monitoring.

2.30.2 FORMS

None

2.30.3 RELATED DOCUMENTS

- Baffinland - Shipping and Marine Wildlife Management Plan (BAF-PH1-830-P16-0024)

2.31 FRESHET MANAGEMENT

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.31	Freshet Management	B	May 10, 2016

2.31.1 ENVIRONMENTAL CONCERN

The effective management of freshet is imperative to maintaining the usability of the Tote Road and stability of camp pad and associated infrastructure. Improper or mismanaged preparation activities can result in significant washouts of the Tote Road directly impacting Project production, scheduling as well as incur disruptions to transport and supplies to Project Sites. Also, the failure to properly prepare for, and manage freshet along the Tote road is a major risk to the Company that can potentially result in major damage to the road, loss of material and personnel movement between Project Sites, significant production losses, schedule delays, and loss of reputation/regulatory enforcement.

2.31.2 ENVIRONMENTAL PROTECTION MEASURES

The following measures must be implemented to minimize the potential risks associated with freshet:

- Only Site Personnel trained in completing culvert excavation and steaming activities are permitted to undertake the following activities.
- Culvert ends must be dug out using an excavator prior to the commencement of the melt to allow access to the ends. When digging out the culverts using the excavator, it is very important not to damage the culvert ends. The culvert ends should have rebar markers; however this activity should be undertaken with the use of a spotter. Also, if the rebar is no longer in place on one end, a metal detector should be used to locate the culvert end by the spotter.
- Culverts found to be substantially or completely blocked will need to be opened using a portable steam generator or steaming truck in order to allow for the passage of the initial melt water. It is important to monitor initial days of runoff as if the weather gets cold once melt begins then the possibility of refreezing of the culverts.
- Once the flows begin, a dedicated monitor is required to watch for potential problem areas including upstream build-up of water, high flows, and upstream and downstream erosion and sedimentation. Should any of the above conditions be observed various measures can be adopted including the use of pumps, berms, the installation of additional overflow culverts, and the installation of riprap or geotextile. Under certain circumstances, a controlled breach of the road may also be necessary to allow upstream flows to subside and to minimize overall the damage to the road.
- Should a washout or erosion occur, all reasonable efforts need to be made to prevent the siltation of downstream water bodies. Methods of controlling the migration of deleterious materials

include silt fences, silt curtains, sumps and check dams, settling ponds, riprap and armoring as well as the use of flocculants.

- Preparation and management activities should follow the Tote Road Freshet management Procedure, however in the event of significant erosion or siltation, please refer to the Aquatic Ecosystem and Surface Water Management Plan.

2.31.3 FORMS

None

2.31.4 RELATED DOCUMENTS

- Baffinland EPP – Sediment and Erosion Control (Section 2.9)
- Baffinland – Surface Water and Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)

2.32 COMPLIANCE INSPECTIONS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.32	Compliance Inspections	B	May 10, 2016

Individual departments are responsible for maintaining a clean, safe and environmentally acceptable work area. Departments are expected to conduct and document regular inspections of their work areas and facilities to ensure the Company's commitments and expectations regarding health, safety and environment are being met or exceeded. Inspection documentation shall be made available to Environment personnel conducting periodic inspections or to external inspectors, regulators, and agencies conducting inspections under the terms and conditions of Baffinland's licences, permits, authorizations, and leases.

In addition to departmental inspections, Environmental personnel will conduct routine inspections throughout the Project site to confirm department personnel are operating in accordance with the Company's Water Licences, permits and other regulatory requirements put in place by stakeholders, land owners and government regulators. Project Personnel who are unsure about certain environmental impacts and/or necessary protection measures should consult the Environmental Protection Plan first followed by the Environment Department before proceeding with the activity under question.

While conducting inspections, departments should pay close attention to the following:

- All hazardous materials and hazardous waste should be contained in a spill tray, a lined containment berm or some other form of secondary containment.
- All waste should be segregated in accordance with the Waste Sorting Guidelines. Departments should ensure that disposal bins for each type of waste (hazardous, landfill, incinerator) are accessible and clearly labelled.
- All food waste and wildlife attractants will be disposed indoors to prevent the attraction and food conditioning of wildlife.
- All refuelling and equipment maintenance activities should employ the use of spill trays to prevent hazardous materials such as fuel, oils and greases from spilling onto the ground. See the Environmental Standard – Use of Spill Trays at Site for more details.
- All spills should be documented and reported to the Environment Department as soon as possible. Spills should be cleaned up as soon as possible after being reported, unless told otherwise by the Environment Department. For more details on spill reporting see Operational Environment Standard: Spill Control Measures and Reporting (Section 2.33).
- For a complete list of project components and items to monitor refer to Environmental Inspection Forms (Section 3.16).

- The schedule for conducting environmental inspections will vary from month to month and will be established by the Environmental Superintendents and Coordinators and approved by the Environmental Manager. The schedule will be developed based on a Project activity risk based approach.

2.32.1 FORMS

- Baffinland EPP - Environmental Inspection Forms (Section 3.16)

2.32.2 RELATED DOCUMENTS

- Baffinland EPP – Spill Control Measures and Reporting (Section 2.33)
- Baffinland EPP – Fuel Storage and Handling (Section 2.7)
- Baffinland EPP – Hazardous Material and Hazardous Waste Management (Section 2.16)
- Baffinland – Environmental Standard - Waste Sorting Guidelines
- Baffinland - Environmental Standard – Use of Spill Trays at Site
- Baffinland – Waste Management Plan (BAF-PH1-830-P16-0028)

2.33 SPILL CONTROL MEASURES AND REPORTING

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
2.33	Spill Control Measures and Reporting	B	May 10, 2016

A wide range of hazardous materials will be used during the life of the Project including Jet-A, diesel, oils, greases, antifreeze, calcium chloride salt, ammonium nitrate, lead acid batteries, cleaners and a variety of other materials. The management of hazardous materials onsite will focus on preventing the materials from causing harm to the health and safety of Project Personnel and the surrounding environment. All spills, leaks and releases of hazardous materials will be reported to the Environment Department immediately and documented by submitting the necessary documentation within 12 hours of the spill using the *Baffinland Incident Investigation Form* (BAF-PH1-810-FOR-0005) and *NT-NU Spill Report Form* (Section 3.6).

Refer to the Spill Contingency Plans and Emergency Response Plans for various response action levels based on type of hazardous product spilled, volume spilled and type of receiving environment. A brief summary of the various spill response action levels are provided below.

Emergency response action levels and response procedures for environmental (spill) emergencies are provided in Baffinland's Emergency Response Plan (ERP) (BAF-PH1-830-P16-0007) in addition to Baffinland's Spill Contingency Plan (BAF-PH1-830-P16-0036).

Baffinland has adopted a classification system that includes three levels of emergency response. Each level of emergency, based on the significance of the event, requires varying degrees of response, effort and support. With emphasis on spills and releases the three response levels are as follows:

- Level 1 (Low) – Minor accidental release of a deleterious substance with:
  - No threat to public safety; and/or
  - Negligible environmental impact to receiving environment.
- Level 2 (Medium) – Major accidental release of a deleterious substance with:
  - Some threat to public safety; and/or
  - Moderate environmental impact to receiving environment
- Level 3 (High) – Uncontrolled hazard which:
  - Jeopardizes project personnel safety: and/or
  - Significant environmental impacts to receiving environment

For spills, the level of emergency response to a spill incident is based on the substance released, quantity spilled, the receiving environment that is potentially impacted, and human health risk. The level of response is also based on whether the location of the spill release is within engineered containment. The following matrix provides a working guideline for project personnel.

SPILL RESPONSE LEVELS

		Level 1 (Low)	Level 2 (Medium)	Level 3 (High)	
Explosives		<100 kg	100 – 1,000 kg	>1,000 kg	in water
		<500 kg	500 – 5,000 kg	>5,000 kg	on land
Sewage		<1,000 L	1,000 – 10,000 L	>10,000 L	in water
		<10,000 L	10,000 – 100,000 L	>100,000 L	on land
Hazardous Materials*		<10 L	10 – 1,000 L	>1,000 L	in water
		<500 L	500 – 5,000 L	>5,000 L	on land
		<1,000 L	1,000 – 100,000 L	>100,000 L	in containment

*Include Fuels (Diesel/JetA), Lubricants, Antifreeze, Hydraulic Oil, Waste Oil, Antifreeze, etc.

Emergency spill response training shall be completed in conjunction with Baffinland's ERP. Baffinland's Emergency Response lead, with support from the Environmental Manager/Superintendents, will identify Project training needs and the resources required to provide the necessary skills to personnel tasked with duties in emergency and spill response. Circumstantially, emergency spill responses often occur in parallel with emergency responses (i.e. an overturned fuel tanker accident along the Tote road not only causes imminent hazards to site personnel, but also to the surrounding environment). To facilitate efficient emergency response to all different types of emergency scenarios, project personnel on the Mine Rescue

Team (MRT) are trained to respond to Health and Safety emergencies and shall also receive sufficient training to effectively respond to accidental releases of hazardous materials.

Internal Baffinland reports are to be provided by the responsible department to the Environment Department via the Baffinland Incident Reporting System. All external reporting to outside agencies are to be provided by the Environment Department.

TABLE 2.33-1: GENERAL SPILL REPORTING AND CLEAN UP STANDARDS

Spill on Land		
Volume (L)	**Required Documentation**	**Spill Clean up**
Less than 1 litre	- Verbal or email report	Environment Department will advise if needed.
Greater than 1 litre and less than 100 litres	- Photos of Spill and Clean-up - Baffinland Incident Investigation Report - NT-NU Spill Report	Spills greater than 30 litres will have an Environmental Monitor present to advise clean-up efforts.
Greater than 100 litres	- Photos of Spill and Clean-up - Baffinland Incident Investigation Report - NT-NU Spill Report - Notification to regulators and the Spill Line	Environmental Superintendent or his/her designate will lead and advise clean-up efforts.
Spill on Water Body or Watercourse		
Volume (L)	**Required Documentation**	**Spill Clean up**
Any volume	- Photos of Spill and Clean-up - Baffinland Incident Investigation Report - NT-NU Spill Report - Notification to regulators and the Spill Line	Environmental Superintendent or his/her designate will lead and advise clean-up efforts.

2.33.1 FORMS

- Baffinland – Baffinland Incident Investigation Form (BAF-PH1-810-FOR-0005)
- Baffinland EPP - NT-NU Spill Report Form (Section 3.6)

2.33.2 RELATED DOCUMENTS

- Baffinland EPP – Hazardous Material & Hazardous Waste Management (Section 2.16)
- Baffinland - Spill Contingency Plan (BAF-PH1-830-P16-0036)
- Baffinland – Emergency Response Plan (BAF-PH1-830-P16-0007)

- Baffinland - Spill Contingency Plan (BAF-PH1-830-P16-0036)
- Baffinland - Exploration Spill Contingency Plan (BAF-PH1-830-P16-0037)
- Baffinland - Emergency Response Plan (BAF-PH1-830-P16-0007)
- Baffinland – Milne Port Oil Pollution Emergency Plan (BAF-PH1-830-P16-0013)

3 DOCUMENTATION LOGS AND FORMS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.0	Documentation Logs and Forms	E	August 6, 2016

DOCUMENTATION PROCEDURES

A key aspect of the EPP is effective record-keeping. The following logs and forms are to be used to record key information:

- Cultural Heritage Chance Find Discovery Form (Section 3.1).
- Human Use Log (Section 3.2)
- Mary River Visitor Access Routes (Section 3.3)
- Water Collection Log (Section 3.4)
- Drill Inspection Forms (Section 3.5)
- NT-NU Spill Report Form (Section 3.6)
- Daily Tank Farm Inspection Checklist (Section 3.7).
- Fuel Tank Dipping Form (Section 3.8)
- Polar Bear Readiness Audit Form (Section 3.9)
- Wildlife Log (Section 3.10)
- Active Migratory Bird Nest Search Form (Section 3.11)
- Off-site Waste Disposal Log (Section 3.12)
- Wastewater Log (Section 3.13)
- Watercourse Crossing Monitoring Data Form (Section 3.14)
- Turbidity Monitoring Data Form (Section 3.15)
- Environmental Inspection Forms (Section 3.16)

The record keeping forms are described further in their respective sections of the EPP. All completed logs and forms are to be submitted to the appropriate departments.

3.1 CULTURAL HERITAGE AND CHANCE FIND DISCOVERY FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.1	Cultural Heritage Chance Find Discovery Form	A	July 15, 2014

Cultural Heritage Chance Find Discovery Form			Reference No. (Environment Department to assign)
Please complete this form in the event of a chance find of a suspected burial, archaeological finds scatter, or an isolated find of a single artifact (e.g. stone tools/arrowheads, eggshell, pottery, concave milling/grinding stones, spherical hammerstones)			
Date of discovery			**Time**
Name of discoverer/team			**Tel no.** **Email**
Location of the discovery	Project area : GPS coordinates :		
Description of archaeological discovery			
Estimated weight	Kg		
Dimensions	x x cm		
Sketch of discovery area	**Drawing of chance find(s)**		
Temporary protection implemented			
Name	**Signature**		**Date**
Received by Environmental Manager	**Signature**		**Date**
Notes : If you need more room to draw or describe the discovery area/finds, please use back of the page. **Please return this form to the Environment Department as soon as possible (within 24 hours of discovery at the most).**			

3.2 HUMAN USE LOG

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.2	Human Use Log	B	July 15, 2014

Land and resource uses in the Project Area include; hunting, fishing, trapping, and tourism. Potential impacts to existing land use will include the interruption of camping, hunting, tourism and marine activities mainly in Milne Inlet and Mary River areas, but also extending throughout North Baffin Island. Baffinland has made a commitment to minimize disturbance to other land users to the extent possible.

Approvals issued to Baffinland require that the Company monitor the potential effects of its activities on Inuit harvesting activities. To do so, Baffinland wants to be aware of when people come into the area. The objective is to understand the activities of other land users only as much as needed to be able to modify Project activities to minimize disruption to other land users. Baffinland does not want to know other people's personal business!

TABLE 3.2.1: MARY RIVER HUMAN USE OF OBSERVATION LOG

Date	Where (GPS)	Number of People In Party	Inuit or Non-Inuit	Activities Observed (Camp, Hunting, Travel, Etc.)

3.3 VISITOR ACCESS ROUTES

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.3.1	Mary River Visitor Access Routes	A	July 29, 2016

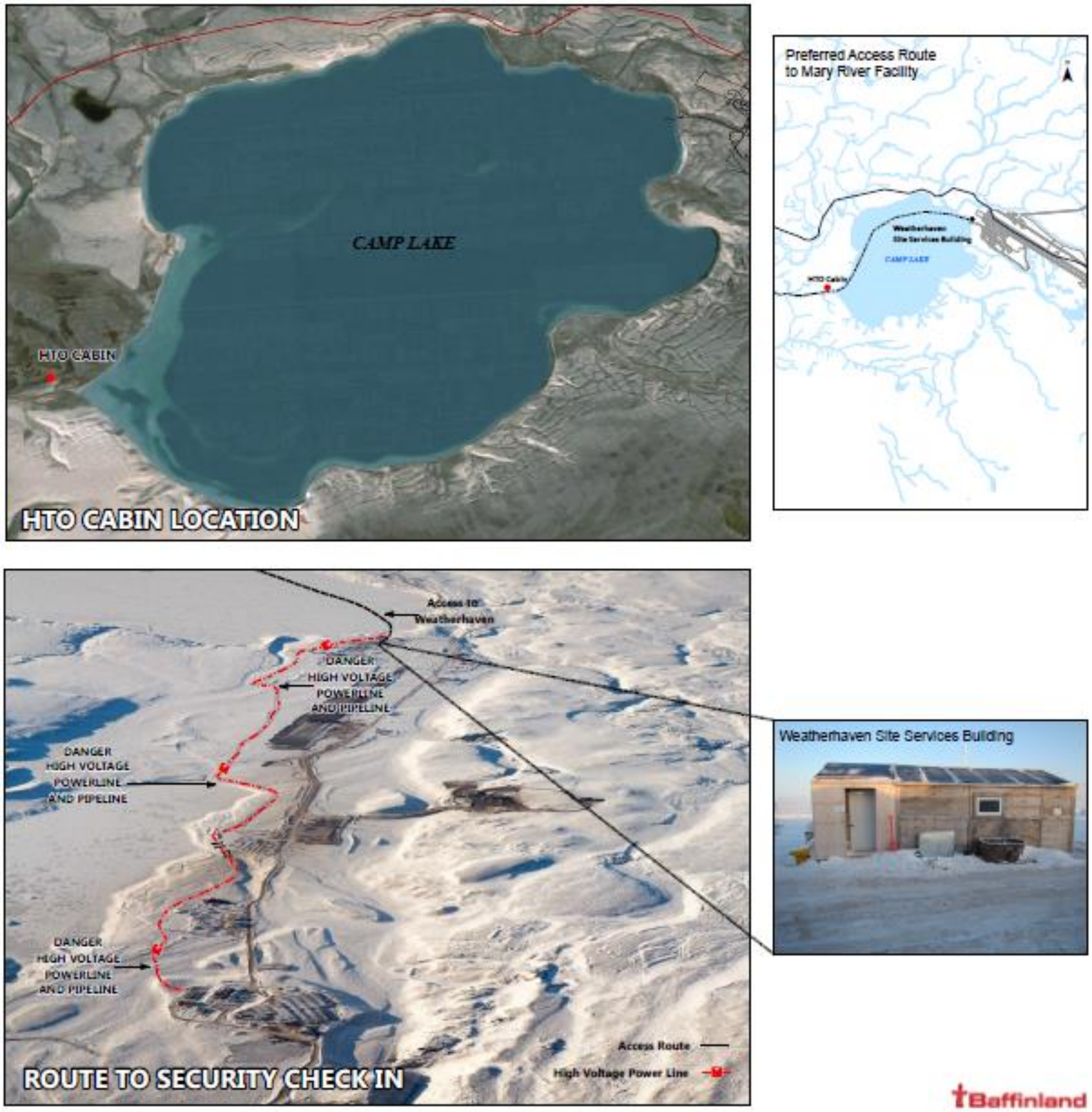


Figure 3.3.1 – Mary River Access Route

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.3.2	Milne Port Visitor Access Routes	A	July 29, 2016

Figure 3.3.2 – Milne Port Access Route

3.4 WATER COLLECTION LOG

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.4	Water Collection Log	A	July 15, 2014

Baffinland

Water Collection Log

Date	Time	Truck ID	No. Loads	Source	Discharge Location	Operator name	Initials

3.5 DRILL INSPECTION FORMS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.5	Drilling Inspection Forms	B	July 19, 2009

PRE-DRILLING INSPECTION REPORT

Baffinland	PRE-DRILLING INSPECTION REPORT **Baffinland personnel:** **Date:** **Time:** **Proposed hole ID:** **Final hole ID:**

PROPOSED HOLE INFORMATION:

Deposit #:	**Collar location:**	E
Project:	(NAD 83)	N
Area:	**Dip:**	
NTS:	**Azimuth:**	
Elevation:	**Target depth:**	

Description of drill hole location:
Purpose of drill hole:

DRILLING INFORMATION:

Has site been approved by drill foreman?
Drill contractor: Drill personnel: Drill #:
Expected start of drilling:
Is moving of drill hole required?
If yes, provide reason:
New collar location: E N

WATER MANAGEMENT:

Water source:
Pump Station #:
Sump location identified and constructed?: Yes/No (Photo required)
Corner 1: E N
Corner 2: E N
Silt fence(s) constructed?: Yes/No (Photo required)
Corner 1: E N
Corner 2: E N

SITE ASSESSMENTS:

Are wildlife present?: (If yes, record in log)
Is site safe for drilling?

Stable platform	Yes /No	Fire Extinguisher	Yes /No
First Aid kit	Yes /No	Eye Wash	Yes /No
PPE	Yes /No	Spill Kits	Yes /No

Safety concerns/issues:
Environmental concerns?

PHOTOGRAPHIC RECORD:

Photo of drill hole location prior to setup? Yes /No
Name: Folder:
Uploaded to hard drive?

COMMENTS:

DAILY DRILLING INSPECTION REPORT

Baffinland	**DAILY DRILL INSPECTION REPORT**
	Baffinland personnel: **Date:** **Time:** **Hole ID:**

HOLE INFORMATION:

Deposit #:	1	**Collar location:**	E
Location:		(NAD 83)	N

DRILLING INFORMATION

Drill contractor:
Drill personnel:
Drill #:

DRILLING PROGRESS:

Day Shift	**Night Shift**
Start depth:	**Start depth:**
End depth:	**End depth:**
Total depth drilled:	**Total depth drilled:**
Casing installed:	**Casing installed:**

Any rods/casing/tools lost in the drill hole? If yes, what was lost?

Delays/Problems: (breakdowns, stuck rods, bit change, weather, wait time, drill move, etc.) Provide time estimate

WATER USE ASSESSMENT:

Sediment control measures in place:
Assessment of effectiveness:
Approximate water level in sump:
Color of water in sump:
Color of runoff?

Conductivity readings?:	Station #	Reading
	Station #	Reading
	Station #	Reading
Turbidity sample(s) taken?:	Sample #	Reading
	Sample #	Reading

DAILY WATER USE MONITORING:

Water meter reading (start of day):

Water meter reading (end of day):

SITE ASSESSMENT:

Are wildlife present?: (check log for previous wildlife activity)

Is site safe for drilling?

Stable platform	Yes /No	Fire Extinguisher	Yes / No
First Aid kit	Yes /No	Eye Wash	Yes / No
PPE	Yes /No	Spill Kits	Yes / No
Lined Berms	Yes /No		

Safety concerns/issues:
Environmental concerns?
Corrective action required?: Action plan (if required):
Responsible party:
Date to be completed: Photograph (only required to document problems and corrective actions)

PHOTOGRAPHIC RECORD:

Photo of drill hole during drilling? Photo of water management measures? Yes /No
Name: Folder:
Uploaded to hard drive?

COMMENTS:

POST-DRILLING INSPECTION REPORT

Baffinland	**POST-DRILLING INSPECTION REPORT**
	Baffinland personnel: **Date:** **Time:** **Final hole ID:**

HOLE INFORMATION:

Deposit #:		**Collar location:**	E
Project:	MARY RIVER	(NAD 83)	N
Area:	BAFFIN ISLAND	**Dip:**	
NTS:	37G/5	**Azimuth:**	
Elevation:		**EOH:**	

Description of drill hole location:
Purpose of drill hole:

DRILLING INFORMATION:

Drill contractor:
Drill personnel:
Drill #:
End of drilling:
Casing:
Any rods/casing/tools lost in the drill hole? If yes, what was lost?

Are rods/casing left in the ground cut at ground level and is the hole properly plugged and capped? Yes / No
Next set-up collar location: E N

WATER USE ASSESSMENT:

Water source: Mary River
Pump station #:
Total amount of hours water was pumped from pump station:

SITE ASSESSMENT:

All materials and debris removed from site? Yes /No
Any environmental concerns? Yes /No If yes, please describe below:

Any additional work required? Yes /No If yes, please describe below:

Corrective action:
Responsible party:
Date to be completed by:

PHOTOGRAPHIC RECORD:

Photo of drill hole location following demobilization and clean up? Yes /No
Name: Folder:
Uploaded to hard drive?

COMMENTS:

INSPECTION COMPLETED BY:

Baffinland signature: Drill contractor signature:

3.6 NT-NU SPILL REPORT FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION	REVISION DATE
3.6	NT-NU Spill Report Form	A	July 15, 2014

Northwest Territories Nunavut Canada

NT-NU SPILL REPORT

OIL, GASOLINE, CHEMICALS AND OTHER HAZARDOUS MATERIALS

NT-NU 24-HOUR SPILL REPORT LINE
TEL: (867) 920-8130
FAX: (867) 873-6924
EMAIL: spills@gov.nt.ca

REPORT LINE USE ONLY

A	REPORT DATE: MONTH – DAY – YEAR	REPORT TIME	☐ ORIGINAL SPILL REPORT, OR	REPORT NUMBER
B	OCCURRENCE DATE: MONTH – DAY – YEAR	OCCURRENCE TIME	☐ UPDATE # TO THE ORIGINAL SPILL REPORT	
C	LAND USE PERMIT NUMBER (IF APPLICABLE) IOL - Commercial Lease No.: Q13C301	WATER LICENCE NUMBER (IF APPLICABLE) 2AM-MRY1325 Type "A"		
D	GEOGRAPHIC PLACE NAME OR DISTANCE AND DIRECTION FROM NAMED LOCATION	REGION ☐ NWT X NUNAVUT ☐ ADJACENT JURISDICTION OR OCEAN		
E	LATITUDE DEGREES MINUTES SECONDS	LONGITUDE DEGREES MINUTES SECONDS		
F	RESPONSIBLE PARTY OR VESSEL NAME	RESPONSIBLE PARTY ADDRESS OR OFFICE LOCATION		
G	ANY CONTRACTOR INVOLVED	CONTRACTOR ADDRESS OR OFFICE LOCATION		
H	PRODUCT SPILLED	QUANTITY IN LITRES, KILOGRAMS OR CUBIC METRES	U.N. NUMBER	
	SECOND PRODUCT SPILLED (IF APPLICABLE)	QUANTITY IN LITRES, KILOGRAMS OR CUBIC METRES	U.N. NUMBER	
I	SPILL SOURCE	SPILL CAUSE	AREA OF CONTAMINATION IN SQUARE METRES	
J	FACTORS AFFECTING SPILL OR RECOVERY	DESCRIBE ANY ASSISTANCE REQUIRED	HAZARDS TO PERSONS, PROPERTY OR ENVIRONMENT	
K	ADDITIONAL INFORMATION, COMMENTS, ACTIONS PROPOSED OR TAKEN TO CONTAIN, RECOVER OR DISPOSE OF SPILLED PRODUCT AND CONTAMINATED MATERIALS			

L	REPORTED TO SPILL LINE BY	POSITION	EMPLOYER	LOCATION CALLING FROM	TELEPHONE
M	ANY ALTERNATE CONTACT	POSITION	EMPLOYER	ALTERNATE CONTACT LOCATION	ALTERNATE TELEPHONE

REPORT LINE USE ONLY

N	RECEIVED AT SPILL LINE BY	POSITION STATION OPERATOR	EMPLOYER	LOCATION CALLED YELLOWKNIFE, NT	REPORT LINE NUMBER (867) 920-8130

LEAD AGENCY ☐ EC ☐ CCG ☐ GNWT ☐ GN ☐ ILA ☐ INAC ☐ NEB ☐ TC   SIGNIFICANCE ☐ MINOR ☐ MAJOR ☐ UNKNOWN   FILE STATUS ☐ OPEN ☐ CLOSED

AGENCY	CONTACT NAME	CONTACT TIME	REMARKS
LEAD AGENCY			
FIRST SUPPORT AGENCY			
SECOND SUPPORT AGENCY			
THIRD SUPPORT AGENCY			

PAGE 1 OF ____

3.7 DAILY TANK INSPECTION CHECKLIST

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION	REVISION DATE
3.7	Daily Tank Inspection Checklist	A	July 15, 2014

Baffinland

Daily Fuel Tank Farm Inspection Checklist

Week Ending Date:______________________________

Check box to indicate area inspected:

☐ **Milne Inlet** : main bulk tank facility and distribution / dispensing stations.
☐ **Mary River** : bulk tank facility and distribution / dispensing stations.
☐ Other: ____

All functional areas will be inspected daily.

EMPLOYEE NAME:	M	T	W	T	F	S	S
Visually inspect entire bulk fuel facility, tanks, pipelines and pump buildings.							
Note any alarms or lit warning lamps, and determine cause.							
Check evidence of tank leakage, damage, or any unusual condition.							
Check evidence of pipeline connection leakage or any unusual condition.							
Are all pipe supports solidly in place?							
Check that the correct tank supply valves are open.							
Check condition of catwalks, stairs and building access - clear snow.							
Empty trash containers and remove trash from all areas inside and out.							
Reduce or eliminate drips or seeps where possible.							
Ensure that all drips are cleaned and sorbent pads are regularly changed.							
Ensure that an adequate supply of new sorbent pads are on hand.							
Confirm all listed fire extinguishers are checked.							
Check and confirm the availability and contents of the spill response kits.							
Ensure that electric lighting is adequate and no lamps are burned out.							
Confirm that signs are posted indicating no smoking, no ignition sources.							
Ensure that eyewash and first aid kits are in place.							

Comments: ____

3.8 FUEL TANK DIPPING FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION	REVISION DATE
3.8	Fuel Tank Dipping Form	A	July 15, 2014

Fuel Tank Dipping Form

Tank 1	Top of Flange					
	Dip 1	Dip 2	Dip 3	Final	Temperature	Calculated Volume
Comments or notes						

Tank 2	Top of Flange					
	Dip 1	Dip 2	Dip 3	Final	Temperature	Calculated Volume
Comments or notes						

Tank 3	Top of Flange					
	Dip 1	Dip 2	Dip 3	Final	Temperature	Calculated Volume
Comments or notes						

Tank 4	Top of Flange					
	Dip 1	Dip 2	Dip 3	Final	Temperature	Calculated Volume
Comments or notes						

Tank being Filled (Outlet Valves Open)	
Tank being Consumed from (Inlet Valves Open)	
Light Vehicle Meter reading at dispense	
Refueler Truck Meter reading at dispense	
Dipped By	
Date & Time	
Weather conditions	

NOTE: A MINIMUM OF 2 DIPS FOR EACH TANK ARE REQUIRED. IF THEY ARE DIFFERENT A 3rd DIP IS REQUIRED FOR A 2 DIP MATCH
CHECK FOR ANY SAFETY CONCERNS BEFORE CLIMBING THE STAIRS SUCH AS ICE ON THE STEPS.
ALWAYS HOLD THE HAND RAIL WHEN CLIMBING OR DESCENDING THE STAIRS
BE SURE TO RECORD WHICH TANKS ARE BEING FILLED OR CONSUMED FROM ON THE DIP DAY

PPE REQUIRED FOR DIP
FULL PPE REQUIRED. SPECIAL PPE REQUIRED WILL BE GLOVES FIT FOR PURPOSE, DRESS FOR WEATHER CONDITIONS

TOOLS REQUIRED FOR DIP
CARRY BAG, DIPPING TAPE WITH BRASS WEIGHT TIP, DIPPING THERMOMETER, WIPING RAGS, FUEL & WATER PASTE (Ajax)

3.9 POLAR BEAR READINESS AUDIT FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION	REVISION DATE
3.9	Polar Bear Readiness Audit Form	A	July 29, 2016

Baffinland

Polar Bear Audit

Auditors: ______________________________ Date: ______________________________

Dressing Hardware

- ☐ Two 6 inch Buck Knives
- ☐ Two 4 inch Buck Knives
- ☐ One Sawblade

Fire Arm Approved MRT Members on site

Name	Shift	Room

Preapproved Polar Bear Dressers

Name	Shift	Room

Carcass Sorage Location

Storage location	Temperature

Carcass Delivery Capabilities

Delivery Method	Delivery Timeline

3.10 WILDLIFE LOG

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION	REVISION DATE
3.10	Wildlife Log	C	July 15, 2014

DID YOU SEE ANY WILDLIFE?

LET US KNOW ᐅᒪᔪᓐᓂᒃ

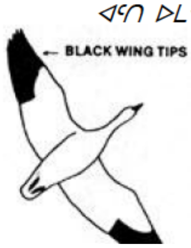
ᑕᑯᓚᐅᖅᐱᑦ ? ᐊᑦᑎ ᖃᐅᔨᑲᖅᑎᒍᑦ

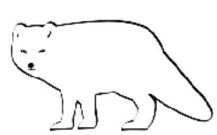
Wildlife observations by site personnel make very important contributions to environmental baseline studies. It is important enough that Baffinland asks you to record any observations of wildlife by listing them on this form.
ᐅᒪᔪᓐᓂᒃ ᖃᐅᔨᓴᖅᑕᕐᓂᖅ ᓴᕕᒃᓴᕐᓂᐊᕐᕕᖕᒥ ᓴᓇᔪᓐᓂᑦ ᐊᑐᕈᑎᖃᑎᐊᕐᒪᑦ ᐊᕙᑎᒥᒃ ᖃᐅᔨᓴᕐᓂᕐᒥᒃ.
ᐊᑐᕈᑎᖃᕐᓂᖓ ᐱᔪᑎᒋᓗᒍ ᐸᕝᕙᓚᑯᑦ ᐃᓕᓯᓐᓂᒃ ᐊᐱᕆᔫᑦ ᐅᒪᔪᓐᓂᒃ ᑕᑯᖕᒐᕕᑦ ᑎᑎᖃᖅᑕᐅᓯᑦ

DATE ᐅᓪᓗᖓ	ANIMAL & HOW MANY? ᐅᒪᔪᖅ ᑭᓯᓚᐅᖅᐸ ᐊᒻᒪᓗ ᖃᔅᓯᐅᓚᐅᖅᐸᑦ ?	WHERE? ᓇᖕᒥ ?	COMMENTS ᐅᖃᐅᓯᑦ

Please leave wildlife alone. Do not feed them and never leave waste behind.

ᐊᑦᑎ ᐅᒪᔪᑦ ᐅᓚᕕᓴᖅᑕᕆᑦᑐᒋᑦ. ᖄᒥᓇᕙᕆᑦᑐᒋᑦ ᐊᒻᒪᓗ ᑕᒪᐅᕆᖁᑐᐃᓇᖅ
ᐃᒋᑎᖅᑕᕆᑦᑐᑎᑦ





3.11 ACTIVE MIGRATORY BIRD NEST SEARCH FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION	REVISION DATE
3.11	Active Migratory Bird Nest Search Form	A	July 29, 2016

Active Migratory Bird Nest Search Form

Survey Date: MM/DD/YYYY	Start Time: 24 hour	End Time: 24 hour

Names of Surveyors:	Total # of Surveyors:

Weather Conditions (Precipitation, Cloud cover, Wind, Temperature) – Note: Surveys should not be conducted in rain, snow or other inclement weather

Description of Search Area (Location – Geographic Place Name or Distance & Direction from Named Location, Size etc.):	Photos of Site:

Survey Map (Include any existing disturbance, water bodies or other geographic features and the location of any nests found)	Waypoint Corners of Search Area (Waypoint #, Latitude, Longitude)
	Waypoint Corner 1:
	Waypoint Corner 2:
	Waypoint Corner 3:
	Waypoint Corner 4:

Number of Nests Found (Details on Page Two)

Nest Observations:

Nest ID #	Waypoint (Waypoint #, Latitude, Longitude)	Species/Species Group	# Eggs/Young
	Description of Nest		Photo Numbers

	Nest Buffer Applied (Size, How it was Determined, How it was Marked)		
Nest ID #	Waypoint (Waypoint #, Latitude, Longitude)	Species/Species Group	# Eggs/Young
	Description of Nest		Photo Numbers
	Nest Buffer Applied (Size, How it was Determined, How it was Marked)		
Nest ID #	Waypoint (Waypoint #, Latitude, Longitude)	Species/Species Group	# Eggs/Young
	Description of Nest		Photo Numbers
	Nest Buffer Applied (Size, How it was Determined, How it was Marked)		
Nest ID #	Waypoint (Waypoint #, Latitude, Longitude)	Species/Species Group	# Eggs/Young
	Description of Nest		Photo Numbers
	Nest Buffer Applied (Size, How it was Determined, How it was Marked)		

3.12 OFF-SITE WASTE DISPOSAL LOG

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.4	Off-Site Waste Disposal Log	C	July 15, 2014

Line	Prov. Code	Shipping Name of Waste (i.e. Kitchen Grease, Contaminated Oily Solid, etc.)	Class	UN	P.G	Quant. Shipped (kg)	Packaging				Phys. State (S, L, G)
							Mine Site	Milne Port	Total	Packaging Type	
Note : PACKAGING TYPE : 01 drum; 02 tank; 03 bulk; 04 carton; 05 bag; 06 roll-off or lugger; 07 other											

3.13 WASTEWATER LOG

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.13	Wastewater Log	A	July 15, 2014

Baffinland

Wastewater Log

Date	Time	Truck ID	No. Loads	Source	Discharge Location	Operator name	Initials

3.14 WATERCOURSE CROSSING DATA MONITORING FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.14	Watercourse Crossing Data Monitoring Form	A	June 4, 2008

CROSSING ID:												
Construction Duration:			**Start:**				**Finish:**					
		Environmental Inspector:				**Start (Date and Time):**			**Finish (Date and Time):**			
Env. Inspector on site during in-water work:												
LOCATION		**Datum:**				**Zone:**						
Easting (m):			**Northing (m):**			**Elevation (from mapping):**			**Other notes:**			
FISH ASSESSMENT PRIOR TO CONSTRUCTION				**Date of Inspection:**								
Fish Present?		**Y / N**		**If Yes, distance from crossing:**					**US / DS**			
Spawning Arctic Char present at crossing?				**Y / N**	**(If yes, contact biologist)**							
Spawning site present 20 m upstream or downstream of crossing?						**Y / N**						
CHANNEL CHARACTERISTICS		**Date Measured:**										
		Pre-Construction					**Post Construction**					
Location	**Distance**	**Width (m)**		**Water Depth (m)**			**Width (m)**		**Water Depth (m)**			
		Wetted	**High W**	**Max**	**Avg.**		**Wetted**	**High W**	**Max**	**Avg.**		
Crossing												
Upstream												
Downstream												

SEDIMENT AND EROSION CONTROL MEASURES	
Measure installed:	**Date installed:**
	Dated removed:
	Turbidity monitored Y / N
Measures taken to stabilize disturbed areas:	

CROSSING INSTALLATION DETAILS			
1.2 m	**culverts**	**lengths of culvert**	**Notes:**
1.0 m	**culverts**	**lengths of culvert**	
0.5 m	**culverts**	**lengths of culvert**	

PHOTOS ***View across crossing, view from upstream, view from downstream and any other to illustrate conditions.***

	Photo #	Date	Direction	Vantage point		Photo #	Date	Direction	Vantage point
Before					**After**				
across					across				
from US					from US				
from DS					from DS				
During					**Sed Con**				
across					across				
from US					from US				
from DS					from DS				

NOTES

3.15 TURBIDITY MONITORING DATA FORM

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.15	Turbidity Monitoring Data Form	A	June 4, 2008

CROSSING ID:

Field Crew:		**Date:**	**Time:**
LOCATION **Datum:**		**Zone:**	
Easting (m):	**Northing (m):**	**Elevation (from mapping):**	**Other notes:**

CURRENT WEATHER: Wind: **Air Temp:** **Precipitation:** **Cloud Cover (%):**

Recent Weather Events:

CONSTRUCTION **Construction Phase (circle one):** Pre-Construction During Construction Post-Construction

Type of Activity: **Equipment in Use:**

Date Construction Began:

Is the crossing location changing? (i.e. Is the crossing moving upstream or downstream of its original location? How far? Which direction?)

SITE SKETCH, NOTES, REMARKS: (i.e. high water table, high turbidity, natural bank erosion, water color, char observed in stream, algae in water, etc.)

Is there anything unique about this crossing compared to other watercourses? (i.e. steep banks, clay in water, etc.)

Substrate Particles **% Areal Coverage (est.)**	**Riparian Vegetation and Shading (describe):**
% sand/silt/clay (<2mm) **% gravel (2 - 64 mm)** **% cobble (64 - 256 mm)** **% boulder (> 256 mm)** **% bedrock**	

***IN SITU* TURBIDITY READINGS** (complete at least one measurement upstream and downstream of crossing)

Meter Make and Model:

Location	Distance from crossing (m)	Turbidity (NTU)	Time	Location	Distance from crossing (m)	Turbidity (NTU)	Time
Upstrea				**Upstream**			
Crossing				**Crossing**			
Dwnstrm				**Downstrea**			

FLOW ESTIMATES **Location :**	
High Water Width (m):	**Distance between points (m):**
Wetted Channel Width:	**Time (min):** /
Approx. Average Depth:	**Surface velocity estimate:**
	Average Velocity (0.8 [(1)] x Surface Velocity) (V) =

Note (1) - depends on substrate composition: 0.8 for rough, loose rocks or coarse gravel / 0.9 for smooth mud, sand, or hard pan rock

PHOTOS: (upstream, crossing, downstream)

NOTES:

3.16 ENVIRONMENTAL INSPECTION FORMS

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
3.13	Environmental Inspection Forms	A	July 15, 2014

Aircraft Fuel Dispensing Areas Inspection Checklist

Date:
Inspecting Personnel:
Camp:

Baffinland

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Is a spill kit present and fully stocked?					
2	Is a drum or disposal bin present for used absorbent pads?					
3	Is there a spill tray present for re-fuelling activities?					
4	Are spill trays damaged or overflowing?					
6	Are fuel lines damaged or leaking?					
7	Does the Jet A fuel tank have visible signs of overflow (ex. stains on the side of the tank)?					
8	Are there visible leaks or free product within the fuel berm?					
9	Is there evidence of leaking or visible staining outside of lined area?					
10	Is there water present in the bermed area? If so, specify maximum water depth.					
11	Is there free phase product visible on any water surface within the bermed area?					
12	Are there signs of instability or tears in bermed areas? (i.e. collapsing berm or exposed liner).					
13	Is there any other refuse present? (i.e. garbage, loose materials, etc.)					

Additional Notes:

Containment Berms and Accommodations Complex Fuel Storage Inspection Checklist

Baffinland

Date:	
Inspecting Personnel:	
Camp:	

Area		Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
Accomodations Complex - Fuel Tanks (Day)	1	Are spill kits present, labelled and fully stocked?					
	2	Is there any visible damage to the fuel tanks?					
	3	Are any lines, fittings, or pipes damaged and/or leaking?					
	4	Are there any fuel stains or visible spills near the fuel storage tanks?					
	5	Are storage tanks protected by cement barriers?					
Containment Berms (Bladder Farm, New Product Berms, Steel Tank Farm)	1	Is a spill kit present, labelled and stocked at each berm?					
	2	Are there visible leaks or stains within or outside the berms?					
	3	Is there water present in the bermed areas? If so, specify maximum water depth.					
	4	Is there free phase product visible on any water surface within the bermed areas?					
	6	Are there signs of instability or tears in bermed areas? (i.e. collapsing berm or exposed liner)					
	7	Are all containers within the berms labelled, stored upright, and in good condition (i.e. free of structural defects)?					
	8	Is there any refuse present? (i.e. garbage, loose materials, etc.)					

Additional Notes:

Hazardous Waste Containment Berm Inspection Checklist

Date:

Inspecting Personnel:

Camp:

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Are spill kits present, labelled, and fully stocked?					
2	Are all containers within the berm correctly labelled, stored upright and in good condition (i.e. free of structural defects)?					
3	Is there evidence of leaking or visible staining outside of lined area?					
4	Is there water present in the bermed area? If so, specify maximum water depth.					
5	Is there free phase product visible on any water surface within the bermed area?					
6	Is there free phase product visible on the ground within the bermed area?					
7	Are there signs of instability or tears in bermed areas? (i.e. collapsing berm or exposed liner)					
8	Is there any other refuse present? (i.e. garbage, loose materials, etc.)					

Additional Notes:

Crusher and Quarry Inspection Checklist

Date:
Inspecting Personnel:
Camp:

Baffinland

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Are hazardous materials and waste being stored in secondary containment?					
2	Are spill kits present, labelled, and fully stocked?					
3	Is explosives packaging (boxes, plastic bags) being burnt in an approved open burn location?					
4	Is ash generated from open burns being transferred and stored in the appropriate drums?					
5	Are waste items being properly sorted and diposed of?					
6	Are the natural drainage patterns of the quarried area still intact?					
7	Are silt fences or settling ponds in place to limit sediment transport into surrounding water bodies?					
8	Is there any signs of pooling water or thawing permafrost?					
9	Are there any fuel stains or visible spills?					
10	Is topsoil or overburden being stockpiled in area away from drainage routes?					
11	Are operators conducting pre-operation checks on their equipment?					
12	Do equipment operators have an adequate amount of spill reponse supplies on board?					

Genset Area Inspection Checklist

Date:
Inspecting Personnel:
Camp:

Area		Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
Genset Area	1	Is a spill kit present, labelled and fully stocked?					
	2	Are spill berms present under the oil drains, hose connections, and any other points of potential leakage?					
	3	Are spill berms in danger of overflowing?					
	4	Is there visible staining under the oil drains or other areas of potential leakage?					
	5	Are any hoses or nozzles cracked, damaged or leaking?					
	6	Are all hazardous waste/materials in secondary containment?					
	7	Is there any other refuse present? (i.e. garbage, loose materials, etc.)					

Additional Notes:

Incinerator and Burnable Waste Storage Inspection Checklist

Date:
Inspecting Personnel:
Camp:

Baffinland

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Is a spill kit present, labelled and fully stocked?					
2	Are fuel lines damaged or leaking?					
3	Are spill trays present at any points of potential leakage in fuel lines? (e.g. hose connections)					
4	Is any burnable waste securely contained within the sea can?					
5	Are any inappropriate waste types present (ex. styrofoam, aerosols, waste batteries)?					
6	Is the surrounding area free of loose debris?					
8	Are there any animal attractants (ex. food waste being left outdoors)?					
9	Is the door to the incinerator securely shut to prevent animal access?					
11	Do all ash drums have lids on them?					
12	Are operators filling out the incinerator log?					
13	Is there signage describing acceptable wastes?					

Additional Notes:

Maintenance Shop Inspection Checklist

Date:
Inspection Personnel:
Camp:

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Are spill trays present and in use at all points of potential leakage?					
2	Are the vehicles needing maintenance leaking? If so, is there a spill tray underneath?					
3	Is there visible staining under areas of potential leakage?					
4	Are all fuel or other hazardous products (e.g. jerry cans, 5 gallon pails, batteries etc.) located in secondary containment?					
5	Is waste properly segregated into labelled containers? (e.g. oil filers, used absorbents etc.)?					
6	Is a spill kit present, labelled, and fully stocked?					
7	Is there any other refuse present? (i.e. garbage, loose materials, etc.)					

Additional Notes:

Accommodations Complex Waste Management Inspection Checklist

Date:
Inspection Personnel:
Camp:

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
	Accommodations Complex					
1	Do the aerosol/waste battery disposal bins contain only the designated waste?					
2	Are the aerosol/waste battery disposal bins properly labelled?					
6	Do the garbage cans contain acceptable wastes (ex. food items and packaging, paper products, small plastics)?					
7	Are garbage cans located in a well ventilated area?					
8	Are signs located over washroom sinks, kitchen sinks etc. indicating acceptable drain waste?					
9	Are signs located in the washroom stalls indictating flushable wastes?					
10	Are the Waste Sorting Guidelines posted throughout the complex?					
11	Is all waste from the kitchen (food product, waste grease etc.) being segregated into the proper bins?					
12	Is all hazardous waste being stored in secondary containment (oils, greases, fuel)?					
13	Are there animal attractants located outside (i.e. food wastes)?					

Additional Notes:

Tent City (Exploration Camp) Inspection Checklist

Date:
Inspecting Personnel:
Camp:

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Are fuel berms present behind each tent?					
2	Are fuel berms structurally sound? (i.e. no rips, tears or leaks)					
3	Are fuel berms in danger of overflowing?					
4	Are fuel drum and fuel drum stands structurally sound? (i.e. punctures, tilting, etc.)					
5	Is there any staining around fuel berms or tents indicating a spill?					
6	Are the fuel lines damaged or leaking?					
7	Is there any refuse present? (i.e. Loose garbage)					
8	Is environmental lab waste stored in a labelled quatrex bag?					

Additional Notes:

Truck Refueling Modules Inspection Checklist

Date:
Inspecting Personnel:
Camp:

Baffinland

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Is a spill kit present and fully stocked?					
2	Is a drum or disposal bin present for used absorbent pads?					
3	Is there a spill tray present for re-fuelling activities?					
4	Are all jerry cans and hazardous materials stored in secondary containment?					
5	Are spill trays damaged or overflowing?					
6	Are lights operational in the sea-can and pump?					
7	Is a re-fuelling SOP present?					
8	Are fuel lines cracked or damaged?					
9	Is there evidence of leaking or visible staining outside of lined area?					
10	Are there visible leaks or stains within the lined area?					
11	Is there any other refuse present? (i.e. garbage, loose materials, etc.)					

Additional Notes:

Tote Road Construction Inspection Checklist

Date:
Inspecting Personnel:
Section of Road Inspected:

	Condition	Y/N or NA	Recommended Corrective Action (if necessary)	Responsible Party	Corrective Action Taken or Plan	Completion Date
1	Are all archaeology sites clearly marked?					
2	Are streams and water bodies within construction zones clearly visible?					
3	Are borrow pits 31 meters away from all streams and water bodies?					
4	Are borrow pits 50 meters away from all archaeological sites?					
5	Is there any signs of construction activity or disturbance within 50 meters of any archaeology site?					
6	Do equipment operators have an adequate amount of spill response supplies on board?					
7	Are operators conducting pre-operation checks on their equipment?					
8	Are there any fuel stains or visible spills?					
9	Are hazardous materials and waste being stored in secondary containment?					
10	Are spill kits present, labelled, and fully stocked at high activity areas (i.e. quarries, borrow pits)?					
11	Are silt fences in place to minimize sediment transport into surrounding water bodies?					
12	Are there any signs of wildlife nearby (i.e. tracks, sightings)?					

Baffinland

Waste Sorting Area Inspection Checklist

Date: ______________________

Time: ______________________

Inspector name: ______________________

Inspector's position: ______________________

Please review and complete the form as applicable. Any non-conformances with the waste sorting area should be reported to the Environment Department.

General Site			
	Yes	No	Corrective Action
Is the route to the waste sorting area in suitable condition to provide truck access?			
Are the waste sorting signs in good condition?			
Are the waste containers upright and in their appropriate locations?			
Does the waste appear to be sorted?			
Is the site clean and free of litter?			
Are there any unacceptable wastes present? (ie. food scraps, cardboard, paper, scrap wood, small plastics or other burnables)			

Waste Sorting Containers						
	Container type* (drum or quatrex)	Quantity	Capacity (Full, half, empty)	Condition (OK, damaged, leaky)	Signage (OK, damaged, missing)	Comments
Aerosol cans						
Used absorbents						
Propane Containers						
Used oil filters						
Waste batteries						
Contaminated hoses						
Mixed waste containers						
Oily plastics						

Additional Comments

____

____

Baffinland

General Environmental Inspection Form

NAME:____________________________ DATE:______________________

AREA(S) INSPECTED:____

____

____

____

ENVIRONMENTAL CONCERNS: ______.____

____

____

CORRECTIVE ACTIONS REQUIRED:____

____

____

____

COMMENTS:____

____

____

Landfill Facility Inspection Form

Date: ____________________
Time: ____________________
Inspector name: ____________________
Inspector's position: ____________________

Please review and complete the form as applicable. Any non-conformances with the landfill should be reported to the Site Manager(s) in writing, for action.

General Site

	Yes	No
Is the route to the landfill in suitable condition to provide truck access?		
If not, describe location and problem.		
Is the unloading area at the working face levelled?		
If not, explain.		
Are the User Rules and Landfill Waste Sorting signs in good condition?		
If not, explain.		
Is the tundra around the outside perimeter of the landfill berm stable?		
If not, describe problem.		
Is open burning occurring or is there evidence of open burning?		
If so, list the applicable permit.		

Surface Water and Site Runoff

Please inspect within landfill area, around berms and follow drainage to observe the following:

	Yes	No
Any pooling of water present within landfill area or against berms?		
If so, where?		
Any leachate developing in and around landfill area?		
If so, where?		
Are culverts draining?		
If not, explain. Ground Frozen		
Is the water flow silt free?		
If not, describe problem. Ground Frozen		
Is site runoff draining properly around landfill and directed towards Sheardown Lake?		
If not, explain. Ground Frozen		

Geotechnical Assessment

Please examine the integrity of the berms and floor of landfill area to observe the following:

	Yes	No
Any evidence of ground temperature warming? e.g. soil creep, subsidence, heaving, etc.		
If so, where?		
Any visible sign of erosion from wind or runoff?		
If so, where?		
Any indication of berm settlement? e.g. low spots or pooling water		
If so, where?		
Does the most recent cell cover have 0.1 m on the face and 0.3 m on the deck?		
If not, how is it?		

Baffinland

Waste Composition, Litter Control and Placement

Please inspect areal placement and contents of landfill to observe the following:

	Yes	No
Is cover material stockpiled?		
Is the working face length as small as practical and below 12 m?		
Is the perimeter litter fences established?		
Are the litter fences capturing the litter?		
Do the wastes appear to be compacted on a regular basis? Recent waste has not been compacted		
Has the site been cleaned of litter in the last two weeks?		
Are there any unacceptable wastes present or proposed for landfill?		

If so, describe in the following table:

Unacceptable Waste Type	None	1-5 pieces	6-10 pieces	>10 pieces
Aerosol cans				
Batteries				
Food				
Food packaging				
Incinerator waste				
Oil contaminated waste				
Oil products and containers				
Other:				
Other:				

Wildlife Observations

Species	Number	Comments

Wildlife Signs (tracks, scats, or chews)

Species	Type of Sign	Number	Comments

Other Comments

Baffinland

PWSP Inspection Form

Date: ____________________
Inspectors: ________________
Inspectors' Positions: ______________
Camp: ____________________________

Pond 1

		Yes	No
1	Is the roadway up to the pond suitable for truck access? If no, please provide an explanation below: ________________________________ ________________________________		
2	Is there any evidence of soil creep or berm displacement along the slope of the berm? ________________________________ ________________________________		
3	Is the berm area free of loose debris? (e.g. garbage, loose materials, etc.) ________________________________ ________________________________		
4	Is there any indication of berm settlement underneath the liner? ________________________________ ________________________________		
5	Are there any unwanted materials floating in the pond? ________________________________ ________________________________		
6	Are there unidentified tears in the liner that need to be repaired?		

Additional comments:
____
____

Pond 2

		Yes	No
1	Is the roadway up to the pond suitable for truck access? If no, please provide an explanation below: ________________________________ ________________________________		
2	Is there any evidence of soil creep or berm displacement along the slope of the berm? ________________________________ ________________________________		
3	Is the berm area free of loose debris? (e.g. garbage, loose materials, etc.) ________________________________		

Baffinland

	______________________________		
4	Is there any indication of berm settlement underneath the liner? ______________________________ ______________________________		
5	Are there any unwanted materials floating in the pond? ______________________________ ______________________________		
6	Are there unidentified tears in the liner that need to be repaired?		

Additional comments:

____

____

____

Pond 3

		Yes	No
1	Is the roadway up to the pond suitable for truck access? If no, please provide an explanation below: Access road to Pond # 1 not accessible, snowdrift build up ______________________________ ______________________________		
2	Is there any evidence of soil creep or berm displacement along the slope of the berm? ______________________________ ______________________________		
3	Is the berm area free of loose debris? (e.g. garbage, loose materials, etc.) ______________________________ ______________________________		
4	Is there any indication of berm settlement underneath the liner? ______________________________ ______________________________		
5	Are there any unwanted materials floating in the pond? ______________________________ ______________________________		
6	Are there unidentified tears in the liner that need to be repaired?		

Additional comments: ______________________________

____

4 REQUEST FOR REVISION TO AN OPERATIONAL ENVIRONMENT STANDARD

SECTION	OPERATIONAL ENVIRONMENT STANDARD	REVISION #	REVISION DATE
4.0	Request for Revision to an Operational Environment Standard	C	July 15, 2014

The Environmental Protection Plan is a living document, and its users are encouraged to suggest changes to the content or wording of Operational Environment Standards to make the document more useful, appropriate to the work being conducted, and user-friendly.

Please submit a copy of this Request for Revision to an Operational Environment Standard to the Baffinland Environmental Superintendent.

Section To Be Revised (or Title of New Operational Environment Standard): (E.g. Section 2.1 Archaeology)
Nature of Proposed Change: (E.g. update, addition, new, etc.)
Rationale For Request (E.g. Environmental Protection, worker safety, etc.)
The Revision (or New Operational Environment Standard): (Text)

Appendix A -
Polar Bear Readiness Procedure and Audit

POLAR BEAR READINESS PROCEDURE AND AUDIT

Introduction

The purpose of this document is to ensure that all Polar Bear incidents are documented and promptly reported to regulators and that all preparation and requirements regarding Polar Bear mortalities are in place. The Polar Bear Safety Plan should be referenced for additional information pertaining to Polar Bear Mortalities.

Reporting Requirements

In the event of a Polar Bear mortality QIA, HTO and the GN Wildlife Officer must be notified within 2 hours of the kill.

QIA
Mr. David Qamaniq, Acting QIA Environmental Monitor, (867) 899-8640, dqamaniq@qia.ca
Mr. Stephen Bathory, Acting QIA Environmental Monitor, (867) 975-8400, swbathory@qia.ca.

HTO
Mrs. Rebecca Mikki, HTO Manager (Igloolik), (867) 934-8807, igloolikhto@gmail.com
Mr. David Arreak , HTO Manager (Pond Inlet), (867) 899-8856, htopond@qiniq.com

Government of Nunavut Wildlife Officer
Mr. George Koonoo, Wildlife Officer, (867) 899-1330, pondwildlife@qiniq.com

Preparations and Procedure

Firearm use

Only pre-approved designated individuals that are active MRT members who have documented their Possession and Acquisition licence with Security are authorised to shoot a Polar Bear.

Dressing

A preapproved Inuit worker documented by Human Resources with the experience and expertise will attend to field dressing, gutting, skinning, and cutting the carcass, if an on-site QIA representative does not identify a desired individual. A Wildlife Carcass Dressing Kit consisting of two 6 inch blades, two 4 inch blades and one sawblade will be provided by the Environment Department.

In the event of polar bear mortality, the following parts must be preserved and delivered to the Conservation Officer:

i. The lower jaw or an undamaged post-canine tooth,
ii. Any lip tattoos present,
iii. Any radio collars or ear tags present, and
iv. Evidence of sex (i.e. penis/baculum).

Carcass Storage

All salvageable parts of the carcass must be delivered to the designated community within 24 hours of the kill if possible. Prior to being delivered and to avoid spoilage, all salvageable wildlife parts must be promptly and safely stored in a refrigerated place. The meat and salvageable parts should not be stored in a c-can or be allowed to spoil.

Polar Bear Audit

Auditors: ______________________________ Date: ______________________________

Dressing Hardware

☐ Two 6 inch Buck Knives

☐ Two 4 inch Buck Knives

☐ One Sawblade

Fire Arm Approved MRT Members on site

Name	Shift	Room

Preapproved Polar Bear Dressers

Name	Shift	Room

Carcass Storage Location

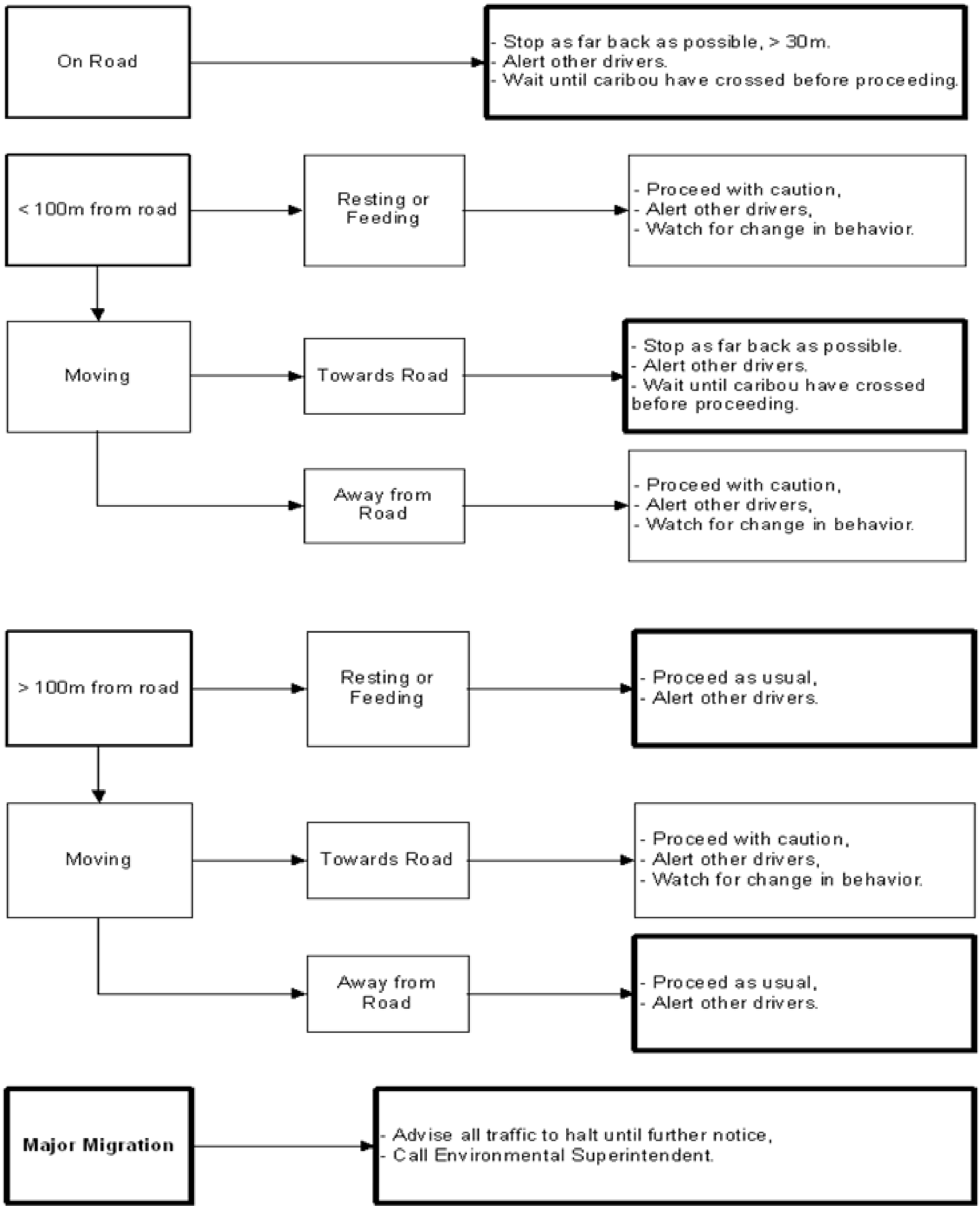
Storage location	Temperature

Carcass Delivery Capabilities

Delivery Method	Delivery Timeline

Comments:

Appendix B-
Caribou Encounters Decision Tree


On Road
- Stop as far back as possible, > 30m.
- Alert other drivers.
- Wait until caribou have crossed before proceeding.
< 100m from road
Resting or Feeding
- Proceed with caution,
- Alert other drivers,
- Watch for change in behavior.
Moving
Towards Road
- Stop as far back as possible.
- Alert other drivers.
- Wait until caribou have crossed before proceeding.
Away from Road
- Proceed with caution,
- Alert other drivers,
- Watch for change in behavior.
> 100m from road
Resting or Feeding
- Proceed as usual,
- Alert other drivers.
Moving
Towards Road
- Proceed with caution,
- Alert other drivers,
- Watch for change in behavior.
Away from Road
- Proceed as usual,
- Alert other drivers.
Major Migration
- Advise all traffic to halt until further notice,
- Call Environmental Superintendent.

Appendix C - Mary River Active Migration Bird Surveys Protocol

Table 1. Recommended setback distances for activity near bird nests.

Species Group	Recommended Setbacks Distances (m)	
	Pedestrian / ATV's	Roads/Construction/Inustrial Activity
Songbirds	30	100
Shorebirds	50[a]	100[a]
Terns & Gulls	200[b]	300[b]
Ducks	100	150
Geese	300	500
Loons & Cranes	500	750

a For nests of American Golden Plover or Ruddy Turnstone, these setbacks should be increased to 150 m for pedestrians/ATVs and 300 m for Roads/Construction/Industrial Activities respectively. For nests of Black-bellied Plover, Whimbrel, or Red Knot, these setbacks should be increased to 300 m for pedestrians/ATVs and 500 m for Roads/Construction/Industrial Activities. If field crews are untrained in the identification of these species, then the higher setbacks should be applied for all shorebird species. In areas where several species are nesting in proximity, setbacks for the most sensitive species should be used if they are present.

b For project activities in proximity to nests of Ross's Gull these setbacks should be increased to 500 m for pedestrians/ATVs and 750 m for Roads/Construction/Industrial Activities. The draft Recovery Strategy for Ivory Gull currently identifies the area within a 2 km radius around colonies where at least one individual was observed nesting any time between 2002 and 2009 as Critical Habitat. As a precautionary approach, a 2 km setback should also be applied to any Ivory Gull nest that is encountered in an area that is not currently identified as Critical Habitat in the Recovery Strategy.

For further information, contact Baffinland's on-site Environment Team, or Environment Canada at

Director, Prairie and Northern Region, Canadian Wildlife Service, Environment Canada
Twin Atria Building, Room 200, 4999–98 Avenue, Edmonton AB, T6B 2X3
Phone: 780-951-8850

Further information on incidental take is available on the internet (as of June 2012):
http://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=FA4AC736-1

EDI ENVIRONMENTAL DYNAMICS INC.

Baffinland Iron Mines Corporation

Mary River Active Migratory Bird Nest Survey (AMBNS) Protocol

ALL ACTIVE BIRD NESTS ARE PROTECTED FROM DISTURBANCE

Federal government regulations protect all active migratory bird nests from disturbance and destruction. Baffinland is committed to the protection of all active bird nests and this AMBNS protocol will be used during the Mary River Project's construction and operation. From 31 May to 31 August, when disturbance (clearing) or other industrial activities occur in previously undisturbed areas, Baffinland will conduct AMBNSs and protect nests and nesting birds with no disturbance buffers around active nests. This guide provides an overview of how to conduct an AMBNS and establish appropriate no disturbance buffers.

Background

The Migratory Birds Regulations, under the Migratory Birds Convention Act (MBCA), 1994, prohibit the harming of migratory birds and the disturbance or destruction of their nests and eggs. The inadvertent destruction of nests and eggs from industrial activity is called "incidental take" and is illegal. Environment Canada, responsible for the MBCA, expects that Baffinland will exercise due diligence to avoid harm to migratory birds, their nests, eggs, and young.

To avoid conflict with nesting birds, clearing should be completed outside of the migratory bird nesting season. In the Mary River Project area, bird nesting activity can occur from 31 May to 31 August. In the event that clearing unavoidably overlaps with the breeding bird season, Baffinland will conduct Active Migratory Bird Nest Surveys (AMBNS) and establish no-disturbance buffers to reduce the likelihood of disturbing or destroying active nest.

APPENDIX F2

AQUATIC EFFECTS MONITORING PLAN

Baffinland Iron Mines Corporation

AQUATIC EFFECTS MONITORING PLAN

BAF-PH1-830-P16-0039

Rev 1

Prepared By: Jim Millard
Department: Environment
Title: Environmental Manager
Date: October 30, 2015
Signature:

Approved By: Oliver Curran
Department: Sustainable Development
Title: Director, Sustainable Development
Date: October 30, 2015
Signature:

DOCUMENT REVISION RECORD

Issue Date MM/DD/YY	Revision	Prepared By	Approved By	Issue Purpose
06/27/14	0	Jim Millard	Oliver Curran	Part I, Item 2 of Type A Water Licence No. 2AM-MRY1325
10/30/15	1	William Bowden		Part I, Item 2 of Type A Water Licence N0. 2AM-MRY1325 Amendment No.1

Index of Major Changes/Modifications in Revision 1

Item No.	Description of Change	Relevant Section
1	Updated: Issued date and scope of Type A Water Licence 2AM-MRY1325 – Amendment No.1 pertaining to the AEMP	Section 1.1
2	Updated: Reference to monitoring MS-08 and Mine pit discharge	Section 2.1.1
3	Updated: Water consumption restrictions under the Amended Type A Water Licence	Section 2.2
4	Updated: Additional Water licence sites established for hydrological monitoring	Section 3.3
5	Updated: Hydrometric stations operated in consideration of the Water Survey of Canada's national standards	Section 3.3
6	Updated: Additional new monitoring stations and status; Table 3.2 Established SNP Monitoring Stations Associated with ERP	Section 3.5
7	Updated: Additional SNP monitoring stations; Figure 3.2 Mine Site Surveillance Network Program (SNP)	Section 3.5
8	Updated: Additional SNP monitoring stations; Figure 3.3 Milne Port Surveillance Network Program (SNP)	Section 3.5
9	Updated: Status of Table 3.3 Future SNP stations Associated with ERP	Section 3.5
10	Updated: Tote Road Monitoring details prescribed under the Amended Type A Water Licence	Section 3.6.1
11	Updated: Lake Sedimentation Monitoring Program methodology justification	Section 4.3.1
12	Updated: Stream Diversion Barrier Study methodology justification	Section 4.3.3
13	Updated: Preferred and alternative statistical methodology	Section 5.2

TABLES

FIGURES

APPENDICES

ABBREVIATIONS

*** Project	the project
AANDC	Aboriginal Affairs and Northern Development Canada
AEMP	the Aquatic Effects Monitoring Plan
ANFO	Ammonium Nitrate Fuel Oil
BC MOE	Ministry of the Environment
CanNor	Canadian Northern Economic Development Agency
CCME	Canadian Council of Ministers of the Environment
CES	Critical Effect Size
CREMP	Core Receiving Environmental Monitoring Program
CWQG-PAL	Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life
DFO	Department of Fisheries and Oceans
EC	Environment Canada
EDA	Exploratory Data Analysis
EEM	Environmental Effects Monitoring Program
ERP	Early Revenue Phase
ETMF	Exposure Toxicity Modifying Factors
FEIS	Final Environmental Impact Statement
HADD	Harmful Alternation, Disruption or Destruction of Fish Habitat
INAC	Indian and Northern Affairs Canada
MHTO	Mittimatalik Hunters and Trappers Organization
MMER	Metal Mining Effluent Regulations
NLCA	Nunavut Land Claims Agreement
NSC	North/South Consultants Inc.
NWB	Nunavut Water Board
QIA	Qikiqtani Inuit Association
ROM	Run-of-Mine
SDA	Statistical Data Analysis
SNP	Surveillance Network Program
SSWQO	Site-specific Water Quality Objective
TAP	Technical Advisory Panel
TEMMP	Terrestrial Environment Management and Monitoring Plan
TEWG	Terrestrial Environment Working Group
TOC	Total Organic Carbon
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
VECs	Valued Ecosystem Components
WWTF	Wastewater Treatment Facility

1 INTRODUCTION

This Aquatic Effects Monitoring Plan (AEMP) describes how monitoring of the aquatic environment will be undertaken at the Mary River Project. The AEMP was identified as a follow-up monitoring program in Baffinland`s Final Environmental Impact Statement (FEIS; Baffinland, 2012) and is prescribed by Baffinland`s Type A Water Licence No. 2AM-MRY1325 Amendment No. 1. The AEMP is a monitoring program designed to:

- Detect short-term and long-term effects of the Project's activities on the aquatic environment resulting from the Project;
- Evaluate the accuracy of impact predictions;
- Assess the effectiveness of planned mitigation measures; and
- Identify additional mitigation measures to avert or reduce unforeseen environmental effects.

The AEMP focuses on the key potential impacts to freshwater environment valued ecosystems components (VECs), as identified in the FEIS and the Addendum to the FEIS (FEIS Addendum; Baffinland, 2013a) for the Early Revenue Phase (ERP). The freshwater VECs are:

- Water quantity;
- Water and sediment quality; and
- Freshwater biota and fish habitat.

The AEMP has been structured to serve as an overarching 'umbrella' that conceptually provides an opportunity to integrate results of individual but related aquatic monitoring programs. Table 1.1 describes the organization of the AEMP document.

Table 1.1 AEMP Document Organization

Section	Heading	Description
1	Introduction	The scope of the AEMP, the applicable regulatory requirements for an AEMP, and consultation undertaken during its development.
2	Problem Formulation	An overview of key issues and pathways in which the Project may affect freshwater aquatic valued ecosystem components (VECs). Potential issues and concerns are also presented by project component and water management area.
3	AEMP-Related Programs	A brief description of ongoing monitoring programs that are peripheral to but may inform monitoring as part of the AEMP.
4	AEMP Component Studies	A summary of the various long-term and targeted component studies included under the AEMP umbrella, for which detailed study designs are presented in appendices.
5	Assessment Approach and Management Response	A description of the process used to develop benchmarks for comparison for the various AEMP components (i.e., water, sediment, nutrients, and biota) and the common approach to reviewing and assessing monitoring data and implementing action if necessary.
6	Quality Assurance and Quality Control	An overview of the QA/QC measures to be implemented in the collection of samples and the handling of data, for the various aquatic components.
7	Annual Reporting	A description of the content and frequency of reporting under the AEMP
8	List of Contributors	Key Baffinland staff and consultants involved in the development of the AEMP

Section	Heading	Description
9	References	Documents referenced in the report

The AEMP targets flows, water and sediment quality, primary productivity (phytoplankton), benthic community structure and fish (specifically Arctic Char) within the streams and lakes potentially affected by project activities. Development of individual monitoring programs/studies under the umbrella AEMP has allowed for the application of a common platform in terms of study design and sampling protocols.

The following are the component studies that comprise the AEMP:

- **Environmental Effects Monitoring (EEM) Program**, as required under the Metal Mining Effluent Regulations (MMER);
- **Core Receiving Environment Monitoring Program (CREMP)**, which includes monitoring of the core mine site area (water, sediment, benthic invertebrates and fish);
- **Lake Sedimentation Monitoring Program**, evaluating baseline and project-influenced lake sedimentation rates;
- **Dustfall Monitoring Program**, evaluating dustfall rates in proximity to the road, port and mine; and
- **Stream Diversion Barrier Study**, an initial study evaluating potential for fish barriers under natural conditions and due to Project-related stream diversions.

The EEM Program is a legal requirement of metal mines such as the Mary River mine. The Draft EEM Cycle One Study Design has been included under the umbrella of the AEMP and follows a separate but related regulatory function. Baffinland proposes to meet the requirements of the MMER on its own, but report the outcome of EEM monitoring as part of the AEMP.

The CREMP forms the backbone of the AEMP. The CREMP is a detailed aquatics monitoring program intended to complement and expand the scope of an EEM Program required under the MMER. The CREMP is intended to monitor the effects of multiple stressors on the aquatic environment, including the discharge of mine effluents and treated sewage effluent as well as ore dust deposition. The CREMP will include the monitoring of water, sediment, phytoplankton, benthic invertebrates and fish in the mine site area streams and lakes.

Specific effects monitoring (or targeted monitoring) is defined as monitoring conducted to address a specific question or potential impact and/or studies that are relatively confined in terms of spatial and/or temporal scope. Targeted environmental studies relate to specific environmental concerns that require further investigation or follow-up but are not anticipated to be components of the core monitoring program. The Lake Sedimentation Study, Dustfall Monitoring Program, and the Stream Diversion Monitoring Study are such studies.

Stand-alone study designs have been prepared. These are briefly described in Section 4 and are included in the appendices of this report. Table 1.2 lists and provides a description of the stand-alone study designs and related technical support documents.

Monitoring prescribed under the related and water licence prescribed Surveillance Network Program (SNP) focuses on detecting short-term project-related effects. The AEMP is designed to detect project-related impacts at greater temporal and spatial scales that are ecologically relevant (i.e., on a basin spatial scale).

The AEMP is a living document that is expected to be updated periodically throughout the life of the mine to account for the close-out of shorter-term monitoring programs, changes in study designs that are driven by the findings of monitoring or changes to the Project, and new information in the field of aquatic effects monitoring including updated toxicological data.

The AEMP components and the relationship of the AEMP to the Water Licence and other aquatic monitoring activities are shown on Figure 1.1.

Table 1.2 AEMP Component Studies and Technical Support Documents

Appendix	Document Title	Description
Appendix A	Draft EEM Cycle One Study Design	A draft of the initial (cycle one) study design report, which will be formally submitted to Environment Canada 12 months from initial date when Mine was subject to the Metal Mining Effluent Regulations (MMER)
Appendix B	Water and Sediment Quality Review and CREMP Study Design	Presents the water and sediment quality CREMP including a review of the water and sediment quality baseline
Appendix C	Development of Water and Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project	A technical document describing the process and outcome for development of benchmarks for application in the water and sediment quality CREMP
Appendix D	Core Receiving Environment Monitoring Program: Freshwater Biota	Presents the freshwater biota CREMP including a review of the freshwater biota baseline
Appendix E	Candidate Reference Lakes: Preliminary Survey 2013	Presents work completed to date on candidate reference lakes, supporting the CREMP.
Appendix F	Lake Sedimentation Monitoring Program	A targeted study on baseline and project-influences lake sedimentation rates
Appendix G	Dustfall Monitoring Program	The dustfall monitoring program contained in the Terrestrial Environment Management and Monitoring Plan (TEMMP; Baffinland, 2014)
Appendix H	Initial Stream Diversion Barrier Study	A targeted study on monitoring the effects of Project-related Stream Diversion

1.1 WATER LICENCE REQUIREMENTS

The Nunavut Water Board (NWB) issued Type A Water Licence No: 2AM-MRY1325 to Baffinland on June 10, 2013. The licence is valid for 12 years, expiring on June 10, 2025.

Part I of the licence outlines conditions related to general and aquatic effects monitoring. Part I (1) approved with the issuance of the water licence for the construction phase of the Project an AEMP Framework prepared in February 2013 (Baffinland, 2013b). Part I (1) also required Baffinland, upon further consultation, submit a revised AEMP Framework that considered recommendations received during the final technical review and public hearing during the water licensing process. An Updated AEMP Framework was submitted to the Nunavut Water Board on November 29, 2013 (Baffinland, 2013c).

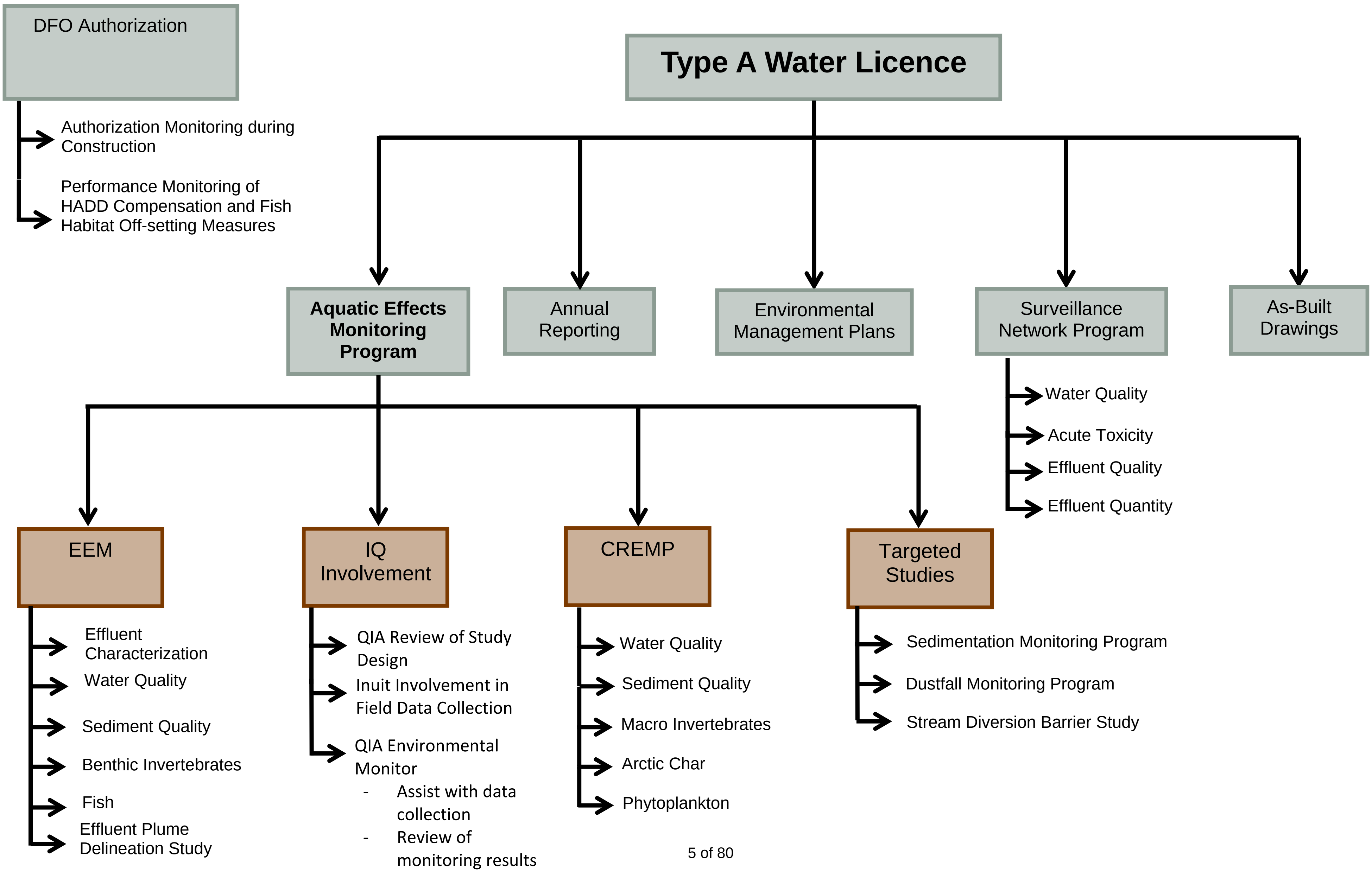
Part I (2) of the licence requires Baffinland to submit to the board for approval in writing an Aquatic Effects Management Plan (AEMP) at least 60 days prior to commencing the operating phase of the project. This document will be submitted to the NWB in fulfillment of this requirement.

On September 2, 2015 The Nunavut Water Board (NWB) issued the Type A Water Licence No: 2AM-MRY1325 Amendment No.1 to Baffinland. The Amended Licence incorporates the entire scope of the

Type "B" Water Licences Nos. 8BC-MRY1314 and 8BC-MRY1416, issued to the Mary River Project for construction and site preparation work; specific elements on the scope of Type "B" Licence No 2BE-MRY1421, issued to the project for Exploration and Bulk Sample Programs; most of the scope of the Amendment No.1 Application, which includes the Early Revenue Phase (ERP) activities and facilities.

Part I, Item 2 requires Baffinland to submit to the board for approval in writing a revised version of the AEMP 60 days following the issuance of the Amended Type A Water Licence. The submission of this document satisfies this condition once approved

Figure 1.1 AEMP Components and Relationship to Other Monitoring Programs



1.2 RELEVANT PROJECT CERTIFICATE CONDITIONS

NIRB issued Project Certificate No. 005 to Baffinland on December 28, 2012. Through 2013 and the first half of 2014, Baffinland sought an amendment to its Project Certificate (PC) to allow for an Early Revenue Phase (ERP) of the Project. At the time of writing, the NIRB Board and the federal Minister of Aboriginal Affairs and Northern Development Canada (AANDC) have approved the Project in writing and NIRB hosted a project certificate workshop. NIRB has issued a final hearing report for the ERP identifying proposed amendments and additions to the terms and conditions in PC No. 005 (NIRB, 2014). Baffinland anticipates that an amended PC will be received in the near future.

A number of Project Certificate terms and conditions (PC Conditions) relate to the protection of the aquatic environment, namely #16 through 19 (hydrology and hydrogeology); #20 through 24 (ground and surface waters); and #41 through 48 (freshwater aquatic environment including biota and habitat). PC Conditions not captured directly by permits, licences, authorizations and approvals (including the Type A Water Licence Amendment No. 1) have been incorporated into the various management plans required by the Type A Water Licence Amendment No. 1 and/or the PC No.005.

PC Condition #21 relates specifically to the AEMP, and states the following (from NIRB, 2014):

The Proponent shall ensure that the scope of the Aquatic Effects Monitoring Plan (AEMP) includes, at a minimum:

a. monitoring of non-point sources of discharge, selection of appropriate reference sites, measures to ensure the collection of adequate baseline data and the mechanisms proposed to monitor and treat runoff, and sample sediments; and

b. measures for dustfall monitoring designed as follows:

i. To establish a pre-trucking baseline and collect data during Project operation for comparison;

ii. To facilitate comparison with existing guidelines and potentially with thresholds to be established using studies of Arctic char egg survival and/or other studies recommended by the Terrestrial Environment Working Group (TEWG); and,

iii. To assess the seasonal deposition (rates, quantities) and chemical composition of dust entering aquatic systems along representative distance transects at right angles to the Tote Road and radiating outward from Milne Port and the Mine Site.

The AEMP addresses Part (a) of PC Condition #21. Part (b) overlaps with the current dustfall monitoring program described in the TEMMP (Baffinland, 2014). The existing dustfall monitoring program from the TEMMP is included in Appendix G. Interpretation of the dustfall monitoring data in relation to the aquatic environment forms part of the lake sedimentation targeted study described in Section 4.3.1 and Appendix F.

1.3 CONSULTATION DURING DEVELOPMENT OF THE AEMP

Baffinland would like to acknowledge the participation and contributions of a number of stakeholder agencies in the development of this AEMP:

- Aboriginal Affairs and Northern Development Canada (AANDC);
- Canadian Northern Economic Development Agency (CanNor);
- Department of Fisheries and Oceans Canada (DFO);

- Environment Canada (EC);
- Nunavut Water Board (NWB); and
- Qikiqtani Inuit Association (QIA).

The above organizations were invited and participated in workshops and on-line presentations, and reviewed various iterations of an AEMP Framework document that was circulated. Key consultation activities in the development of this AEMP are listed in Table 1.3.

Table 1.3 Consultation during AEMP Development

Date	Activity
July 6, 2012	Initial AEMP Consultation Meeting by WebEx
November 13, 2012	Conceptual Framework Development Workshop, 1-day workshop held in-person and by WebEx at Hatch Associated Ltd. Offices in Mississauga
December 12, 2012	Draft AEMP Framework filed with NWB and circulated to interested parties
January 14-18, 2013	Technical Meetings on the Type A Water Licence Application, held in Pond Inlet
February 12, 2013	Second AEMP Framework Development Workshop, 1-day workshop held in-person and by WebEx at Hatch Associated Ltd. Offices in Mississauga
February 26, 2013	AEMP Framework filed with NWB and circulated to interested parties
April 23-25, 2013	Final Hearings for the Type A Water Licence Application, held in Pond Inlet
November 15, 2013	Draft Updated AEMP Framework circulated to interested parties
November 21, 2013	WebEx Presentation on Draft Updated AEMP Framework with interested parties
November 29, 2013	Updated AEMP Framework filed with NWB and circulated to interested parties in accordance with Part I, Section 1 of the Type A Water Licence
April 3, 2014	WebEx meeting presenting refined AEMP component study plans to appear in this AEMP document

As mentioned above, Baffinland is grateful for the participation and contributions of the interested parties listed above.

2 PROBLEM FORMULATION

2.1 PROJECT DESCRIPTION

The Project is an iron ore mine with a production rate of 21.5 Mt/a, consisting of the following major components:

- Milne Port;
- Mine Site;
- Railway; and
- Steensby Port.

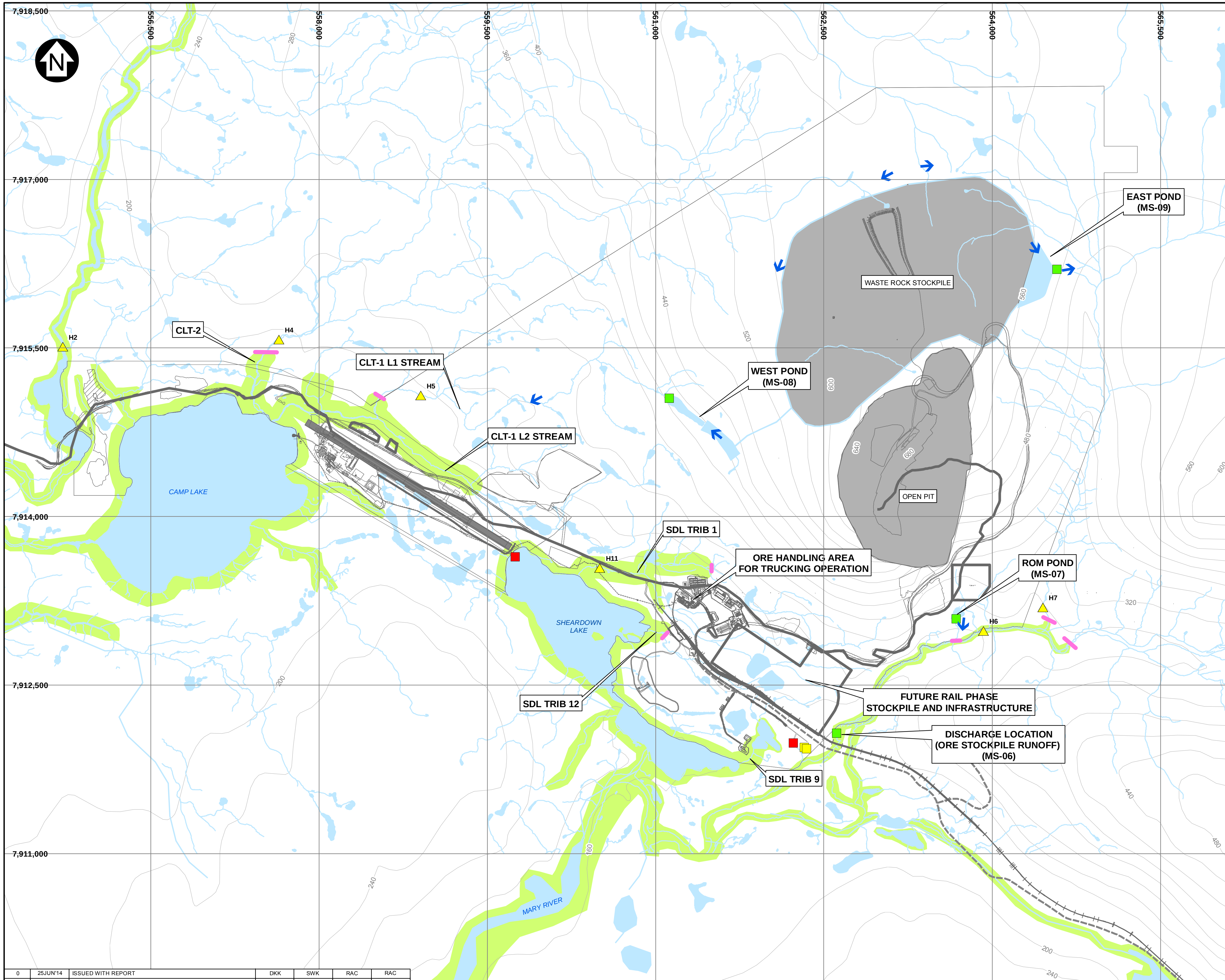
Each development site (excluding the railway) will have all the facilities it needs to operate effectively including maintenance and administrative buildings, warehouses and laydown areas, ore stockpiles and associated runoff management facilities, camps, water supply, wastewater treatment plants, waste management facilities including landfills, power generation, fuel depots, telecommunication facilities, and airstrips.

Baffinland is approved to mine Deposit No. 1 at the mine site by open pit mining methods. Since the Mary River iron ore is of a very high-grade, there is no need to have a process plant (or mill) on site, resulting in no tailings being generated. As such, no tailings pond will be required. This is accomplished by crushing and screening of the ore to produce two iron ore products:

- Lump ore – sized between 6.3 mm and 31.5 mm (about golf ball size); and
- Fine ore - sized less than 6.3 mm (about pea size).

Ore will be stockpiled at the mine site and transported either by truck to Milne Port or by railway to Steensby Port. Ore handling facilities at the mine site will consist of the open pit, separate ore stockpiles for the trucking and railway operations, and water management facilities to collect runoff from ore stockpiles. Waste rock will be stockpiled in a single stockpile next to the open pit, and up to two ponds will collect runoff from the stockpile. The trucking and railway operations will have separate ore stockpiles and runoff collection ponds but will otherwise share common water management facilities and final discharge points (Figure 2.1).

Mining began September 2014 with a low-capital trucking operation involving the mining of 3.5 million tonnes per annum (Mt/a) of iron ore being transported year-round by truck to Milne Port, with marine shipping to market during the open water season. Ore handling facilities at Milne Port consist of truck unloading facilities, ore stockpiles and ship-loading facilities at an ore dock. Runoff from the stockpile area at Milne Port will be collected inponds that will discharge to the marine waters of Milne Inlet. Environment Canada has advised Baffinland that the mine effluent discharge to Milne Inlet will not be subject to the MMER, though the *Fisheries Act* still apply, including Section 36(3) regarding the prohibition of discharges of a deleterious substance in waters frequented by fish (Anne Wilson, pers.comm.) Monitoring of effects to the marine environment is beyond the scope of this AEMP.



LEGEND:

- MINE EFFLUENT FINAL DISCHARGE POINT
- SUMMER DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT
- WINTER LAND DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT TO MARY RIVER
- STREAM FLOW GAUGING STATION
- FISH BARRIER
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- CONFIRMED ARCTIC CHAR HABITAT

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.
5. ARCTIC CHAR HABITAT (PRESENCE) FROM NSC, 2012 MARY RIVER PROJECT FRESHWATER AQUATIC BASELINE SYNTHESIS. REPORT: 2005-2011.

SCALE 250 125 0 250 500 750 1,000 1,250 1,500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MINE SITE LAYOUT

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	1

FIGURE 2.1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAC

SAVED: I:\102\00181\34\A\GIS\Figs\B53_r0.mxd; Jun 26, 2014 3:57 PM; asimpson

At some point in the future when the iron ore market and economic conditions for financing capital-intensive projects improves, an 18 Mt/a railway operation will be constructed. This will involve the construction and operation of a 149-km railway to Steensby Port. Steensby Port, once constructed, will be equipped with a railway car dumper and associated conveying equipment, an ore stockpile, and ship-loading facilities to load ore onto ice-breaking ore carriers.

Shipping of ore from Steensby Port will take place year-round. Runoff from the ore stockpile at Steensby Port will be collected and discharged to the marine waters in Steensby Inlet. Environment Canada similarly advised that the mine effluent discharge to marine waters from the ore stockpile at Steensby Port would not be subject to the MMER but would otherwise be subject to the *Fisheries Act*.

A number of proven mitigation measures have been included in the Project to reduce potential effects on water quality, freshwater fish, fish habitat, and other aquatic organisms. At each of the ore handling locations, crushers and screens will be installed inside buildings, and conveyors will be covered and equipped with wind ventilation hoods to reduce wind exposure and the potential for dust generation. All ventilation ducts will be routed to dust collectors which will limit dust emissions. Specific management plans detail the many ways that water will be protected (Baffinland, 2012).

The operational life of the Project, based on current ore reserves and a production rate of 21.5 Mt/a, is 21 years. The Closure of the facilities is expected to be carried out over a three to five year period and post-closure monitoring will follow for an additional five years. If closure objectives are not met, post closure would extend beyond five years.

2.1.1 Water Management Facilities and Final Discharge Points

A total of four ponds will collect runoff from stockpiles and the open pit at the mine site:

- West Pond – will collect runoff from the west side of the waste rock stockpile;
- East Pond – will collect runoff from the east side of the waste rock stockpile;
- ROM Pond – will collect runoff from the ROM stockpile; and
- Ore Stockpile Pond – will collect runoff from the ore stockpiles. Initially this will be one smaller pond for the ERP, and eventually a second pond will be constructed to support the rail phase.

Monitoring of the Waste Rock Pile (MS-08) in a settling pond commenced during the summer of 2015 which coincided with the early development of the waste rock pile. Currently, the pit has not developed sufficiently to the point that there is a sump with active discharge. A suitable monitoring location and analytical schedule will be established once this has occurred.

Mine effluent will be discharged to two watercourses (Figure 2.1):

- Mary River; and
- Camp Lake Tributary 1.

There will be three final discharge points that will discharge mine effluent to the Mary River as follows:

- East Pond discharge collecting stormwater from the east side of the waste rock stockpile;
- Run-of-mine (ROM) stockpile discharge; and
- Ore stockpile discharges (trucking and rail phases) at the rail load-out area

There will be one final discharge point to Camp Lake Tributary 1, from the West Pond collecting stormwater from the west side of the waste rock stockpile.

2.1.2 Stream Diversions

The development of the open pit, a waste rock stockpile, and associated water management facilities (ditches, berms and settling ponds) will divert and redirect runoff away from certain watercourses during the operational phase of the Mary River Project (Baffinland, 2012). Five tributary streams are anticipated to be affected by diversions in the Mine Area (Figure 2.1).

The reduced production rate associated with the ERP will result in a considerably smaller mining footprint (open pit and waste rock stockpile) than associated with the future rail phase. As such, Project-related stream diversions will be negligible during the ERP.

A discussion of the Project's effects on the freshwater VECs follows.

2.2 WATER QUANTITY

Article 20 Inuit Water Rights of the Nunavut Land Claims Agreement (NLCA) formally recognizes the importance of water quantity and flow to the Inuit. Under the NLCA, Inuit require compensation if a project or activity will substantially affect the quantity of water flowing through Inuit-Owned Lands. Therefore, water quantity has been identified as a VEC. The water quantity VEC can be defined as the spatial and temporal variability of the volume of water within the RSA that may be subject to alteration by Project activities.

Conditions applying to water use and management have been outlined in Part E of the Water Licence (NWB, 2013). These conditions will be adhered to throughout applicable timeframe of this licence. The current limits on water use in the Type A Water Licence Amendment No.1 are 1,888 m^3/day and 689,000 m^3/year total water use from all sources during the construction phase, and 967 m^3/day or 353,000 m^3/year during the operation phase, for total domestic camp and industrial water use from all sources.

<u>Key Issues and Pathways for Water Quantities</u>

Key issues identified for freshwater quantity are listed below:

- Water Withdrawal;
- Water Diversion (stream diversion or changes to flow patterns in a specific watershed); and
- Runoff or effluent discharge.

<u>Key Indicators and Benchmarks</u>

The key indicators for water quantity are listed below:

- Water withdrawn for consumption (measured in cubic metres – m^3); and
- Streamflow increase or decrease (measured as a percent change of mean).

The benchmarks are the water quantities authorized under the Type A Water Licence Amendment No.1.

<u>Diversions, Drainage Flows (Runoff) and Effluent Discharges</u>

Diversions, drainage flows and effluent discharges are mainly impacted at the Mine Site and have potential effects on fish habitat due to reduction or increase in flows that result from the site development. This is discussed in Section 4.3.3.

2.3 WATER AND SEDIMENT QUALITY VEC

Key Issues and Pathways

Key issues considered for the surface water and sediment quality VEC are summarized in Table 2.1.

Table 2.1 Key Issues for Water and Sediment Quality at the Mine Site

PATHWAY	KEY ISSUES	LOCATION	PROJECT PHASES
Surface runoff	Uncontrolled runoff at construction site Erosion and sediment entrainment Site drainage control Spills and contamination Drainage from quarry sites	All	Construction Operation Closure
Discharges from secondary containment	Fuel depots/storage - contact water may be contaminated with hydrocarbon/petroleum products	Milne Port, Mine Site, Railway construction, Steensby Port, Quarry sites	Construction Operation Closure
Discharge of brine used for drilling in permafrost	Salinity of the discharge	Railway tunnels	Construction
Pooling water in landfarm	Pooling water maybe contaminated with hydrocarbon/petroleum product and may require treatment prior to discharge	Milne Port Mine Site Steensby Port	Construction Operation Closure
Pooling water in landfill	Pooling water maybe contaminated with metals, hydrocarbon/petroleum product and may require treatment prior to discharge	Mine Site Steensby Port	Construction Operation Closure
Treated sewage effluent discharges	Effectiveness of treatment - pH, flows, Biological oxygen demand (BOD), Faecal Coliform (FC), TSS, nutrient, metals, oil and grease	Sheardown Lake Mary River outfall	Construction Operation Closure
Treated oily water treatment plant discharge	Effectiveness of treatment - pH, flows, TSS, metals, oil and grease	Mary River outfall	Construction Operation Closure
Dustfall	TSS in runoff, sediment deposition on stream and lake bottoms	Mine Site	Construction Operation Closure
Run of mine ore stockpile contact water	Metals, TSS	Mary River	Operation
Ore stockpile contact water	Metals, TSS	Mary River	Operation
Mine pit dewatering	Metals, TSS, blasting residue (ammonia)	Camp Lake Tributary	Operation
Waste rock stockpile runoff – west pond	ARD, metals, TSS, blasting residue (ammonia)	Camp Lake Tributary	Operation Closure Post-closure
Waste rock stockpile runoff – east pond	ARD, metals, TSS, blasting residue (ammonia)	Mary River	Operation Closure Post-closure

PATHWAY	KEY ISSUES	LOCATION	PROJECT PHASES
Surface runoff	Uncontrolled runoff at construction site Erosion and sediment entrainment Site drainage control Spills and contamination Drainage from quarry sites	All	Construction Operation Closure
Discharges from secondary containment	Fuel depots/storage - contact water may be contaminated with hydrocarbon/petroleum products	Milne Port, Mine Site, Railway construction, Steensby Port, Quarry sites	Construction Operation Closure
Discharge of brine used for drilling in permafrost	Salinity of the discharge	Railway tunnels	Construction
Pooling water in landfarm	Pooling water maybe contaminated with hydrocarbon/petroleum product and may require treatment prior to discharge	Milne Port Mine Site Steensby Port	Construction Operation Closure
Pooling water in landfill	Pooling water maybe contaminated with metals, hydrocarbon/petroleum product and may require treatment prior to discharge	Mine Site Steensby Port	Construction Operation Closure
Treated sewage effluent discharges	Effectiveness of treatment - pH, flows, Biological oxygen demand (BOD), Faecal Coliform (FC), TSS, nutrient, metals, oil and grease	Sheardown Lake Mary River outfall	Construction Operation Closure
Treated oily water treatment plant discharge	Effectiveness of treatment - pH, flows, TSS, metals, oil and grease	Mary River outfall	Construction Operation Closure
Dustfall	TSS in runoff, sediment deposition on stream and lake bottoms	Mine Site	Construction Operation Closure
Run of mine ore stockpile contact water	Metals, TSS	Mary River	Operation
Ore stockpile contact water	Metals, TSS	Mary River	Operation
Mine pit water	ARD, metals	Open pit	Post-closure

2.4 FRESHWATER AQUATIC BIOTA AND HABITAT

Key Issues and Pathways

Arctic Char (*Salvelinus alpinus*) are the primary freshwater biota of interest regarding potential effects of the Project on the aquatic environment. Potential linkages between the Project components/activities and Arctic Char are presented on Figure 2.2. These linkage pathways can be categorised into three key issues as follows:

- Key Issue #1: Potential effects on the health and condition of Arctic Char;
- Key Issue #2: Potential effects on Arctic Char habitat; and
- Key Issue #3: Potential effects on direct mortality of Arctic Char.

2.4.1 Potential Effects on the Health and Condition of Arctic Char

Project-related changes in water and/or sediment quality have the potential to affect the health and condition of Arctic Char. The major pathways of effects are based on the residual effects identified in the water and sediment quality assessment. Linkages considered for potential effects include three general categories:

- Point source discharges (treated sewage effluent, waste rock stockpile runoff, ore stockpile runoff, mine pit water, run of mine stockpile runoff, and exploration drilling runoff);
- Aqueous non-point sources (NPS; including effects related to sediment and erosion, release of blasting residues, general site runoff, development of quarries and borrow pits); and
- Dust emissions and introduction to surface waters.

Effects considered under this key issue relate to sub-lethal effects of Project-related changes in water and/or sediment quality on fish health and condition.

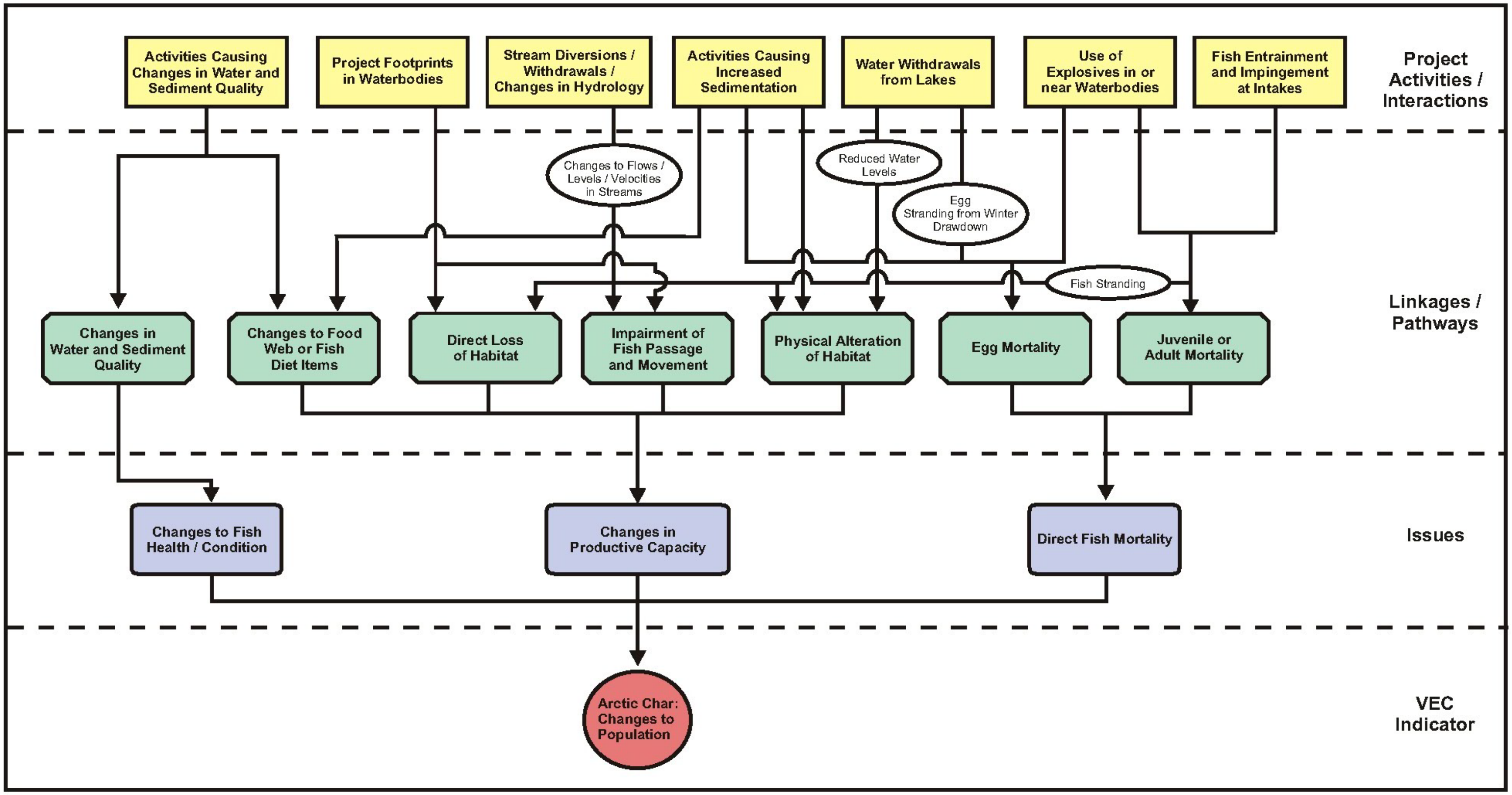
2.4.2 Potential Effects on Fish Habitat

Project activities with the potential to affect Arctic Char habitat include the following:

- Placement of Project infrastructure in water bodies (e.g., water intakes, sewage outfalls, stream crossings, lake encroachments, laydown areas);
- Various Project-related effects pathways that may alter other aquatic biota that are food sources for Arctic Char or form a component of the food web and thus may affect the productive capacity of their habitat (i.e., lower trophic level biota);
- Project-related effects on sedimentation rates that may result in alteration of habitat quality (e.g., due to dust deposition);
- Project-related changes to hydrology and subsequent effects on aquatic habitat (e.g., water withdrawal, stream diversion);
- Project-related effects on fish passage, with subsequent effects on the availability of habitat, including:
  - Stream crossing construction and operation; and
  - Changes in hydrology that may alter hydraulic conditions necessary for fish passage (e.g., stream velocities, water depth).

Most of these key issues relate to construction activities in or near water bodies.

Figure 2.2 Project Activities/Pathways of Potential Effects to Arctic Char



The following changes are associated with mine site development and also have the potential to affect fish and fish habitat:

- Water withdrawn from Camp Lake for domestic and industrial consumption will be discharged (after treatment) to the Mary River;
- Water withdrawal from Camp Lake will affect lake water levels and outflow discharge;
- Drainage patterns where the Mine site infrastructures/facilities are located will be altered. Most site runoff will be redirected to Mary River. As a result, less runoff will discharge to Sheardown Lake and Camp Lake. Tributaries of Sheardown Lake will be impacted. Lower flows may create barriers to fish passage; and
- Mine pit dewatering will be directed to the waste rock sedimentation pond which discharges into a Camp Lake tributary, thus diverting flows from the Mary River.

2.4.3 Potential Effects on Direct Fish Mortality

Project-related activities with the potential to cause direct mortality of Arctic char that are considered include the following:

- Effects of sedimentation on mortality of eggs;
- Potential egg stranding related to winter drawdown at water source lakes;
- Blasting in or near Arctic Char habitat;
- Placement of Project infrastructure in Arctic Char habitat (i.e., potential spawning areas);
- Potential for entrainment and/or impingement of Arctic Char eggs and juveniles at water intakes; and
- Potential fish stranding related to water diversions and/or alterations in discharge or water levels.

Potential effects of sedimentation on survival (hatching success) of Arctic Char eggs will be addressed through monitoring sediment deposition rates in Sheardown Lake as a target study (see Section 8). Potential for winter drawdown to cause egg stranding will be addressed through monitoring of water levels as the primary indicator, supported by information on Arctic char population monitoring (e.g., year class strengths, recruitment). Potential effects of blasting in or near Arctic Char habitat is addressed through the blasting management and monitoring program (see Section 4.11). The potential for placement of Project infrastructure to cause direct mortality of Arctic Char (i.e., placement of infrastructure on fish eggs) is addressed through mitigation and management, specifically through avoidance of potential spawning areas and/or by adherence to timing windows to avoid the egg incubation period. Potential for entrainment and impingement of fish at water intakes will be mitigated through adherence to DFO`s Freshwater intake end-of-pipe fish screen guideline (DFO, 1995). The last potential pathway of effect will be addressed through a follow-up target study to confirm fish passage at Mine area streams affected by water diversions (see Section 8.1.2).

2.4.4 Potential Effects of Blasting on Fish

Blasting will be conducted to support the construction and operation phases of the Project. The concern for potential effects on fish due to blasting overpressure mainly arises for the railway construction along Cockburn Lake where significant blasting is required for the following project components:

- The railway embankment on the east flank of Cockburn Lake; and
- The tunnel construction.

Effects of blasting on free-swimming Arctic Char and their eggs will be mitigated through the implementation of a detailed blasting management plan developed in accordance with DFO's blasting guidelines (Wright and Hopky, 1998).

2.4.5 Stream and River Crossing Construction and Lake Encroachments

Construction activities at watercourse crossings along the railway, railway access road, and Milne Inlet Tote Road have the potential to cause the following effects:

- Stranding of Arctic Char due to the need for isolation of the watercourses. This effect will be mitigated through the use of appropriate timing windows for construction when possible and through fish salvage operations when required.
- Potential impediments to fish passage at stream crossings due to changes in water levels, flows and/or velocities. This potential pathway of effect would be addressed through follow-up monitoring at selected stream crossings (i.e., a subset) to evaluate fish passage. This monitoring is described in detail in Appendix H.

2.5 POTENTIAL ISSUES AND CONCERNS BY PROJECT COMPONENT

Potential effects on aquatic ecosystems are presented below for each of the Project components within the two geographical areas for the construction and operation phases of the Project. Since abandonment and reclamation activities are similar in nature to construction activities, the concerns identified for the construction phase are also relevant for the closure phase.

2.5.1 Mine Site (Water Management Area 48)

The Mine Site includes the infrastructure required to support mining activities (camp, maintenance shops, fuel depots, wastewater treatment facility (WWTF), laydown areas, waste handling and storage facilities, landfill site and landfarm, explosives storage, manufacture and use). The freshwater supply for the Mine Site will be drawn from Camp Lake. Two quarries will be developed within the Mine Site area to provide aggregate material for the site development.

Potential aquatic effects at the Mine Site are listed in Table 2.2. The locations of all controlled discharges from the mine site are presented in Section 3.4.

2.5.2 Milne Port (Water Management Area 48)

The construction period at Milne Port began in the summer of 2013 following issuance of the Type A Water Licence (NWB, 2013). Milne Port will serve as the main staging areas for material and equipment required for the construction activities at the Mine Site and the northern section of the railway. The site includes the airstrip, fuel depots, camp and WWTF, laydown areas, maintenance facilities, and, temporary waste transit areas. Two sites have been identified for the fresh water supply for this facility (Phillip's Creek in summer; Km32 Lake in winter). Two quarries will be developed to provide aggregate for the site development.

Table 2.2 Potential Residual Effects to the Mine Site Aquatic Environment

VEC	CONCERN	PATHWAY	INDICATOR
Water Quantity	Withdrawal of water from Camp Lake		Volume withdrawn
	Flow diversion from Sheardown Lake		Visual – water level
Water and Sediment Quality	Earthworks	Surface runoff discharging to Camp Lake, Sheardown Lake, lake tributaries and Mary River	TSS, dust, spills
	Construction activities		TSS, dust, spills
	Site drainage		TSS, dust, spills
	Quarry site drainage		TSS, dust, spills, residual ammonia
	Fuel tank farms	Discharges from secondary containment areas to receiving environment – surface drainage	Hydrocarbons
	Waste storage area		Metals
	Bermed storage area		Metals, hydrocarbon
	Landfarm		Metals, hydrocarbon
	Landfill		Metals, hydrocarbon
	Treated Sewage Effluent (exploration camp)	Outfall to Sheardown Lake	BOD, TSS, nutrient
	Treated Sewage Effluent (main camp)	Outfall to Mary River	BOD, TSS, nutrient
	Treated Effluent from Oily Water Treatment Plant	Outfall to Mary River	TSS, hydrocarbon
	Waste rock stockpile drainage	Discharge to Camp Lake tributary	TSS, metals, nutrients
	Waste rock stockpile drainage	Discharge to Mary River	TSS, metals, nutrients
	ROM stockpile drainage	Discharge to Mary River	TSS, metals, nutrients
	Ore stockpile drainage	Discharge to Mary River	TSS, metals, nutrients
	Mine pit dewatering	Discharge to Camp Lake tributary	TSS, metals, nutrients/blasting residues
	Mine pit water post closure	End of life mine life pit water quality	Metals
	Dust	TSS in runoff	TSS
Freshwater Biota and Fish Habitat	Footprint of facilities in water bodies – water crossings	Loss of habitat – crossing of Mary River , Camp Lake tributaries	Habitat compensation
	Integrity of water crossing	Alteration of habitat	Erosion, blockage
	Fish passage	Alteration of habitat	Blockage, barrier
	Water diversions – changes in streams	Alteration or loss of habitat	Low flow and barrier to fish passage
	Changes in water and sediment quality (point and non-point sources)	Effects on Arctic Char health and condition; effects on lower trophic level biota (Arctic Char habitat)	Arctic char health and condition; population metrics; benthic invertebrate community metrics
	Dust Deposition	Alteration of habitat	Increased sediment deposition in streams and lakes Benthic invertebrate community metrics
		Deposition on Arctic Char eggs – reduced egg survival	Sedimentation rates in Arctic Char spawning habitat
Groundwater quality	Landfill	seepage in groundwater	Metals

At Milne Port, all site drainage is channeled to a central ditch that discharges into Milne Inlet (Figure 3.3). Treated sewage effluent as well as treated oily water effluent also discharge to this ditch at a distance of approximately 200 m from the Milne Inlet shoreline. As a result, site drainage and effluent discharge have no effects on the freshwater receiving environment. The original location of this ditch will be relocated to the east as a result of the final development plan for Milne Port.

The concerns for potential freshwater aquatic effects during the construction, operation and closure of the Milne Port site are listed below:

Water Quantity

- Withdrawal of water from Philips Creek (summer) and KM 32 Lake (winter)

Water and Sediment Quality

- Quarry management (runoff quality, ARD potential, residual ammonia from blasting activities)
- Construction of water intakes - TSS/turbidity
- Spills caused by accidents and malfunctions

Freshwater Biota and Fish Habitat

- Low magnitude effects to fish and fish habitat related to water quality changes

The discharge criteria for the effluent and runoff water quality are presented in the Type A Water Licence Amendment No.1 . The locations of all controlled discharges from the Milne Port site are presented in Section 3.4.

2.5.3 Tote Road (Water Management Area 48)

The Milne Inlet Tote Road connects Milne Port to the Mine Site. All material received at Milne Port will be transported by truck on the Tote Road. Realignment and re-grading of some road sections will be required. Select water crossings may be rebuilt as part of the ongoing maintenance of the road. A number of borrow pits have been identified along the Tote Road that will provide the necessary aggregate and material for ongoing road maintenance and road improvement.

The concerns for potential aquatic effects during construction, operation and closure of the Tote road are related to:

Water and Sediment Quality

- Dustfall from road traffic and related effects on water quality
- Drainage management from borrow pits

Freshwater Biota and Fish Habitat

- Construction and ongoing maintenance of stream crossing
- Changes in water quality that may affect biota
- Bank erosion, stability, blockage, integrity of the water crossings, fish passage

2.5.4 Railway (Water Management Areas 48 and 21)

Ore will be transported from the Mine Site to the Steensby Port by railway. The concerns for potential aquatic effects occur mainly during the construction period of the railway embankment. Four construction camps (with sewage treatment plant and waste incinerators) will be established at the onset of the construction period. Sewage effluent from these camps will be transported by truck to either the Mine Site or the Steensby Port sewage treatment facilities for treatment. There will be no local discharges of treated effluent (trucked to Steensby or Mine site sewage treatment plant). Domestic water supply and water required for construction activities will be drawn from a number of local lakes. A number of quarries will be developed along the railway alignment in order to provide the necessary rock and aggregate required for the rail embankment, stream crossing and bridge construction.

The concerns for potential aquatic effects during construction, operation and closure of the railway are related to the loss or alteration of fish habitat:

Water Quantity (Potable Water and Construction Activities)

- Water withdrawals affecting downstream flows

Water and Sediment Quality

- Surface runoff water quality (TSS, spills, dust from traffic)
- Quarry management (runoff water quality, TSS, ARD, blasting and ammonia)

Freshwater biota and fish habitat

- Stream/river crossings - flow velocity, TSS, erosion, fish stranding, fish passage and integrity of the water crossing
- Lake and river encroachment - loss of habitat, TSS (construction)
- Changes in water quality (e.g., dust, sewage effluent) - effects on Arctic Char health and condition/habitat
- Blasting near water (blasting overpressure) along Cockburn Lake

2.5.5 Steensby Port (Management Area 21)

The iron ore will be sized and stockpiled at Steensby Port prior to being loaded into the ore carriers for shipment. Steensby Port will contain large infrastructure required for ongoing support of the Port, the railway operation as well as the mine. The infrastructure at Steensby will include an airstrip, maintenance facilities (vehicles and railway), fuel depots, camps, a WWTF, warehouses, laydown areas, waste handling and storage facilities, landfill site, landfarm, explosives storage facilities, a freight dock, an ore stockpile and the ore loading dock. The freshwater supply for the Steensby Port will be drawn from two local lakes. Two quarries will be developed to provide aggregate for the development of the site.

At the Steensby site, surface drainage will be directed toward Steensby Inlet. Treated sewage effluent and treated oily water will discharge to Steensby Inlet via an outfall at a 35 m depth. As a result, site drainage and effluent discharge have minimal effects on the freshwater receiving environment.

The concerns for potential freshwater aquatic effects during the construction, operation and closure of the Steensby port are related to:

Water Quantity

- Withdrawal of water from 3 KM Lake (dust suppression and other minor uses) and ST347 Lake (permanent camp)

Water and Sediment Quality

- Quarry management (runoff quality, ARD potential, residual ammonia from blasting activities)
- Construction of water intakes - TSS/turbidity
- Spills caused by accidents and malfunctions

Freshwater Biota and Fish Habitat

- Stream/river crossings - flow velocity, TSS, erosion, fish stranding, fish passage and integrity of the water crossing
- Lake and river encroachment - loss of habitat, TSS (construction)
- Construction of water intakes - avoidance of spawning areas

The discharge criteria for the effluent and runoff water quality are presented in the Type A Water Licence Amendment No.1.

3 AEMP RELATED MONITORING PROGRAMS

A number of environmental monitoring programs relate to and support the AEMP.

3.1 INUIT QAUJIMAJATUQANGIT

The INAC (2009) AEMP Guidelines provide a basis for incorporating traditional knowledge (in the case of Nunavut this is termed Inuit Qaujimajatuqangit or IQ) into AEMP programs in an efficient and effective manner. The guidelines recognize a need for a flexible process for developing and implementing AEMPs that provide opportunities for input by interested parties including local communities and organizations. This is to ensure that Inuit interests and needs are understood and respected, especially in regard to potential effects of land or water use in potentially affected watersheds. The INAC (2009) AEMP Guidelines identify three key sources of IQ that contribute to an understanding of the environment.

1. Shared information within the community, and an oral history spanning multiple generations including specific observations, patterns of biophysical, social, and cultural phenomena, inferences relative to cause and effect, and predictions of the impacts of human activities. This information is obtained by means of direct observation and experience of the Inuit peoples.
2. Essential information on the use and management of the environment which can enhance understanding of cultural practices and social activities, land use patterns, archeological sites, harvesting practices, and harvesting levels, both now and in the past.
3. Information on the values that people place on the environment.

During the development of the AEMP, the Qikiqtani Inuit Association (QIA) participated in the consultation activities listed in Section 1.3, so that IQ may be incorporated into AEMP development and the implementation process. During these meetings, several of the participants had extensive experience with past projects where attempts were made to incorporate IQ and western science based programs as part of the AEMP. These participants openly shared their experiences with meeting attendees especially in regard to the difficulties involved in successfully incorporating IQ into AEMPs which by their very nature are highly scientific and statistical. However, success was made, and based on suggestions and discussions between Baffinland and QIA, and the application of the INAC Guidelines (2009), the following initiatives are proposed for consideration.

- As has been the practice over the last two years, Baffinland will continue to recruit and train local skilled Inuit environmental technologists to assist with future AEMP field sampling and monitoring programs. In this way, Baffinland Project staff can continue to mentor local Inuit in regards to the scientific and technical aspects of the AEMP and the Inuit can share their practical, historical, and traditional knowledge with Baffinland personnel.
- The QIA will have an Environmental Monitor on-site. The Environmental Monitor will be involved in field data collection and will have an opportunity to review and comment on monitoring results.
- The QIA is expected to continue to utilize suitably qualified technical staff and consultants to review the AEMP and future revisions as well as monitoring data.

In the first half of 2014, Baffinland consulted with the Mittimatalik Hunters and Trappers Organization (MHTO) regarding plans for fish habitat compensation off-sets in the marine environment, related to construction of the ore dock at Milne Port. This type of opportunistic discussion and consultation on aquatic related programs and monitoring will be undertaken from time to time.

3.2 METEOROLOGICAL STATIONS

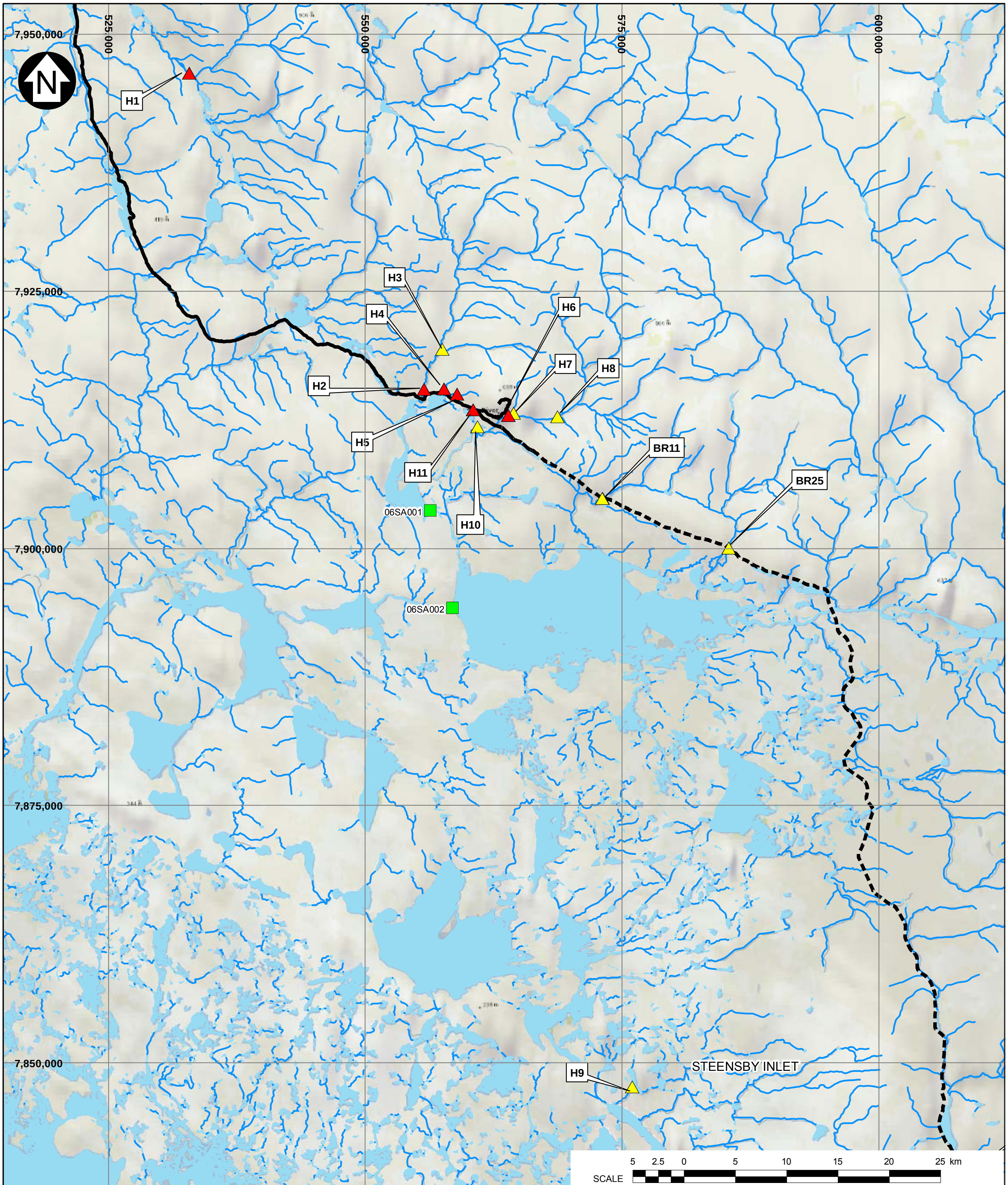
Three meteorological stations have been established, one each at the mine site, Steensby Port, and Milne Port locations. The stations record air temperature, relative humidity, precipitation, wind direction, and wind speed.

3.3 STREAMFLOW MONITORING

A long-term hydrological record does not exist for the North Baffin Region. Stream flow has been monitored at the Mary River Project since 2006, with up to 16 seasonal stream gauges on smaller river/creek systems and four year-round hydrometric stations operated by the Water Survey of Canada operated at various times. Table 3.1 summarizes the stream flow record. Six of the stations will continue to be operated in 2015 and onward (bolded in Table 3.1; shown on Figure 3.1). In addition to these six stations, nine Surveillance Network Monitoring (SNP) stations have hydrometric stations installed, six at the mine site and three at Milne Port (indicated in Table 3.2; depicted in Figure 3.2, 3.3). The 9 hydrometric monitoring stations were installed to measure surface water discharge at or near each of the SNP stations.

Table 3.1 Project Stream Gauging Record

STATION ID	STATION TYPE	PERIOD OF RECORD	DRAINAGE AREA (km^2)	COORDINATES (UTM)		
				Zone	Easting	Northing
H01	Stream flow	2006-2008, 2011-2013	250	17W	532831	7946247
H02	Stream flow	2006-2008, 2010, 2012, 2013	210	17W	555712	7915514
H03	Stream flow	2006-2008, 2010	30.5	17W	557485	7919401
H04 (CLT-2)	Stream flow	2006-2008, 2010, 2012, 2013	8.3	17W	557639	7915579
H05 (CLT-1 L1)	Stream flow	2006-2008, 2010-2013	5.3	17W	558906	7915079
H06 (Mary River)	Stream flow	2006-2008, 2010-2013	240	17W	563922	7912984
H07	Stream flow	2006-2008, 2011, 2013	14.7	17W	564451	7913194
H08	Stream flow	2006-2008	208	17W	568732	7912881
H09	Stream flow	2006-2008	158	17W	576011	7847687
H10	Water Level	2008	8.2	17W	560905	7911838
H11 (SDLT-1)	Stream flow	2011-2013	3.6	17W	560503	7913545
H12	Water Level	2011, 2012	-	17W	597867	7800065
BR11	Stream flow	2008, 2012	53	17W	573122	7904914
BR25	Stream flow	2008, 2012	113	17W	585420	7900082
BR96-2	Stream flow	2008, 2012	31	17W	609300	7839474
BR137	Stream flow	2008,2010-2012	314	17W	598663	7807981
Isortoq River	Stream flow	2006-2012	7170	18W	432810	7780920
Mary River	Stream flow	2006-2012	690	17W	556360	7903750
Raven River	Stream flow	2006-2012	8220	17W	558020	7894160
Rowley River	Stream flow	2006-2012	3500	18W	411230	7818830



LEGEND:

- ACTIVE STREAM FLOW GAUGING STATION
- INACTIVE STREAM FLOW GAUGING STATION
- WATER SURVEY OF CANADA HYDROMETRIC STATION (2006-2012)
- MILNE INLET TOTE ROAD
- PROPOSED RAIL ALIGNMENT
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM NAD83 ZONE 17 AND IS IN METRES.
3. PROPOSED RAIL ALIGNMENT PROVIDED BY CANARAIL CONSULTANTS INC. IN OCTOBER 2010.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MINE SITE HYDROLOGY MONITORING STATION LOCATIONS

Knight Piésold CONSULTING

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAM

P/A NO. NB102-181/34 | REF NO. 1

FIGURE 3.1 | REV 0

SAVED: I:\102\00181\34\A\GIS\Figs\A14_r0.mxd; Jun 26, 2014 04:12 PM;

The following stream gauges are directly relevant to the stream diversion study (Section 4.3.3 and Appendix H):

- Station H05 – located on Camp Lake Tributary 1 (CLT-1), which will receive mine effluent from the west pond (Station H05);
- Station H04 – located on Camp Lake Tributary 2 (CLT-2), which will experience reductions in streamflow during the full-scale Project; and
- Station H11 – located on Sheardown Lake Tributary 1 (SDLT-1), which will experience decreased flows due to diversions associated with the west pond and open pit.

In addition, Station H06 is located on the Mary River, which will receive mine effluent from the east pond, ROM pond and ore stockpiles along with treated sewage effluent from the camp.

The data quality to date has been good though the record is relatively short. The AEMP and Water Licence stations have been installed and are operated in consideration of the national standards set out by the Water Survey of Canada (WSC). Baffinland is committed to maintaining and operating all the hydrometric stations to the WSC standards whenever possible.

3.4 SURVEILLANCE NETWORK PROGRAM

3.4.1 Surveillance Network Program Overview

The Surveillance Network Program (SNP) is a compliance-based monitoring program defined in the Type A Water Licence Amendment No.1. The SNP is the “General Monitoring Program” outlined in Schedule I of the Type A Water Licence Amendment No.1, Conditions Applying to General and Aquatic Effects Monitoring. Data generated by the SNP will help inform effects evaluations conducted as part of the AEMP by providing the loading information on controlled and authorized discharges (flow and quality).

A number of discharges are authorized and regulated by the Type A Water Licence Amendment No.1, including:

- Mine effluent (pit water and runoff from ore and waste rock stockpiles);
- Treated sewage effluent;
- Sewage sludge;
- Oily water;
- Solid waste landfilled on-site;
- Hazardous and non-hazardous wastes taken off-site for disposal;
- Landfill seepage/effluent;
- Water from bulk fuel storage containment facilities;
- Hydrocarbon impacted soil treated in landfarms; and
- Waste rock disposal.

The coordinates for each discharge location and SNP monitoring stations are listed in Table 3.2 and are shown on the following figures:

- Mine Site Surveillance Network Program (Figure 3.2);
- Milne Port Surveillance Network Program (Figure 3.3); and
- Steensby Port Surveillance Network Program (Figure 3.4).

SNP stations that include hydrological monitoring are denoted in Table 3.2 and distinguished in Figure 3.2 and Figure 3.3.

In addition, the SNP stations listed in Table 3.3 are those associated with future ERP infrastructure that has not yet been built. SNP stations associated with the rail project that are identified in the Type A Water Licence Amendment No.1 will be listed in a future revision to the AEMP, once that project phase is pursued by Baffinland.

Schedule I, Table 12 of the Type A Water Licence Amendment No.1 presents the monitoring group parameters. Tables 13, 14 and 15 of Schedule I present the SNP stations at the Milne Port, the Mine Site and Steensby Port, respectively.

Some SNP stations will be utilized for monitoring of contact mine water under the EEM Program (Section 4.1). The SNP results are integrated into interpretation and recommendations of the annual AEMP program.

3.4.2 Effluent Quantity and Quality

The Water Licence requires the reporting of monthly and annual volumes of effluents and wastes discharged by the Project, as well as discharge quality criteria applicable to the various effluents generated by the Project. Effluent quantity and quality together provide loadings data for downstream receiving environments.

3.4.3 Acute Toxicity

Periodic acute toxicity testing for end of pipe sewage effluent discharge locations provides data on possible acute impacts to effluent exposure areas. Testing of treated sewage effluent is required by the licence to confirm that the effluent is not acutely toxic.

3.5 AIR QUALITY MONITORING

The Air and Noise Abatement Management Plan provides guidance on the abatement and management of air emissions and noise from construction and operation activities. The plan also describes the air quality monitoring that will be carried out for the Project.

Passive and active air quality monitoring will be conducted at Milne Port, the Mine Site and Steensby Port. Active monitoring will involve measuring total suspended particulate (TSP) in areas of activity at the mine site and Steensby Port. Passive sampling will include collecting sulphur dioxide (SO_2), nitrogen dioxides (NO_2), ozone (O_3), and dustfall samples simultaneously.

During both construction and operation, the monitoring program will focus on TSP and dust deposition. Air quality data will be collected via active (TSP) and passive sampling methods (SO_2, NO_2, O_3, and dustfall, including metal deposition). Emission testing is being conducted on Project incinerators. Snow-core sampling may be used to determine dust fall at specified locations. Dustfall monitoring is being conducted at transects along the Milne Inlet Tote Road, at Milne Port and the Mine Site as part of the TEMMP (Appendix G).

The approach, indicators, thresholds and proposed response actions are described in the Air and Noise Abatement Management Plan.

Air quality monitoring program is a supporting monitoring program to the AEMP as dustfall monitoring is required by PC Condition #21. Dustfall monitoring may be able inform the findings of monitoring of the aquatic environment under the AEMP, as well as measure changes in dustfall due to changes in the Project or in the application of mitigation measures (Section 4.3.2; Appendix G).

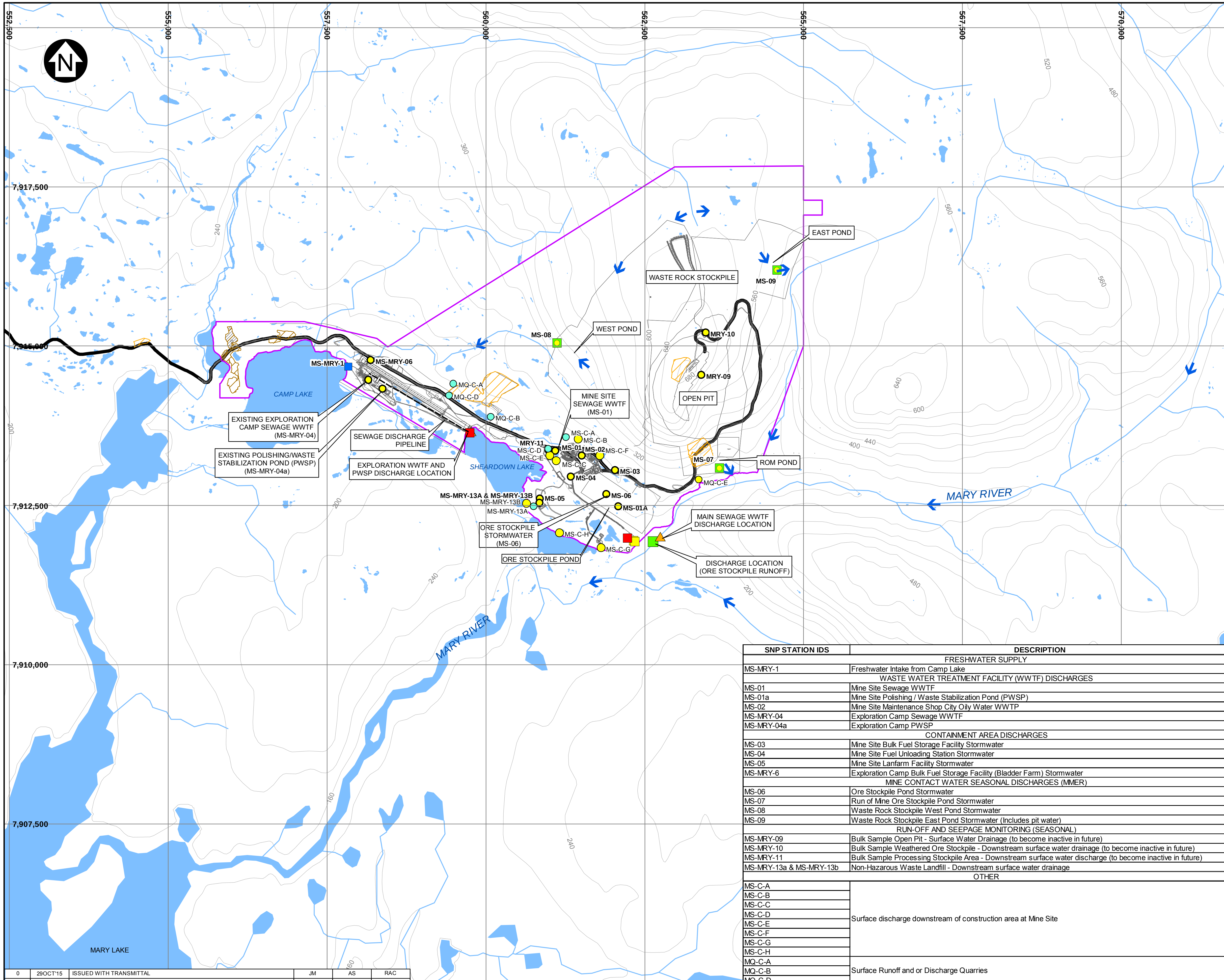
Table 3.2 Established SNP Monitoring Stations Associated with ERP

Monitoring Station	Description	UTM Coordinates (NAD83, Zone 17) Easting (m)	Northing (m)	Status
Milne Port Site				
MP-MRY-2	Fresh Water Intake at Philips Creek (Summer)	514,503	7,964,579	Future
MP-MRY-3	Fresh Water Intake from Km 32 Lake (Winter)	521,547	7,953,735	Active
MP-01	Milne Port Sewage Treatment Facilities (discharge into ditch prior to ocean)	503,209	7,976,485	Active
MP-01a	Milne Port Waste Stabilisation Pond	503,625	7,976,015	Active
MP-02	Milne Port Maintenance Shop Oily water	503,319	7,975,805	Future
MP-05	Milne Port Ore Stockpile Settling Pond (East)	503,069	7,976,338	Future
MP-06	Milne Port Ore Stockpile Settling Pond (West)	503,459	7,976,366	Future
MP-MRY-04[1]	Milne Exploration Phase Sewage Treatment Facilities	503,462	7,975,764	Inactive
MP-MRY-04a[1]	Milne Exploration Phase Sewage PWSP	503,344	7,976,118	Inactive
MP-MRY-7[1]	Milne Exploration Phase Bladder Farm Fuel Storage Facility Storm water	503,309	7,976,097	Inactive
MP-MRY-12	Bulk Sample Stockpile Area Seepage	503,357	7,976,453	Inactive
MP-C-A	Surface discharge downstream of construction area at Milne Port	503,214	7,976,483	Inactive
MP-C-B		503,191	7,975,396	Active / Hydrology
MP-C-C		503,436	7,975,427	Inactive
MP-C-D		503,651	7,976,363	Inactive
MP-C-E		503,736	7,976,346	Inactive
MP-C-F		503,922	7,976,304	Inactive
MP-C-G		503,006	7,976,484	Inactive
MP-C-H		504,113	7,976,509	Active
MP-Q1-01	Surface Runoff and or Discharge Quarries	503,828	7,975,062	Active / Hydrology
MP-Q1-02		503,811	7,975,272	Active / Hydrology
Mine Site				
MS-MRY-1	Fresh Water Intake from Camp Lake	557,793	7,914,684	Active
MS-01	Mine Site Sewage Treatment Facilities	561,322	7,913,257	Active
MS-09	Waste Rock Stockpile Pond	562,984	7,916,316	Active
MS-MRY-4	Exploration Camp Sewage Treatment Facility	558,141	7,914,427	Inactive
MS-MRY-4a	Exploration Camp Polishing Waste Stabilization Ponds	558,470	7,914,237	Active
MS-MRY-6	Exploration Camp Bulk Fuel Storage Facility (Bladder Farm) Stormwater	558,186	7,914,780	Active
MS-MRY-9[1]	Bulk Sample Open Pit - Surface water drainage	563,246	7,914,632	Active
MS-MRY-10[1]	Bulk Sample Weathered Ore Stockpile - Downstream surface water drainage	563,488	7,915,197	Active
MRY-11[1]	Bulk Sample Processing - Downstream surface water discharge	560,690	7,913,350	Active
MS-MRY-13a & MS-MRY-13b	Non-Hazardous Waste Landfill - Downstream surface water drainage	13a: 560,754 13b: 560,642	13a: 7,912,484 13b: 7,912,527	Active / Hydrology
MS-C-A	Surface discharge downstream of construction area at Mine Site	561,263	7,913,571	Active / Hydrology
MS-C-B		561,454	7,913,537	Active
MS-C-C		561,110	7,913,199	Active

Monitoring Station	Description	UTM Coordinates (NAD83, Zone 17)		Status
		Easting (m)	Northing (m)	
MS-C-D	Surface discharge downstream of construction area at Mine Site	561,008	7,913,280	Active
MS-C-E		560,980	7,913,388	Active / Hydrology
MS-C-F		561,797	7,913,278	Active
MS-C-G		561,813	7,911,830	Active
MS-C-H		561,162	7,912,067	Active
MQ-C-A	Surface Runoff and or Discharge Quarries	559,489	7,914,408	Active / Hydrology
MQ-C-B		560,083	7,913,905	Active / Hydrology
MQ-C-D		559,447	7,914,258	Active / Hydrology

NOTE:

1. SNP STATION WILL BECOME INACTIVE IN THE FUTURE.



LEGEND:

- SURVEILLANCE NETWORK PROGRAM (SNP) STATION
- SURVEILLANCE NETWORK PROGRAM (SNP) STATION INCLUDING HYDROLOGY MONITORING
- MINE EFFLUENT FINAL DISCHARGE POINT
- SUMMER DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT
- WINTER DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT TO MARY RIVER
- TREATED SEWAGE DISCHARGE LOCATION
- FRESHWATER INTAKE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER

SURVEILLANCE NETWORK PROGRAM (SNP):

- FIRST LEVEL OF MONITORING FOCUSES ON DISCHARGE QUALITY.
- THERE IS OFTEN AN OVERLAP WITH SNP STATIONS AND EEM STATIONS REQUIRED UNDER THE METAL MINING EFFLUENT REGULATION (MMER).

SNP STATION IDS	DESCRIPTION
	FRESHWATER SUPPLY
MS-MRY-1	Freshwater Intake from Camp Lake
	WASTE WATER TREATMENT FACILITY (WWTF) DISCHARGES
MS-01	Mine Site Sewage WWTF
MS-01a	Mine Site Polishing / Waste Stabilization Pond (PWSP)
MS-02	Mine Site Maintenance Shop City Oily Water WWTP
MS-MRY-04	Exploration Camp Sewage WWTF
MS-MRY-04a	Exploration Camp PWSP
	CONTAINMENT AREA DISCHARGES
MS-03	Mine Site Bulk Fuel Storage Facility Stormwater
MS-04	Mine Site Fuel Unloading Station Stormwater
MS-05	Mine Site Lanfarm Facility Stormwater
MS-MRY-6	Exploration Camp Bulk Fuel Storage Facility (Bladder Farm) Stormwater
	MINE CONTACT WATER SEASONAL DISCHARGES (MMER)
MS-06	Ore Stockpile Pond Stormwater
MS-07	Run of Mine Ore Stockpile Pond Stormwater
MS-08	Waste Rock Stockpile West Pond Stormwater
MS-09	Waste Rock Stockpile East Pond Stormwater (Includes pit water)
	RUN-OFF AND SEEPAGE MONITORING (SEASONAL)
MS-MRY-09	Bulk Sample Open Pit - Surface Water Drainage (to become inactive in future)
MS-MRY-10	Bulk Sample Weathered Ore Stockpile - Downstream surface water drainage (to become inactive in future)
MS-MRY-11	Bulk Sample Processing Stockpile Area - Downstream surface water discharge (to become inactive in future)
MS-MRY-13a & MS-MRY-13b	Non-Hazarous Waste Landfill - Downstream surface water drainage
	OTHER
MS-C-A	Surface discharge downstream of construction area at Mine Site
MS-C-B	
MS-C-C	
MS-C-D	
MS-C-E	
MS-C-F	
MS-C-G	
MS-C-H	
MQ-C-A	Surface Runoff and or Discharge Quarries
MQ-C-B	
MQ-C-D	

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE 17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.

SCALE 500 250 0 500 1,000 1,500 2,000 2,500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MINE SITE SURVEILLANCE NETWORK PROGRAM (SNP)

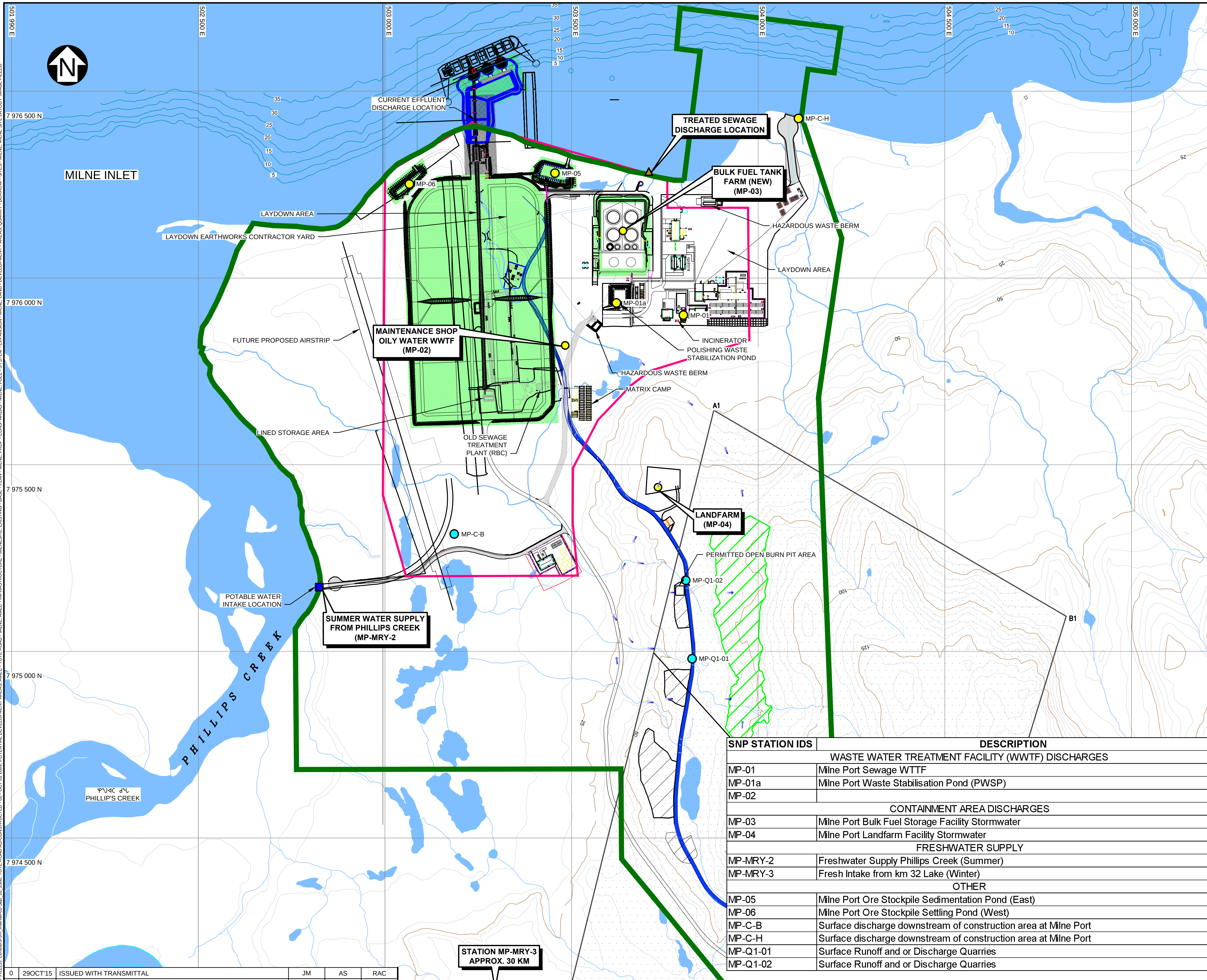
Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/36	NB15-00491

FIGURE 3.2 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	29OCT'15	ISSUED WITH TRANSMITTAL	JM	AS	RAC

SAVED: I:\102\00181\36\A\GIS\Figs\B34_r0.mxd; Oct 29, 2015 10:32 AM; asimpson



SNP STATION IDS	DESCRIPTION
	WASTE WATER TREATMENT FACILITY (WWTF) DISCHARGES
MP-01	Milne Port Sewage WTTF
MP-01a	Milne Port Waste Stabilisation Pond (PWSP)
MP-02	
	CONTAINMENT AREA DISCHARGES
MP-03	Milne Port Bulk Fuel Storage Facility Stormwater
MP-04	Milne Port Landfarm Facility Stormwater
	FRESHWATER SUPPLY
MP-MRY-2	Freshwater Supply Phillips Creek (Summer)
MP-MRY-3	Fresh Intake from km 32 Lake (Winter)
	OTHER
MP-05	Milne Port Ore Stockpile Sedimentation Pond (East)
MP-06	Milne Port Ore Stockpile Settling Pond (West)
MP-C-B	Surface discharge downstream of construction area at Milne Port
MP-C-H	Surface discharge downstream of construction area at Milne Port
MP-Q1-01	Surface Runoff and or Discharge Quarries
MP-Q1-02	Surface Runoff and or Discharge Quarries

LEGEND:

- WATER
- LAYDOWN AREA
- RIVER/STREAM/DRAINAGE
- MILNE INLET TOTE ROAD
- POTENTIAL DEVELOPMENT AREA
- FLOW DIRECTION
- MONITORING LOCATION
- SURVEILLANCE NETWORK PROGRAM (SNP) STATION INCLUDING HYDROLOGY MONITORING
- FRESHWATER INTAKE LOCATION
- TREATED SEWAGE DISCHARGE LOCATION

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL IS 5 METRES.
4. SITE INFRASTRUCTURE PROVIDED BY SIKUMIUT (NOVEMBER, 2012).
5. CONTOURED BATHYMETRY PROVIDED BY ENTERPRISES NORMAND JUNEAU INC., DATED SEPTEMBER 9, 2010 (CONTOUR INTERVAL 1m).

SCALE A 100 50 0 100 200 300 400 500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MILNE PORT SURVEILLANCE NETWORK PROGRAM (SNP)

Knight Piésold CONSULTING

P/A NO. NB102-181/36 | REF NO. NB15-00491

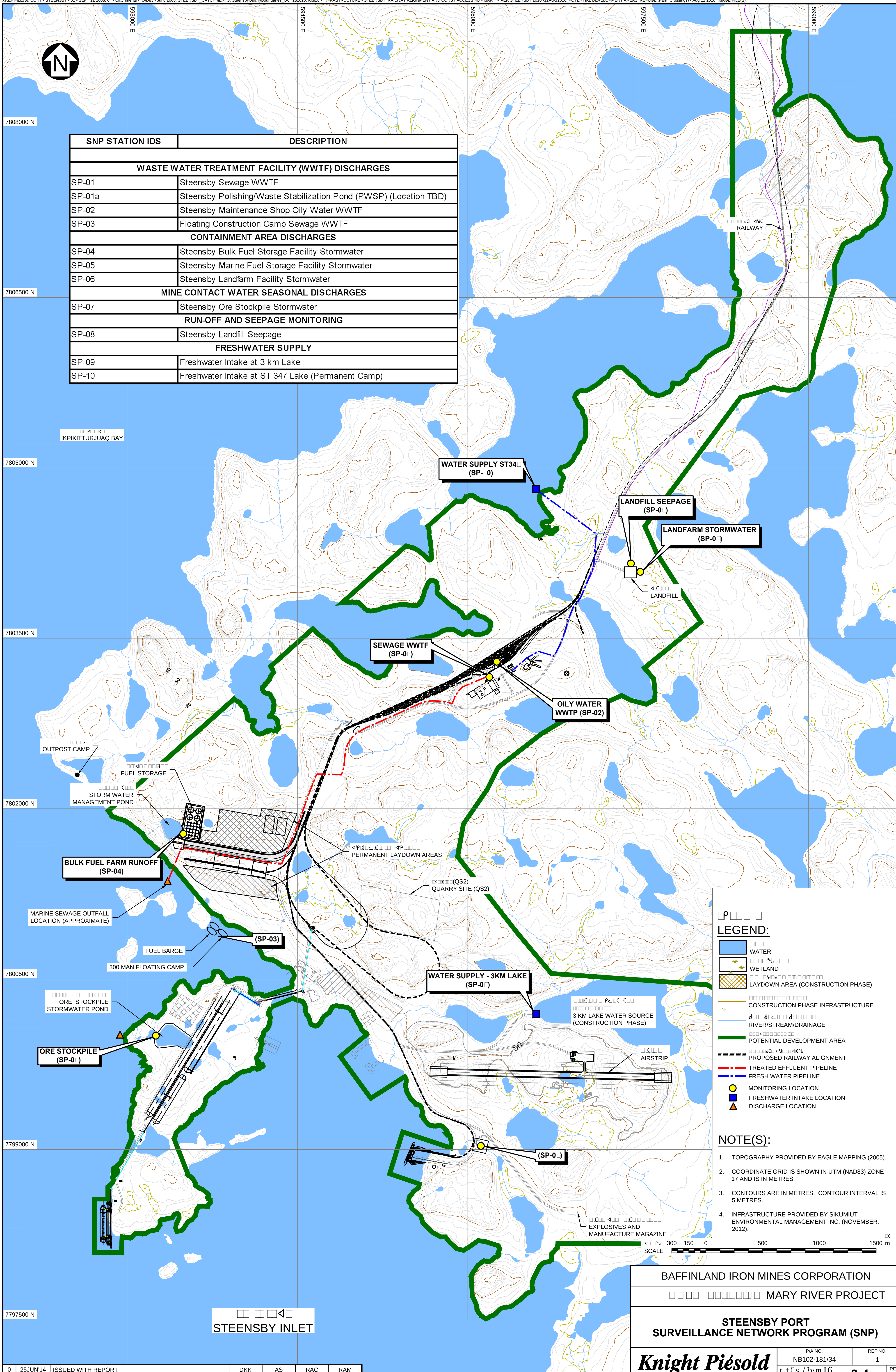
FIGURE 3.3 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	29OCT'15	ISSUED WITH TRANSMITTAL	JM	AS	RAC

SAVED: I:\1\02\00181\36\A\Acad\FIGS\B15_r0, 10/29/2015 10:35:23 AM , ASIMPSON PRINTED: 10/29/2015 11:06:48 AM, Layout1, ASIMPSON

SAVED: I:\1\02\00181\34\A\Acad\FIGS\B13_r0 , 6/27/2014 10:01:09 AM , ASIMPSON PRINTED: 6/27/2014 10:03:28 AM , PORTRAIT , ASIMPSON
XREF FILE(S): CONT - STEENSBY - 01 - SEPT 22 2008; 04 - Catchments - NAD83 - Jul 8 2008; STEENSBY_CATCHMENTS; SteensbyQuarryBoundaries_OCT182010; AMEC - INFRASTRUCTURE - STEENSBY; RAILWAY ALIGNMENT AND CONST ACCESS RD - MARY RIVER STEENSBY 2010 -12AUG2010; POTENTIAL DEVELOPMENT AREAS; REFUGE (Farm Crossings) - Aug 12 2010 IMAGE FILE(S):

SNP STATION IDS	DESCRIPTION
WASTE WATER TREATMENT FACILITY (WWTF) DISCHARGES	
SP-01	Steensby Sewage WWTF
SP-01a	Steensby Polishing/Waste Stabilization Pond (PWSP) (Location TBD)
SP-02	Steensby Maintenance Shop Oily Water WWTF
SP-03	Floating Construction Camp Sewage WWTF
CONTAINMENT AREA DISCHARGES	
SP-04	Steensby Bulk Fuel Storage Facility Stormwater
SP-05	Steensby Marine Fuel Storage Facility Stormwater
SP-06	Steensby Landfarm Facility Stormwater
MINE CONTACT WATER SEASONAL DISCHARGES	
SP-07	Steensby Ore Stockpile Stormwater
RUN-OFF AND SEEPAGE MONITORING	
SP-08	Steensby Landfill Seepage
FRESHWATER SUPPLY	
SP-09	Freshwater Intake at 3 km Lake
SP-10	Freshwater Intake at ST 347 Lake (Permanent Camp)



NOTE(S):

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL IS 5 METRES.
4. INFRASTRUCTURE PROVIDED BY SIKUMIUT ENVIRONMENTAL MANAGEMENT INC. (NOVEMBER, 2012).

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STEENSBY PORT
SURVEILLANCE NETWORK PROGRAM (SNP)

Knight Piésold CONSULTING

P/A NO. NB102-181/34 | REF NO. 1

FIGURE 3.4 | REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

Table 3.3 Future SNP Stations Associated with ERP

Monitoring Station	Description	Status
MP-03	Milne Port Bulk Fuel Storage Facility Stormwater	Active
MP-04	Milne Port Landfarm Facility Storm water	Active
MS-01a	Mine Site Polishing/Waste Stabilization Pond (PWSP)	Active
MS-02	Mine Site Maintenance Shop Oily Water WWTF	Future
MS-03	Mine Site Bulk Fuel Storage Facility Stormwater	Active
MS-04	Mine Site Fuel Unloading Station Stormwater	Future
MS-05	Mine Site Landfarm Facility Stormwater	Future
MS-06+	Ore Stockpile Pond Stormwater	Future
MS-07	Run of Mine Ore Stockpile Pond Stormwater	Future
MS-08	Waste Rock Stockpile West pond	Active
MS-09	Waste Rock Stockpile East pond	Future

3.6 HABITAT COMPENSATION

Baffinland must obtain appropriate authorizations or letters of advice from the DFO for in-water construction activities such as at water crossings. Section 35 of the *Fisheries Act* prohibits the serious harm to fish that are part of, or that support, a commercial, recreational or Aboriginal fishery, and provides the Minister with the power to authorize terms and conditions which would allow projects to proceed in compliance with the *Act*. Serious harm occurs when the physical, chemical, or biological features of a water body are sufficiently altered, such that habitat becomes less suitable for one or more life history processes of fish. Habitat offsetting is an option for mitigating residual impacts of projects on habitat productive capacity that are deemed harmful after other less invasive options have been implemented. Habitat offsetting involves replacing the loss of fish habitat with newly created habitat or improving the productive capacity of some other natural habitat. Depending on the nature and scope of the compensatory works proposed, habitat offsetting may require multiple seasons of post-construction monitoring. A Fish Habitat Offsetting Plan is a requirement of a *Fisheries Act* authorization.

Mitigation measures are likely to be implemented during the project's planning, design, construction and/or operation phases in order to protect fish and fish habitat. The mitigation plans are prepared and implemented by the Company with advice typically provided by DFO staff.

Commonly used mitigation measures can include:

- Working within fisheries timing windows to minimize interference with fish migration and spawning
- Selecting the least harmful equipment/materials/construction methods
- Ensuring fish passage around obstructions during and after construction
- Implementing measures to control siltation at construction sites

Upgrades to some of the existing Tote Road crossings will be required to support the construction phase of the project and the installation of new crossings and encroachments within lakes will be required as part of the railway construction and operation.

Permanent or temporary water crossings are also authorized under the Type A Water Licence Amendment No.1, provided the DFO has granted authorizations for undertaking the proposed work.

3.6.1 Tote Road Upgrade (Water Management Area 48)

The Bulk Sampling Program completed in 2007-2008 involved upgrading the Milne Inlet Tote Road to all-season capability. The upgrades completed included adjustments to the road alignment to facilitate haul road travel, road bed improvements, road widening and installation of drainage crossings along the route. The Tote Road upgrades were designed to enhance the flow conditions of the waterways, reduce potential erosion-related effects, and improve the opportunity for fish to access upstream habitat.

The DFO issued a HADD authorization (Harmful Alteration, Disruption or Destruction of Fish Habitat authorization; now a Serious Harm authorization) for approximately 8,500 m^2 of fish habitat that was to be disturbed for the Tote Road upgrade. Based on subsequent monitoring, this estimate was revised to 7,850 m^2 of disturbance with habitat compensation (now habitat offsetting) measures to be implemented that would restore and enhance approximately 15,000 m^2 of habitat. The original *Fisheries Act* Authorization and Fish Habitat No Net Loss and Monitoring Plan to support the construction of 25 crossings identified as HADD (and 14 crossings identified as Habitat Compensation) were issued and approved in 2007 (Knight Piésold, 2007). The Plan outlined the measures necessary to mitigate and compensate, to the greatest possible extent practicable, the impacts to fish habitat at the Tote Road watercourse crossings. The plan also described a monitoring plan to be implemented during and after construction. A fisheries biologist conducts a survey of the performance of the stream crossings on an annual basis and the results of this survey are provided in an annual report provided to the DFO and other regulators/agencies including the QIA. Monitoring downstream of quarries and borrow source operations is currently a requirement of the Water Licence as well as quarry and borrow source management plans that are submitted under the Water Licence. The Water Licence provides water quality criteria for areas downstream of construction and quarries/borrow sources. This plan has been implemented during the period of construction (2007-2009) and post-construction from 2009 to the present. Baffinland has submitted annual reports for the above to DFO each year since 2007.

In addition, Letters of Advice were issued by the DFO to for construction of smaller watercourses along the road.

Road upgrades associated with the mine development project include the replacement of box culvert (sea can) crossings with bridge structures. DFO has/is issuing Letters of Advice for this work and has indicated that an authorization under the *Fisheries Act* will not be required. Nevertheless, monitoring of the tote road crossings continues as per the original authorization and Fish Habitat No Net Loss and Monitoring Plan (Knight Piésold, 2007).

3.6.2 Milne Port Ore Dock (Water Management Area 48)

In accordance with the revised *Fisheries Act*, the footprint of the Milne Ore Dock was determined by DFO to constitute a Serious Harm to fish habitat. In its decision, DFO has indicated that the required Habitat Offset can be addressed through designed-in mitigation in the form of placement of coarse habitat features along the perimeter of the structure. DFO is currently reviewing an Application for *Fisheries Act* Authorization that reflects this approach to meeting *Fisheries Act* requirements.

3.6.3 Rail Phase Infrastructure (Water Management Areas 21 and 48)

The northern portion of the railway is located in Water Management Area 48. The southern portion of the railway and Steensby Port are located in Water Management Area 21.

Once Baffinland decides to pursue the rail phase of the Project, the company will seek an authorization under the revised *Fisheries Act* for components of the Project that DFO constitutes a Serious Harm to fish habitat. This may include the following infrastructure:

- Select crossings and lake encroachments along the railway
- Steensby ore and freight docks

It is expected that habitat offsets will be required under a future *Fisheries Act* authorization. The authorization will require the implementation of various mitigation measures, and will specify monitoring required during and following construction.

3.7 OTHER ENVIRONMENTAL MANAGEMENT AND MONITORING PLANS

A number of management and monitoring plans (EMMPs) were developed as part of the FEIS and/or the Amended Type A Water Licence. These plans include:

- Environmental Protection Plan
- Surface Water and Aquatic Ecosystems Management Plan
- Quarry and Borrow Pit Management Plan
- Waste Water Management Plan
- Waste Management Plan
- Hazardous Materials and Hazardous Waste Management Plan
- Explosives Management Plan
- Blasting Management Plan
- Waste Rock Management Plan
- Emergency Response and Spill Contingency Plan
- Abandonment and Reclamation Plan

The above management plans all have linkages to water, and the issues and concerns identified in Section 2 involve mitigation measures identified in the above plans. Like the AEMP, these plans are living documents which will be updated periodically throughout the Project life to account for changes in the Project, the success of mitigation measures and the results of monitoring.

4 AEMP COMPONENT STUDIES

As described in Section 1, the following are component studies that comprise the AEMP:

- **EEM Program**, as required under the MMER;
- **CREMP**, which includes monitoring of the core mine site area (water, sediment, benthic invertebrates and fish);
- **Lake Sedimentation Monitoring Program**, evaluating baseline and project-influenced lake sedimentation rates;
- **Dustfall Monitoring Program**, evaluating dustfall rates in proximity to the road, port and mine; and
- **Stream Diversion Barrier Study**, an initial study evaluating potential for fish barriers under natural conditions and due to Project-related stream diversions.

The EEM Program is a legal requirement of metal mines such as the Mary River mine. The Draft EEM Cycle One Study Design has been included under the umbrella of the AEMP and follows a separate but related regulatory function.

The CREMP forms the backbone of the AEMP. The CREMP is a detailed aquatics monitoring program intended to complement and expand the scope of an EEM Program required under the MMER. The CREMP is intended to monitor the effects of multiple stressors on the aquatic environment, including the discharge of mine effluents and treated sewage effluent as well as ore dust deposition. The CREMP will include the monitoring of water, sediment, phytoplankton, benthic invertebrates and fish in the Project's mine site streams and lakes.

Specific effects monitoring (or targeted monitoring) is defined as monitoring conducted to address a specific question or potential impact and/or studies that are relatively confined in terms of spatial and/or temporal scope. Targeted environmental studies relate to specific environmental concerns that require further investigation or follow-up but are not anticipated to be components of the core monitoring program. The Lake Sedimentation Targeted Study, Dustfall Monitoring Program, and the Stream Diversion Monitoring Targeted Study are such studies.

Stand-alone study designs have been prepared. These are briefly summarized below and are included in the appendices of this report.

4.1 EEM CYCLE ONE STUDY DESIGN

4.1.1 Overview

As a metal mine, the discharge of mine effluents from this metal mine is regulated by the MMER. These regulations, administered under the federal *Fisheries Act*, apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. Mining began September 2014, at which time temperatures are below zero, precipitation falls as snow, and runoff has ceased in local rivers and streams. Therefore, the 50 m^3/day mine effluent discharge rate was achieved during freshet in on July 10, 2015.

The MMER outline requirements for routine effluent monitoring, acute lethality testing, and EEM. The objective of EEM is to determine whether mining activity is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources (based on mercury accumulation in fish tissues).

This Cycle One EEM study design in Appendix A has been prepared in accordance with the MMER as prescribed by the Environment Canada (2012) EEM technical guidance document. The study design describes in detail how the Cycle One EEM biological monitoring study will be undertaken. It outlines the proposed activities involved in the investigation of water quality, sediment quality, and freshwater biota community to meet the objectives of the EEM program in accordance with the MMER. In accordance with the technical guidance document (Environment Canada, 2012), this study will take into account all relevant site characterization information, previous biological monitoring data, and comments and/or recommendations stemming from previous efforts in the area.

Any comments on this draft study design will be incorporated into a final study design that will be formally submitted for review and approval by the Environment Canada Technical Advisory Panel (TAP) prior to initiation of the Cycle One EEM biological monitoring study field work.

4.1.2 Final Discharge Points

Mine effluent will be discharged to two watercourses (Figure 4.1):

- Mary River; and
- Camp Lake Tributary 1.

There will be three final discharge points will discharge mine effluent to the Mary River as follows:

- East Pond discharge (MS-08) collecting stormwater from the east side of the waste rock stockpile;
- Run-of-mine (ROM) stockpile discharge; and
- The main ore stockpile at the rail load-out area.

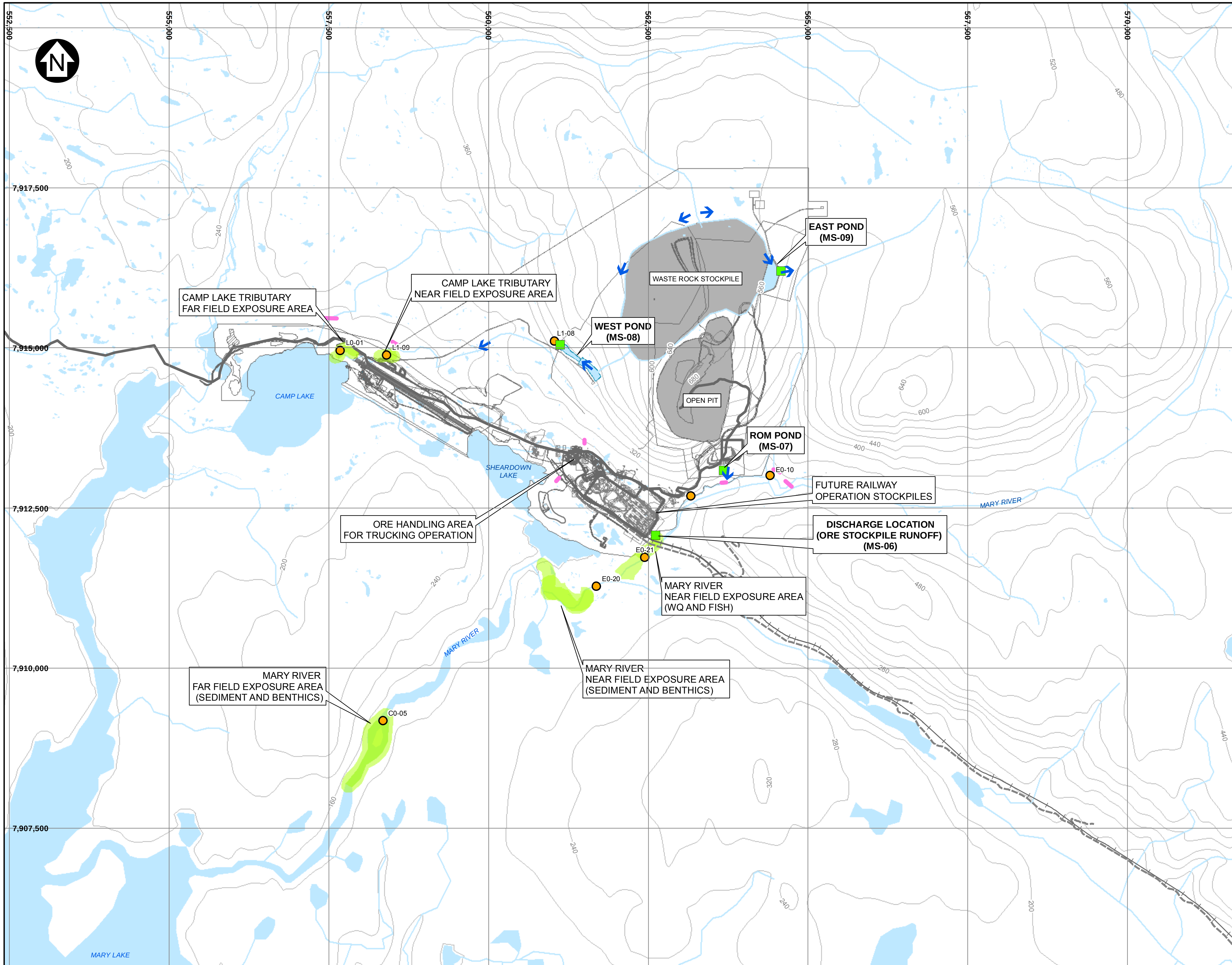
There will be one final discharge point to Camp Lake Tributary 1, from the West Pond collecting stormwater from the west side of the waste rock stockpile.

4.1.3 Site Characterization

Baseline environmental data has been collected at the exposure and reference areas by North/South Consultants Inc. (NSC) and Knight Piésold Ltd. (KP) on behalf of Baffinland. The exposure and candidate reference areas are listed in Table 4.1. The study area site characterization program involved:

- Identifying the in-situ habitat conditions;
- In-situ and laboratory water quality sampling;
- Sediment quality sampling;
- Benthic invertebrate community sampling; and
- Fish community and population sampling.

The exposure area habitat information was used to evaluate suitability of the candidate reference study areas, and to position the proposed field replicate stations. Candidate reference areas are shown on Figure 4.2. Characterizing more than one reference site for each exposure area increases the ability to evaluate natural variability, ecological relevance and confounding factors, and improves the ability to evaluate the adequacy of the chosen reference site(s) (Environment Canada, 2012).



LEGEND:

- MINE EFFLUENT FINAL DISCHARGE POINT
- ENVIRONMENTAL EFFECTS MONITORING STATION (EEM) (WATER, SEDIMENT, BENTHICS AND FISH)
- EEM STUDY DESIGN EXPOSURE AREA
- FISH BARRIER
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 500 250 0 500 1,000 1,500 2,000 2,500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

EEM PROGRAM EXPOSURE AREAS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	1

FIGURE 4.1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAM

SAVED: I:\102\00181\34\A\GIS\Figs\B54_r0.mxd; Jun 26, 2014 3:47 PM; asimpson

Table 4.1 Freshwater EEM Study Design Exposure and Candidate Reference Areas

Study Area ID	Latitude (Deg. Min. Sec.)	Longitude (Deg. Min. Sec.)
Camp Lake Tributary Near Field Exposure Area	71° 19' 46" N	79° 21' 46" W
Camp Lake Tributary Far Field Exposure Area	71° 19' 46" N	79° 22' 46" W
Camp Lake Tributary Reference Area 2	71° 31' 51" N	80° 15' 42" W
Camp Lake Tributary Reference Area 3	71° 15' 56" N	79° 06' 27" W
Camp Lake Tributary Reference Area 4	71° 15' 28" N	79° 04' 23" W
Mary River Near Field Exposure Area (Surface water & Fish at outfall)	71 17' 50" N	79° 15' 57" W
Mary River Near Field Exposure Area (Sediment & Benthos)	71° 17' 42" N	79° 16' 47" W
Mary River Far Field Exposure Area	71° 16' 42" N	79° 22' 11" W
Mary River Reference Area 1	71° 12' 47" N	79° 56' 17" W
Mary River Reference Area 2	71° 13' 21" N	79° 02' 46" W
Mary River Reference Area 3	71° 10' 26" N	78° 39' 31" W
Mary River Reference Area 4	71° 20' 43" N	79° 00' 04" W

NOTE:

1. AREA COORDINATES REPRESENT THE UPSTREAM EXTENT OF EACH STUDY AREA.

4.1.4 Study Design Methodology

4.1.4.1 Effluent Plume Delineation Study

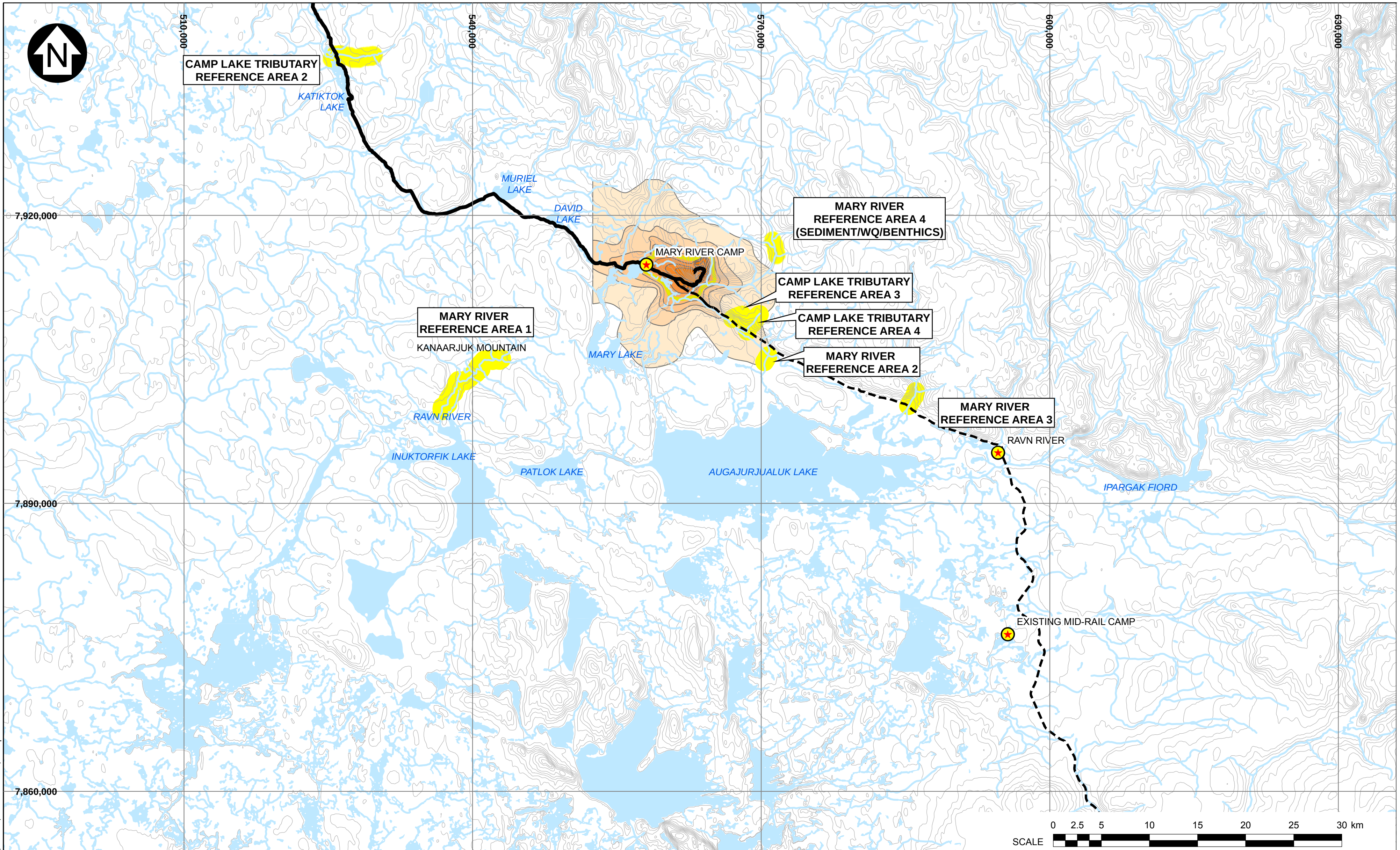
Based on estimated effluent discharge volumes compared with the estimated 10-year low flow conditions of the receivers, effluent concentrations in the Mary River and Camp Lake Tributary are estimated to be greater than 1% within 250 m of the final discharge points. Therefore, an effluent plume delineation study will be carried out to confirm the estimated effluent concentration and the manner in which mine effluent will mix with the receiving environment. The effluent plume delineation study will follow guidance provided by Environment Canada (2003 and 2012).

4.1.4.2 Water Quality Monitoring

Sampling and analysis of water quality will be undertaken as part of the cycle one EEM biological monitoring study to compare the current water quality of the reference locations to that of the exposure locations. Water quality samples will be taken concurrently with sediment and benthic sampling unless otherwise noted.

4.1.4.3 Supporting Benthic Invertebrate Community Measures

Supporting measures for the benthic invertebrate community survey will be recorded to support the appropriateness of the selected reference areas. These measures include hydrology, stream morphology and substrate characterization.



LEGEND:

- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- PHOTO/VIDEO RECORD (2012-2013)
- WATER

Annual TSP Dep. (g/m^2/yr)

- 2 - 7.5
- 7.5 - 15
- 15 - 30
- 30 - 55
- 55 - 120
- 120 - 240
- 240 - 480
- > 480

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOUR INTERVAL IS 20 METRES.
4. TOTAL SUSPENDED PARTICULATE CONTOURS PROVIDED BY RWDI AIR INC. (2011). PRESENTED IN THE FINAL ENVIRONMENT IMPACT ASSESSMENT.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CANDIDATE REFERENCE AREAS FOR EEM PROGRAM

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	1

FIGURE 4.2 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAM

SAVED: I:\102\00181\34\A\GIS\Figs\A15_r0.mxd; Jun 26, 2014 3:49 PM; asimpson

4.1.4.4 Benthic Invertebrate Community Survey

A benthic invertebrate community survey will be conducted as part of the cycle one EEM biological study as required by the MMER. The results of this survey will compare the benthic invertebrate communities between the exposure and reference areas. It is proposed that the benthic invertebrate survey take place in the late summer or early fall (late July to late August), as previous studies have indicated that this is an appropriate season to ensure the collection of the widest diversity of invertebrates.

Benthic samples will be analyzed by a taxonomist. Following identification and enumeration, a list of individuals collected for each sample will be included in the final interpretive report.

The benthic community will be investigated to determine if mine discharge is having an effect on the receiving system, as defined by Environment Canada (2012).

4.1.4.5 Fish Community, Population and Usability Survey

Sufficient historical data have been collected to properly characterize the freshwater fish community in the study areas. Only two fish species are present in the exposure areas; Arctic char and ninespine stickleback.

A fish population survey of the exposure and reference areas will be conducted as required under the MMER. This is required as the effluent concentration is estimated to be above 1% at a distance of 250 metres from the final discharge points. This study will attempt to collect sufficient numbers (n=100) of the proposed sentinel species (Arctic char). The absence of ninespine stickleback in suitable numbers in the exposure and proposed reference areas precludes their use as a second sentinel species. Environment Canada officials will be notified of insufficient collection numbers during the study, and an agreed upon course of action will be followed to complete the study.

Non-destructive capture methods will be employed for all fish population sampling. Backpack electrofishing will be utilized as the primary means of sampling. A non-lethal survey will pose less of an impact on the fish population than a lethal survey.

Aging using otoliths as the primary structure for 10% (min. n=10) of the individuals collected will be undertaken. Pectoral fin rays will also be sampled from the retained individuals to evaluate accuracy of ages between ageing structures. This will evaluate the need for 10% intentional mortality future studies versus a completely non-lethal survey utilizing fin rays as the primary ageing structure.

Effluent quality has been estimated using humidity cell testing results of the ore, local precipitation volumes as well as contact time that precipitation will have with the ore and waste rock stockpiles. The effluent quality is not expected to contain mercury concentrations ≥ 0.01 µg/L, therefore a fish usability study is not proposed in this study design. Should effluent characterization results report concentrations of mercury ≥ 0.01 µg/L a fish usability study will be undertaken as required by the MMER.

4.1.5 Summary and Schedule

The 2013 site characterization program confirmed in-situ conditions at the exposure areas and candidate reference areas. The most suitable reference areas to evaluate the benthic invertebrate community effect endpoints are as follows:

- Camp Lake Tributary Near Field (CLT-NF):
  - Camp Lake Tributary Reference Area 3 (CLT-REF3)
  - Camp Lake Tributary Reference Area 4 (CLT-REF4)
- Mary River Near Field (MRY-NF):
  - Mary River Reference Area 2 (MRY-REF2)
  - Mary River Reference Area 4 (MRY-REF4)

The statistical comparisons of the fish population data between the exposure and reference areas for both receivers show significant difference within and between all groups. As such, additional data analysis may be performed following discussions with Environment Canada to determine an acceptable reference area for the fish component of the EEM cycle one biological monitoring study.

The current and anticipated timeline that includes milestones associated with the MMER requirements is provided below, and is subject to change based on regulatory approvals and the start of mining.

July 10 2015	Mine is subject to MMERs once effluent discharge rate reaches 50 m^3/day
September 2015	Submission of Identifying Information & Final Discharge Points (within 60 days after date mine is subject to MMERs)
December 2015	Submission Cycle One Study Design (12 months from initial date when Mine was subject to MMERs)
	Environment Canada review of Cycle One Study Design (6 months)
August-Sept 2016	Conduct Cycle One Biological Monitoring Study (conducted no sooner than 6 months after Cycle One SD submission date)
November 2017	Submission of Cycle One Interpretive Report (within 30 months from initial date when Mine was subject to MMERs)

Based on comments on the draft study design presented in Appendix A and summarized above, the Cycle One Study Design report will be formally submitted to Environment Canada in accordance with the schedule outlined above.

4.2 CREMP STUDY DESIGN

4.2.1 CREMP Overview

The Core Receiving Environment Monitoring Program (CREMP) is being established to monitor effects of the Project on the downstream aquatic environment. The CREMP focuses on follow-up monitoring to validate predictions to aquatic valued ecosystem components (VECs) and key indicators, as follows:

- Water quantity;
- Water and sediment quality; and
- Freshwater biota (benthic invertebrate indicators, phytoplankton and Arctic Char).

The EEM study design (Section 4.1) identifies the exposure areas in the freshwater environment that will receive mine effluent discharges. The CREMP encompasses a larger geographic extent than the EEM program and is intended to monitor potential effects to the aquatic environment via other pathways such as dust deposition or changes in water flow due to diversions.

Based on the conclusions in the FEIS, mine site aquatic effects will be primarily confined to the Mary River, Camp Lake, Sheardown Lake and their associated tributaries (Figure 2.1). Mary Lake is the ultimate receiving water for these drainage areas, but is of sufficient size that detectable effects are not predicted. The CREMP includes monitoring in Mary Lake to confirm this prediction.

The CREMP is intended to monitor effects as follows:

- Camp and Sheardown Lake tributaries - will be affected by dust deposition and water diversions; Camp Lake Tributary 1 will receive waste rock stockpile runoff from the West Pond;
- Sheardown Lake - will experience changes in water quality due to airborne dust dispersion and runoff, sewage effluent discharges from the exploration camp during construction, changes in hydrology, and potential changes in productivity to tributaries of Sheardown Lake;
- Camp Lake – will receive runoff from tributaries affected by dust deposition and mine effluent (west pond), will be affected by water diversions and withdrawals, as well as changes in water quality due to airborne dust dispersion;
- Mary River – will be subject to airborne dust dispersion and will receive three streams of mine effluent as well as treated sewage effluent; and
- Mary Lake – is the ultimate receiving waters of Camp Lake, Sheardown Lake and the Mary River.

A brief description of the CREMP by component is provided below. The water and sediment quality CREMP is presented in more detail in Appendix B (Knight Piésold, 2014a), and the freshwater biota CREMP (inclusive of phytoplankton, benthic invertebrates and fish) is presented in Appendix D (NSC, 2014a).

4.2.2 Water Quality

The key pathways of potential effects of the Project on water quality include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and CLT-1);
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and

- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area).

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

The primary issue of concern with respect to water quality is related to the combined effects on metal and TSS concentration from mine effluent discharges and ore dust deposition on water quality in adjacent lakes and streams. As such, the CREMP and the baseline data review focused on waterbodies that will receive mine effluent discharges and are closest to the sources of ore dust. Camp Lake and CLT-1, as well as the Mary River and Mary Lake, will receive mine effluent discharges. These waterbodies, along with Sheardown Lake, may also be affected by ore dust deposition and non-point sources of fugitive dust (i.e., road dust).

The discharge of treated sewage effluent also has the potential to cause eutrophication, with phosphorus being the limiting nutrient. TP concentrations are highly variable, however, making it a poor indicator. While TP will continue to be monitored as part of the CREMP, Chlorophyll a will be monitored as a more reliable indicator of potential eutrophication, as part of the freshwater biota CREMP (Section 4.2.4 and Appendix D).

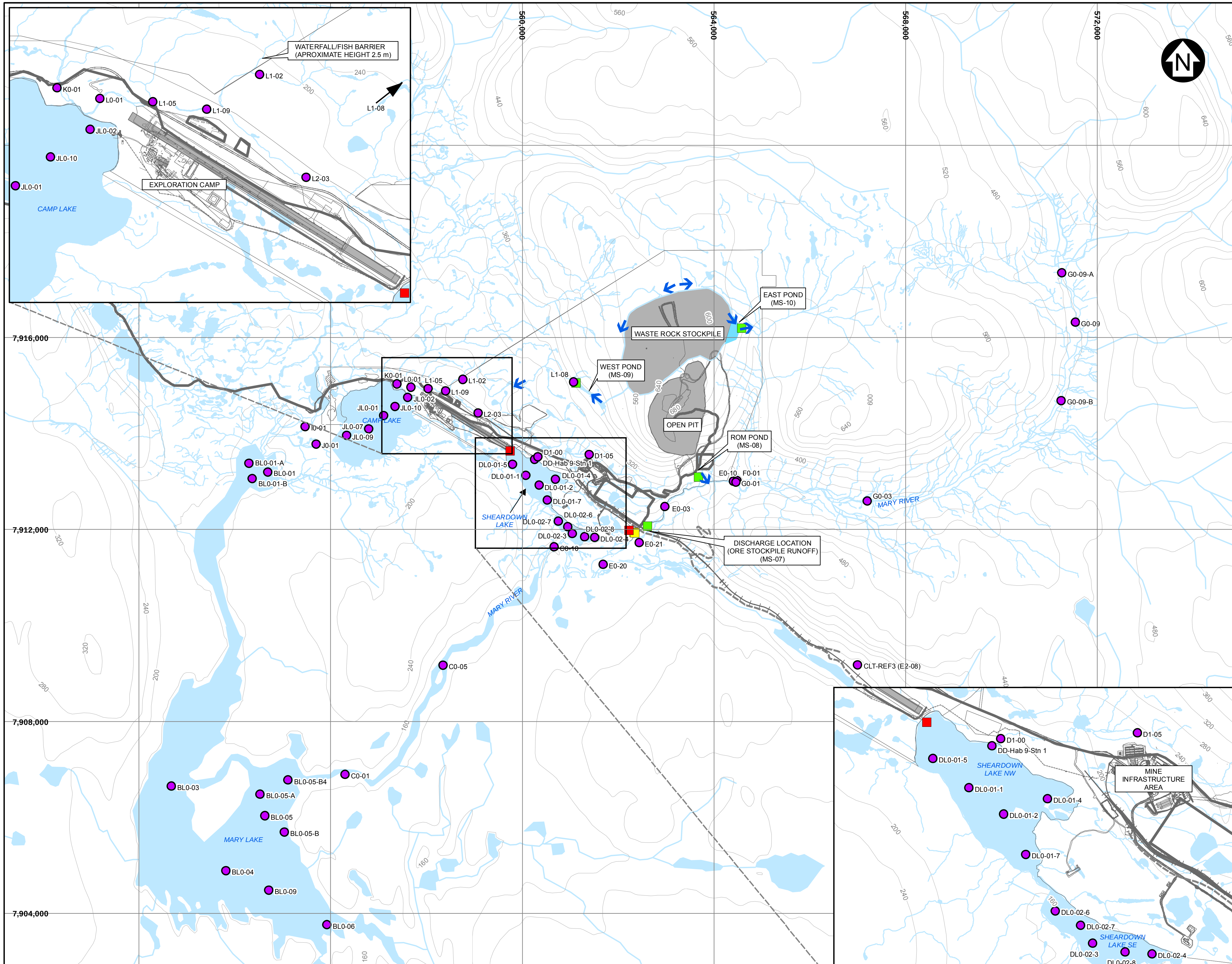
The proposed water quality CREMP stations are shown on Figure 4.3. An *a priori* power analysis supported a monitoring program that uses the existing baseline stations, and recommended the addition of the following stations:

- Two stations within the basin at the north arm of Mary Lake, near BL0-01 (stations BL0-01-A and BL0-01-B);
- Two additional stations within the main basin of Mary Lake, near the Mary River inlet near BL0-05 (BL0-05-A and BL0-05-B);
- Sampling of an additional station within Sheardown Lake SE (existing station DL0-02-6);
- Addition of a station in vicinity of L1-09, location to be determined (L1-05);
- Addition of one or two reference stations upstream on Mary River (G0-09-A, G0-09-B); and
- Sampling of identified reference lakes, consistent with EEM program and as identified in Appendix E.

The following sampling frequencies are recommended for each of the different programs:

- Lakes - three sampling events in each available season (winter, summer and fall) during the first three years of mine operation are expected to have adequate power to detect early warning flag concentrations for lake data; and
- Streams - four samples (one set of seasonal samples) per year is likely adequate for most parameters to determine significance.

Sampling will be conducted annually during the initial years of operation but sampling frequency will be evaluated regularly (i.e., each year) to determine if modifications are warranted. The sampling frequency and schedule will be evaluated after three years of monitoring.



0	25JUN'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

SAVED: I:\102\00181\34\A\GIS\Figs\B55_r0.mxd; Jun 26, 2014 3:55 PM; asimpson

LEGEND:

- WATER QUALITY CREMP STATION
- SUMMER DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT
- WINTER LAND DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT TO MARY RIVER
- MINE EFFLUENT FINAL DISCHARGE POINT
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- PROPOSED SITE INFRASTRUCTURE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CREMP WATER QUALITY STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	1

FIGURE 4.3 REV 0

4.2.3 Sediment Quality Study Design

The key pathways of potential effects of the Project on sediment quality include:

- Sediment quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Sediment quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Sediment quality changes due to direct deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Sediment quality changes due to dust deposition on land and subsequent runoff into lakes and streams (Mine Area in zone of dust deposition).

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

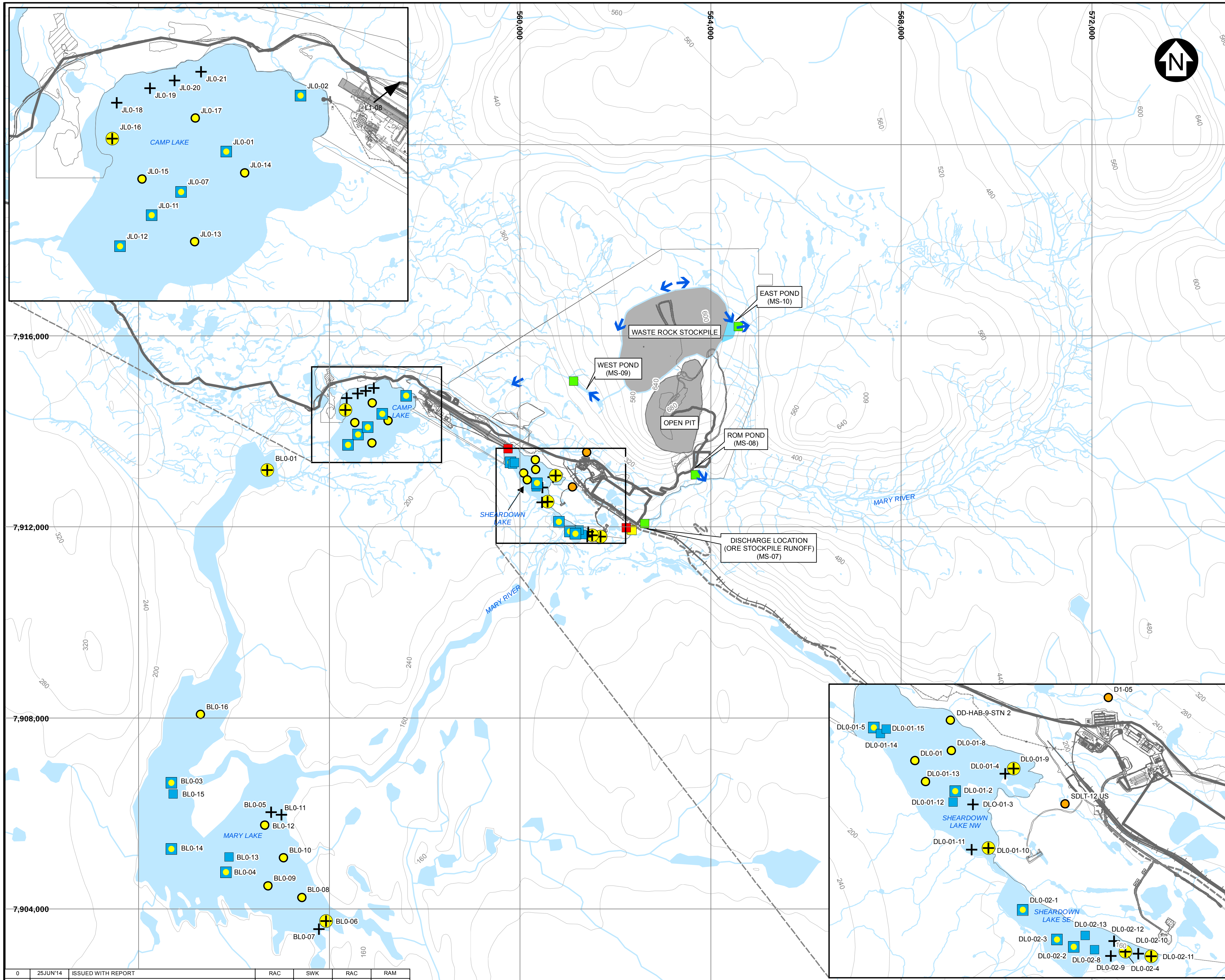
The primary issue of concern with respect to sediment quality is the effect of ore dust containing elevated metals being deposited on, or running off into, lakes and streams. As such, the CREMP will focus upon waterbodies that are closest to the sources of ore dust, with an emphasis on lakes compared with streams. The review of baseline sediment quality noted that the high-energy streams in the mine site area do not readily accumulate metals, and metals concentrations tend to be highly variable, in comparison to depositional lake sediment stations typically characterized by high organic carbon content and a higher proportion of fines (Knight Piésold, 2014a).

Preliminary sediment sampling locations are shown on Figure 4.4 and are listed in Table 3.7. The review of sediment quality baseline identified the need for additional sediment quality stations in the mine site lakes. The lake sediment stations make use of existing and new (proposed) stations as follows:

- Camp Lake – 14 stations including three historic stations and 11 new stations;
- Sheardown Lake NW - 14 stations including six historic stations and eight new stations;
- Sheardown Lake SE – 10 stations including four historic stations and six new stations; and
- Mary Lake – 15 stations including five historic stations and 10 new stations.

Lake sediment samples will be collected along transects positioned along the anticipated path of effluent (i.e., direction of inflow stream). A portion of the additional lake sediment stations correspond to proposed benthic invertebrate monitoring stations to be monitored under the freshwater biota CREMP (Section 4.2.5; Appendix D). At each station, field technicians will establish final locations for the sediment stations that are within depositional areas of the lake. This field fit of the sampling stations will likely result in some modifications to the gradient study design.

Additional pre-mining sediment sampling will be carried out in 2014 to increase the number of baseline sediment samples for comparison in future monitoring. It will be necessary to identify additional stations in depositional areas characterized by high TOC and fines content (or lower sand content), as the depositional areas are more sensitive to change.



LEGEND:

- LAKE SEDIMENT SAMPLE LOCATION
- STREAM SEDIMENT SAMPLE LOCATION
- BIC HAB 14 LAKE SAMPLE LOCATION
- BIC HAB 9 LAKE SAMPLE LOCATION
- SEDIMENT AND BIC HAB 14 SAMPLE LOCATION
- SEDIMENT AND BIC HAB 9 SAMPLE LOCATION
- MINE EFFLUENT FINAL DISCHARGE POINT
- SUMMER DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT
- WINTER LAND DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT TO MARY RIVER
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- PROPOSED SITE INFRASTRUCTURE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SEDIMENT QUALITY CREMP STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	1

FIGURE 4.4 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM

SAVED: I:\102\00181\34\A\GIS\Figs\B56_r0.mxd; Jun 26, 2014 4:00 PM; asimpson

In the long-term, sediment sampling under the CREMP will be conducted every three years, coinciding with biological monitoring studies. However, Baffinland will conduct sediment sampling in 2014 to collect additional pre-mining baseline data, and then annually for the first three years of mining. After monitoring three operating (mining) years, the sediment sampling program will be conducted on a three year cycle. The increased number of sediment samples proposed for 2014 may be reduced over time, depending on the outcome of initial monitoring.

4.2.4 Phytoplankton

The following section provides a description of monitoring of phytoplankton under the CREMP, with an emphasis on monitoring of lakes in the Mine Area, where potential for eutrophication is greatest.

The key pathways of potential effects of the Project on phytoplankton communities include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area).

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources on phytoplankton abundance in Mine Area lakes?

The primary issue of concern with respect to the phytoplankton community is related to nutrient enrichment and eutrophication, though effects on water clarity (e.g., changes in TSS) could also affect primary productivity. As such, the CREMP and the baseline data review presented in Appendix D focused upon waterbodies most at risk to eutrophication in relation to pathways of effect for the Project; in general, lakes (rather than streams) are most vulnerable to eutrophication in the mine area. Sheardown Lake NW has received treated sewage effluent discharge during the construction phase and may also be affected by dust deposition, stream diversions, and non-point sources. Although treated sewage effluent will be discharged to the Mary River during the operation phase, Mary Lake is the ultimate receiving environment for all point sources in the Mine Area, including discharge of treated sewage effluent, and is more vulnerable to effects of nutrient enrichment due to its lacustrine nature.

The selected indicator will be chlorophyll *a* and the benchmark will be 3.7 µg/L. Further description on the selection of a suitable indicator and derivation of the benchmark is provided in Section 5.3.4.

The monitoring area for phytoplankton includes mine area lakes, specifically Camp and Mary lakes, and Sheardown Lake NW and SE, and selected streams. In addition, monitoring will be conducted at a minimum of one reference lake (NSC, 2014b; Appendix E).

An *a priori* power analysis was conducted using existing baseline data for chlorophyll *a* for Sheardown Lake NW and Mary Lake to advise on the power of the existing dataset and to identify sample sizes for the CREMP; these two lakes represent the range of baseline conditions for the Mine Area lakes as a whole. Power analyses indicate relatively high power to detect a change of the magnitude of the benchmark for each sampling season in each lake. Power is greater for Sheardown Lake NW owing to the lower baseline concentrations of chlorophyll *a* than Mary Lake.

Sampling will be conducted annually during the initial years of operation but sampling frequency should be regularly evaluated (i.e., each year) to determine if modifications are warranted. Sampling in lakes would consist of two open-water periods (summer and late summer/fall) and once in late winter. Streams will be sampled three times in the open-water season. These sampling frequencies are consistent with baseline sampling programs conducted in the Mine Area to date.

Phytoplankton data will be assessed during each year of monitoring and would follow the assessment framework presented in Section 5.2. The phytoplankton CREMP study design and review of baseline data is described in detail in Appendix D.

4.2.5 Benthic Invertebrates

Key questions were developed to guide the design of the monitoring program. These questions and metrics focus upon key potential effects identified in the FEIS, as well as metrics commonly applied for characterizing the BMI community.

The key pathways of potential effects of the Project on the BMI community include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (Mine Area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Changes in sediment quality due to effluent discharge and/or dust deposition;
- Dust deposition in aquatic habitat (i.e., sedimentation); and
- Effects of the Project on primary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, aquatic habitat loss or alteration, sedimentation, and changes in primary producers on BMI abundance and community composition in Mine Area lakes?

A description of the selection of BMI indicators and derivation of benchmarks is provided in Section 5.3.5.

The overall objective of this program is to collect habitat-based abundance, composition, and distribution information for the BMI community across a range of habitat types in the Mine Area lakes and streams.

The monitoring area for BMI includes Mine Area lakes, specifically Camp, Sheardown NW and SE, and Mary lakes, and Sheardown Lake tributaries 1, 9, and 12, several sites on the Mary River located upstream and downstream of effluent discharges, and Camp Lake tributaries 1 and 2. In addition, monitoring will be conducted at a minimum of one reference lake and one reference stream.

Two lake habitat types will be targeted: habitat types 9 (nearshore) and 14 (offshore). Replicate stations will overlap sediment quality sampling locations where feasible, to provide supporting information for interpretation and analysis of results (e.g., metals concentrations). Five replicate stations will be sampled in each lake habitat type and each stream reach.

Timing of sampling will be concentrated within a single sampling season; benthic invertebrate sampling has been consistently conducted in the mine area in late summer/fall. This is an ecologically relevant time for sampling and is most appropriate considering the effluent discharge regime (i.e., discharge during the open-water season only), hydrology (i.e., streams/rivers freeze solid), and dust deposition (i.e., introduction during the open-water season).

As existing baseline data for potential reference lakes and streams are minimal the monitoring program will focus upon before-after comparisons of key metrics within the mine area waterbodies, with an emphasis on mine area lakes.

Sampling will be conducted in the first three years of operation during the ERP of the Project; subsequent sampling and sampling frequency will be evaluated following completion of the first 3 years of monitoring and in consideration of the current plans for mining activities at that time (e.g., will mine production be increased or remain at a similar level). Sampling frequency will be evaluated (i.e., each year of monitoring) to determine if modifications are warranted.

BMI data will be assessed during each year of monitoring and would follow the assessment framework presented in Section 5.2. The BMI CREMP study design and baseline data review is described in detail in Appendix D.

4.2.6 Fish (Arctic Char)

Key questions were developed to guide the design of the fish monitoring program. The key pathways of potential residual effects of the Project on Arctic Char include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and CLT-1);
- Water quality changes related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (mine area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (mine area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Dust deposition (i.e., sedimentation) in Arctic Char spawning areas (habitat) and on Arctic Char eggs; and
- Effects of the Project on primary and secondary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, sedimentation, habitat loss or alteration, and changes in primary or secondary producers on Arctic Char in mine area lakes (Sheardown Lake NW and SE, Camp Lake, and Mary Lake) and streams?

Given that there are only two fish species present in the area, fish monitoring in the mine area would be limited to successful capture of sufficient numbers of both of these fish species in the exposure areas. In most lakes and streams in the exposure area, Arctic Char are sufficiently abundant that successful capture of enough fish for monitoring purposes is possible. In contrast, Ninespine Stickleback are absent or uncommon in a number of waterbodies. For these reasons only a single species, Arctic Char, will be targeted under the CREMP.

Non-lethal sampling methods will be used to the extent possible to minimize impacts of monitoring on the Arctic Char populations. As a result, metrics that can be reliably obtained from live fish will be included in CREMP. Metrics will include indicators of fish growth, condition, and reproduction. The evaluation and selection of indicators and benchmarks for Arctic Char are presented in Section 5.3.6.

The monitoring area for Arctic Char includes mine area lakes, specifically Camp and Mary lakes, and Sheardown Lake NW and SE. Monitoring of lakes is a key component of the CREMP because the mine area lakes provide overwintering and spawning habitat, support the full range of age classes, and because they may be affected differently than streams. In addition, monitoring will be conducted at a minimum of one reference lake, and potentially in one stream.

Sampling will be conducted in the first three years of operation during the ERP of the Project; subsequent sampling and sampling frequency will be evaluated following completion of the first 3 years of monitoring and in consideration of the current plans for mining activities at that time (e.g., will mine production be increased or remain at a similar level). Sampling frequency should be regularly evaluated (i.e., each year of monitoring) to determine if modifications are warranted. Lake monitoring will occur in late summer/fall near the end of the growing season.

The study design is a non-lethal fish survey, which would consist of a lake-based program in late summer/fall using a combination of gear types.

Fish data will be assessed during each year of monitoring and would follow the assessment framework presented in Section 5.2. The fish CREMP study design and baseline data review is described in detail in Appendix D.

4.3 TARGETED STUDIES

As described in Section 1, specific effects monitoring (or targeted monitoring) programs/studies have been identified to address specific questions or potential impacts. These are programs or studies that are relatively confined in terms of spatial and/or temporal scope. Targeted environmental studies relate to specific environmental concerns that require further investigation or follow-up but are not anticipated to be components of the core monitoring program. The Lake Sedimentation Study, Dustfall Monitoring Program, and the Stream Diversion Barrier Study are the targeted studies identified in this AEMP.

4.3.1 Lake Sedimentation Monitoring Program

A specific effects monitoring study will be conducted to monitor effects related to the introduction of dust, and other sources of suspended solids, in surface waters and subsequent deposition in aquatic habitat (NSC, 2014c; Appendix F).

Sedimentation rates will be monitored in Sheardown Lake NW through deployment of sediment traps, as described in detail in Appendix F. In brief, the program will involve year-round deployment of sediment traps in different lake habitat types for the analysis of total dry weight of sediment. Traps will be emptied and redeployed after ice-off and in fall to provide measures of seasonal (i.e., open-water and ice-cover season) deposition rates. A sampling program was initiated in 2013 and is on-going. Through comparisons of the measured sedimentation at Sheardown Lake NW to sedimentation amounts known to adversely affect salmonid egg survival that are available from published literature, the current lake sedimentation monitoring program will provide a strong scientific basis for the determination of any sediment deposition effects on Arctic charr egg survival at Sheardown Lake NW.

4.3.2 Dustfall Monitoring Program

The amended NIRB Project Certificate No. 005 included requirements for dustfall monitoring. In 2013, Baffinland implemented a dustfall monitoring program as part of the TEMMP that meets the requirements (Baffinland, 2014). A description of this program is included in Appendix G. The dustfall monitoring program consists of operating dustfall buckets positioned along transects radially out from the main development areas: Milne Port, the tote road and the mine site, along with reference dustfall monitoring stations. Dustfall measurements (the amount of dustfall per unit time) will be completed seasonally (summer and winter) and the dustfall will be analyzed to determine the metals composition of the dust.

The dustfall monitoring results will be reviewed to estimate the seasonal deposition (rates, quantities) and chemical composition of dust entering aquatic systems along representative distance transects at right angles to the Tote Road and radiating outward from Milne Port and the Mine Site, as per PC Condition #21.

4.3.3 Initial Stream Diversion Barrier Study

A streamflow reduction barrier study was identified as a follow-up program in the FEIS (Baffinland, 2012). The Initial Stream Diversion Barrier Study is presented in Appendix H (Knight Piésold, 2014c).

The primary objectives of the study are to monitor the effects of both increases and reductions in streamflow at several mine site streams and to further understand how Project-related reductions in streamflow may result in the creation of fish barriers that have the potential to occur at low flows. The monitoring program may identify the need for mitigation measures to address Project-related fish stranding.

An initial study is proposed that will focus on obtaining a better understanding for existing flow conditions and, in particular, the frequency and duration of the occurrence of fish barriers and fish stranding that was identified in five (5) mine site streams (see Figure 1.1):

- CLT-1;
- CLT-2;
- SDLT-1;
- SDLT-9;

- AndSDLT-12.

Since the stream diversion barrier study was identified in the FEIS, Baffinland has developed plans to initiate an Early Revenue Phase (ERP) of the Project (Baffinland, 2013). The ERP will involve mining 3.5 million tonnes per annum (Mt/a) of iron ore. The iron ore will be transported year-round by truck to Milne Port and then to market by ship during the open water season. Baffinland has contemplated a 5-year operating plan for the ERP, after which time the full-scale railway project would also be brought on-line. This development schedule is subject to a commercial decision by Baffinland to proceed and will be influenced by both market conditions and available financing.

The reduced production rate associated with the ERP will result in a considerably smaller mining footprint (open pit and waste rock stockpile) than was originally envisioned. As such, Project-related stream diversions will be negligible. The absence of diversions provides Baffinland with an opportunity to better understand existing flow conditions as it relates to fish passage. This initial study is exploratory in nature with the following objectives (which contribute to the primary objectives stated above):

- Develop an understanding of low-flow conditions that may result in barriers to fish passage within two tributaries of Camp Lake and three tributaries of Sheardown Lake; and
- Document fish presence throughout the stream length under various flow conditions. It is important to document upstream access during spring freshet, since high water velocities in the spring can prevent fish passage. It is also important to document the downstream passage of fish in the fall, when they are returning to overwintering habitat in the lakes.

The five streams of interest will be monitored in spring and fall during the initial years of operation. Low and high flow periods will be targeted where possible. Results of this initial monitoring will be reviewed to determine whether mitigation and/or ongoing monitoring are required. In spring, all five streams will be visually assessed to monitor for potential barriers and obstructions to upstream fish passage. Surveys will document conditions within the monitoring streams between the upstream fish barriers and their outlets into Camp Lake and Sheardown Lake. Implementation of these visual assessments by an experienced biologist will allow effective determination of whether perceived barriers result in the prevention of fish migration within each tributary, and thus electro fishing surveys are not deemed necessary for the assessment. During report preparation, the combination of visual observations of barriers, fish presence and associated flows at the time of the survey can be used to determine the conditions in which fish migration will be limited within each tributary under various flow conditions

Other monitoring programs will contribute data relevant to this study. For example, Baffinland`s hydrology monitoring program includes stream gauges on three streams monitored under this program, and the freshwater biota monitoring will be undertaken as part of the CREMP. Monitoring data from both these programs will be used in the analysis of data from this initial stream diversion monitoring study.

The 3-year initial stream diversion study monitoring report will be presented with the AEMP Annual Monitoring Report in the first half of 2017. The report will also include recommendations on potential mitigation measures and future monitoring.

Continuation of the monitoring program will depend upon the schedule and size of the Project. The Approved Project (18 Mt/a) will result in meaningful reductions in streamflow and monitoring will be required to identify Project-related fish barriers and fish stranding. If the ERP were to continue beyond 2017 and the 3-year study has met the stated objectives, then this targeted study may be discontinued until such time as the Approved Project proceeds. If possible, monitoring for the Approved Project will start one year prior to the start of larger scale mining.

5 ASSESSMENT APPROACH AND MANAGEMENT RESPONSE

5.1 OBJECTIVES

As stated in Section 1, the AEMP is a monitoring program designed to:

- Detect short-term and long-term effects of the Project's activities on the aquatic environment resulting from the Project;
- Evaluate the accuracy of impact predictions;
- Assess the effectiveness of planned mitigation measures; and
- Identify additional mitigation measures to avert or reduce unforeseen environmental effects.

Monitoring data will be collected from the various programs. A common approach for the assessment of data and the implementation of a management response will be applied to all AEMP monitoring programs.

5.2 ASSESSMENT APPROACH AND RESPONSE FRAMEWORK

Monitoring data collected through the AEMP requires a systematic data evaluation process, as well as management responses that would be taken, in response to certain data evaluation outcomes. A common assessment (data evaluation) and management response framework will be implemented, as outlined on Figure 5.1.

This multi-step process includes the following:

Step 1 - Data Management and Evaluation

This step includes the QA/QC; comparisons to the AEMP benchmark and to reference and/or baseline; and review of the data using various tools such as Exploratory Data Analysis (EDA) and Statistical Data Analysis (SDA), to determine if change is occurring. A change may be detected statistically or qualitatively, relative to benchmarks, baseline values and/or spatial or temporal trends. A change may be statistically significant, but professional judgement will also be applied using the various evaluation tools to detect a change qualitatively.

If Step 1 does not detect change, then no action is required. If a change is observed, then further evaluation of the data for that/those indicator(s) will be carried out under Step 2.

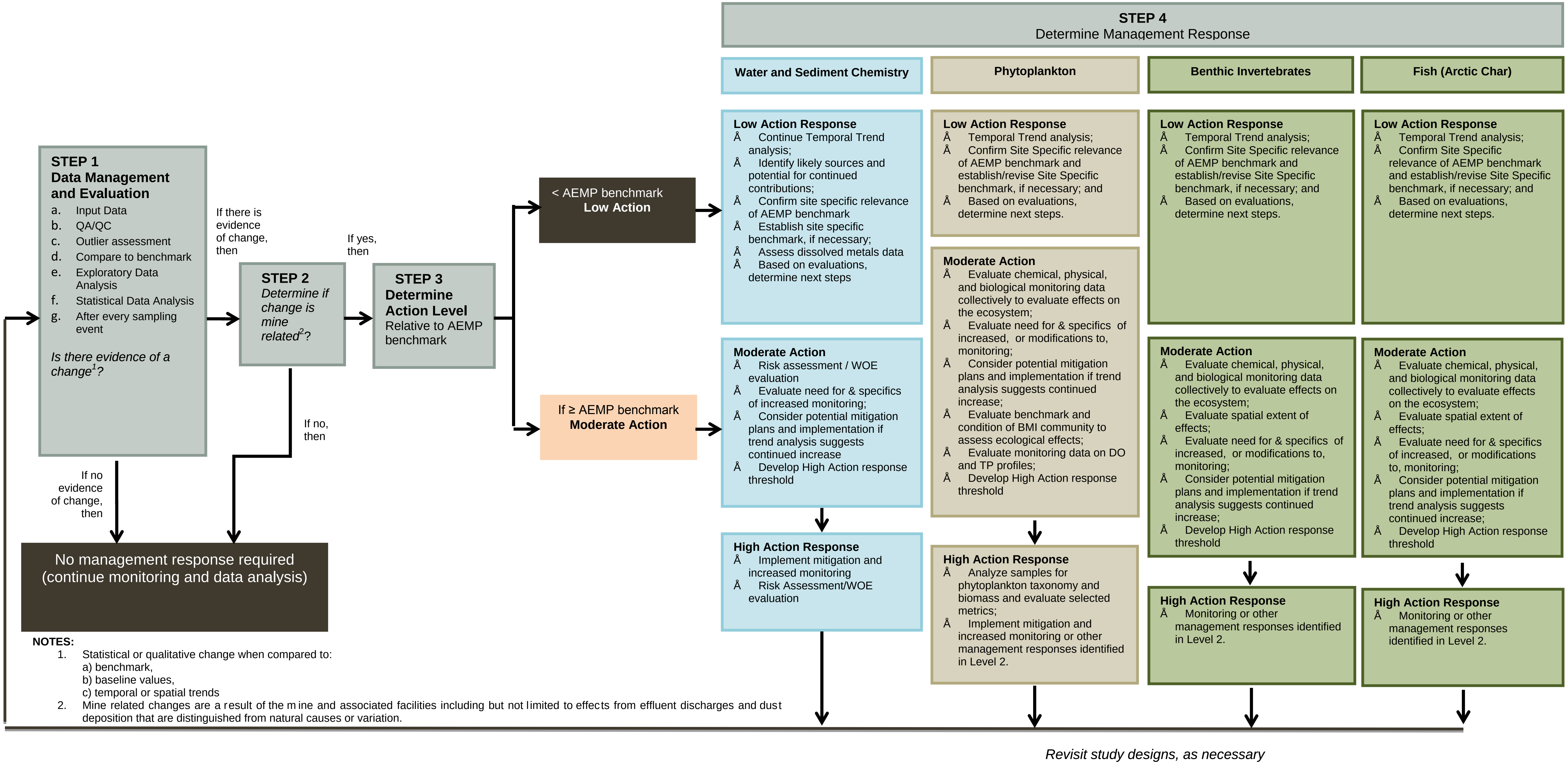
Step 2 – Determining Whether the Observed Change is Mine-Related

Step 2 involves determining if the changes in the indicator(s) of concern are due to the Project or due to natural variability or other causes.

Project activities with the potential to induce the observed change will be reviewed to identify potential Project-related causes or sources. This could include evaluating effluent quality, discharge regime/rates, and loading, dust deposition, and other point/non-point sources as required. Also, any evidence of potential natural causes (i.e., a major erosional event such as a slumping riverbank) will be investigated. Sampling data sheets and site personnel will be a source of this information.

This question will be addressed using EDA and subsequently using SDA. EDA will be completed to visualize overall data trends, and could include evaluating spatial patterns, to examine the spatial extent and pattern of observed changes.

Figure 5.1 Data Assessment Approach and Response Framework



NOTES:
1. Statistical or qualitative change when compared to:
a) benchmark,
b) baseline values,
c) temporal or spatial trends
2. Mine related changes are a result of the mine and associated facilities including but not limited to effects from effluent discharges and dust deposition that are distinguished from natural causes or variation.

The exploratory data analyses could include comparisons of data from Mine Area streams to data from reference streams and comparisons of Mine Area Lakes to reference lake(s). This can further assist with determining whether the observed changes were due to natural variability or the Project. Graphical analyses may be used to confirm assumptions required for statistical testing (normality, sample size, independence). Differences in fish and other biotic endpoints between mine-exposed and reference areas will be preferentially tested using pair-wise, single factor ANOVA. Prior to ANOVA, all data will be evaluated for normality and homogeneity of variance to ensure that applicable statistical test assumptions will be met. In instances in which normality cannot be achieved through data transformation, non-parametric Mann-Whitney U-test statistics will be used to confirm the statistical results from the ANOVA using transformed data. Similarly, in instances in which variances of normal data could not be homogenized by transformation, pair-wise comparisons will be conducted using Student's t-tests assuming unequal variance to confirm the statistical findings of the ANOVA tests. SDA will be used as outlined in the individual assessment frameworks and can be applied to the parameters of interest to test the primary hypothesis for the effects of mine-related change.

If the Step 2 analysis concludes that the changes in water quality parameters of concern are, or are likely, due to the Project, the assessment will proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response will be required.

Step 3 - Determine Action Level

If the evaluation conducted in Step 2 has indicated with some certainly that the measured change is project-related, Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark. Three levels of action have been identified: low, moderate, and high; and the response actions range from increased monitoring and data analysis (e.g., trend analysis); identification of possible sources; to risk assessment and/or mitigation. The specifics for each aquatic component (water and sediment quality, phytoplankton, benthic invertebrates and arctic char) are summarized in Figure 5.1 and are described further in each of the component study designs. Below is a generic description of each of the levels of response.

If the benchmark is not exceeded, a **low action response** would be undertaken and could include any number of potential responses, including the following:

- Evaluate temporal trends
- Identify likely source(s) and potential for continued contributions
- Confirm the site-specific relevance of benchmark and establish a site-specific benchmark, if necessary
- Further evaluation of data (for example, for water quality, review dissolved metals data or supporting variables).
- Based on evaluations, determine next steps

If the benchmark is exceeded and it is concluded to be Project-related, a **moderate action level response** would be undertaken and could include, in addition to analyses identified for a low action response, the following:

- Consider a weight-of-evidence (WOE) evaluation and/or risk assessment, considering other monitoring results collectively with the indicator that has changed, to evaluate effects on the ecosystem
- Evaluate the need for and specifics of increased monitoring

- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the **high action level response** has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in the indicator parameter(s) of concern on the lakes as a whole. Also, the benchmark may need to be revised in consideration of ongoing monitoring results. The precise relationships between water quality, sediment quality and lower trophic level changes and the collective effects on fish is difficult to predict and therefore actions undertaken under Level 2 will attempt to explore these relationships to advise on overall effects to the ecosystem. Results would be discussed with regulatory agencies and the next steps would be identified. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) could include:

- Implementation of increased monitoring to further assess the potential for effects and/or define magnitude and spatial extent if warranted
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response

The specifics of how the framework is implemented are described in the individual study designs in the appendices.

5.3 INDICATORS AND BENCHMARKS

Indicators are measurable parameters that can be used to detect change in the environment. Benchmarks are established for various indicators to establish the point at which actions will be triggered before unacceptable adverse effects occur (INAC, 2009). Benchmarks have been identified for each of the aquatic components to be monitored at the mine.

5.3.1 Process for Developing Water and Sediment Quality Benchmarks

Since the mine site occurs within an area of metals enrichment, generic water quality and sediment guidelines established for all areas within Canada may naturally be exceeded near the mine site. Therefore, the selection of appropriate benchmarks must consider established water and sediment quality guidelines, such as those developed by the Canadian Council of Ministers of the Environment (CCME), as well as site-specific natural enrichment, and other factors such as Exposure Toxicity Modifying Factors (ETMF), including pH, water hardness, dissolved organic carbon, etc. (CCME, 2007).

The assessment of surface water and sediment quality data over the life of the project will be on-going, and the identified benchmarks may change throughout this process, as more data become available. For example, an AEMP benchmark established early on in the life of the mine may require updating in 10 years to a site-specific water quality objective (SSWQO), based on new published literature which has become available, or site specific toxicity tests conducted to further understand ETMF or resident species toxicity. In addition, sediment data will be collected in 2014 prior to mine-related discharge to augment the baseline database and is expected to be integrated into the baseline data, and will likely result in modifications to the suggested AEMP sediment benchmarks presented herein. The iterative, cyclical nature of modification of benchmarks under an AEMP is well established (MacDonald et al., 2009).

The approach for benchmark development involved the following steps:

- Determine, using the FEIS, which substances are present at naturally elevated concentrations, and/or those that could be released at elevated concentrations as a result of mining activities, into the future, as well as substances regulated or potentially regulated under the MMER;
- Evaluate baseline data, and determine a statistical metric of baseline levels which is considered representative of background for any naturally occurring substances (metals/metalloids);
- Evaluate national (CWQG-PAL or CSQG-PAL) or other relevant guidelines from other regulatory jurisdictions, where appropriate. Appropriate guidelines could include Site-Specific Water Quality Objectives (SSWQOs) developed using data from the Mary River area, or from other northern Mine sites, where data are appropriate; and
- Select the higher of either baseline or regulatory or SSWQO as the benchmark for the AEMP.

The specifics of the benchmark selection process for both sediment and surface water are outlined in Appendix C, with a summary provided herein.

5.3.2 Water Quality Benchmarks

Selection of Substances for Benchmark Development

Based on the baseline data collected between 2005 and 2013, and the outcomes of the FEIS, substances having the potential to be either naturally elevated in the environment, or elevated as a result of future mine site activities in lake water were identified as requiring AEMP benchmarks. In addition, metals regulated or which may be potentially regulated under MMER for base metal mines (as a result of the current re-evaluation of the MMER regulations) were similarly considered for benchmark development. The substances of interest shortlisted for benchmark development in surface waters were as follows:

- Metals/Metalloids: Al, As, Cd, Cr, Co, Cu, Fe, Pb, Ni, Ag, Tl, V, Zn; and
- General Parameters and Nutrients: Chloride, Sulphate, Ammonia, Nitrite, Nitrate.

In addition, numerous parameters will be evaluated in the Exploratory Data Analysis (Step 1 of Assessment Framework), including pH, DO, hardness, TSS, Alkalinity, Mg, P, K, Total Organic Carbon and Dissolved Organic Carbon, to monitor potential change. If changes in these substances are noted, benchmarks can be developed at a later stage.

Baseline Data Evaluation

Data treatment conducted in the water and sediment quality baseline review (Knight Piésold, 2014a; Appendix B) involved the following steps:

- Removing all duplicate samples, to avoid “double counting” of data;
- All samples which were non-detect were assumed to equal the detection limit for statistical calculations; and
- Where detection limits were elevated compared to later sampling events, they were substituted with lower detection limits (Appendix B).

A detailed assessment of lake and river/stream data is presented in the Water and Sediment Quality CREMP Study Design and the baseline review in the appendices (Appendix B). A summary of trends observed in lakes and rivers, respectively, in addition to how the data were treated for benchmark development is as follows (details are provided in Intrinsik, 2014; Appendix C):

- Geographic trends between discrete sampling sites within lakes were not observed in Camp Lake or Sheardown Lake NW, although some substances were elevated within Mary Lake at the inlet. No geographic trends were observed within Mary River, but within Camp Lake Tributary, Station L0-01 had higher concentrations of several substances;
- Within lakes, distinct depth trends were not observed for Camp Lake, Mary Lake or Sheardown Lake NW and lakes were considered to be completely mixed (Knight Piésold, 2014; Appendix B), with the exception of aluminum in Sheardown Lake NW. This suggests that combining the shallow and deep datasets would be appropriate (with the exception of aluminum), since the shallow and deep samples were collected on the same day at the same site. The possible effects of pseudoreplication (since both shallow and deep samples were taken on the same day) were explored, and deemed to be not significant, and hence, these samples were combined.
- An evaluation of the water quality samples from Sheardown Lake NW, Sheardown Lake SE and Sheardown Lake near shore was also undertaken, to determine if these datasets could be combined to calculate a lake-specific AEMP benchmark, and it was concluded that this was a reasonable approach.
- Seasonality was observed for several substances in lakes (e.g., Aluminium had higher concentrations in summer in all lakes; whereas copper, nickel and/or arsenic tended to have higher concentrations in winter).

For the purposes of water quality benchmark development, each water body was assessed separately. Statistical summaries are provided in Appendix C of all lakes and rivers, with respect to minimum, maximum, % detects, mean, median, 95th percentile, and 97.5th percentile for each substance of interest (Intrinsik, 2014).

The typical starting point for assessment of surface water data collected in any aquatic effects monitoring program are the Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life (CWQG-PAL) values, established by the Canadian Council of Ministers of the Environment (CCME, various years, with updates up to 2012). These guidelines reflect the most current scientific data at the time they were developed, and are intended to provide protection to all forms of aquatic life and aquatic life cycles, including the most sensitive life stages, at all locations across Canada (CCME, 2007). Since they are generic and do not account for site-specific factors that can alter toxicity, these national guidelines can be modified using widely accepted procedures, to derive site-adapted or site-specific guidelines or objectives for a given project or location (CCME, 2003).

The focus of AEMP benchmark development was on total metals, since available CWQG-PAL focus on total metals benchmarks, as opposed to dissolved metals data. Dissolved data will be assessed under the Assessment Approach and Response Framework in the Low Action Response (Step 3 of Figure 5.1) to examine trends, and where deemed appropriate, based on assessment of both dissolved and total analyses, dissolved benchmarks will be considered for development if data are suggesting mine-related increases are occurring. Dissolved water quality guidelines are available for some parameters from the US EPA (2014), as well as British Columbia Ministry of Environment, and these guidelines would be considered as a first point of comparison, in conjunction with baseline levels, as well as SSWQO, where appropriate.

The approach for selecting water quality benchmarks was the following:

- Select CWQG-PAL guideline, where available or a SSWQO, if already derived;
- Where CWQG-PAL are not available, or are not considered relevant, a surrogate guideline from another jurisdiction was selected (e.g., provincial water quality guideline; US EPA; relevant guideline from another operator, etc.);
- In addition, baseline data was assessed, and a statistical metric of baseline levels (e.g., 97.5th percentile of baseline data) for any naturally occurring substances (metals/metalloids) was calculated;
- The higher of the CWQG-PAL/surrogate guideline or natural baseline was selected as the benchmark;
- Where no water quality guidelines are available, the 97.5th percentile was selected to represent the benchmark;
- Where data had <5% detected values, the higher of the water quality guideline (where available), or 3 times the method detection limit (MDL) was selected;
- Where modifications were required based on site-specific parameters, such as hardness or pH, the 25% percentile hardness and 25% percentile pH values for the water body in question was used in order to calculate a protective guideline. For ammonia, the 75th percentile temperature and pH were used to calculate the guideline. Where parameters are trending up towards these benchmarks, site-specific values should be substituted for comparison purposes (in Low Action).
- Where no CWQG-PAL guideline was available for a substance of interest, a BC MOE (Ministry of the Environment) Approved or Working guideline for the water column were used, where available (BC MOE, undated website). In addition, several water quality guidelines established by the CCME are currently under revision (i.e., lead and iron) or have been released in draft form for comments (silver). Once finalized, these revised benchmarks should be evaluated, using the benchmark selection process outlined, and benchmarks updated accordingly. Details on the specific guidelines selected are presented in Appendix C (Intrinsik, 2014).

Based on the approach used, proposed water quality benchmarks for area lakes and rivers are presented in Tables 5.1 and 5.2, respectively. In most cases, the recommended AEMP benchmarks are consistent between lakes and rivers, with the vast majority of selected benchmarks being regulatory water quality guidelines.

Table 5.1 Selected Water Quality Benchmark Approach and Values for Mine Site Lakes

Parameter	Units	Water Quality Guideline	Camp Lake	Mary Lake	Sheardown Lake	Selected Benchmark	Benchmark Method
Metals [3]							
Aluminium	mg/L	0.1	0.026	0.137	0.179 (Shallow) 0.173 (Deep)	CL = 0.1 ML = 0.13; SDL shall/deep = 0.179/0.173	A (CL), B (ML/SDL)
Arsenic	mg/L	0.005	NC	0.00018	0.0001	0.005	A
Cadmium	mg/L	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	NC	0.000023	0.000017	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	A
Chromium	mg/L	NGA	NC	0.001	0.000641	0.0003 (CL) (ML) = 0.0005[8] (SDL) = 0.000642[9]	B (ML/SDL), C (CL)
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	NC	0.0089	A

Parameter	Units	Water Quality Guideline	Camp Lake	Mary Lake	Sheardown Lake	Selected Benchmark	Benchmark Method
Chromium $^{+6}$	mg/L	0.001	NC	0.001	NC	0.003 – 0.015 (CL)[5] 0.003 (ML/SDL)[5]	C
Cobalt	mg/L	0.004	NC	NC	0.0002	0.004	A
Copper	mg/L	0.002	0.0113	0.00239	0.00243	(CL) = 0.004[7] (ML) = 0.0024 (SDL) = 0.0024	B
Iron	mg/L	0.3	0.0421	0.173	0.211	0.3	A
Lead	mg/L	0.001	0.000334	0.00013	0.00026	0.001	A
Nickel	mg/L	0.025	0.000941	0.00080	0.000973	0.025	A
Silver	mg/L	0.0001	NC	NC	0.0000104	0.0001	A
Thallium	mg/L	0.0008	NC	NC	0.0001	0.0008	A
Vanadium	mg/L	0.006	NC	0.00146	0.001	0.006	A
Zinc	mg/L	0.030	0.0037	0.003	0.00391	0.030	A
Water Quality Parameters							
Chloride (Cl^-)	mg/L	120	4	13	5	120	A
Ammonia (NH_3+NH_4)	mg N/L	0.855[4]	0.84	0.32	0.44	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.1[6]	0.1[6]	0.1[6]	0.060	A
Nitrate (NO_3)	mg N/L	13	NC	0.11	NC	13	A
Sulphate	mg/L	218	3	7	5	218	A

<u>NOTES</u>:

1. NGA = NO GUIDELINE AVAILABLE; NC = NOT CALCULATED; TBD = TO BE DETERMINED; GUIDELINE STILL UNDER DEVELOPMENT; CL = CAMP LAKE; ML = MARY LAKE; SDL = SHEARDOWN LAKE.
2. METHOD A = WATER QUALITY GUIDELINE FROM CCME/B.C. MOE; METHOD B = 97.5%ILE OF BASELINE; METHOD C = 3* MDL.
3. TOTAL METALS UNLESS OTHERWISE NOTED.
4. ASSUMES TEMPERATURE AT 10 DEGREES C, AND pH OF 8.
5. THE 2013 DETECTION LIMIT FOR Cr^{6+} INCREASED IN 2013 FROM 0.001 to 0.005, HENCE THIS AFFECTS THE 3* MDL CALCULATION FOR THE BENCHMARK IN CAMP LAKE. EFFORTS WILL BE MADE TO REDUCE THIS MDL IN 2014, AND COMPARISONS TO THE LOWER OF THE 2 BENCHMARKS WOULD THEN BE APPLIED IN CAMP LAKE. IF DETECTION LIMITS IMPROVE, METHOD A (SELECTION OF THE GUIDELINE) MAY BE IMPLEMENTED.
6. THESE VALUES ARE ELEVATED DETECTION LIMITS, AND HENCE, THE GUIDELINE HAS BEEN SELECTED AS THE AEMP BENCHMARK.
7. THE MAXIMUM VALUE OF 0.0113 MG/L COPPER WAS REMOVED TO CALCULATE THE 97.5TH PERCENTILE, AS THIS VALUE APPEARS TO BE AN OUTLIER.
8. AN ELEVATED DETECTION LIMIT OF 0.001 MG/L WAS REMOVED FROM THE DATASET AND CALCULATIONS, AND THE AEMP SELECTED WAS THE 97.5th PERCENTILE, WHICH IS 0.0005 mg/L.
9. SEVERAL DETECTED VALUES RANGING FROM 0.00079 - 0.00316 mg/L Cr HAVE BEEN REPORTED IN THE DATASET FOR SDL, AND HENCE, THESE VALUES WERE CONSIDERED TO REPRESENT BASELINE, AND WERE INCLUDED IN THE 97.5th PERCENTILE CALCULATION.

Table 5.2 Selected Water Quality Benchmark Approach and Values for Mine Site Streams

Parameter	Units	Water Quality Guideline	Camp Lake Tributary	Mary River[3]	Selected Benchmark	Benchmark Method
Metals[4]						

Parameter	Units	Water Quality Guideline	Camp Lake Tributary	Mary River[3]	Selected Benchmark	Benchmark Method
Aluminum	mg/L	0.1	0.179	0.97	CLT = 0.179 MR = 0.966	B
Arsenic	mg/L	0.005	0.00012	0.00013	0.005	A
Cadmium	mg/L	0.00008 (CLT) 0.00006 (MR)	NC	0.00002	CLT = 0.00008 MR = 0.00006	A
Chromium	mg/L	NGA	0.000856	0.0023	CLT = 0.000856 MR = 0.0023	B
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	0.0089	A
Chromium $^{+6}$	mg/L	0.001	NC	NC	0.003[5]	C
Cobalt	mg/L	0.004	NC	0.0004	0.004	A
Copper	mg/L	0.002	0.00222	0.0024	CLT = 0.0022 MR = 0.0024	B
Iron	mg/L	0.3	0.326	0.874	CLT = 0.326 MR = 0.874	B
Lead	mg/L	0.001	0.000333	0.00076	0.001	A
Nickel	mg/L	0.025	0.00168	0.0018	0.025	A
Silver	mg/L	0.0001	NC	0.0001	0.0001	A
Thallium	mg/L	0.0008	0.0002	0.0002	0.0008	A
Vanadium	mg/L	0.006	NC	0.002	0.006	A
Zinc	mg/L	0.030	0.0035	0.01	0.030	A
Water Quality Parameters						
Chloride (Cl^-)	mg/L	120	23	21.55	120	A
Ammonia (NH_3+NH_4)	mg N/L	0.855[6]	0.60	0.60	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.095[7]	0.06	0.060	A
Nitrate (NO_3)	mg N/L	13	0.118	0.14	13	A
Sulphate	mg/L	218	6	8	218	A

NOTES:

1. NGA = NO GUIDELINE AVAILABLE; NC = NOT CALCULATED; TBD = TO BE DETERMINED; GUIDELINE STILL UNDER DEVELOPMENT; MR = MARY RIVER; CLT = CAMP LAKE TRIBUTARY.
2. METHOD A = WATER QUALITY GUIDELINE FROM CCME/B.C. MOE; METHOD B = 97.5%ILE OF BASELINE; METHOD C = 3* MDL.
3. ONE SAMPLE (OUTLIER) CONTAINING CHEMICAL CONCENTRATIONS ORDERS OF MAGNITUDE ABOVE OTHER VALUES WAS NOT INCLUDED IN THE CALCULATIONS FOR MARY RIVER.
4. TOTAL METALS UNLESS OTHERWISE NOTED.
5. EFFORTS WILL BE MADE TO REDUCE THIS MDL IN 2014, AND COMPARISONS TO THE HIGHER OF THE METHOD A OR C WOULD THEN BE APPLIED AS THE AEMP BENCHMARK.
6. ASSUMES TEMPERATURE AT 10 DEGREES C, AND pH of 8.0.
7. 97.5th PERCENTILE IS BEING DRIVEN BY ELEVATED DETECTION LIMIT, THEREFORE, THE GUIDELINE WAS SELECTED.

In most cases, the benchmarks are consistent between lakes and streams, with the vast majority of selected benchmarks being generic WQOs (i.e., CWQG-PAL or surrogate). Where natural concentrations varied, and exceeded available WQOs, or < 5% of values was detected, recommended benchmarks varied.

5.3.3 Sediment Quality Benchmarks

Selection of Substances for Benchmark Development

Based on the baseline data collected between 2005 and 2013, and the outcomes of the FEIS, the following substances have the potential to be either naturally elevated in the environment, or elevated as a result of future mine site activities. Therefore, these substances merited benchmark development:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Iron;
- Manganese;
- Nickel; and
- Phosphorus.

In addition, lead, mercury and zinc were also included for benchmark development, as CCME sediment quality guidelines exist for these substances. Further details are presented in Appendix C (Intrinsik, 2014).

Baseline Data Evaluation

Data treatment conducted in the Water and Sediment Quality Baseline Review (Knight Piésold, 2014; Appendix B) involved the following steps:

- Removing all duplicate samples, to avoid “double counting” of data;
- All samples which were non-detect were assumed to equal the detection limit for statistical calculations; and
- Review of sediment quality laboratory detection limits.

Additional assessment of baseline data was conducted to examine metals concentrations relative to depositional characteristics of sampling locations, in order to explore the relationships between depositional characteristics (such as Total Organic Carbon (TOC) (e.g., high TOC represents a higher propensity to accumulate metals) and presence of sand (% sand; e.g., high sand content would represent lower potential for accumulation of metals, due to lower binding potential), and metal concentrations (Appendix B). This assessment concluded that all sediment sampling locations with TOC concentrations < 60% (0.6) and sand content of > 80% or those stations wherein sand alone was > 90% (irrespective of TOC) do not represent depositional zones, and these stations should no longer be included as potential monitoring stations. As such, these stations were removed from the baseline chemistry calculations. Removal of these stations is justified since stations exhibiting these characteristics have a low potential to accumulate metals, and hence, will have a low likelihood of exhibiting substantial changes in chemistry in the future.

The remaining data were evaluated using two approaches, based on the dataset as a whole (N=52), and also on an area-by-area basis, to attempt to evaluate similarities and differences between the lakes, and to determine if there were differences between lakes which would suggest a need for differing AEMP benchmarks for different lakes. With respect to possible approaches that can be taken to estimate background, upper percentile values are frequently used (either 95th percentile or 97.5th percentile) as reasonable metrics for characterizing upper estimate of baseline. While both statistical metrics are presented, the final metric used to represent baseline was the 97.5th percentile, based on approaches established by Ontario Ministry of Environment (OMOE, 2011). Details of the assessment of the entire area-wide dataset, as well as lake by lake comparisons, are presented in Appendix C (Intrinsik, 2014). The outcomes of the assessment can be summarized as follows:

- Sample sizes within a number of area lakes were limited (e.g., Camp Lake, n=9; Sheardown Lake SE, n=6; Mary Lake, n=6, Tributaries of Sheardown Lake, n=5), compared with Sheardown Lake NW (n=25). In light of this, more sediment data will be collected in 2014 prior to commencement of mining, to further characterize baseline sediment concentrations in these lakes and confirm whether enrichment for metals/metalloids may require lake-specific sediment quality benchmarks. As a result of the need for more sediment data to more fully characterize baseline, only interim sediment quality benchmarks are presented at this time;
- An assessment of temporal changes within Sheardown Lake NW was conducted, to examine whether concentrations in that basin have increased over time. The data suggest that Cr, Cu and Ni appear to be trending upwards, although this has not been confirmed statistically. Phosphorus data are too limited to interpret. Collection of additional data in 2014 will assist in interpretation of trends, and influenced data would be removed from final AEMP benchmark calculations. All Sheardown Lake NW has been retained for the interim benchmark calculations.
- Interim benchmarks are based on the area-wide data from all depositional watercourses, with the exception of the Tributaries of Sheardown Lake (n=5). It was determined that some metal concentrations within the Tributaries of Sheardown Lake were increasing the 95th and 97.5th percentile calculations for the area-wide data set, and hence these data were removed for the purposes of interim benchmark calculations. This area will be sampled in 2014, and further assessment of the data will occur at that time, relative to other areas, and earlier sediment data.

The proposed approach for selecting AEMP sediment benchmarks included the following:

- Select CCME sediment quality guidelines, where available. The ISQG will be considered as the initial point of comparison, where one exists. The PEL is also being considered to provide added perspective related to risk potential.
- Where CCME guidelines are not available, a surrogate guideline from another jurisdiction will be selected (e.g., provincial sediment quality guidelines; US EPA, etc.).
- In addition, baseline data will be assessed, and a statistical metric of baseline levels (e.g., 97.5th percentile of baseline data) for any naturally occurring substances (metals/metalloids) will be calculated.

The higher of the CCME/surrogate guideline or natural baseline was selected as the Interim AEMP benchmark. The outcome of this evaluation process is presented in Table 5.1.

As mentioned above, additional sediment sampling will be conducted in all mine site lakes, focusing on depositional areas, as per the analysis outlined in the CREMP to gather more data to characterize baseline prior to commencement of mining operations. 2014 data will be evaluated for temporal trends, and to determine whether lakes can be aggregated for some or all metals of interest with respect to AEMP benchmark development. Final AEMP benchmarks will be established following analysis of the 2014 data, and interim sediment quality benchmarks can be used for assessment purposes until that time.

5.3.4 Nutrient/Eutrophication Indicators and Benchmarks

During the NIRB review of the FEIS as well as the water licensing technical review and final hearings, Environment Canada expressed concern regarding the potential for discharges of treated sewage effluent to result in eutrophication of the receiving waters (Sheardown Lake NW and Mary River).

Although phosphorus is typically the limiting nutrient in freshwater ecosystems, eutrophication response variables (e.g., abundance of phytoplankton, dissolved oxygen depletion) are typically what are of concern in freshwater environments.

Therefore, while nutrients (i.e., TP and TN) will continue to be monitored under the water quality component of the CREMP, effects of nutrient enrichment on Mine Area waterbodies will be monitored through measurement of primary productivity (i.e., phytoplankton).

The indicator for phytoplankton abundance will be chlorophyll *a* (NSC, 2014a; Appendix D). Chlorophyll *a* is the most widely used indicator of phytoplankton abundance and is relatively easy to sample. It is also associated with lower analytical variability and is more cost-effective than biomass and community composition metrics. Further, biological benchmarks for phytoplankton community metrics have not been developed to the same extent as for chlorophyll *a* and phytoplankton indices are not as strongly linked to primary drivers of eutrophication (i.e., nutrients). While this parameter is associated with relatively high variability in the lakes currently, the variability is largely a function of low concentrations and in particular, a relatively high frequency of censured values (i.e., below detection; Appendix D).

The phytoplankton monitoring program will also consider related/supporting variables including nutrients (phosphorus and nitrogen), measures of water clarity (i.e., TSS, turbidity, Secchi disk depth), and temperature in the data analysis and reporting phase.

Phytoplankton abundance may either be increased by the Project through nutrient enrichment or may be decreased by the Project through changes in other factors such as water clarity. Therefore, the phytoplankton monitoring component is intended to monitor for either increases or decreases in algal abundance. However, owing to the particular concern related to nutrient enrichment and potential for eutrophication in Mine Area lakes related to phosphorus additions, the benchmark for the CREMP was developed to address potential increases in chlorophyll *a*. In addition, decreases in chlorophyll *a* relative to current (baseline) conditions would be difficult to measure owing to the low concentrations and high frequency of censured values.

While there are no established benchmarks for phytoplankton metrics for application in monitoring programs, there is an extensive literature base regarding the issue of eutrophication of freshwater ecosystems as well as numerous trophic categorization schemes for lakes and several for freshwater streams. Mine Area lakes are currently oligotrophic based on several different lake trophic categorization schemes using chlorophyll *a*. While a significant relationship was found between total phosphorus (TP) and chlorophyll *a* in Mine Area lakes, the relationship is weak and cannot be used to construct a predictive model linking nutrient concentrations to phytoplankton. Therefore, a benchmark for chlorophyll *a* was derived based on existing baseline data and in consideration of approaches applied in other recent/ongoing arctic AEMPs and trophic categories/status.

Table 5.3 Selected Approach and Interim Area-Wide Sediment Quality Benchmarks

Jurisdiction, Type of Guideline and Statistical Metric		Hg	As	Cd	Cr	Cu	Fe	Mn	Ni	P	Pb	Zn
CCME	**ISQG**	0.17	5.9	0.6	37.3	35.7	NGA	NGA	NGA	NGA	35	123
	PEL	0.486	17	3.5	90	197	NGA	NGA	NGA	NGA	91.3	315
Ontario Sediment Quality Guideline	**LEL**	0.2	6	0.6	26	16	20,000	460	16	600	31	120
	SEL	2	33	10	110	110	40,000	1100	75	2,000	250	820
US EPA Sediment Quality Guidelines	**Screening**	0.18	9.8	0.99	43.4	31.6	20,000	460	22	NGA	35.8	121
97.5th Percentiles of Each Lake Area (sample size)												
Tributaries of Sheardown Lake (5)		0.1	2.95	1.9	118	106	28,370	809	115	295	52	171
Mary Lake (6)		0.1	4.95	0.5	97	38	51,463	4,305	61	1,580	28	103
Camp Lake (9)		0.1	4	0.5	83	50	40,920	1,057	74	1,480	23	69
Sheardown Lake NW (25)		0.1	7.95	0.5	96	60	56,240	5,612	81	2,310	24	92
Sheardown Lake SE (6)		0.1	2.0	0.9	80	32	32,988	547	66	1,278	18	57
95th Percentile of Area-Wide Data (47)[2]		NC	5.2	0.5	93	56	50,430	3,874	76	1,565	24	91
97.5th Percentile of Area-Wide Data (47)[2]		NC	6.2	0.5	97	58	52,200	4,530	77	1,958	24	94
Proposed Interim AEMP Benchmark		**0.17**	**6.2**	**1.5**	**97**	**58**	**52,200**	**4,530**	**77**	**1,958**	**35**	**123**
Benchmark Method		A	B	C	B	B	B	B	B	B	A	A

NOTES:

1. NC = NOT CALCULATED AS ALL VALUES < MDL.
2. TRIBUTARIES OF SHEARDOWN LAKE DATA ARE NOT INCLUDED DUE TO ELEVATED RESULTS IN THIS AREA.
3. GUIDELINE IS BASED ON SEDIMENT QUALITY GUIDELINE.
4. GUIDELINE IS BASED ON 97.5TH%ILE OF BASELINE DATA.
5. GUIDELINE IS BASED ON 3 TIMES MDL, THE 97.5TH%ILE IS EQUAL TO THE MDL.
6. MERCURY WAS NOT DETECTED IN ANY SAMPLES; MERCURY DETECTION LIMIT IS USED TO REPRESENT THE 95TH AND 97.5TH PERCENTILES.

The benchmark for chlorophyll *a* for the Mary River Project (3.7 µg/L) is based on maintaining the trophic status (i.e., oligotrophic) of Mine Area lakes. Specifically, the benchmark represents the average of the upper and lower ranges of trophic boundaries for lakes based on chlorophyll *a*, as designated and/or adopted in the scientific literature (Table 5.4).

This benchmark is lower than the recently developed benchmark for Lac de Gras in relation to the Diavik Diamond Mines Project. Lac de Gras has a similar background concentration of chlorophyll *a*; the “normal range” of chlorophyll *a* in Lac de Gras (mean±2 x SD) was identified as 0.89 µg/L and the mean was 0.52 µg/L for the open-water season (Golder Associates Ltd., 2014). This value is similar to the same statistic for Sheardown Lake NW but much lower than statistics for the other mine area lakes.

Table 5.4 Derivation of the Benchmark for Chlorophyll a

Reference	Chlorophyll *a* (µg/L)	
	Maximum Oligotrophic	**Minimum Mesotrophic**
OECD (1982) and AENV (2014)	2.5	2.5
Wetzel (2001)	4.5	3
Nürnberg (1996)	3.5	3.5
Carlson (1977)	2.6	2.6
Swedish EPA (2000)	5	5
USEPA (2009)	2	2
University of Florida (2002)	3	3
Galvez-Cloutier R. and M. Sanchez. (2007)	3	3
Ryding and Rast (1989)	8	8
Mean	**3.79**	**3.62**

5.3.5 Benthic Macroinvertebrate Indicators and Benchmarks

A number of BMI metrics were reviewed for inclusion in the CREMP, including:

- abundance - total macroinvertebrate density (individuals/m^2±SE);
- composition - Chironomidae proportion (% of total density);
- Shannon’s Equitability (evenness);
- Simpson’s Diversity Index; and
- Richness metrics (total taxa and Hill’s Effective richness, both at the genus level).

The variability of the BMI metrics measured during the baseline studies program were evaluated and described to assist with identifying the most robust metrics for further statistical exploration and consideration under the CREMP. The least variable metrics identified for both mine area lakes and streams through this process were:

- Chironomidae proportion;
- Shannon’s Equitability;
- Simpson’s Diversity Index; and
- Total Taxa Richness.

Total BMI density was associated with a relatively high variability in all lake habitat types and stream reaches. However, this metric was retained as it is one of the most commonly used indicators for the status of the benthic macroinvertebrate community in waterbodies.

Unlike water or sediment, where protection of aquatic life guidelines may be used to develop triggers or thresholds for effects assessment, there are no universal benchmarks for biological variables such as abundance or diversity. Rather, the magnitude of change or difference relative to expected conditions is typically used to establish CESs for biological variables.

Environment Canada (2012) identifies CESs for a BMI metric as multiples of within-reference-area standard deviations (i.e., ±2SD). As for fish, confirmed effects are based on the results of two consecutive surveys.

The benchmark for the BMI program that will be conducted under the CREMP is a change of ± 50% in the mean of key metrics. A preliminary assessment of the statistical power of baseline data indicated that the power of the data set for Sheardown Lake NW and Tributary 1, Reach 4 to be able to detect a post-Project change in the mean of ± 50% was high for the majority of metrics investigated, with the exception of total macroinvertebrate density. More sensitive metrics to change were identified and these include Chironomidae proportion, Shannon's Equitability, Simpson's Diversity Index, and total taxa richness. In before-after comparisons of metrics, the power to detect differences is greater when there are more monitoring events in the before and after periods included in the analysis. Overall, it is expected that the CREMP will be capable of detecting larger impacts in a short time period, but will require longer time periods to detect more subtle effects (i.e., as more data are acquired).

5.3.6 Arctic Char Indicators and Benchmarks

The Mine Area streams and lakes support only two fish species: land-locked Arctic Char; and, Ninespine Stickleback (*Pungitius pungitius*). Of these, abundance and distribution of Ninespine Stickleback are relatively limited and highly localized while Arctic Char are overwhelmingly the most abundant and widely distributed fish species in the area. As mine area streams freeze solid during winter, overwintering habitat is provided exclusively by lakes.

Environment Canada (2012) recommends monitoring of sexually mature individuals of a minimum of two fish species for EEM programs and use of invasive sampling (i.e., lethal) if acceptable. Alternative study designs include non-lethal sampling methods for fish populations/communities, as well as studies of juvenile fish if appropriate and/or required.

Given that there are only two fish species present in the area, fish monitoring in the mine area would be limited to successful capture of sufficient numbers of both of these fish species in the exposure areas. In most lakes and streams in the exposure area, Arctic Char are sufficiently abundant that successful capture of enough fish for monitoring purposes is possible. In contrast, Ninespine Stickleback is absent or uncommon in a number of waterbodies. It is unlikely, even with extensive effort, that sufficient numbers of Ninespine Stickleback could be captured for monitoring purposes from either the receiving environments or from prospective reference areas. For these reasons only a single species, Arctic Char, will be targeted under the CREMP program.

Non-lethal sampling methods will be used to the extent possible to minimize impacts of monitoring on the Arctic Char populations. As a result, metrics that can be reliably obtained from live fish will be included in CREMP. Metrics will include indicators of fish growth, condition, and reproduction.

Environment Canada (2012) recommends that non-lethal sampling should include fork length for fish with a forked caudal fin (±1 mm), total body weight (±1.0%), assessment of external condition (i.e., deformities, erosion, lesions, and tumours [DELTs]), external sex determination (if possible), and age (where possible; ±1 year). Metrics based on these measurements that will be examined under the CREMP are indicated in Table 5.4. In addition, catch-per-unit-effort (CPUE) will be calculated and examined in the analysis and reporting as a general indicator of abundance.

Although there are no established benchmarks for biological variables (e.g., abundance), including fish, that can be readily adopted or considered for monitoring effects on freshwater biota, CESs for selected biological metrics are prescribed in the EEM Guidance Document (Environment Canada, 2012) and have been proposed and applied in other recent monitoring programs that fall outside of EEM requirements, such as the Diavik Diamond Mine in the Northwest Territories (Golder Associates Ltd., 2014).

The MMER identifies CESs for a fish population as a percentage of change from the "reference mean" (Table 5.5). As noted by Indian and Northern Affairs Canada (INAC 2009), "these effect sizes do not reflect the method recommended by Environment Canada (2004); namely effect sizes that correspond with unacceptable ecological changes." INAC (2009) also notes that Environment Canada (2008) identified these CESs "in the absence of clear scientific understanding of the long-term implications of these effects". However, as further noted by INAC (2009), these CESs "may serve as a starting point for discussions on acceptable effect sizes that occur during AEMP development".

As it is not possible to identify a level of change in Arctic Char population metrics that would be indicative of long-term effects or "unacceptable ecological changes" for the mine area fish populations, the CREMP will initially apply the recommended EEM benchmarks (Table 5.6). However, it is recommended that the applicability/appropriateness of these benchmarks be reviewed on a regular basis and, if appropriate, modified as the CREMP progresses. The management response framework should also be regularly reviewed and adjusted over time to ensure the program is effective, sensitive, and ecologically meaningful.

5.4 EFFECTS EVALUATION FRAMEWORK

A risk-based approach to integrating the results of the component monitoring programs will be undertaken, drawing from the approach applied at the Meadowbank Mine (Azimuth, 2010). Monitoring results will be evaluated using the following risk-oriented criteria:

- Magnitude – the degree to which an indicator approaches or exceeds the established benchmark (or other guideline, if different than the benchmark)
- Extent – the scale at which the change or exceedance occurs
- Causation – the strength of evidence for a mine-related cause
- Reversibility – the likelihood that the effect may be reversed over time
- Uncertainty – the confidence or lack thereof in the findings regarding the above criteria

Table 5.5 Fish Metrics and Statistical Analysis Methods Recommended Under EEM

Effect Indicators	Fish Effect Endpoint	
	Non-Lethal Survey	Statistical Test
Growth	*Length of YOY (age 0) at end of growth period	ANOVA
	*Weight of YOY (age 0) at end of growth period	ANOVA
	*Size of 1+ fish	ANOVA
	*Size-at-age (body weight at age)	ANCOVA
	Length-at-age	ANCOVA
	Body Weight	ANOVA
	Length	ANOVA
Reproduction	*Relative abundance of YOY (% composition of YOY)	Kolmorgorov-Smirnov test performed on length-frequency distributions with and without YOY included; OR proportions of YOY can be tested using a Chi-squared test.
	OR relative age-class strength	
Condition	*Condition Factor	ANCOVA
Survival	*Length-frequency distribution	2-sample Kolmorgorov-Smirnov test
	*Age-frequency distribution (if possible)	2-sample Kolmorgorov-Smirnov test
	YOY Survival	

NOTE:
1. METRICS INDICATED WITH AN ASTERISK ARE ENDPOINTS USED FOR DETERMINING EFFECTS UNDER EEM, AS DESIGNATED BY STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN EXPOSURE AND REFERENCE AREAS. OTHER ENDPOINTS MAY BE USED TO SUPPORT ANALYSES.

Table 5.6 MMER EEM Critical Effects Sizes for Fish Populations Using Non-Lethal Sampling

Effect Indicators	Fish Effect Endpoint	CES[1]
Growth	Length and weight of YOY (age 0) and age 1+ at end of growth period	± 25%
Reproduction	Relative abundance of YOY (% composition of YOY) OR relative age-class strength	± 25%
Condition	Condition Factor	± 10%
Survival	Length or age frequency distribution	± 25%

NOTE:
1. CES'S ARE EXPRESSED AS A PERCENTAGE OF THE REFERENCE MEANS.

The above criteria will be applied to each monitoring indicator for each aquatic component, with results summarized using the rating system presented in Table 5.7.

5.5 INTEGRATED DATA EVALUATION

Once data are summarized for each component program, key findings from each program will be evaluated together in the AEMP so that issues can be identified and response actions developed. The data evaluation will be based on the Data Assessment Approach and Response Framework presented as Figure 5.1, applied at the AEMP level.

5.6 MANAGEMENT ACTIONS

Management actions will be implemented as identified in the low and moderate action responses for each aquatic component, based on assessment of whether the change is considered to be mine-related, and the action level determined relative to the benchmark(s) (Figure 5.1). In the instance of detecting change among multiple stressors, action will be implemented according to a weight of evidence evaluation.

Table 5.7 Aquatic Effects Evaluation Rating Criteria

Criteria	Classification	
Magnitude The degree of change; specific to the Indicator/VEC and the impact	Level I	Change to the Indicator is not distinguishable from natural variation and is well below benchmark
	Level II	Change to the Indicator is clearly distinguishable and approaching benchmark
	Level III	Change to the Indicator is clearly distinguishable and exceeds to the benchmark
Extent The physical extent of the effect, relative to study area boundaries	Level I	Isolated occurrence or very small area
	Level II	Moderately sized area affected, such as a portion of a basin
	Level III	An entire lake basin or lake is likely to be affected
Causation The strength of evidence that the effect is mine-related	Level I	No evidence that effect is mine-related
	Level II	Some likelihood that the effect is mine-related
	Level III	Very likely to be mine-related
Reversibility The likelihood of the Indicator/VEC to recover from the effect	Level I	Fully reversible in less than 10 years
	Level II	Reversible over a long period of time (i.e., decades)
	Level III	Largely irreversible for at least several decades
Certainty Degree of certainty or uncertainty in the findings of the monitoring data	High	Limited or conflicting monitoring data, resulting in a low certainty
	Medium	Moderate certainty in findings based on monitoring data
	Low	High certainty in findings based on monitoring data

Mitigation measures will be evaluated, as outlined in Figure 5.1, and implemented on a case-by-case basis, based on an issue-specific assessment of the situation, and action level. Exceedance of a benchmark triggers a moderate action response. Moderate Action Responses may include mitigation measures that are easily implemented at low-cost and in a short time-frame. Such mitigation measures may already be identified as contingency or adaptive management measures within various management plans for the Project.

One of the moderate action responses is to develop a High Action Responses, which will be implemented if the trend over time is a continued change relative to the benchmark (increase in the magnitude of the effect). High Action Responses will be reviewed by key regulatory agencies prior to implementation.

6 QUALITY ASSURANCE AND QUALITY CONTROL

Each of the monitoring programs comprising the AEMP will implement standard QA/QC measures as follows:

- Staffing the project with experienced and properly trained individuals
- Ensuring that representative, meaningful data are collected through planning and efficient research
- Using standard protocols for sample collection, preservation, and documentation
- Calibrating and maintaining all field equipment

Various additional QA/QC measures will be implemented for each of the components studies, as described below.

6.1 WATER AND SEDIMENT QUALITY

A strict QA/QC program is in place to ensure that high quality and representative data are obtained in a manner that is scientifically defensible, repeatable and well documented. This program aims to ensure that the highest level of QA/QC standard methods and protocols are used for the collection of all environmental media samples. Quality assurance is obtained at the project management level through organization and planning, and the enforcement of both external and internal quality control measures. In addition to those standard QA/QC measures listed in Section 6 above, the following QA/QC procedures and practices will be implemented in water and sediment quality programs:

- Internal Quality Control:
  - Collecting duplicate, blank, filter and travel blank samples for submission for analysis (approximately 10% of overall samples)
- External Quality Control:
  - Employing fully accredited analytical laboratories for the analysis of all samples
  - Determining analytical precision and accuracy through the interpretation of the analysis reports for the blind duplicate, blank, filter and travel blank samples

The field sampling protocols being applied to the water and sediment quality program is presented as an appendix of the water and sediment quality CREMP in Appendix B (Knight Piésold, 2014b).

The quality of the data obtained for a project is assessed via their adherence to the pre-set data quality objectives (DQOs). DQOs provide a means of assessing whether the data in question are precise, accurate, representative, and complete. The results from QA/QC samples are reviewed to determine if sample contamination occurred. These data are further used to determine if the contamination occurred during collection, handling, storage, or shipping. Upon receipt from the laboratory, the data are uploaded into a database along with copies of field notes, photos, Sample Receipt Confirmations, Microsoft Excel data, and Certificates of Analysis.

6.2 BENTHIC INVERTEBRATE SURVEY

Field sub-samples will be collected from each BMI replicate station, to compensate for the spatial variability encountered with these organisms. Sub-samples collected from Sheardown Lake NW in 2013 were analysed separately to evaluate precision and to advise on study design. The results of this analysis indicated a high level of precision associated with five sub-samples and the CREMP will therefore continue to collect five sub-samples but will pool the sub-samples in the field.

Appropriate QA/QC measures related to processing and identification of BMI samples, as outlined in the EEM technical guidance document will be followed and are described below (Environment Canada, 2012). These measures will incorporate the proper steps related to re-sorting, sub-sampling and maintenance of a voucher collection, as needed. The voucher collection will be taxonomically analysed by a second qualified invertebrate taxonomist.

BMI samples will be sorted with the use of a stereomicroscope. Samples will be washed through a 500 micron sieve and sorted entirely, except in the following instances: those samples with large amounts of organic matter (i.e., detritus, filamentous algae) and samples with high densities of major taxa. In these cases, samples will be first washed through a large mesh size sieve (3.36 mm), to remove all coarse detritus, leaves, and rocks. Large organisms such as leeches, crayfish, late instar dragonflies, stoneflies, and mayflies retained in the sieve will be removed from the associated debris. The remaining sample fraction will be sub-sampled quantitatively, if necessary. For QA/QC evaluation, the sorted sediments and debris will be re-preserved and retained for up to six months following submission of the first cycle interpretive report for the EEM program. For those samples that were sub-sampled, sorted and unsorted fractions will be re-preserved separately. Sorted organisms will be re-preserved.

All invertebrates will be identified to the lowest practical level, usually genus or species level. Chironomids and oligochaetes will be mounted on glass slides in a clearing media prior to identification. In samples with large numbers of oligochaetes and chironomids, a random sample of no less than 20% of the selected individuals from each group will be removed from the sample for identification, up to a maximum of 100 individuals.

Following identification and enumeration, a detailed list of individuals collected will be submitted for each replicate station. The list will be in a standard spreadsheet format.

6.3 FISH

QA/QC technical procedures will be utilized for all field sampling, laboratory analysis, data entry and data analysis.

The fish ages will be determination by experienced technicians and a minimum of 10% of fish ageing structures that are processed will be independently and blindly aged by a second technician.

All data entered electronically will undergo a 100% transcription QA/QC by a second person to identify any transcription errors and/or invalid data.

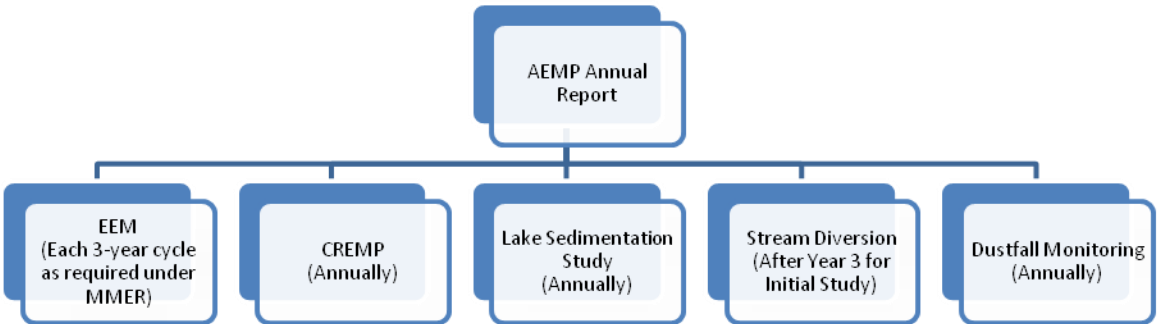
6.4 DATA EVALUATION

All data will be entered into an electronic database with controlled access. Screening studies will be employed to check for transcription errors or suspicious data points. An individual not responsible for entering the data will confirm that the data entered represents the original.

7 ANNUAL REPORTING

AEMP monitoring results will be presented an a AEMP Annual Report that will accompany the Type A Water Licence Amendment No.1 Annual Report, as required by Schedule B, Section e, Item (i) of the Water Licence. The AEMP Annual Report will consist of a high level summary of monitoring activities and outcomes and any management responses. Monitoring results will be presented in technical reports for each component study, as appendices to the AEMP Annual Report. The AEMP Annual Report structure and frequency of reporting of component studies is shown on Figure 7.1.

Figure 7.1 AEMP Annual Report Structure



The AEMP Annual Report will provide a compilation, assessment and interpretation of findings across monitoring programs, and present an evaluation of effects. Revisions to study designs or management response actions will be summarized and discussed for each key issue.

The AEMP will be updated periodically, as required. Updates to the AEMP will be filed with the Water Licence Annual Report in accordance with Schedule B, Section g, Item (ii) of the Water Licence. Updates to the AEMP may consist of modifications to study designs, or termination of shorter-term targeted studies accompanied by adequate rationale.

8 LIST OF CONTRIBUTORS

This document has been prepared by Baffinland and a consultant team as follows:

Baffinland

- Erik Madsen – Overall corporate responsibility
- Oliver Curran – Primary client contact and reviewer
- Jim Millard – technical review
- Fernand Beaulac – consultant advisor contributing to initial AEMP Framework

Knight Piésold Ltd.

- Richard Cook – Consultant Team Project Manager; contributions to the water and sediment quality CREMP; management response framework; senior review
- Dale Klodnicki – EEM Study Design; QA/QC; EEM, water and sediment quality field programs
- Pierre Stecko (Minnow Environmental) – senior technical review of EEM Study Design
- Laurie Ainsworth – Graphical analysis and statistical design of water and sediment quality baseline and CREMP
- Elizabeth Ashby – water and sediment quality baseline review and CREMP study design

North/South Consultants Inc.

- Megan Cooley – Freshwater biota baseline review and CREMP study design
- Richard Remnant – Freshwater biota baseline review
- Mike Johnson – Fisheries field programs
- Leanne Zrum – benthic macroinvertebrate baseline review and CREMP study design

Intrinsik Environmental Sciences Inc.

- Christine Moore – development of management response framework and benchmarks for water and sediment quality; senior review

9 REFERENCES

Alberta Environment. (updated 2013). *Lake water trophic status*. http://environment.alberta.ca/01715.html. Accessed February 22, 2014.

Azimuth Consulting Group Inc. 2010. *Aquatic Effects Management Program: Meadowbank Gold Project, Version 1*. Project No. AE-10-01. Prepared for Agnico-Eagle Mines Ltd., Baker Lake, Nunavut. May 2010.

Baffinland Iron Mines Corporation (Baffinland). 2012. *Final Environmental Impact Statement*. February 2012.

Baffinland. 2013a. *Addendum to the Final Environmental Impact Statement*. June 2013.

Baffinland. 2013b. *Aquatic Effects Monitoring Program Framework*. February 2013.

Baffinland. 2013c. *Updated Aquatic Effects Monitoring Program Framework*. December 2013.

Baffinland. 2014. Terrestrial Environment Management and Monitoring Plan, Version 3.0. January 2014.

British Columbia Ministry of the Environment, undated. Water Quality Guidelines (Criteria) Reports. Available at: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html. Accessed April 2014.

Carlson R.E. 1977. A trophic state index for lakes. *Limnol. Oceanogr*. 22: 361-369.

CCME. 1999. *Canadian environmental quality guidelines*. Canadian Council of Ministers of the Environment, Winnipeg, MB. Updated to 2014. Available at: http://st-ts.ccme.ca/.

CCME. 2007. *Canadian sediment quality guidelines for the protection of aquatic life: Summary tables and fact sheets. Update 2002*. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Department of Fisheries and Oceans Canada (DFO). 1995. *Freshwater Intake End-of-Pipe Fish Screen Guideline*. Ottawa: Ministry of Supply and Services Canada. Catalogue No. Fs 23-270 / 1995E.

Environment Canada. 2003. *Revised Technical Guidance on How to Conduct Effluent Plume Delineation Studies.* National EEM Office, National Water Research Institute and Environment Canada. March 2003.

Environment Canada. 2004. Canadian guidance framework for the management of phosphorus in freshwater systems. Ecosystem Health: Science-based Solutions Report No. 1-8. National Guidelines and Standards Office, Water Policy and Coordination Directorate, Environment Canada. 114 p.

Environment Canada. 2012. *Metal Mining Technical Guidance for Environmental Effects Monitoring*. National Environmental Effects Monitoring Office.

Fisheries Act. R.S.C. (1985). c. F-14, June 29, 2012.

Galvez-Cloutier R. and M. Sanchez. 2007. Trophic status evaluation for 154 lakes in Quebec, Canada: monitoring and recommendations. *Wat. Qual. Res. J. Can*. 42: 252-268.

Golder Associates. 2014. Diavik Diamond Mines aquatic effects monitoring program study design Version 3.4. Prepared for Diavik Diamond Mines Inc. by Golder Associates Ltd., Calgary, AB, January 2014. 318 p.

Indian and Northern Affairs Canada. 2009. *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories*. Yellowknife. June 2009. Volumes 1-6.

Knight Piésold Ltd. 2014a. *Baffinland Iron Mines Corporation – Mary River Project – Water and Sediment Quality Review and CREMP Study Design*. Ref. No. NB102-181/33-1, Rev. 2, dated June 25, 2014.

Knight Piésold Ltd. 2014b. *Baffinland Iron Mines Corporation – Mary River Project – Water and Sediment Quality Sampling Protocol*. Ref. No. NB102-181/33-2, Rev.0, dated March 28, 2014.

Knight Piésold Ltd. 2014c. *Initial Stream Diversion Barrier Study - Rev. 0 - Mary River Project - Aquatic Effects Monitoring Program*. Memo Ref. No. NB14-00160, dated June 25, 2014.

Knight Piésold Ltd., 2007. *Mary River Project – Bulk Sampling Program – Fish Habitat No Net Loss and Monitoring Plan*. Ref. No. NB102-181/10-4, Rev. 0, dated August 30, 2007.

MacDonald, D.D., Clark, M.J.R., Whitfield, P.H., and Wong, M.P. (2009). Designing monitoring programs for water quality based on experience in Canada I. Theory and framework. Trends in Analytical Chemistry 28(2):204-213.

Minister of Justice (MOJ). 2012. Consolidation Metal Mining Effluent Regulations. SOR/2002-222. Current to September 12, 2012.

North/South Consultants Inc. 2008. *Mary River Project Freshwater Aquatic Environment Baseline Draft Report: Fish and Fish Habitat*. Winnipeg, MB.

North/South Consultants Inc. 2010. *Mary River Project Freshwater Aquatic Biota and Habitat Baseline Synthesis Report 2005-2010*. November 2010. Winnipeg, MB.

North/South Consultants Inc. 2014. *Preliminary review of Baseline Data for Freshwater Biota: Mary River Mine Site.* Issued in Draft August 2013.

North/South Consultants (NSC). (2013b). *Mary River Project Candidate Reference Lakes: Preliminary Survey August 3-7, 2013*. Draft Technical Memorandum.

Nürnberg, G.K. (1996). Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management. 8: 17-30.

Nunavut Impact Review Board. 2012. In the matter of an application by Baffinland Iron Mines Corporation for development of the Mary River Project Proposal in the Qikiqtani Region of Nunavut: NIRB Project Certificate No. 005. Dated December 28, 2012.

Nunavut Impact Review Board. 2014. Nunavut Impact Review Board - Public Hearing Report - Mary River Project: Early Revenue Phase Proposal - Baffinland Iron Mines Corporation - NIRB File No. 08MN053. March 2014.

Nunavut Water Board (NWB). 2013. *Water Licence No: 2AM-MRY1325*. Motion Number 2013-10-P4-05. June 10, 2013.

Ontario Ministry of the Environment. 2011. *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*. PIBS # 7382e01, dated April 15, 2011.

Organization for Economic Cooperation and Development (OECD). (1982). Eutrophication of waters: Monitoring, assessment and control. Final Report. OECD cooperative programme on monitoring of inland waters (eutrophication control). Environment Directorate, OECD, Paris, France.

Nürnberg G.K. 1996. Trophic state in clear and colored, soft and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. *Lake Reserv. Manage*. 12: 432-447.

Organization for Economic Cooperation and Development (OECD). 1982. Eutrophication of waters. Monitoring, assessment and control. Final report, OECD cooperative programme on monitoring of inland waters (eutrophication control), Environment Directorate. OECD, Paris. 154 p.

Ryding., S.-O. and W. Rast. 1989. *The Control of Eutrophication of Lakes and Reservoirs.* Vol. 1. UNESCO, Paris and the Parthenon Publishing, United Kingdom. 314 p.

Swedish Environmental Protection Agency (EPA). 2000. Environmental quality criteria. Lakes and watercourses. Swedish EPA Report 5050. 102 p.

University of Florida, Florida Lakewatch. 2002. Trophic state: a waterbody's ability to support plants, fish and wildlife. Gainesville, FL, USA.

United States Environmental Protection Agency (USEPA). 2009. National lake assessment: A collaborative survey of the nation's lakes. EPA 841-R-09-001. USEPA, Office of Water and Office of Research and Development, Washington, D.C.104 p.

United States Environmental Protection Agency (USEPA). 2014. National Recommended Water Quality Criteria: Aquatic Life Criteria Table. Office of Water, Office of Science and Technology, USEPA, Washington, DC. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable. Last modified May 22, 2014.

Wetzel, R. 1983. *Limnology 2nd Ed*: Lake and River Ecosystem. Academic Press, San Diego, C

Wright, D. G. & Hopky, G. E. 1998. *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters*. Canadian Technical Report of Fisheries Aquatic Sciences 2107.

APPENDICES

Appendix A

Draft EEM Cycle One Study Design

APPENDIX A

STUDY AREA CHARACTERIZATION DATA

(Pages A-1 to A-14)

Knight Piésold
CONSULTING

TABLE A.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
2013 STUDY AREAS: REPLICATE STATION LOCATION SUMMARY

Print Jun/26/14 11:25:00

Study Area ID	Replicate Station ID	UTM Easting	UTM Northing	Latitude	Longitude	Latitude-Degrees	Latitude-Minutes	Latitude-Seconds	Longitude-Degrees	Longitude-Minutes	Longitude-Seconds
CLT-NF	CLT-NF-1	558493	7914937	71.32949	-79.3627138	71	19	46.14645	-79	21	45.76973
	CLT-NF-2	558516	7914899	71.32914	-79.3620992	71	19	44.9003	-79	21	43.55694
	CLT-NF-3	558511	7914871	71.32889	-79.3622603	71	19	44.00128	-79	21	44.13689
	CLT-NF-4	558479	7914872	71.32891	-79.3631547	71	19	44.06153	-79	21	47.35698
	CLT-NF-5	558422	7914879	71.32898	-79.3647441	71	19	44.33718	-79	21	53.07857
CLT-FF	CLT-FF-1	557896	7914927	71.32954	-79.3794235	71	19	46.34319	-79	22	45.9247
	CLT-FF-2	557863	7914945	71.32971	-79.3803333	71	19	46.95251	-79	22	49.19981
	CLT-FF-3	557831	7914975	71.32999	-79.3812061	71	19	47.94811	-79	22	52.34189
	CLT-FF-4	557776	7915001	71.33023	-79.3827254	71	19	48.83451	-79	22	57.81143
	CLT-FF-5	557705	7914980	71.33006	-79.3847275	71	19	48.21825	-79	23	5.019129
CLT-REF2	CLT-REF2-1	526096	7936773	71.53094	-80.261927	71	31	51.36724	-80	15	42.93705
	CLT-REF2-2	526051	7936769	71.5309	-80.2632009	71	31	51.25588	-80	15	47.52339
	CLT-REF2-3	526009	7936767	71.53089	-80.2643894	71	31	51.20786	-80	15	51.8018
	CLT-REF2-4	525970	7936787	71.53107	-80.2654854	71	31	51.86865	-80	15	55.74755
	CLT-REF2-5	525917	7936785	71.53106	-80.266985	71	31	51.82489	-80	16	1.145894
CLT-REF3	CLT-REF3-1	567828	7908060	71.26541	-79.107605	71	15	55.48167	-79	6	27.37784
	CLT-REF3-2	567792	7908083	71.26563	-79.1085886	71	15	56.26002	-79	6	30.91898
	CLT-REF3-3	567784	7908119	71.26595	-79.1087803	71	15	57.42946	-79	6	31.60896
	CLT-REF3-4	567754	7908137	71.26612	-79.109601	71	15	58.04043	-79	6	34.56369
	CLT-REF3-5	567732	7908119	71.26597	-79.1102301	71	15	57.48195	-79	6	36.82838
CLT-REF4	CLT-REF4-1	569095	7907235	71.25766	-79.0730137	71	15	27.57547	-79	4	22.84922
	CLT-REF4-2	569090	7907203	71.25737	-79.0731814	71	15	26.54832	-79	4	23.45315
	CLT-REF4-3	569066	7907186	71.25723	-79.0738654	71	15	26.02461	-79	4	25.91531
	CLT-REF4-4	569055	7907155	71.25695	-79.0741994	71	15	25.03588	-79	4	27.11793
	CLT-REF4-5	569034	7907136	71.25679	-79.0748015	71	15	24.44455	-79	4	29.28542
MRY-NF	MRY-NF-1	561572	7911165	71.29491	-79.2795794	71	17	41.68817	-79	16	46.48597
	MRY-NF-2	561498	7911053	71.29393	-79.2817348	71	17	38.14268	-79	16	54.24531
	MRY-NF-3	561346	7910945	71.293	-79.2860648	71	17	34.79759	-79	17	9.833226
	MRY-NF-4	561012	7911183	71.29522	-79.2952038	71	17	42.78106	-79	17	42.73356
	MRY-NF-5	560944	7911420	71.29736	-79.2969164	71	17	50.48928	-79	17	48.8989
MR-FF	MRY-FF-1	558400	7909217	71.27824	-79.3696302	71	16	41.67648	-79	22	10.66857
	MRY-FF-2	558253	7908669	71.27337	-79.374143	71	16	24.12339	-79	22	26.91465
	MRY-FF-3	558082	7908529	71.27215	-79.3790179	71	16	19.75458	-79	22	44.46431
	MRY-FF-4	558031	7908390	71.27092	-79.3805443	71	16	15.31393	-79	22	49.95946
	MRY-FF-5	557921	7908227	71.26949	-79.383734	71	16	10.14982	-79	23	1.442342
MRY-REF1	MRY-REF1-1	538165	7901502	71.21313	-79.9381601	71	12	47.25956	-79	56	17.37647
	MRY-REF1-2	538066	7901337	71.21166	-79.9409943	71	12	41.99067	-79	56	27.57936
	MRY-REF1-3	537916	7901249	71.2109	-79.9452091	71	12	39.2353	-79	56	42.75266
	MRY-REF1-4	537754	7901067	71.20929	-79.9498027	71	12	33.45272	-79	56	59.2896
	MRY-REF1-5	537598	7900717	71.20618	-79.9543094	71	12	22.24464	-79	57	15.51376
MRY-REF2	MRY-REF2-1	570185	7903339	71.22243	-79.0461442	71	13	20.76502	-79	2	46.11894
	MRY-REF2-2	570159	7903134	71.22061	-79.0470515	71	13	14.17908	-79	2	49.3855
	MRY-REF2-3	570198	7902946	71.21891	-79.0461356	71	13	8.07375	-79	2	46.08823
	MRY-REF2-4	570199	7902749	71.21714	-79.0462848	71	13	1.71772	-79	2	46.62513
	MRY-REF2-5	570288	7902506	71.21494	-79.0440281	71	12	53.78594	-79	2	38.50122
MRY-REF3	MRY-REF3-1	584306	7898429	71.17394	-78.6587003	71	10	26.19909	-78	39	31.32108
	MRY-REF3-2	584254	7898260	71.17245	-78.6603242	71	10	20.8137	-78	39	37.16713
	MRY-REF3-3	584189	7898080	71.17086	-78.6623202	71	10	15.08973	-78	39	44.35286
	MRY-REF3-4	584018	7897936	71.16963	-78.6672174	71	10	10.65884	-78	40	1.982762
	MRY-REF3-5	583948	7897837	71.16876	-78.6692648	71	10	7.553149	-78	40	9.353098
MRY-REF4	MRY-REF4-1	571350	7917079	71.34521	-79.0011024	71	20	42.76226	-79	0	3.968775
	MRY-REF4-2	571393	7917037	71.34482	-78.9999376	71	20	41.3615	-78	59	59.77538
	MRY-REF4-3	571452	7916972	71.34422	-78.9983463	71	20	39.20169	-78	59	54.04653
	MRY-REF4-4	571482	7916886	71.34344	-78.9975862	71	20	36.39546	-78	59	51.31044
	MRY-REF4-5	571491	7916771	71.34241	-78.997441	71	20	32.67622	-78	59	50.78743

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix A - Site Char\Individual Files\[EEM_Appendix A_Table A1 to A3.xlsx]TABLE_A.1

NOTES:

1. UTM COORDINATES WERE COLLECTED USING A HANDHELD GPS ONSITE IN ZONE 17 W, NAD83 DATUM.

Knight Piésold CONSULTING

TABLE A.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
MARY RIVER STUDY AREAS: STREAM MEASUREMENTS

Print Jun/26/14 11:26:31

STUDY AREA		CLT-NF-1	CLT-NF-2	CLT-NF-3	CLT-NF-4	CLT-NF-5	CLT-FF-1	CLT-FF-2	CLT-FF-3	CLT-FF-4	CLT-FF-5	CLT-REF2-1	CLT-REF2-2	CLT-REF2-3	CLT-REF2-4	CLT-REF2-5	CLT-REF3-1	CLT-REF3-2	CLT-REF3-3	CLT-REF3-4	CLT-REF3-5	CLT-REF4-1	CLT-REF4-2	CLT-REF4-3	CLT-REF4-4	CLT-REF4-5
CHARACTERIZATION DATE		20-Aug-13					29-Aug-13					24-Aug-13					22-Aug-13					22-Aug-13				
MEASUREMENT	UNIT																									
Distance to U/S Replicate Station	m	-	48	28	32	58	-	40	45	62	75	-	47	48	43	56	-	46	38	38	30	-	33	40	40	29
TOTAL DISTANCE	m	**166**					**222**					**194**					**152**					**142**				
Wetted Width	m	5.5	6.3	4.7	5.85	6.5	5.15	3.38	4.9	5.95	5.1	22.6	17.4	10.8	13.45	12.95	4.3	3.3	5.65	5.7	4.15	2.25	3.6	2.2	2.7	2
MEAN WETTED WIDTH	m	**5.8**					**4.9**					**15.4**					**4.6**					**2.6**				
TD1	m	0.10	0.10	0.14	0.15	0.12	0.12	0.12	0.12	0.13	0.06	0.22	0.26	0.13	0.3	0.26	0.07	0.24	0.16	0.23	0.17	0.18	0.16	0.06	0.16	0.16
VEL1	m/sec	0.48	0.08	0.19	0.06	0.10	0.31	0.47	0.19	0.27	0.25	0.38	0.28	0.8	0.59	0.85	0.47	0.16	0.25	0.2	0.05	0.3	0.16	0.13	0.44	0.38
TD2	m	0.08	0.08	0.20	0.26	0.15	0.16	0.07	0.11	0.14	0.06	0.31	0.3	0.15	0.22	0.29	0.09	0.2	0.15	0.17	0.22	0.13	0.2	0.08	0.18	0.14
VEL2	m/sec	0.22	0.21	0.46	0.14	0.10	0.51	0.61	0.46	0.4	0.07	0.49	0.69	0.65	0.59	0.2	0.11	0.23	0.08	0.16	0.03	0.14	0.48	0.39	0.52	0.5
TD3	m	0.10	0.06	0.20	0.26	0.20	0.18	0.08	0.18	0.18	0.1	0.27	0.2	0.2	0.24	0.24	0.18	0.13	0.17	0.18	0.22	0.17	0.17	0.08	0.24	0.18
VEL3	m/sec	0.12	0.06	0.20	0.38	0.40	0.28	0.39	0.21	0.17	0.34	0.45	0.54	0.28	0.55	0.84	0.08	0.12	0.09	0.14	0.03	0.2	0.35	0.52	0.44	0.48
TD4	m	0.16	0.10	0.18	0.30	0.26	0.14	0.13	0.21	0.22	0.11	0.34	0.24	0.22	0.2	0.16	0.1	0.15	0.12	0.18	0.25	0.11	0.17	0.1	0.2	0.15
VEL4	m/sec	0.26	0.20	0.41	0.40	0.30	0.74	0.32	0.5	0.48	0.34	0.77	0.64	0.59	0.61	0.72	0.19	0.42	0.12	0.24	0.04	0.05	0.31	0.25	0.17	0.26
TD5	m	0.11	0.09	0.20	0.18	0.28	0.22	0.18	0.18	0.18	0.1	0.07	0.16	0.2	0.12	0.1	0.08	0.24	0.05	0.18	0.24	0.17	0.18	0.14	0.12	0.08
VEL5	m/sec	0.35	0.29	0.11	0.25	0.29	0.5	0.53	0.45	0.54	0.41	0.11	0.66	0.58	0.4	0.38	0.41	0.23	0.03	0.07	0.08	0.5	0.4	0.56	0.3	0.42
TD6	m	0.10	0.06	0.22	0.09	0.16	0.14	0.1	0.22	0.13	0.08	0.1	0.13	0.16	0.18	0.14	0.06	0.12	0.13	0.21	0.24	0.18	0.13	0.14	0.14	0.07
VEL6	m/sec	0.56	0.21	0.22	0.46	0.45	0.46	0.59	0.33	0.31	0.43	0.41	0.24	0.47	0.53	0.34	0.28	0.43	0.16	0.27	0.16	0.41	0.25	0.5	0.31	0.22
TD7	m	0.11	0.18	0.18	0.16	0.17	0.17	0.18	0.15	0.1	0.13	0.16	0.08	0.21	0.16	0.12	0.08	0.2	0.2	0.18	0.17	0.08	0.07	0.14	0.08	0.08
VEL7	m/sec	0.05	0.12	0.30	0.45	0.85	0.68	0.54	0.3	0.13	0.5	0.55	0.17	0.47	0.51	0.32	0.36	0.47	0.23	0.11	0.18	0.02	0.2	0.54	0.37	0.52
TD8	m	0.10	0.15	0.06	0.30	0.14	0.14	0.14	0.24	0.08	0.13	0.12	0.14	0.2	0.14	0.2	0.1	0.2	0.24	0.14	0.19	0.12	0.06	0.06	0.13	0.14
VEL8	m/sec	0.23	-0.02	0.16	0.36	0.34	0.21	0.62	0.32	0.18	0.49	0.56	0.32	0.78	0.66	0.41	0.48	0.34	0.16	0.13	0.2	0.35	0.42	0.57	0.49	0.56
TD9	m	0.14	0.20	0.14	0.20	0.12	0.13	0.18	0.13	0.06	0.14	0.1	0.36	0.24	0.11	0.16	0.12	0.17	0.2	0.18	0.16	0.09	0.16	0.17	0.16	0.15
VEL9	m/sec	0.60	0.17	0.41	0.16	0.34	0.61	0.43	0.39	0.15	0.15	0.57	0.46	0.77	0.22	0.55	0.12	0.12	0.02	0.14	0.06	0.2	0.68	0.33	0.49	0.6
TD10	m	0.12	0.10	0.26	0.14	0.19	0.1	0.16	0.12	0.08	0.19	0.3	0.44	0.28	0.14	0.25	0.22	0.13	0.12	0.21	0.2	0.1	0.12	0.1	0.19	0.12
VEL10	m/sec	0.41	0.18	0.28	0.35	0.05	0.39	0.47	0.07	0.13	0.35	0.31	0.53	1	0.39	0.42	0.36	0.54	0.06	0.31	0.12	0.3	0.58	0.17	0.4	0.44
MEAN TOTAL DEPTH	m	**0.11**	**0.11**	**0.18**	**0.20**	**0.18**	**0.15**	**0.13**	**0.17**	**0.13**	**0.11**	**0.20**	**0.23**	**0.20**	**0.18**	**0.19**	**0.11**	**0.18**	**0.15**	**0.19**	**0.21**	**0.13**	**0.14**	**0.11**	**0.16**	**0.13**
MEAN VELOCITY	m/sec	**0.33**	**0.15**	**0.27**	**0.30**	**0.32**	**0.47**	**0.50**	**0.32**	**0.28**	**0.33**	**0.46**	**0.45**	**0.64**	**0.51**	**0.50**	**0.29**	**0.31**	**0.12**	**0.18**	**0.10**	**0.25**	**0.38**	**0.40**	**0.39**	**0.44**
MINIMUM DEPTH	m	**0.06**					**0.06**					**0.07**					**0.05**					**0.06**				
MAXIMUM DEPTH	m	**0.30**					**0.24**					**0.44**					**0.25**					**0.24**				
MEAN TOTAL DEPTH	m	**0.16**					**0.14**					**0.20**					**0.17**					**0.13**				
MINIMUM VELOCITY	m/sec	**-0.02**					**0.07**					**0.11**					**0.02**					**0.02**				
MAXIMUM VELOCITY	m/sec	**0.85**					**0.74**					**1.00**					**0.54**					**0.68**				
MEAN VELOCITY	m/sec	**0.28**					**0.38**					**0.51**					**0.20**					**0.37**				

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix A - Site Char\Individual Files\[EEM_Appendix A_Table A1 to A3.xlsx]TABLE_A.2

NOTES:

1. TOTAL DEPTH AND VELOCITY MEASUREMENTS TAKEN USING A MRCH MCBIRNEY FLO-MATE WITH TOP-SETTING WADING ROD.
2. MEASUREMENTS TAKEN AT BENTHIC INVERTEBRATE REPLICATE STATIONS, NEAR THE FIELD SUB-SAMPLE LOCATIONS.

Knight Piésold
CONSULTING

TABLE A.3

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
MARY RIVER STUDY AREA STREAM MEASUREMENTS

Print Jun/26/14 11:27:31

	STUDY AREA	MRY-NF-1	MRY-NF-2	MRY-NF-3	MRY-NF-4	MRY-NF-5	MRY-FF-1	MRY-FF-2	MRY-FF-3	MRY-FF-4	MRY-FF-5
	CHARACTERIZATION DATE	23-Aug-13	23-Aug-13	23-Aug-13	23-Aug-13	23-Aug-13	28-Aug-13	28-Aug-13	28-Aug-13	28-Aug-13	28-Aug-13
MEASUREMENT	UNIT										
Distance to U/S Replicate Station	m	-	170	195	440	275	-	564	215	145	196
TOTAL DISTANCE	m			1080					1120		
Wetted Width	m	33	32	46	38	30	98	47	52	37	46
AVERAGE WIDTH	m			36					56		
TD1	m	0.32	0.22	0.20	0.20	0.27	0.19	0.32	0.26	0.28	0.33
VEL1	m/sec	0.66	0.22	0.18	0.39	0.55	0.23	0.26	0.25	0.50	0.36
TD2	m	0.25	0.28	0.32	0.26	0.35	0.26	0.24	0.46	0.26	0.29
VEL2	m/sec	0.55	0.36	0.39	0.38	0.50	0.22	0.25	0.38	0.40	0.50
TD3	m	0.16	0.36	0.32	0.30	0.33	0.18	0.28	0.39	0.19	0.16
VEL3	m/sec	0.14	0.29	0.32	0.39	0.56	0.34	0.23	0.58	0.36	0.36
TD4	m	0.16	0.37	0.43	0.29	0.31	0.20	0.40	0.34	0.18	0.16
VEL4	m/sec	0.08	0.38	0.50	0.45	0.46	0.22	0.29	0.50	0.43	0.29
TD5	m	0.22	0.30	0.29	0.30	0.36	0.27	0.40	0.29	0.20	0.19
VEL5	m/sec	0.18	0.36	0.48	0.42	0.50	0.40	0.36	0.40	0.25	0.28
TD6	m	0.28	0.36	0.26	0.39	0.29	0.32	0.36	0.30	0.26	0.14
VEL6	m/sec	0.23	0.50	0.38	0.56	0.58	0.34	0.32	0.37	0.26	0.26
TD7	m	0.37	0.49	0.22	0.41	0.27	0.34	0.31	0.28	0.22	0.24
VEL7	m/sec	0.40	0.51	0.23	0.36	0.51	0.22	0.39	0.38	0.15	0.28
TD8	m	0.42	0.47	0.25	0.36	0.27	0.30	0.10	0.26	0.10	0.22
VEL8	m/sec	0.49	0.46	0.35	0.52	0.65	0.03	0.17	0.42	0.19	0.34
TD9	m	0.36	0.26	0.19	0.36	0.30	0.14	0.22	0.24	0.14	0.28
VEL9	m/sec	0.23	0.18	0.29	0.45	0.58	0.14	0.34	0.31	0.08	0.08
TD10	m	0.26	0.17	0.33	0.32	0.31	0.19	0.16	0.20	0.17	0.22
TD10	m/sec	0.23	0.29	0.38	0.34	0.47	0.19	0.24	0.26	0.20	0.53
MEAN TOTAL DEPTH	m	**0.28**	**0.33**	**0.28**	**0.32**	**0.31**	**0.24**	**0.28**	**0.30**	**0.20**	**0.22**
MEAN VELOCITY	m/sec	**0.32**	**0.36**	**0.35**	**0.43**	**0.54**	**0.23**	**0.29**	**0.39**	**0.28**	**0.33**
MINIMUM DEPTH	m			**0.16**					**0.10**		
MAXIMUM DEPTH	m			**0.49**					**0.46**		
MEAN TOTAL DEPTH	m			**0.30**					**0.25**		
MINIMUM VELOCITY	m/sec			**0.08**					**0.03**		
MAXIMUM VELOCITY	m/sec			**0.65**					**0.58**		
MEAN VELOCITY	m/sec			**0.40**					**0.30**		

	STUDY AREA	MRY-REF1-1	MRY-REF1-2	MRY-REF1-3	MRY-REF1-4	MRY-REF1-5	MRY-REF2-1	MRY-REF2-2	MRY-REF2-3	MRY-REF2-4	MRY-REF2-5
	CHARACTERIZATION DATE	27-Aug-13	27-Aug-13	27-Aug-13	27-Aug-13	27-Aug-13	25-Aug-13	25-Aug-13	25-Aug-13	25-Aug-13	25-Aug-13
MEASUREMENT	UNIT										
Distance to U/S Replicate Station	m	-	210	167	262	410	-	220	224	226	258
TOTAL DISTANCE	m			1049					928		
Wetted Width	m	44	38	30	35	37	31	35	52	43	50
AVERAGE WIDTH	m			37					42		
TD1	m	0.20	0.48	0.46	0.40	0.50	0.36	0.16	0.19	0.16	0.10
VEL1	m/sec	0.29	0.07	0.26	0.21	0.47	0.49	0.31	0.60	0.45	0.36
TD2	m	0.22	0.31	0.54	0.46	0.54	0.24	0.14	0.22	0.22	0.10
VEL2	m/sec	0.40	0.02	0.18	0.18	0.57	0.35	0.40	0.90	0.37	0.25
TD3	m	0.26	0.32	0.44	0.49	0.56	0.30	0.13	0.22	0.24	0.16
VEL3	m/sec	0.33	0.33	0.38	0.39	0.42	0.65	0.18	0.95	0.64	0.18
TD4	m	0.30	0.30	0.32	0.40	0.44	0.24	0.13	0.24	0.26	0.18
VEL4	m/sec	0.37	0.29	0.10	0.36	0.21	0.40	0.22	0.64	0.61	0.45
TD5	m	0.24	0.28	0.25	0.46	0.42	0.32	0.21	0.28	0.30	0.20
VEL5	m/sec	0.49	0.30	0.36	0.39	0.20	0.32	0.23	0.78	0.70	0.56
TD6	m	0.25	0.20	0.29	0.57	0.50	0.24	0.22	0.14	0.27	0.22
VEL6	m/sec	0.59	0.42	0.18	0.25	0.26	0.21	0.51	0.57	0.61	0.51
TD7	m	0.34	0.26	0.32	0.48	0.36	0.14	0.22	0.18	0.14	0.16
VEL7	m/sec	0.33	0.31	0.39	0.30	0.27	0.15	0.42	0.55	0.32	0.39
TD8	m	0.16	0.30	0.28	0.46	0.36	0.20	0.18	0.14	0.24	0.13
VEL8	m/sec	0.48	0.32	0.30	0.40	0.26	0.43	0.32	0.32	0.49	0.53
TD9	m	0.20	0.22	0.34	0.36	0.28	0.14	0.18	0.12	0.22	0.14
VEL9	m/sec	0.27	0.09	0.31	0.26	0.24	0.50	0.34	0.24	0.70	0.45
TD10	m	0.28	0.28	0.42	0.34	0.29	0.12	0.26	0.14	0.27	0.23
TD10	m/sec	0.30	0.38	0.32	0.29	0.17	0.65	0.41	0.36	0.61	0.66
MEAN TOTAL DEPTH	m	**0.25**	**0.30**	**0.37**	**0.44**	**0.43**	**0.23**	**0.18**	**0.19**	**0.23**	**0.16**
MEAN VELOCITY	m/sec	**0.39**	**0.25**	**0.28**	**0.30**	**0.31**	**0.42**	**0.33**	**0.59**	**0.55**	**0.43**
MINIMUM DEPTH	m			**0.16**					**0.10**		
MAXIMUM DEPTH	m			**0.57**					**0.36**		
MEAN TOTAL DEPTH	m			**0.35**					**0.20**		
MINIMUM VELOCITY	m/sec			**0.02**					**0.15**		
MAXIMUM VELOCITY	m/sec			**0.59**					**0.95**		
MEAN VELOCITY	m/sec			**0.31**					**0.46**		

	STUDY AREA	MRY-REF3-1	MRY-REF3-2	MRY-REF3-3	MRY-REF3-4	MRY-REF3-5	MRY-REF4-1	MRY-REF4-2	MRY-REF4-3	MRY-REF4-4	MRY-REF4-5
	CHARACTERIZATION DATE	26-Aug-13	26-Aug-13	26-Aug-13	26-Aug-13	26-Aug-13	30-Aug-13	30-Aug-13	30-Aug-13	30-Aug-13	30-Aug-13
MEASUREMENT	UNIT										
Distance to U/S Replicate Station	m	-	188	200	220	125	-	60	88	93	115
TOTAL DISTANCE	m			733					356		
Wetted Width	m	46	34	45	26	40	22	25	27	30	24
AVERAGE WIDTH	m			38					26		
TD1	m	0.31	0.26	0.21	0.25	0.19	0.44	0.32	0.18	0.28	0.22
VEL1	m/sec	0.18	0.25	0.40	0.76	0.33	0.15	0.23	0.15	0.54	0.09
TD2	m	0.34	0.18	0.10	0.25	0.14	0.36	0.30	0.10	0.24	0.29
VEL2	m/sec	0.30	0.77	0.13	0.70	0.16	0.20	0.24	0.21	0.06	0.10
TD3	m	0.32	0.34	0.16	0.28	0.21	0.38	0.42	0.24	0.19	0.20
VEL3	m/sec	0.37	1.06	0.67	0.51	0.34	0.20	0.23	0.30	0.24	0.20
TD4	m	0.36	0.30	0.14	0.21	0.20	0.36	0.30	0.11	0.18	0.24
VEL4	m/sec	0.12	0.46	0.38	0.58	0.08	0.36	0.09	0.15	0.45	0.13
TD5	m	0.33	0.32	0.15	0.20	0.22	0.40	0.28	0.18	0.14	0.24
VEL5	m/sec	0.40	0.50	0.33	0.70	0.30	0.49	0.10	0.36	0.33	0.26
TD6	m	0.24	0.23	0.12	0.20	0.26	0.33	0.25	0.14	0.14	0.24
VEL6	m/sec	0.34	0.20	0.13	0.66	0.44	0.22	0.11	0.22	0.21	0.10
TD7	m	0.32	0.20	0.19	0.22	0.35	0.28	0.28	0.11	0.22	0.24
VEL7	m/sec	0.45	0.24	0.26	0.30	0.52	0.22	0.20	0.16	0.17	0.20
TD8	m	0.20	0.16	0.25	0.16	0.34	0.22	0.34	0.08	0.12	0.22
VEL8	m/sec	0.53	0.44	0.40	0.45	0.36	0.14	0.21	0.10	0.31	0.07
TD9	m	0.20	0.14	0.28	0.26	0.13	0.11	0.36	0.20	0.23	0.33
VEL9	m/sec	0.26	0.32	0.47	0.26	0.17	0.06	0.24	0.33	0.45	0.21
TD10	m	0.16	0.15	0.24	0.26	0.30	0.16	0.36	0.30	0.17	0.29
TD10	m/sec	0.40	0.27	0.24	0.32	0.10	0.20	0.12	0.38	0.21	0.16
MEAN TOTAL DEPTH	m	**0.28**	**0.23**	**0.18**	**0.23**	**0.23**	**0.30**	**0.32**	**0.16**	**0.19**	**0.25**
MEAN VELOCITY	m/sec	**0.34**	**0.45**	**0.34**	**0.52**	**0.28**	**0.22**	**0.18**	**0.24**	**0.30**	**0.15**
MINIMUM DEPTH	m			**0.10**					**0.08**		
MAXIMUM DEPTH	m			**0.36**					**0.44**		
MEAN TOTAL DEPTH	m			**0.23**					**0.25**		
MINIMUM VELOCITY	m/sec			**0.08**					**0.06**		
MAXIMUM VELOCITY	m/sec			**1.06**					**0.49**		
MEAN VELOCITY	m/sec			**0.39**					**0.22**		

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix A - Site Char\Individual Files\[EEM_Appendix A_Table A1 to A3.xlsx]TABLE_A.3

NOTES:

1. TOTAL DEPTH AND VELOCITY MEASUREMENTS TAKEN USING A MRCH MCBIRNEY FLO-MATE WITH TOP-SETTING WADING ROD.
2. MEASUREMENTS TAKEN AT BENTHIC INVERTEBRATE REPLICATE STATIONS, NEAR THE FIELD SUB-SAMPLE LOCATIONS.

PHOTO 1 – CLT-NF-1 facing upstream towards waterfall barrier.

PHOTO 2 – CLT-NF-3 facing downstream.

PHOTO 3 – CLT-NF-4 and CLT-NF-5 facing upstream.

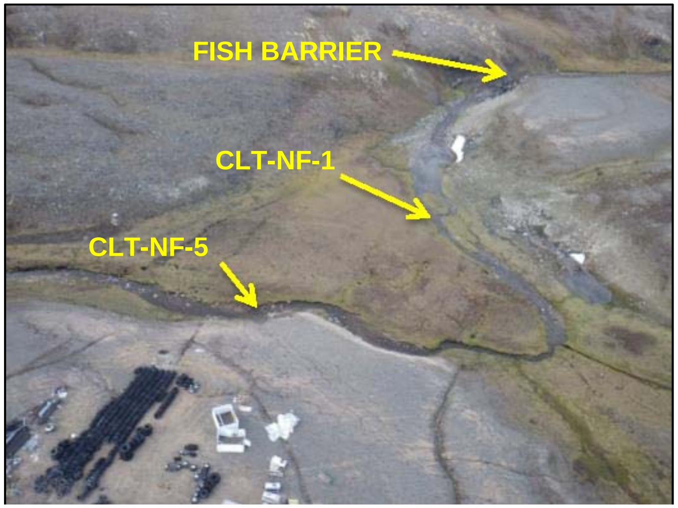


PHOTO 4 – CLT-NF aerial view including fish barrier upstream.

PHOTO 5 – CLT-FF-1 facing upstream to Tote Road culverts.

PHOTO 6 – CLT-FF-1 facing downstream.

PHOTO 7 – CLT-FF-4 facing downstream.

PHOTO 8 – CLT-FF-5 facing downstream towards Camp Lake.

PHOTO 9 – CLT-REF2-1 facing downstream.

PHOTO 10 – CLT-REF2-1 facing upstream.

PHOTO 11 – CLT-REF2-3 facing downstream.

PHOTO 12 – CLT-REF2-5 facing downstream towards Tote Road.


PHOTO 13 – CLT-REF3-1 facing downstream.


PHOTO 14 – CLT-REF3-2 facing downstream.


PHOTO 15 – CLT-REF3-4 facing downstream.


PHOTO 16 – CLT-REF3 aerial view of study area.

PHOTO 17 – CLT-REF4-1 facing upstream.

PHOTO 18 – CLT-REF4-3 facing downstream.

PHOTO 19 – CLT-REF4-5 facing upstream.

PHOTO 20 – CLT-REF4 aerial view of study area.

PHOTO 21 – MRY-NF-1 facing upstream, Deposit No.1 on horizon.

PHOTO 22 – MRY-NF-4 facing upstream.

PHOTO 23 – MRY-NF sediment characterization and BIC study area.

PHOTO 24 – MRY-NF fish community and water quality study area.

PHOTO 25 – MRY-FF-2 facing upstream.

PHOTO 26 – MRY-FF-4 facing upstream.

PHOTO 27 – MRY-FF-5 facing upstream from right bank.

PHOTO 28 – MRY-FF aerial view of study area facing upstream.


PHOTO 29 – MRY-REF1-1 facing upstream.


PHOTO 30 – MRY-REF1-3 facing downstream.


PHOTO 31 – MRY-REF1-5 facing upstream.


PHOTO 32 – MRY-REF1 aerial view facing upstream.

PHOTO 33 – MRY-REF2-1 facing downstream.

PHOTO 34 – MRY-REF2-2 facing upstream.

PHOTO 35 – MRY-REF2-5 facing downstream.

PHOTO 36 – MRY-REF2-1 to REF2-4 aerial view of study area.

PHOTO 37 – MRY-REF3-1 facing downstream.

PHOTO 38 – MRY-REF3-2 facing upstream.

PHOTO 39 – MRY-REF3-5 facing downstream.

PHOTO 40 – MRY-REF3 aerial view of study area facing upstream.

PHOTO 41 – MRY-REF4-1 facing upstream.

PHOTO 42 – MRY-REF4-2 facing left bank.

PHOTO 43 – MRY-REF4-3 facing downstream.

PHOTO 44 – MRY-REF4-5 facing downstream.

APPENDIX B

SEDIMENT QUALITY DATA

(Pages B-1 to B-3)

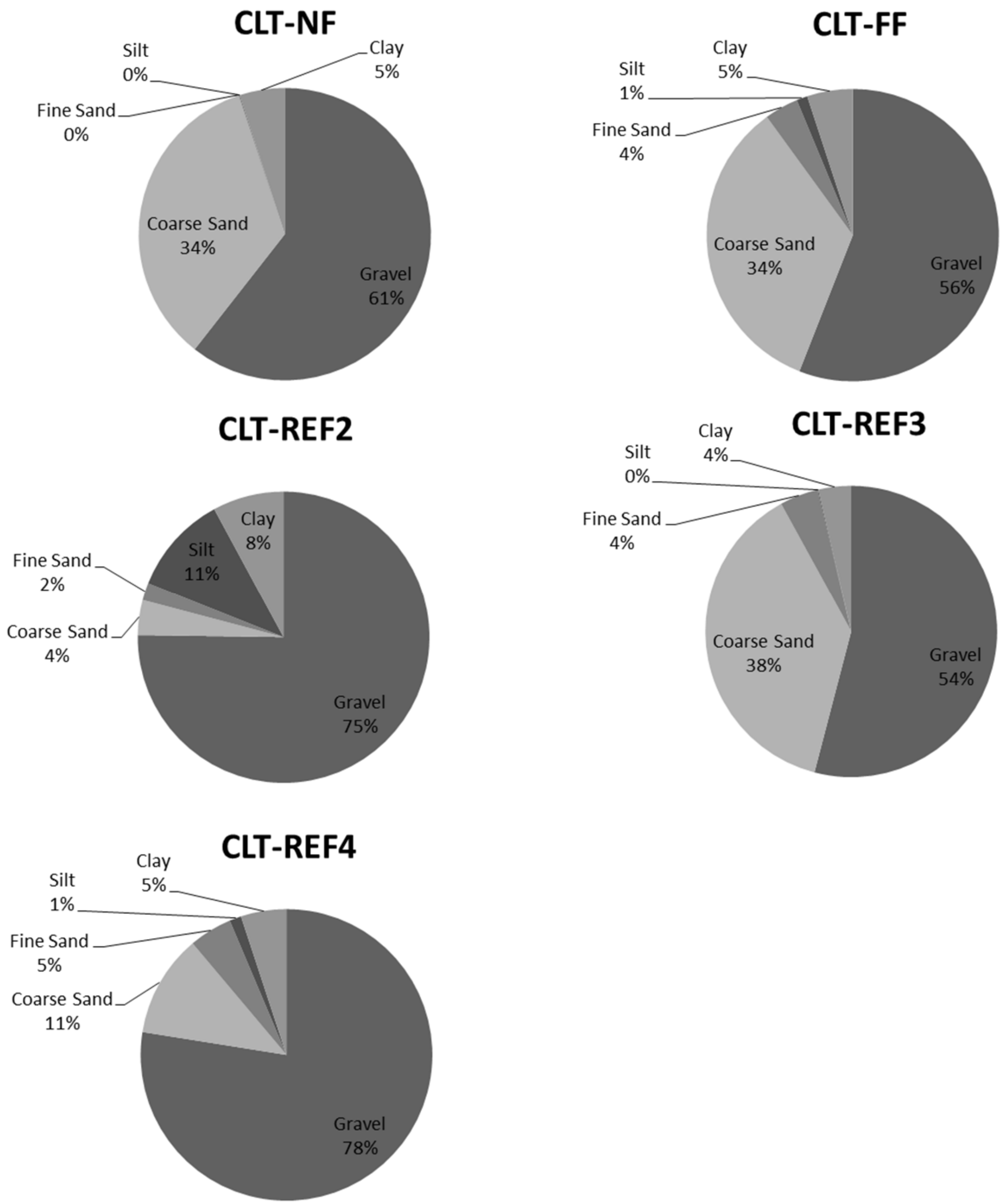


Figure B.1 Camp Lake Tributary Study Areas: Particle Size Distribution and TOC Summary

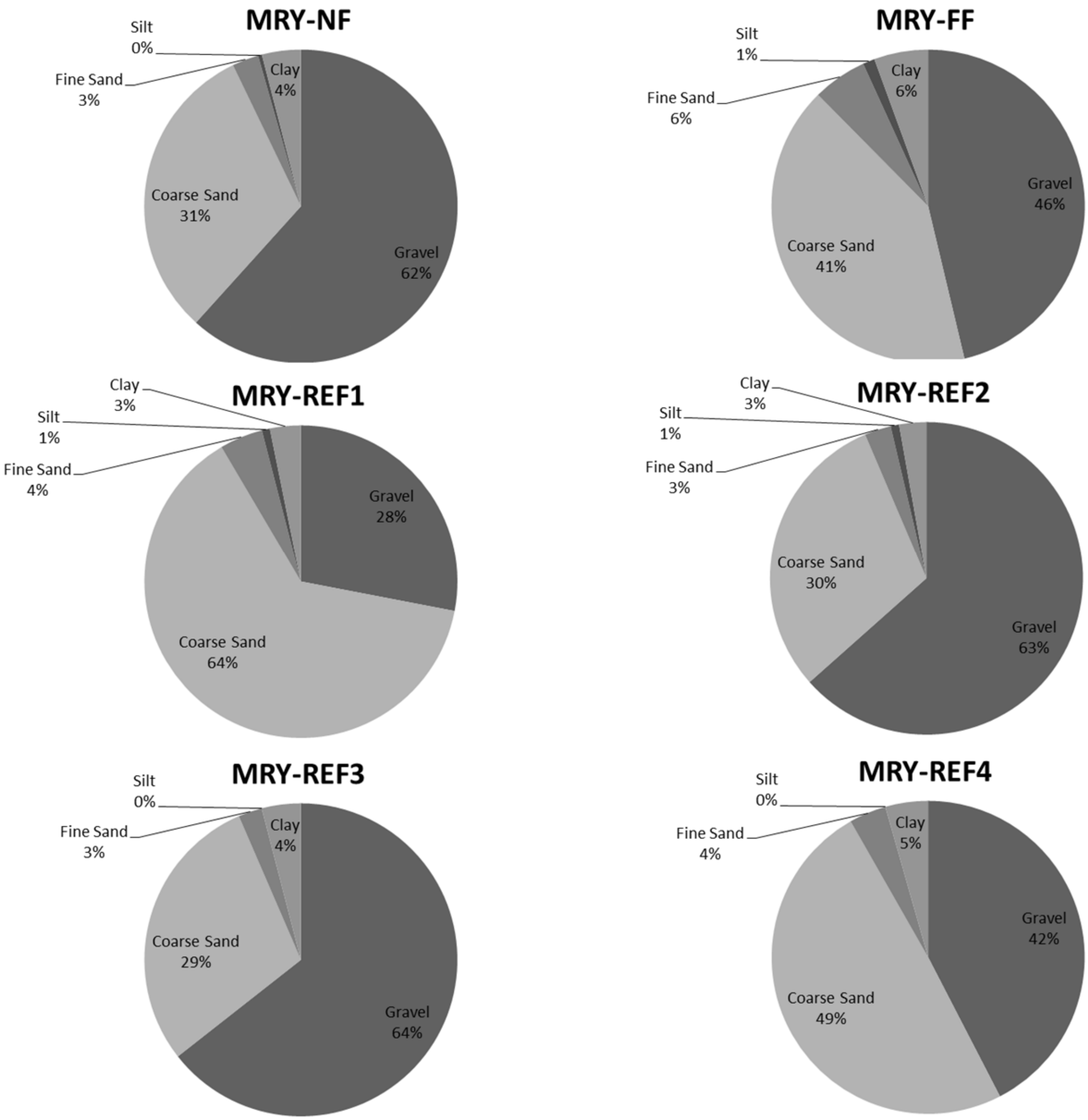


Figure B.2 Mary River Study Areas: Particle Size Distribution and TOC Summary

APPENDIX C

WATER QUALITY DATA

(Pages C-1 to C-6)

Knight Piésold
CONSULTING

TABLE C.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
CAMP LAKE TRIBUTARY AREAS: SURFACE WATER QUALITY SUMMARY

Print Jun/26/14 11:47:26

			EEM STATION ID	CLT-NF	CLT-NF	CLT-FF	CLT-FF	CLT-REF2	CLT-REF2	CLT-REF3	CLT-REF3	CLT-REF4	CLT-REF4
			CREMP STATION ID	L1-09	L1-09	L0-01	L0-01						
			SAMPLE DATE	23/07/2013	20/08/2013	23/07/2013	20/08/2013	24/07/2013	24/08/2013	23/07/2013	20/08/2013	23/07/2013	22/08/2013
PARAMETER	**UNIT**	**MRL**	**CWQG**										
In-situ Measurements													
Water Temperature	°C	-	-	13.51	5.88	13.52	6.05	12.50	2.0	12.39	4.70	10.70	1.75
Dissolved Oxygen	mg/L	-	6.5-9.5	10.39	14.3	10.37	13.16	10.45	13.74	10.61	12.52	10.88	13.77
pH	pH units	-	6.5-9.0	7.71	7.40	7.94	7.88	8.12	8.48	7.56	6.63	7.37	8.22
Conductivity	μS/cm	-	-	120	208	130	240	211	286	70	116	54	99
General Parameters													
pH			6.5-9.0	7.59	7.99	7.36	8.08	8.23	8.31	6.88	7.47	7.09	7.16
Alkalinity as CaCO3	mg/L	5	-	58	99	59	103	116	150	18	60	29	52
Conductivity	μS/cm	5	-	119	218	131	227	221	288	54	122	55	105
Dissolved Organic Carbon (DOC)	mg/L	0.5	-	2.6	2.5	2.4	2.4	1.5	1.9	0.9	0.8	1.4	1.3
Total Suspended Solids (TSS)	mg/L	2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Turbidity	NTU	0.1	-	0.4	0.7	0.4	0.4	0.2	0.1	5.2	>100	2.3	1.7
Hardness as CaCO3 (Dissolved)	mg/L	0.5	-	57.6	104	62.3	111	117	158	20.2	55.7	24.4	46.4
Total Dissolved Solids (TDS)	mg/L	1	-	77	142	85	148	144	187	35	79	36	68
Total Organic Carbon (TOC)	mg/L	0.5	-	2.5	2.6	2.5	2.6	1.5	2.2	0.8	1.2	1.4	1.4
Biomass													
Chlorophyll-a	mg/m^3	0.2	-	<0.2	<0.2	<0.2	3.6	1.7	<0.2	<0.2	2.1	<0.2	0.8
Pheophytin-a	mg/m^3	0.2	-	3.4	3.7	1.5	<0.2	<0.2	0.4	8.2	<0.2	11.4	<0.2
Nutrients and Anions													
Bromide	mg/L	0.25	-	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Chloride	mg/L	1	120	3	9	3	9	1	2	3	<1	<1	<1
N-NH3 (Ammonia)	mg/L	0.02	Table [7]	<0.02	0.06	<0.02	<0.02	**0.83**	0.04	<0.02	<0.02	<0.02	<0.02
N-NO2 (Nitrite)	mg/L	0.005	0.06	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
N-NO3 (Nitrate)	mg/L	0.1	13	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
NO2 + NO3 as N	mg/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenols	mg/L	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sulphate	mg/L	3	-	<3	4	6	4	3	5	6	4	<3	4
Total Kjeldahl Nitrogen (TKN)	mg/L	0.1	-	0.1	0.2	0.54	0.14	1.43	0.14	<0.10	0.1	<0.10	<0.10
Total Phosphorus	mg/L	0.003	-	0.005	0.003	0.004	0.013	<0.003	0.003	0.005	0.007	0.004	0.005

TABLE C.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
CAMP LAKE TRIBUTARY AREAS: SURFACE WATER QUALITY SUMMARY

Print Jun/26/14 11:47:26

			EEM STATION ID	CLT-NF	CLT-NF	CLT-FF	CLT-FF	CLT-REF2	CLT-REF2	CLT-REF3	CLT-REF3	CLT-REF4	CLT-REF4
			CREMP STATION ID	L1-09	L1-09	L0-01	L0-01						
			SAMPLE DATE	23/07/2013	20/08/2013	23/07/2013	20/08/2013	24/07/2013	24/08/2013	23/07/2013	20/08/2013	23/07/2013	22/08/2013
PARAMETER	**UNIT**	**MRL**	**CWQG**										
Total Metals													
Aluminum	ug/L	1	Variable [3]	13.1	9.4	10.7	7.8	<1.0	4.1	**172**	93.4	**105**	77.1
Antimony	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic	ug/L	0.1	5	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	ug/L	0.05	-	6.89	11	7.32	11.3	2.84	3.31	6.08	5.77	3.74	5.7
Beryllium	ug/L	0.02	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.10
Bismuth	ug/L	0.5	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron	ug/L	10	1,500	<10.0	<10.0	<10.0	<10.0	10	11	<10.0	<10.0	<10.0	<10.0
Cadmium	ug/L	0.01	0.09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium	mg/L	0.05	-	11.6	22.1	12.6	22.8	32.9	42.6	4.47	12.4	4.92	9.55
Chromium	ug/L	0.02	-	0.12	0.15	0.13	0.15	<0.02	0.12	0.34	0.21	0.2	0.14
Chromium, Trivalent (III)	ug/L	5	8.9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chromium Hexavalent (Cr(VI))	ug/L	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Copper	ug/L	0.2	Equation [4]	1.88	1.53	1.47	1.47	<0.20	<0.20	1.07	0.63	0.71	0.66
Iron	ug/L	3	300	43	93	33	66	<3	<3	148	101	47	50
Lead	ug/L	0.05	Equation [6]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.15	0.07	0.06	0.08
Lithium	ug/L	0.05	-	1.16	2.12	1.32	2.22	1.14	1.47	0.51	<0.05	<0.05	0.9
Magnesium	mg/L	0.1	-	6.84	12.4	7.47	13.1	8.13	11.2	2.26	6.79	2.79	5.42
Manganese	ug/L	0.05	-	2.04	5.44	1.57	2.65	0.056	0.165	1.89	2.55	0.531	0.677
Mercury	ug/L	0.01	0.026	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum	ug/L	0.05	73	0.327	0.523	0.319	0.5	<0.050	<0.050	0.256	0.27	0.107	0.221
Nickel	ug/L	0.5	Equation [5]	0.66	0.94	0.73	1.02	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Potassium	mg/L	0.05	-	1.1	1.45	1.16	1.49	0.306	0.28	0.69	0.614	0.505	0.611
Selenium	ug/L	0.01	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10
Silicon	ug/L	50	-	570	1050	640	1030	580	790	890	860	700	840
Silver	ug/L	0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010
Sodium	mg/L	0.0012	-	0.985	1.89	1.06	2.04	0.539	0.802	1.75	1.54	1.69	3.08
Strontium	ug/L	0.4	-	9.81	32.4	10.9	29.5	23.2	30.1	9.1	9.07	3.83	7.66
Thallium	ug/L	0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010
Tin	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Titanium	ug/L	10	-	<10	<10	<10	<10	<10	<10	10	<10	<10	<10
Uranium	ug/L	0.01	15	0.47	1.67	0.513	1.75	0.231	0.404	0.342	4.43	0.262	1.38
Vanadium	ug/L	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	ug/L	3	30	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<0.33

Knight Piésold CONSULTING

TABLE C.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
CAMP LAKE TRIBUTARY AREAS: SURFACE WATER QUALITY SUMMARY

Print Jun/26/14 11:47:26

			EEM STATION ID	CLT-NF	CLT-NF	CLT-FF	CLT-FF	CLT-REF2	CLT-REF2	CLT-REF3	CLT-REF3	CLT-REF4	CLT-REF4
			CREMP STATION ID	L1-09	L1-09	L0-01	L0-01						
			SAMPLE DATE	23/07/2013	20/08/2013	23/07/2013	20/08/2013	24/07/2013	24/08/2013	23/07/2013	20/08/2013	23/07/2013	22/08/2013
PARAMETER	**UNIT**	**MRL**	**CWQG**										
Dissovled Metals													
Aluminum	ug/L	1	-	4.7	2.7	3	6	1.2	<1.00	19.8	4.2	17.5	6
Antimony	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	ug/L	0.05	-	8.56	11.2	7.19	11.3	2.9	3.35	4.71	5.28	3.31	5.21
Beryllium	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth	ug/L	0.5	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron	ug/L	10	-	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Cadmium	ug/L	0.01	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium	mg/L	0.05	-	11.9	21.6	12.8	23.7	33.5	44.5	4.49	11.6	5.08	9.54
Chromium	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Copper	ug/L	0.2	-	1.49	1.23	1.39	1.42	<0.20	0.26	0.65	0.36	0.54	0.56
Iron	ug/L	10	-	20	50	20	40	<10	<10	<10	10	<10	<10
Lead	ug/L	0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lithium	ug/L	0.5	-	0.93	2.19	0.93	2.17	1.19	0.99	<0.50	0.64	<0.50	0.56
Magnesium	mg/L	0.1	-	6.75	12.3	7.36	12.7	8.11	11.5	2.17	6.45	2.84	5.49
Manganese	ug/L	0.05	-	2.74	4.45	0.86	2.2	<0.050	0.051	0.153	1.48	0.086	0.1
Mercury	ug/L	0.01	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum	ug/L	0.05	-	0.324	0.487	0.299	0.494	<0.050	0.051	0.288	0.267	0.109	0.228
Nickel	ug/L	0.5	-	0.63	0.84	0.72	0.97	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Potassium	mg/L	0.05	-	1.2	1.5	1.14	1.6	0.315	0.296	0.611	0.569	0.431	0.546
Selenium	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silicon	ug/L	50	-	570	990	630	1030	580	850	610	660	570	680
Silver	ug/L	0.001	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Sodium	mg/L	0.0012	-	0.992	1.91	1.01	2.05	0.544	0.822	1.6	1.44	1.45	3.02
Strontium	ug/L	0.4	-	10.4	29.9	10.1	29.8	22.6	29.4	9.34	8.67	3.38	7.78
Thallium	ug/L	0.01	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin	ug/L	0.1	-	<0.10	<0.10	<0.10	0.29	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Titanium	ug/L	10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Uranium	ug/L	0.01	-	0.469	1.61	0.474	1.57	0.24	0.411	0.263	4.24	0.196	1.33
Vanadium	ug/L	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	ug/L	0.33	-	3.5	<0.33	2.2	5.8	1.3	<0.33	1.3	<0.33	<0.33	<0.33

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix C - WQ\Individual files\[EEM_Appendix C_WQ_20140313.xlsx]Table C.1

NOTES:

1. SAMPLES ANALYZED BY EXOVA ACCUTEST IN OTTAWA, ON AND ALS LABORATORIES IN VANCOUVER, BC.
2. CANADIAN WATER QUALITY GUIDELINES (CWQG): CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT, CCME.CA; WATER QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE, LONG TERM EFFECTS.
3. ALUMINUM CEQG VALUES BASED ON pH: 5µg/L IF pH <6.5, 100 µg/L IF pH ≥6.5.
4. COPPER CEQG VALUES ARE CALCULATED BY SAMPLE USING THE CCME.CA WEBSITE.
5. NICKEL CEQG VALUES ARE CALCULATED BY SAMPLE USING THE CCME.CA WEBSITE.
6. LEAD CEQG VALUES ARE CALCULATED BY SAMPLE USING THE CCME.CA WEBSITE.
7. TOTAL AMMONIA CEQG VALUES ARE BASED ON A TABLE AVAILABLE AT CCME.CA.
8. LABORATORY RESULTS THAT ARE BOLDED AND SHADED ARE EQUAL TO OR ABOVE THE RESPECTIVE CWQG GUIDELINES.

Knight Piésold
CONSULTING

TABLE C.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
MARY RIVER AREAS: SURFACE WATER QUALITY SUMMARY

Print Jun/26/14 11:49:00

			EEM STATION ID	MRY-NF	MRY-NF	MRY-NF	MRY-NF	MRY-FF	MRY-REF1	MRY-REF1	MRY-REF2	MRY-REF2	MRY-REF3	MRY-REF3	MRY-REF4	MRY-REF4
			CREMP STATION ID	E0-20	E0-20	E0-21	E0-21	C0-05							G0-09	G0-09
			SAMPLE DATE	24/07/2013	20/08/2013	24/07/2013	20/08/2013	28/08/2013	24/07/2013	27/08/2013	23/07/2013	25/08/2013	23/07/2013	26/08/2013	25/07/2013	22/08/2013
PARAMETER	**UNIT**	**MRL**	**CWQG**													
In-situ Measurements																
Water Temperature	°C	-	-	13.54	5.54	13.54	5.28	2.18	14.62	2.50	11.69	2.08	9.44	3.16	7.68	6.71
Dissolved Oxygen	mg/L	-	6.5-9.5	9.73	13.40	9.69	13.39	13.73	10.10	13.48	10.97	15.74	11.28	13.37	10.86	13.67
pH	pH units	-	6.5-9.0	7.81	7.67	7.79	7.71	8.25	8.00	8.12	7.45	7.80	7.68	7.72	7.37	8.09
Conductivity	μS/cm	-	-	59	177	57	153	164	122	219	57	92	53	80	60	143
General Parameters																
pH			6.5-9.0	6.95	7.68	7.04	7.65	7.53	7.61	7.83	7.03	7.14	7.22	6.8	6.97	7.39
Alkalinity as CaCO3	mg/L	5	-	34	70	33	67	70	62	89	26	42	37	25	27	61
Conductivity	μS/cm	5	-	70	154	69	149	158	125	195	57	99	70	86	56	148
Dissolved Organic Carbon (DOC)	mg/L	0.5	-	1	0.8	0.9	0.8	1.6	3.4	4.5	1.2	1.9	1.2	1.1	0.6	0.9
Total Suspended Solids (TSS)	mg/L	2	-	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Turbidity	NTU	0.1	-	4.7	2	5	3.4	1.8	0.8	1.2	2.8	4.3	0.9	6.9	7.7	3.1
Hardness as CaCO3 (Dissolved)	mg/L	0.5	-	31.6	69.8	30.9	66	73.7	61.2	94.4	24.6	44.1	33.9	32.2	24.6	63.5
Total Dissolved Solids (TDS)	mg/L	1	-	46	100	45	97	103	81	127	37	64	46	56	36	96
Total Organic Carbon (TOC)	mg/L	0.5	-	1.2	0.9	0.7	0.8	1.5	3.5	4.4	1.2	1.7	1.3	1.4	0.7	1.1
Biomass																
Chlorophyll-a	mg/m^3	0.2	-	<0.2	0.4	0.3	3.3	0.4	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	0.4
Pheophytin-a	mg/m^3	0.2	-	2.8	<0.2	0.9	<0.2	<0.2	1.2	<0.2	8.2	1.2	26.6	1.2	5.1	0.3
Nutrients and Anions																
Bromide	mg/L	0.25	-	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Chloride	mg/L	1	120	1	4	1	4	5	2	8	2	4	<1	5	1	7
N-NH3 (Ammonia)	mg/L	0.02	Table [7]	0.14	0.03	0.04	0.04	0.03	0.75	<0.02	<0.02	0.06	<0.02	<0.02	0.06	0.02
N-NO2 (Nitrite)	mg/L	0.005	0.06	<0.005	0.007	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.006
N-NO3 (Nitrate)	mg/L	0.1	13	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
NO2 + NO3 as N	mg/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenols	mg/L	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sulphate	mg/L	3	-	<3	5	<3	5	5	<3	3	3	5	<3	10	<3	6
Total Kjeldahl Nitrogen (TKN)	mg/L	0.1	-	0.27	0.14	0.14	0.13	0.16	0.83	0.18	0.11	0.11	0.15	<0.10	<0.10	0.1
Total Phosphorus	mg/L	0.003	-	0.006	0.005	0.007	0.011	<0.003	0.003	0.005	0.004	0.007	0.005	0.01	0.014	0.003

Knight Piésold
CONSULTING

TABLE C.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
MARY RIVER AREAS: SURFACE WATER QUALITY SUMMARY

Print Jun/26/14 11:49:00

			EEM STATION ID	MRY-NF	MRY-NF	MRY-NF	MRY-NF	MRY-FF	MRY-REF1	MRY-REF1	MRY-REF2	MRY-REF2	MRY-REF3	MRY-REF3	MRY-REF4	MRY-REF4
			CREMP STATION ID	E0-20	E0-20	E0-21	E0-21	C0-05							G0-09	G0-09
			SAMPLE DATE	24/07/2013	20/08/2013	24/07/2013	20/08/2013	28/08/2013	24/07/2013	27/08/2013	23/07/2013	25/08/2013	23/07/2013	26/08/2013	25/07/2013	22/08/2013
PARAMETER	**UNIT**	**MRL**	**CWQG**													
Total Metals																
Aluminum	ug/L	1	Variable [3]	**160**	**153**	**157**	**243**	69.3	18.3	36.7	**110**	**176**	40.3	**503**	**346**	**222**
Antimony	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic	ug/L	0.1	5	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	ug/L	0.05	-	5.48	9.84	5.31	9.9	9.96	3.94	5.82	4.71	7.25	3.69	10.4	6.35	9.85
Beryllium	ug/L	0.02	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bismuth	ug/L	0.5	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron	ug/L	10	1,500	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Cadmium	ug/L	0.01	0.09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium	mg/L	0.05	-	6.59	14.9	6.4	14	16	13.8	20	5.19	9.38	7.19	7.29	5.68	13.6
Chromium	ug/L	0.02	-	0.36	0.37	54	0.56	0.23	0.31	0.27	0.21	0.32	0.12	0.97	0.75	0.47
Chromium, Trivalent (III)	ug/L	5	8.9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chromium Hexavalent (Cr(VI))	ug/L	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt	ug/L	0.1	-	<0.10	<0.10	0.12	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.18	0.15	<0.10
Copper	ug/L	0.2	Equation [4]	0.74	0.89	**3.03**	0.92	0.93	0.54	0.55	0.64	0.86	0.53	1.58	1.01	1.12
Iron	ug/L	3	300	125	136	**528**	219	61	85	80	71	132	37	**414**	**325**	176
Lead	ug/L	0.05	Equation [6]	0.12	0.11	0.12	0.18	0.06	<0.05	<0.05	0.07	0.13	<0.05	0.36	0.28	0.14
Lithium	ug/L	0.05	-	0.54	0.74	0.55	0.88	0.9	0.75	1.33	<0.05	0.6	<0.05	0.95	0.92	1.1
Magnesium	mg/L	0.1	-	3.72	8.27	3.54	7.76	9.02	6.8	10.9	2.87	5.05	3.92	3.89	3.23	7.52
Manganese	ug/L	0.05	-	1.63	2.07	6.62	3.2	1.42	1.52	2.89	1.27	1.96	1.13	5.13	3.8	2.15
Mercury	ug/L	0.01	0.026	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum	ug/L	0.05	73	0.181	0.415	0.297	0.381	0.467	<0.050	<0.050	0.127	0.212	0.14	0.443	0.132	0.405
Nickel	ug/L	0.5	Equation [5]	<0.50	0.63	1.36	0.63	0.62	<0.50	<0.50	<0.50	<0.50	<0.50	0.61	<0.50	<0.50
Potassium	mg/L	0.05	-	0.643	1.01	0.659	1.02	1.01	0.397	0.587	0.539	0.685	0.474	0.952	0.706	1.18
Selenium	ug/L	0.01	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon	ug/L	50	-	770	1050	740	1270	990	490	1210	660	1150	580	2180	1240	1220
Silver	ug/L	0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	mg/L	0.0012	-	0.961	2.19	0.988	2.26	2.7	1.04	2.63	1.26	2.03	0.821	2.6	1.05	3.2
Strontium	ug/L	0.4	-	6.03	14	6.07	13.8	14.9	7.43	11.5	5.51	10.8	4.99	16.2	6.49	16.8
Thallium	ug/L	0.001	-	<0.001	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.011	<0.001
Tin	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Titanium	ug/L	10	-	<10	<10	<10	20	<10	<10	<10	<10	<10	<10	30	20	10
Uranium	ug/L	0.01	15	0.472	2.69	0.497	2.83	2.89	0.221	0.61	0.332	1.05	0.775	0.953	0.606	4.15
Vanadium	ug/L	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	ug/L	3	30	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Knight Piésold
CONSULTING

TABLE C.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
MARY RIVER AREAS: SURFACE WATER QUALITY SUMMARY

Print Jun/26/14 11:49:00

			EEM STATION ID	MRY-NF	MRY-NF	MRY-NF	MRY-NF	MRY-FF	MRY-REF1	MRY-REF1	MRY-REF2	MRY-REF2	MRY-REF3	MRY-REF3	MRY-REF4	MRY-REF4
			CREMP STATION ID	E0-20	E0-20	E0-21	E0-21	C0-05							G0-09	G0-09
			SAMPLE DATE	24/07/2013	20/08/2013	24/07/2013	20/08/2013	28/08/2013	24/07/2013	27/08/2013	23/07/2013	25/08/2013	23/07/2013	26/08/2013	25/07/2013	22/08/2013
PARAMETER	**UNIT**	**MRL**	**CWQG**													
Dissolved Metals																
Aluminum	ug/L	1	-	13.7	5.3	15.8	4.8	4.8	8.9	6	16	7.5	8.6	10.6	14.7	7.8
Antimony	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	ug/L	0.05	-	4.37	8.78	4.26	8.64	9.01	3.78	5.58	4.15	6.43	3.57	7.02	3.53	8.24
Beryllium	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth	ug/L	0.5	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron	ug/L	10	-	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Cadmium	ug/L	0.01	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium	mg/L	0.05	-	6.65	14.5	6.57	13.8	15.1	13.5	19.6	5.21	9.31	7.22	7.14	5.19	13.4
Chromium	ug/L	0.1	-	<0.10	<0.10	0.71	<0.10	<0.10	0.1	0.14	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Copper	ug/L	0.2	-	0.56	0.59	0.55	0.57	0.72	0.47	0.45	0.47	0.53	0.43	0.98	0.49	0.73
Iron	ug/L	10	-	<10	<10	20	<10	<10	60	40	10	10	20	20	<10	<10
Lead	ug/L	0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lithium	ug/L	0.5	-	<0.50	0.75	<0.50	0.54	<0.50	0.74	0.79	<0.50	<0.50	<0.50	0.8	0.5	0.93
Magnesium	mg/L	0.1	-	3.64	8.17	3.53	7.65	8.72	6.68	11	2.8	5.07	3.85	3.48	2.81	7.32
Manganese	ug/L	0.05	-	0.257	0.375	0.285	0.263	0.594	1.37	2.37	0.39	0.697	0.713	1.32	0.128	0.124
Mercury	ug/L	0.01	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum	ug/L	0.05	-	0.192	0.355	0.228	0.344	0.455	<0.050	<0.050	0.126	0.179	0.144	0.408	0.155	0.39
Nickel	ug/L	0.5	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Potassium	mg/L	0.05	-	0.613	0.917	0.604	0.905	0.939	0.388	0.559	0.486	0.616	0.44	0.78	0.549	1.04
Selenium	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silicon	ug/L	50	-	500	680	490	610	810	480	1150	510	740	530	880	440	740
Silver	ug/L	0.001	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Sodium	mg/L	0.0012	-	0.978	2.09	0.981	2.23	2.49	1.01	2.38	1.21	2.07	0.823	2.57	0.976	3.14
Strontium	ug/L	0.4	-	5.96	12.9	6.08	12.7	14.3	7.02	11	5.85	10.2	5.19	14.9	5.52	16.3
Thallium	ug/L	0.01	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin	ug/L	0.1	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Titanium	ug/L	10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Uranium	ug/L	0.01	-	0.452	2.59	0.461	2.61	2.9	0.209	0.579	0.317	0.952	0.787	0.712	0.442	3.68
Vanadium	ug/L	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	ug/L	0.33	-	<0.33	<0.33	1	<0.33	<0.33	1.6	<0.33	<0.33	<0.33	2.9	1.9	<0.33	<0.33

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix C - WQ\Individual files\[EEM_Appendix C_WQ_20140313.xlsx]Table C.2

NOTES:
1. SAMPLES ANALYZED BY EXOVA ACCUTEST IN OTTAWA, ON AND ALS LABORATORIES IN VANCOUVER, BC.
2. CANADIAN WATER QUALITY GUIDELINES (CWQG): CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT, CCME.CA; WATER QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE, LONG TERM EFFECTS.
3. ALUMINUM CEQG VALUES BASED ON pH: 5µg/L IF pH <6.5, 100 µg/L IF pH ≥6.5.
4. COPPER CEQG VALUES ARE CALCULATED BY SAMPLE USING THE CCME.CA WEBSITE.
5. NICKEL CEQG VALUES ARE CALCULATED BY SAMPLE USING THE CCME.CA WEBSITE.
6. LEAD CEQG VALUES ARE CALCULATED BY SAMPLE USING THE CCME.CA WEBSITE.
7. TOTAL AMMONIA CEQG VALUES ARE BASED ON A TABLE AVAILABLE AT CCME.CA.
8. LABORATORY RESULTS THAT ARE BOLDED AND SHADED ARE EQUAL TO OR ABOVE THE RESPECTIVE CWQG GUIDELINES.

APPENDIX D

BENTHIC INVERTEBRATE DATA

(Pages D-1 to D-26)

1 SAMPLE PROCESSING METHODS AND ENDPOINT SUMMARIES

1.1 SAMPLE PROCESSING

Benthic macroinvertebrate samples for the 2013 characterization program were processed by ZEAS Inc., Nobleton, Ontario. Upon arrival, samples were immediately logged and inspected to ensure adequate preservation to a minimum level of 10% buffered formalin and checked for correct labeling.

Benthic macroinvertebrate samples were sorted at a magnification of between 7 and 10 times with the use of a stereomicroscope. To expedite sorting, prior to processing, all samples were stained with a protein dye that is absorbed by aquatic organisms but not by organic material, such as detritus and algae. The stain has proven to be effective in increasing sorting recovery.

Prior to sorting, samples were washed free of formalin in a 500 µm sieve. In samples containing sand, gravel, or rocks, elutriation techniques were used to separate the lighter benthic macroinvertebrates and associated debris from the heavier sand, gravel and rocks. Elutriation techniques effectively remove almost all organisms except some heavy-bodied organisms such as molluscs and caddisflies with rock cases. As such, the remaining sand and gravel fraction is closely inspected. After elutriation, the remaining debris and benthic macroinvertebrates were washed through a series of two sieves, (i.e., 3.36 mm and 500 µm respectively). The screening of material through a series of sieves is used to facilitate sorting. This procedure separates macroinvertebrates and detritus into a set of size-based fractions that can be sorted under a more constant magnification.

Benthic macroinvertebrates were enumerated and sorted into major taxonomic groups, (i.e., order and family), placed in glass bottles and represerved in 80% ethanol for more detailed taxonomic analysis by senior staff. Each bottle was labeled internally (on 100% cotton paper) with the survey name, date, station and replicate number.

1.1.1 Subsampling

For each sample, material retained on the 3.36 mm sieve, was sorted entirely. Some sample material retained on the 500 µm sieve may have require subsampling due to the large amounts of organic matter or high densities of particular groups.

Subsampling was carried out using the “pie method”. The pie method entails dividing the bottom surface area of the sieve into a desired number of subsamples and then removing one or more of the sub-sample “pie” sections for sorting and detailed identification. Samples are split down to fractions requiring a minimum sorting time of approximately 4 hours.

1.2 DETAILED IDENTIFICATION

All macroinvertebrates were identified to the lowest practical level. Taxonomy was based on the most recent publications. Taxonomic resolution was dependent on available keys, ease of identification, the condition, (i.e., damage), and maturity of the organism, (i.e., only mature larvae can be identified to species). A list of all taxonomic keys is presented below.

1.2.1 Quality Assurance and Quality Control Measures

ZEAS incorporated the following set of QA/QC procedures in all benthic projects undertaken by the company to ensure the generation of high quality and reliable data:

- Samples are logged upon arrival, inspected, and enumerated.
- Samples are checked for proper preservation.
- Samples are stained to facilitate sorting.
- Taxonomic identifications are based on the most updated and widely used keys.
- 10 % of the samples are re-sorted, documenting 90 % recovery.
- Precision and accuracy estimates are calculated (where possible).
- A voucher will be compiled.
- Sorted sediments and debris are represerved in 10 % formalin and are retained for up to three months. For samples subject to subsampling, sorted and unsorted fractions are represerved separately.
- Sorted organisms from each sample are archived at the ZEAS laboratory indefinitely.
- To ensure against data entry errors or incorrect spelling of macroinvertebrate names, the data spreadsheets are inspected by a second person and data are cross-checked with bench sheets.

1.3 TAXONOMIC REFERENCES

Allen, R.K., and G.F. Edmunds, Jr. (1963). A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). VII. The subgenus *Eurylophella*. The Canadian Entomologist 95: 597-623.

Allen, R.K., and G.F. Edwards, Jr. (1965). A review of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VIII. The subgenus *Ephemerella* in North America. Misc. Publ. Ent. Soc. Am. 4:243-282.

Archangelsky, M. (1997). S*tudies on the Biology, Ecology, and Systematics of the Immature Stages of New World Hydrophiloidea (Coleoptera: Staphyliniformia)*. Ohio Biological Survey, Columbus, Ohio. 207pp.

Bednarik, A.F., and W.P. McCafferty. (1979). Biosystematic Revision of the Genus *Stenonema* (Ephemeroptera: Heptageniidae). Canadian Bulletin of Fisheries and Aquatic Sciences, Bulletin 201, Department of Fisheries and Oceans.

Bousfield, E.L., (1967). *Freshwater amphipod crustaceans of glaciated North America*. The Canadian Field-Naturalist. Vol. 72, No. 2, pp. 55-113.

Brinkhurst, R.O. (1986). *Guide to the Freshwater Aquatic Microdrile Oligochaetes of North America.* Department of Fisheries and Oceans, Ottawa.

Brown, H.P. (1972). *Aquatic Dryopoid Beetles (Coleoptera) of the United States.* Biota of Freshwater Ecosystems Identification Manual No. 6, Water Pollution Control Research Series, Environmental Protection Agency.

Burch, J.G. (1989). *North American Freshwater Snails.* Malacological Publications, Hamburg, Michigan.

Clarke, A.H. (1981). *The freshwater molluscs of Canada*. National Museum of Natural Sciences. Ottawa.

Crocker, D.W., and D.W. Barr. (1968). *Handbook of the Crayfishes on Ontario*. University of Toronto Press.

Edmunds, G.F., Jr., Jensen, S.L., and L. Berner. (1976). *The Mayflies of North and Central America*. University of Minnesota Press., Minneapolis.

Epler, J.H. (2001). *Identification Manual for the Larval Chironomidae (Diptera) of North and South Carolina North Carolina Department of Environment and Natural Resources.* 526 pp.

Frest, T.J. and E.J. Johannes. (1999). *Field Guide to Survey and Manage Freshwater Mollusk Species*. U.S. Fish and Wildlife Service.

Fullington, K.E., and K.W. Stewart. (1980). Nymphs of the stonefly genus *Taeniopteryx* (Plecoptera: Taeniopterygidae) of North America. *Journal of the Kansas Entomological Society,* 53(2): 237-259.

Harper, P.P., and H.B.N. Hynes. (1971a). *The Leuctridae of Eastern Canada (Insecta: Plecoptera)*. Can. J. Zool. 49:915-920.

Harper, P.P., and H.B.N. Hynes. (1971b). *The nymphs of the Nemouridae of Eastern Canada (Insecta: Plecoptera).* Can. J. Zool. 49:1129-1142.

Harper, P.P., and H.B.N. Hynes. (1971c). *The nymphs of the Taeniopterygidae of Eastern Canada (Insecta: Plecoptera)*. Can J. Zool. 49: 941-947.

Hilsenhoff, W.L. (1995). *Aquatic Insects of Wisconsin: Keys to Wisconsin genera and notes on biology, distribution and species*. Publication Number 3 of the Natural History Museums Council, University of Wisconsin-Madison 79 pp.

Hilsenhoff, W.L., and K.L. Schmude. (1992). *Riffle beetles of Wisconsin (Coleoptera: Dryopidae, Elmidae, Lutrochidae, Psephenidae) with notes on distribution, habitat, and identification*. The Great Lakes Entomologist 25(3): 191-213.

Hitchcock, S.W. (1974). *Guide to the Insects of Connecticut*. Part VII. The Plecoptera or Stoneflies of Connecticut. State Geological and Natural History Survey of Connecticut, Bulletin No. 107, 262pp.

Holsinger, J.R. (1976). *The Freshwater Amphipod Crustaceans (Gammaridae) of North America*. Biota of Freshwater Ecosystems Identification Manual No. 5, Water Pollution Control Research Series, U.S. Environmental Protection Agency.

Ide, F.P. (1937). *Descriptions of eastern North American species of Baetine mayflies with particular reference to the nymphal stages*. The Canadian Entomologist 11: 217-243.

Jackson, G.A. (1977). *Nearctic and Palaerarctic Paracladopelma Harnisch and Saetheria n. gen. (Diptera: Chironomidae)*. J. Fish. Res. Board Canada. 34: 1321-1359.

Jokinen, E.H. (1992). *The freshwater snails (Mollusca: Gastropoda) of New York State*. New York State Museum Bulletin 482, Albany, New York. 112pp.

Kathman, R.D. and R.O. Brinkhurst. (1999). *Guide to the Freshwater Oligochaetes of North America*. Aquatic Resources Center, Tennessee.264pp.

Klemm, D.J. (1991). *Taxonomy and Pollution Ecology of the Great Lakes Region.* Leeches (Annelida:Hirudinea). Michigan Academician 24:37-103.

Larson, D.J., Alarie, Y. and R.E. Roughley. (2000). *Predaceous Diving Beetles (Coleoptera: Dytiscidae) of the Nearctic Region, with emphasis on the fauna of Canada and Alaska*. NRC Research Press. 982 pp.

Lee, T. and Foighil, D. (2003). *Phylogenetic Structure of the Sphaeriinae, a Global Clade of Freshwater Bivalve Molluscs, inferred from Nuclear IITS-1) and Mitochondrial (16S) Ribosomal Gene Sequences*. Zoological Journal of the Linnean Society 137: 245-260.

Mackie, G.L., and D.G. Huggins. (1983). *Sphaeriacean Clams of Kansas*. Technical Publications of the State Biological Survey of Kansas, University of Kansas, No. 14. 92pp.

Maschwitz, D.E. and E.F. Cook. (2000). *Revision of the Nearctic Species of the Genus Polypedilum Kieffer (Diptera: Chironomidae) in the Subgenera P. (Polypedilum) Kieffer and P. (Uresipedilum) Oyewo and Saether*. Ohio Biological Survey, Ohio State University. 135pp.

McCafferty, W.P. (2000). *The Mayflies of North America: Species List.*

McCafferty, W.P. (1976). *The burrowing mayflies of the United States (Ephemeroptera: Ephemeroidea)*. Trans. Amer. Ent. Soc., 101:447-504.

McCafferty, W.P., and R.D. Waltz. (1990). *Revisionary synopsis of the Baetidae (Ephemeroptera) of North and middle America*. Transactions of the American Entomological Society. 116(4): 769-799.

Merritt, R.W., Cummins, K.W. & M.B. Berg (eds.). (2008). *An Introduction to the Aquatic Insects of North America*. 4th edition. Kendall/Hunt Publishing Co. Dubuque, Iowa. 1158 pp.

Morihara, D.K., and W.P. McCafferty. (1979). T*he Baetis larvae of North America (Ephemeroptera: Baetidae)*. Trans. Amer. Ent. Soc. 105:139-219.

Oliver, D.R. and M.E. Dillon. (1990). *A Catalog of Nearctic Chironomidae*. Research Branch Agriculture Canada. 89pp.

Oliver, D.R. and M.E. Roussel. (1983). *Redescription of Brillia Dieffer (Diptera: Chironomidae) with descriptions of nearctic species*. The Canadian Entomologist 115:257-279.

Pennak, R.W. (1989). *Freshwater invertebrates of the United States*. 3rd edition. Protozoa to Mullusca. John Wiley and Son, Inc. New York, Toronto.

Schefter, P.W., and G.B. Wiggins. (1986). *A Systematic Study of the Nearctic Larvae of the Hydropsyche morosa Group (Trichoptera: Hydropsychidae)*. Miscellaneous Publication of the Royal Ontario Museum, Toronto. 94pp.

Schuster, G.A. and D.A. Etnier. (1978). *A manual for the identification of the larvae of the caddisfly genera Hydropsyche Pictet and Symphitopsyche Ulmer in eastern and central North America (Trichoptera : Hydropsychidae)*. United States Environmental Protection Agency Report 600/ 4-78-060. 129pp.

Simpson, K.W., R.W. Bode and P. Albu. (1983). *Keys for the Genus Cricotopus*. New York State Museum Bulletin No. 450. 133pp.

Simpson, K.W. and R.W. Bode. (1980). *Common Larvae of Chironomidae (Diptera) From New York State Streams and Rivers*. New York State Museum, Bulletin No. 439. 105 pp.

Stewart, K.W., and B.P. Stark. (1988). *Nymphs of North American Stonefly Genera (Plecoptera)*. Thomas Say Foundation, Entomol. Soc. Amer. 12:1-460.

Thorp, J.H., and A.P. Covich (eds.). (1991). *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, Inc., San Diego, California 911 pp.

Walker, E.M. (1953). *The Odonata of Canada and Alaska*. Vol. 1: Part I: General. Part II: The Zygoptera - Damselflies. University of Toronto Press. Toronto, Ontario. 292 pp.

Walker E.M. (1958). *The Odonata of Canada and Alaska*. Vol. 2: Part III: The Anisoptera - Four Families. University of Toronto Press. Toronto, Ontario. 318 pp.

Walker, E.M. and P.S. Corbet. (1978) *The Odonata of Canada and Alaska*. Vol. 3: Part III: The Anisoptera - Three Families. University of Toronto Press. Toronto, Ontario. 308 pp.

Waltz, R.D. (1994). *Key to the larvae of Baetid genera known east of the Mississippi River (Ephemeroptera: Baetidae)*. Indiana Department of Natural Resources, unpublished.

Westfall, M.J. Jr. and M.L. May. (1996). Damselflies of North America. Scientific Publishers. Washington. 649pp.

Wetzel, M.J., Kathman, R.D., Fend, S.V. and K.A. Coates. (2000). *Taxonomy, Systematics, and Ecology of Freshwater Oligochaeta*. Workbook prepared for North American Benthological Society Technical Information Workshop, 48th Annual Meeting, Keystone Resort, CO. 120p. + app.

Waltz, R.D. (1994). *Key to the larvae of Baetid genera known east of the Mississippi River (Ephemeroptera: Baetidae*). Indiana Department of Natural Resources, unpublished.

Wiederhom, T. (Ed.). (1983). *Chironomidae of the Holarctic Region: Keys and Diagnoses*. Part 1. Larvae. Entomologica Scandinavica Supplement No. 19.

Wiggins, G.B. (1996). *Larvae of North American Caddisfly Genera (Trichoptera)*. Second Edition. University of Toronto Press, Toronto, Ont. 457p.

1.4 DATA EVALUATION

All data were entered into an electronic database with controlled access. Screening studies were employed to check for transcription errors or suspicious data points. An individual not responsible for entering the data confirmed that the data entered represents the original. Missing data was distinguished from absence of particular taxa by using non-zero value codes, with definitions built into each file.

The benthic communities surveyed in this assessment were characterized using the indices specified in the *Metal Mining Technical Guidance Document For Environmental Effects Monitoring* (EC, 2012) discussed below.

1.4.1 Total Invertebrate Density (TID)

TID was reported as the total number of all individuals of all taxonomic categories expressed per unit area (individuals per m^2). TID were calculated for each station.

1.4.2 Taxonomic Richness

Taxonomic Richness was reported as the total number of families at each station. Taxonomic richness is directly related to diversity and health of the invertebrate community.

1.4.3 Simpson's Diversity Index

Simpson's diversity index (D) takes into account both the abundance patterns and taxonomic richness of the community (EC, 2011). Simpson's Index is heavily weighted towards the most abundant species in the sample, while being less sensitive to species richness. This measure is calculated by determining the proportion of individuals that each taxonomic group at a station contributes to the total number of individuals in the station. Simpson's index (D) represents the probability that two individuals randomly selected from a sample will belong to different families. Simpson's diversity ranges from 0 to 1, with higher values representing greater diversity. Simpson's diversity index was calculated according to Krebs (1985):

$$D = 1 - \sum_{i=1}^{s} (p_i)^2$$

where:
- D = Simpson's index of diversity
- s = the total number of taxa (group) at the station
- p_i = the proportion of the i^{th} taxon (group) at the station

1.4.4 Simpson's Evenness Index

Evenness refers to how evenly taxa are distributed within the community. Evenness ranges between 0 and 1; a community with a high number of individuals of one group and few of other groups has low evenness and a low evenness value closer to 0. Evenness (E) was calculated according to Smith and Wilson (1996):

$$E = 1 / \sum_{i=1}^{s} (p_i)^2 / S$$

where:
- E = Evenness
- p_i = the proportion of the i^{th} taxon (group) at the station
- S = the total number of taxa (group) at the station

1.4.5 Bray-Curtis Similarity Index

The Bray-Curtis similarity index was used to compare survey results between the exposure areas and candidate reference areas. The Bray-Curtis similarity index was calculated according to Legendre and Legendre (1983):

$$B - C = \frac{\sum_{i=1}^{n} |y_{i1} - y_{i2}|}{\sum_{i=1}^{n} (y_{i1} + y_{i2})}$$

where:
- B - C = Bray-Curtis distance between sites 1 and 2
- Y_{i1} = the count for taxon i at site 1
- Y_{i2} = the count for taxon i at site 2
- n = the total number of taxa (families) present at the two sites

1.4.5.1 QA/QC

Triplicate field sub-samples from each replicate station were collected for benthic invertebrate analyses, to compensate for the spatial variability encountered with these organisms. Appropriate QA/QC measures related to processing and identification, as outlined in guidance document were followed (EC, 2012). These measures incorporated the proper steps related to re-sorting, sub-sampling and maintenance of a voucher collection, as needed.

1.5 REFERENCES

Environment Canada (EC). (2011). *Environmental Effects Monitoring Technical Guidance Document*. National Environmental Effects Monitoring Office.

Krebs CJ. (1985). *Ecology: the experimental analysis of distribution and abundance*. 3rd edition. New York (NY): Harper and Row.

Legendre L, Legendre P. (1983). *Numerical ecology*. Amsterdam (NL): Elsevier.

Smith B, Wilson JB. (1996). *A consumer's guide to evenness indices*. Oikos 76:70-82.

Knight Piésold
CONSULTING

TABLE D.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
CAMP LAKE TRIBUTARY STUDY AREAS: BENTHIC INVERTEBRATE TAXONOMIC DATA

Print Jun/26/14 12:09:21

Phyllum	Group (Class/Order)	Family	CLT-NF-1	CLT-NF-2	CLT-NF-3	CLT-NF-4	CLT-NF-5	CLT-FF-1	CLT-FF-2	CLT-FF-3	CLT-FF-4	CLT-FF-5	CLT-REF2-1	CLT-REF2-2	CLT-REF2-3	CLT-REF2-4	CLT-REF2-5	CLT-REF3-1	CLT-REF3-2	CLT-REF3-3	CLT-REF3-4	CLT-REF3-5	CLT-REF4-1	CLT-REF4-2	CLT-REF4-3	CLT-REF4-4	CLT-REF4-5
ROUNDWORMS																											
P. Nemata			23	14	3	7	10	17	38	10	2	4	2	3	1	0	1	16	18	9	13	24	22	7	6	75	4
FLATWORMS																											
P. Platyhelminthes																											
	Cl. Turbellaria		0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
ANNELIDS																											
P. Annelida	WORMS																										
	Cl. Oligochaeta	F. Enchytraeidae	7	3	4	2	2	3	78	0	1	3	0	2	3	3	1	2	7	4	1	18	8	1	3	33	2
		F. Lumbriculidae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
ARTHROPODS																											
P. Arthropoda	MITES																										
	Cl. Arachnida																										
	Subcl. Acari																										
	O. Trombidiformes																										
		F. Hygrobatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
		F. Lebertiidae	0	0	1	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		F. Sperchonidae	30	17	57	40	38	42	22	21	19	25	7	12	5	6	10	0	5	9	9	8	25	17	23	17	27
	HARPACTICOIDS																										
	O. Harpacticoida		0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	SEED SHRIMPS																										
	Cl. Ostracoda		1	1	3	0	0	1	0	1	0	0	1	0	0	1	1	0	0	0	2	3	6	4	10	3	12
	SPRINGTAILS																										
	Cl. Entognatha																										
	O. Collembola		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INSECTS																											
	Cl. Insecta																										
	MAYFLIES																										
	O. Ephemeroptera	F. Baetidae	11	4	2	0	1	3	6	1	4	3	0	0	2	1	3	15	9	4	0	4	21	15	25	26	22
	STONEFLIES																										
	O. Plecoptera	F. Capniidae	0	0	0	0	0	1	2	2	0	0	1	8	2	4	2	0	1	0	0	0	10	4	12	3	11
	CADDISFLIES																										
	O. Trichoptera	F. Limnephilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	8	0	1	0	0	0
TRUE FLIES																											
	O. Diptera																										
	BITING-MIDGE	F. Ceratopogonidae	0	0	0	0	0	0	2	0	1	0	1	0	4	2	1	0	0	0	0	0	8	75	77	67	31
	MIDGES	F. Chironomidae	304	152	303	220	314	423	500	311	263	239	18	25	21	32	31	343	290	178	87	320	342	248	254	317	185
		F. Empididae	2	0	0	0	4	0	3	3	2	1	13	20	30	24	23	0	1	0	0	1	25	8	30	38	12
		F. Simuliidae	7	4	1	2	0	0	3	0	6	2	0	1	1	0	0	50	2	4	2	28	8	3	6	18	9
		F. Tipulidae	13	23	30	12	25	22	20	29	9	31	24	43	47	89	46	9	16	19	26	30	21	21	26	16	17
TOTAL NUMBER OF ORGANISMS			398	218	406	283	396	513	674	379	307	310	68	114	116	163	119	435	349	228	143	449	496	404	472	614	332

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix D - BIC\Individual files\[AppD_Tables_20130304.xlsm]TABLE_D.1

NOTES:

1. BENTHIC INVERTEBRATE SAMPLES SORTED AND IDENTIFIED BY ZEAS INCORPORATED.
2. BENTHIC INVERTEBRATE SAMPLES WERE SORETED TO THEIR ENTIRETY.

Table D.2 Camp Lake Tributary Study Areas: Benthic Invertebrate Taxonomic QA/QC Data

Field Sub-sample	Number of Organisms Recovered in Initial Sort	Number of Organisms Recovered in Re-sort	Percent Recovery
CLT-FF-1C	168	184	91%
CLT-NF-3B	178	190	94%
CLT-REF3-5B	113	116	97%
CLT-REF2-3A	49	50	98%
CLT-REF4-3A	183	189	97%
CLT-REF3-3A	81	81	100%
CLT-NF-5C	134	136	99%
CLT-REF4-5A	149	151	99%
		Average % Recovery	97%

NOTES:

1. BENTHIC INVERTEBRATE SAMPLES SORTED AND IDENTIFIED BY ZEAS INCORPORATED, NOBLETON, ONTARIO.
2. ALL SAMPLES WERE SORTED TO THEIR ENTIRETY.

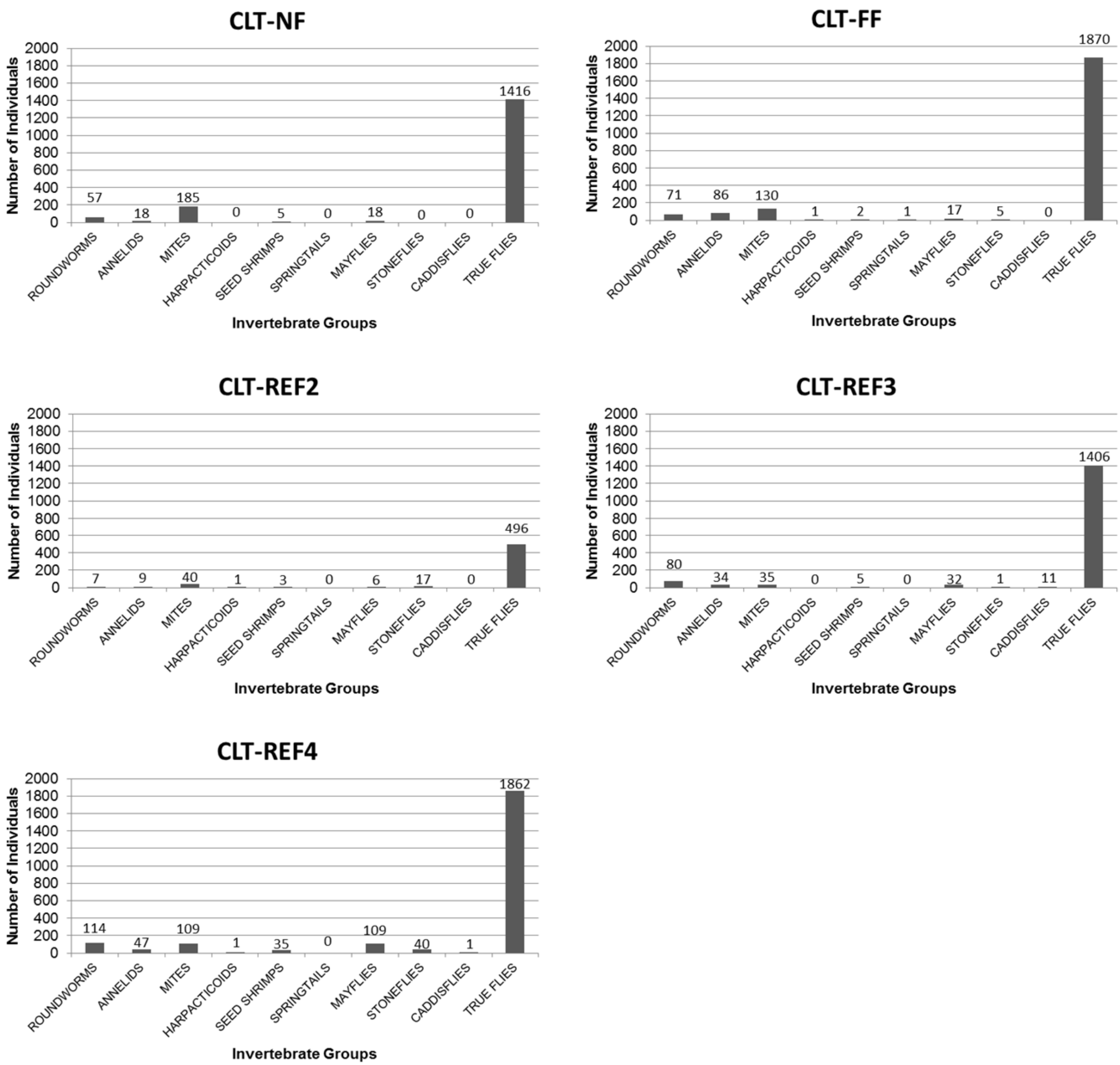


Figure D.1 Camp Lake Tributary Study Areas: Benthic Invertebrate Community Summary

Table D.3 Camp Lake Tributary Study Areas: Benthic Invertebrate Community Summary

Endpoint	Descriptor	CLT-NF	CLT-FF	CLT-REF2	CLT-REF3	CLT-REF4
Total Invertebrate Density(TID)	Data Distributed Normally	Y	Y	Y	Y	Y
	Mean	1269	1634	440	1178	1681
	Standard error (SE)	147	247	60	223	144
	Standard deviation (SD)	328	552	133	498	321
	Median	1450	1426	446	1283	1767
	Minimum	787	1182	248	496	1225
	Maximum	1543	2465	624	1636	2074
	Different from CLT-NF (p<0.10)	**-**	**N**[2]	**Y**[2]	**N**[2]	**N**[2]
Taxa Richness	Data Distributed Normally	N	Y	Y	Y	N
	Mean	6	8	8	8	9
	Standard error (SE)	0	1	1	1	0
	Standard deviation (SD)	1	1	1	2	0
	Median	7	8	8	7	9
	Minimum	5	6	6	5	9
	Maximum	7	9	9	11	10
	Different from CLT -NF (p<0.10)	**-**	**N**	**N**	**N**	**Y**
Simpson's Diversity Index (D)	Data Distributed Normally	Y	Y	N	Y	Y
	Mean	0.36	0.30	0.71	0.36	0.58
	Standard error (SE)	0.02	0.03	0.02	0.04	0.04
	Standard deviation (SD)	0.04	0.06	0.05	0.10	0.08
	Median	0.34	0.28	0.73	0.33	0.62
	Minimum	0.32	0.25	0.63	0.23	0.45
	Maximum	0.42	0.37	0.75	0.49	0.65
	Different from CLT NF (p<0.10)	**-**	**N**	**Y**	**N**	**Y**
Simpson's Evenness Index (E)	Data Distributed Normally	Y	Y	Y	Y	Y
	Mean	0.25	0.19	0.48	0.22	0.27
	Standard error (SE)	0.02	0.01	0.05	0.03	0.02
	Standard deviation (SD)	0.04	0.02	0.11	0.06	0.05
	Median	0.24	0.20	0.46	0.21	0.29
	Minimum	0.21	0.17	0.34	0.15	0.20
	Maximum	0.30	0.22	0.61	0.29	0.31
	Different from CLT -NF (p<0.10)	**-**	**N**[2]	**Y**[2]	**N**[2]	**N**[2]

NOTES:
1. TUKEY TEST RESULTS FOR POST-HOC COMPARISON PRESENTED UNLESS OTHERWISE NOTED.
2. VARIANCE NOT HOMOGENEOUS, GAMES-HOWELL TEST RESULTS PRESENTED.
3. SEE TABLE D.8 FOR CAMP LAKE TRIBUTARY STUDY AREA BRAY-CURTIS POST-HOC COMPARISON.

Table D.4 Camp Lake Tributary Study Areas: Total Invertebrate Density

Test of Normality

Area	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
CLT-NF	0.849	5	0.19	Normal
CLT-FF	0.868	5	0.26	Normal
CLT-REF2	0.919	5	0.52	Normal
CLT-REF3	0.899	5	0.40	Normal
CLT-REF4	0.976	5	0.91	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
3.354	4	20	0.03	Yes – Variance not homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	4968951.4	4	1242237.9	7.94	0.001	Y
Within Groups	3129212.0	20	156460.6			
Total	8098163.4	24				

Multiple Comparison Post-hoc Test

Games-Howell		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF	CLT-FF	-364.8	287.46	0.72	N	-1415.4	685.8
	CLT-REF2	829.0	158.48	0.02	Y	206.9	1451.1
	CLT-REF3	91.6	266.87	1.00	N	-866.3	1049.5
	CLT-REF4	-411.4	205.39	0.34	N	-1121.1	298.3

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.5 Camp Lake Tributary Study Areas: Taxa Richness

Test of Normality

Area	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
CLT-NF	0.771	5	0.05	Normal
CLT-FF	0.961	5	0.81	Normal
CLT-REF2	0.961	5	0.81	Normal
CLT-REF3	0.932	5	0.61	Normal
CLT-REF4	0.552	5	0.00	Not Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
1.669	4	20	0.20	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	19.8	4	5.0	2.95	0.05	N
Within Groups	33.6	20	1.7			
Total	53.4	24				

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF	CLT-FF	-1.2	.82	0.60	N	-3.7	1.3
	CLT-REF2	-1.2	.82	0.60	N	-3.7	1.3
	CLT-REF3	-1.2	.82	0.60	N	-3.7	1.3
	CLT-REF4	-2.8	.82	0.02	Y	-5.3	-0.4

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.6 Camp Lake Tributary Study Areas: Simpson's Diversity Index

Test of Normality

Area	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
CLT-NF	0.865	5	0.25	Normal
CLT-FF	0.796	5	0.08	Normal
CLT-REF2	0.715	5	0.01	Not Normal
CLT-REF3	0.978	5	0.92	Normal
CLT-REF4	0.854	5	0.21	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
1.543	4	20	0.23	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	0.6	4	0.154	32.773	0.000	Y
Within Groups	0.1	20	0.005			
Total	0.7	24				

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF	CLT-FF	0.1	0.04	0.67	N	-0.1	0.2
	CLT-REF2	-0.4	0.04	0.000	Y	-0.5	-0.2
	CLT-REF3	0.007	0.04	1.00	N	-0.1	0.1
	CLT-REF4	-0.2	0.04	0.001	Y	-0.4	-0.1

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0..10.

Table D.7 Camp Lake Tributary Study Areas: Simpson's Evenness Index

Test of Normality

Area	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
CLT-NF	0.861	5	0.23	Normal
CLT-FF	0.944	5	0.69	Normal
CLT-REF2	0.953	5	0.76	Normal
CLT-REF3	0.865	5	0.25	Normal
CLT-REF4	0.871	5	0.27	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
4.971	4	20	0.01	Yes – Variance not homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	0.26	4	0.064	14.82	0.000	Y
Within Groups	0.09	20	0.004			
Total	0.34	24				

Multiple Comparison Post-hoc Test

Games-Howell		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF	CLT-FF	0.06	0.02	0.17	N	-0.02	0.14
	CLT-REF2	-0.23	0.05	0.04	Y	-0.44	-0.01
	CLT-REF3	0.03	0.03	0.90	N	-0.09	0.15
	CLT-REF4	-0.02	0.03	0.97	N	-0.12	0.08

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.8 Camp Lake Tributary Study Areas: Bray-Curtis Similarity Index

Descriptive Statistics

Area	Mean	Standard Error	Standard Deviation	Median	Minimum	Maximum
CLT-REF2	0.73	0.03	0.06	0.74	0.63	0.79
CLT-NF – CLT-REF2	0.14	0.04	0.09	0.09	0.05	0.25
CLT-REF3	0.16	0.04	0.08	0.11	0.08	0.29
CLT-NF – CLT-REF3	0.20	0.08	0.17	0.17	0.03	0.48
CLT-REF4	0.28	0.02	0.05	0.27	0.22	0.37
CLT-NF – CLT-REF4	0.12	0.03	0.06	0.14	0.03	0.17

Test of Normality

Area	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
CLT-NF – CLT-REF2	0.842	5	0.17	Normal
CLT-NF – CLT-REF3	0.867	5	0.25	Normal
CLT-NF – CLT-REF4	0.849	5	0.19	Normal
CLT-REF2	0.871	5	0.27	Normal
CLT-REF3	0.897	5	0.40	Normal
CLT-REF4	0.863	5	0.24	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
1.337	5	24	.283	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	1.4	5	0.272	30.146	0.000	Y
Within Groups	0.2	24	0.009			
Total	1.6	29				

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF – CLT-REF2	CLT-REF2	0.6	0.06	0.000	Y	0.41	0.78
CLT-NF – CLT-REF3	CLT-REF3	-0.1	0.06	0.97	N	-0.23	0.14
CLT-NF – CLT-REF4	CLT-REF4	0.2	0.06	0.11	N	-0.02	0.35

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Knight Piésold CONSULTING

TABLE D.9

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DRAFT EEM CYCLE ONE STUDY DESIGN
MARY RIVER STUDY AREAS: BENTHIC INVERTEBRATE TAXONOMIC DATA

Print Jun/26/14 12:09:21

Phyllum	Group (Class/Order)	Family	MRY-NF-1	MRY-NF-2	MRY-NF-3	MRY-NF-4	MRY-NF-5	MRY-FF-1	MRY-FF-2	MRY-FF-3	MRY-FF-4	MRY-FF-5	MRY-REF1-1	MRY-REF1-2	MRY REF1-3	MRY-REF1-4	MRY-REF1-5	MRY-REF2-1	MRY-REF2-2	MRY-REF2-3	MRY-REF2-4	MRY-REF2-5	MRY-REF3-1	MRY-REF3-2	MRY-REF3-3	MRY-REF3-4A	MRY-REF3-5	MRY-REF4-1	MRY-REF4-2	MRY-REF4-3	MRY-REF4-4	MRY-REF4-5
ROUNDWORMS																																
P. Nemata			0	4	3	4	1	3	5	0	4	5	4	9	15	10	17	2	0	1	0	0	1	0	0	3	0	2	0	9	5	2
FLATWORMS																																
P. Platyhelminthes																																
	Cl. Turbellaria		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDS																																
P. Annelida	WORMS																															
	Cl. Oligochaeta	F. Enchytraeidae	0	2	13	3	1	3	0	0	2	6	16	7	25	5	0	8	0	1	1	2	0	0	0	0	0	1	0	0	0	0
		F. Lumbriculidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARTHROPODS																																
P. Arthropoda	MITES																															
	Cl. Arachnida																															
	Subcl. Acari																															
	O. Trombidiformes																															
		F. Hygrobatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0
		F. Lebertiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		F. Sperchonidae	3	2	20	8	2	10	8	3	14	23	10	13	12	2	8	22	24	6	6	2	2	0	0	0	0	14	1	3	4	5
	HARPACTICOIDS																															
	O. Harpacticoida		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SEED SHRIMPS																															
	Cl. Ostracoda		0	0	0	1	0	0	0	0	0	0	1	0	0	2	0	1	3	1	1	1	0	0	0	0	0	0	0	0	0	0
	SPRINGTAILS																															
	Cl. Entognatha																															
	O. Collembola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INSECTS																																
	Cl. Insecta																															
	MAYFLIES																															
	O. Ephemeroptera	F. Baetidae	4	4	0	6	10	7	1	4	11	10	2	0	1	0	0	15	4	4	7	1	0	0	1	0	0	2	0	1	0	0
	STONEFLIES																															
	O. Plecoptera	F. Capniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	1	1	0	2	1	0	1	0	1	0
	CADDISFLIES																															
	O. Trichoptera	F. Limnephilidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRUE FLIES																																
	O. Diptera																															
	BITING-MIDGE	F. Ceratopogonidae	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	0	0	0	0	0	0	0
	MIDGES	F. Chironomidae	103	127	691	224	249	188	173	125	270	228	129	359	456	294	537	252	177	172	60	197	36	25	28	59	13	326	244	297	321	231
		F. Empididae	0	2	2	3	2	0	1	0	0	0	0	0	0	1	0	29	14	8	6	7	2	0	0	1	0	0	0	0	0	1
		F. Simuliidae	2	3	1	11	2	11	1	6	10	2	0	0	0	0	0	10	3	20	1	12	1	1	0	2	1	56	29	24	99	11
		F. Tipulidae	0	1	8	6	1	1	0	1	2	1	2	3	3	10	4	4	4	0	5	6	2	0	0	0	0	5	4	6	5	3
TOTAL NUMBER OF ORGANISMS			113	146	738	266	268	223	189	139	313	275	164	391	513	325	567	344	232	219	87	229	45	28	29	67	18	406	279	340	435	253

\\NB4\Project$\1\02\00181\34\A\Report\Report 5 Rev B - EEM Study Design\Appendix D - BIC\Individual files\[AppD_Tables_20130304.xlsm]TABLE_D.9

NOTES:

1. BENTHIC INVERTEBRATE SAMPLES SORTED AND IDENTIFIED BY ZEAS INCORPORATED.
2. BENTHIC INVERTEBRATE SAMPLES WERE SORTED TO THEIR ENTIRETY.

Table D.10 Mary River Study Areas: Benthic Invertebrate Taxonomic QA/QC Data

Field Sub-sample	Number of Organisms Recovered in Initial Sort	Number of Organisms Recovered in Re-sort	Percent Recovery
MRY-NF-5B	57	57	100%
MRY-REF2-5C	27	29	93%
MRY-REF3-5B	4	4	100%
MRY-REF1-2C	236	238	99%
MRY-REF1-3B	231	240	96%
MRY-REF1-4C	95	99	96%
MRY-REF2-3A	108	114	95%
MRY-NF-1B	59	59	100%
MRY-REF1-5C	152	153	99%
		Average % Recovery	98%

NOTES:
1. BENTHIC INVERTEBRATE SAMPLES SORTED AND IDENTIFIED BY ZEAS INCORPORATED, NOBLETON, ONTARIO.
2. ALL SAMPLES WERE SORTED TO THEIR ENTIRETY.

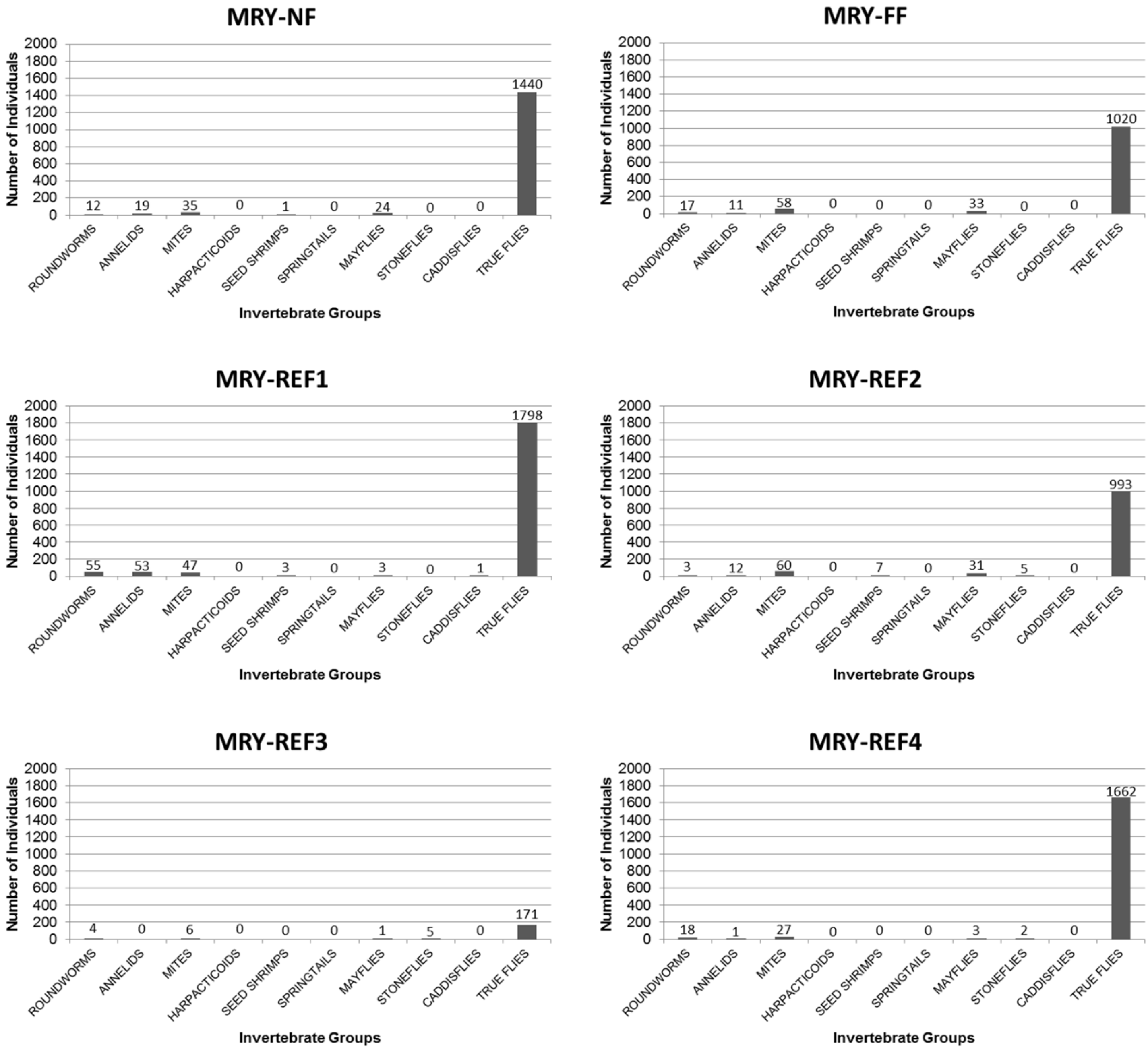


Figure D.2 Mary River Study Areas: Benthic Invertebrate Community Summary

Table D.11 Mary River Study Areas: Benthic Invertebrate Community Summary

ENDPOINT	DESCRIPTOR	MRY-NF	MRY-FF	MRY-REF1	MRY-REF2	MRY-REF3	MRY-REF4
TOTAL INVERTEBRATE DENSITY(TID)	Data Distributed Normally	Y	Y	Y	Y	Y	Y
	Mean	1177	870	1474	853	142	1314
	Standard error (SE)	435	117	269	157	31	134
	Standard deviation (SD)	972	261	601	351	69	300
	Median	1012	853	1481	884	112	1283
	Minimum	438	539	616	333	70	973
	Maximum	2849	1198	2132	1322	248	1667
	Different from MRY-NF (p<0.05)	**-**	**N**	**N**	**N**	**Y**	**N**
TAXA RICHNESS	Data Distributed Normally	Y	N	Y	N	Y	N
	Mean	7	6	5	8	4	5
	Standard error (SE)	1	0	0	0	1	0
	Standard deviation (SD)	1	1	1	1	1	0
	Median	7	6	5	8	4	5
	Minimum	5	5	4	7	2	5
	Maximum	8	6	6	8	6	6
	Different from MRY-NF (p<0.05)	**-**	**N**	**N**	**N**	**N**[2]	**N**
SIMPSON'S DIVERSITY INDEX (D)	Data Distributed Normally	Y	Y	Y	Y	Y	Y
	Mean	0.174	0.215	0.153	0.386	0.236	0.256
	Standard error (SE)	0.026	0.030	0.047	0.041	0.067	0.045
	Standard deviation (SD)	0.058	0.066	0.106	0.092	0.149	0.100
	Median	0.167	0.232	0.116	0.387	0.199	0.224
	Minimum	0.115	0.114	0.046	0.249	0.067	0.151
	Maximum	0.259	0.278	0.327	0.493	0.444	0.389
	Different from MRY-NF (p<0.05)	**-**	**N**	**N**	**Y**	**N**	**N**
SIMPSON'S EVENNESS INDEX (E)	Data Distributed Normally	Y	Y	Y	Y	Y	N
	Mean	0.188	0.229	0.246	0.220	0.367	0.263
	Standard error (SE)	0.015	0.005	0.022	0.019	0.054	0.017
	Standard deviation (SD)	0.033	0.011	0.050	0.043	0.121	0.037
	Median	0.188	0.226	0.262	0.223	0.312	0.248
	Minimum	0.156	0.217	0.189	0.166	0.246	0.235
	Maximum	0.240	0.246	0.297	0.282	0.536	0.328
	Different from MRY-NF (p<0.05)	**-**	**N**	**N**	**N**	**N**[2]	**Y**

NOTES:

1. TUKEY HSD TEST USED FOR COMPARISON BETWEEN MRY-NF AND REF AREAS UNLESS OTHERWISE NOTED.
2. GAMES-HOWELL COMPARISON USED.
3. SEE TABLE D.16 FOR MARY RIVER STUDY AREA BRAY-CURTIS COMPARISON RESULTS.

Table D.12 Mary River Study Areas: Total Invertebrate Density

Test of Normality

AREA	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
MRY-NF	0.782	5	0.06	Normal
MRY-FF	0.984	5	0.95	Normal
MRY-REF1	0.965	5	0.84	Normal
MRY-REF2	0.908	5	0.45	Normal
MRY-REF3	0.923	5	0.55	Normal
MRY-REF4	0.930	5	0.60	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
2.395	5	24	0.07	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	5623175.6	5	1124635.1	4.24	0.01	Y
Within Groups	6372451.2	24	265518.8			
Total	11995626.8	29				

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF	MRY-FF	306.8	325.90	0.93	N	-700.9	1314.5
	MRY-REF1	-297.6	325.90	0.94	N	-1305.3	710.1
	MRY-REF2	323.2	325.90	0.92	N	-684.5	1330.9
	MRY-REF3	1034.8	325.90	0.04	Y	27.2	2042.5
	MRY-REF4	-137.2	325.90	1.00	N	-1144.9	870.5

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.13 Mary River Study Areas: Taxa Richness

Test of Normality

AREA	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
MRY-NF	0.961	5	0.81	Normal
MRY-FF	0.684	5	0.01	Not Normal
MRY-REF1	0.821	5	0.12	Normal
MRY-REF2	0.684	5	0.01	Not Normal
MRY-REF3	0.883	5	0.33	Normal
MRY-REF4	0.552	5	0.00	Not Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
0.858	5	24	0.52	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	40.3	5	8.1	9.5	0.000	Y
Within Groups	20.4	24	0.9			
Total	60.7	29				

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF	MRY-FF	1.0	0.58	0.54	N	-0.8	2.8
	MRY-REF1	1.6	0.58	0.10	N	-0.2	3.4
	MRY-REF2	-1.0	0.58	0.54	N	-2.8	0.8
	MRY-REF3	2.6	0.58	0.002	Y	0.8	4.4
	MRY-REF4	1.4	0.58	0.20	N	-0.4	3.2

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.14 Mary River Study Areas: Simpson's Diversity Index

Test of Normality

AREA	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
MRY-NF	0.945	5	0.70	Normal
MRY-FF	0.922	5	0.54	Normal
MRY-REF1	0.872	5	0.28	Normal
MRY-REF2	0.975	5	0.90	Normal
MRY-REF3	0.969	5	0.87	Normal
MRY-REF4	0.933	5	0.62	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
1.292	5	24	0.30	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	0.2	5	0.03	3.452	0.02	Y
Within Groups	0.2	24	0.01			
Total	0.4	29				

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF	MRY-FF	-0.04	0.06	0.99	N	-0.24	0.15
	MRY-REF1	0.02	0.06	1.00	N	-0.17	0.22
	MRY-REF2	-0.21	0.06	0.03	Y	-0.41	-0.02
	MRY-REF3	-0.06	0.06	0.92	N	-0.26	0.13
	MRY-REF4	-0.08	0.06	0.78	N	-0.28	0.11

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.15 Mary River Study Areas: Simpson's Evenness Index

Test of Normality

AREA	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
MRY-NF	0.912	5	0.48	Normal
MRY-FF	0.922	5	0.55	Normal
MRY-REF1	0.871	5	0.27	Normal
MRY-REF2	0.984	5	0.96	Normal
MRY-REF3	0.908	5	0.46	Normal
MRY-REF4	0.754	5	0.03	Not Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
7.987	5	24	0.000	Yes – Variance not homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	0.10	5	0.019	5.318	0.002	Y
Within Groups	0.09	24	0.004			
Total	0.18	29				

Multiple Comparison Post-hoc Test

Games-Howell		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF	MRY-FF	-0.04	0.02	0.24	N	-0.11	0.03
	MRY-REF1	-0.06	0.03	0.35	N	-0.16	0.04
	MRY-REF2	-0.03	0.02	0.78	N	-0.12	0.06
	MRY-REF3	-0.18	0.06	0.15	N	-0.43	0.07
	MRY-REF4	-0.08	0.02	0.07	Y	-0.16	0.01

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Table D.16 Mary River Study Areas: Bray-Curtis Similarity Index (Page 1 of 2)

Descriptive Statistics

Area	Mean	Standard Error	Standard Deviation	Median	Minimum	Maximum
MRY-REF1	0.37	0.07	0.15	0.32	0.22	0.57
MRY-NF - MRY-REF1	0.18	0.07	0.17	0.14	0.00	0.45
MRY-REF2	0.29	0.08	0.18	0.21	0.13	0.60
MRY-NF - MRY-REF2	0.18	0.07	0.17	0.08	0.06	0.45
MRY-REF3	0.76	0.06	0.13	0.80	0.59	0.92
MRY-NF - MRY-REF3	0.21	0.07	0.15	0.19	0.05	0.38
MRY-REF4	0.34	0.07	0.16	0.43	0.16	0.52
MRY-NF - MRY-REF4	0.09	0.02	0.05	0.09	0.01	0.15

Test of Normality

AREA	Shapiro-Wilk			
	Statistic	df	p-value	Distribution at p>0.05
MRY-NF - MRY-REF1	0.908	5	0.45	Normal
MRY-NF - MRY-REF2	0.840	5	0.16	Normal
MRY-NF - MRY-REF3	0.949	5	0.73	Normal
MRY-NF - MRY-REF4	0.842	5	0.17	Normal
MRY-REF1	0.914	5	0.49	Normal
MRY-REF2	0.800	5	0.08	Normal
MRY-REF3	0.863	5	0.24	Normal
MRY-REF4	0.924	5	0.56	Normal

Test of Homogeneity of Variance

Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.05
1.045	7	32	0.42	No – Variance homogeneous

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.05
Between Groups	1.5	7	0.21	9.138	0.000	Y
Within Groups	0.7	32	0.02			
Total	2.2	39				

Table D.16 Mary River Study Areas: Bray-Curtis Similarity Index (Page 2 of 2)

Multiple Comparison Post-hoc Test

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF - MRY-REF1	MRY-REF1	0.2	0.10	0.51	N	-0.1	0.5
MRY-NF - MRY-REF2	MRY-REF2	0.1	0.10	0.94	N	-0.2	0.4
MRY-NF - MRY-REF3	MRY-REF3	0.5	0.10	0.000	Y	0.2	0.9
MRY-NF - MRY-REF4	MRY-REF4	0.3	0.10	0.17	N	-0.1	0.6

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

APPENDIX E

FISHERIES DATA

(Pages E-1 to E-11)

Table E.1 2013 Fall Electrofishing Summary & ARCH Fork Length and Round Weight Descriptive Statistics Summary

STUDY AREA	CLT-NF	CLT-REF2	CLT-REF3	CLT-REF4	MRY-NF	MRY-REF1	MRY-REF2	MRY-REF3
Survey Date(s)	21-Aug-13	22-Aug-13	22-Aug-13	22-Aug-13	25+28-Aug-13	27-Aug-13	25-Aug-13	26-Aug-13
Number of ARCH	120	30	116	117	108	26	22	114
Number of NSSB	0	0	0	1	0	26	0	0
Total Catch	120	30	116	118	108	52	22	114
Realtime Effort	45	60	30	45	120	65	70	120
Electrofishing Effort	14	25	13	22	69	42	31	57
Total CPUE	8.57	1.22	9.11	5.30	1.56	1.22	0.71	2.01
ARCH CPUE	8.57	1.22	9.11	5.25	1.56	0.61	0.71	2.01
Arctic Char Fork Length (mm) Measurement Summary								
Number of samples	100	30	100	100	100	26	22	100
Mean	148	127	90	117	126	121	100	104
Median	142	121	78	107	118	115	100	99
Standard Deviation	28	35	35	37	26	37	21	34
Standard Error	3	6	3	4	3	7	5	3
Minimum	98	49	38	67	76	76	68	46
Maximum	243	210	187	275	204	222	138	204
Arctic Char Weight (g) Measurement Summary								
Number of samples	100	30	100	100	100	26	22	100
Mean	32	23	10	21	23	25	11	15
Median	25	20	5	13	17	17	10	9
Standard Deviation	21	17	12	27	14	28	7	15
Standard Error	2	3	1	3	1	6	1	1
Minimum	7	1	1	3	5	5	3	1
Maximum	151	79	60	191	78	141	27	90
Arctic Char Age (years) Verification Summary								
Number of samples	10	10	10	10	10	10	10	10
Mean	3	4	4	4	4	4	3	3
Median	3	3.5	3.5	4	3.5	3	3	3
Standard Deviation	2	2	2	1	2	1	1	1
Standard Error	1	1	0	0	1	0	0	0
Minimum	1	2	2	3	2	2	2	1
Maximum	7	7	6	7	7	5	3	5
Condition Factor (K)								
Number of samples	100	30	100	100	100	26	22	100
Mean	0.89	0.99	0.95	1.01	1.03	1.07	1.02	0.99
Median	0.88	1.00	0.96	1.01	1.02	1.07	1.02	0.99
Standard Deviation	0.08	0.13	0.11	0.08	0.10	0.08	0.08	0.09
Standard Error	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.01
Minimum	0.72	0.72	0.63	0.80	0.82	0.86	0.89	0.81
Maximum	1.17	1.18	1.37	1.33	1.43	1.29	1.18	1.23

NOTES:

1. ARCH – ARCTIC CHAR.
2. NSSB – NINESPINE STICKLEBACK.
3. REALTIME – TOTAL NUMBER OF MINUTES ELECTROFISHING.
4. EFFORT – NUMBER OF MINUTES THE ELECTROFISHING UNIT WAS ENGAGED.
5. CPUE – CATCH-PER-UNIT-EFFORT EXPRESSED AS THE NUMBER ON INDIVIDUALS CAUGHT PER MINUTE.

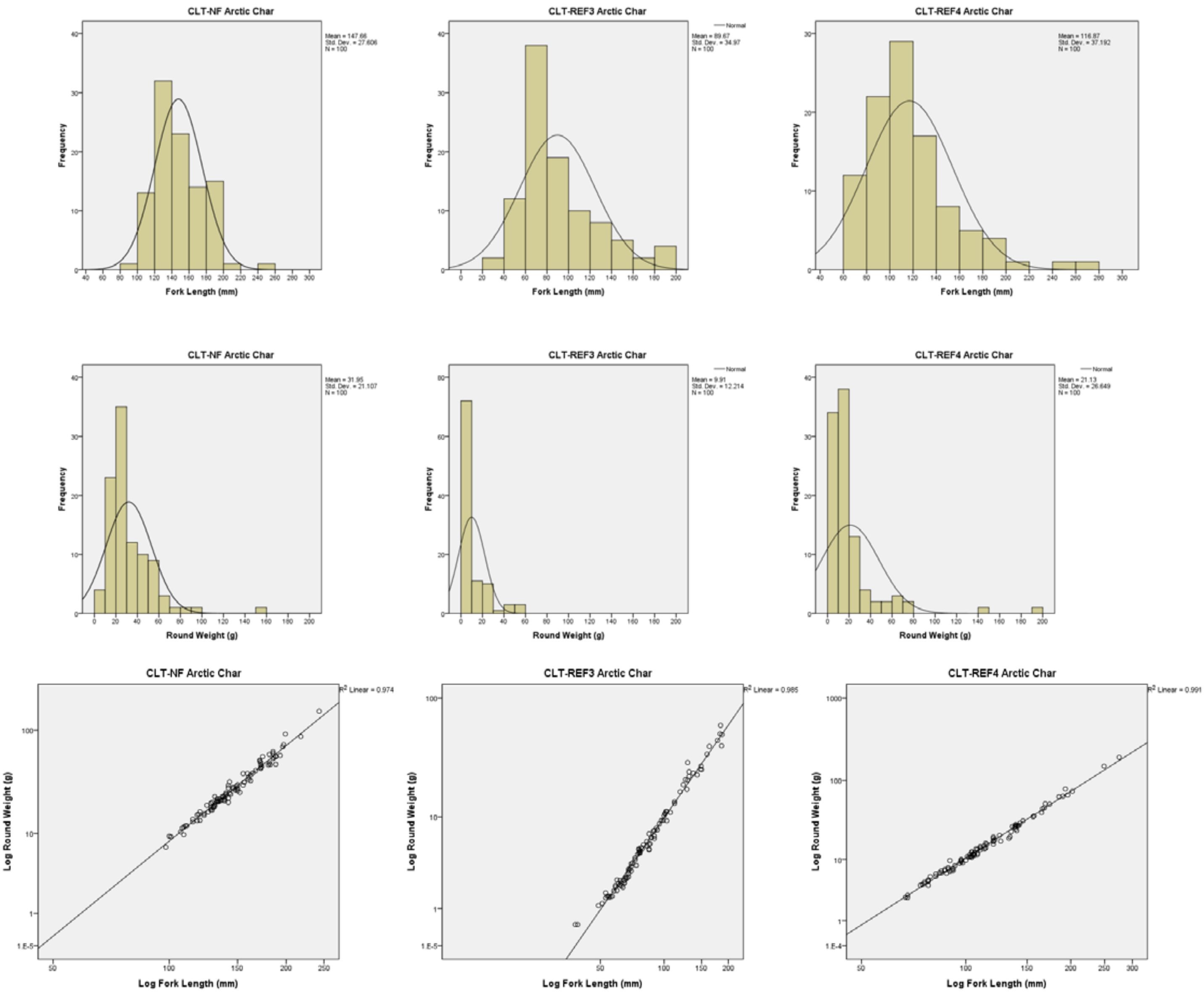


Figure E.1 Camp Lake Tributary Study Areas: Arctic Char Round Weight to Fork Length Data and Comparison

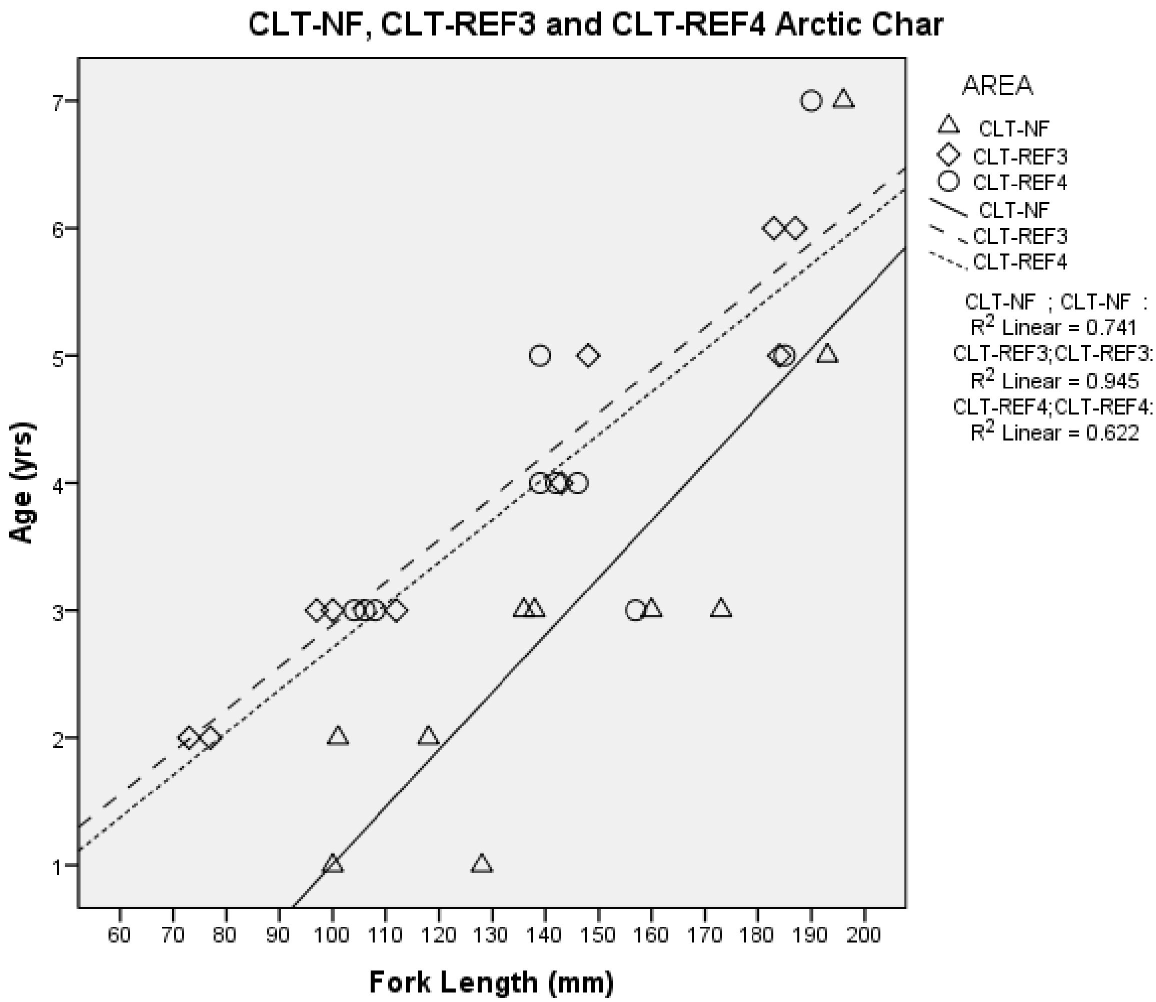


Figure E.2 Camp Lake Tributary NF, REF3 and REF4 Study Areas: Relationship between Arctic Char Age and Fork Length

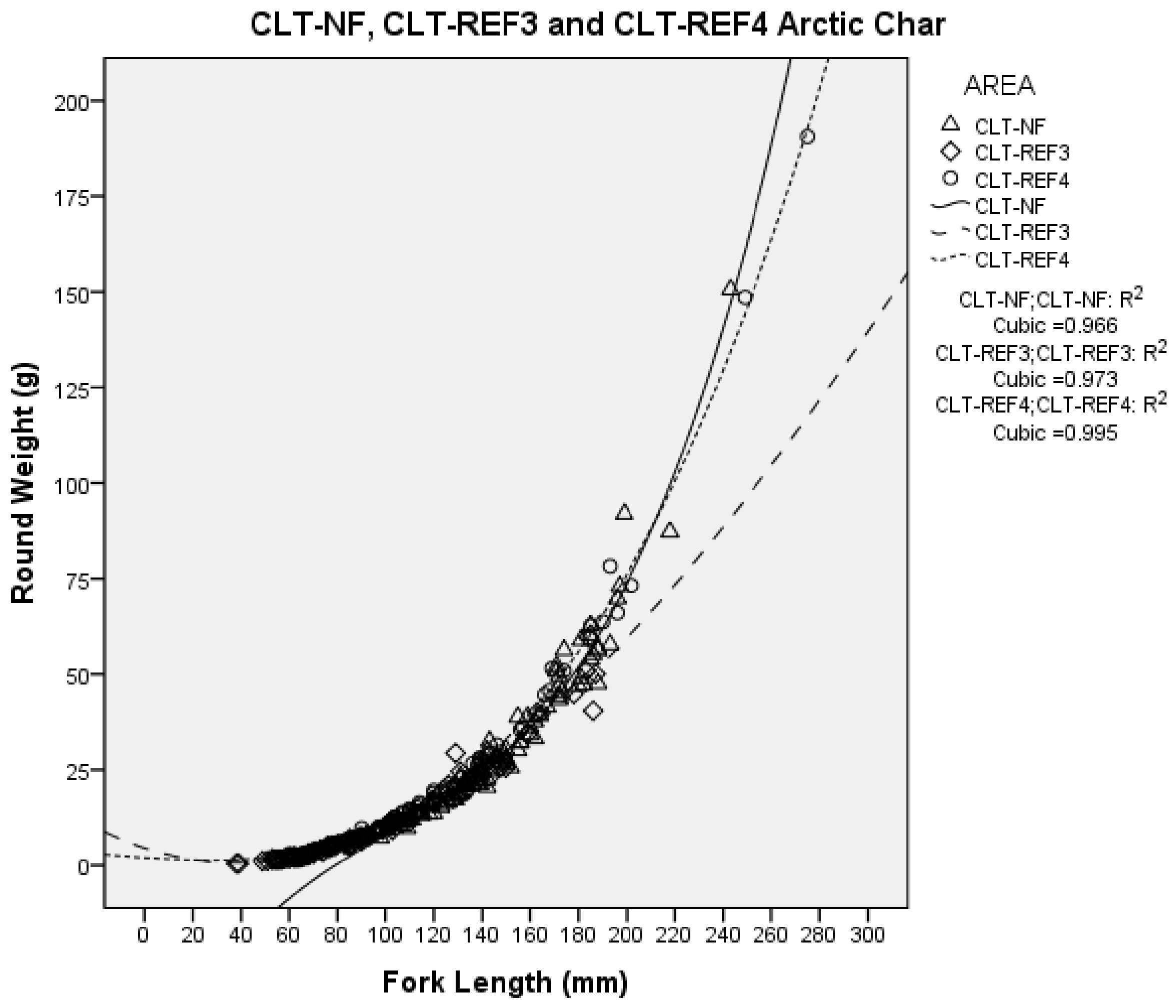


Figure E.3 **Camp Lake Tributary NF, REF3 and EF4 Study Areas: Relationship between Arctic Char Round Weight and Fork Length**

Table E.2 Camp Lake Tributary Study Areas: ARCH Fork Length and Round Weight Data Comparison Summary (Page 1 of 2)

Test of Normality

Measure	Area	Shapiro-Wilk			
		Statistic	df	p-value	Distribution at p>0.05
Fork Length (mm)	CLT-NF	0.964	100	0.008	Not Normal
	CLT-REF3	0.878	100	0.000	Not Normal
	CLT-REF4	0.874	100	0.000	Not Normal
Round Weight (g)	CLT-NF	0.798	100	0.000	Not Normal
	CLT-REF3	0.699	100	0.000	Not Normal
	CLT-REF4	0.565	100	0.000	Not Normal

Test of Homogeneity of Variance

Measure	Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.10
Fork Length (mm)	1.943	2	297	0.155	No – Variance homogeneous
Round Weight (g)	5.801	2	297	0.003	Yes – Variance not homogeneous

ANOVA Results – Fork Length

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.10
Between Groups	168356.8	2	84178.4	74.98	0.000	Y
Within Groups	333455.9	297	1122.8			
Total	501812.7	299				

ANOVA Results – Round Weight

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.10
Between Groups	24282.8	2	12141.4	27.9	0.000	Y
Within Groups	129179.3	297	435.0			
Total	153462.1	299				

Table E.2 Camp Lake Tributary Study Areas: ARCH Fork Length and Round Weight Data Comparison Summary (Page 2 of 2)

Multiple Comparison Post-hoc Test – Fork Length

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF	CLT-REF3	58.0	4.74	0.000	Y	46.8	69.2
	CLT-REF4	30.8	4.74	0.000	Y	19.6	42.0

Multiple Comparison Post-hoc Test – Round Weight

Games-Howell		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
CLT-NF	CLT-REF3	22.0	2.44	0.000	Y	16.3	27.8
	CLT-REF4	10.8	3.40	0.005	Y	2.8	18.9

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

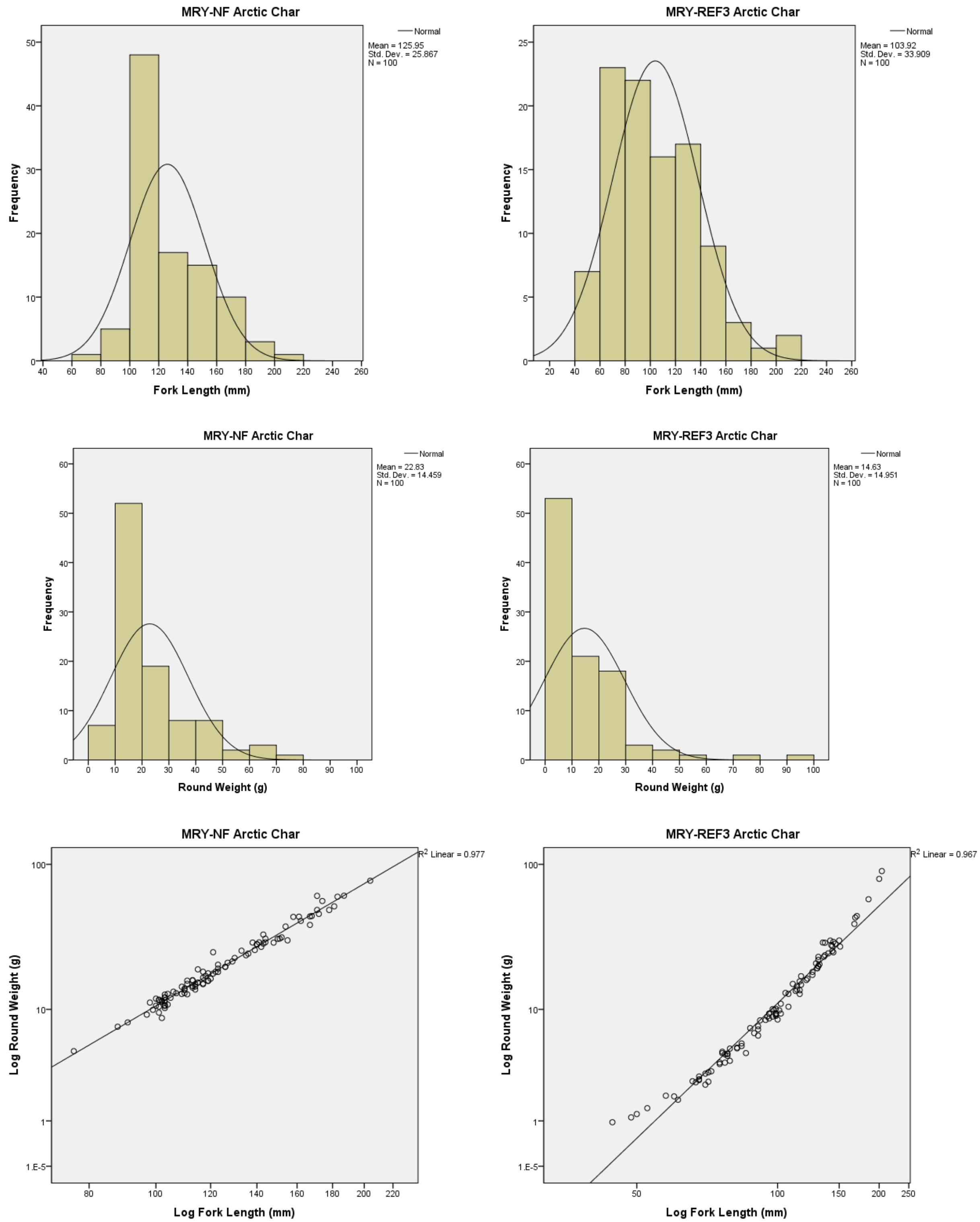


Figure E.4 Mary River NF and REF3 Study Areas: Arctic Char Round Weight to Fork Length Data and Comparison

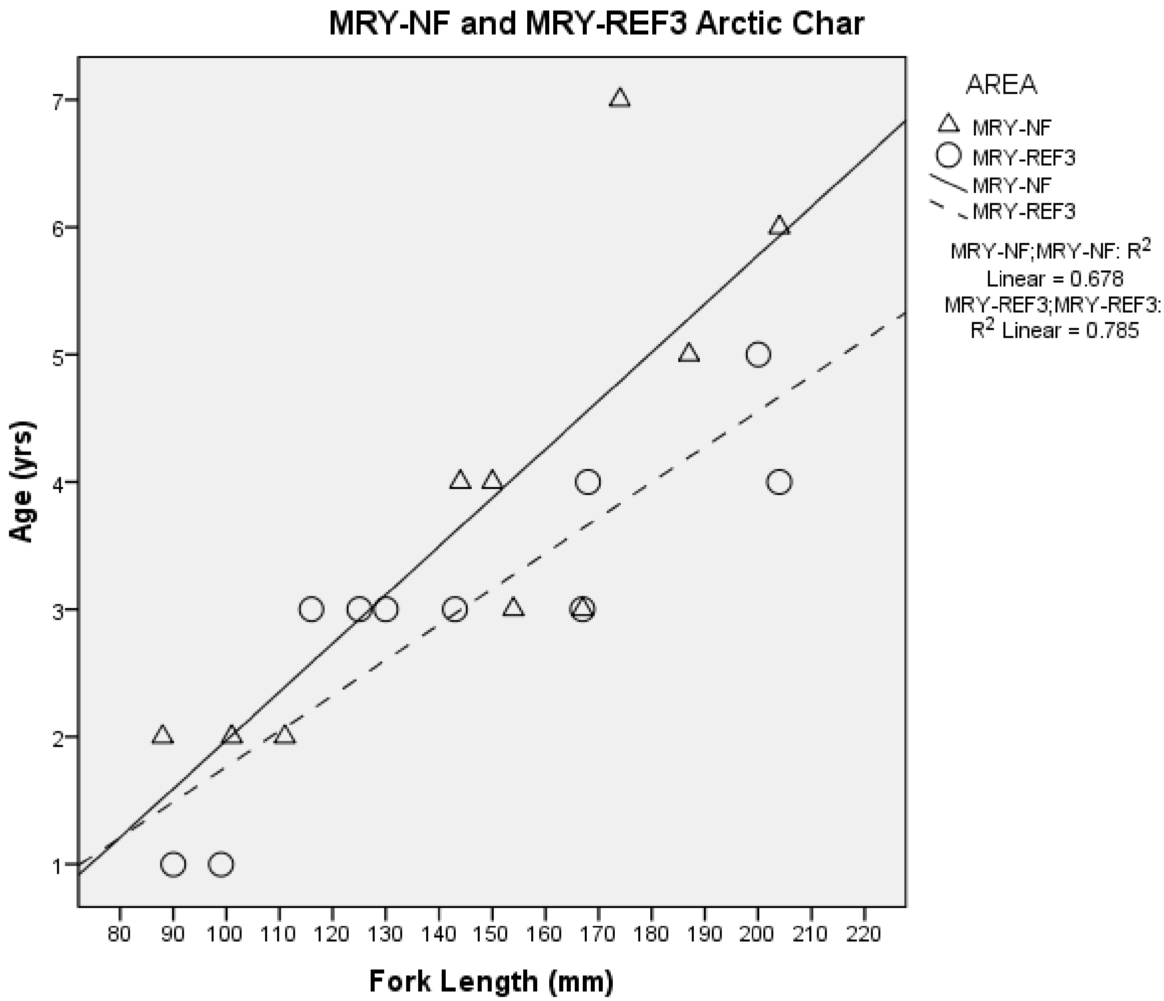


Figure E.5 **Mary River NF and REF3 Study Areas: Relationship between Arctic Char Age and Fork Length**

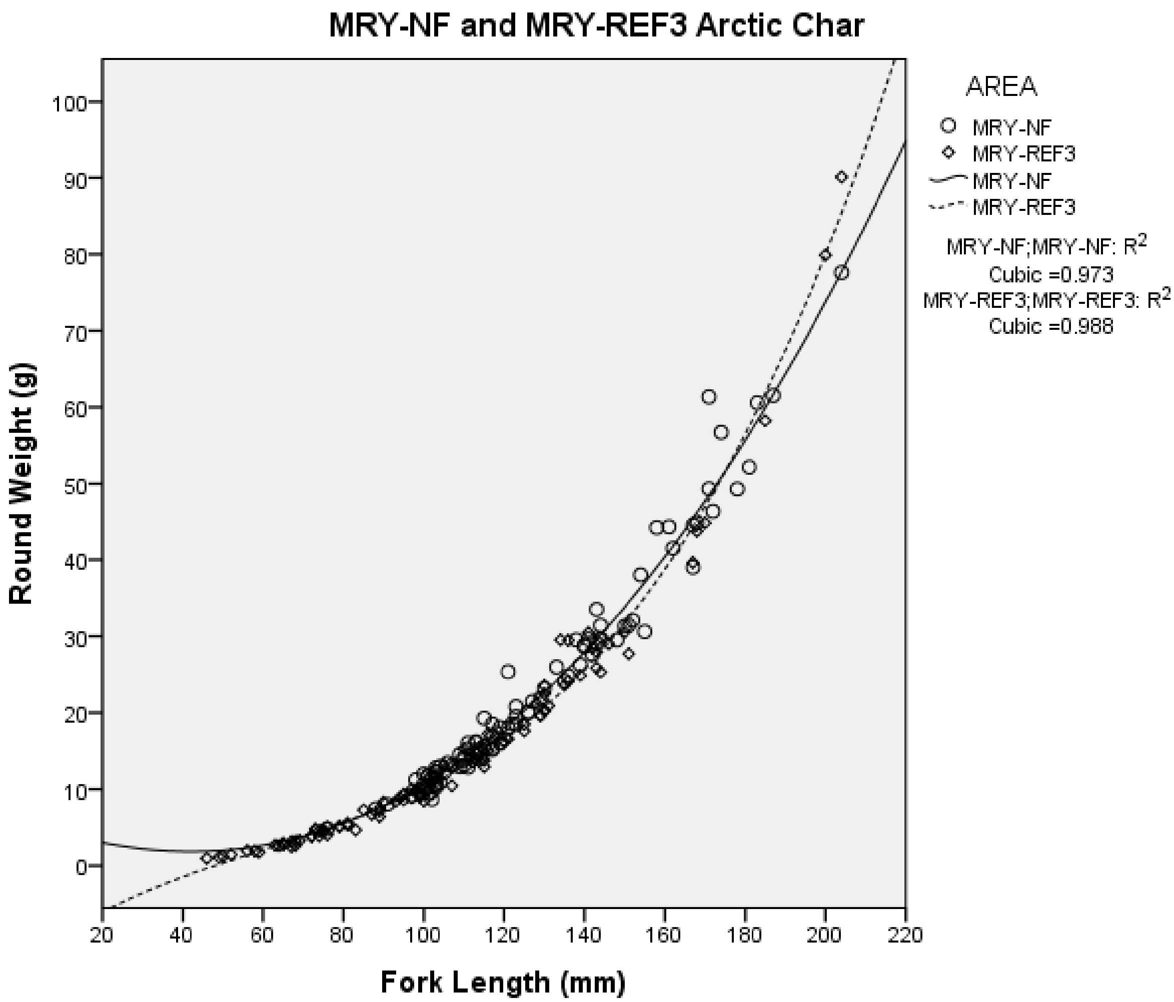


Figure E.6 Mary River NF and REF3 Study Areas: Relationship between Arctic Char Weight and Fork Length

Table E.3 Mary River Study Areas: ARCH Fork Length and Round Weight Data Comparison Summary (Page 1 of 2)

Test of Normality

Measure	Area	Shapiro-Wilk			
		Statistic	df	p-value	Distribution at p>0.05
Fork Length (mm)	MRY-NF	0.922	100	0.000	Not Normal
	MRY-REF3	0.965	100	0.009	Not Normal
Round Weight (g)	MRY-NF	0.834	100	0.000	Not Normal
	MRY-REF3	0.746	100	0.000	Not Normal

Test of Homogeneity of Variance

Measure	Levene Statistic	df1	df2	p-value	Homogeneity of Variance at p<0.10
Fork Length (mm)	6.808	1	198	0.01	Yes – Variance not homogeneous
Round Weight (g)	0.414	1	198	0.52	No – Variance homogeneous

ANOVA Results – Fork Length

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.10
Between Groups	24266.1	1	24266.1	26.682	0.000	Y
Within Groups	180072.1	198	909.5			
Total	204338.2	199				

ANOVA Results – Round Weight

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Sig. at p<0.10
Between Groups	3359.7	1	3359.7	15.533	0.000	Y
Within Groups	42825.1	198	216.3			
Total	46184.8	199				

Table E.3 Mary River Study Areas: ARCH Fork Length and Round Weight Data Comparison Summary (Page 2 of 2)

Multiple Comparison Post-hoc Test – Fork Length

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF	MRY-REF3	22.0	4.3	0.000	Y	11.0	33.1
Games-Howell		**Mean Difference**	**Std. Error**	**p-value**	**Difference Sig. at p<0.10**	**95% Confidence Interval**	
Exposure Area	**Comparison Area**	**(Exp. – Comp.)**				**Lower Bound**	**Upper Bound**
MRY-NF	MRY-REF3	22.0	4.3	0.000	Y	11.0	33.1

Multiple Comparison Post-hoc Test – Round Weight

Tukey HSD		Mean Difference	Std. Error	p-value	Difference Sig. at p<0.10	95% Confidence Interval	
Exposure Area	Comparison Area	(Exp. – Comp.)				Lower Bound	Upper Bound
MRY-NF	MRY-REF3	8.2	2.3	0.002	Y	2.3	14.1
Games-Howell		**Mean Difference**	**Std. Error**	**p-value**	**Difference Sig. at p<0.10**	**95% Confidence Interval**	
Exposure Area	**Comparison Area**	**(Exp. – Comp.)**				**Lower Bound**	**Upper Bound**
MRY-NF	MRY-REF3	8.2	2.1	0.001	Y	2.8	13.6

NOTE:

1. SHADED CELLS INDICATE A SIGNIFICANT DIFFERENCE FROM THE EXPOSURE AREA AT P<0.10.

Appendix A

Draft EEM Cycle One Study Design

MARY RIVER PROJECT

DRAFT – REV B
EEM CYCLE ONE STUDY DESIGN

JUNE 2014

Table of Contents

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

1.1 OVERVIEW

The Mary River Project is an iron ore mine located on northern Baffin Island in the Qikiqtani Region of Nunavut. The Project is owned by Baffinland Iron Mines Corporation (Baffinland).

As a metal mine, the discharge of mine effluents from this metal mine is regulated by the Metal Mining Effluent Regulations (MMER) (MOJ, 2012). These regulations, administered under the federal *Fisheries Act* (1985), apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. Mining is expected to begin as early as the second half of September 2014 at which time temperatures are below zero, precipitation falls as snow, and runoff has ceased in local rivers and streams. Therefore, the 50 m^3/day mine effluent discharge rate will be achieved during freshet in June 2015.

The MMER outline requirements for routine effluent monitoring, acute lethality testing, and Environmental Effects Monitoring (EEM). The objective of EEM is to determine whether mining activity is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources (based on mercury accumulation in fish tissues).

This Draft EEM Cycle One Study Design has been prepared in accordance with the MMER as prescribed by the EEM technical guidance document (EC, 2012), for inclusion as a component study to Baffinland's Aquatic Effects Monitoring Plan (AEMP). The study design describes in detail how the Cycle One EEM biological monitoring study will be undertaken. It outlines the proposed activities involved in the investigation of water quality, sediment quality, and freshwater biota community to meet the objectives of the EEM program in accordance with the MMER. In accordance with the technical guidance document (EC, 2012), this study will take into account all relevant site characterization information, previous biological monitoring data, and comments and/or recommendations stemming from previous efforts in the area.

Any comments on this draft study design will be incorporated into a final study design that will be formally submitted for review and approval by the Environment Canada Technical Advisory Panel (TAP) prior to initiation of the Cycle One EEM biological monitoring study field work.

1.2 OTHER MONITORING PROGRAMS

With respect to regulations that apply to the discharge of contact water and surface runoff from the Mary River Mine, and in addition to the MMER, the Nunavut Water Board (NWB) issued a Type A Water Licence (2AM-MRY1325) that came into effect on June 10, 2013 and is due to expire on June 10, 2025 (NWB, 2013). This Type A Water Licence is a requirement under the Nunavut Waters and Nunavut Surface Rights Tribunal Act and the Agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada (referred to as the Nunavut Land Claims Agreement; NLCA).

The Type A Water Licence effluent quality limits for the open pit, stockpile and sedimentation ponds are generally more restrictive than those in the MMER (Table 1.1). The points of compliance at the mine for the effluent quality standards included in this Licence are the final points of control at stations MS-06, MS-07, MS-08, and MS-09 as shown on Figure 1.1. All test results for the effluent water quality parameters listed in this Licence shall be provided by a laboratory accredited by the Canadian Association for

Laboratory Accreditation (CALA). Effluent characterization and water quality monitoring conducted under the Type A Water Licence is consistent with MMER protocols.

Table 1.1 Compliance Monitoring Limits Applicable to Mine Effluent Discharges

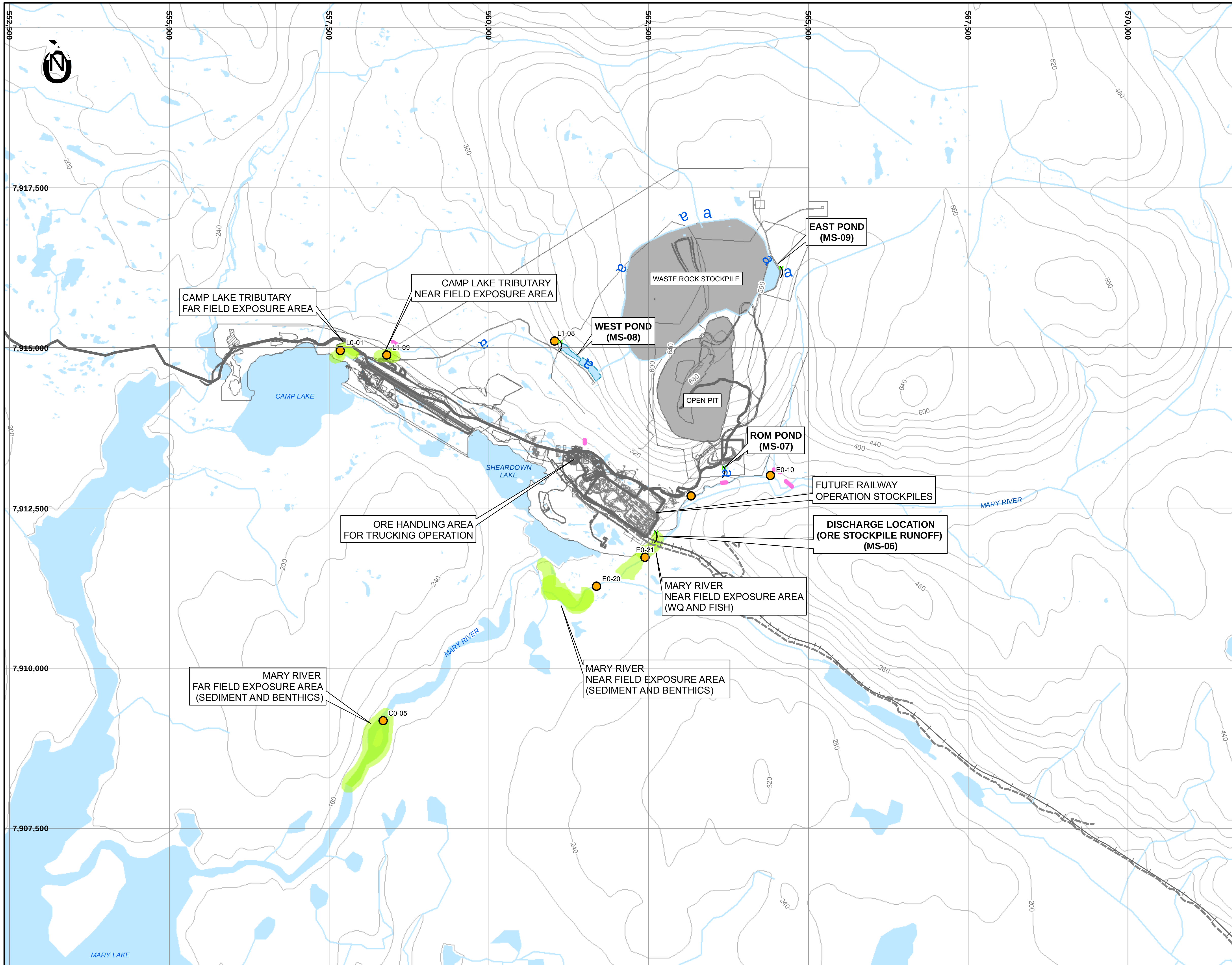
Parameter	MMER Effluent Quality Standards (Schedule 4)			Water Licence 2AM-MRY1325 Open Pit, Stockpile and Sedimentation Ponds Effluent Discharge Quality Limits
	Maximum Monthly Mean Concentration	Maximum Concentration in a Composite Sample	Maximum Concentration in a Grab Sample	Maximum Concentration of Any Grab Sample
Arsenic	0.50	0.75	1.00	0.50
Copper	0.30	0.45	0.60	0.30
Cyanide	1.00	1.50	2.00	
Lead	0.20	0.30	0.40	0.20
Nickel	0.50	0.75	1.00	0.50
Zinc	0.50	0.75	1.00	0.50
TSS	15.00	22.50	30.00	15
Radium 226 (Bq/L)	0.37	0.74	1.11	
pH (pH units)	-	-	-	Between 6.0 and 9.5
Oil and Grease	-	-	-	No visible sheen
Acute Toxicity Testing				
96-hr Rainbow Trout	$Pass_{50}$ [2]			Not acutely toxic

NOTES:

1. ALL PARAMETER CONCENTRATIONS ARE TOTAL VALUES, EXPRESSED IN MG/L UNLESS OTHERWISE SPECIFIED.
2. A PASS RESULT IS <50% MORTALITY IN 100% EFFLUENT.

The Type A Water Licence requires the development of an Aquatic Effects Monitoring Plan (AEMP). A number of component studies form the AEMP for the Mary River Project, including this EEM Program. Another component study is the Core Receiving Environment Monitoring Program (CREMP), which draws upon the same technical guidance document as the EEM Program to monitor aquatic effects due to multiple pathways (i.e., mine effluent discharges, but also sewage effluent discharges and effects due to dust deposition) within the near and far-field streams and mine site lakes: Camp, Sheardown NW and SE, and Mary Lake.

Additional details on the AEMP including the CREMP can be found in the AEMP (Baffinland, 2014).



LEGEND:

- FINAL DISCHARGE POINT
- ENVIRONMENTAL EFFECTS MONITORING STATION (EEM) (WATER, SEDIMENT, BENTHICS AND FISH)
- EEM STUDY DESIGN EXPOSURE AREA
- FISH BARRIER
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

DRAFT

SCALE 500 250 0 500 1,000 1,500 2,000 2,500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PROPOSED EXPOSURE AREAS FOR THE ENVIRONMENTAL EFFECTS MONITORING (EEM) PROGRAM

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	5

FIGURE 1.1 REV A

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
A	20MAY'14	ISSUED WITH REPORT	DKK	SWK	PS	RAC

SAVED: I:\102\00181\34\A\GIS\Figs\B45_rA.mxd; May 21, 2014 11:45 AM; asimpson

2 SITE CHARACTERIZATION

2.1 PROJECT DESCRIPTION

The Project is an iron more mine with a production rate of 21.5 Mt/a, consisting of the following major components:

- Milne Port
- Mine Site
- Railway
- Steensby Port

Each development site (excluding the railway) will have all the facilities it needs to operate effectively including maintenance and administrative buildings, warehouses and laydown areas, ore stockpiles and associated runoff management facilities, camps, water supply, wastewater treatment plants, waste management facilities including landfills, power generation, fuel depots, telecommunication facilities, and airstrips.

Baffinland is approved to mine Deposit No. 1 at the mine site by open pit mining methods. Since the Mary River iron ore is of a very high-grade, there is no need to have a process plant (or mill) on site, resulting in no tailings being generated. As such, no tailings pond will be required. This is accomplished by crushing and screening of the ore to produce two iron ore products:

- Lump ore – sized between 6.3 mm and 31.5 mm (about golf ball size), and
- Fine ore - sized less than 6.3 mm (about pea size).

Ore will be stockpiled at the mine site and transported either by truck to Milne Port or by railway to Steensby Port. Ore handling facilities at the mine site will consist of the open pit, separate ore stockpiles for the trucking and railway operations, and water management facilities to collect runoff from ore stockpiles. Waste rock will be stockpiled in a single stockpile next to the open pit, and up to two ponds will collect runoff from the stockpile. The trucking and railway operations will have separate ore stockpiles and runoff collection ponds but will otherwise share common water management facilities and final discharge points.

Mining is expected to begin in the second half of September 2014 beginning with a low-capital trucking operation involving the mining of 3.5 million tonnes per annum (Mt/a) of iron ore that will be transported year-round by truck to Milne Port, with marine shipping to market during the open water season. Ore handling facilities at Milne Port will consist of truck unloading facilities, ore stockpiles and ship-loading facilities at an ore dock. Runoff from the stockpile area at Milne Port will be collected in a pond that will discharge to the marine waters of Milne Inlet. Environment Canada has advised Baffinland that the mine effluent discharge to Milne Inlet will not be subject to the MMER, though the *Fisheries Act* still apply, including Section 36(3) regarding the prohibition of discharges of a deleterious substance in waters frequented by fish (Anne Wilson, pers.comm.)

At some point in the future when the iron ore market and economic conditions for financing capital-intensive projects improves, an 18 Mt/a railway operation will be constructed. This will involve the construction and operation of a 149-km railway to Steensby Port. Steensby Port, once constructed, will be equipped with a railway car dumper and associated conveying equipment, an ore stockpile, and ship-loading facilities to load ore onto ice-breaking ore carriers. Shipping of ore from Steensby Port will take place year-round. Runoff from the ore stockpile at Steensby Port will be collected and discharged to the marine waters in Steensby Inlet. Environment Canada similarly advised that the mine effluent discharge to marine waters from the ore stockpile at Steensby Port would not be subject to the MMER but would otherwise be subject to the *Fisheries Act*.

A number of proven mitigation measures have been included in the Project to reduce potential effects on water quality, freshwater fish, fish habitat, and other aquatic organisms. At each of the ore handling locations, crushers and screens will be installed inside buildings, and conveyors will be covered and equipped with wind ventilation hoods to reduce wind exposure and the potential for dust generation. All ventilation ducts will be routed to dust collectors which will limit dust emissions. Specific Management Plans detail the many ways that water will be protected (Baffinland, 2012).

The operational life of the Project, based on current ore reserves and a production rate of 21.5 Mt/a, is 21 years. The Closure of the facilities is expected to be carried out over a three to five year period and post-closure monitoring will follow for an additional five years. If closure objectives are not met, post closure would extend beyond five years.

2.2 FINAL DISCHARGE POINTS

Mine effluent will be discharged to two watercourses (Figure 1.1):

- Mary River
- Camp Lake Tributary 1

There will be three final discharge points will discharge mine effluent to the Mary River as follows:

- East Pond discharge collecting stormwater from the east side of the waste rock stockpile
- Run-of-mine (ROM) stockpile discharge
- The main ore stockpile at the rail load-out area

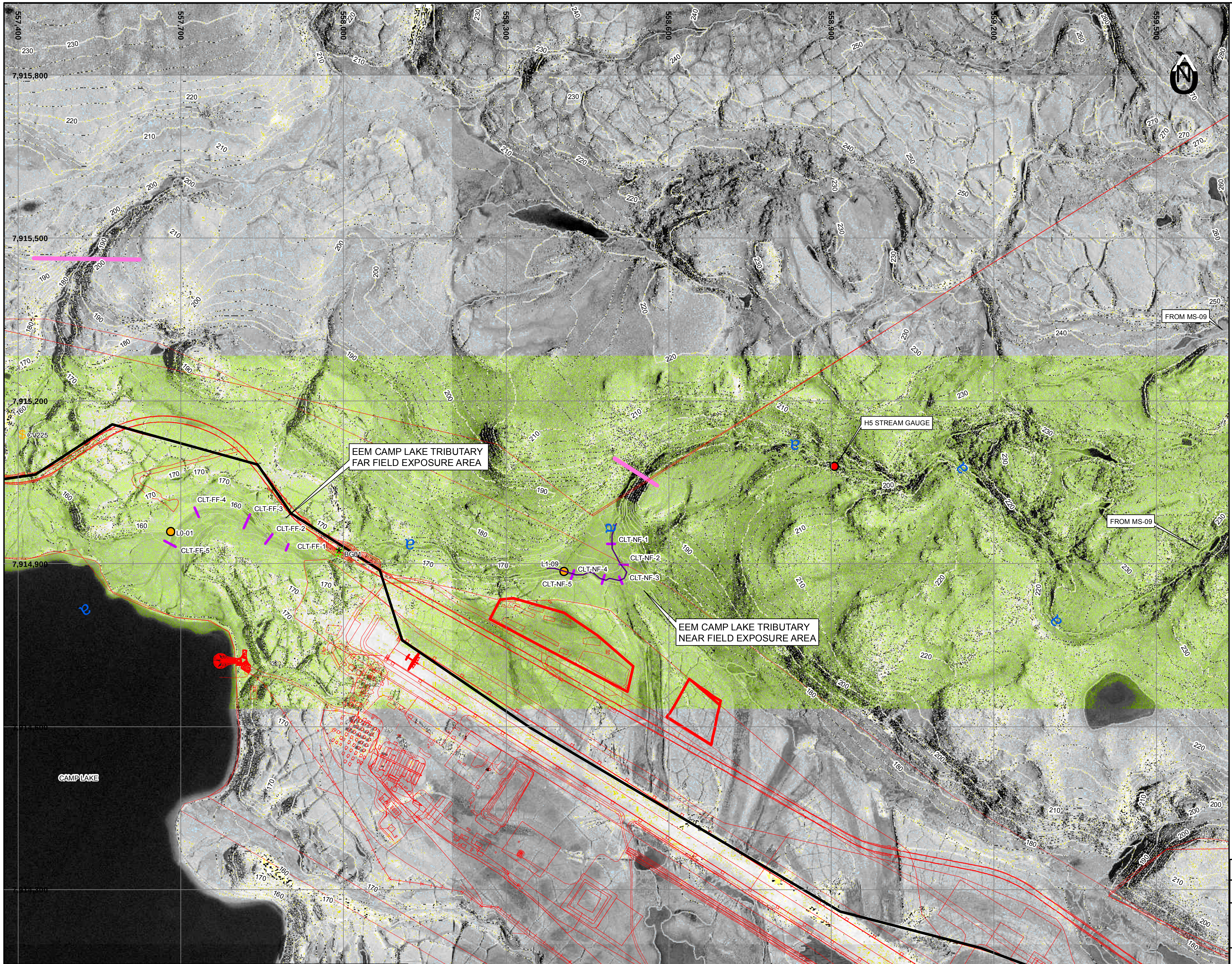
There will be one final discharge point to Camp Lake Tributary 1, from the West Pond collecting stormwater from the west side of the waste rock stockpile.

2.3 HISTORICAL DATA

In preparation for the MMER regulatory obligations, Baffinland characterized the two exposure areas (Mary River and Camp Lake Tributary 1) and several candidate reference areas in 2013.

The candidate reference areas were characterized to compare the in-situ physical and biological conditions to the conditions of the exposure areas. The candidate reference areas were identified through a series of desktop screenings and ground-truthing activities in 2012 and 2013. At least three candidate reference areas for each receiving watercourse were characterized.

The coordinates of the exposure and candidate reference areas characterized for the study design are shown in Table 2.1. The locations of the proposed exposure areas on the Camp Lake Tributary and Mary River are shown on Figure 1.1, and in greater detail on Figures 2.1 and 2.2. Reference areas for the study are shown on Figure 2.3.



LEGEND:

- ACTIVE WATER QUALITY SAMPLE LOCATION
- ACTIVE STREAM GAUGE LOCATION
- CULVERT CROSSING
- DIRECTION OF WATER FLOW
- MAJOR CONTOUR
- EXISTING TOTE ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- EEM REPLICATE TRANSECTS
- FISH BARRIER
- EEM STUDY DESIGN EXPOSURE AREA

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE 17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL IS 2 m.
4. ORTHO PHOTOS PROVIDED BY EAGLE MAPPING (2006).
5. INFRASTRUCTURE PROVIDED BY HATCH ON JANUARY 31, 2014.

DRAFT

SCALE 75 37.5 0 75 150 225 300 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CAMP LAKE TRIBUTARY EEM EXPOSURE AREAS

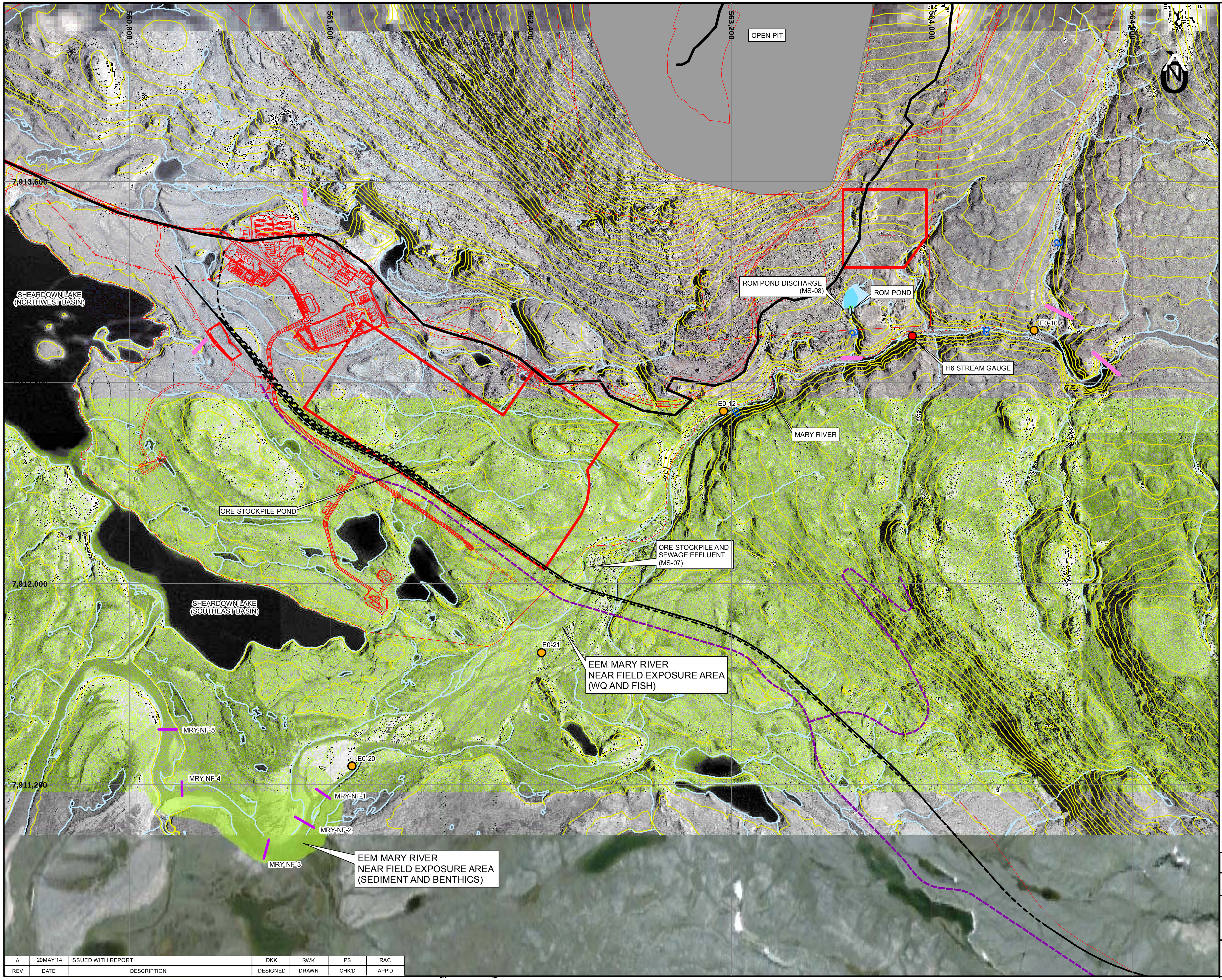
Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	5

FIGURE 2.1 REV A

A	20MAY'14	ISSUED WITH REPORT	DKK	SWK	PS	RAC
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

SAVED: I:\1\02\00181\34\A\GIS\Figs\B47_rA.mxd; Jun 26, 2014 1:48 PM; asimpson



LEGEND:

- ACTIVE WATER QUALITY SAMPLE LOCATION
- ACTIVE STREAM GAUGE LOCATION
- FINAL DISCHARGE POINT
- DIRECTION OF WATER FLOW
- CONTOUR
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- EEM REPLICATE TRANSECT
- FISH BARRIER
- WATER
- HIGHLIGHTED WATER FEATURE
- EEM STUDY DESIGN EXPOSURE AREA

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE 17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL IS 2 m.
4. ORTHO PHOTOS PROVIDED BY EAGLE MAPPING (2006).
5. INFRASTRUCTURE PROVIDED BY HATCH ON JANUARY 31, 2014.

DRAFT

SCALE 200 100 0 200 400 600 800 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MARY RIVER NEAR FIELD EEM EXPOSURE AREA

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	5

FIGURE 2.2 REV A

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
A	20MAY'14	ISSUED WITH REPORT	DKK	SWK	PS	RAC

SAVED: I:\1\02\00181\34\A\GIS\Figs\B46_rA.mxd; Jun 26, 2014 1:46 PM; asimpson

LEGEND:

- HISTORIC WATER QUALITY SAMPLE LOCATION
- ACTIVE WATER QUALITY SAMPLE LOCATION
- DIRECTION OF WATER FLOW
- MAJOR CONTOUR
- MINOR CONTOUR
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- EEM REPLICATE TRANSECT
- WATER
- EEM STUDY DESIGN EXPOSURE AREA

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE 17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL IS 2 m.
4. ORTHO PHOTOS PROVIDED BY EAGLE MAPPING (2006).
5. GOOGLE IMAGERY OBTAINED NOVEMBER 6 2012.

DRAFT

SCALE 200 100 0 200 400 600 800 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MARY RIVER FAR FIELD EEM EXPOSURE AREA

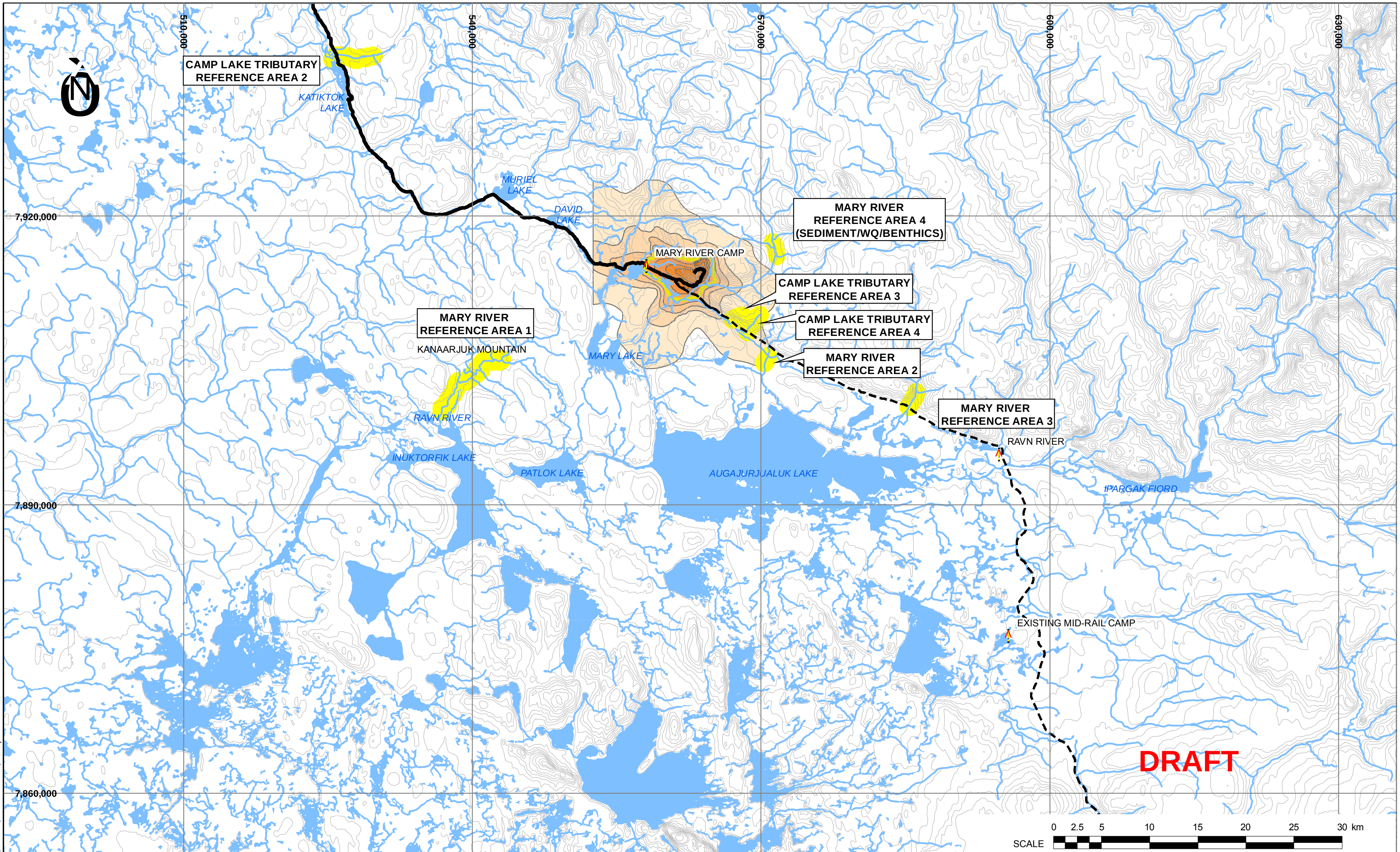
Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	5

FIGURE 2.3 REV A

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
A	20MAY'14	ISSUED WITH REPORT	DKK	SWK	PS	RAC

SAVED: I:\102\00181\34\A\GIS\Figs\B48_A.mxd; Jun 26, 2014 1:49 PM; asimpson



LEGEND:

- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- PHOTO/VIDEO RECORD (2012-2013)
- WATER

Annual TSP Dep. (g/m²/yr)

- 2 - 7.5
- 7.5 - 15
- 15 - 30
- 30 - 55
- 55 - 120
- 120 - 240
- 240 - 480
- > 480

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOUR INTERVAL IS 20 METRES.
4. TOTAL SUSPENDED PARTICULATE CONTOURS PROVIDED BY RWDI AIR INC. (2011). PRESENTED IN THE FINAL ENVIRONMENT IMPACT ASSESSMENT.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CANDIDATE REFERENCE AREAS FOR EEM PROGRAM

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	5

FIGURE 2.4 REV A

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
A	20MAY'14	ISSUED WITH REPORT	DKK	SWK	PS	RAC

SAVED: I:\1102\00181\34\A\GIS\Figs\A13_rA.mxd; Jun 26, 2014 1:32 PM; asimpson

Baseline environmental data has been collected at the exposure and reference areas by North/South Consultants Inc. (NSC) and Knight Piésold Ltd. (KP) on behalf of Baffinland. The 2013 study area site characterization program involved:

- Identifying the in-situ habitat conditions
- In-situ and laboratory water quality sampling
- Sediment quality sampling
- Benthic invertebrate community sampling
- Fish community and population sampling

The exposure area habitat information was used to evaluate suitability of the candidate reference study areas and to position the proposed field replicate stations. Characterizing more than one reference site for each exposure area increases the ability to evaluate natural variability, ecological relevance and confounding factors, and improves the ability to evaluate the adequacy of the chosen reference site(s) (EC, 2012).

Table 2.1 Freshwater EEM Study Design Exposure and Candidate Reference Areas

Study Area ID	Latitude (Deg. Min. Sec.)	Longitude (Deg. Min. Sec.)
Camp Lake Tributary Near Field Exposure Area	71° 19’ 46” N	79° 21’ 46” W
Camp Lake Tributary Far Field Exposure Area	71° 19’ 46” N	79° 22’ 46” W
Camp Lake Tributary Reference Area 2	71° 31’ 51” N	80° 15’ 42” W
Camp Lake Tributary Reference Area 3	71° 15’ 56” N	79° 06’ 27” W
Camp Lake Tributary Reference Area 4	71° 15’ 28” N	79° 04’ 23” W
Mary River Near Field Exposure Area (Surface water & Fish at outfall)	71 17' 50" N	79° 15' 57" W
Mary River Near Field Exposure Area (Sediment & Benthos)	71° 17’ 42” N	79° 16’ 47” W
Mary River Far Field Exposure Area	71° 16’ 42” N	79° 22’ 11” W
Mary River Reference Area 1	71° 12’ 47” N	79° 56’ 17” W
Mary River Reference Area 2	71° 13’ 21” N	79° 02’ 46” W
Mary River Reference Area 3	71° 10’ 26” N	78° 39’ 31” W
Mary River Reference Area 4	71° 20' 43” N	79° 00' 04” W

NOTES:
1. AREA COORDINATES REPRESENT THE UPSTREAM EXTENT OF EACH STUDY AREA.

The habitat at each area was documented, including a description of the riparian vegetation, substrate composition and general stream morphology characteristics. A photographic record of each area is provided in Appendix A to support the habitat descriptions. Point velocity and depth measurements were taken at each replicate station and are also provided in Appendix A summary tables.

Substrate samples were collected for particle size distribution analysis and total organic carbon (TOC) content at each of the five replicate stations in each study area to characterize the habitat and as a supporting measure for the benthic invertebrate community survey data. The replicate stations were located in wadeable, erosional habitat, therefore depositional organic sediment was not available for sampling or utilized for total metals analysis. Summary figures and tables of the substrate laboratory results are provided in Appendix B.

Surface water quality samples and measurements were taken at existing monitoring stations where available. The in-situ and laboratory results are provided in Appendix C.

The benthic invertebrate community was sampled using a Hess sampler with 500 micron mesh as recommended by the technical guidance document (EC, 2012). Three grab samples were collected at each replicate station and retained in separate containers for discrete analysis for evaluation of within station variability. The benthic invertebrate community data for each replicate station, descriptions of the effects endpoints and supporting endpoint summary tables are provided in Appendix D. Discussion of the benthic community results and comparisons between exposure and candidate reference area are provided in the following sections. These results describe the community assemblages and support rationale for the selection of suitable reference areas.

Fish community and population sampling was conducted utilizing a Smith-Root backpack electrofishing unit. The collection of 100 juvenile Arctic char (*Salvelinus alpinus*) older than young-of-year (YOY) was attempted at all study areas. Subsamples of the captured fish (n=10) were retained for age verification to characterize the Arctic char population. The fish data (fork length and round weight) measured in the field and age verification data from the subsampled individuals are provided in Appendix E. Ninespine stickleback (*Pungitius pungitius*) are the only other fish species present in the mine area freshwater streams. The ninespine stickleback collected during the fall 2013 program were enumerated, but insufficient numbers were collected to perform statistical comparisons of the reference and exposure areas. Discussion of study area population composition, including age verification results are provided in the following sections.

2.4 CAMP LAKE TRIBUTARY EXPOSURE AREAS AND REFERENCE AREAS

The Camp Lake Tributary exposure area is located on the west side of Deposit No. 1 and contains the near field study area upstream of the existing Tote Road, and the far field study area located downstream of the Tote Road stream crossing as shown on Figure 2.1.

Three candidate reference areas were characterized to evaluate their suitability as EEM reference areas for the exposure area. The reference areas included one area along the Tote Road between the mine site and Milne Port, and two locations near the rail alignment, north of Angajurjualuk Lake. The locations of these reference areas are shown on Figure 2.4. Originally, a fourth candidate reference area (CLT-REF1) was selected, but this area was deemed unsuitable following a ground-truthing site visit in the summer 2013.

2.4.1 Historical Site Characterization

Prior to the 2013 fall (late August) site characterization program, various baseline aquatic data collection programs have been conducted in the exposure and some of the reference streams. A summary of the study areas, corresponding historical studies and reference to the 2013 photographs included in Appendix A are provided in Table 2.2.

Table 2.2 Camp Lake Tributary Study Areas: Historical Characterization Summary

EEM Study Area ID	CLT-NF	CLT-FF	CLT-REF2	CLT-REF3	CLT-REF4
Historical ID	L1-09	L0-01	CV-078, N1-060	CV-004-1 E2-08	CV-006-1
Study Type	**Historical Study Years**				
Water Quality	2011-2013	2005-2007, 2011-2013	2005, 2006, 2011, 2012	2005, 2012	2008
Substrate/Sediment Quality	2007, 2011-2012	2007, 2011-2012	N/A	2012	N/A
Benthic Invertebrates	2007	2007	N/A	2008	N/A
Fish Community	2007, 2010	2007, 2010	2009, 2010	2008	2008
Appendix A Photographs	1 to 4	5 to 8	9 to 12	13 to 16	17 to 20

The land immediately adjacent to these streams is typically flat, and the streams have steep vertical banks. Riparian vegetation includes grasses, mosses, and wildflowers. The streams have varying amount of undercut banks and all have boulders that provide in-stream cover.

2.4.2 Water Quality

The 2013 surface water quality data from the exposure areas (CLT-NF and CLT-FF) shows this stream is "moderately soft" with no Canadian Water Quality Guideline exceedances of criteria for the protection of freshwater aquatic life (CWQG-PAL) (CCME, 2007) as provided in Appendix C (Table C.1). The exposure areas were highly oxygenated, which is an important measure to support aquatic life. A discussion of the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron and nickel are provided in the water and sediment quality review and preliminary study design report contained within the AEMP document (Baffinland, 2014).

The candidate reference areas varied in hardness with CLT-REF2 shown to have hard water and CLT-REF3 and CLT-REF4 shown to have soft water (Appendix C, Table C.1). Analytical results from reference area CLT-REF2 show a total ammonia concentration (0.83 mg/L) of from the July 2013 sample that is above the CWQG-PAL criteria. This was the only criteria exceedance documented at CLT-REF2. The laboratory results from CLT-REF3 and CLT-REF4 reference areas both show concentrations of total aluminum above the CWQG-PAL criteria (Appendix C, Table C.1). Total aluminum was the only CWQG-PAL criteria exceedance from these reference areas. All reference areas were highly oxygenated and comparable to the exposure areas.

2.4.3 Benthic Invertebrate Community Effect Endpoints

Benthic invertebrate community effect endpoints comparing the exposure and reference areas are summarized in Table 2.3. These endpoints show area CLT-REF3 was the only reference area not significantly different from CLT-NF for all effect endpoint calculations, and is the recommended reference area for use in the cycle one EEM biological monitoring study. Reference area CLT-REF4 should also be utilized in the cycle one study since family richness was the only significant difference and the use of multiple reference areas captures the natural variability of these streams, providing a less narrow comparison to a single reference area. Benthic invertebrate sample processing methods and details of the endpoint calculations are provided in Appendix D.

Table 2.3 Camp Lake Tributary Study Areas: Benthic Invertebrate Community Summary

Endpoint	Descriptor	Study Area			
		CLT-FF	CLT-REF2	CLT-REF3	CLT-REF4
Total Invertebrate Density(TID)	Different from CLT-NF ($p<0.10$)	N[2]	Y[2]	N[2]	N[2]
Taxa Richness	Different from CLT -NF ($p<0.10$)	N	N	N	Y
Simpson's Evenness Index (E)	Different from CLT -NF ($p<0.10$)	N[2]	Y[2]	N[2]	N[2]
Bray-Curtis Similarity Index	Different from CLT -NF ($p<0.10$)	-	Y	N	N

NOTES:
1. TUKEY TEST RESULTS FOR POST-HOC COMPARISON PRESENTED UNLESS OTHERWISE NOTED.
2. VARIANCE NOT HOMOGENEOUS, GAMES-HOWELL TEST RESULTS PRESENTED.
3. SEE APPENDIX D FOR CAMP LAKE TRIBUTARY STUDY AREA ENDPOINT CALCULATIONS.

Baffinland has identified the Bray-Curtis Similarity Index as one of the benthic invertebrate community effect endpoints, in accordance with EC (2012), as shown in Table 2.3. It has been acknowledged in a study commissioned by EC that this current procedure results in a highly inflated type I error rate (Borcard and Legendre, 2013). Prior to submitting the final Cycle One Study Design, Baffinland plans to seek further guidance from EC on this issue, and give due consideration to using the replacement tests identified by Borcard and Legendre (2013).

2.4.4 Supporting Benthic Invertebrate Community Measures

Reference sites must share natural habitat features with the exposure sites and represent the environmental variability of the study region. Supporting measures for the benthic invertebrate community survey were recorded to support recommendations of the appropriate reference areas. These include hydrology, stream morphology and substrate characterization.

The hydrological and morphological characteristics of the Camp Lake Tributary study areas include channel wetted width, total water depth and point velocity measurements. The wetted width was measured at each of the five replicate stations. Total water depth and point velocity measurements were recorded at ten locations per replicate station, near to where the benthic invertebrate community sampling occurred. Reference areas CLT-REF3 and CLT-REF4 are the most similar to exposure area CLT-NF, whereas CLT-REF2 is much wider and has nearly twice the mean water velocity (Table 2.4). Detailed field measurement are provided in Appendix A including the total water depths, wetted widths and water velocities in each study area.

Substrate characterization included particle size distribution analysis and determination of total organic carbon (TOC) content. Reference area CLT-REF3 had particle size fractions similar to those measured at exposure area CLT-NF. Both areas were dominated by gravel and coarse sand. Reference area CLT-REF4 was also dominated by these size classes, but had higher gravel content.

Table 2.4 Camp Lake Tributary Study Areas: Stream Characterization Summary

Measure	Units	Study Area				
		CLT-NF	CLT-FF	CLT-REF2	CLT-REF3	CLT-REF4
Mean Wetted Width	m	5.8	4.9	15.4	4.6	2.6
Mean Total Depth	m	0.16	0.14	0.20	0.17	0.13
Mean Velocity	m/s	0.28	0.38	0.51	0.20	0.37

Reference area CLT-REF2 was dominated by gravel and silt, and is not a suitable representation of exposure area habitat. TOC content at CLT-REF3 and CLT-REF4 were most similar to the TOC content of the exposure area CLT-NF. The particle size distributions and TOC results for the Camp Lake Tributary study areas are shown in Table 2.5. Detailed field measurements, laboratory results and graphs are provided in Appendix B to assist with interpretation of the supporting measures.

Table 2.5 Camp Lake Tributary Study Areas: Substrate Characterization Summary

Mean Particle Size Fraction (%)	Size (mm)	Study Area				
		CLT-NF	CLT-FF	CLT-REF2	CLT-REF3	CLT-REF4
Gravel	16.0 - 2.0	58	57	73	54	79
Coarse Sand	2.0 - 0.2	33	35	4	38	12
Fine Sand	0.2 - 0.062	0	4	2	4	5
Silt	0.062 - 0.0039	0	1	11	0	1
Clay	< 0.0039	5	5	8	4	5
Mean TOC (%)	-	0.15	0.20	0.21	0.12	0.17

2.4.5 Fish Community and Population

Backpack electrofishing during the fall 2013 program captured arctic char at all Camp Lake Tributary study areas. The fish appeared healthy, with no visible abnormalities. A summary of the fish collection results and mean measurements from the study area populations are shown in Table 2.6. Detailed collection data are presented in Appendix E.

Table 2.6 Camp Lake Tributary Study Areas: Fish Sampling Data Summary

Measure	Study Area			
	CLT-NF	CLT-REF2	CLT-REF3	CLT-REF4
Number or Arctic char collected	120	30	116	117
Number of Ninespine stickleback collected	0	0	0	1
Arctic char catch-per-unit-effort (CPUE)	8.57	1.22	9.11	5.25
Mean Arctic char fork length (mm)	148	127	90	117
Mean Arctic char round weight (g)	32	23	10	21
Mean Arctic char age (yrs), (n=10/study area)	3	4	4	4
Mean Fulton's Condition (weight at length)	1.17	1.18	1.37	1.33

The collection of 100 individuals from each area is required under the EEM program to conduct comparisons between study areas. Due to the limited capture success at reference area CLT-REF2 (n=30), only reference areas CLT-REF3 and CLT-REF4 were compared to the exposure area. Ninespine stickleback were only captured from reference area CLT-REF4 (n=1) and no further data are discussed regarding this species.

The arctic char catch-per-unit-effort (CPUE) results are shown in Table 2.5, with the highest capture rate in reference area CLT-REF3. The CLT-REF4 area had approximately half the CLT-REF3 capture success, and was lower than the CPUE recorded at the exposure area CLT-NF.

The fork lengths of the first 100 individuals from the CLT-NF, CLT-REF3 and CLT-REF4 study areas are graphically shown in Appendix E (Figure E.1). Arctic char in the exposure area were the largest and consequently the heaviest of the three study area populations. Ten individuals were retained for age verification from each study area, and ages ranged from 1 to 7 years old.

Descriptive statistics of the fork length and round weight measurements are presented in Appendix E (Table E.1). Statistical comparisons of the CLT-REF3 and CLT-REF4 length and weight data to the CLT-NF data are presented in Appendix E (Table E.2). Tests of normality show the length and weight data for all Camp Lake Tributary study areas are not normally distributed. Transforming the data did not resolve this condition. An ANOVA comparison shows length and weight data of the study areas are significantly different.

The fish population data shows both reference areas CLT-REF3 and CLT-REF4 were significantly different from the CLT-NF study area.

2.4.6 Camp Lake Tributary Exposure and Reference Area Summary

Reference areas CLT-REF3 and CLT-REF4 are the most suitable study areas for use in the EEM cycle one biological monitoring study. These areas are representative of the benthic invertebrate community seen in the near field exposure area CLT-NF, with similar water quality, substrate, hydrology and stream morphology measures.

Comparison of the fish community and population data shows CLT-REF3 and CLT-REF4 have different fish age distributions and are statistically different from CLT-NF. Additional data analysis may be performed following discussions with Environment Canada to determine an acceptable reference area for the fish component of the EEM cycle one biological monitoring study.

2.5 MARY RIVER EXPOSURE AREAS AND REFERENCE AREAS

The Mary River is located southeast of the mine site and flows in a southwest direction reporting to Mary Lake approximately 12.8 km downstream. The exposure area will receive effluent inputs from three discrete MMER final discharge points listed below in descending order, upstream to downstream as follows (Figure 1.1):

- East waste rock pond discharge (MS-10)
- Run of mine (ROM) pond discharge (MS-08)
- Ore stockpile runoff (MS-07)

The Mary River aquatic habitat between these effluent discharge points is a high energy environment dominated by a boulder substrate and steep sloping banks. The Mary River near field (MRY-NF) exposure area has two stream sections proposed for the cycle one EEM biological monitoring study as shown on Figure 2.2. During study design development, the challenges of standard biological sampling in the immediate vicinity of the final discharge points were discussed with Environment Canada. Following a site visit by Environment Canada staff, it was agreed that the benthic invertebrate and substrate sampling would take place in wadeable river habitat downstream of the dangerous, high velocity conditions. It was also decided that receiving water quality sampling will remain near the discharge locations as per the CREMP as well as the fish sampling EEM component that will take place upstream of the benthic study area, as close to the final discharge point as safely possible.

The upstream extent of the Mary River far field (MRY-FF) exposure area is located approximately 3,900 m downstream of the Sheardown Lake outlet channel confluence as shown on Figure 2.3. Existing CREMP stations are located within this study area as shown on Figure 2.3. Baseline surface water quality monitoring at station C0-05 was conducted in 2007, 2008 and 2011. Sediment quality sampling at station C0-05 was conducted in 2007 and 2011. A fish community survey had not historically been conducted at this location on the river however the barrier-free conditions between MRY-FF and MRY-NF permits fish migration through these exposure areas.

Four reference areas geographically outside of the range of anticipated mining influences were selected for comparison to the Mary River exposure areas (Figure 2.4). One of these areas (MRY-REF4) was included following a recommendation by Environment Canada to locate a study area on the Mary River. The only available areas upstream of the final discharge points and predicted dust plume are located upstream of the Mary River fish barrier (waterfall). Study area MRY-REF4 is a candidate reference area for the benthic invertebrate community EEM component. It has been shown that the Mary River is fishless upstream of the waterfall (NSC, 2008). As such, study area MRY-REF4 would not satisfy the requirements of the fish population effects endpoints.

Four candidate reference areas were visited during the 2013 site characterization program. These streams are between 11 km and 27 km away from the MRY-NF exposure area. Three of these candidate areas are in separate drainage basins from MRY-NF. These areas include drainage basins located north of Inuktorfik Lake and two areas near the rail alignment north of Angajurjualuk Lake. The fourth candidate reference area is located on the Mary River, upstream of the Mary River waterfall (Figure 2.4).

2.5.1 Historical Site Characterization

Prior to the 2013 fall (late August) site characterization program, various baseline aquatic data collection programs have been conducted in the exposure and in some of the reference streams. A summary of the study areas, corresponding historical studies and reference to the 2013 photographs included in Appendix A are provided in Table 2.7.

The land immediately adjacent to these streams is typically flat, with steep banks on one or both sides away from the main channel. The in-streams banks are vertical with riparian vegetation including grasses, mosses, and wildflowers. The streams have varying amount of undercut banks and all have boulders that provide in-stream cover.

Table 2.7 Mary River Study Areas: Historical Characterization Summary

EEM Study Area ID	MRY-NF	MRY-FF	MRY-REF1	MRY-REF2	MRY-REF3	MRY-REF4
Historical ID	E0-20 & E0-21	C0-05	N/A	BR 011-1, S2-010	BR-025-1, S2-020	G0-09
Study Type	**Historical Study Years**					
Water Quality	2011 & 2012	2007, 2008, 2011	-	2006 & 2011	2006 & 2011	2006, 2007, 2012
Substrate/Sediment Quality	2011	2007 & 2011	-	-	-	2006, 2007, 2009, 2010 & 2012
Benthic Invertebrates	2007	-	-	-	-	2007
Fish Community	2006 & 2008	-	-	2008	2008	2006 & 2008
Appendix A Photographs	21 to 24	25 to 28	29 to 32	33 to 36	37 to 40	41 to 44

2.5.2 Water Quality

The 2013 surface water quality data from the exposure areas (MRY-NF and MRY-FF) shows these areas are “soft” (MRY-NF) and “moderately hard” (MRY-FF) with concentrations of aluminum, copper and iron measured above the CWQG-PAL criteria at the MRY-NF study areas (Appendix C, Table C.1). A discussion of the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron and nickel are provided in the water and sediment quality review and preliminary study design report contained within the AEMP document (Baffinland, 2014).

The candidate reference areas were all shown to have “soft” water with the exception of MRY-REF1 that had “moderately hard” water. Laboratory results from reference areas MRY-REF3 and MRY-REF4 show concentrations of aluminum and iron above the CWQG-PAL criteria, with aluminum as the only exceedance reported from MRY-REF2. There were no CWQG-PAL criteria exceedances reported from MRY-REF1.

2.5.3 Benthic Invertebrate Community Effect Endpoints

Benthic invertebrate community effect endpoints comparing the exposure and reference areas are summarized in Table 2.8. These endpoints show three of the four reference areas are not significantly different from MRY-NF for all effect endpoint calculations. Benthic invertebrate sample processing methods and details of the endpoint calculations are provided in Appendix D.

As mentioned in Section 2.4.3, prior to submitting the final Cycle One Study Design, Baffinland plans to seek further guidance from EC on the use of the Bray-Curtis Similarity Index, and give due consideration to using the replacement tests identified by Borcard and Legendre (2013).

Table 2.8 Mary River Study Areas: Benthic Invertebrate Community Summary

Endpoint	Descriptor	Study Area				
		MRY-FF	MRY-REF1	MRY-REF2	MRY-REF3	MRY-REF4
Total Invertebrate Density (TID)	Different from MRY-NF (p<0.10)	N	N	N	Y	N
Taxa Richness	Different from MRY-NF (p<0.10)	N	N	N	N[2]	N
Simpson's Evenness Index (E)	Different from MRY-NF (p<0.10)	N	N	N	N[2]	N
Bray-Curtis Similarity Index	Different from MRY-NF (p<0.10)	-	N	N	Y	N

NOTES:
1. TUKEY TEST RESULTS FOR POST-HOC COMPARISON PRESENTED UNLESS OTHERWISE NOTED.
2. VARIANCE NOT HOMOGENEOUS, GAMES-HOWELL TEST RESULTS PRESENTED.
3. SEE APPENDIX D FOR MARY RIVER STUDY AREA ENDPOINT CALCULATIONS.

2.5.4 Supporting Benthic Invertebrate Community Measures

Reference sites must share natural habitat features with the exposure sites and represent the environmental variability of the study region. Supporting measures for the benthic invertebrate community survey were recorded to support recommendations of the appropriate reference areas. These include hydrology, stream morphology and substrate characterization.

The hydrological and morphological characteristics of the Mary River study areas include channel wetted width, total water depth and point velocity measurements. The wetted width was measured at each of the five replicate stations. Total water depth and point velocity measurements were recorded at ten locations per replicate station, near to where the benthic invertebrate community sampling occurred. Reference area MRY-REF1 and MRY-REF3 were the most similar to exposure area MRY-NF but are unlike the exposure area for other comparison criteria. The MRY-REF2 and MRY-REF4 study areas are shallower than the exposure area with higher and lower average point velocities respectively than the MRY-NF study area. Detailed field measurement are provided in Appendix A including the total water depths, wetted widths and water velocities in each study area.

Table 2.9 Mary River Study Areas: Stream Characterization Summary

Measure	Units	Study Area					
		MRY-NF	MRY-FF	MRY-REF1	MRY-REF2	MRY-REF3	MRY-REF4
Mean Wetted Width	m	36	56	37	42	38	26
Mean Total Depth	m	0.30	0.25	0.35	0.20	0.23	0.25
Mean Velocity	m/s	0.40	0.30	0.31	0.46	0.39	0.22

Substrate characterization included particle size distribution analysis and determination of total organic carbon (TOC) content. Reference areas MRY-REF2 and MRY-REF3 had particle size fractions similar to those measured at exposure area MRY-NF. These areas were dominated by gravel and coarse sand. Reference area MRY-REF4 had nearly equal fractions of gravel and coarse sand, whereas MRY-REF1 had the highest percent coarse sand fraction. TOC content at MRY-REF2 and MRY-REF4 were nearly equal to the TOC concentration at MRY-NF as shown in Table 2.10. Detailed field measurements, laboratory results and graphs are provided in Appendix B to assist with interpretation of the supporting measures.

Table 2.10 Mary River Study Areas: Substrate Characterization Summary

Mean Particle Size Fraction (%)	Size (mm)	Study Area					
		MRY-NF	MRY-FF	MRY-REF1	MRY-REF2	MRY-REF3	MRY-REF4
Gravel	16.0 - 2.0	61	46	28	63	64	42
Coarse Sand	2.0 - 0.2	31	41	64	30	29	49
Fine Sand	0.2 - 0.062	3	6	4	3	2	4
Silt	0.062 - 0.0039	0	1	1	1	0	0
Clay	< 0.0039	4	6	3	3	4	4
Mean Total Organic Carbon (%)	-	0.10	0.16	0.07	0.11	0.21	0.11

2.5.5 Fish Community and Population

Backpack electrofishing during the fall 2013 program captured arctic char at all Mary River study areas. The fish appeared healthy, with no visible abnormalities. A summary of the fish collection results and mean measurements from the study area populations are shown in Table 2.11. Detailed collection data are presented in Appendix E.

Table 2.11 Mary River Study Areas: Fish Sampling Data Summary

Measure	Study Area			
	MRY-NF	MRY-REF1	MRY-REF2	MRY-REF3
Number or Arctic char collected	108	26	22	114
Number of Ninespine stickleback collected	0	26	0	0
Arctic char catch-per-unit-effort (CPUE)	1.56	0.61	0.71	2.01
Mean Arctic char fork length (mm)	126	121	100	104
Mean Arctic char round weight (g)	23	25	11	15
Mean Arctic char age (yrs), (n=10/study area)	4	4	3	3
Mean Fulton's Condition (weight at length)	1.43	1.29	1.18	1.23

The collection of 100 individuals from each area is required under the EEM program to conduct comparisons between study areas. Due to the limited capture success at reference area MRY-REF1 and MRY-REF2, only reference area MRY-REF3 compared to the exposure area. During the field studies at MRY-REF2, weather conditions limited the fishing effort, given more time it is likely that sufficient numbers of arctic char could have been collected. Ninespine stickleback were only captured from reference area MRY-REF1 (n=26) and no further data are discussed regarding this species.

The arctic char catch-per-unit-effort (CPUE) results are shown in Table 2.11, with the highest capture rate in reference area MRY-REF3. The remaining two reference areas showed less than half the CPUE recorded at the MRY-NF study area, however MRY-REF2 received half the fishing effort that was spent at the exposure area.

The fork lengths of the first 100 individuals from the MRY-NF and MRY-REF3 study areas are graphically shown in Appendix E (Figure E.4). Arctic char in the exposure area were the largest and consequently the heaviest of the Mary River study area populations. Ten individuals were retained for age verification from each study area, and ages ranged from 1 to 7 years old.

Descriptive statistics of the fork length and round weight measurements are presented in Appendix E (Table E.1). Statistical comparisons of the MRY-REF3 length and weight data to the MRY-NF data are presented in Appendix E (Table E.3). Tests of normality show the length and weight data for the Mary River study areas are not normally distributed. Transforming the data did not resolve this condition. An ANOVA comparison shows length and weight data of the study areas are significantly different.

The fish population data shows reference area MRY-REF3 was significantly different from the MRY-NF study area.

2.5.6 Mary River Reference Area Summary

Reference areas MRY-REF2 and MRY-REF4 are the most suitable study areas for use in the EEM cycle one biological monitoring study. These areas are representative of the benthic invertebrate community seen in the near field exposure area MRY-NF, with similar water quality, substrate, hydrology and stream morphology measures.

Comparison of the fish community and population data shows MRY-REF3 has different fish age distributions and is statistically different from MRY-NF. It is possible with additional sampling, MRY-REF2 could provide sufficient numbers of arctic char for a comparison using the endpoints. Additional data analysis may be performed following discussions with Environment Canada to determine an acceptable reference area for the fish component of the EEM cycle one biological monitoring study.

3 STUDY DESIGN METHODOLOGY

3.1 EFFLUENT PLUME DELINEATION STUDY

Site characterization will include an effluent plume delineation study to confirm the estimated effluent concentration and the manner in which mine effluent will mix with the receiving environment. The effluent plume delineation study will follow guidance provided in the *Revised Technical Guidance on How to Conduct Effluent Plume Delineation Studies* document available from Environment Canada (2003) as well as information provided in the technical guidance document for EEM (EC, 2012).

Effluent discharge has been estimated for the MMER final discharge points. The estimated 10-year low flow conditions of the receivers are presented in Table 3.1.

The three final discharge points to the Mary River will have a total estimated effluent discharge of 3,340,600 m^3/yr. The estimated 10-year low flow conditions of Mary River at the furthest downstream discharge point (E0-21) are 56,793,000 m^3/yr. The effluent concentration is estimated to be 6%, with little dilution between E0-21 and the outlet to Mary Lake.

Camp Lake Tributary will receive effluent from the West Pond (MS-08). Effluent concentrations have been estimated at station L1-09, which is located upstream of the L1 and L0 stream confluence (Table 6.2). The estimated 10-year low flow conditions of Camp Lake Tributary, at station L0-01, which is upstream of the outlet to Camp Lake, is 410,110 m^3/yr. The estimated effluent concentration in Camp Lake Tributary, before reporting to Camp Lake is 46%.

Based on these calculations, effluent concentrations in the Mary River and Camp Lake Tributary are estimated to be greater than 1% within 250 m of the final discharge points.

Table 3.1 Estimated Mine Effluent and Baseline Receiving Water Flows

Effluent Source	Receiving Water	Station ID	Baseline Receiver Discharge at Station (m^3/yr)	Estimated Effluent Discharge (m^3/yr)
East Pond (MS-09)	Mary River	E0-10	53,166,000	3,133,000
ROM Pond (MS-07)	Mary River	E0-12	N/A	97,600
Ore Stockpile Runoff (MS-06)	Mary River	E0-21	56,793,000	110,000
		Mary River Total	**56,793,000**	**3,340,600**
West Pond (MS-08)	Camp Lake Tributary (upstream of Camp Lake)	L0-01	410,100	354,100[1]
		Camp Lake Tributary Total	**410,100**	**354,100[1]**

NOTE:
1. DISCHARGE DATA PROVIDED IN THE FINAL ENVIRONMENTAL IMPACT ASSESSMENT (BAFFINLAND, 2012).

The predicted water quality of the mine effluent to be discharged into the Camp Lake Tributary and Mary River was presented in the FEIS. The predicted effluent quality from ore stockpiles was derived from lysimeter monitoring results of the bulk sample ore stockpile, whereas source terms for runoff from the waste rock stockpile was derived from geochemical testing of representative waste rock materials. Subsequently, mean ore stockpile source terms for the Mary River and the west waste rock pile source terms for Camp Lake Tributary were determined as shown in Table 3.2.

Table 3.2 Predicted Water Quality from Discharge Sources

Parameter	Unit	CWQG-PAL	West Pond	East Pond	Ore Stockpile
			Mean	Mean	95th Percentile
pH	pH	6.5 to 9.0	6.9	6.9	6.65
Arsenic	mg/L	0.005	0.006	0.003	0.002
Copper	mg/L	0.002 to 0.004[4]	0.007	0.004	0.007
Lead	mg/L	0.001 to 0.007[4]	0.0005	0.0002	0.001
Nickel	mg/L	0.025 to 0.150[4]	0.005	0.002	0.17
Zinc	mg/L	0.030	0.031	0.015	0.041

NOTES:
1. MODIFIED FROM FEIS (BAFFINLAND, 2012).
2. EFFLUENT QUALITY UNDER 10-YEAR DRY CONDITIONS PRESENTED
3. RECEIVING WATER QUALITY OBJECTIVES OBTAINED FROM THE CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROTECTION OF FRESHWATER AQUATIC LIFE (CWQG-PAL).
4. CWQG-PAL GUIDELINE VALUE IS HARDNESS DEPENDENT.
5. ADDITIONAL PARAMETERS ARE PROVIDED IN THE FEIS TABLE 7-3.16 AND 7-3.20.

3.2 WATER QUALITY MONITORING

Sampling and analysis of water quality will be undertaken as part of the cycle one EEM biological monitoring study to compare the current water quality of the reference locations to that of the exposure locations. Water quality samples will be taken concurrently with sediment and benthic sampling unless otherwise noted. Field staff will follow the methods outlined in the water and sediment quality sampling protocol (KP, 2014).

The samples will be obtained by sub-surface grabs at least 15 cm below the surface directly into pre-labelled laboratory sample containers. All samples will be preserved according to protocol and stored at 4°C in a chilled cooler until delivered for laboratory analysis. Sample identification, date, time and other pertinent project information will be recorded in a field logbook, on the sample container and on the Chain of Custody forms.

All water samples will be submitted to the selected analytical laboratory for the following analyses as prescribed by the MMER and the technical guidance document: total metals (Ag, Al, As, Ba, B, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Ni, Na, Pb, Sb, Se, Si, Ti, Te, U, V, Zn, Ra 226), CN-, hardness, dissolved anions (Cl-, F-, SO2-4, NO2-, NO3-), total suspended solids, alkalinity, NH3, total P, total organic carbon and pH.

Detection limits for the above parameters will be at or below the site specific receiving water quality criteria based on the CCME guidelines for the protection of freshwater aquatic life. Field measurements of standard water quality parameters; pH, conductivity, dissolved oxygen (DO), water temperature and stream discharge will also be recorded at each study area using portable instruments, calibrated daily with standards of known value (where applicable).

For QA/QC purposes a laboratory prepared trip blank will accompany water samples during sampling and transport. Field blanks for 10% of the samples will also be performed. In addition, three discrete water quality samples will be collected at each study area as recommended in the technical guidance document (EC, 2012). Laboratory blanks, duplicates, spikes and reference standards will be employed according to standard operating procedures. Chain of custody forms will accompany all samples for identification, tracking and transporting purposes. The level of QA/QC employed will provide confidence in the data collected.

3.3 SUPPORTING BENTHIC INVERTEBRATE COMMUNITY MEASURES

Supporting measures for the benthic invertebrate community survey will be recorded to support the appropriateness of the selected reference areas. These measures include hydrology, stream morphology and substrate characterization.

The wetted width of the channel at time of sampling will be measured at each replicate station. Water depth and point velocities at a minimum of ten locations will be recorded near to the benthic invertebrate community sampling locations at each replicate station. Substrate samples will be collected using a core-style sampler to obtain representative samples of the top 5 cm to characterize the particle size distribution and total organic carbon content at each replicate station.

3.4 BENTHIC INVERTEBRATE COMMUNITY SURVEY

A benthic invertebrate community survey will be conducted as part of the cycle one EEM biological study as required by the MMER. The results of this survey will compare the benthic invertebrate communities between the exposure and reference areas. It is proposed that the benthic invertebrate survey take place in the late summer or early fall (late July to late August), as previous studies have indicated that this is an appropriate season to ensure the collection of the widest diversity of invertebrates.

For the benthic survey, the values of and will both be set at 0.1. This will result in a power of 0.9. To achieve this, the sample size will be set at five. Five replicate stations will be located within each of the exposure and reference sampling areas. The replicate stations will be positioned near to the 2013 site characterization program stations (Table A.1, Appendix A).

Three replicate field sub-samples will be collected at each of the five replicate stations (transects). The replicate field sub-samples will be collected and preserved as composite samples. These field sub-samples will be placed randomly within the replicate station so that all members of the benthic community within the area have an equal chance of being collected. Replicates are needed to ensure that a larger surface area at each station is collected, resulting in a larger proportion of the benthic community represented in the results.

Benthic samples will be collected from similar habitats at each of the monitoring areas, and area characterized as wadeable, erosional areas. The substrate type, stream width/depth, flow dynamics and vegetation will be evaluated prior to sample collection at all replicate stations. The benthic samples will be collected using a Hess sampler with a 500 micron mesh at all the stations.

The surficial area sampled will be recorded for each sample collected. Each benthic sample will be collected, stored separately and preserved with 10% buffered formalin solution. The habitat at each station will be described in detail while in the field, and a field collection record will be completed for each station. Chain of custody forms will accompany all samples for identification, tracking and transporting purposes.

3.4.1 Sample Processing

Benthic samples will be analyzed by a taxonomist. All samples will be sorted with the use of a stereo microscope (10X). A second independent taxonomist will verify the original analyses.

Samples will be washed through a 500 micron sieve and sorted entirely, except in the following instances: those samples with large amounts of organic matter (i.e., detritus, filamentous algae) and samples with high densities of major taxa. In these cases, samples will be first washed through a large mesh size sieve (3.36 mm), to remove all coarse detritus, leaves, and rocks. Large organisms such as fourth instar stoneflies and mayflies retained in the sieve will be removed from the associated debris. The remaining sample fraction will be sub-sampled quantitatively, if necessary.

3.4.2 Taxonomy

All invertebrates will be identified to the lowest practical level, usually family level. Additional identification of oligochaetes, stoneflies, mayflies, dragonflies, amphipods, adult beetles and bugs may be identified to species.

Chironimids and oligochaetes will be mounted on glass slides in a clearing media prior to identification. In samples with large numbers of oligochaetes and chironomids, a random sample of no less than 20% of the selected individuals from each group will be removed from the sample for identification, up to a maximum of 100 individuals.

Following identification and enumeration, a list of individuals collected for each sample will be included in the final interpretive report. The list will be in a standard spreadsheet format.

3.4.3 Data Evaluation

All data will be entered into an electronic database with controlled access. Screening studies will be employed to check for transcription errors or suspicious data points. An individual not responsible for entering the data will confirm that the data entered represents the original. Missing data will be distinguished from absence of particular taxa by using non-zero value codes, with definitions built into each file.

The variation among stations within the study area and analytical variation (among laboratory replicates) will be calculated as estimates of the components of variation in the data set and compared to the expected values.

The benthic community will be investigated to determine if mine discharge is having an effect on the receiving system, as defined by Environment Canada (2012). An effect will be deemed to have occurred in the benthic community when a significant statistical difference between the exposure and reference areas is found for one or more of the key descriptors. The critical effect size of +/- 2 standard deviations will be used to identify higher risk to the aquatic environment as per the EEM technical guidance document (EC, 2012).

Using the standard community indices within an Analysis of Variance (ANOVA) model for control/impact designs, the benthic community at the exposure areas will be compared to their representative reference area(s) to determine effect and provide supporting data (Table 3.3).

Table 3.3 Benthic Invertebrate Community Survey Effect Indicators and Endpoints

Effect Indicator	Effect Endpoints
Total benthic invertebrate density (TID)	Number of animals per unit area
Evenness index	Simpson's evenness
Taxa (family) richness	Number of taxa
Similarity index	Bray-Curtis index

NOTE:
1. MODIFIED FROM METAL MINING TECHNICAL GUIDANCE DOCUMENT TABLE 3-1 (EC, 2012).

As mentioned in Sections 2.4.3 and 2.5.3, prior to submitting the final Cycle One Study Design, Baffinland plans to seek further guidance from EC on the use of the Bray-Curtis Similarity Index, and give due consideration to using the replacement tests identified by Borcard and Legendre (2013).

3.4.4 QA/QC

A composite of three field sub-samples from each replicate station will be collected for benthic invertebrate analyses, to compensate for the within station, spatial variability encountered with benthic organisms. Appropriate QA/QC measures related to processing and identification, as outlined in the EEM technical guidance document will be followed (EC, 2012). These measures will incorporate the proper steps related to re-sorting, sub-sampling and maintenance of a voucher collection, as needed. A subset of the voucher collection will be taxonomically analysed by a second invertebrate taxonomist.

3.5 FISH COMMUNITY, POPULATION AND USABILITY SURVEY

3.5.1 Fish Community

Sufficient historical data have been collected to properly characterize the freshwater fish community in the study areas. Only two fish species are present in the exposure areas; Arctic char and ninespine stickleback. A fish population survey will be conducted as discussed below; any new fish species collected during this study will be documented in the final interpretive report.

3.5.2 Fish Population

A fish population survey of the exposure and reference areas will be conducted as required under the MMER. This is required as the effluent concentration is estimated to be above 1% at a distance of 250 metres from the final discharge points. This study will attempt to collect sufficient numbers (n=100) of the proposed sentinel species (Arctic char). The absence of ninespine stickleback in suitable numbers in the exposure and proposed reference areas precludes their use as a second sentinel species. Environment Canada officials will be notified of insufficient collection numbers during the study, and an agreed upon course of action will be followed to complete the study.

Non-destructive capture methods will be employed for all fish population sampling. Backpack electrofishing will be utilized as the primary means of sampling. A non-lethal survey will pose less of an impact on the fish population than a lethal survey.

Sections of aquatic habitat within the vicinity of each sample area will be fished. The operator of the electrofishing unit will start at a downstream location (relative to the area) and fish in an upstream direction towards natural or placed barriers where possible (e.g., waterfall, natural dam or block net). In this manner, all fish resident in the section of stream being sampled can be captured for measurement. A summary table of the specific sampling dates, collection method, fish species and corresponding numbers collected as well as a calculated CPUE will be included in the final interpretive report.

The fish community survey will follow the non-lethal fish sampling requirements as outlined in the technical guidance document (EC, 2012). Attempts will be made to capture at least 100 Arctic char older than young of the year (+YOY). Any YOY individuals collected will be measured and the proportion of fish that are YOY will be estimated from the first 100 fish collected.

Fish lengths will be measured to the nearest millimetre on a fish board. Weighs of the measured fish will be determined using a digital scale to the nearest 0.01 g. All fish captured will be released alive except for a sub-sample to be retained for aging purposes. Table 3.4 and Table 3.5 outline the fish survey measurements and effect indicators proposed for this study.

Table 3.4 Fish Survey Measurements, Expected Precision and Summary Statistics

Measurement Requirement	Expected Precision	Reporting of Summary Statistics
Length (fork and total)	+/- 1 mm	Mean, median, SD, standard error, minimum and maximum values for sampling areas
Total body weight (fresh)	+/- 1.0%	Mean, median, SD, standard error, minimum and maximum values for sampling areas
Age	+/- 1 year	Mean, median, SD, standard error, minimum and maximum values for sampling areas
Abnormalities	N/A	Presence of any lesions, tumours, parasites, or other abnormalities.
Sex	N/A	N/A

NOTE:
1. MODIFIED FROM THE TECHNICAL GUIDANCE DOCUMENT TABLE 3-1 (EC, 2012).

Table 3.5 Fish Population Effect Indicators and Endpoints

Effect Indicator	Non-lethal Effect and Supporting Endpoints
Survival	Length-frequency distribution Age-frequency distribution (if possible)
Growth	Length of YOY (age 0) at end of growth period Weight of YOY (age 0) at end of growth period Size of YOY+ (age 1+) Size at age (if possible)
Reproduction	Relative abundance of YOY (% composition of YOY) YOY survival
Condition	Body weight at length

NOTE:
1. MODIFIED FROM THE TECHNICAL GUIDANCE DOCUMENT TABLE 3-3 (EC, 2012).

Aging using fin rays will be undertaken. Aging structures will be removed from a minimum of 10% of the test populations sampled and from all incidental mortalities. The ratio of male/female specimens retained for age verification will be attempted, though sex determination of small, immature fish may not be conclusive.

Data will be tested for normality and homogeneity of variance prior to specific hypothesis testing. Transformations of the original data will be performed to normalize or homogenize the variances, where needed. An ANOVA model will be used to test for population differences related to the areas sampled (Reference versus Exposure), for length, weight, and condition factor provided the populations are normally distributed, of equal variance and independent of one another. An ANCOVA model will test for interactions for size-at-age and condition factor (length versus weight by area).

3.5.3 Fish Usability

Effluent quality has been estimated using humidity cell testing results of the ore, local precipitation volumes as well as contact time that precipitation will have with the ore and waste rock stockpiles. The effluent quality is not expected to contain mercury concentrations ≥ 0.01 µg/L, therefore a fish usability study is not proposed in this study design. Should effluent characterization results report concentrations of mercury ≥ 0.01 µg/L a fish usability study will be undertaken as required by the MMER.

4 SUMMARY AND SCHEDULE

The 2013 site characterization program confirmed in-situ conditions at the exposure areas and candidate reference areas. The most suitable reference areas to evaluate the benthic invertebrate community effect endpoints are as follows:

- Camp Lake Tributary Near Field (CLT-NF) : Camp Lake Tributary Reference Area 3 (CLT-REF3)
- Mary River Near Field (MRY-NF) : Mary River Reference Area 4 (MRY-REF4)

The statistical comparisons of the fish population data between the exposure and refernce areas for both receivers show significant difference within and between all groups. As such, additional data analysis may be performed following discussions with Environment Canada to determine an acceptable reference area for the fish component of the EEM cycle one biological monitoring study.

The anticipated timeline that includes milestones associated with the MMER requirements is provided below, and is subject to change based on regulatory approvals and the start of mining.

Mid-September 2014	Start of mining
June 2015	Mine is subject to MMERs once effluent discharge rate reaches 50 m^3/day
September 2015	Submission of Identifying Information & Final Discharge Points (within 60 days after date mine is subject to MMERs)
December 2015	Submission Cycle One Study Design (12 months from initial date when Mine was subject to MMERs)
	Environment Canada review of Cycle One Study Design (6 months)
August-Sept 2016	Conduct Cycle One Biological Monitoring Study (conducted no sooner than 6 months after Cycle One SD submission date)
November 2017	Submission of Cycle One Interpretive Report (within 30 months from initial date when Mine was subject to MMERs)

5 REFERENCES

Baffinland Iron Mines Corporation. 2014. Aquatic Effects Monitoring Program (in-progress).

Borcard, D and P. Legendre. 2013. Review of the pros and cons of available indices applicable to the Environmental Effects Monitoring (EEM) to evaluate changes in benthic invertebrate community structure in response to effluent exposure. Final Report. Project No. K2A80-12-0010. Dated March 15, 2013.

Canadian Council of Ministers of the Environment (CCME). (2007). *Canadian water quality guidelines for the protection of aquatic life: Summary table*. Updated December 2007. In: Canadian environmental quality guidelines, 1999. Winnipeg, MB.

Environment Canada. 2003. *Revised technical guidance on how to conduct effluent plume delineation studies.* National EEM Office, National Water Research Institute and Environment Canada. March 2003.

Environment Canada. 2012. *Metal Mining Technical Guidance for Environmental Effects Monitoring*. The National Environmental Effects Monitoring Office.

Fisheries Act. R.S.C. 1985. c. F-14, June 29, 2012.

Games, P.A., Keselman, H.J., & Rogan, J.C., 1983. *A review of simultaneous pairwise multiple comparisons*. Statistica Neerlandica 37: 53–58.

Knight Piésold Ltd. 2014. *Water and Sediment Quality Review and CREMP Study Design*. Ref.No.NB102-181/33-1, Rev. 2, dated June 26. 2014.

Krebs, C. J. 2001. Ecology. San Francisco, California, Benjamin Cummings.

Minister of Justice. 2014. Consolidation Metal Mining Effluent Regulations. SOR/2002-222. Current to January 23, 2014.

North/South Consultants Inc. 2008. *Mary River Project Freshwater Aquatic Environment Baseline Draft Report: Fish and Fish Habitat*. Winnipeg, MB.

Nunavut Water Board. 2013. *Water Licence No: 2AM-MRY1325*. Motion Number 2013-10-P4-05. June 10, 2013.

Ricker, W.E., 1975. *Computation and interpretation of biological statistics of fish populations*. Ca. Bull. Fish. Aquat. Sci. 191. 382 p.

Wilson, Anne. 2014. Head, Water Quality, Expert Support and Contaminated Sites, Environment Canada. Personal Communication on April 3, 2014.

Appendix B

Water and Sediment Quality CREMP

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT



WATER AND SEDIMENT QUALITY REVIEW AND CREMP STUDY DESIGN

PREPARED FOR:

Baffinland Iron Mines Corporation
2275 Upper Middle Road East, #300
Oakville, Ontario, L6H 0C3

PREPARED BY:

Knight Piésold Ltd.
1650 Main Street West
North Bay, ON   P1B 8G5 Canada
p. +1.705.476.2165 | f. +1.705.474.8095

NB102-181/33-1
Rev 2
June 25, 2014

Knight Piésold
CONSULTING
www.knightpiesold.com

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WATER AND SEDIMENT QUALITY REVIEW AND CREMP STUDY DESIGN
NB102-181/33-1

Rev	Description	Date	Approved
2	Minor Updates to Sections 2.7.8 and 3.6.8	June 25, 2014	
1	Revised Study Design to Align with freshwater biota CREMP	May 30, 2014	RAM
0	Issued in Final	March 28, 2014	RAM

Knight Piésold Ltd.
1650 Main Street West
North Bay, Ontario Canada P1B8G5
Telephone: (705) 476-2165
Facsimile: (705) 474-8095
www.knightpiesold.com

Knight Piésold
CONSULTING

EXECUTIVE SUMMARY

Introduction

Baffinland Iron Mines Corporation (Baffinland) has conducted water and sediment quality baseline studies on the Mary River Project since 2005. This work has been completed in support of an environmental review by the Nunavut Impact Review Board (NIRB) and water licensing by the Nunavut Water Board (NWB). The Project was approved by the NIRB on December 28, 2012 (with the issuance of Project Certificate No. 005) and the NWB issued Type A Water Licence No. 2AM-MRY1325 to Baffinland on July 24, 2013. Baffinland initiated construction of the mine in the summer of 2013.

Baffinland initiated the development of an Aquatic Effects Monitoring Program (AEMP) with the development of an AEMP Framework (Baffinland, 2013a) and an updated AEMP Framework (Baffinland 2013b). A detailed AEMP Plan has been under preparation and will be submitted to the NWB prior to initiating mining in the second half of 2014.

A component study of the AEMP will be a Core Receiving Environment Monitoring Program (CREMP). The CREMP is a detailed aquatics monitoring program that is intended to complement and expand the scope of the Environmental Effects Monitoring (EEM) Program that is required under the Metal Mining Effluent Regulations (MMER). The CREMP is intended to monitor the effects of multiple stressors on the aquatic environment, including the discharge of mine effluents, the discharge of treated sewage effluent and the deposition of ore dust. The CREMP will include the monitoring of water, sediment, phytoplankton, benthic invertebrates and fish in the Project's mine site streams and lakes. Knight Piésold has prepared this baseline review and CREMP study design for the water and sediment components of the aquatic environment, in consultation with North/South Consultants Inc. who have led the freshwater biota aspects of the work and Intrinsik Inc. who have provided toxicological support in the development of the AEMP benchmarks that the monitoring results will be compared against.

A review of water and sediment quality data was undertaken to:

- Identify data quality issues
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water or sediment quality in the mine site area
- Understand the seasonal, depth (for lakes) and inter-annual variability in the water quality data
- Understand natural enrichment of the mine site area waters and sediment
- Determine the potential to pool data from multiple sample stations in order to increase the statistical power of the baseline water and sediment quality dataset
- Develop study designs for monitoring water and sediment quality in mine site streams and lakes
- Determine if changes to the existing water and sediment quality monitoring program are required to meet monitoring objectives

Previous Site Activities

Baffinland has been actively undertaking mineral exploration, bulk sampling and feasibility level studies at the Project site since 2004. These activities have had the potential to affect the water and sediment in the mine site area. Based on our review, limited evidence of effects from exploration activities are apparent.

Review of Baseline Water Quality

The collection of baseline water quality data began in 2005 and was carried through to 2013. Work was completed each year; although only a few samples were collected during 2009 and 2010. As such, there is about 7 to 8 years of baseline data available for the Project. To ensure consistency, all the field work was undertaken by the same small group of individuals.

Streams were typically sampled once in the spring (June), summer (July) and fall (late August/early September). The timing of spring sampling was dependent on the onset of freshet and fall sampling was carried out before the streams ran dry or froze (typically in the second half of September to early October).

Lake water quality/limnology was studied in 2006, 2007, 2008, 2011, 2012 and 2013, but not all lakes were studied in all years. Open lake water quality samples were typically collected during the fall (late August or early September). Winter sampling was carried out in select years at the mine site lakes (Camp, David, Mary and Sheardown Lakes), with sampling carried out typically in late April. Sheardown Lake has been the most studied in the area, since the lake was the receiving water for treated sewage during the open season in 2009, 2011, 2012 and 2013. Lake water quality samples were collected from both shallow depths (1 m below the waterline) and deep depths (approximately 1 m above the lake bottom).

Various graphical analysis tools were utilized to characterize the baseline water quality within the mine site area, with reference to the Canadian Council of Ministers of the Environment's Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-PAL). The following lentic and lotic systems were examined: Mary River, Camp Lake Tributary, Camp Lake, Mary River and Sheardown Lake. In general, all lakes are well mixed and did not show concentration differences with depth, noting the exception of aluminum and chromium. In addition, general chemistry characteristics of the lakes and river site-wide are very similar. Within the Project area, water is characterized as circum-neutral/slightly alkaline pH and high alkalinity/low sensitivity to acidic inputs. Hardness ranges from "soft" to "moderately soft" and is almost entirely carbonate hardness. Seasonal analyses of general chemistry parameters within Mary River show a relationship between spring freshet and hardness, pH, TSS and DOC. TSS does not show distinct trends. Both pH and hardness tend to be slightly lower during spring and increase during summer, to a maximum concentration recorded in the fall. DOC is at its peak during spring and decreases substantially during summer and fall.

Site-wide, nitrate, arsenic and cadmium generally occur at detection limit, with the exception of one site in each river system that has elevated concentrations of both arsenic and cadmium (E0-02 in Mary River and L1-02 in the Camp Lake Tributary) and Mary Lake, which also has elevated concentrations of arsenic and cadmium. Due to detection limit interference, it is difficult to discern temporal and seasonal trends for these parameters.

Iron, aluminum, chromium and copper are observed to be elevated within Mary River and Camp Lake Tributary. Concentrations of these parameters are generally considerably lower in the identified lakes; however, copper remains slightly elevated in all lakes. Aluminum concentrations are slightly elevated, and close to guidelines within Mary Lake and Sheardown Lake SE. The inlets to

Mary Lake see increased concentrations of a number of metals, compared to other stations, but these concentrations generally remain below applicable guidelines. Site-wide, nickel concentrations are quite low. Site-wide, iron concentrations are slightly enriched, but always occur below guidelines.

Iron concentrations are at their peak site-wide during the summer, although elevated concentrations were noted in the Camp Lake Tributary during the spring. Iron concentrations reduce slightly, but remain elevated during the fall. Stream water quality stations consistently depict concentrations in excess of lake water quality stations.

With the exception of one large outlying value for nickel, there are relatively conserved concentrations for nickel are observed throughout the site, during different seasons. There are slightly lower nickel concentrations in the spring; however, a small sample size is also observed.

Copper concentrations increase slightly during the summer and remain slightly elevated during the fall. Some particularly high copper values have been recorded in Camp Lake, which has maximum values that exceed those observed in Mary River.

Stream aluminum concentrations are depressed in the spring, and elevated in the summer. Stream concentrations, particularly those recorded in Mary River are greater than the concentrations recorded in the lakes. Fall concentrations are elevated, when compared to fall and winter, but are less than those concentrations recorded in the summer.

Power Analysis of Water Quality

An initial power analysis was run using a paired Before-After-Control-Impact (BACI) design for each station. The goal was to assess the statistical power of various sample sizes for detecting site-specific change. The power analysis attempted to use a basic BACI design with one impact station and one control station before and after commencement of mining activity. This method was modified in two ways for water quality data: 1) in the absence of pre-mining reference data, only a Control-Impact (CI) assessment was completed, and 2) for parameters with a large amount of data below detection limits, a comparison of proportions was used.

Power analysis was completed for a subset of parameters in select areas within Camp Lake, Sheardown Lake NW, Sheardown Lake SE, Mary Lake, Mary River and Camp Lake Tributary. Key stations were selected, which often corresponded with the EEM near-field and far-field stations. Parameters that were elevated in baseline sampling and expected to be most affected during mine operation were selected to provide conservative representations of other measured parameters. Benchmarks values for water quality developed for the Project (CWQG-PAL or other; Intrinsik, 2014) were applied in the power analysis. Power analysis was completed based on all the existing data, and is expected to be revisited after completion of additional baseline sampling in 2014. The 2014 baseline sampling will occur concurrently with construction, but prior to mine-related effluent or ore dust emissions. To be conservative when creating the study design, a second effect size was added to act as an early warning flag. The second effect size was determined to be halfway between the station mean and the benchmark value.

Water Quality Study Design

The power analysis supported a monitoring program that uses the existing baseline stations, and recommended the addition of the following stations:

- Two stations within the basin at the north arm of Mary Lake, near BL0-01 (stations BL0-01-A and BL0-01-B)
- Two additional stations within the main basin of Mary Lake, near the Mary River inlet near BL0-05 (BL0-05-A and BL0-05-B)
- Sampling of an additional station within Sheardown Lake SE (existing station DL0-02-6)
- Addition of a station in vicinity of L1-09, location to be determined (L1-05)
- Addition of one or two reference stations upstream on Mary River (G0-09-A, G0-09-B)
- Sampling of identified reference lakes, consistent with EEM program

The following sampling frequencies are recommended for each of the different programs:

- Lakes - three sampling events in each available season (winter, summer and fall) during the first three years of mine operation are expected to have adequate power to detect early warning flag concentrations for lake data.
- Streams - four samples (one set of seasonal samples) per year is likely adequate for most parameters to determine significance.

Sampling will be conducted annually during the initial years of operation but sampling frequency will be evaluated regularly (i.e., each year) to determine if modifications are warranted. The sampling frequency and schedule will be evaluated after three years of monitoring.

Review of Sediment Quality

The collection of baseline sediment quality samples for the Project was carried out between 2005 and 2008 and between 2011 and 2013 in conjunction with the water quality baseline program. Sampling of sediment in streams and lakes around the mine site was typically conducted once in the fall (late August/early September) in conjunction with and at the same stations as the water quality and benthic invertebrate sampling.

Metals concentrations in sediment are positively correlated with both finer grained particles as well as higher organic carbon content (Horowitz, 1991). Smaller particles have more binding sites and a higher affinity for metals than coarser grained material. Organic carbon within sediment decreases the dissolved oxygen and creates a more anoxic environment. Depending on pH, an anoxic environment may influence metal solubility and speciation. Within depositional areas of the lake that are characterized by higher concentrations of TOC and/or greater proportions of fine grained sediment, concentrations of several metals regularly exceeded the CSQG-PAL ISQGs or the PSQG-LEL. This includes chromium, copper, iron, nickel and phosphorus, and sometimes arsenic. Iron and manganese in some instances exceeded the PSQG-SEL. Most metals correlated well; in samples where one of the metals was elevated, all others were also elevated, except arsenic and manganese.

At the mine site, depositional environments were predominantly found within the lakes. The main exception to this is the stations within the main tributary of Sheardown Lake (Tributary 1). Streams at the mine site are mostly high gradient, high energy depositional environments that are not likely to have substantial amounts of fine grained sediment or sediment with high organic carbon content.

Power Analysis of Sediment Quality

After an initial exploratory analysis of the sediment baseline data, fifty-two (52) samples were retained that fit cut-off criteria established for TOC and percent sand. Sufficient power to detect a change from baseline values was desired for each station. Baseline data not collected at reference stations and therefore, since baseline reference (control) data not available, a full BACI design was not used for the power analysis. Instead, a before-after (BA) design was used. The power analysis was carried out using a two sample t-test which assumes independence between the before and after samples. Interim area-wide benchmarks for sediment quality developed for the Project (CSQG-PAL, PSQG or other; Intrinsik, 2014) were applied in the power analysis.

After consideration of the inclusion criteria, six to twenty samples were recorded within each of the depositional area lake sampling locations. An additional year of comprehensive sediment sampling within the mine site lakes in 2014 is recommended to supplement this dataset and provide a better basis for refined power analysis.

Instead of using highly variable estimates of station means from the limited baseline data, a generic analysis was used. Power to detect a change from a baseline mean to 97.5th percentiles for a normally distributed variable was used to obtain sample size estimates which apply to all stations and metals. This analysis will be refined for specific stations and metals after 2014 samples are collected and benchmarks have been finalized.

Sediment Quality Study Design

The review of sediment quality baseline identified the need for additional sediment quality stations in the mine site lakes. Additional stations were identified in each lake, corresponding with proposed benthic invertebrate monitoring stations to be monitored under the freshwater biota CREMP (North/South, 2014).

Preliminary sediment sampling locations in each of Camp Lake, Sheardown Lake and Camp Lake are shown on Figures 3.9, 3.10 and 3.11, respectively, and are listed in Table 3.7. The lake sediment stations make use of existing and new (proposed) stations as follows:

- Camp Lake - 14 stations including three historic stations and 11 new stations
- Sheardown Lake NW - 14 stations including six historic stations and eight new stations
- Sheardown Lake SE - 10 stations including four historic stations and six new stations
- Mary Lake - 15 stations including five historic stations and 10 new stations

Lake sediment samples will be collected along transects positioned along the anticipated path of effluent (i.e., direction of inflow stream). At each station, field technicians will establish final locations for the sediment stations that are within depositional areas of the lake. This field fit of the sampling stations will likely result in some modifications to the gradient study design.

Limited stream sediment sampling is proposed for the reasons described in Section 3.5. Select existing stream sediment sampling stations will continue to be monitored as described below (see Figures 3.9, 3.10 and 3.11):

- Four sediment stations within Sheardown Tributary 1 (SDLT-1), a portion of which meet the TOC and % sand cut-offs (SDLT1-R1, D1-01, D1-05, and SDLT1-R4)
- One sediment station in each of Sheardown Tributaries 9, 12 and 13 (SDLT-9-US, SDLT-12-US, SDLT-12-DS), none of which meet the TOC and % sand cut-offs
- Three sediment stations within Camp Lake Tributaries 1 and 2 (CLT-1 and CLT-2) which do not meet the TOC and % sand cut-offs but are the lowest energy stations available (CLT-1-US, CLT-1-DS, CLT-2-DS)
- Two sediment stations on the Mary River, downstream of effluent discharges where sediment collection is possible (E0-20 and C0-05)

Additional pre-mining sediment sampling will be carried out in 2014 to increase the number of baseline sediment samples for comparison in future monitoring. It will be necessary to identify additional stations in depositional areas characterized by high TOC and fines content (or lower sand content), as the depositional areas are more sensitive to change.

In the long-term, sediment sampling under the CREMP will be conducted every three years, coinciding with biological monitoring studies. However, Baffinland will conduct sediment sampling in 2014 to collect additional pre-mining baseline data, and then annually for the first three years of mining. After monitoring three operating (mining) years, the sampling frequency will be conducted on a three year cycle provided annual sampling up to that time supports this change.

TABLE OF CONTENTS

PAGE

TABLES

FIGURES

APPENDICES

1 – INTRODUCTION

1.1 BACKGROUND

Baffinland Iron Mines Corporation (Baffinland) has conducted water and sediment quality baseline studies at the Mary River Project since 2005. This work has been completed in support of an environmental review by the Nunavut Impact Review Board (NIRB) and water licensing by the Nunavut Water Board (NWB). The water and sediment quality baseline data were utilized to support the preparation of the Final Environmental Impact Statement (FEIS) submitted to NIRB in February 2012 (Baffinland, 2012). The Project was approved by the NIRB on December 28, 2012 (with the issuance of Project Certificate No. 005; NIRB, 2012) and the NWB issued Type A Water Licence No. 2AM-MRY1325 to Baffinland on July 24, 2013 (NWB, 2013). Baffinland initiated construction of the mine in the summer of 2013.

At this stage in the Project, attention is shifting from baseline data collection to the development and execution of monitoring programs. These programs include the development of the Aquatic Effects Monitoring Program (AEMP), which is a requirement of Baffinland`s Type A Water Licence. A draft AEMP Framework was issued to the NWB and other regulators on February 26, 2013 (Baffinland, 2013a) and an updated draft AEMP Framework was distributed on December 1, 2013 (Baffinland, 2013b). A final detailed AEMP is under development from the existing framework and will be submitted to the NWB prior to initiating the operations phase of the Project in 2014.

This document presents a review of water and sediment quality data and the development of a study design for the water and sediment components of a key monitoring program referred to as the Core Receiving Environment Monitoring Program (CREMP). The CREMP will be a component program of the AEMP.

1.2 SCOPE OF REVIEW AND STUDY DESIGN

The scope of the baseline review and study design for water and sediment quality monitoring was to:

- Identify data quality issues
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water or sediment quality in the mine site area
- Understand the seasonal, depth (for lakes) and inter-annual variability of water quality
- Understand natural enrichment of the mine site area waters and sediment
- Determine the potential to pool data from multiple sample stations to increase the statistical power of the baseline water and sediment quality dataset
- Develop study designs for monitoring water and sediment quality in mine site streams and lakes, including an a priori power analysis[1]
- Determine if changes to the existing water and sediment quality monitoring program are required to meet monitoring objectives

[1] Power analysis can be used to calculate the minimum sample size required so that one can be reasonably likely to detect an effect of a given size. A power analysis completed before data are collected is an *a priori* or prospective power analysis. *A priori* power analysis is used in estimating sufficient sample sizes to achieve adequate power.

Parameters of interest in the baseline review included water quality stressors of potential concern (SOPCs) identified on the basis of the existence of an established water quality guideline, as well as other factors such as Exposure Toxicity Modifying Factors (ETMF): pH, water hardness, dissolved organic carbon, etc., and indicator parameters (alkalinity, chloride, nitrate). Baseline water quality data was compared to Canadian Council of Ministers of the Environment (CCME) - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-PAL). The focus was on total concentrations (versus dissolved) since CWQG-PAL guidelines are developed for total concentrations. The parameters of interest are displayed graphically in box plots. The box plots are used to portray natural ranges of selected parameters. Concentration data measured for the parameters of interest has been log transformed and further analyzed to investigate the possibility of aggregating data, bearing in mind:

- Seasonal variability (between spring, summer, fall and winter samples)
- Inter-annual variability (from 2006 through 2008 and 2011 through 2013)

To assist in the development of study designs, parameter and station-specific a priori power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework (see Section 2.7.8), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmark values were developed for the identified SOPCs that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 2.7.3 of the main report). Draft benchmarks were applied in the power analysis of the baseline presented in this review.

The results of the above review were used to develop preliminary study designs for the ongoing monitoring of water quality (Section 2.7) and sediment quality (Section 3.6).

1.3 PROJECT ACTIVITIES DURING BASELINE DATA COLLECTION

Baffinland has been actively undertaking mineral exploration, bulk sampling and feasibility level studies at the Project site since 2004. These activities have had the potential to affect the water and sediment in the mine site area. A description of these activities follows.

Baffinland established a camp and initiated exploration drilling at Deposit No. 1 in 2004. Drilling programs were executed most years since 2004, and some exploration was undertaken at nearby Deposit Nos. 2 and 3. Historical drillhole locations are shown in relation to historical water quality sampling stations on Figure 1.1 (mine site area including Mary Lake) and Figure 1.2 (mine site core area). Historic sediment quality sampling stations are shown on Figure 1.3.

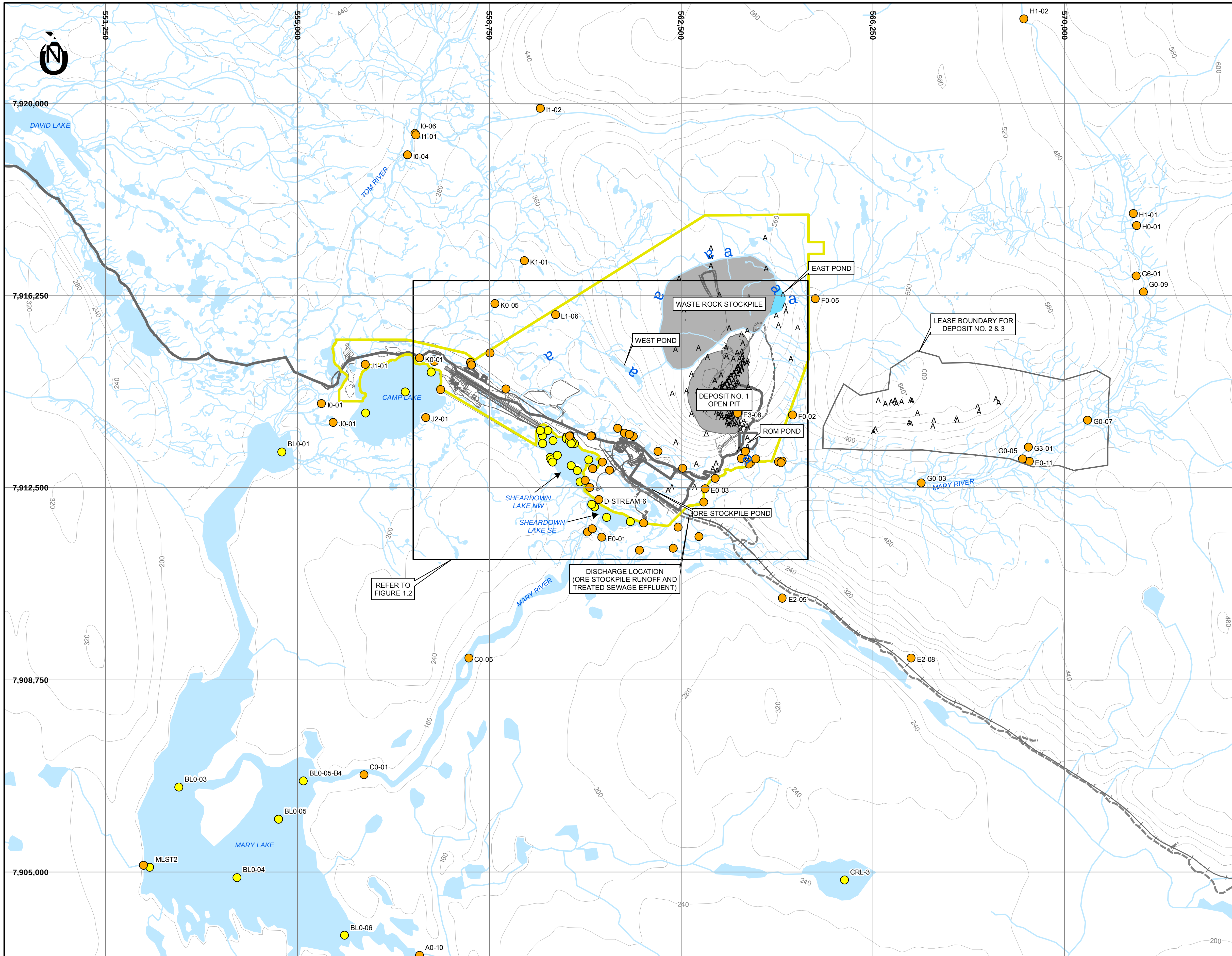
In 2007, Baffinland's operations and facilities were expanded to carry out a bulk sampling program and to accommodate expanded geotechnical investigations and environmental baseline studies. The exploration camp at the mine site was enlarged, the Milne Inlet Tote Road was upgraded, and small camps were established at Milne Port, Steensby Port and mid-way along the proposed railway alignment. With preparatory work completed in 2007, the bulk ore sample was mined in 2008. This included construction of a haul road to Deposit No. 1; mining of an 118,000 tonne bulk sample; crushing, screening and stockpiling of ore at the mine site; haulage of ore over the tote road; and stockpiling and ship loading the ore at Milne Port.

Between 2009 and the start of construction in 2013, site activities typically involved operating a summer camp to support ongoing exploration drilling at Deposits No. 1, 2 and 3; geotechnical investigations; and regional mineral exploration. A small contingent of care and maintenance staff maintained the camp and airstrip and monitored site conditions during the winter months.

The following historic activities have had the potential to affect local water and sediment quality:

- Exploration drilling on Deposits No. 1, 2 and 3 have involved the use of calcium chloride brine. Progressively sophisticated and effective measures were employed over the years to recycle and contain the brine. Monitoring of water quality in the Mary River downstream of Deposit No. 1 has confirmed that calcium chloride has reached the river.
- Treated sewage effluent has been discharged to Sheardown Lake during most open water seasons starting in 2009.
- The bulk sampling program in 2007 and 2008 involved various construction activities, the mining of the ore from the top of Deposit No. 1, as well as the crushing, stockpiling and transport of ore to Milne Port. The crushing activities resulted in the dispersion of dust in the vicinity of Sheardown Lake and its main tributary. Monitoring detected only minor changes to water and sediment quality potentially attributable to bulk sampling operations.

These activities were considered during the review of the baseline dataset.



LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- A DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS MINE SITE AREA

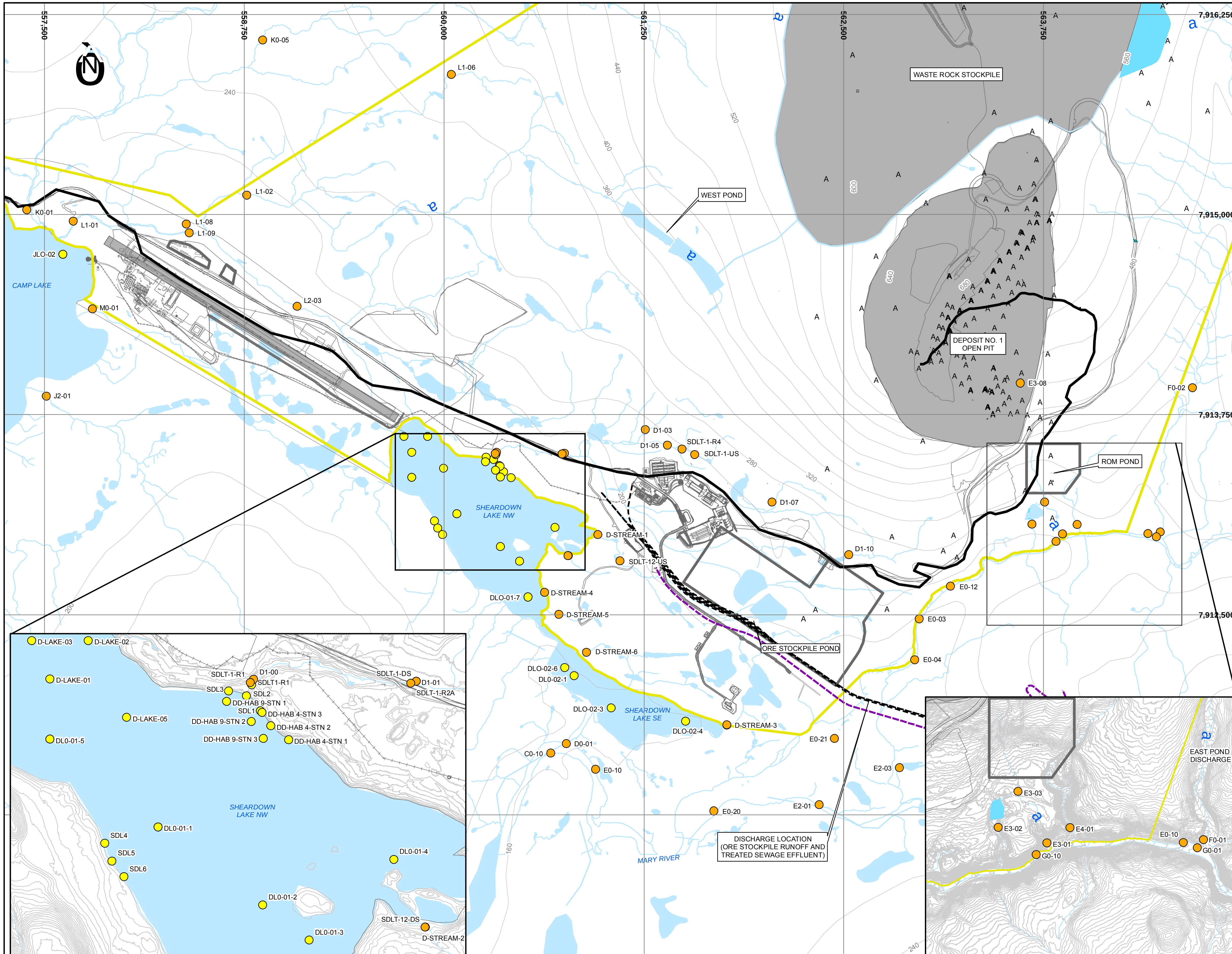
Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 1.1 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM

SAVED: I:\1\02\00181\33\A\GIS\Figs\B20_r1.mxd; Jun 26, 2014 4:19 PM; asimpson



REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	EJA	SWK	RAC	RAM

SAVED: I:\1\02\00181\33\A\GIS\Figs\B21_r1.mxd; Jun 26, 2014 4:22 PM; asimpson

LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- A DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 250 125 0 250 500 750 1,000 1,250 m

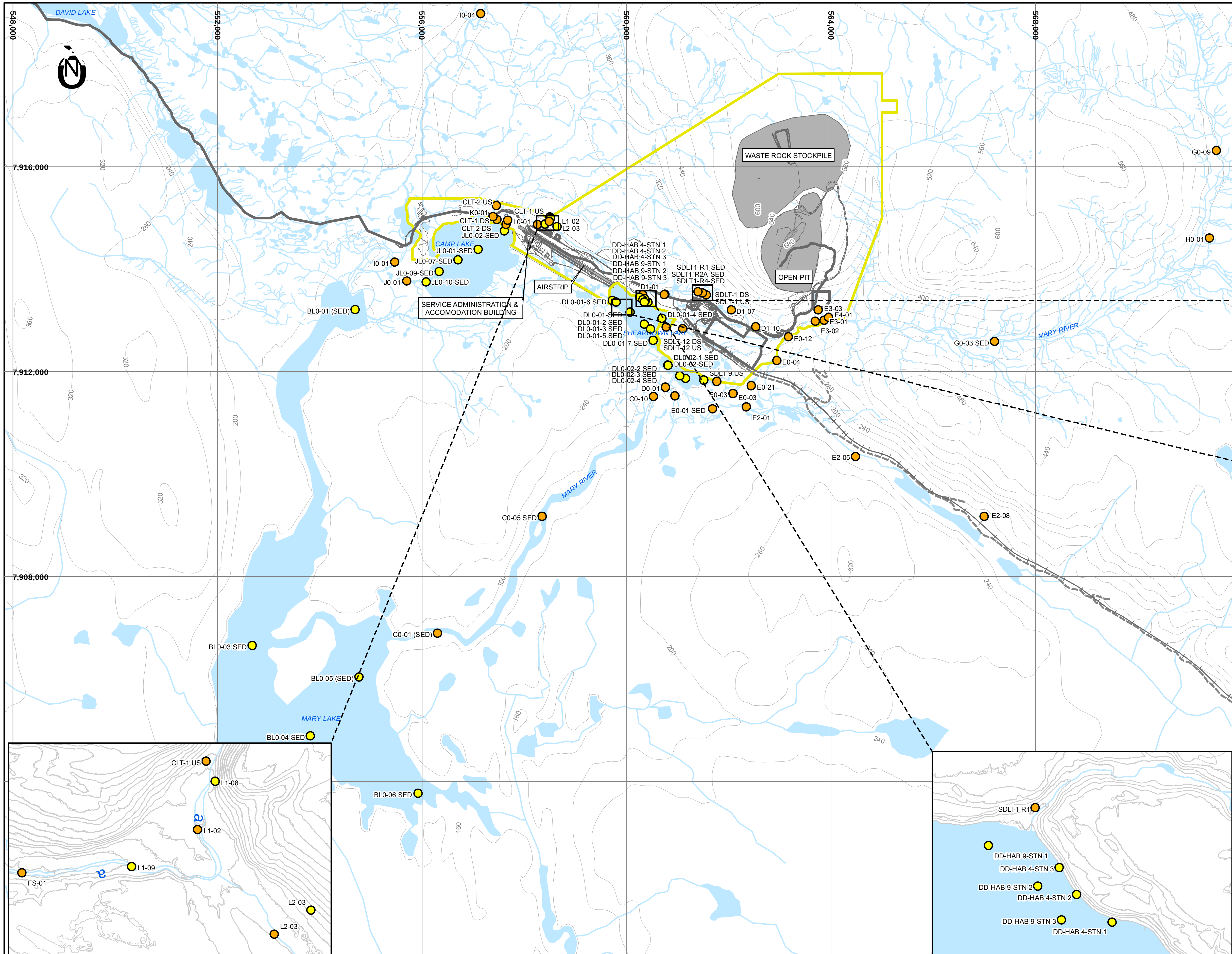
BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

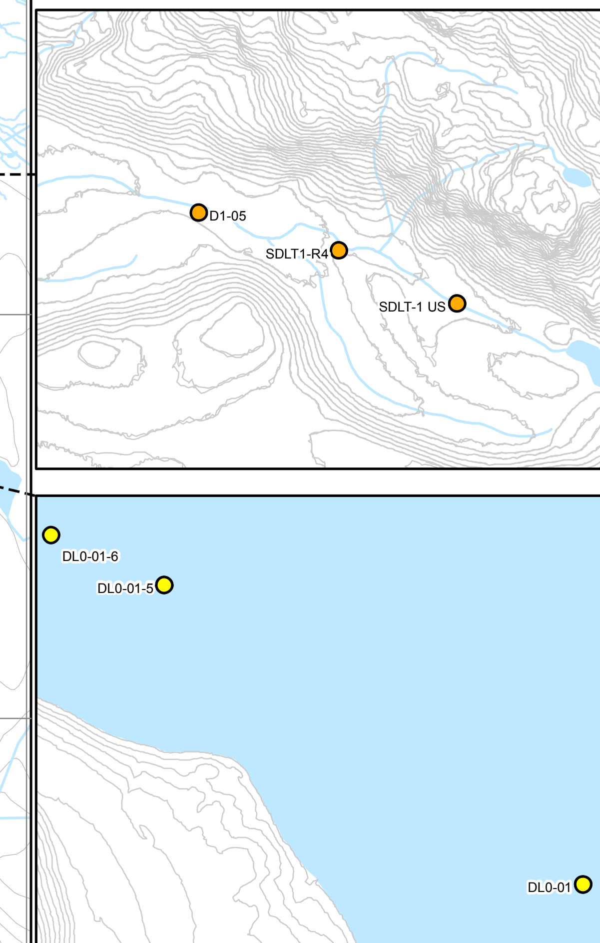
HISTORIC WATER QUALITY STATIONS IMMEDIATE MINE SITE AREA

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 1.2 REV 1



REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM



LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC SEDIMENT QUALITY STATIONS
MINE SITE AREA

Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE 1.3 | REV 1

2 – WATER QUALITY REVIEW

2.1 SUMMARY OF WATER QUALITY PROGRAM

The collection of baseline water quality data began in 2005 and was carried through to 2013. Work was completed each year; however, a very limited number of samples were collected during 2009 and 2010 when the global financial crisis reduced Baffinland's project activities. As such, about 7 to 8 years of baseline data are available for the Project.

Results of the various studies are presented in a number of baseline reports prepared over the years (KP, 2007, 2008, 2010a, 2010b, 2011 and 2012; North/South Consultants Inc., 2008). Water quality data collected in 2012 and 2013 were not previously reported upon but are included within this review.

Sampling and analytical methods, and quality assurance/ quality control (QA/QC) procedures applied during the sampling period are described in the referenced baseline reports. Current sampling methods are described in Appendix A. To ensure consistency, the field work was undertaken by the same small group of individuals.

Historic water quality stations in the mine site area are shown on Figures 1.1 and 1.2. Streams were typically sampled once in the spring (June), summer (July) and fall (late August/early September). The timing of spring sampling was dependent on the onset of freshet and fall sampling was carried out before the streams ran dry or froze (typically in the second half of September to early October). The stream sampling history is presented in Table 2.1.

Lake water quality/limnology was studied in 2006, 2007, 2008, 2011, 2012 and 2013, but not all lakes were studied in all years (Table 2.2). Open lake water quality samples were typically collected during the fall (late August or early September). Winter sampling was carried out in select years at the mine site lakes (Camp, David, Mary and Sheardown Lakes), with sampling carried out typically in late April. Sheardown Lake has been the most studied in the area, since the lake was the receiving water for treated sewage during the open season in 2009, 2011, 2012 and 2013.

Table 2.1 Timing of Stream Water Quality Sampling

Year	Winter	Spring	Summer	Fall
2005	No sampling	June 9 - 11	August 9 - 12	September 9 - 11
2006	No sampling	June 18 - 26	July 2 - 30; Aug 6 - 14	Aug 20 - Sept 20
2007	No sampling	June 13 - 24	July 1 - 28; August 5 - 12	Aug 19 - 31; Sept 2 - 30
2008	No sampling	June 9 - 24	July 1 - 21; August 1 - 11	Aug 18 - Sept 16
2009	No sampling	June 29	July 6 - 20	Aug 9 - 18; Sept 2 - 14
2010	No sampling	No sampling	No sampling	Aug 13; Sept 15
2011	No sampling	No sampling	July 21 - 26	Aug 28 - Sept 1
2012	No sampling	June 18 - 23	July 22 - 24	Aug 24 - 31
2013	No sampling	June 21 - 23	July 23 - 25	Aug 20 - Sept 3

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30.
2. DUE TO NO FLOW, NO SAMPLING OF STREAMS OCCURRED DURING THE WINTER.
3. DURING 2009 AND 2010 VERY LIMITED SAMPLING OCCURRED ONLY WITHIN MARY RIVER.

Table 2.2 Timing of Lake Water Quality Sampling

Year	Winter (Lakes)	Spring	Summer	Fall
2005	No sampling	No sampling	No Sampling	No sampling
2006	No sampling	No sampling	July 31 - Aug 2	Aug 31 - Sept 6
2007	May 6 - 8	No sampling	Aug 5 - Aug 14	Aug 13 - 20; Sept 13 - 20
2008	May 11	June 25	July 30 - 31; Aug 5 - 7	Sept 2 -14
2009	No sampling	No sampling		
2010	No sampling	No sampling		
2011	No sampling	No sampling	July 24 - 26	Sept 2 - 6
2012	April 27 - 28	No sampling	No sampling	Aug 21 - 26
2013	May 2 - 5	No sampling	July 25 - 28	Aug 24 - Sept 1

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30TH.
2. LAKE SAMPLING GENERALLY DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE, WITH THE EXCEPTION OF ONE SAMPLING EVENT IN 2008.
3. NO SAMPLING OCCURRED DURING 2009 AND 2010.

2.2 REVIEW OF WATER QUALITY DETECTION LIMITS

Method detection limits (MDLs; also referred to as Method Recording Limits - MRLs or Limits of Quantification - LOQs) have changed for a number of water quality parameters since baseline sampling was initiated in 2005. These changes are primarily due to improvements in laboratory instrumentation. The MDLs for key parameters are presented in Table 2.3.

Baffinland is interested in utilizing its existing baseline dataset to the maximum extent possible. The objective is to reduce the number of sampling events that would be required to detect a statistical change during project monitoring. Power analyses can be used to calculate the minimum sample size needed to reasonably detect an effect of a given size. The statistical power needed to detect change during future monitoring is a function of the number of sampling events and the spread in the results.

A number of parameters, particularly metals, are present in the water quality dataset at low concentrations (below their MDLs). For several parameters, the dataset contained different detection limits over the sampling period due to improvements in analytical laboratory tools. As such, the dataset contains a high proportion of non-detects at various MDLs.

In the interest of utilizing as many results as possible to increase the statistical power of the dataset, the baseline dataset was plotted in relation to the MDL(s) for each metal parameter. An example plot for silver is presented as Figure 2.1. Plots of this type provide a visual representation of the various MDLs and their influence on the dataset.

From review of the statistics (i.e., number and percent detects), the following actions were taken:

- For those parameters in which at least 85% of the water quality dataset was below detect limits even at the lowest MDL, the lower MDL number was adopted and replaced the higher MDL non-detect results.
- For those parameters in which less than 85% of the water quality dataset was non-detect (or conversely, more than 15% of the dataset was measured at detectable concentrations), a replacement of the lower MDL was not undertaken. Instead, the non-detect results at the higher MDL(s) were removed from the dataset. While these deletions reduce the potential statistical power of the dataset, the higher MDL non-detect results will skew the baseline results if they are left in the dataset.

Table 2.3 summarizes the yearly detection limits for each of the parameters along with any MDL adjustments that were undertaken. The MDL assessment successfully removed the occurrence of most historically elevated MDLs. In instances where 15% of the data were detectable, and below an MDL, the non-detect values at the elevated MDL were removed. In some cases, more than one MDL remained below detectable concentrations. In these instances, the MDLs were kept as is. For this reason, it is still possible to locate multiple detection limits within the data. As discussed, these lower valued MDLs are not expected to interfere with data analysis.

Knight Piésold CONSULTING

TABLE 2.3

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WATER AND SEDIMENT QUALITY REVIEW AND PRELIMINARY CREMP STUDY DESIGN
REVIEW OF WATER QUALITY METHOD DETECTION LIMITS

Print Apr/01/14 11:25:12

Parameters	Units	Receiving Water Quality Objectives (2012)	Method Detection Limits							% Detects in the Dataset	MDL Changes to the Dataset
			2005	2006	2007	2008	2011	2012	2013		
General Parameters											
Alkalinity	mg/L CaCO3	-	2	5	5	5	5	5	5	Not reviewed	No changes
Br-	mg/L	-	0.3	0.05	0.05	0.05	0.25	0.25	0.25		
Cl-	mg/L	120	0.2	1	1	1	1	1	1		
Conductivity	uS/cm	-	1	5	5	5	5	5	5		
NH3+NH4	mg/L N	0.021-2313	0.1	0.02	0.02	0.02	0.02	0.02	0.02		
NO2-	mg/L N	0.06	0.06	0.005	0.005	0.005	0.1	0.005	0.005		
NO3-	mg/L N	13	0.05	0.1	0.1	0.1	0.1	0.1	0.1		
NO2+NO3	mg/L N	-	0.06	0.1	0.1	0.1	0.1	0.1	0.1		
Phenols	mg/L	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001		
Chlorophyll-a	mg/m3	-					0.2				
Pheophytin-a	mg/m3	-					0.2				
SO4-	mg/L	-	0.5	1	1	1	1	3	3		
TKN	mg/L	-			0.1	0.1	0.1	0.1	0.1		
TOC	mg/L	-			0.5	0.5	0.5	0.5	0.5		
DOC	mg/L	-			0.5	0.5	0.5	0.5	0.5		
TSS	mg/L	-			2	2	2	2	2		
TDS	mg/L	-	30	5	5	5	1	1	1		
Hardness	mg/L CaCO3	-	0.5	1	1	0.5	0.5	0.5	0.5		
Phosphorus	Total	-	0.02	0.01	0.003	0.003	0.003	0.003	0.003		
Turbidity	NTU	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Total and Dissolved Metals											
Aluminum	mg/L	0.94	0.004	0.005	0.001	0.001	0.003	0.003	0.003	93%	
Antimony	mg/L	-	0.0004	-	0.0001	0.0001	0.0001	0.0001	0.0001	0%	
Arsenic	mg/L	0.005	0.005	0.001	0.0001	0.0001	0.0001	0.0001	0.0001	5%	Non-detects at 0.005 and 0.001 were revised to <0.0001
Barium	mg/L	-	0.01	0.01	0.00005	0.00005	0.00005	0.00005	0.00005	68%	
Beryllium	mg/L	-	0.005	-	0.0005	0.0005	0.0005	0.0001	0.00002	0%	
Bismuth	mg/L	-	0.0003	-	0.0005	0.0005	0.0005	0.0005	0.0005	0%	
Boron	mg/L	1.5	0.05	0.01	0.01	0.01	0.01	0.01	0.01	5%	
Cadmium	mg/L	0.000029	0.0001	0.0001	0.000017	0.000010	0.00001	0.00001	0.00001	8%	Non-detects at 0.0001 were revised to <0.00001
Calcium	mg/L	-	0.05	1	0.05	0.05	0.05	0.05	0.05		
Chromium	mg/L	0.0047	0.001	0.001	0.0005 0.001	0.0005	0.0005 0.001	0.0001	0.0001	16%	Non-detects from 2005 through 2011 were revised to <0.0001
(Hexavalent) Chromium	mg/L							0.001	0.001		
(Trivalent) Chromium	mg/L							0.005	0.005		
Cobalt	mg/L	-	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	12%	
Copper	mg/L	0.002	0.0008	0.001	0.0001 0.001	0.0001	0.0005	0.0005	0.0005	72%	Non-detects at 0.001 were removed from the dataset
Iron	mg/L	0.3	0.02	0.03	0.03	0.03	0.03	0.01	0.01	64%	
Lead	mg/L	0.001	0.0002	0.001	0.00005	0.00005	0.00005	0.00005	0.00005		Non-detects at 0.001 were removed from the dataset
Lithium	mg/L	-	-	-	0.005	0.005	0.005	0.0005	0.0005	4%	
Magnesium	mg/L	-	0.005	1	0.1	0.1	0.1	0.1	0.1	100%	
Manganese	mg/L	-	0.0007	0.01	0.00005 0.01	0.00005	0.00005	0.00005	0.00005	62%	Non-detects at 0.01 were removed from the dataset
Mercury	mg/L	0.000026	0.0001	0.00005	0.00005	0.00001	0.00001	0.00001	0.00001	1%	Non-detects at 0.0001 and 0.00005 were revised to <0.00001
Molybdenum	mg/L	0.073	0.0003	0.005	0.00005 0.005	0.00005	0.00005 0.005	0.00005	0.00005	55%	Non-detects at 0.005 were removed from the dataset
Nickel	mg/L	0.083	0.001	0.005	0.0005	0.0005	0.0005	0.0005	0.0005	42%	Non-detects at 0.001 and 0.005 were removed from the dataset
Potassium	mg/L	-	0.02	0.01	2	0.05	0.05	0.05	0.05	48%	
Selenium	mg/L	0.001	0.005	0.001	0.001	0.001	0.001			1%	Non-detects at <0.001 and <0.005 were revised to <0.0001
Silicon	mg/L	-	-	-	0.05	0.05	0.05	0.05	0.05	99%	
Silver	mg/L	0.0001	0.0001	0.0001	0.00001 0.00005 0.00001	0.00001	0.000001	0.000001	0.000001	3%	Non-detects at 0.001 and 0.00005 revised to <0.000001
Sodium	mg/L	-	0.05	0.05	2	0.05	0.0012	0.0012	0.0012	86%	
Strontium	mg/L	-	0.001	0.001	0.0001	0.0001	0.0001	0.0002	0.0002	100%	
Thallium	mg/L	0.0008	0.0002	-	0.0001	0.0001	0.0001	0.00001	0.00001	0%	
Tin	mg/L	-	0.001	0.01	0.0001	0.0001	0.0001	0.0001	0.0001	10%	
Titanium	mg/L	-	0.003	-	0.01	0.01	0.01	0.01	0.01	20%	
Uranium	mg/L	0.015	-	-	0.00001	0.00001	0.00001	0.00001	0.00001	98%	
Vanadium	mg/L	0.006	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	8%	
Zinc	mg/L	0.03	0.001	0.01	0.001	0.001	0.003	0.003	0.003	22%	Non-detects at 0.01 were removed from the dataset

I:\1\02\00181\33\A\Report\Report 1 - Baseline WQ Review and CREMP Design\Rev 0\Tables\[Table 2.3 MDL Review 140221 RAC.xlsx]NB Table

NOTES:

1. MDL VALUES MAY BE ELEVATED IN INDIVIDUAL SAMPLES DUE TO SAMPLE MATRICES. THE MDL VALUES ABOVE REPRESENT THE NORMAL VALUE.
2. MULTIPLE MDL VALUES ARE NOTED FOR SEVERAL PARAMETERS IN 2007 DUE TO TWO LABORATORIES DOING METALS ANALYSIS FOR COMPARISON PURPOSES.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	28MAR'14	ISSUED WITH REPORT NB102-181/33-1	MAS	RAC	RAM

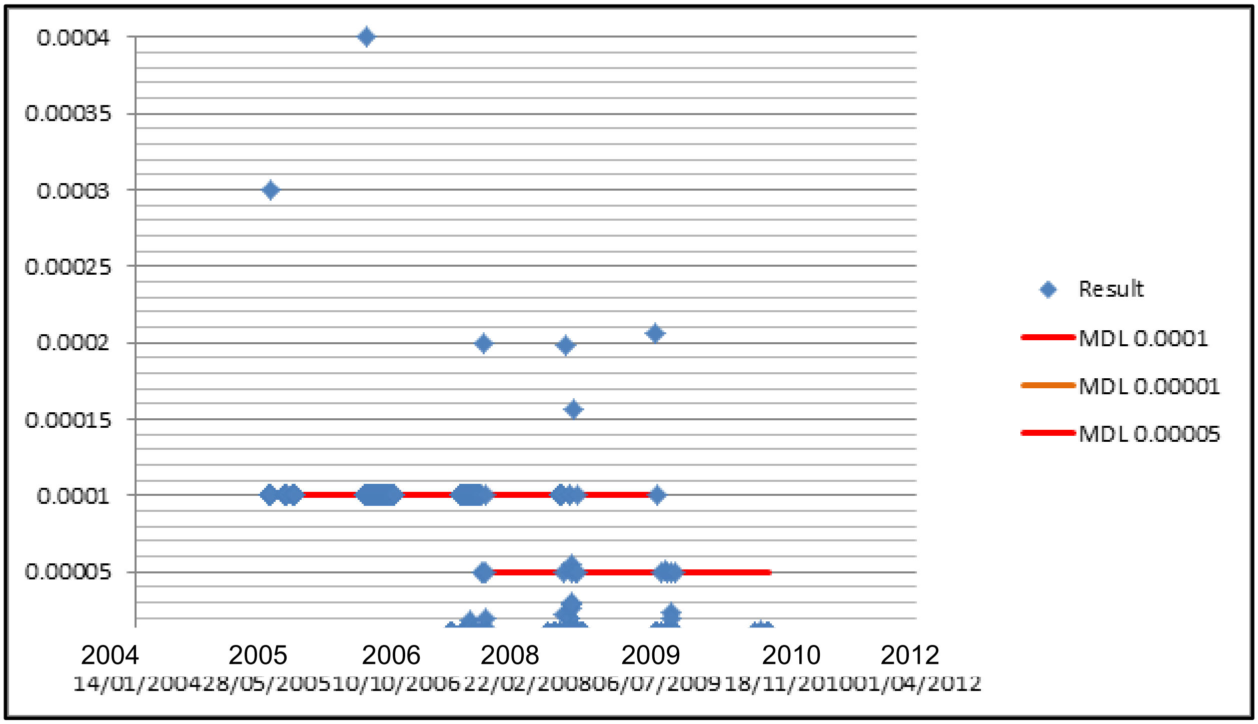


Figure 2.1 Example MDL Evaluation Graph - Silver

2.3 TREATMENT OF OUTLIERS

Once the non-detect results were modified or removed, the data were then plotted graphically and reviewed statistically in order to identify outliers. An outlier is an unusually extreme value for a variable, given the statistical model in use (Edwards, 1998). It is important to note that water quality data are among the environmental data that naturally produces extreme values. As such, outlier removal was only undertaken if there were a data entry error or if there was a quality assurance explanation that justified data removal.

2.4 WATER QUALITY PARAMETERS OF CONCERN

The parameters of concern are those metals predicted by water quality modeling to be of most concern during mine operation, and those that are currently enriched naturally. These parameters are the focus on the baseline review and include:

- Aluminum
- Arsenic
- Cadmium
- Chloride
- Chromium
- Copper
- Iron

- Nitrate
- Nickel

Aluminum, copper, iron and nickel were found to be naturally enriched in the Project Area, relative to the Water Quality Guidelines. Other parameters that have the potential to be elevated, but at a lower magnitude, due to mine site releases include the following (these parameters were not a focus of the baseline review):

- Cobalt
- Lead
- Phosphorous
- Silver
- Thallium

Not surprisingly, several of the above parameters were found to be naturally elevated in the vicinity of the mine site. In several watercourses, the mean concentrations of the above parameters occasionally exceeded the generic criteria of the Canadian Environmental Quality Guidelines for the protection of freshwater aquatic life (CWQG-PAL). As such, interim site-specific water quality objectives (SSWQOs) were initially developed by Knight Piésold (2012b) during review of the FEIS.

These Interim SSWQOs and the generic CWQG-PAL criteria are referred to in the following discussions for the above parameters.

2.5 GRAPHICAL ANALYSIS OF WATER QUALITY DATA

A detailed review of water quality was undertaken using various graphical analysis tools to characterise the baseline water quality for waterbodies expected to be most influenced by mine operations. A detailed review of the mine site area lake and stream water quality is presented in Appendix B and Appendix C, respectively. The raw data for pH, hardness, alkalinity and parameters of interest are displayed graphically in box plots and scatter plots in these two appendices. A summary of the key findings of the reviews presented in Appendices B and C is presented in the following sub-sections.

2.5.1 Lake Water Quality

Lake water quality sampling was completed in the vicinity of the mine site at Camp Lake, Sheardown Lake and Mary Lake between 2006 and 2008 and between 2011 and 2013 (Figures 1.1 and 1.2). Lake water quality samples were collected from both shallow depths (1 m below the waterline) and deep depths (approximately 1 m above the lake bottom).

The lakes in the study area are typically ice covered between October and June. As such, most of the data was collected during the summer and fall, while the least amount of data were collected during the winter.

Table 2.4 summarizes the range and median values of the general water chemistry parameters selected for evaluation. The water chemistry is similar between the three mine site lakes and is generally slightly alkaline and soft with alkalinity values similar to hardness values, suggesting that the hardness is predominantly carbonate hardness.

Table 2.4 Concentrations of Select General Chemistry Parameters in Mine Site Lakes

Parameter	Camp Lake	Sheardown L. NW	Sheardown L. SE	Mary Lake
In Situ pH (pH)	6.93 - 8.23 (7.88)	6.76 - 8.33 (7.94)	6.41 - 8.32 (7.85)	6.71 - 8.55 (7.68)
Alkalinity (mg/L $CaCO_3$)	50 - 74 (60)	47 - 72 (57)	43 - 82 (50)	25 - 126 (38)
Hardness (mg/L)	50 - 77 (59.6)	43 - 77.9 (60.5)	16 - 82 (51.75)	24.9 - 137 (39.5)
Chloride (mg/L)	<1 - 4 (1)	<1 - 4 (3)	<1 - 5 (3)	<1 - 14 (2)
Nitrate (mg/L)	<0.10	<0.10 - 0.18 (0.10)	<0.10	<0.10

NOTES:
1. MEDIAN CONCENTRATIONS IN BRACKETS.

A summary of the trends observed during the review of water quality within the individual lakes follows.

2.5.1.1 Camp Lake

The trends observed in the Camp Lake baseline data included:

- Distinct depth trends are not observed for Camp Lake, which suggests that the lake is completely mixed through much of the year. Review of data above suggests aggregation of deep and shallow stations may be appropriate.
- Geographic trends between discrete sampling stations were not observed for any parameters.
- With the exception of chloride and chromium, parameters did not show any distinct inter-annual trends/variability over the six year sampling history. Chloride and chromium concentrations in Camp Lake measured from 2011 through 2013 are elevated compared to earlier samples from 2005 to 2010.
- Parameters with MDL interference and/or that do not show seasonal trends include: cadmium, chloride, arsenic, iron and nitrate.
- Parameters that have maximum concentrations occurring in the summer: nitrate and aluminum. This is likely as a result of the spring runoff period caused by rapid melt of winter snowpack.
- Parameters that have maximum concentrations occurring in the winter: copper and nickel. Most of this concentration occurs in a dissolved form, not as particulate.
- Parameters that have maximum concentrations occurring in the fall: chromium.

2.5.1.2 Sheardown Lake

Summary of trends observed during review of Sheardown Lake NW baseline data:

- Deeper sampling stations show slightly elevated concentrations of aluminum. Distinct depth trends are not observed for other parameters within Sheardown Lake, which suggests that lake is completely mixed throughout the year, despite winter ice. As a result, aggregation of deep and shallow stations is appropriate for all parameters except aluminum.
- Detection limits decreased over the course of sampling and this decrease is particularly apparent in the copper and iron concentration data.
- Little variability was observed between geographically distinct sampling stations.
- Parameters below MDLs and/or do not show any seasonal trends: arsenic, cadmium, chloride, chromium, copper, nitrate and iron.
- Parameters with highest concentration occurring in the fall: aluminum.

- Parameters with highest concentrations occurring in the winter: nickel. The majority of the elevated nickel and copper total concentrations are in predominantly dissolved form.

Summary of trends observed during review of Sheardown Lake SE baseline data:

- Distinct depth trends are not observed for any parameters within Sheardown Lake SE. This suggests that the lake is completely mixed throughout the year, despite winter ice.
- Elevated concentrations observed at DL0-02-4 compared to other stations: copper, iron and nickel.
- Early data (2007, 2008) appears elevated when compared to more recent data: copper and nickel.
- Parameters below MDLs and/or do not show any seasonal trends: nitrate, arsenic, cadmium, chromium and copper.
- Parameters with highest concentration occurring in the summer and/or fall: aluminum and iron.
- Parameters with highest concentrations occurring in the winter: chloride and nickel.

2.5.1.3 Mary Lake

Summary of trends observed during review of Mary Lake baseline water quality data:

- Distinct depth trends were not observed for any parameters within Mary Lake, which suggests complete mixing of the lake. As a result, both deep and shallow station data have been utilized to inform baseline trends in water quality.
- Inlet sampling shows elevated concentrations for certain parameters: aluminum, chloride, copper, iron, hardness, chromium and nickel.
- Parameters that occur below MDL or do not show seasonal trends include: cadmium, copper, nitrate, and chromium.
- Parameters with the highest concentrations in the summer include: aluminum and iron.
- Parameters with the highest concentration during the fall include: arsenic.
- Parameters with the highest concentration during the winter: chloride, nickel and cadmium.
- The overall trends in the lake baseline water quality data include:
- The only parameter with distinct depth trends is aluminum in Mary Lake. The rest of the data gathered at lake stations suggests aggregations of deep and shallow stations is appropriate.
- Mary Lake inlet sampling was the only station that showed variability between geographically distinct sampling stations. In particular, slightly elevated concentrations for aluminum, chloride, copper, iron, hardness, chromium and nickel were observed (although elevated, these concentrations were below guidelines). Outlet sample locations show elevated concentrations of arsenic.
- Aluminum was noted to have high summer concentrations at all stations, with the exception of Sheardown Lake NW where highest concentrations were recorded in the fall. This would be expected given the magnitude of the spring runoff that is caused by rapid melting of the winter snowpack.
- Arsenic, cadmium and nitrate (except for some slightly elevated fall concentrations) generally occurred below MDL and seasonal affects were difficult to discern.
- Chloride, iron and copper did not show conserved seasonality trends at most stations.

- Nickel was generally high during the winter, which was not necessarily expected. One possibility is that under-ice formation concentrates solutes at depth. However, this trend would be expected to occur for all parameters. Data indicates that nickel and copper were present predominately in their dissolved form during the winter, while other parameters were present predominately in particulate form.

2.5.2 Stream Water Quality

Since 2005, a variety of watercourses have been sampled as part of the baseline monitoring program. For the purposes of the CREMP, a subset of the baseline sampling stations was selected that were deemed applicable for future monitoring. As a result, only two river/tributary systems were examined: Mary River and the Camp Lake Tributary. In general, similar station-wide and seasonal trends were noted for each parameter within rivers/tributary systems on the property. No distinct inter-annual trends were noted. Comparison of the general chemistry of the two systems indicates the general composition is quite similar: water is characterised as circum-neutral/slightly alkaline pH and high alkalinity/low sensitivity to acidic inputs. Hardness ranges from “soft” to “moderately soft” and is almost entirely carbonate hardness.

Chemical concentration trends were analysed with the knowledge that the intense spring runoff period resulting from winter snowpack melting characterizes the artic hydrologic cycle (Stewart and Lamoureux, 2011). Our data indicates highest trace metal concentrations occur during summer (and occasionally fall), and that spring concentrations are generally lowest. This indicates that the snowpack is acting as a fresh, diluting seasonal input.

Station-wide, nitrate, arsenic and cadmium general occur at detection limit. Chloride and nickel generally occur above MDL, but below guideline values. Chloride concentration increases through the seasons from the lowest recorded concentration in the spring to the highest recorded concentrations in the fall. In Mary River, the highest nickel concentrations occur in the summer; whereas, no seasonal trends are noted for nickel within the Camp Lake Tributary. Copper concentrations are consistently close to guideline value throughout the station, with highest concentrations occurring in the summer and fall.

Aluminum and iron show slightly different trends between stations within Mary River and the Camp Lake Tributary. Within Mary River, median total aluminium concentrations occur above CWQG-PAL guidelines, but below the SSWQO and are highest during the summer. Within the Camp Lake Tributary, median total aluminum concentrations are generally low and below the CWQG-PAL guideline and are highest during the spring. Total iron concentrations within Mary River are consistently close to the guideline, with maximum values exceeding guideline and highest concentrations occurring in the summer. Within the Camp Lake Tributary, iron concentrations are consistently below guidelines, with maximum values occurring during the spring.

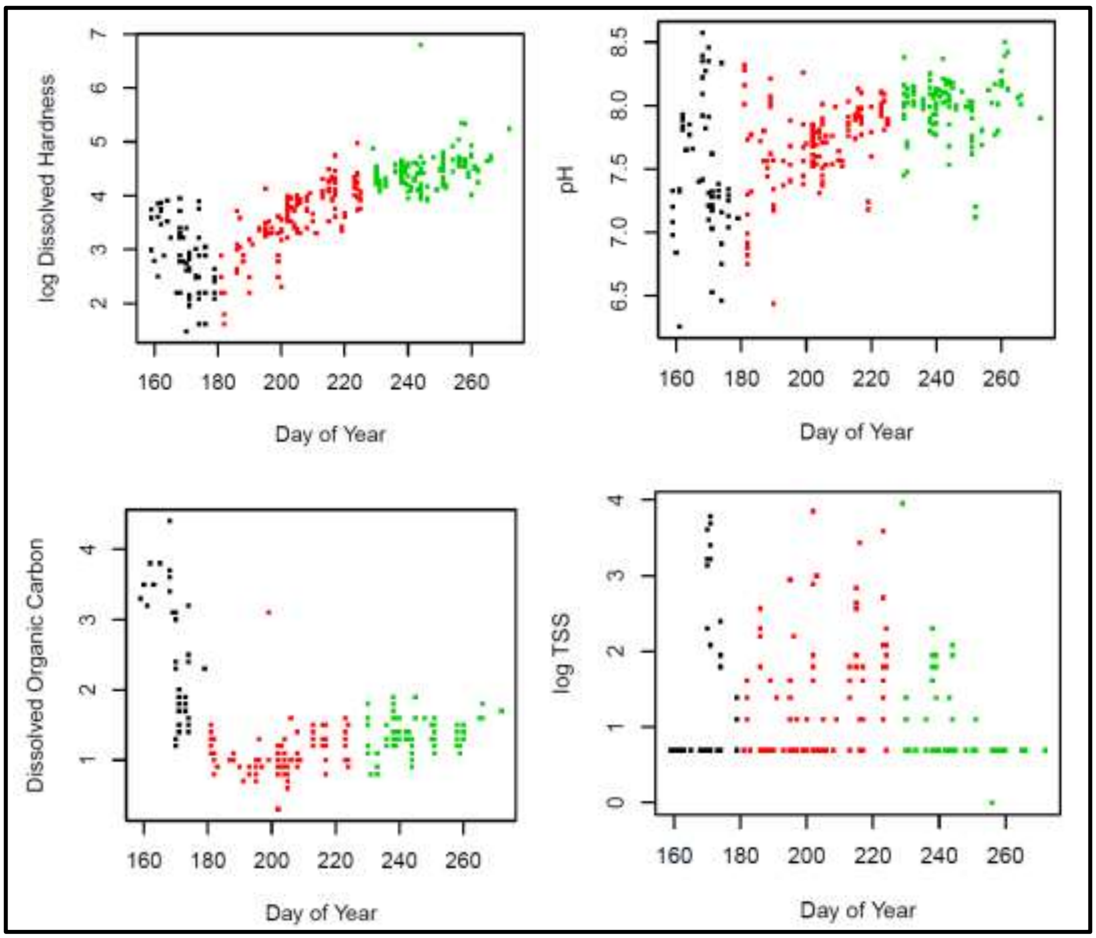
2.5.3 Site-Wide Overview of Water Quality Including Seasonal Trends

General site-wide trends were noted for the concentration of many parameters. Few inter-annual trends of significance were noted, with the exception of a general decline in detection limits. Site-wide and seasonal trends are parameter-specific and were fairly consistent for river stations. Seasonal trends for lake stations were less consistent. In general, all lakes are well mixed and did not show concentration differences with depth, with the exception of aluminum.

2.5.3.1 General Chemistry

Site-wide, general water chemistry is consistent across stations within rivers and lakes. Circum-neutral/slightly alkaline pH (7.3 through 7.8) is noted throughout the site. The water is characterized by high alkalinity, indicating low sensitive to acidic inputs and "soft" hardness and is composed almost entirely of carbonate hardness. Water within the Camp Lake tributary ranges from "moderately soft" to "soft". In general, metal concentrations within the three lakes (Camp Lake, Sheardown Lake and Mary Lake) are reduced and below guidelines, when compared to river samples from Mary River and the Camp Lake tributary, which exceed certain guidelines. High background metal concentrations are expected in an area with such a rich ore body.

Seasonal review of general chemistry shows the relationship between spring freshet and hardness, pH, TSS and DOC. TSS does not show very distinct trends. Both pH and hardness tend to be slightly lower during spring and increase during summer, to a maximum level recorded in the fall. DOC is at its peak during spring and decreases substantially during summer and fall (Figure 2.2). Geographic trends for pH are not noted within Mary River (Figure 2.3).



NOTES:

1. BLACK (SPRING); RED (SUMMER); GREEN (FALL).

Figure 2.2 Mary River - pH, TSS, DOC and Hardness

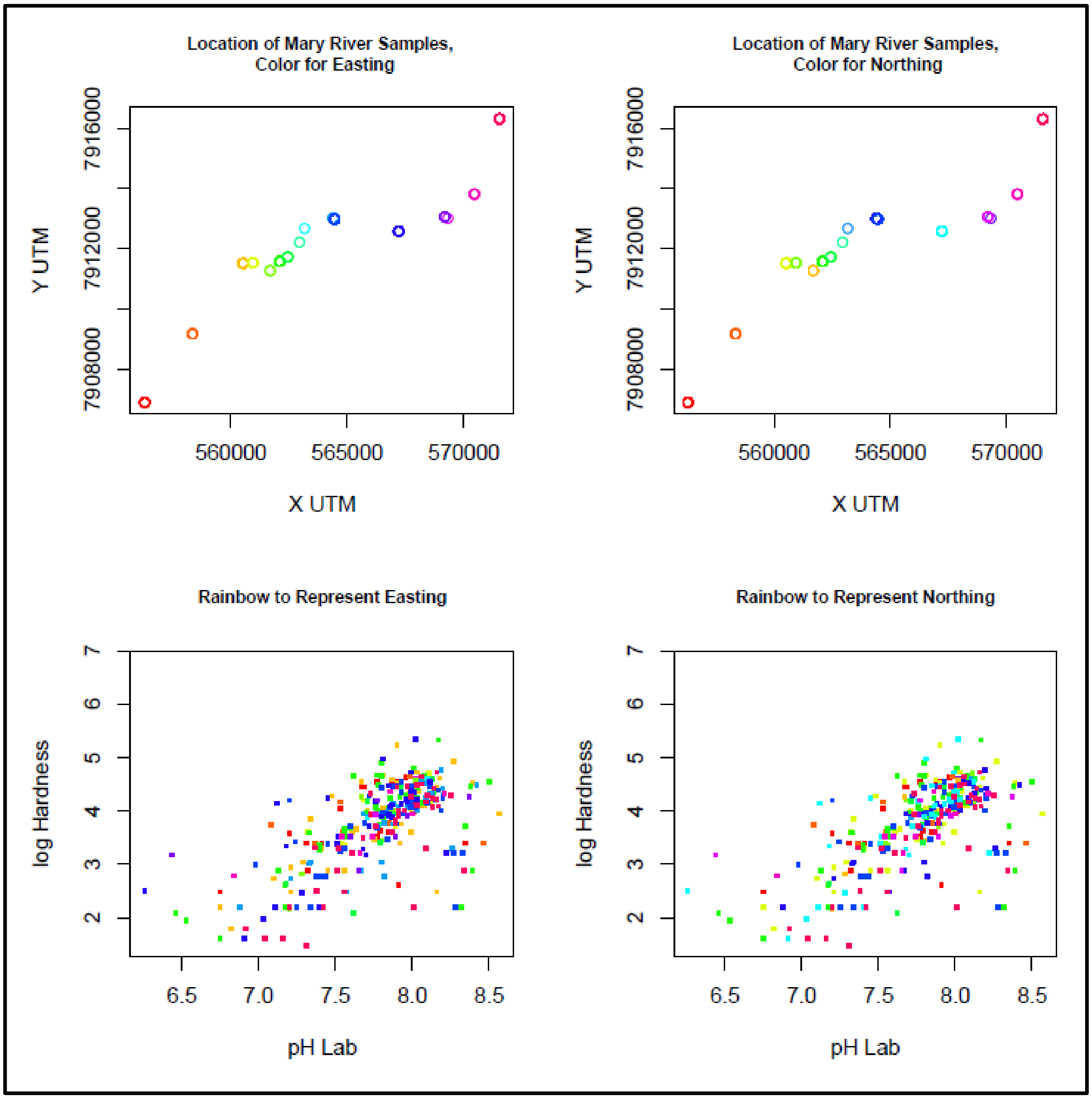


Figure 2.3 Mary River - Geographic pH Trends

2.5.3.2 Anions, Nutrients and Metals

Site-wide, nitrate, arsenic and cadmium occur at detection limit, with the exception of the Mary Lake outlet, which has slightly elevated arsenic concentrations. Due to detection limit interference, it is difficult to discern temporal and seasonal trends for these parameters.

Iron, aluminum, copper and chromium are observed to be elevated and often occur above guideline values within Mary River and Camp Lake tributary. Concentrations of these parameters are generally quite a bit lower in the identified lakes. Camp lake has high outlying iron concentrations; Mary Lake has elevated aluminum and chromium concentrations and Sheardown Lake SW has elevated aluminum and copper concentrations (Table B.9). Site-wide, iron concentrations are slightly enriched, but always occur below guidelines.

A more detailed discussion of seasonal trends site-wide for chloride, iron, nickel, copper and aluminum follows. Site-wide trends observed match closely to the trends observed for streams, but not lakes. This is simply a result of the magnitude difference between stream and lake concentrations. Lake concentrations are consistently depressed when compared to stream concentrations. Lake concentrations also have subtle differences in seasonality that can only be determined by looking at the lake in question. With the exception of chloride and nickel, site-wide the other elevated parameters are seen to increase during the summer months.

Exploration drilling on Deposits No. 1, 2 and 3 has involved the use of calcium chloride brine, as mentioned in Section 1.3. Progressively more sophisticated and effective measures were employed over the years to recycle and contain the brine. Monitoring of water quality in the Mary River in the E3 tributary, downstream of Deposit No. 1 in 2007/2008 confirmed that calcium and chloride were quite elevated downstream of this activity. Chloride concentrations reached maximum concentrations of approximately 3,000 mg/L. Detailed analysis of concentrations at E0-03 indicated that calcium and chloride concentrations were significantly reduced, but slightly elevated. Chloride concentrations reached a maximum of 73 mg/L within E0-03 and had seasonal peaks during the summer (Figure 2.4 and Figure 2.5). Despite use of the drilling salts during baseline, plots of the entire dataset indicate chloride concentrations are not distinctly elevated.

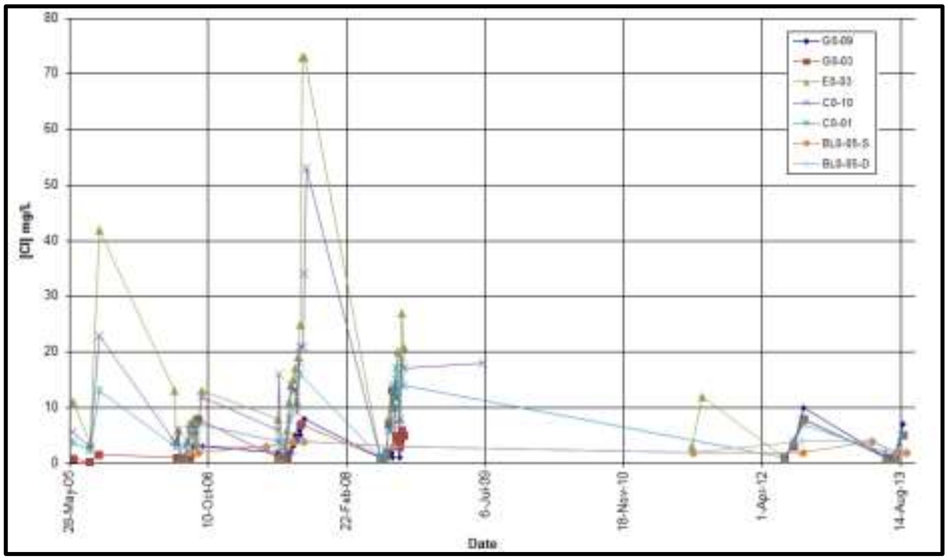
Figures 2.6 through 2.8 depict the changes in concentrations that occur during seasons in both the streams and lake in vicinity to the proposed mine site. Spring lake concentrations are never depicted and neither are winter stream concentrations. Figure 2.6 shows a small increase in chloride concentrations during the fall, with highest concentrations recorded at E0-03 and C0-01 and within the Camp Lake Tributary. In general, lake concentrations of chloride are below concentrations of chloride measured in the streams.

Iron concentrations are at their peak site-wide during the summer, although elevated concentrations were noted in the Camp Lake Tributary during the spring, as shown on Figure 2.7. Iron concentrations reduce slightly, but remain elevated during the fall. Stream water quality stations consistently depict concentrations in excess of lake water quality stations.

With the exception of one large outlying value for nickel, Figure 2.8 shows relatively conservative concentrations for nickel are observed throughout the site, during different seasons. Slightly lower nickel concentrations in the spring; however, a small sample size is also observed.

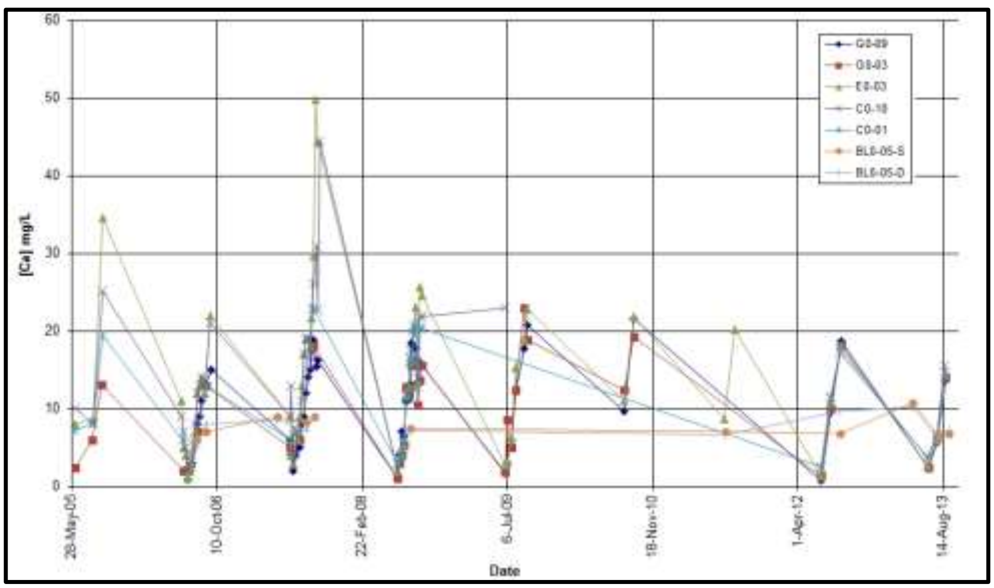
Copper concentrations increase slightly during the summer and remain slightly elevated during the fall, as depicted on Figure 2.9. Some particularly high copper values have been recorded in Camp Lake, which has maximum values that exceed those observed in Mary River.

Stream aluminum concentrations are depressed in the spring, and elevated in the summer, as shown in Figure 2.10. Stream concentrations, particularly those recorded in Mary River are greater than the concentrations recorded in the lakes. Fall concentrations are elevated, when compared to fall and winter, but are less than those concentrations recorded in the summer.



NOTES:
1. G0-09 REPRESENTS BACKGROUND CONDITIONS.
2. E0-03 REPRESENTS A LOCATION DIRECTLY INFLUENCED BY DRILLING ACTIVITIES.
3. G0-03 REPRESENTS BACKGROUND IN 2005 AND 2006 (NO DRILLING AT DEPOSITS NO. 2 AND 3).

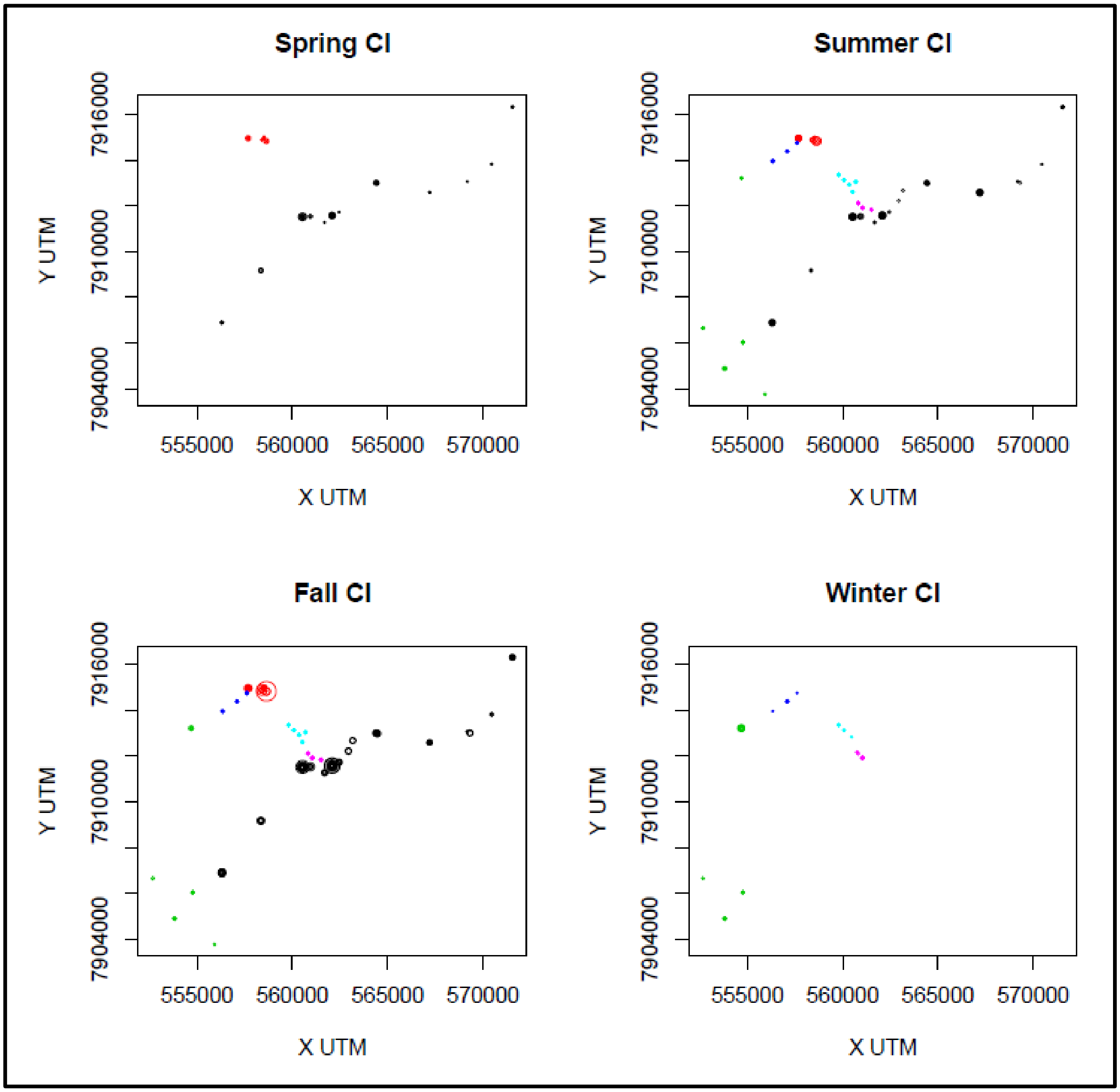
Figure 2.4 Chloride Concentrations in Mine Site Waters over the Study Period



NOTES:
1. G0-09 REPRESENTS BACKGROUND CONDITIONS.
2. E0-03 REPRESENTS A LOCATION DIRECTLY INFLUENCED BY DRILLING ACTIVITIES.
3. G0-03 REPRESENTS BACKGROUND IN 2005 AND 2006, AS THERE WAS NO DRILLING ON DEPOSITS NO. 2 AND 3.

Figure 2.5 Calcium Concentrations in Mine Site Waters over the Study Period

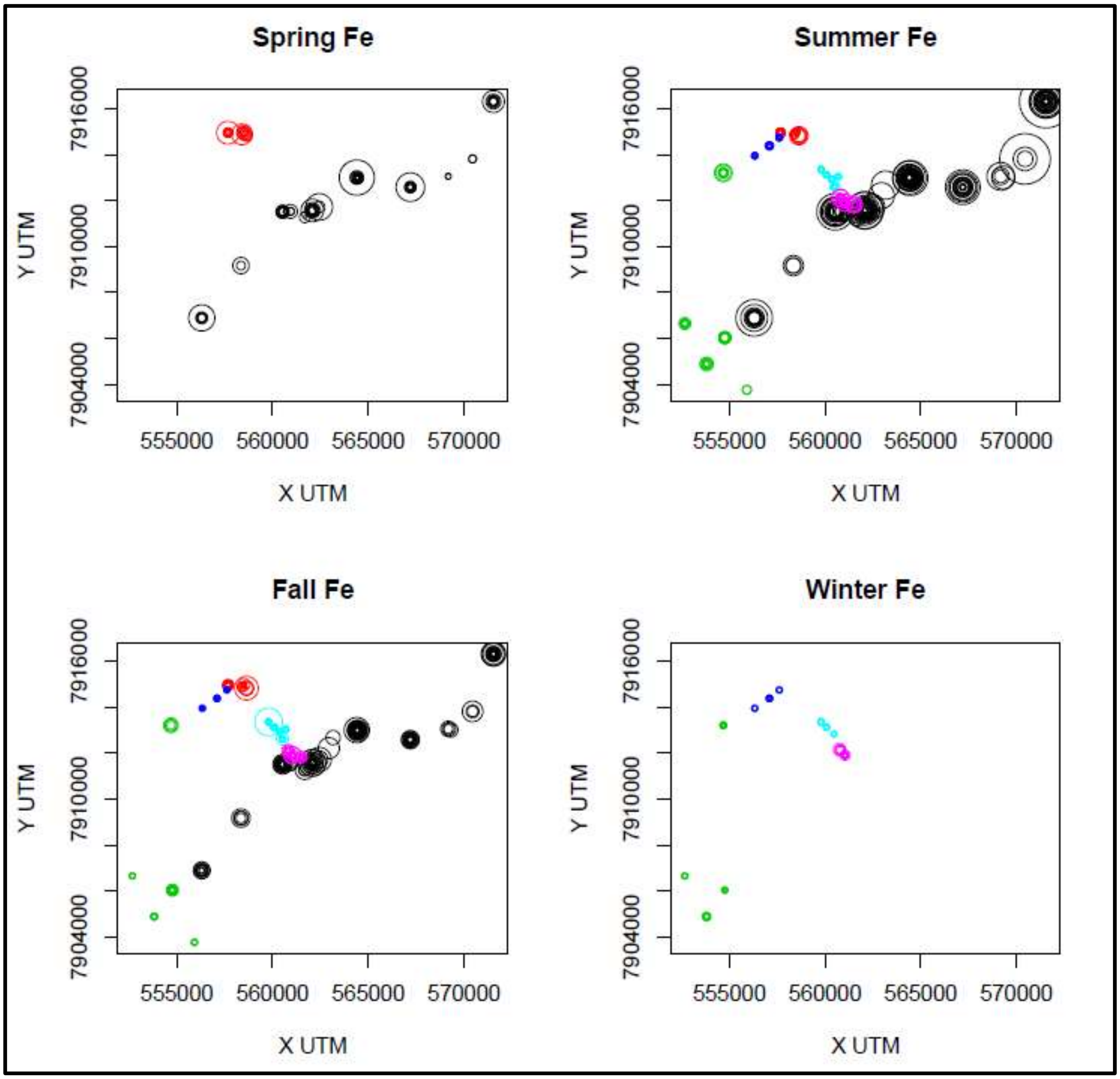
Knight Piésold CONSULTING



NOTES:

1. AREA OF THE DOT IS EQUAL TO CONCENTRATION OF THE PARAMETER.
2. BLACK (MARY RIVER); RED (CAMP LAKE TRIBUTARY); GREEN (MARY LAKE); DARK BLUE (CAMP LAKE); LIGHT BLUE (SHEARDOWN LAKE NW); PINK (SHEARDOWN LAKE SE).
3. THE SITE WITH CLEARLY ELEVATED CONCENTRATIONS IS E0-03.

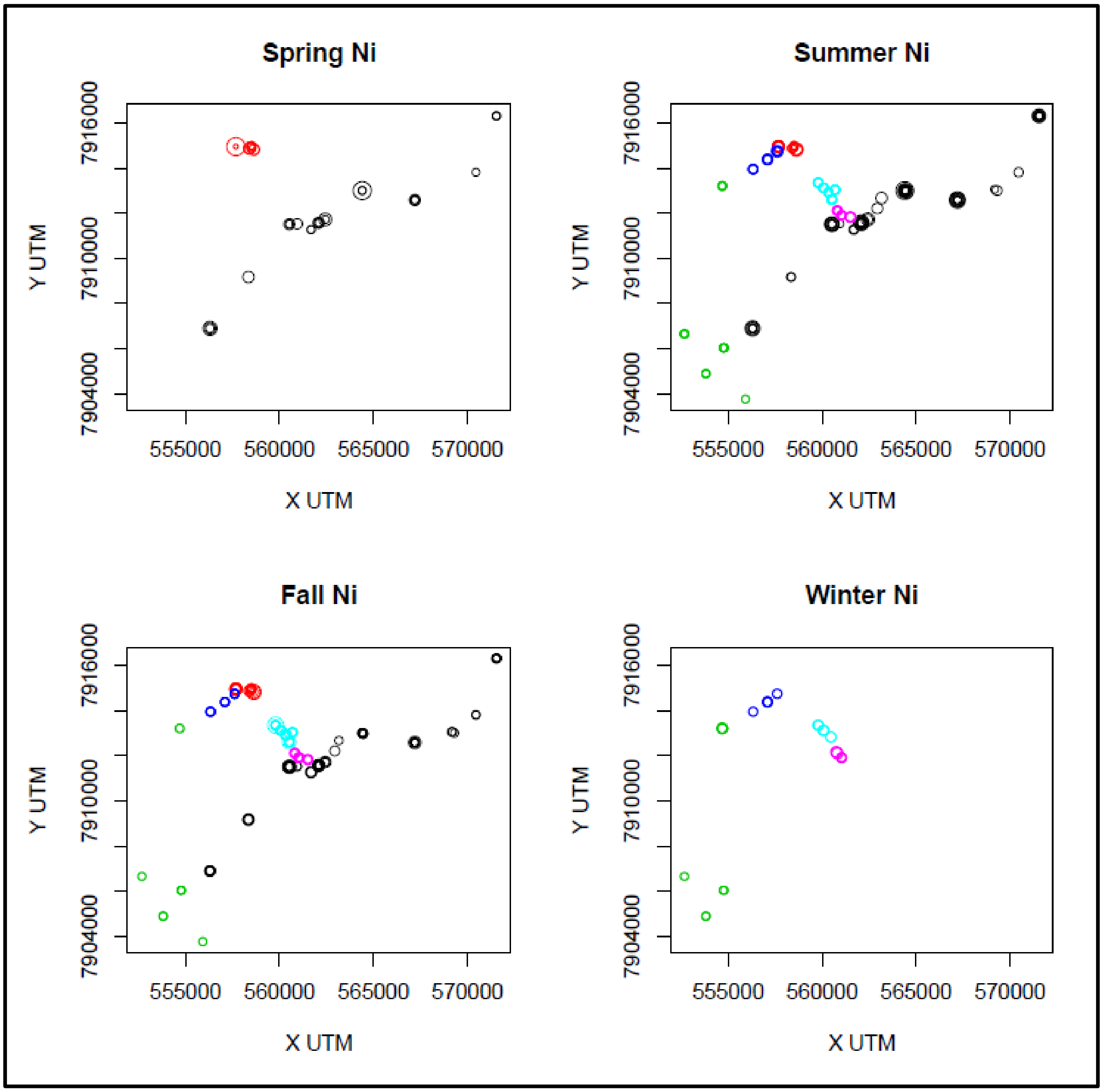
Figure 2.6 Site-Wide Seasonal Trends for Chloride



NOTES:

1. AREA OF THE DOT IS EQUAL TO CONCENTRATION OF THE PARAMETER.
2. BLACK (MARY RIVER); RED (CAMP LAKE TRIBUTARY); GREEN (MARY LAKE); DARK BLUE (CAMP LAKE); LIGHT BLUE (SHEARDOWN LAKE NW); PINK (SHEARDOWN LAKE SE).

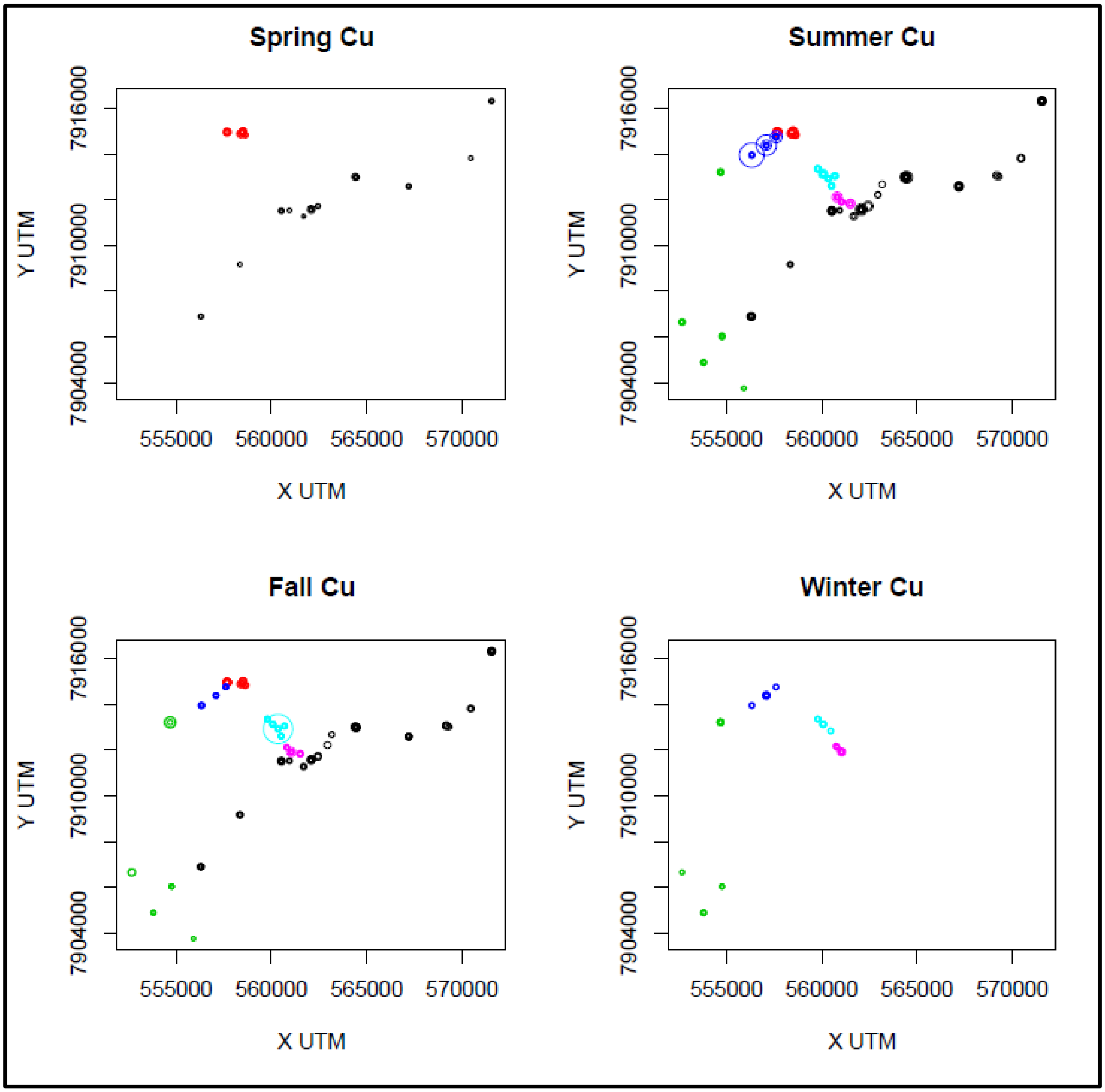
Figure 2.7 Site-Wide Seasonal Trends for Total Iron



NOTES:

1. AREA OF THE DOT IS EQUAL TO CONCENTRATION OF THE PARAMETER.
2. BLACK (MARY RIVER); RED (CAMP LAKE TRIBUTARY); GREEN (MARY LAKE); DARK BLUE (CAMP LAKE); LIGHT BLUE (SHEARDOWN LAKE NW); PINK (SHEARDOWN LAKE SE).

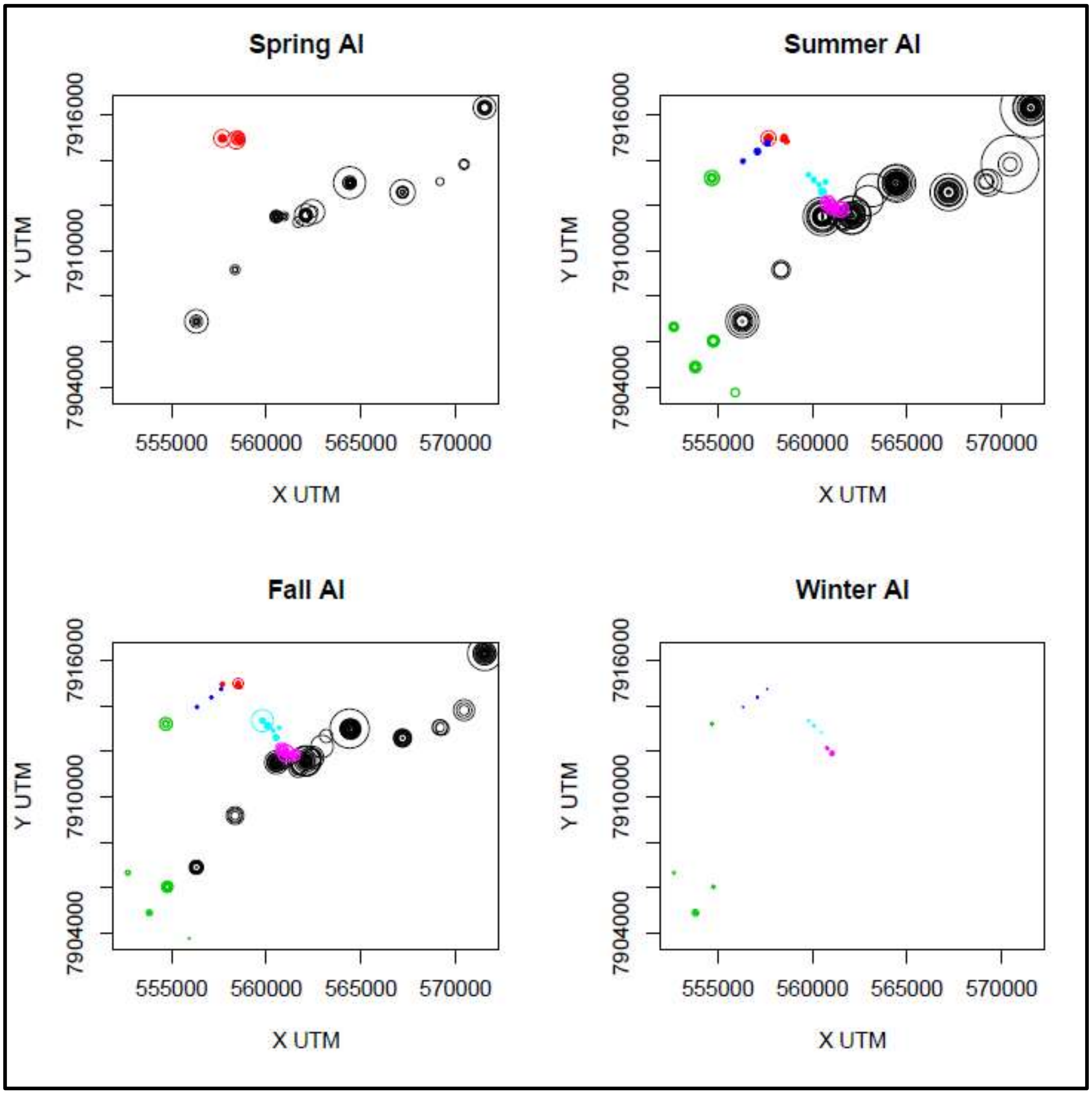
Figure 2.8 Site-Wide Seasonal Trends for Total Nickel



NOTES:

1. AREA OF THE DOT IS EQUAL TO CONCENTRATION OF THE PARAMETER.
2. BLACK (MARY RIVER); RED (CAMP LAKE TRIBUTARY); GREEN (MARY LAKE); DARK BLUE (CAMP LAKE); LIGHT BLUE (SHEARDOWN LAKE NW); PINK (SHEARDOWN LAKE SE).

Figure 2.9 Site-Wide Seasonal Trends for Total Copper



NOTES:

1. AREA OF THE DOT IS EQUAL TO CONCENTRATION OF THE PARAMETER.
2. BLACK (MARY RIVER); RED (CAMP LAKE TRIBUTARY); GREEN (MARY LAKE); DARK BLUE (CAMP LAKE); LIGHT BLUE (SHEARDOWN LAKE NW); PINK (SHEARDOWN LAKE SE).

Figure 2.10 Site-Wide Seasonal Trends for Total Aluminum

2.5.3.3 Chromium

A discussion of chromium is appropriate since most of the sampling to date has been for total chromium yet the CWQG-PAL guidelines are for two chromium species (trivalent chromium - Cr III and hexavalent chromium - Cr VI). During review of the FEIS, naturally elevated concentrations of total chromium were identified within mine site waterbodies, and as discussed in Section 2.4, an interim SSWQO of 0.0047 mg/L was established based on the 95th percentile of baseline concentration of total chromium in the Mary River upstream of the deposits.

In 2012 and 2013, analysis of chromium (III) and chromium (VI) was added to the program to understand the concentrations of these two chromium species. The generic criteria for chromium (III) and chromium (VI) is 0.0089 mg/L and 0.001 mg/L, respectively.

The majority of total chromium samples as well as chromium (III) and chromium (VI) samples were measured below MDLs. The MDLs for total chromium, chromium (III) and chromium (VI) are presented in Table 2.5.

Table 2.5 Water Quality Objectives for Chromium

Parameter	CWQG-PAL or SSWQO (mg/L)	MDL (mg/L)
Cr (total)	0.047	0.0001
Cr (III)	0.0089	0.005
Cr (VI)	0.001	0.001

The MDLs are higher for Cr (III) and Cr (VI) compared to total chromium. Total chromium was measured in 36% of samples within the Camp Lake Tributary and 38% of the samples in Mary River. There were no detectable concentrations of Cr (III) and Cr (VI) in Mary River for only 5% of Cr (III) and 2% of Cr (VI) samples were above MDLs.

Monitoring of chromium in water will likely need to focus on total chromium as a parameter of concern; however, the proportion of detectable concentrations of Cr (III) and Cr (VI) will also be monitored as an indicator of increasing concentrations over time.

2.5.3.4 Total Phosphorus and Total Kjeldahl Nitrogen

Total phosphorus was found to be elevated in the water in the streams and in the sediment in depositional areas of streams (Sheardown Lake tributary) and in the lakes (Camp, Mary and Sheardown Lakes). The distribution of total phosphorus within the Mary River system from the station furthest upstream of Deposit No. 1 (G0-09) to the station as far downstream as Mary Lake is presented in Table 2.5.

It can be seen from this table that the total phosphorus concentrations are elevated in the baseline condition throughout the Mary River system. According to Baffinland, limestone in the area is high in phosphorus up to a couple of percent by weight (Michael Zurowski, pers. comm.). This limestone outcrops to the west of Sheardown Lake and the weathered material from this limestone is found in the overburden throughout the mine site area. As such, it is possible that the concentrations of total phosphorus in the Mary River system is due to increased contact with local soils. Moss (2012) notes clay particles in soils also tend to bind tightly with phosphorus making the phosphorous resistant to simple leaching by water.

Concentrations of total phosphorus in lake sediment are high and regularly exceed the Ontario Sediment Quality Guideline`s Lower Effects Level (LEL) criterion for total phosphorus in depositional areas of the lake where metals also tend to accumulate. Sediment quality results are discussed in more detail in Appendix D, Section 3.

Monitoring of nutrients from sewage discharges to Sheardown Lake NW and the Mary River is anticipated to form a component of the AEMP. Table 2.6 suggests that total phosphorus concentrations in the mine site waters are elevated, and more importantly for monitoring, are highly variable, ranging widely from below the MDL of 0.003 mg/L (ultra-oligotrophic) to 0.035 to 0.100 mg/L (eutrophic) at each of the sampling stations in the Mary River, Mary Lake and Sheardown Lake.

Table 2.6 Total Phosphorus in the Mary River and Mary Lake

Sample Location	Total Phosphorus Concentration (mg/L)				CCME Eutrophication Scale	
	Min	Mean	Max		Category	TP (mg/L)
G0-09 (upstream)	<0.003	0.015	0.069		Ultra-oligotrophic	<0.004
G0-01	<0.003	0.010	0.032		Oligotrophic	0.004 to 0.010
E0-03	<0.003	0.014	0.060		Mesotrophic	0.010 to 0.020
Sheardown Lake NW	<0.003	0.006	0.090		Meso-eutrophic	0.020 to 0.035
C0-10	<0.003	0.014	0.060		Eutrophic	0.035 to 0.100
C0-01	<0.003	0.015	0.062		Hyper-eutrophic	>0.100
Mary Lake	<0.003	0.006	0.020			

NOTES:

1. NON-DETECT MEASUREMENTS AT OR ABOVE 0.01 MG/L WERE REMOVED BEFORE CALCULATING THE ABOVE STATISTICS.

Ongoing monitoring of total phosphorus is proposed as part of the CREMP; however, the high natural variability of total phosphorus do not allow for the measurement of statistically significant Project-related changes over time. An alternate indicator, Chlorophyll a, is proposed to monitor effects of nutrient additions to mine site waters as part of the freshwater biota CREMP being developed by North/South Consultants Inc.

The total nitrogen (TN) and total phosphorous (TP) ratio can vary with a waterbody's trophic status (Downing & McCauley, 1992). As noted above, the Mary River and Mary Lake stations show these waterbodies are oligotrophic to mesotrophic. The majority of limnological literature identifies total phosphorus as the limiting nutrient in freshwater environments that can influence phytoplankton communities. The range of TN:TP ratios for the mine area waterbodies are provided in Table 2.7.

Table 2.7 Range of Total Nitrogen : Total Phosphorus Ratios in Mine Site Lakes

Lake	TN:TP Ratio Calculation Method	Minimum TN:TP Ratio	Average TN:TP Ratio	Maximum TN:TP Ratio
Camp Lake	Mass	13	56	150
	Molar Weight	29	124	332
Sheardown Lake NW	Mass	20	65	177
	Molar Weight	44	144	391
Mary Lake	Mass	33	70	113
	Molar Weight	74	154	249

It is likely that, despite the periodically high total phosphorus concentrations measured in the mine site lakes, total phosphorus remains the limiting nutrient.

2.6 POWER ANALYSES

Parameter-specific and site-specific power analyses were completed to assess the sample size required to detect changes at individual stations. The analyses are presented in detail in Appendix C and the conclusions are presented in Section 2.7.4.

The parameters selected for power analysis include:

- Aluminum
- Arsenic
- Cadmium
- Copper
- Iron

These parameters were selected as they are expected to be the most affected parameters during mine operation. Stations were strategically selected to ensure sampling and subsequent statistical analyses would be able to provide information regarding the source of any contaminants that might be caused by mine development.

Power analyses were completed to determine the sample size required to detect changes in mean concentration with respect to the selected benchmarks, as per the AEMP Framework (Baffinland, 2013b). Also of interest was the ability to detect smaller statistically significant changes below the AEMP benchmark that would lead to low action adaptive management. Several “low-action” benchmarks were investigated for each parameter at each station.

Key sources of variation in the data were identified in the exploratory analysis:

- Spatial variability - from waterbody to waterbody and station to station, as for example from near field to far field
- Temporal variability - seasonal trends
- Within station variability - due to varying weather conditions such as rainfall effects on stream data (not shown here)

The following types of power analysis were completed, depending on the data available:

1) The power to detect a change in means was assessed for parameters with sufficient data above MDL (<15% of non-detected data). A before-after-control-impact (BACI) design was used to assess the power to detect differences in log mean concentration values (using the methods of Stroup, 1999)[2]. A BACI design is rigorous in the sense that it shows a change in the difference between impact (exposure) and control (reference) stations from before to after the commencement of a potential environmental impact. The following modifications to the complete BACI approach were taken, as dictated by the data available:

    i. Before-after (BA) design was used when control data was not available. Under this design, power analysis was carried out using a two sample t-test to compare means.

    ii. Control-impact (CI) design was assumed when very little baseline data was available. Under this design, power analysis for testing means was carried out using a paired t-test.

2) The power to detect a change in the proportion of values above MDL was assessed for parameters with a large proportion of values below MDL (>15% of non-detected data). For some parameters the baseline dataset is represented predominantly by values below MDL. This occurred for arsenic and cadmium at all stations.

    i. BA designs were assessed using a test for two independent proportions (Agresti, 1990).

    ii. McNemar's test (Agresti, 1990) was used to assess the power to detect a difference between the paired proportions at impact and control stations.

The outcome of the preliminary power analysis is provided in the preliminary study design (Section 2.8.4). Further details on the methodology used are provided in Section C.3 and D.3.

2.7 WATER QUALITY CREMP STUDY DESIGN

The water quality CREMP will monitor water quality within mine site lakes and streams with the objective of identifying project-related effects to water quality from multiple sources. The water quality CREMP applies the assessment approach and response framework identified in the AEMP that is being applied to the various components of the aquatic environment (i.e., water, sediment, biota).

The water quality CREMP study design is consistent with the requirements for the Environmental EEM Program as specified under the Metal Mining Effluent Regulations (MMER). The CREMP water quality stations overlap with those identified in the Draft EEM Cycle One Study Design (Baffinland, 2014; AEMP Appendix A).

2.7.1 Pathways of Effect and Key Questions

Key questions were developed for the CREMP to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. These questions and metrics focus upon key potential

[2] Comparison of medians or log means are both supported methods to compare data sets. Median comparisons are more robust when distributions are non-normally distributed. Median or mean comparisons are equally robust when distributions are normally distributed. Log distribution of water quality data collected created a data set that was normally distributed. As a result, mean comparison was determined appropriate.

effects identified in the Final Environmental Impact Statement (FEIS) and the Early Revenue Phase (ERP) addendum, as well as metrics commonly applied for characterizing water quality.

The key pathways of potential effects of the Project on water quality include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1)
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW)
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition)
- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area)

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

The primary issue of concern with respect to water quality is related to the combined effects on metal and TSS concentration from mine effluent discharges and ore dust deposition on water quality in lake and streams. As such, the CREMP and the baseline data review focused on waterbodies that will receive mine effluent discharges and are closest to the sources of ore dust. Camp Lake and its Tributary 1 (CLT-1), as well as the Mary River and Mary Lake, will receive mine effluent discharges. These waterbodies, along with Sheardown Lake, may also be affected by ore dust deposition and non-point sources of fugitive dust (i.e., road dust).

The discharge of treated sewage effluent also has the potential to cause eutrophication, with phosphorus being the limiting nutrient. As discussed in Section 2.5.3.4, however, TP concentrations are highly variable making it a poor indicator. While TP will continue to be monitored as part of the CREMP, Chlorophyll a will be monitored as a more reliable indicator of potential eutrophication, as part of the freshwater biota CREMP (North/South, 2014).

2.7.2 Indicators and Metrics

Water quality indicators identified for monitoring include various physical parameters, metals and nutrients. They were selected on the basis of the following:

- The potential to be naturally elevated in the environment
- The potential to become elevated in the environment as a result of future mine site activities
- Discharge limit(s) have been established for the parameter in the Type A Water Licence
- An established criterion exists for the protection of freshwater aquatic life
- Regulation under the MMER, or potential regulation as a result of the current re-evaluation of the regulations
- The parameter is an exposure toxicity modifying factor (ETMF) for other parameters of concern

The stressors of potential concern (SOPCs) and supporting parameters are listed in Table 2.8.

Table 2.8 Water Quality Parameters Selected for Monitoring

Contaminants of Potential Concern		Exploratory Data Analysis Only
Aluminum	Dissolved oxygen	Hardness
Arsenic	pH	Total Dissolved Solids
Cadmium	Total Suspended Solids	Turbidity
Chromium	Chloride	Alkalinity
Copper	Ammonia (NH3+NH4)	Calcium
Cobalt	Nitrite (NO2-)	Magnesium
Iron	Nitrate (NO3-)	Potassium
Lead	Phosphorus	Total Organic Carbon (TOC)
Nickel	Sulphate	Dissolved Organic Carbon (DOC)
Silver		
Thallium		
Vanadium		
Zinc		

2.7.3 Benchmarks

Since the mine site occurs within an area of metals enrichment, generic water quality guidelines established for all areas within Canada may naturally be exceeded near the mine site. Therefore, the selection of appropriate benchmarks must consider established water quality guidelines, such as those developed by the Canadian Council of Ministers of the Environment (CCME), as well as site-specific natural enrichment, and other factors (such as Exposure Toxicity Modifying Factors (ETMF) including pH, water hardness, dissolved organic carbon, etc.), in the selection or development of final benchmarks for monitoring data comparison (CCME, 1999, updated to 2014).

The assessment of surface water and sediment quality data over the life of the project will be ongoing, and the recommended benchmarks of comparison throughout this process may change, as more data become available. For example, a site-specific water quality guideline established early on in the life of the mine may require updating in 10 years, based on new published literature which has become available, or site-specific toxicity tests conducted to further understand ETMF or resident species toxicity. The iterative, cyclical nature of modification of benchmarks under an AEMP is well established (MacDonald et al., 2009).

Intrinsik Environmental Sciences Inc. was retained by Baffinland to develop water and sediment quality benchmarks to be applied in the CREMP (Intrinsik, 2014; see Appendix F of the AEMP). Water quality benchmarks were identified for mine site lakes and streams individually, considering the higher of the generic water quality objective (i.e., CCME or other jurisdiction) or the 97.5^{th} percentile of baseline concentrations. For parameters that are mostly below MDL (less than 5% detected values), either the Water Quality Guideline was selected (if available), or 3 * MDL was adopted as the benchmark, as follows:

- **Method A:** Water Quality Guideline was higher than 97.5%ile, and therefore was selected
- **Method B:** 97.5%ile was higher than the Water Quality Guideline, and therefore was selected
- **Method C:** Parameter has < 5% detected values, and either the Water Quality Guideline was selected (if available), or 3 * MDL was used to derive benchmark

If Method B was selected, additional assessment of the data was conducted to ensure the percentile calculations were not being driven by elevated detection limits, or other factors.

The selected benchmark development method and corresponding water quality benchmarks for the mine site lakes are presented in Table 2.9. The benchmark method and benchmark values for stream water quality are presented in Table 2.10.

Table 2.9 Selected Water Quality Benchmark Approach and Values for Mine Site Lakes

Parameter	Units	Water Quality Guideline	Camp Lake	Mary Lake	Sheardown Lake	Selected Benchmark	Benchmark Method
Metals [3]							
Aluminium	mg/L	0.1	0.026	0.137	0.179 (Shallow) 0.173 (Deep)	CL = 0.1 ML = 0.13; SDL shall/deep = 0.179/0.173	A (CL), B (ML/SDL)
Arsenic	mg/L	0.005	NC	0.00018	0.0001	0.005	A
Cadmium	mg/L	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	NC	0.000023	0.000017	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	A
Chromium	mg/L	NGA	NC	0.001	0.000641	0.0003 (CL) (ML) = 0.0005[8] (SDL) = 0.000642[9]	B (ML/SDL), C (CL)
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	NC	0.0089	A
Chromium $^{+6}$	mg/L	0.001	NC	0.001	NC	0.003 – 0.015 (CL)[5] 0.003 (ML/SDL)[5]	C
Cobalt	mg/L	0.004	NC	NC	0.0002	0.004	A
Copper	mg/L	0.002	0.0113	0.00239	0.00243	(CL) = 0.004[7] (ML) = 0.0024 (SDL) = 0.0024	B
Iron	mg/L	0.3	0.0421	0.173	0.211	0.3	A
Lead	mg/L	0.001	0.000334	0.00013	0.00026	0.001	A
Nickel	mg/L	0.025	0.000941	0.00080	0.000973	0.025	A
Silver	mg/L	0.0001	NC	NC	0.0000104	0.0001	A
Thallium	mg/L	0.0008	NC	NC	0.0001	0.0008	A
Vanadium	mg/L	0.006	NC	0.00146	0.001	0.006	A
Zinc	mg/L	0.030	0.0037	0.003	0.00391	0.030	A

Parameter	Units	Water Quality Guideline	Camp Lake	Mary Lake	Sheardown Lake	Selected Benchmark	Benchmark Method
Water Quality Parameters							
Chloride (Cl^-)	mg/L	120	4	13	5	120	A
Ammonia (NH_3+NH_4)	mg N/L	0.855[4]	0.84	0.32	0.44	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.1[6]	0.1[6]	0.1[6]	0.060	A
Nitrate (NO_3)	mg N/L	13	NC	0.11	NC	13	A
Sulphate	mg/L	218	3	7	5	218	A

NOTES:

1. NGA = NO GUIDELINE AVAILABLE; NC = NOT CALCULATED; TBD = TO BE DETERMINED; GUIDELINE STILL UNDER DEVELOPMENT; CL = CAMP LAKE; ML = MARY LAKE; SDL = SHEARDOWN LAKE.
2. METHOD A = WATER QUALITY GUIDELINE FROM CCME/B.C. MOE; METHOD B = 97.5%ILE OF BASELINE; METHOD C = 3* MDL.
3. TOTAL METALS UNLESS OTHERWISE NOTED.
4. ASSUMES TEMPERATURE AT 10 DEGREES C, AND pH OF 8.
5. THE 2013 DETECTION LIMIT FOR Cr^{6+} INCREASED IN 2013 FROM 0.001 to 0.005, HENCE THIS AFFECTS THE 3* MDL CALCULATION FOR THE BENCHMARK IN CAMP LAKE. EFFORTS WILL BE MADE TO REDUCE THIS MDL IN 2014, AND COMPARISONS TO THE LOWER OF THE 2 BENCHMARKS WOULD THEN BE APPLIED IN CAMP LAKE. IF DETECTION LIMITS IMPROVE, METHOD A (SELECTION OF THE GUIDELINE) MAY BE IMPLEMENTED.
6. THESE VALUES ARE ELEVATED DETECTION LIMITS, AND HENCE, THE GUIDELINE HAS BEEN SELECTED AS THE BENCHMARK.
7. THE MAXIMUM VALUE OF 0.0113 MG/L COPPER WAS REMOVED TO CALCULATE THE 97.5TH PERCENTILE, AS THIS VALUE APPEARS TO BE AN OUTLIER.
8. AN ELEVATED DETECTION LIMIT OF 0.001 MG/L WAS REMOVED FROM THE DATASET AND CALCULATIONS, AND THE AEMP SELECTED WAS THE 97.5th PERCENTILE, WHICH IS 0.0005 mg/L.
9. SEVERAL DETECTED VALUES RANGING FROM 0.00079 - 0.00316 mg/L Cr HAVE BEEN REPORTED IN THE DATASET FOR SDL, AND HENCE, THESE VALUES WERE CONSIDERED TO REPRESENT BASELINE, AND WERE INCLUDED IN THE 97.5th PERCENTILE CALCULATION.

Table 2.10 Selected Water Quality Benchmark Approach and Values for Mine Site Streams

Parameter	Units	Water Quality Guideline	Camp Lake Tributary	Mary River[3]	Selected Benchmark	Benchmark Method
Metals[4]						
Aluminum	mg/L	0.1	0.179	0.97	CLT = 0.179 MR = 0.966	B
Arsenic	mg/L	0.005	0.00012	0.00013	0.005	A
Cadmium	mg/L	0.00008 (CLT) 0.00006 (MR)	NC	0.00002	CLT = 0.00008 MR = 0.00006	A
Chromium	mg/L	NGA	0.000856	0.0023	CLT = 0.000856 MR = 0.0023	B
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	0.0089	A
Chromium $^{+6}$	mg/L	0.001	NC	NC	0.003[5]	C
Cobalt	mg/L	0.004	NC	0.0004	0.004	A
Copper	mg/L	0.002	0.00222	0.0024	CLT = 0.0022 MR = 0.0024	B

Parameter	Units	Water Quality Guideline	Camp Lake Tributary	Mary River[3]	Selected Benchmark	Benchmark Method
Iron	mg/L	0.3	0.326	0.874	CLT = 0.326 MR = 0.874	B
Lead	mg/L	0.001	0.000333	0.00076	0.001	A
Nickel	mg/L	0.025	0.00168	0.0018	0.025	A
Silver	mg/L	0.0001	NC	0.0001	0.0001	A
Thallium	mg/L	0.0008	0.0002	0.0002	0.0008	A
Vanadium	mg/L	0.006	NC	0.002	0.006	A
Zinc	mg/L	0.030	0.0035	0.01	0.030	A
Water Quality Parameters						
Chloride (Cl^-)	mg/L	120	23	21.55	120	A
Ammonia (NH_3+NH_4)	mg N/L	0.855[6]	0.60	0.60	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.095[7]	0.06	0.060	A
Nitrate (NO_3)	mg N/L	13	0.118	0.14	13	A
Sulphate	mg/L	218	6	8	218	A

NOTES:

1. NGA = NO GUIDELINE AVAILABLE; NC = NOT CALCULATED; TBD = TO BE DETERMINED; GUIDELINE STILL UNDER DEVELOPMENT; MR = MARY RIVER; CLT = CAMP LAKE TRIBUTARY.
2. METHOD A = WATER QUALITY GUIDELINE FROM CCME/B.C. MOE; METHOD B = 97.5%ILE OF BASELINE; METHOD C = 3* MDL.
3. ONE SAMPLE (OUTLIER) CONTAINING CHEMICAL CONCENTRATIONS ORDERS OF MAGNITUDE ABOVE OTHER VALUES WAS NOT INCLUDED IN THE CALCULATIONS FOR MARY RIVER.
4. TOTAL METALS UNLESS OTHERWISE NOTED.
5. EFFORTS WILL BE MADE TO REDUCE THIS MDL IN 2014, AND COMPARISONS TO THE HIGHER OF THE METHOD A OR C WOULD THEN BE APPLIED AS THE AEMP BENCHMARK.
6. ASSUMES TEMPERATURE AT 10 DEGREES C, AND pH of 8.0.
7. 97.5th PERCENTILE IS BEING DRIVEN BY ELEVATED DETECTION LIMIT, THEREFORE, THE GUIDELINE WAS SELECTED.

In most cases, the recommended benchmarks are consistent between lakes and streams, with the vast majority of selected benchmarks being generic WQOs. Where natural concentrations varied, and exceeded available water quality guidelines, or < 5% of values was detected, recommended benchmarks varied.

As discussed in the baseline review in Section 2.5 and Appendices B (lakes) and C (streams), some parameters have been shown to exhibit some changes in concentrations with season. For those parameters, Step 1 of the assessment framework (see Section 2.7.8) will include an evaluation of seasonality trends relative to the benchmark and baseline. Benchmarks may need to be re-visited for these compounds, and SSWQO can be considered.

Several water quality guidelines established by the CCME are currently under revision (i.e., lead and iron) or have been released in draft form for comments (silver). Once finalized, these revised benchmarks can be evaluated, using the benchmark selection process outlined, and benchmarks updated accordingly.

2.7.4 Monitoring Area and Sampling Stations

The monitoring area for water quality includes mine area lakes, specifically Camp Lake, Mary Lake, and Sheardown Lake NW and SE; selected tributaries of each lake; and the Mary River (Figure 2.11). The power analysis supported the selection of the existing baseline stations, and identified the addition of the following stations:

- Two stations within the basin at the north arm of Mary Lake, near BL0-01 (stations BL0-01-A and BL0-01-B)
- Two additional stations within the main basin of Mary Lake, near the Mary River inlet near BL0-05 (BL0-05-A and BL0-05-B)
- Sampling of an additional station within Sheardown Lake SE (existing station DL0-02-6)
- Addition of a station in vicinity of L1-09, location to be determined (L1-05)
- Addition of one or two reference stations upstream on Mary River (G0-09-A, G0-09-B)
- Sampling of identified reference lakes, consistent with EEM program and as identified by North/South (2014)

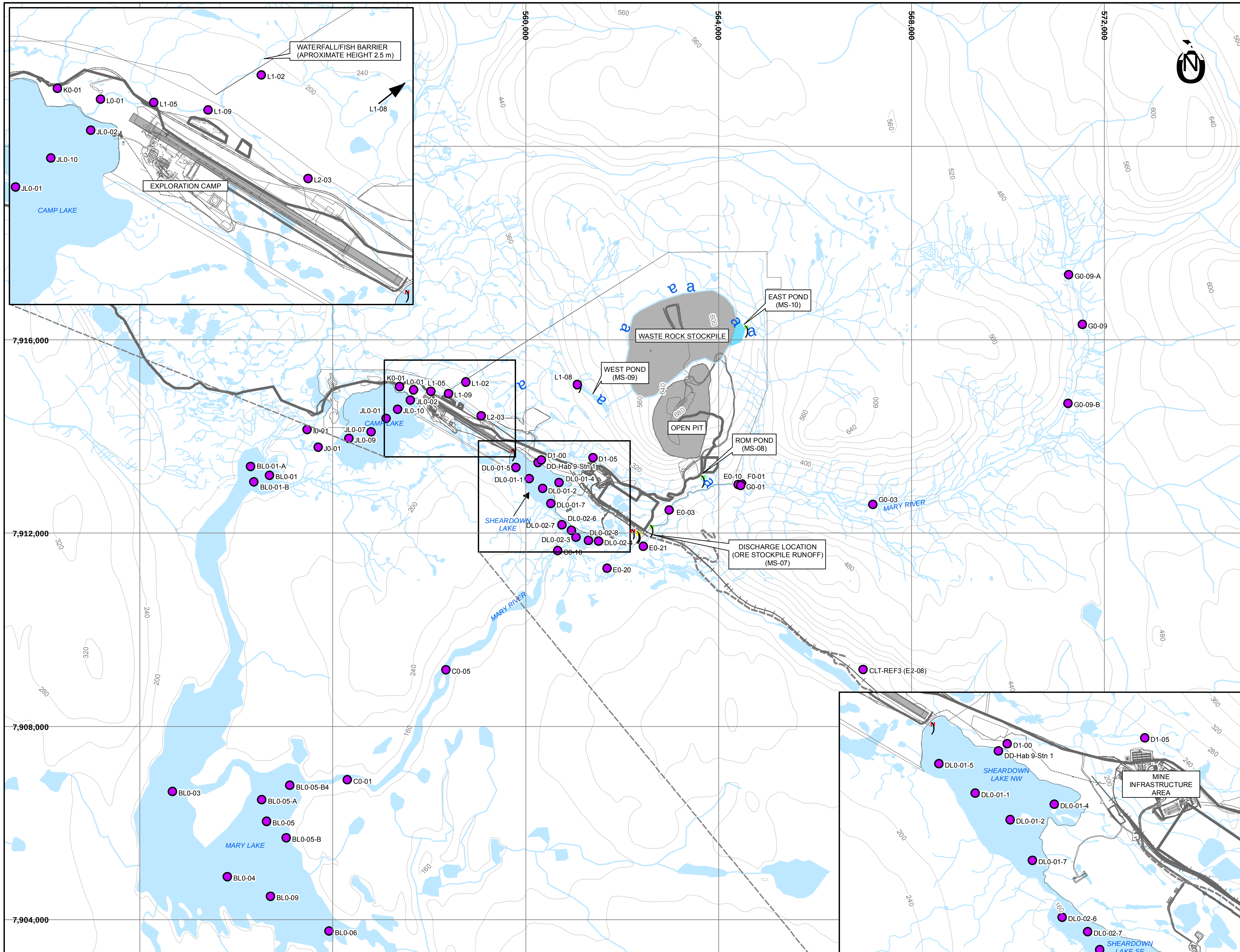
The water quality CREMP monitoring stations are presented in Table 2.11.

An initial power analysis was run using a paired BACI design for each station. The goal was to assess the statistical power of various sample sizes for detecting site-specific change. The power analysis used a basic BACI design with one impact station and one control station before and after commencement of mining activity. This method was modified in three ways:

- Simplified power analysis was used for sediment sampling
- In the absence of pre-mining reference data, only a Control-Impact (CI) assessment was completed
- For parameters with a large amount of data below detection limits, a comparison of proportions was used

Environment Canada defines statistical difference between exposure and reference stations to be a difference of a "factor of 2", except when there are applicable WQOs, detection limit interference, water quality guidelines, changes in pH and/or locations of reference stations within different watersheds. For the Mary River Project, benchmarks were derived as summarized in Section 2.7.3. These benchmarks account for the naturally elevated metals in the Project area. As a result, the ultimate effect size used in the power analysis was the difference between the station baseline mean and the benchmark. To be conservative when creating the study design, a second effect size was added to act as an early warning flag. The second effect size was determined to be halfway between the station mean and the benchmark value.

Power analysis was completed for a subset of parameters in select areas within Camp Lake, Sheardown Lake NW, Sheardown Lake SE, Mary Lake, Mary River and Camp Lake Tributary (Appendices B and C). Key stations were selected, which corresponded with the EEM near-field and far-field stations. Parameters that were elevated in baseline sampling and expected to be most affected during mine operation were selected to provide conservative representations of other measured parameters.



LEGEND:

- WATER QUALITY CREMP STATION
- SUMMER DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT
- WINTER LAND DISCHARGE LOCATION OF TREATED SEWAGE EFFLUENT TO MARY RIVER
- MINE EFFLUENT FINAL DISCHARGE POINT
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- PROPOSED SITE INFRASTRUCTURE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CREMP WATER QUALITY STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 2.11 REV 2

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
2	25JUN'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	RAC	AS	RAC	RAM

SAVED: I:\1\02\00181\33\A\GIS\Figs\B24_r2.mxd; Jun 26, 2014 3:50 PM; asimpson

Table 2.11 Water Quality CREMP Station Details

Station ID	Easting	Northing	Winter	Spring	Summer	Fall	Description/Rationale
	NAD83, Zone 17N						
Mary Lake (North Basin)							
BL0-01	554691	7913194	2		2	2	North basin receiving water from Camp Lake
BL0-01-A	554300	7913378	2		2	2	
BL0-01-B	554369	7913058	2		2	2	
Mary Lake (South Basin)							
BL0-03	552680	7906651	2		2	2	Main basin receiving water from north basin
BL0-04	553817	7904886	2		2	2	
BL0-05	554632	7906031	2		2	2	Mary Lake, southern basin near outlet of Mary River
BL0-06	555924	7903760	2		2	2	
BL0-05-A	554530	7906478	2		2	2	
BL0-05-B	555034	7905692	2		2	2	
BL0-09	554715	7904479	2		2	2	Main basin between BL0-05 & BL0-06
Mary River (D/S of SDL)							
C0-01	556305	7906894		1	1	1	Mainstem, before outflow to Mary Lake
C0-05[1]	558352	7909170		1	1	1	Mainstem, d/s of mine
C0-10	560669	7911633		1	1	1	Mainstem, d/s Sheardown Lake outflow
SDL-Trib 1							
D1-00	560329	7913512		1	1	1	Tributary D1
D1-05	561397	7913558		1	1	1	
Sheardown Lake NW							
DD-Hab 9-Stn1	560259	7913455	2		2	2	Nearshore monitoring location
DL0-01-1	560080	7913128	2		2	2	Long-term lake monitoring
DL0-01-2	560353	7912924	2		2	2	
DL0-01-4	560695	7913043	2		2	2	
DL0-01-5	559798	7913356	2		2	2	
DL0-01-7	560525	7912609	2		2	2	
Sheardown Lake SE							
DL0-02-3	561046	7911915	2		2	2	Long-term lake monitoring
DL0-02-4	561511	7911832	2		2	2	
DL0-02-6	560756	7912167	2		2	2	
DL0-02-7	560952	7912054	2		2	2	
DL0-02-8	561301	7911846	2		2	2	
Mary River (US of SDL)							
E0-03	562974	7912472		1	1	1	Mainstem, u/s of Deposit 1
E0-10	564405	7913004		1	1	1	Mainstem, u/s of Deposits No. 2 and 3, d/s of F0-01
E0-20[1]	561688	7911272		1	1	1	Mainstem u/s of trib E2 and d/s of ore/sewage discharge
E0-21[1]	562444	7911724		1	1	1	
F0-01	564483	7913015		1	1	1	Mainstem tributary from east pond
G0-01	564459	7912984		1	1	1	Mainstem, u/s of F0-01
G0-03	567204	7912587		1	1	1	Upstream, potential reference station within anticipated dust plume
G0-09[1]	571546	7916317		1	1	1	Upstream, potential reference station beyond anticipated dust plume
G0-09-A	571264	7917344		1	1	1	
G0-09-B	571248	7914682		1	1	1	

Station ID	Easting (NAD83, Zone 17N)	Northing (NAD83, Zone 17N)	Winter	Spring	Summer	Fall	Description/Rationale
Camp Lake							
JL0-01	557108	7914369	2		2	2	Long-term lake monitoring
JL0-02	557615	7914750	2		2	2	
JL0-07	556800	7914094	2		2	2	
JL0-09	556335	7913955	2		2	2	
JL0-10	557346	7914562	2		2	2	
Camp Lake Tributaries							
I0-01	555470	7914139		1	1	1	Tom River, below tote road
J0-01	555701	7913773		1	1	1	Outlet of Camp Lake
K0-01	557390	7915030		1	1	1	Drains to north region of Camp Lake
Camp Lake Tributary 1 (CLT-1)							
L0-01	557681	7914959		1	1	1	Mainstem tributary of CLT-1
L1-02	558765	7915121		1	1	1	Northern tributary of CLT-1, upstream of L0-01
L1-05	558040	7914935		1	1	1	
L1-08	561076	7915068		1	1	1	
L1-09[1]	558407	7914885		1	1	1	Receives west pond outflow
L2-03	559081	7914425		1	1	1	Southern tributary of CLT-1
Camp Lake Tributary Reference Areas							
CLT-REF3 (E2-08)[1]	567004	7909174		1	1	1	Reference stream outside dust plume
CLT-REF4 (CV-006-1)[1]	568533	7907874		1	1	1	
Mary River Reference Areas							
MRY-REF3 (S2-020)[1]	585407	7900061		1	1	1	Reference river outside dust plume
MRY-REF2 (S2-010)[1]	570650	7905045		1	1	1	
Reference Lakes							
TBD					12	12	
Duplicates			**5**	**3**	**9**	**9**	**26**
TOTAL			**57**	**31**	**101**	**101**	**290**

NOTES:

1. STATIONS INCLUDED IN THE EEM PROGRAM.
2. LAKE STATIONS REQUIRE SHALLOW AND DEEP SAMPLES (N=2 PER SEASON).

Power analysis was completed based on all the existing data, and is expected to be revisited after completion of additional baseline sampling in 2014. The 2014 baseline sampling will occur concurrently with construction, but prior to mine-related effluent or ore dust emissions.

At certain stations, combining analysis of data from stations with similar effluent additions may be required to achieve sufficient power. Using this method, data is combined together but remains attributed to a station. In this way, variability between stations and between impact areas and reference areas can be quantified. This approach increases power, while considering the variability that might occur between stations. During statistical analysis, the following stations are expected to have similar effluent concentrations and therefore similar station mean and variability values:

- BL0-01, BL0-01-A and BL0-01-B
- BL0-05 and BL0-05-A

- L1-09 and additional station
- Stations within Camp Lake
- Stations within the Sheardown Lake SE

2.7.5 Sampling Frequency and Schedule

Environment Canada (2012) specifies that four samples collected over a 12-month period from the same exposure and reference locations is the minimum amount of sampling required to detect differences in median values between exposure and reference stations. As described above, a power analysis was completed based on the effect sizes calculated using average baseline pre-mining data and benchmarks. To ensure a conservative study design, several actions were taken. For instance, the power analyses were completed based on an early warning flag (difference between measured baseline and 50% of AEMP benchmark).

The following sampling frequencies are recommended for each of the different programs:

- Lakes - three sampling events in each available season (winter, summer and fall) during the first three years of mine operation are expected to have adequate power to detect the early warning flag concentrations for lake data.
- Streams - four samples (one set of seasonal samples) per year is likely adequate for most parameters to determine significance.

Sampling will be conducted annually during the initial years of operation but sampling frequency will be evaluated regularly (i.e., each year) to determine if modifications are warranted. The sampling frequency and schedule will be evaluated after three years of monitoring.

2.7.6 Quality Assurance/Quality Control

A strict QA/QC program is in place to ensure that high quality and representative data are obtained in a manner that is scientifically defensible, repeatable and well documented. This program aims to ensure that the highest level of QA/QC standard methods and protocols are used for the collection of all environmental media samples. Quality assurance is obtained at the project management level through organization and planning, and the enforcement of both external and internal quality control measures. The following lists summarize the QA/QC procedures and practices being followed:

- Internal Quality Control:
  - Staffing the project with experienced and properly trained individuals
  - Ensuring that representative, meaningful data are collected through planning and efficient research
  - Using standard protocols for sample collection, preservation, and documentation
  - Calibrating and maintaining all field equipment
  - Collecting duplicate, blank, filter and travel blank samples for submission for analysis (approximately 10% of overall samples)
  - External Quality Control:
  - Employing fully accredited analytical laboratories for the analysis of all samples
  - Determining analytical precision and accuracy through the interpretation of the analysis reports for the blind duplicate, blank, filter and travel blank samples

The field sampling protocols being applied to the water (and sediment) quality programs are presented in Appendix A.

The quality of the data obtained for a project is assessed via their adherence to the pre-set data quality objectives (DQOs). DQOs provide a means of assessing whether the data in question are precise, accurate, representative, and complete. The results from QA/QC samples are reviewed to determine if sample contamination occurred. These data are further used to determine if the contamination occurred during collection, handling, storage, or shipping. Upon receipt from the laboratory, the data are uploaded into EQWin® along with copies of field notes, photos, Sample Receipt Confirmations, Microsoft Excel data, and Certificates of Analysis.

2.7.7 Study Design and Data Analysis

The purpose of effluent characterization and water quality monitoring is to answer the question:

What is the estimated mine-related change in contaminant concentrations in the exposed area

To answer this question, the study has been designed to test the following three hypotheses:

- Null hypothesis: Change over time is the same for exposure and reference stations. Alternate hypothesis: Data from exposure stations is statistically different from data measured at reference stations.
- Null hypothesis: Difference between exposure and reference stations is due to natural environmental variation. Alternate hypothesis: Difference in exposure and reference station is due to mine effects.
- Null hypothesis: Magnitude of concentrations at the reference station does not exceed the benchmark. Alternate hypothesis: Magnitude of concentrations at the reference station exceeds the benchmark.

Environment Canada (2012) does not explicitly define the program design required to monitor effects to water quality. Environment Canada does specify that:

- Comparisons between reference and exposure stations should identify parameters for which there are differences. This approach is consistent with a Control-Impact (CI) approach to design.
- If logistically possible, samples of effluent and water for reference and exposure stations be collected on the same day or in as close succession as possible. This implies paired sampling.
- If there is adequate pre-mining data in the exposure area, then this data may be used a basis for comparison to determine post-mining effects. This provision suggests comparison of concentrations before and after disturbance (BA design).

With federal EEM monitoring guidance in mind, and following guidance from INAC (2009) and peer-reviewed scientific journal articles (Green, 1979; Underwood, 1992; Smith, 2002), the selected program design framework is a BACI design. The BACI design addresses each of the three points above. A BACI design compares changes over time at exposure and control stations, while considering natural variation that may occur over this same time period. With this Project, the historical pre-mining data has already been collected for exposure and reference stations. Post-mining data at the exposure stations and reference stations would then be collected during mine operations. The BACI design will be used to detect changes in mean concentration with respect to the selected benchmarks, as per the assessment framework (Section 2.7.8).

A BACI design is good for assessing large short term changes and is a natural starting point for long term monitoring. A BACI design compares the baseline mean to the post-mining mean, which ignores time trends in the post-mining data. While this is reasonable for the initial mining period, long term temporal trends require adjustments to the statistical analyses that consider the rate of change over time.

2.7.8 Assessment Framework

Monitoring data will be assessed during each year of monitoring and would follow the assessment framework as outlined in Figure 2.12 and described below.

2.7.8.1 Step 1: Initial Data Analysis

Initial data analysis will involve following specific data management and monitoring protocols in the handling and initial comparison of data. These protocols are in accordance with the conceptual sampling approach defined in Figure 2.12.

Data Input and Storage

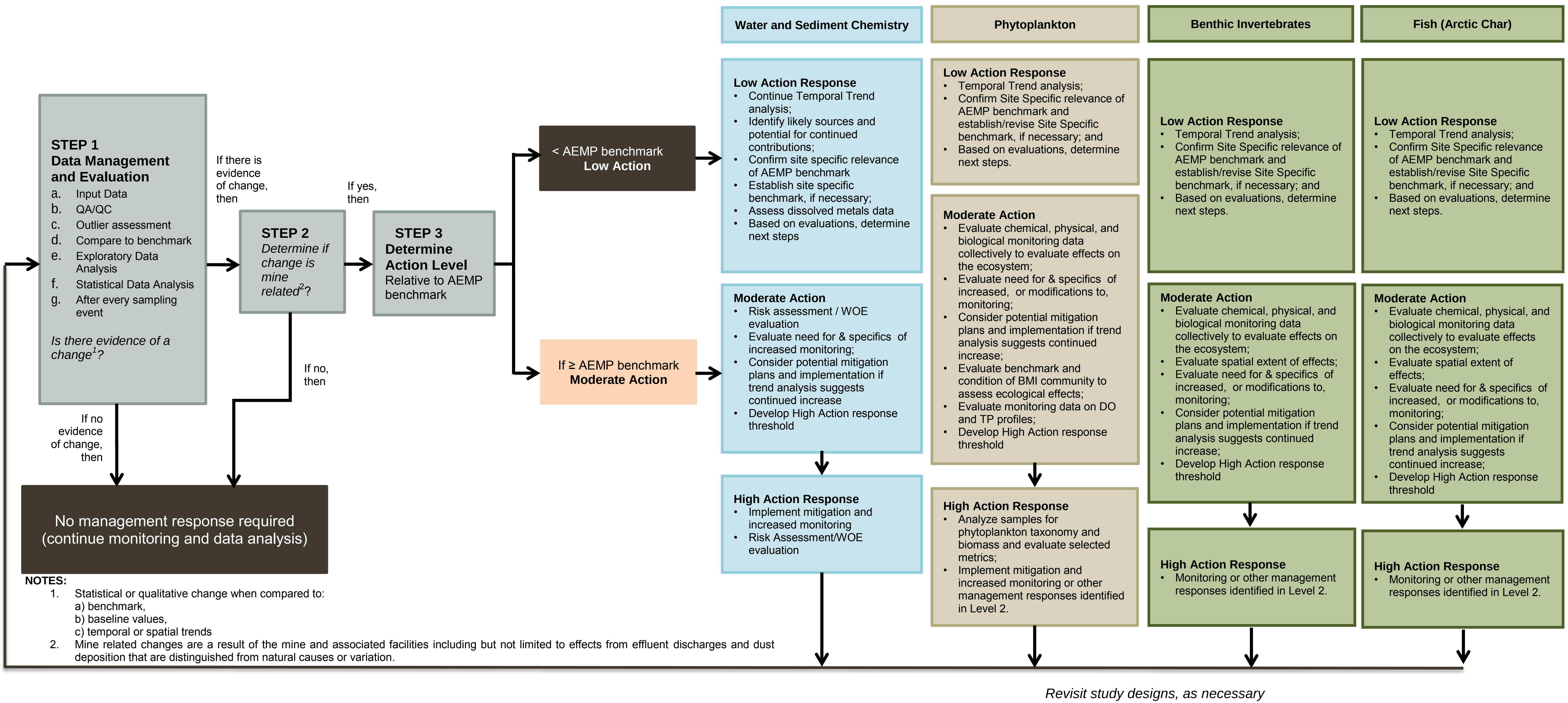
Following data collection, and upon receipt of the laboratory reports, data will be entered into the Project EQWin® database. The EQWin® Software was developed for collecting, analyzing, storing and interpreting sample data from environmental monitoring programs. All environmental data will be stored in EQWin® to expedite quality assurance/quality control and all subsequent analyses.

Initial Data Analysis including Outlier Assessment

The initial data analysis will include the following:

- Completion of summary statistics for parameters sampled (average, median, maximum, minimum, quartiles)
- Flagging of values greater than the defined benchmark values
- Flagging of values at or exceeding the mid-point between the baseline mean and the benchmark
- Evaluating temporal changes in the data by season

The initial data analysis will include an outlier assessment after data entry and the completion of quality assurance and quality control steps. An outlier assessment is completed after each round of sampling to ensure data anomalies are identified early. If necessary, the laboratory can be contacted to re-analyze samples. Any identified outliers will be investigated to ensure no data integrity issue exists. For example, duplicate and blank samples will be assessed along with any holding time exceedances. If no evidence exists to discard data, then the data will remain in the dataset but be flagged for future consideration.



NOTES:

1. Statistical or qualitative change when compared to:
   a) benchmark,
   b) baseline values,
   c) temporal or spatial trends
2. Mine related changes are a result of the mine and associated facilities including but not limited to effects from effluent discharges and dust deposition that are distinguished from natural causes or variation.

Figure 2.12 AEMP Assessment Approach and Response Framework

2.7.8.2 Step 2: Determine if Change is Mine Related

Step 2 involves determining if the changes in water quality parameters of concern are due to the Project or due to natural variability or other causes. This question will be addressed using exploratory data analysis (EDA) and subsequently using statistical data analysis (SDA), as described below.

Prior to conducting EDA and SDA, Project activities with the potential to alter water quality will be reviewed to identify potential Project-related causes or sources. This could include evaluating effluent quality, discharge regime/rates, and loading, dust deposition, and other point/non-point sources as required. Also, any evidence of potential natural causes (i.e., a major erosional event such as a slumping riverbank) will be investigated. Sampling data sheets and site personnel will be a source of this information.

Exploratory Data Analysis

Exploratory data analysis (EDA) will be completed to visualize overall data trends. This could include evaluating spatial patterns in water quality results for the Mine Area as a whole, including Mine Area lakes and streams, to evaluate if changes are widespread or specific to certain waterbodies, or proximate to mine-related sources, and to identify the spatial extent and pattern of observed changes.

Other exploratory data analyses could include comparisons of data from Mine Area streams to data from reference streams and comparisons of Mine Area Lakes to reference lake(s). This will further assist with determining whether the observed changes were due to natural variability or the Project.

Graphical analyses may be used to confirm assumptions required for statistical testing (normality, sample size, independence). Results of the EDA can be used in tandem with the Statistical Data Analysis (SDA) to evaluate the observed statistical trends and further assess whether the changes noted are mine related.

Statistical Data Analysis

Primary SDA consistent with the statistical methodology used for power analysis (BACI design) will be completed on total metals to determine the magnitude of change during post-mining. This step in the analysis tests the primary hypothesis for the effects of mine-related change and will be applied to the parameters of interest.

If the Step 2 analysis concludes that the changes in water quality parameters of concern are, or are likely, due to the Project, the assessment will proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response will be required.

2.7.8.3 Step 3: Determine Action Level

Once EDA and primary SDA has indicated with some certainly that the measured change is project-related, Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark.

If the benchmark is not exceeded, a **low action response** would be undertaken and would include:

- Evaluate temporal trends
- Identify likely loading source(s) and potential for continued loading contributions
- Confirm the site-specific relevance of benchmark and establish a site-specific benchmark, if necessary
- Further evaluate data (for example, for water quality, review dissolved metals data and/or supporting variables)
- Based on evaluations, determine next steps

If the benchmark is exceeded and it is concluded to be Project-related, a **moderate action level response** would be undertaken and could include, in addition to analyses identified for a low action response, the following:

- Consider a weight-of-evidence (WOE) evaluation and/or risk assessment, considering other monitoring results collectively with water quality to evaluate effects on the ecosystem
- Evaluate the need for and specifics of increased monitoring
- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the **high action level response** has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in water quality parameters of concern on the lakes as a whole, as well as the monitoring results from the freshwater biota CREMP. Also, the benchmark may need to be revised in consideration of ongoing monitoring results. The precise relationships between water quality, sediment quality and lower trophic level changes and the collective effects on fish is difficult to predict and therefore actions undertaken under Step 3 will attempt to explore these relationships to advise on overall effects to the ecosystem. Results would be discussed with regulatory agencies and the next steps would be identified. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) could include:

- Implementation of increased monitoring to further assess the potential for effects and/or define magnitude and spatial extent if warranted
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response

3 – SEDIMENT QUALITY REVIEW

3.1 SUMMARY OF SEDIMENT SAMPLING PROGRAM

The collection of baseline sediment quality samples for the Project was carried out between 2005 and 2008 and between 2001 and 2013 in conjunction with the water quality baseline program. Results up to and including 2011 were presented in the baseline reports referenced in Section 2.1. Sediment quality data collected in 2012 and 2013 are included in this review but were not previously reported.

Sampling of sediment in streams and lakes around the mine site was typically conducted once in the fall (late August/early September) in conjunction with and at the same stations as the water quality and benthic invertebrate sampling. Table 3.1 summarizes the sediment quality baseline program by year and location around the mine site. The Mine site sediment sampling locations are shown on Figure 1.3.

Table 3.1 Number of Sediment Samples by Year and Location

Grouping	2005	2006	2007	2008	2011	2012	2013
Camp Lake	0	0	6	0	0	3	3
Camp Lake Tributary	3	0	4	0	3	7	5
Mary River Downstream	2	1	5	0	10	4	3
Mary Lake	0	2	5	0	0	1	1
Sheardown Lake NW	0	0	7	12	3	4	6
Sheardown Lake SE	0	0	5	0	0	1	1
Sheardown Lake Tributary	2	0	5	3	4	3	1
Mary River Upstream	1	1	1	0	0	0	1

Sampling and analytical methods, and quality assurance/quality control (QA/QC) procedures applied during the sampling period are described in the sampling protocol included as Appendix A. In the initial years, sediment sampling was carried out using of a Petite Ponar dredge sampler to collect a maximum sample collection thickness of 5 cm. This depth is appropriate for monitoring studies where historical contamination is not a priority (Environment Canada, 2012). During the NIRB review, Baffinland agreed to a recommendation from Environment Canada that the upper 1 to 2 cm of sediment be collected as part of Project monitoring. Most infaunal organisms and the most recently introduced sediment (including any contaminants of concern) are found in the upper 2 cm of the sediment. Arctic lakes experience low sedimentation rates and therefore collection of a thinner sample on surface using a sediment core sampler should provide better resolution of changes in sediment quality. Collection of thinner (2 cm) sediment samples was implemented by Baffinland starting in 2012.

Laboratory analysis of the sediment samples included physical tests, as well as tests for nutrients, carbon and metal concentrations (Table 3.2). Specific metal parameters have been identified as parameters of interest due to their potentially toxic effects when present at defined concentrations. These are the parameters for which sediment quality criteria have been established in order to protect aquatic life. It is important to establish baseline concentrations for these parameters prior to development of the Project for post-Project comparison.

Table 3.2 Summary of Baseline Sediment Quality Analytical Parameters

Parameter Category	Analytes
Physical Tests	Moisture, Particle Size (% Sand, % Silt, % Clay)
Nutrients	Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen (TKN)
Carbon	Total Organic Carbon (TOC)
Metals	Aluminium, Antimony, **Arsenic**, Barium, Beryllium, Boron, Cadmium, Calcium, **Chromium**, Cobalt, **Copper**, Gold, **Iron**, Lead, Magnesium, **Manganese**, Mercury, Molybdenum, **Nickel**, Potassium, Selenium, Sodium, Strontium, Thallium, Vanadium, Zinc

NOTES:
1. THE PARAMETERS OF INTEREST ARE INDICATED IN BOLD FONT.

Baseline analytical sediment quality data were compared to relevant guidelines for the Project that include:

- Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CSQG-PAL) established by the CCME (CCME, 2001)
- MOE Ontario Provincial Sediment Quality Guidelines (PSQG) (Fletcher et al., 2008)ss

The CSQG established Interim Sediment Quality Guidelines (ISQGs) for select parameters. These guidelines correspond to the concentration thresholds below which adverse biological effects are not expected. The Probable Effect Level (PEL) corresponds to the concentration above which adverse biological effects are frequently found (CCME, 2001).

The PSQG established a Lowest Effect Level (LEL) threshold for parameters that correspond to concentrations that can be tolerated by the majority of sediment dwelling organisms. The Severe Effect Level (SEL) corresponds with concentrations expected to be detrimental to the majority of sediment dwelling organisms (Fletcher et al., 2008).

The laboratory detection limits for many metals improved over the duration of the testing program (i.e., between 2005 and 2013). All laboratory results and their respective detection limits for each year are presented in Section 3.3.

3.2 RELATED STUDIES

Other studies that have been undertaken that provide information on sediment quality, include:

- Substrate mapping associated with aquatic biota studies
- Monitoring of water and sediment quality and benthic invertebrates in Sheardown Lake and its tributary. This work was related to dust emissions associated with an ore crushing operation in 2008 during a bulk sampling program.
- Measurements of baseline sedimentation rates in Sheardown Lake

Each of these studies is described in the following sub-sections.

3.2.1 Substrate Mapping

Bathymetry and substrate mapping of Camp Lake, Sheardown Lake and Mary Lake are shown in Figures 3.1, 3.2 and 3.3, respectively. Substrate was described by North/South (2012) as either:

- Cobble/boulder
- Gravel/pebble
- Sand
- Fine sand/silt/clay

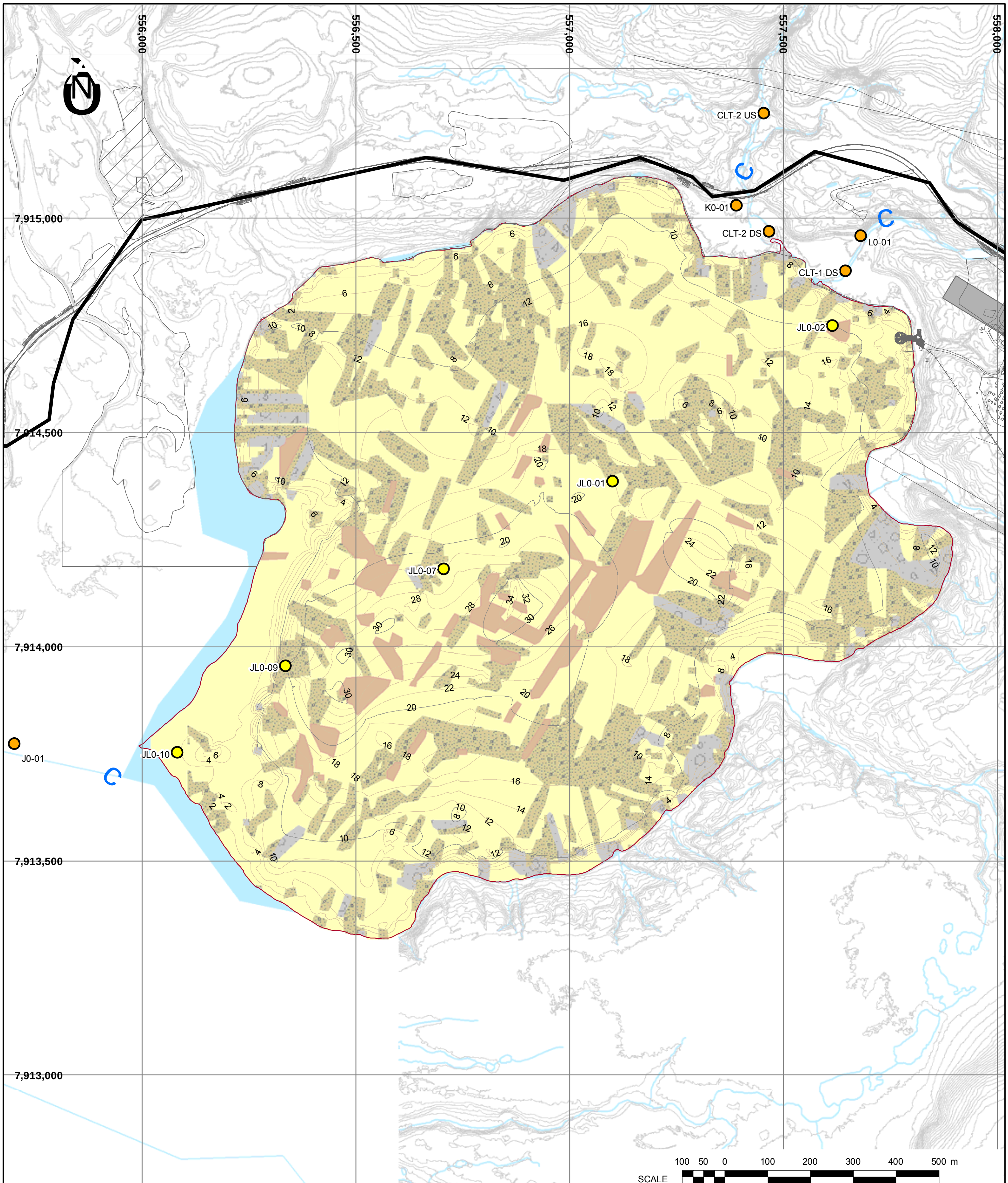
Substrate mapping provides a coarse representation of the substrate. Substrate conditions within each of the study lakes (Mary Lake, Camp Lake and Sheardown Lake), described by North/South (2012):

Camp Lake In this lake the shoreline, littoral/euphotic, and profundal zones occupy approximately 16 ha (8%), 117 ha (37%), and 78 ha (55%), respectively. Camp Lake has a maximum depth of 35.1 m and a mean depth of 13.0 m. In general, depth extends to 10 m within approximately 100 to 200 m of the shoreline with a relatively uniform depth (10 to 20 m) throughout the majority of the lake (Figure 3.1). The shoreline in Camp Lake consists primarily of gravel/pebble (or smaller-sized substrate, particularly in the southwest), with small, isolated areas of cobble/boulder shoreline in the east, southeast, and northwest sections of the lake. Sand is the dominant substrate in Camp Lake and is found throughout the near shore and offshore areas. Small patches of finer substrates are dispersed primarily in deeper, offshore areas, while patches of cobble/boulder substrate are found primarily in shallower, near shore areas (i.e., shoreline zone). Gravel/ pebble sized substrates are dispersed throughout the lake.

Sheardown Lake NW Within the northwest basin of Sheardown Lake, the shoreline, littoral/euphotic, and profundal zones occupy approximately 8 ha (12%), 28 ha (42%), and 32 ha (46%), respectively. Sheardown Lake NW is characterized by maximum and mean depths of 30.1 m and 12.1 m, respectively. This basin typically reaches depths of greater than 10 m at distances of less than 50 m from shore (Figure 3.2). The exception to this is a broad, shallow area in the southeast section of this basin. The shoreline in Sheardown Lake NW is primarily sand or gravel/pebble with a few areas of cobble/boulder. Substrate in the northwest basin consists primarily of sand or gravel/pebble with some cobble/boulder areas (usually in the littoral zone) and a few, small patches of fine substrates (typically in the profundal zone).

Sheardown Lake SE The southeast basin of Sheardown Lake is shallower than the northeast basin with maximum and mean depths of 26.7 m and 7.4 m, respectively. The shoreline, littoral/euphotic, and profundal zones occupy approximately 5 ha (19%), 16 ha (65%), and 4 ha (15%), respectively. Relatively large areas of this basin are less than 10 m in depth (Figure 3.2). This characteristic, combined with high water clarity, results in the lake being dominated by the littoral/euphotic zone.

The southeast basin has a similar proportion of sand to the northwest basin, but lacks finer substrates. An area of relatively dense aquatic macrophyte growth was observed in the southern extent of this basin. This macrophyte growth likely consists of non-vascular plants, such as macroalgae (e.g., *Chara*sp).



SAVED: I:\102\00181\33\A\GIS\Figs\A06_r1.mxd; Jun 26, 2014 4:25 PM; asimpson

LEGEND:

- LAKE SEDIMENT SAMPLE STATION
- STREAM SEDIMENT SAMPLE STATION
- FLOW DIRECTION
- EXISTING TOTE ROAD
- CAMP LAKE SHORELINE
- 2 METRE INTERVAL
- 10 METRE INTERVAL
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

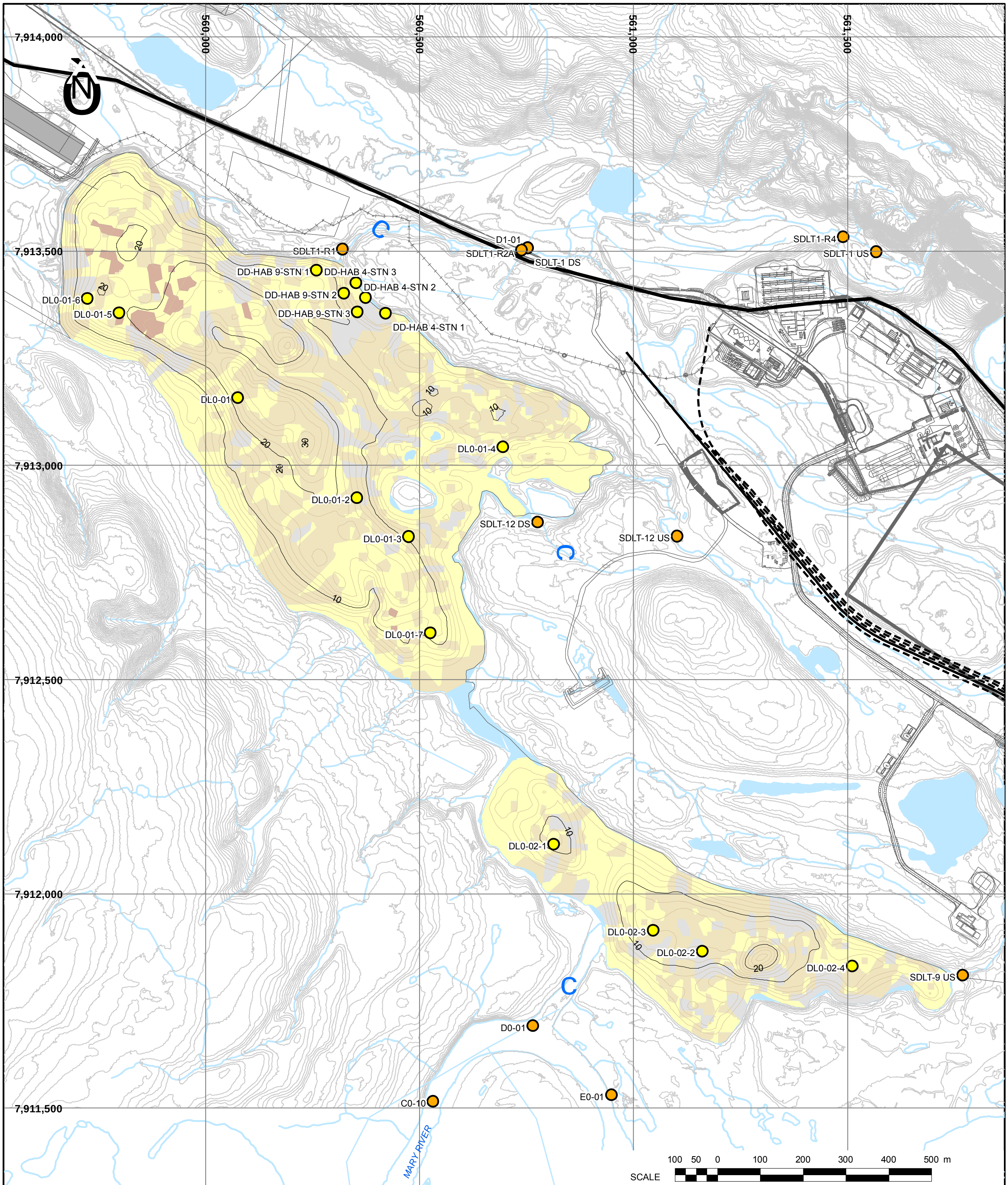
SEDIMENT SAMPLE LOCATIONS
CAMP LAKE

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.1 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM



LEGEND:

- LAKE SEDIMENT SAMPLE STATION
- STREAM SEDIMENT SAMPLE STATION
- FLOW DIRECTION
- EXISTING TOTE ROAD
- CAMP LAKE SHORELINE
- 2 METRE INTERVAL
- 10 METRE INTERVAL
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS SHEARDOWN LAKE

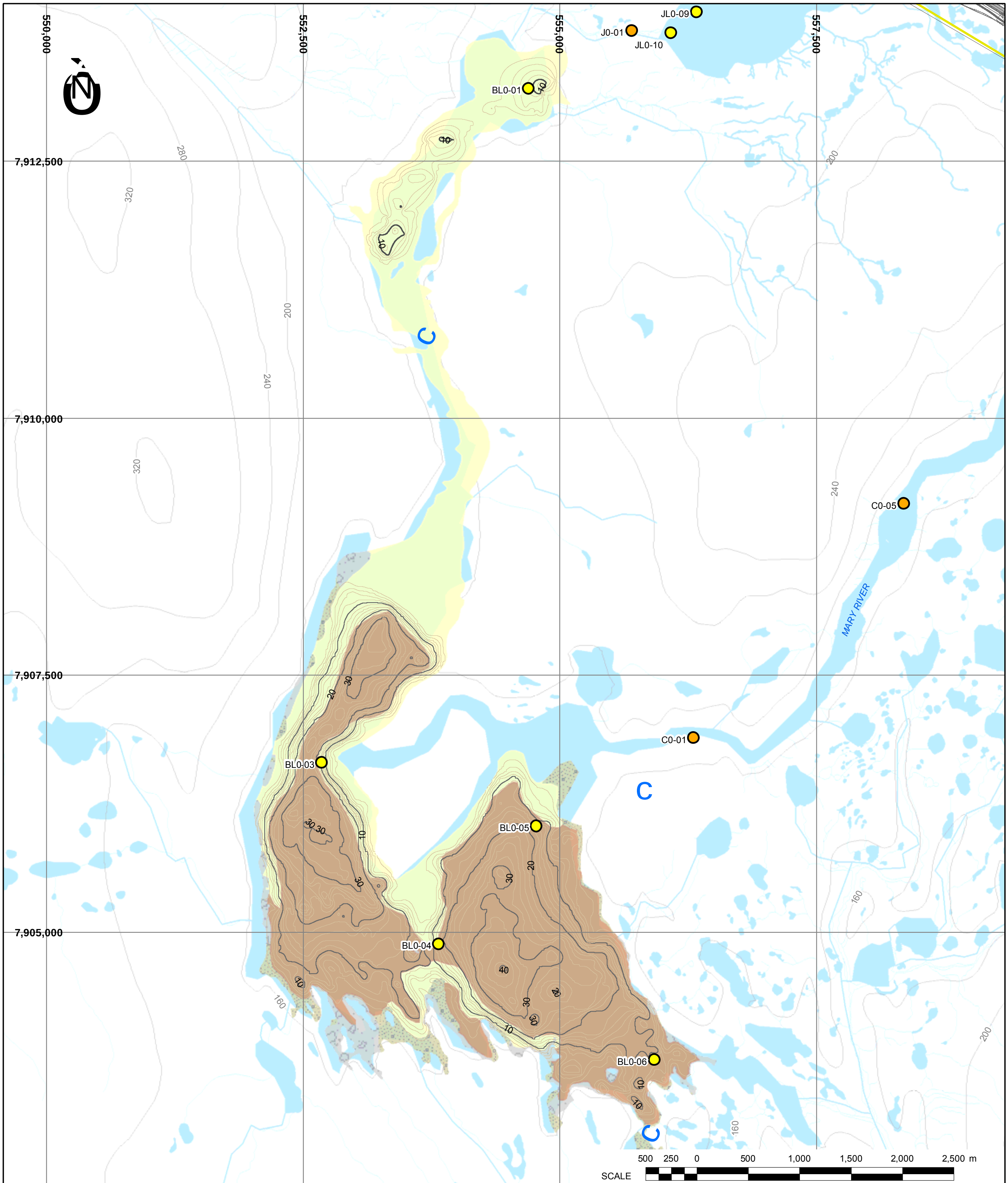
Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE 3.2 | REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\A07_r1.mxd; Jun 26, 2014 4:26 PM; asimpson



LEGEND:

- LAKE SEDIMENT SAMPLE STATION
- STREAM SEDIMENT SAMPLE STATION
- FLOW DIRECTION
- EXISTING TOTE ROAD
- CAMP LAKE SHORELINE
- 2 METRE INTERVAL
- 10 METRE INTERVAL
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS MARY LAKE AREA

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.3 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\A08_r1.mxd; Jun 26, 2014 4:28 PM; asimpson

Mary Lake Similar to Camp Lake, Mary Lake is relatively deep with a maximum depth of 41.1 m in the large south basin. The mean depth of 12.0 m is shallower than Camp Lake and more similar to the NW basin of Sheardown Lake. The shoreline, littoral/euphotic, and profundal zones occupy approximately 493 ha (36%), 365 ha (26%), and 522 ha (38%), respectively. Expansive, shallow, near shore areas at the north end of the south basin (in proximity to the Mary River inlet and outlet) contribute to the comparatively shallow mean depth (Figure 3.3). Near shore substrate in Mary Lake, like the other lakes that have been surveyed for sediment quality, consists primarily of sand with patches of finer substrates and cobble/boulder. The substrata type in the shallower north arm is sand, while relatively fine sand mixed with silt/clay predominates throughout the deeper south basin.

3.2.2 Aquatic Effects Monitoring of Dust from Bulk Sample Ore Crushing

A small, single season study was completed in 2008 that sampled sediment (as well as water quality and lower trophic level components) to monitor dust emissions from ore crushing during the bulk sampling program (North/South, 2010). As part of the bulk sampling program, crushing and screening of ore occurred during the winter and spring of 2008 near Sheardown Lake NW and Tributary SDLT-1 (Tributary 1, which is a main tributary supporting the lake). The above study evaluated the water and sediment quality as well as periphyton, drifting invertebrates and benthic invertebrates within SDLT-1. The near shore environment at the mouth of SDLT-1, and control stations, were also evaluated.

Collectively, the results of the chemical and biological samples obtained did not indicate a definitive effect of dust deposition on the benthic invertebrate density or composition. Water quality monitoring results indicate that aluminum and lead may have been measurably increased in spring near the mouth of the tributary to Sheardown Lake NW, but other effects on sediment quality and lower trophic level biota were not definitive (North/South, 2010). North/South noted that the assessment was hampered by a lack of data collected in the immediately affected area prior to dust deposition and by other confounding factors such as substrate differences that limited direct comparisons.

3.2.3 AEMP Target Study on Lake Sedimentation Rates

A targeted study identified completed in the open-water season of 2013 to measure sedimentation in Sheardown Lake NW. This study was part of Baffinland's Updated AEMP Framework (Baffinland, 2013) and was designed to generate baseline information on lake sedimentation rates for post-Project comparison. Sediment traps were deployed at three stations in the lake, with five replicates at each station. This configuration was utilized to ensure adequate sediment was obtained for laboratory analysis and to provide sufficient information to evaluate variability at each station. The stations were selected to generate measurements of sedimentation rates at a deep station (where sedimentation is typically greatest) and at two shallower locations. This ongoing study may support the interpretation of results generated from CREMP sediment quality monitoring.

3.3 REVIEW OF SEDIMENT QUALITY DETECTION LIMITS

The yearly laboratory MDLs for sediment quality parameters of interest are presented in Table 3.3 and compared to the CSQG limits and PSQG criteria. In general, the detection limits were well below the relevant quality guidelines concentrations, and MDLs did not change meaningfully over the sampling period. The MDL reported for mercury is very close to the CSQG-PAL ISQG concentration. In addition, the MDL reported for cadmium is 0.1 µg/g below the CSQG-PAL ISQG and PSQG-LEL concentrations (the MDL is 0.5 µg/g compared to the guideline value of 0.6 µg/g). Increased resolution for these parameters would better define areas with concentrations above the quality guidelines.

As with the water quality, power analysis can be utilized to calculate the minimum sample size required to be reasonably sure that an effect of a given size can be detected. The ability to detect change during future monitoring is a function of the number of sampling events and the spread in results. Baffinland is interested in utilizing its existing baseline dataset to the maximum extent possible. This approach should reduce the number of monitoring events that will be required to detect a given change.

Table 3.3 Summary of Sediment Quality Laboratory Detection Limits

Parameter	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
Units	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**
CSQG-PAL ISQG	5.9	0.6	37.3	35.7	--	0.17	--	--	35	123
CSQG-PEL	17	3.5	90	197	--	0.486	--	--	91.3	315
PSQG-LEL	6	0.6	26	16	20,000	0.2	460	16	31	120
PSQG-SEL	33	10	110	110	40,000	2	1100	75	250	820
Method Detection Limits (by year)										
2005	0.03	0.006	0.5	0.1	0.5	0.1	0.05	1	0.7	0.1
2006	1.0	0.5	1	1	1	0.1	1	1	1	1
2007	1	0.5	1	1	1	0.1	1	1	1	1
2008	1	0.5	1	0.1	1	0.1	1	1	1	1
2011	1	0.5	1	1	5	0.1	1	1	1	2
2012	1	0.5	1	1	5	0.1	1	1	1	2
2013	1	0.5	1	1	5	0.1	1	1	1	2

3.4 SEDIMENT QUALITY STRESSORS OF POTENTIAL CONCERN

The FEIS for the Project (Baffinland, 2012) identified the following stressors of potential concern for sediment quality given the average geochemical composition of the iron ore:

- Arsenic
- Cadmium

- Iron
- Nickel

The following metals have been noted to be naturally elevated in the sediment in the streams and lakes within the mine site area (see Section 3.5 and Table 3.4):

- Arsenic
- Cadmium
- Chromium
- Copper
- Iron
- Manganese
- Nickel

It is expected that the metals found to be naturally elevated in the sediment is due to the mineralization associated with the ore body. As such, it is possible that these same metals will accumulate in sediment during the Project. On that basis, the metals listed immediately above are the identified sediment quality stressors of potential concern.

Lead and zinc were noted at one location in Sheardown Lake in recent (2012 and 2013) sediment testing. These two metals are not consistently elevated in sediment within the mine site streams and lakes and are, therefore, not carried forward as sediment quality stressors of potential concern. Lead and zinc will still be tested for in sediment as part of the monitoring program.

3.5 REVIEW OF SEDIMENT QUALITY BASELINE

A detailed review of the available sediment quality data using various graphical analysis tools is presented in Appendix D.

3.5.1 Metals Accumulation in Sediment and Total Organic Carbon and Fines

Metals concentrations in sediment are positively correlated with both finer grained particles as well as higher organic carbon content (Horowitz, 1991). Smaller particles have more binding sites and a higher affinity for metals than coarser grained material. Organic carbon within sediment decreases the dissolved oxygen and creates a more anoxic environment. Depending on pH, an anoxic environment may influence metal solubility and speciation. Within depositional areas of the lake that are characterized by higher concentrations of TOC and/or greater proportions of fine grained sediment, concentrations of several metals regularly exceeded the CSQG-PAL ISQGs or the PSQG-LEL. This includes chromium, copper, iron, manganese, nickel and phosphorus, and sometimes arsenic. Iron in some instances exceeded the PSQG-SEL. Most metals correlated well; in samples where one of the metals was elevated, all others were also elevated, except arsenic and manganese.

At the Mary River mine site, depositional environments were predominantly found within the lakes. The main exception to this is the stations within the main tributary of Sheardown Lake (Tributary 1). Streams at the mine site are mostly high gradient, high energy depositional environments that are not likely to have substantial amounts of fine grained sediment or sediment with high organic carbon content. The accumulation of metals in the depositional environments of the lakes is observed when reviewing mean concentrations of key metals as presented in Table 3.4 (numbers have been rounded). Stream versus lake sediment sample groupings are shaded different colours.

Table 3.4 Mean Concentrations of Key Metals in Sediment at the Mine Site

Sample ID		As µg/g	Cd µg/g	Cr µg/g	Cu µg/g	Fe µg/g	Mn µg/g	Ni µg/g	Pb µg/g	Zn µg/g
CCME	ISQG	5.9	0.6	37.3	35.7				35	123
	PEL	17	3.5	90	197				91.3	315
Ontario Sediment Quality Guidelines	LEL	6	0.6	26	16	20,000	460	16	31	120
	SEL	33	10	110	110	40,000	1,100	75	250	820
	n									
Upstream of Deposits	4	0.9	0.4	12.8	1.9	9,446	41	5	1.6	5.9
Downstream of Deposits	22	<1	<0.5	22.9	4.5	11,795	83	13	2.4	8.5
Drainages Off the Deposits	10	<1	<0.5	28.3	12.8	9,688	135	21	2.9	15.1
Mary River Tributary E2	7	1.0	0.4	18.5	3.8	9,507	64	12	2.5	7.0
Mary River Downstream of Mary Lake	2	0.7	0.3	74.5	7.0	6,050	90	29	1.5	7.8
Sheardown Lake Tributaries	18	1.4	0.65	45.2	27.0	13,524	235	39	12.1	47.6
Camp Lake Tributaries	12	0.9	0.4	27.0	12.3	8,501	95	22	3.7	13.3
Tom River	4	<1	<0.5	14.5	2.3	6,993	48	7	1.5	5.8
Mary Lake	9	2.5	<0.5	54.6	21.7	27,469	1,099	40	13.4	51.6
Camp Lake	12	2.7	<0.5	60.2	33.2	27,748	700	52	14.7	48.8
Sheardown Lake NW	32	3.1	<0.5	59.6	36.8	30,687	1,149	54	14.6	56.6
Sheardown Lake SE	7	1.5	0.6	68.0	23.4	27,462	397	57	13.3	46.3

Table 3.4 shows that the metal concentrations in depositional environments tended to be consistently higher in the same metals. In most of the mine site lakes, the mean concentrations of chromium, copper, iron, manganese and nickel exceeded the referenced guidelines.

Metals concentrations in depositional lake samples are relatively consistent between samples, between sample stations within a given lake, and between each of the three mine site lakes (Camp, Mary, Sheardown). The Sheardown Lake Tributary 1 sample location (D1-05) also exhibited the same substrate characteristics and elevated metals concentrations.

Conversely, metals concentrations in lake sediment and most stream sediment stations which were low in fines and/or TOC contained relatively low concentrations of metals. These locations also had a high degree of variability in metals concentrations between sampling events and between nearby sampling stations.

In terms of long-term monitoring, it is recommended that sediment sampling stations in depositional environments be the focus of monitoring along with the application of the Assessment Approach and Response Framework (Figure 2.12):

- Detection of a change[3]
- Establishing if the change is mine related
- Comparison to benchmark
- Undertaking a low or moderate action depending on the result compared to the benchmark

The high level of variability within sediment samples characterized by low TOC and/or low fines (high proportion of sand) do not allow for the detection of statistically significant changes as the variability between samples is likely to be greater than any project-related changes and collection of a sufficient number of samples to obtain statistical power is likely not possible.

As such, further evaluation of the sediment quality database was undertaken to understand the relationship between TOC, the proportion of fines, and metals concentrations.

Figure 3.4 shows the entire sediment quality dataset plotted as percent clay vs percent sand with the circle size representing the proportion of silt. Figure 3.5 shows the same information in another way, plotting the proportion of clay/clay+silt versus the percent sand. The figures show the 3-way relationship between sand, silt and clay and the negative association between sand and clay.

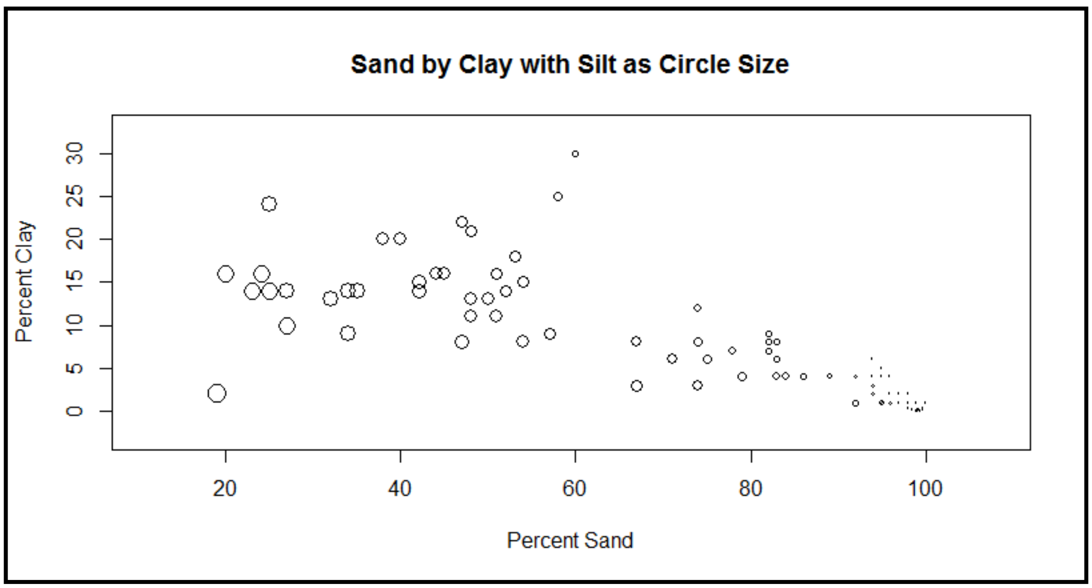


Figure 3.4 Clay by Sand with Silt as Circle Size

1. A change in this instance may be a statistical or qualitative change when compared to: a benchmark, baseline values, or temporal or spatial trends

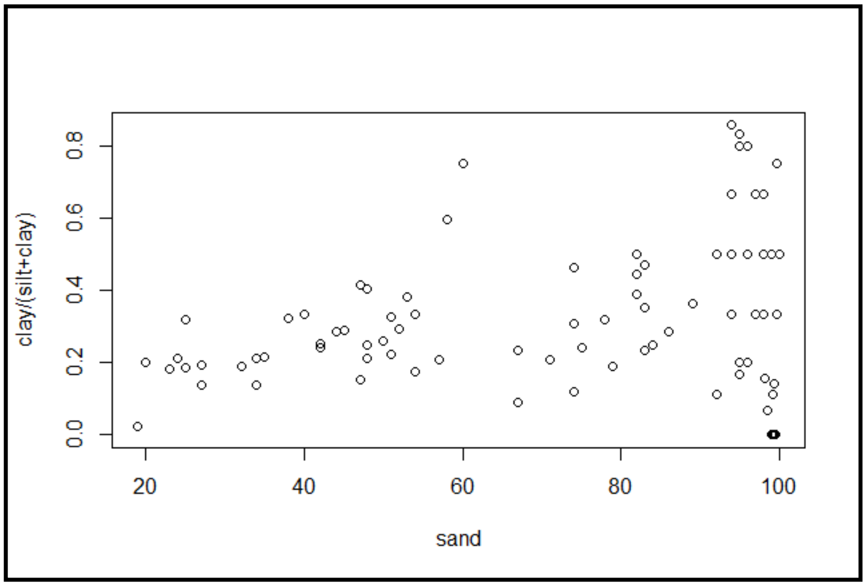


Figure 3.5 Dependent Relationship between Sand, Silt and Clay in Sediment

Colored scatter plots (Figure 3.6) show the relationship between TOC (or log TOC) and sand for lakes, streams and tributaries. Lakes are plotted using circles, streams and tributaries with triangles. Colors are used to identify the specific water bodies. Note that the x axis limits for streams and tributaries were adjusted because all the stream data is clumped at high proportions of sand (minimum of 82%). The figure shows that as expected the majority of lake sediment samples contain elevated TOC and higher proportions of fines (a lower proportion of sand), and conversely, the majority of stream samples are low in TOC and low in fines (predominantly sand).

A further evaluation was undertaken to identify cut offs in TOC and percent sand that could be applied to identify sediment samples in the baseline data. These same cut offs would be applied to sediment samples collected for monitoring.

3.5.2 Cut Point Analysis

Percent sand and TOC are generally related to metals concentrations. Deposition seems to be limited in sediment samples with a lot of sand and very little TOC. The focus of monitoring as part of the CREMP will be on identifying mine-related changes in metals concentrations. Variability due to TOC and particle size introduces extraneous noise. As such, it is generally better to control confounding factors in the study design rather than adjust for them during the data analysis. The data was reviewed to determine appropriate TOC and particle size cut-offs in order to identify sensitive depositional environments and minimize variability related to TOC and particle size. It was clear from the graphical analyses presented in Appendix D that establishing cut-offs in the vicinity of 80 to 90% sand (10 to 20% fines) and around 0.5% to 1% TOC would remove the non-depositional samples with high variability and comparatively low metals accumulation. Analyses were completed for four key parameters: arsenic, cadmium, iron and nickel.

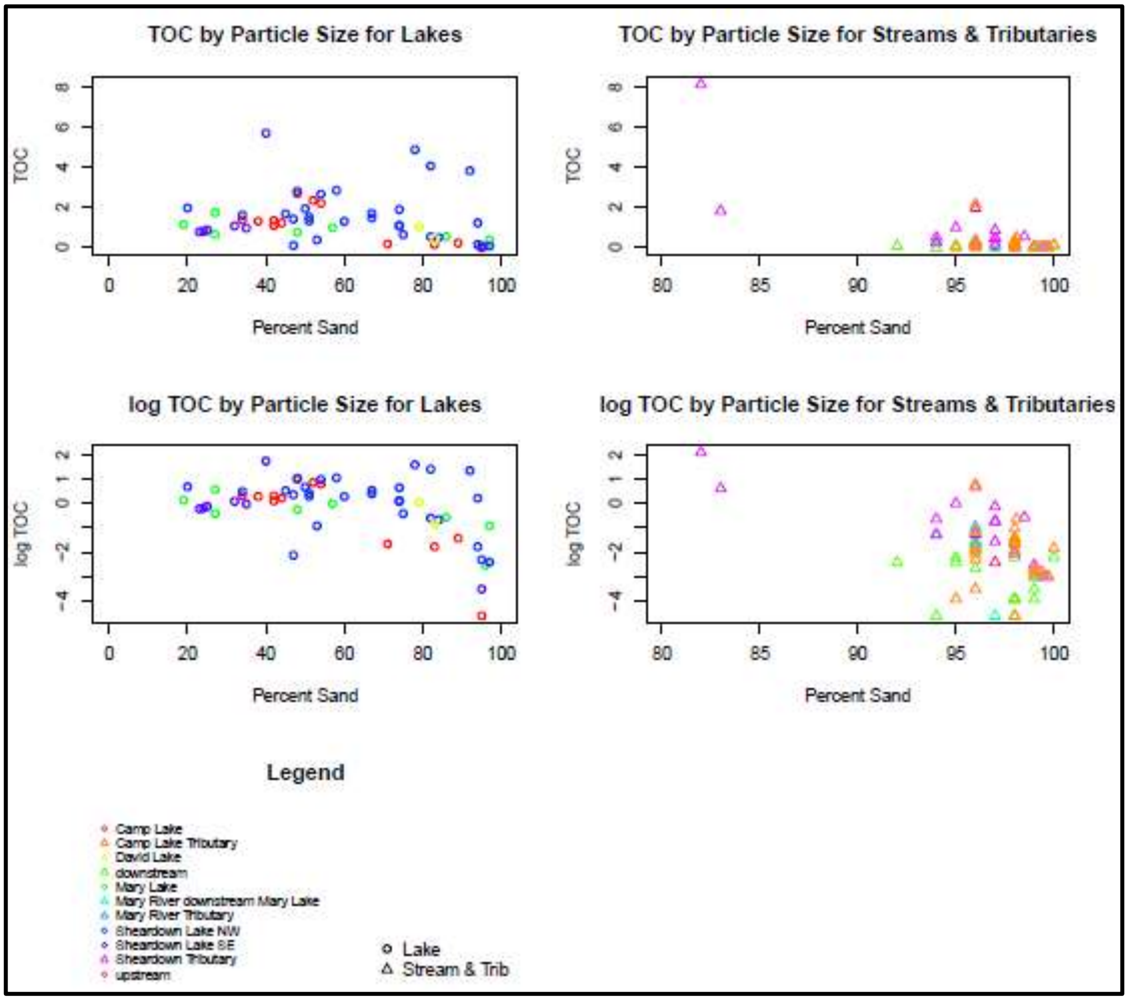


Figure 3.6 Sediment TOC versus Particle Size for Lakes and Streams

Analyses presented in Appendix D helped to identify cut points in the vicinity of inflection points on the curves. These cut points were used in subsequent linear regression analyses to explore the linear relationship above and below the cut off points.

A subset of the data was defined that excluded all samples with greater than 90% sand as well as samples with less than 0.6% TOC and greater than 80% sand (indicated in orange in Figure 3.7). Alternatively, a cut off could be established such as the sloped black line in Figure 3.7. It may be useful to carry out future research with additional data to develop such a rule.

The selection criterion reduces variability associated with TOC and particle size. For post-mining data, using only samples which meet the criterion is expected to be a conservative approach since samples with more than 80% sand and low TOC tend to have the smallest parameter concentration.

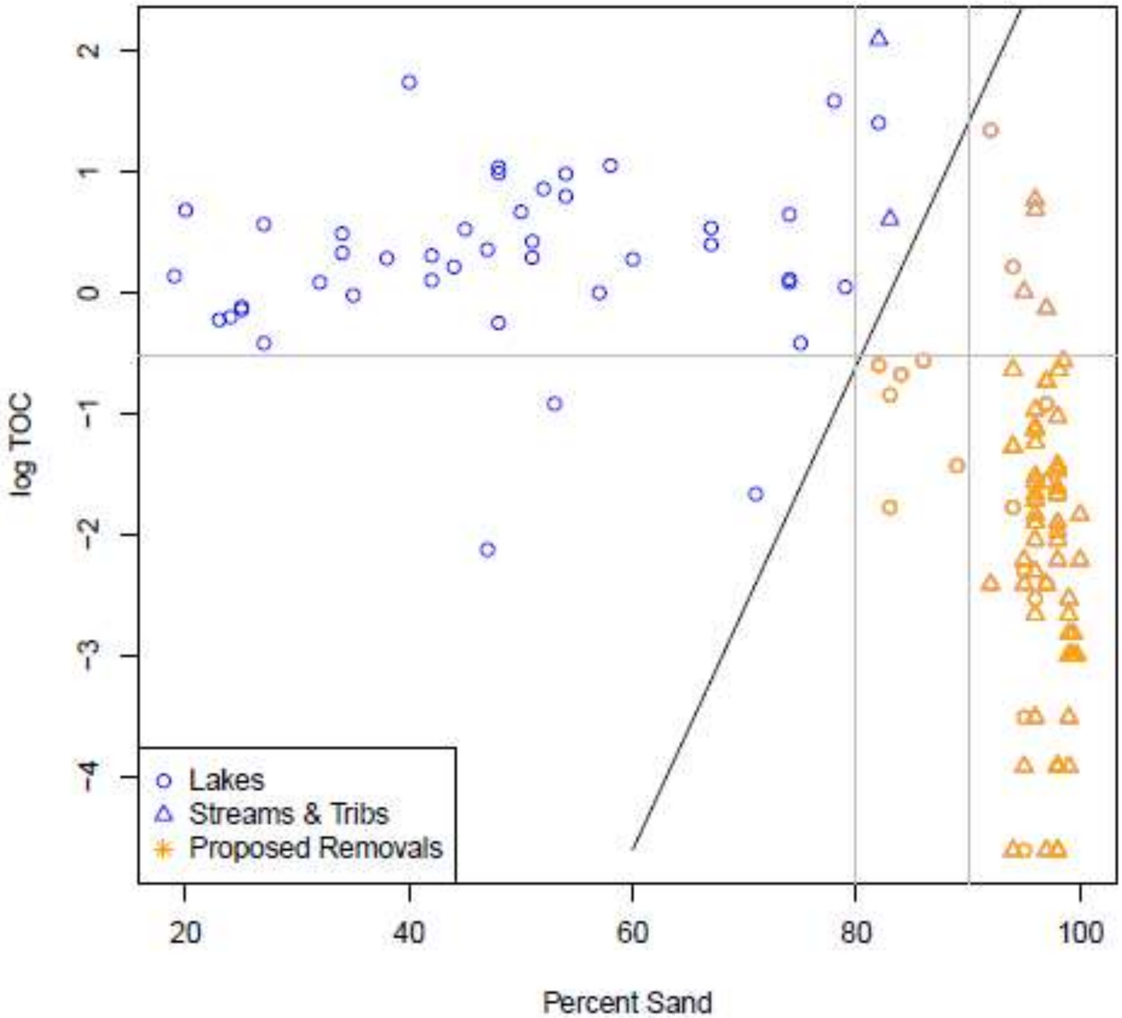


Figure 3.7 Results of Cut Point Analysis for Sediment

Environment Canada (2012) recommends that normalized metal concentrations be used to account for the effects of particle size and organic carbon. This method was considered, but it was found that the best way to minimize the relationship to organic carbon and fines involved creating data cut-offs. Additionally, normalized metals concentrations do not reflect the actual toxicity exposure in the environment.

Cut-off points have been identified for TOC and % sand based on metals accumulation in sediment in the baseline lake sediment samples. Baseline sediment samples with a TOC ≥0.6% and a minimum of 20% fines (or less than 80% sand) have been used for the development of the benchmarks and to calculate mean baseline concentrations (for "before" comparisons). Sediment samples with TOC <0.6% or with >80% sand (<20% fines) have not been included in the calculation of benchmarks, baseline means, and a priori power analyses. The same cut-off points will be applied to CREMP monitoring samples, with samples not meeting these cut-off points being excluded from exploratory and statistical analysis during monitoring.

Knight Piésold CONSULTING

3.5.3 Overview of Lake Sediment Results

Lakes are depositional environments that receive sediment inputs from airborne dust and surface runoff from adjacent shorelines as well as material transported into the lakes from upland areas due to seasonal stream inflows. Concentrations of metals in sediment are greatly influenced by the presence of organic carbon and/or fine sediment particle size in the substrate as described above. Substrate in depositional areas of the lake characterized by higher organic carbon content and/or higher fine sediment particle sizes are well suited for long-term monitoring since:

- These areas tend to accumulate metals due to the substrate characteristics and are therefore expected to be the most consistent with respect to elevated metals as well as the most sensitive to change (increasing accumulation of metals)
- The baseline data between lakes was similar

Each of the mine area lakes (Camp, Mary, Sheardown) showed considerable similarities in metals concentrations in sediment as well as the observed trends regarding metals accumulation at stations with high TOC and higher fines substrates. The variability in substrates that are predominantly sand and their limited TOC concentrations were also evident.

3.5.4 Overview of Stream Sediment Results

Concentrations of metals in sediments were generally highly variable within the streams, which tend to be higher energy environments with limited depositional areas. As such, these environments provide limited amounts of sediment quality data. Two sampling stations on Sheardown Lake (Tributary 1 D1-10 and D1-05) are depositional areas that show slightly higher fine sediments and elevated concentrations of cadmium, chromium, copper, iron, nickel, lead and zinc. These concentrations were above the applicable sediment quality guidelines.

Select near-field stream sediment sampling stations will continue to be monitored as described below:

- Sediment stations within Sheardown Tributary 1 that meet the TOC and % sand cut-offs will be monitored following the lake sediment monitoring program
- All other retained stream sediment stations will be monitored for comparison against previous results. These stations will be evaluated, but the higher energy, non-depositional environment may not be useful for a statistical comparison against CSQG-PAL and AEMP benchmarks. The results may support conclusions of lake samples or may trigger action using a different protocol.

3.6 SEDIMENT QUALITY CREMP STUDY DESIGN

Sediments are frequently part of environmental monitoring programs due to their importance in aquatic ecosystems. Sediments originate from particulates and precipitates that are generated from chemical and biological processes within aquatic systems. The determination of total metal concentrations in sediments is not required as part of the EEM program; however, mines are encouraged to determine total metal concentrations in sediments when completing benthic invertebrate community surveys (Environment Canada, 2012). For EEM monitoring programs where benthic invertebrate sampling is conducted in erosional habitat (e.g., streams), sediment sampling may not be possible and would not be reported. The spring freshet near the mine typically flushes fine grained sediment downstream into depositional areas (e.g., lakes). A summary of the existing baseline sediment data is provided below, in addition to the sampling plan.

The baseline sediment quality monitoring program results from the stream and lake environments surrounding the Project site show naturally elevated concentrations above the CSQG-PAL ISQGs or PSQG-LEL criteria for parameters of concern such as chromium, copper, iron, manganese and nickel (Section 3.5 and Appendix D). Iron and manganese concentrations were also occasionally above Ontario's severe effect levels in the lake environments.

The relationship between fine grained sediments and the accumulation of the parameters of concern suggests that the sediment monitoring program will focus on the depositional lake environments, since they are the end receiver of stream sediments. The proposed assessment protocol of establishing a change will be applied to lake sediment monitoring stations. Limited stream sampling will be undertaken in the Mary River and main tributaries of Camp Lake and Sheardown Lake, and the results compared to benchmarks.

3.6.1 Pathways of Effect and Key Questions

Key questions were developed for the CREMP to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. These questions and metrics focus upon key potential effects identified in the Final Environmental Impact Statement (FEIS) and the Early Revenue Phase (ERP) addendum, as well as metrics commonly applied for characterizing water quality.

The key pathways of potential effects of the Project on sediment quality include:

- Sediment quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1)
- Sediment quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW)
- Sediment quality changes due to direct deposition of dust in lakes and streams (Mine Area in zone of dust deposition)
- Sediment quality changes due to dust deposition on land and subsequent runoff into lakes and streams (Mine Area in zone of dust deposition)

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

The primary issue of concern with respect to sediment quality is related to the effect of ore dust containing elevated metals being deposited on or running off into lakes and streams. As such, the CREMP and the baseline data review focused upon waterbodies that are closest to the sources of ore dust. Sheardown Lake and its tributaries, Camp Lake and its closest tributaries, as well as the Mary River and the north arm of Mary Lake are located within the zone of influence for ore dust deposition and non-point sources of fugitive dust (i.e., road dust). The main basin of Mary Lake receives sediment loading from the Mary River.

3.6.2 Parameters and Metrics

Sediment quality parameters identified for monitoring include various physical parameters, metals and nutrients. They were selected on the basis of the following:

- The potential to be naturally elevated in the environment
- The potential to become elevated in the environment as a result of future mine site activities
- An established criterion exists for the protection of freshwater aquatic life
- Regulation under the MMER, or potential regulation as a result of the current re-evaluation of the regulations
- The parameter affects the attenuation of metals (i.e., particle size and total organic carbon)

The contaminants of potential concern and supporting parameters are listed in Table 3.5. Those SOPCs with local enrichment are noted in the table.

Table 3.5 Sediment Quality Parameters Selected for Monitoring

Contaminants of Potential Concern	Exploratory Data Analysis Only
Arsenic	Moisture content
Cadmium	Particle Size
Chromium *	Total Organic Carbon (TOC)
Copper *	Nitrite
Iron *	Nitrate
Lead	Total Kjeldahl Nitrogen
Manganese *	
Mercury	
Nickel *	
Phosphorus *	
Zinc	

3.6.3 Benchmarks

Since the mine site occurs within an area of metals enrichment, generic sediment quality guidelines established for all areas within Canada may naturally be exceeded near the mine site. Therefore, the selection of appropriate benchmarks must consider established sediment quality guidelines, such as those developed by the Canadian Council of Ministers of the Environment (CCME) and the Ontario Ministry of the Environment (MOE), as well as site-specific natural enrichment in the selection or development of final benchmarks for monitoring data comparison (CCME, 2007).

Intrinsik Environmental Sciences Inc. was retained by Baffinland to develop water and sediment quality benchmarks to be applied in the CREMP (Intrinsik, 2014; see Appendix F of the AEMP). The sediment quality data utilized in benchmark development met the TOC and % sand cut-off points described in Section 3.5.2. The development of sediment quality benchmarks follows the same process identified for the water quality benchmarks (Section 2.7.3), considering the higher of the generic sediment quality objective (i.e., CCME or other jurisdiction) or the 97.5^{th} percentile of baseline concentrations. For parameters that are mostly below MDL (less than 5% detected values), either the generic sediment quality guideline was selected (if available), or 3 * MDL was adopted as the benchmark, as follows:

- **Method A**: Sediment Quality Guideline was higher than 97.5%ile, and therefore was selected
- **Method B**: 97.5%ile was higher than the Sediment Quality Guideline, and therefore was selected
- **Method C**: Parameter has < 5% detected values, and either the Sediment Quality Guideline was selected (if available), or 3 * MDL was used to derive benchmark

If Method B was selected, additional assessment of the data was conducted to ensure the percentile calculations were not being driven by elevated detection limits, or other factors.

Area-wide interim sediment quality benchmarks have been identified for mine site lakes and streams collectively (Table 3.6). Based on the available data, final sediment quality benchmarks cannot be selected at this time, as there are insufficient data within several of the lakes to adequately characterize baseline and confirm that area-wide benchmarks would not underestimate natural levels in several of the lakes (Camp Lake, Mary Lake, Tributaries of Sheardown Lake, and Sheardown Lake SE). Therefore, the area-wide interim benchmarks identified in Table 3.6 will be re-evaluated following additional sediment quality data collection in 2014.

In the case of mercury, lead and zinc, the selected benchmark is the generic sediment quality guideline, as area-wide data were less than or equal to this value. The selection of the generic guideline at this time for these substances appears reasonable. Further sediment characterization in area lakes in 2014 may result in changes to this decision. In the case of arsenic, chromium, copper, iron, manganese, nickel and phosphorus, the suggested area-wide Interim AEMP benchmark is the 97.5^{th} percentile of baseline. The use of the area-wide percentiles as an interim benchmark appears reasonable, based on comparisons to both the existing guidelines, and characterization data for the lakes.

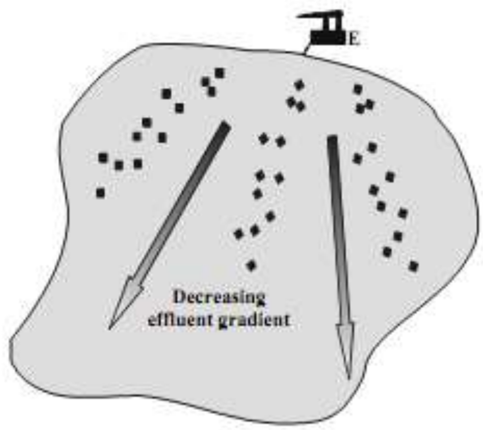
As discussed earlier, further data collection will assist in better understanding baseline within the lakes, and will assist in final benchmark development. With respect to the temporal analysis conducted for Sheardown Lake NW: chromium, copper, and nickel showed some increased trends over time in this basin (see Intrinsik, 2014; AEMP Appendix F). Based on the 97.5^{th} percentile calculations presented in Table 3.6 for this basin, these trends are not considered to substantially influence the outcome of the recommended interim benchmark. This issue will be re-assessed with 2014 data, for final benchmark development. For cadmium, the data are largely non-detect, at an MDL of 0.5 mg/kg. The ISQG is 0.6 mg/kg, and due to the close proximity of the MDL to the ISQG, the 3 times MDL approach was applied for AEMP benchmark development.

As noted in Section 2.7.3 in regard to water quality benchmarks, the assessment of sediment quality data over the life of the project will be on-going, and the recommended benchmarks of comparison throughout this process may change, as more data become available. For example, a site-specific sediment quality guideline established early on in the life of the mine may require updating in 10 years, based on new published literature which has become available, or site-specific toxicity tests conducted to further understand ETMF or resident species toxicity. The iterative, cyclical nature of modification of benchmarks under an AEMP is well established (MacDonald et al., 2009).

3.6.4 Monitoring Area and Sampling Stations

The monitoring area for sediment quality includes mine area lakes, specifically Camp Lake, Sheardown Lake NW and SE; selected tributaries of each lake; Mary Lake; and the Mary River.

Environment Canada (2012) recommends a Control-Impact (CI) or Gradient Sample design for detection of effects in the lake environment benthic invertebrate community (Figure 3.8). A gradient sample design has been defined for the CREMP lake sediment stations that is integrated with benthic invertebrate sampling and utilizes existing sediment sampling locations that meet the cut-off criteria (Section 3.5.2).



c) Radial gradient design for lake or coastal situations

Figure 3.8 Gradient Sampling Design to Lake Sediment Monitoring

Preliminary sediment sampling locations in each of Camp Lake, Sheardown Lake and Camp Lake are shown on Figures 3.9, 3.10 and 3.11, respectively, and are listed in Table 3.7. The lake sediment stations make use of existing and new (proposed) stations as follows:

- Camp Lake - 14 stations including three historic stations and 11 new stations
- Sheardown Lake NW - 14 stations including six historic stations and eight new stations
- Sheardown Lake SE - 10 stations including four historic stations and six new stations
- Mary Lake - 15 stations including five historic stations and 10 new stations

Lake sediment samples will be collected along transects positioned along the anticipated path of effluent (i.e., direction of inflow stream). At each station, field technicians will establish final locations for the sediment stations that are within depositional areas of the lake. This field fit of the sampling stations will likely result in some modifications to the gradient study design.

Limited stream sediment sampling is proposed for the reasons described in Section 3.5. Select existing stream sediment sampling stations will continue to be monitored as described below (see Figures 3.9, 3.10 and 3.11):

- Four sediment stations within Sheardown Tributary 1 (SDLT-1), a portion of which meet the TOC and % sand cut-offs (SDLT1-R1, D1-01, D1-05, and SDLT1-R4)
- One sediment station in each of Sheardown Tributaries 9, 12 and 13 (SDLT-9-US, SDLT-12-US, SDLT-12-DS), none of which meet the TOC and % sand cut-offs

- Three sediment stations within Camp Lake Tributaries 1 and 2 (CLT-1 and CLT-2) which do not meet the TOC and % sand cut-offs but are the lowest energy stations available (CLT-1 US, CLT-1-DS, CLT-2-DS)
- Two sediment stations on the Mary River, downstream of effluent discharges where sediment collection is possible (E0-20 and C0-05)

At least two sediment quality stations on SDLT-1 are located in depositional environments and the review has identified metals accumulation exceeding generic sediment quality guidelines. It is expected that the AEMP assessment and response framework (Section 3.6.8) can be applied to monitoring data from these stations to identify statistical change. All other retained stream sediment stations will be monitored for comparison against previous results. Stream sediment stations will be evaluated and compared to benchmarks, but statistical comparison to baseline will not be possible. The stream sediment sampling results may support conclusions of lake samples or may trigger action based on a qualitative review of the monitoring data.

3.6.5 Sampling Frequency and Schedule

Sediment quality monitoring will be conducted once each monitoring year in the fall to coincide with benthic invertebrate sampling to be conducted as part of the freshwater biota CREMP (AEMP Appendix C).

As outlined in Schedule 5, Part 2 of the MMER, biological monitoring studies are to be conducted on a three year cycle until two consecutive biological monitoring studies indicate no effect on fish populations, on fish tissue and on the benthic invertebrate community. In the long-term, sediment sampling under the CREMP will be conducted every three years, coinciding with biological monitoring studies. However, to be cautious initially, Baffinland will conduct sediment sampling in 2014 to collect additional pre-mining baseline data, and then annually for the first three years of mining. After monitoring three operating (mining) years, the sampling frequency will be re-assessed with the expectation of conducting the monitoring program on a three year cycle provided annual sampling up to that time supports this change.

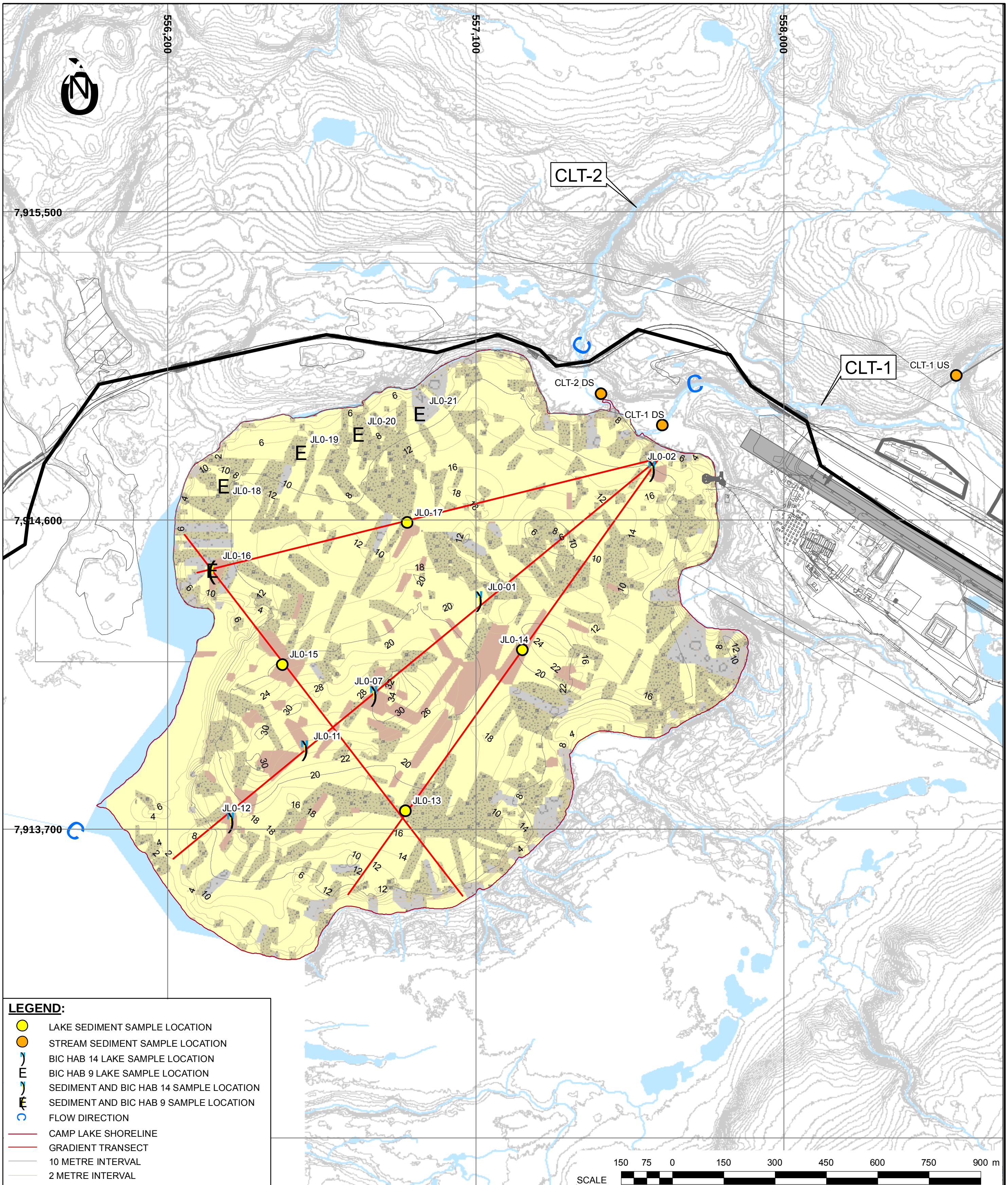
3.6.6 Quality Assurance/Quality Control

The same QA/QC program described in Section 2.6.6 will be applied to sediment quality monitoring. The field sampling protocols being applied to the sediment (and water) quality programs are presented in Appendix A.

Table 3.6 Selected Benchmark Approach and Interim Area-Wide Sediment Quality Benchmarks

Jurisdiction, Type of Guideline and Statistical Metric		Hg	As	Cd	Cr	Cu	Fe	Mn	Ni	P	Pb	Zn
CCME CSQG	**ISQG**	0.17	5.9	0.6	37.3	35.7	NGA	NGA	NGA	NGA	35	123
	PEL	0.486	17	3.5	90	197	NGA	NGA	NGA	NGA	91.3	315
Ontario PSQG	**LEL**	0.2	6	0.6	26	16	20,000	460	16	600	31	120
	SEL	2	33	10	110	110	40,000	1100	75	2,000	250	820
US EPA Sediment Quality Guidelines	**Screening**	0.18	9.8	0.99	43.4	31.6	20,000	460	22	NGA	35.8	121
97.5th Percentiles of Each Lake Area (sample size)												
Tributaries of Sheardown Lake (5)		0.1	2.95	1.9	118	106	28,370	809	115	295	52	171
Mary Lake (6)		0.1	4.95	0.5	97	38	51,463	4,305	61	1,580	28	103
Camp Lake (9)		0.1	4	0.5	83	50	40,920	1,057	74	1,480	23	69
Sheardown Lake NW (25)		0.1	7.95	0.5	96	60	56,240	5,612	81	2,310	24	92
Sheardown Lake SE (6)		0.1	2.0	0.9	80	32	32,988	547	66	1,278	18	57
95th%ile of Area-Wide Data (47)[2]		NC	5.2	0.5	93	56	50,430	3,874	76	1,565	24	91
97.5th %ile of Area-Wide Data (47)[2]		NC	6.2	0.5	97	58	52,200	4,530	77	1,958	24	94
Proposed Interim Area-Wide Benchmark		**0.17**	**6.2**	**1.5**	**97**	**58**	**52,200**	**4,530**	**77**	**1,958**	**35**	**123**
Benchmark Method		A	B	C	B	B	B	B	B	B	A	A

NOTES:
1. SHADED CELLS HAVE CONCENTRATIONS HIGHER THAN THE ISQG OR LEL; NC = NOT CALCULATED AS ALL VALUES < MDL.
2. TRIBUTARIES OF SHEARDOWN LAKE DATA ARE NOT INCLUDED DUE TO ELEVATED RESULTS IN THIS AREA.
3. GUIDELINE IS BASED ON SEDIMENT QUALITY GUIDELINE.
4. GUIDELINE IS BASED ON 97.5TH%ILE OF BASELINE DATA.
5. GUIDELINE IS BASED ON 3 TIMES MDL, THE 97.5TH%ILE IS EQUAL TO THE MDL.
6. MERCURY WAS NOT DETECTED IN ANY SAMPLES; MERCURY DETECTION LIMIT IS USED TO REPRESENT THE 95TH AND 97.5TH PERCENTILES.



LEGEND:

- LAKE SEDIMENT SAMPLE LOCATION
- STREAM SEDIMENT SAMPLE LOCATION
- BIC HAB 14 LAKE SAMPLE LOCATION
- BIC HAB 9 LAKE SAMPLE LOCATION
- SEDIMENT AND BIC HAB 14 SAMPLE LOCATION
- SEDIMENT AND BIC HAB 9 SAMPLE LOCATION
- FLOW DIRECTION
- CAMP LAKE SHORELINE
- GRADIENT TRANSECT
- 10 METRE INTERVAL
- 2 METRE INTERVAL
- EXISTING TOTE ROAD
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

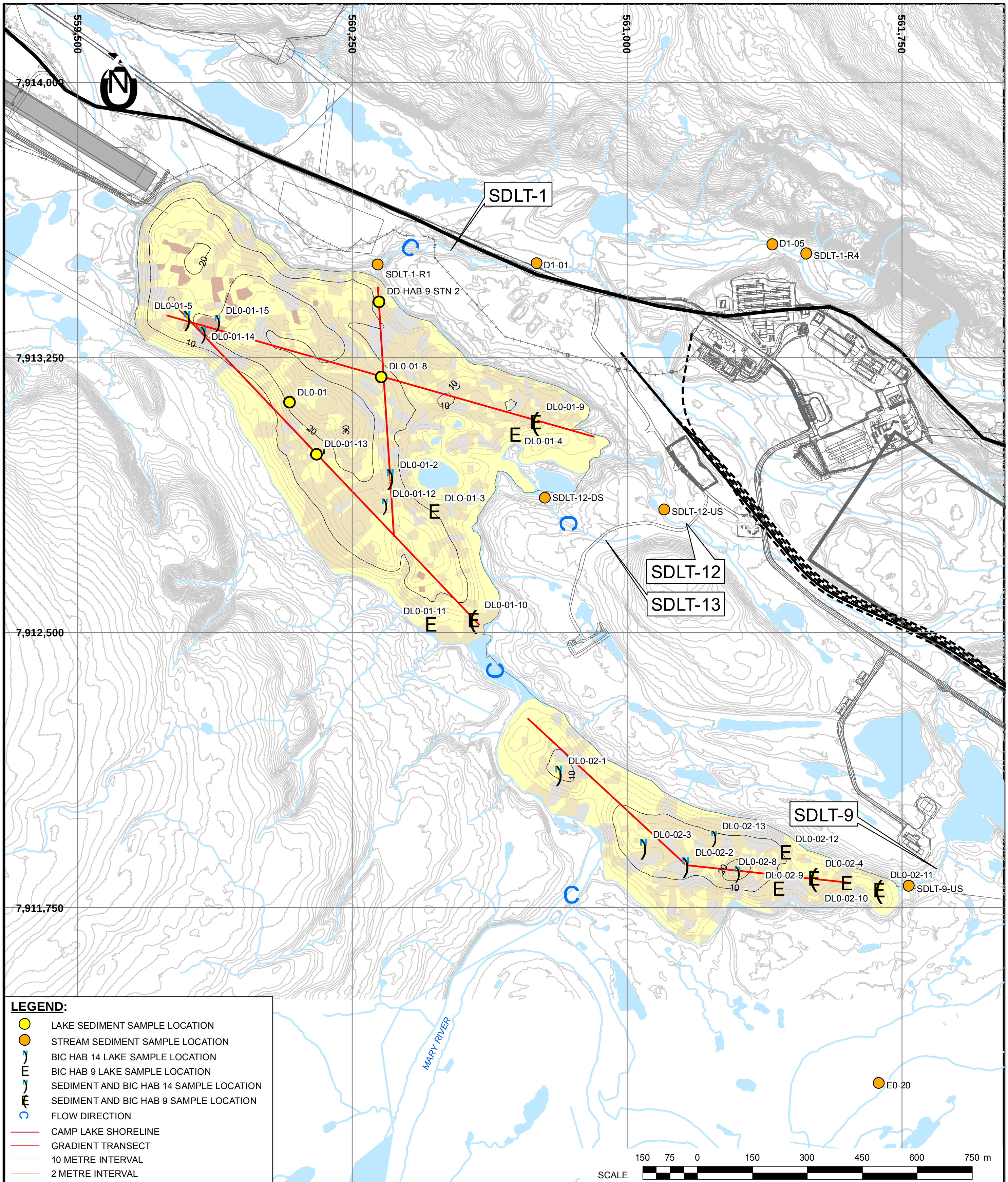
CAMP LAKE PROPOSED SEDIMENT LOCATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.9	REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	DDMMM'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM



NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

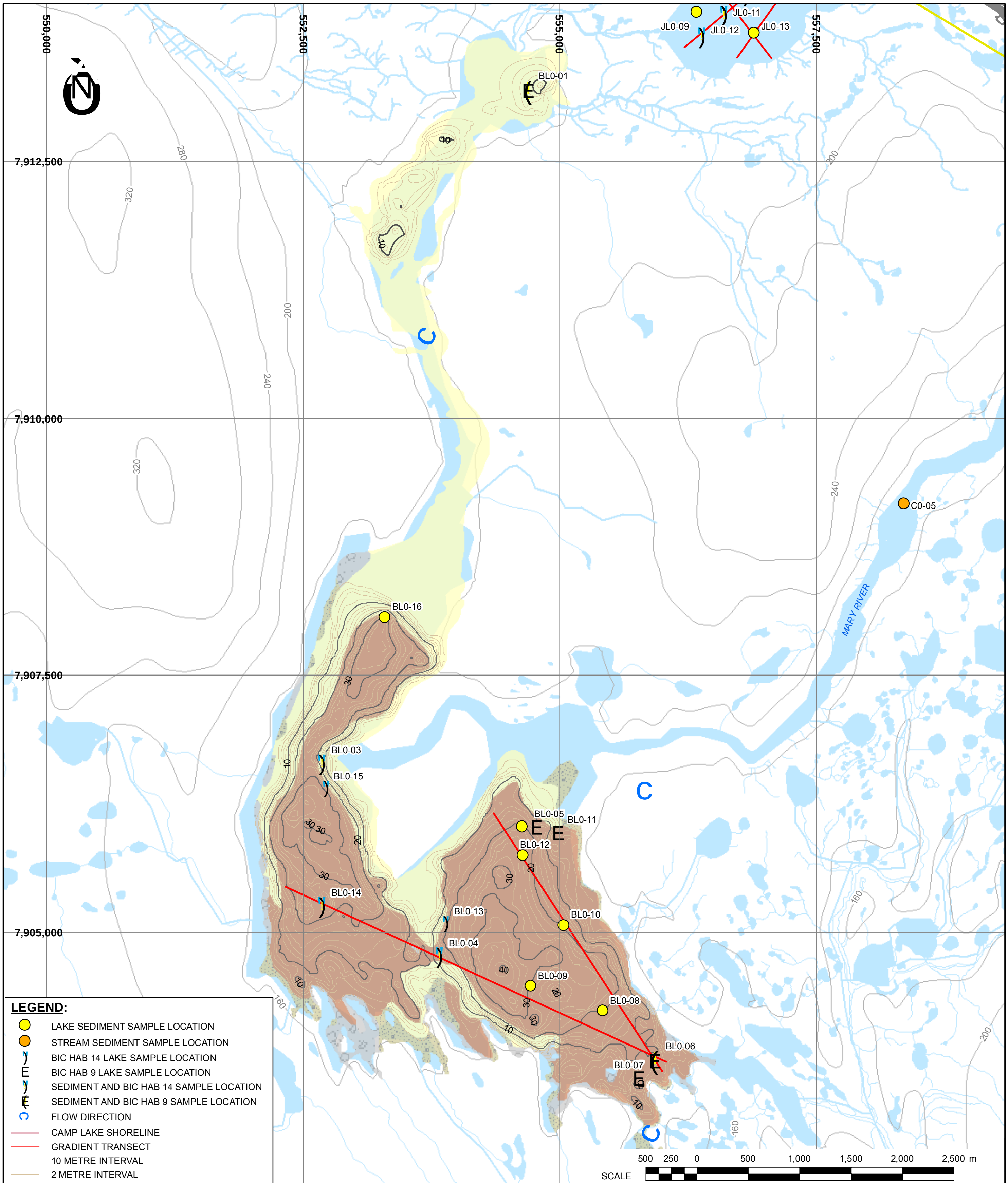
SHEARDOWN LAKE SEDIMENT LOCATIONS

Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE 3.10 | REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAM



LEGEND:

- LAKE SEDIMENT SAMPLE LOCATION
- STREAM SEDIMENT SAMPLE LOCATION
- BIC HAB 14 LAKE SAMPLE LOCATION
- BIC HAB 9 LAKE SAMPLE LOCATION
- SEDIMENT AND BIC HAB 14 SAMPLE LOCATION
- SEDIMENT AND BIC HAB 9 SAMPLE LOCATION
- FLOW DIRECTION
- CAMP LAKE SHORELINE
- GRADIENT TRANSECT
- 10 METRE INTERVAL
- 2 METRE INTERVAL
- EXISTING TOTE ROAD
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAM

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MARY LAKE SEDIMENT LOCATIONS

Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE 3.11 REV 1

SAVED: I:\102\00181\33\A\GIS\Figs\A11_r1.mxd; Jun 26, 2014 4:32 PM; asimpson

Table 3.7 Sediment Quality CREMP Stations Details

Station ID	Easting	Northing	Sediment	BIC Habitat 9	BIC Habitat 14	Description/Rationale
	NAD 83, Zone 17N					
Mary Lake (North Basin)						
BL0-01	554690	7913194	X	X		North basin receiving water from Camp Lake
Mary Lake (South Basin)						
BL0-03	552680	7906651	X		X	Main basin receiving water from north basin
BL0-04	553817	7904886	X		X	Main basin receiving water from north basin
BL0-05	554632	7906031		X		Main basin near outlet of Mary River
BL0-06	555924	7903760	X	X		Main basin near outlet of Mary River
BL0-07	555774	7903588		X		Main basin near outlet of Mary River
BL0-08	555420	7904237	X			Main basin between BL0-05 and BL0-06
BL0-09	554715	7904479	X			Main basin between BL0-05 and BL0-06
BL0-10	555038	7905069	X			Main basin between BL0-05 and BL0-06
BL0-11	554987	7905976		X		Main basin near outlet of Mary River
BL0-12	554641	7905752	X			Main basin near outlet of Mary River
BL0-13	553887	7905092			X	Main basin receiving water from north basin
BL0-14	552679	7905263	X		X	Main basin receiving water from north basin
BL0-15	552716	7906412			X	Main basin receiving water from north basin
BL0-16	553295	7908068	X			Main basin receiving water from north basin
Mary River (D/S of SDL)						
C0-01	556305	7906894	X			Mainstem, before outflow into Mary Lake
C0-05	558352	7909170	X			Mainstem, d/s of mine
SDL-Tributaries						
D1-01	560753	7913507	X			Tributary SDLT-1
D1-05	561397	7913558	X			
SDLT-1-R1	560320	7913504	X			
SDLT-1-R4	561490	7913533	X			
SDLT-9-US	561770	7911810	X			Tributary SDLT-9
SDLT-12-DS	560776	7912867	X			Tributary SDLT-12
Sheardown Lake NW						
DD-Hab 9-Stn 2	560323	7913402	X			Nearshore station
DL0-01	560079	7913128	X			Mid-lake position
DL0-01-2	560353	7912924	X		X	Mid-lake position
DL0-01-3	560474	7912833		X		Southeastern region
DL0-01-4	560695	7913043		X		Eastern region, near SDLT-9 inflow stream
DL0-01-5	559798	7913356	X		X	Near treated wastewater discharge location
DL0-01-8	560329	7913197	X			Mid-lake position
DL0-01-9	560750	7913077	X	X		Eastern region, near SDLT-9 inflow stream
DL0-01-10	560580	7912537	X	X		Near outlet channel to Southeast Basin
DL0-01-11	560464	7912525		X		Near outlet channel to Southeast Basin
DL0-01-12	560337	7912848			X	Mid-lake position
DL0-01-13	560152	7912986	X			Mid-lake position
DL0-01-14	559842	7913316			X	Near treated wastewater discharge location
DL0-01-15	559881	7913347			X	Near treated wastewater discharge location

Station ID	Easting	Northing	Sediment	BIC Habitat 9	BIC Habitat 14	Description/Rationale
	NAD 83, Zone 17N					
Sheardown Lake SE						
DL0-02-1	560813	7912116	X		X	Near inlet channel from Northwest Basin
DL0-02-2	561160	7911866	X		X	Mid-lake position
DL0-02-3	561046	7911915	X		X	Mid-lake position
DL0-02-4	561511	7911832	X	X		Eastern region
DL0-02-8	561301	7911846			X	Mid-lake position
DL0-02-9	561414	7911804		X		Eastern region
DL0-02-10	561600	7911819		X		Eastern region near SDLT-9 stream inflow
DL0-02-11	561688	7911801	X	X		Eastern region near SDLT-9 stream inflow
DL0-02-12	561434	7911904		X		Eastern region
DL0-02-13	561237	7911943			X	Mid-lake position
Mary River (US of SDL)						
E0-20	561688	7911272	X			Near EEM near field exposure area
Camp Lake						
JL0-01	557107	7914369	X		X	On gradient transect between CLT-1 and lake outlet
JL0-02	557614	7914750	X		X	
JL0-07	556800	7914094	X		X	
JL0-11	556598	7913935	X		X	
JL0-12	556382	7913724	X		X	
JL0-13	556894	7913752	X			Southern region
JL0-14	557235	7914222	X			Mid-lake position
JL0-15	556534	7914179	X			Eastern region
JL0-16	556329	7914456	X	X		Near northwest shoreline
JL0-17	556899	7914593	X			Northern region
JL0-18	556361	7914702		X		Along the northwest shoreline
JL0-19	556588	7914800		X		Along the northwest shoreline
JL0-20	556755	7914854		X		Along the northwest shoreline
JL0-21	556935	7914913		X		Along the northwest shoreline
Camp Lake Tributaries						
CLT-1 DS	557645	7914878	X			Lower reach of CLT-1 near lake outlet
CLT-1-US	558504	7915022	X			Upstream of CLT-1 near natural fish barrier
CLT-2 DS	557466	7914969	X			Lower reach of CLT-2 near lake outlet
Reference Lakes						
TBD						
Duplicates			**5**	**-**	**-**	
TOTAL			**50**	**20**	**20**	

NOTES:
1. STATION LOCATIONS PROPOSED BASED ON AVAILABLE SUBSTRATE AND WATER DEPTH DATA, SUBJECT TO CHANGE FOLLOWING IN-SITU FIELD CONFIRMATION OF CONDITIONS.

3.6.7 Study Design and Data Analysis

The purpose of sediment quality monitoring is to answer the same question posed in regard to water quality:

What is the estimated mine-related change in contaminant concentrations in the exposed area

To answer this question, the study has been designed to test the following three hypotheses:

- Null hypothesis: Change over time is the same for exposure and reference stations. Alternate hypothesis: Data from exposure stations is statistically different from data measured at reference stations.
- Null hypothesis: Difference between exposure and reference stations is due to natural environmental variation. Alternate hypothesis: Difference in exposure and reference station is due to mine effects.
- Null hypothesis: Magnitude of concentrations at the exposure station does not exceed the benchmark. Alternate hypothesis: Magnitude of concentrations at the exposure station exceeds the benchmark.

The sediment quality CREMP monitoring program will focus on sediment in lakes, since the depositional characteristics found within the lakes is the final sink for natural and project-related contributions to sediment load.

Environment Canada (2012) recommends a Control-Impact (CI) or Gradient Sample design for detection of effects in the lake environment benthic invertebrate community (Figure 3.8). A gradient sample design has been defined for the CREMP lake sediment stations that is integrated with benthic invertebrate sampling and utilizes existing sediment sampling locations that meet the cut-off criteria (Section 3.5.2). Sediment samples will be collected mainly along lake transects. Transects have been positioned along the anticipated path of effluent (i.e., direction of inflow stream). Preliminary sediment sample locations are presented on Figures 3.9, 3.10 and 3.11, and are discussed in Section 3.6.4.

Candidate reference lakes have been identified for application to the AEMP. Being located outside of the mine area, the reference lakes are expected to be unaffected by local mineralization to the extent that the mine site lakes are. Therefore, a control-impact approach to monitoring change in the mine site lakes may have limited utility in detecting Project-related changes to sediment quality.

With the exception of Sheardown Lake NW, the baseline dataset for sediment quality at the mine area is relatively limited. Additional baseline (pre-mining) sediment quality data will be collected in 2014 to supplement the baseline dataset. Nonetheless, a before-after comparison of monitoring data to baseline data will be carried out to the extent that the dataset allows.

In addition, the gradient design selected for lake sediment quality will allow for an assessment of the spatial extent of mine impacts. Since effluent discharges are fixed and dust deposition can be expected to occur in a gradient, it is expected that concentrations will decrease as the distance from the mine increases In the absence of appropriate control data, it may be necessary to use the exposure data alone to assess mine effects. Mining effects could be observed in several ways:

- Before-After: concentrations increase over time at a given station
- Gradient effect: concentrations increase with increasing proximity to the mine
- Gradient effect changes over time: concentrations are stable across the gradient during baseline but increase with increasing proximity to the mine after mining commences. That is, concentrations increase over time at stations close to the mine but remain relatively stable at far field stations (i.e., the slope of the gradient effect increases over time).

In addition, because there is a relationship between sediment SOPCs, increases in multiple parameters can be used in a weight of evidence to identify project-related changes.

3.6.8 Assessment Framework

Monitoring data will be assessed during each year of monitoring and would follow the assessment framework as outlined in Figure 2.12 and described below. The assessment framework for sediment quality monitoring closely mirrors that described for water quality in Section 2.6.8, with minor differences.

3.6.8.1 Step 1: Initial Data Analysis

Initial data analysis will involve following specific data management and monitoring protocols in the handling and initial comparison of data.

Data Input and Storage

Following data collection, and upon receipt of the laboratory reports, data will be entered into the Project EQWin® database.

Initial Data Analysis including Outlier Assessment

The initial data analysis will include a number of possible steps, such as the following:

- Completion of summary statistics (average, median, maximum, minimum, quartiles)
- Flagging of lake and stream sediment samples that do not meet the TOC and % sand cut-off values
- Flagging of values greater than the defined benchmark values
- Flagging of values at or exceeding the mid-point between the baseline mean and the benchmark
- Evaluating temporal changes in the data by season

The initial data analysis will include an outlier assessment after data entry and the completion of quality assurance and quality control steps. An outlier assessment is completed after each round of sampling to ensure data anomalies are identified early. If necessary, the laboratory can be contacted to re-analyze samples. Any identified outliers will be investigated to ensure no data integrity issue exists. For example, duplicate samples will be assessed along with any holding time exceedances. If no evidence exists to discard data, then the data will remain in the dataset but be flagged for future consideration.

3.6.8.2 Step 2: Determine if Change is Mine Related

Step 2 involves determining if the changes in sediment quality parameters of concern are due to the Project or due to natural variability or other causes. This question will be addressed using exploratory data analysis (EDA) and subsequently using statistical data analysis (SDA), as described below.

Prior to conducting EDA and SDA, Project activities with the potential to alter sediment quality will be reviewed to identify potential Project-related causes or sources. This could include evaluating effluent quality, discharge regime/rates, and loading, dust deposition, and other point/non-point sources as required. Also, any evidence of potential natural causes (i.e., a major erosional event such as a slumping riverbank) will be investigated. Sampling data sheets and site personnel will be a source of this information.

Exploratory Data Analysis

Exploratory data analysis (EDA) will be completed to visualize overall data trends. This could include evaluating spatial patterns in sediment quality results for the mine area as a whole, including mine area lakes and streams, to evaluate if changes are widespread or specific to certain waterbodies, or proximate to mine-related sources, and to identify the spatial extent and pattern of observed changes.

Data from Mine Area lakes will be compared to data from Mine Area streams to reference streams and potentially to reference lake(s) and stream(s). This will further assist with determining whether the observed changes were due to natural variability or the Project.

These graphical analyses will also confirm assumptions required for statistical testing (normality, sample size, independence). Results of the EDA will be used in tandem with the SDA to confirm the observed statistical trends and can be used to evaluate the potential for biologically relevant change.

Statistical Data Analysis

Primary SDA will be completed using methodology consistent with the before-after design used for the power analysis. This will be used to assess the potential magnitude of change during post-mining. This step in the analysis tests the primary hypothesis for the effects of mine-related change and can be applied to the parameters of interest.

If the Step 2 analysis concludes that the changes in sediment quality parameters of concern are, or are likely, due to the Project, the assessment will proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response will be required.

3.6.8.3 Step 3: Determine Action Level

Once EDA and primary SDA has indicated with some certainly that the measured change is project-related, Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark.

If the benchmark is not exceeded, a **low action response** would be undertaken and would include:

- Evaluate temporal trends
- Identify likely source(s) and potential for continued contributions
- Confirm the site-specific relevance of benchmark and establish a site-specific benchmark, if necessary
- Based on evaluations, determine next steps

If the benchmark is exceeded and it is concluded to be due to, or likely due to, the Project, a **moderate action level response** would be undertaken and would include, in addition to analyses identified in for a low action response, the following:

- Consider a weight-of-evidence (WOE) evaluation and/or risk assessment, considering other monitoring results collectively with sediment quality to evaluate effects on the ecosystem

- Evaluate the need for and specifics of increased monitoring
- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the **high action level response** has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in sediment quality parameters of concern on the lakes as a whole, as well as the monitoring results from the freshwater biota CREMP. Also, the benchmark may need to be revised in consideration of ongoing monitoring results. The precise relationships between water quality, sediment quality and lower trophic level changes and the collective effects on fish is difficult to predict and therefore actions undertaken under Level 2 will attempt to explore these relationships to advise on overall effects to the ecosystem. Results would be discussed with regulatory agencies and the next steps would be identified. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) include:

- Implementation of increased monitoring to confirm effects and/or define magnitude and spatial extent of effects if warranted
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response

4 – REFERENCES

Agresti, A, 1990. *Categorical Data Analysis*. Wiley Series, New York.

Baffinland Iron Mines Corporation, 2012. *Mary River Project - Final Environmental Impact Statement.* February.

Baffinland Iron Mines Corporation, 2013a. *Mary River Project - Aquatic Effects Monitoring Program Framework.* February.

Baffinland Iron Mines Corporation, 2013b. *Mary River Project - Updated Aquatic Effects Monitoring Program Framework.* December.

Baffinland Iron Mines Corporation, 2014. *Mary River Project - Aquatic Effects Monitoring Plan.* In-progress.

Canadian Council of Ministers of the Environment, 2002. *Canadian sediment quality guidelines for the protection of aquatic life: Introduction*. Updated. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment, 1999. *Canadian water quality guidelines for the protection of freshwater aquatic life*. Canadian Environmental Quality Guidelines Summary Table on-line, http://st-ts.ccme.ca/. Updated in 2014.

Downing, J.A. and E. McCauley, 1992. The Nitrogen : Phosphorus Relationship in Lakes, in: *Limnol. Oceanogr.* 37(5), pages 936-945. The American Society of Limnology and Oceanography, Inc.

Edwards, D., 1998. Data Quality Control/Quality Assurance, in: *Data and Information Management in the Ecological Sciences: A Resource Guide*. Michener, W.K., Porter, J.H. and Stafford, S.G. (eds.), LTER Network Office, Univ. of New Mexico, Albuquerque, NM, USA.

Environment Canada, 2012. *Metal Mining Technical Guidance for Environmental Effects Monitoring*. Available online at: https://www.ec.gc.ca/esee-eem/AEC7C481-D66F-4B9B-BA08-A5DC960CDE5E/COM-1434---Tec-Guide-for-Metal-Mining-Env-Effects-Monitoring_En_02[1].pdf

Fletcher R., P. Welsh and T. Fletcher, 2008. *Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An Integrated Approach.* Queen`s Printer for Ontario. PIBS 6658e. May 2008.

Green, R., 1979. *Sampling Design and Statistical Methods for Environmental Biologists. In 'Proceedings of the 29th Congress of the Australian Society of Limnology, Jabiru, NT, 1990*'. (Ed. R. V. Hyne.) pp. 105-23. (Office of the Supervising Scientist Alligator Rivers Region, Australian Government Publishing Service: Canberra.).

Knight Piésold Ltd., 2013*. 2013 Lake Surface Water and Sediment Quality Sampling Protocol*. North Bay, Ontario. Ref. No. NB102-181/33-2, Rev. A. July 31.

Knight Piésold Ltd., 2012a. *Compendium to Surface Water and Sediment Quality Baseline Report*. North Bay, Ontario. Ref. No. NB102-00181/30-6, Rev. 0. January 30.

Knight Piésold Ltd., 2012b. Memorandum to Oliver Curran, Baffinland Iron Mines Corporation. Re: *Response to Environment Canada IR EC-23 on Site-Specific Water Quality Objectives*. April 27. North Bay, Ontario. Ref. No. NB12-00183.

Knight Piésold Ltd., 2011. *Surface Water and Sediment Quality Baseline Report*. North Bay, Ontario. Ref. No. NB102-00181/30-5, Rev. 0. December 22.

Knight Piésold Ltd., 2010a. *Surface Water and Sediment Quality Baseline Report*. North Bay, Ontario. Ref. No. NB102-00181/25-2, Rev. 0. October 29.

Knight Piésold Ltd., 2010b. *Compendium to Surface Water and Sediment Quality Baseline Report*. North Bay, Ontario. Ref. No. NB102-00181/25-16, Rev. 0. December 31.

Knight Piésold Ltd., 2008. *2007 Baseline Water Quality Summary Report.* Ref. No. NB102-00181/7-5, Rev. A. June 6.

Knight Piésold Ltd., 2007. *2005/2006 Baseline Water Quality Summary Report.* Vancouver, BC. Vancouver, BC. Ref. No. NB102-00181/4-5, Rev. A. March 13.

Horowitz, Arthur J., 1991. *A Primer on Sediment-Trace Element Chemistry, 2nd Edition*. United States Geological Survey, Open File Report 91-76.

Indian and Northern Affairs Canada, 2009. *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories. Volume 6: Recommended Procedures for Evaluating, Compiling, Analyzing, Interpreting, and Reporting Data and Information Collected under the Aquatic Effects Monitoring Programs*. Available online at: http://mvlwb.com/sites/default/files/documents/INAC%20-%20AEMP%20Guidelines%20-%20Volume%206%20-%202009.pdf

Indian and Northern Affairs Canada, 2009. *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in NWT: Overview Report*. Available online at: http://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-NWT/STAGING/texte-text/aemp_1313792165251_eng.pdf

Intrinsik Environmental Sciences Inc., 2014. *Development of Water and Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project.* Intrinsik Project No. 30-30300.

Nunavut Impact Review Board, 2012. *NIRB Project Certificate No. 005*. In the matter of the Nunavut Land Claims Agreement, Nunavut Land Claims Agreement Act, S.C. 1993, c. 29, Article 12, Part 5 and in the matter of an application by Baffinland Iron Mines Corporation for the development of the Mary River Project Proposal in the Qikiqtani Region of Nunavut: NIRB Project Certificate No. 005.

Nunavut Water Board, 2013. Type A Water Licence No. 2AM-MRY1325. Issued on June 12, 2013.

North/South Consultants Inc., 2014. *Baffinland Iron Mines Corporation - Mary River Project - Core Receiving Environment Monitoring Program: Freshwater Biota*. Internal Draft, dated May 2014.

North/South Consultants Inc., 2012. *Baffinland Iron Mines Corporation - Mary River Project - Freshwater Aquatic Biota and Habitat Baseline Synthesis Report 2005-2011*. January 2012.

North/South Consultants Inc., 2010. Technical Memorandum Describing the Results of Monitoring for Effects of Dust Deposition from the Bulk Sampling Program: 2008. August 31, 2010.

North/South Consultants Inc., 2008. *Freshwater Aquatic Environment Baseline Report: Lake Limnology and Lower Trophic Levels: 2007*.

R Development Core Team, 2012. *R: A language and environment for statistical computing. R Foundation for Statistical Computing*. Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Smith, E., 2002. BACI Design. *Encyclopedia of Environmetrtics*. John Wiley and Sons. 1(141-148).

Stewart, K.A. and Lamoureux, S.F., 2011. Seasonal hydrochemical conditions and limnological response in adjacent High Arctic lakes: Cape Bounty, Melville Island, Nunavut. *Arctic* 64: 169-182.

Stroup, W.W., 1999. *Mixed Model Procedures to Assess Power, Precision, and Sample Size in the Design of Experiments*. Department of Biometry, University of Nebraska.

Underwood, A.J., and C.H. Peterson, 1992. Beyond BACI: experimental designs for detecting human environmental impacts in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology*. 161: 145-178.

5 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared: ______________________________

Elizabeth Ashby, B.I.T, EPt
Staff Scientist

Reviewed: ______________________________

Richard Cook, P.Geo. (Ltd.)
Senior Scientist

Approved: ______________________________

Robert A. Mercer, Ph.D., P.Eng.
Managing Principal - North Bay Office

APPENDIX A

WATER AND SEDIMENT QUALITY SAMPLING PROTOCOL

(Pages A-1 to A-24)

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WATER AND SEDIMENT QUALITY SAMPLING PROTOCOL
NB102-181/33-2

Rev	Description	Date
0	Issued in Final	March 28, 2014

Knight Piésold Ltd.
1650 Main Street West
North Bay, Ontario Canada P1B 8G5
Telephone: (705) 476-2165
Facsimile: (705) 474-8095
www.knightpiesold.com

Knight Piésold
CONSULTING

TABLE OF CONTENTS

PAGE

TABLES

FIGURES

APPENDICES

ABBREVIATIONS

AEMP .... Aquatic Environment Monitoring Program
BIM .... Baffinland Iron Mines Corporation
DO .... dissolved oxygen
EC .... Environment Canada
FEIS .... Final Environmental Impact Statement
KP .... Knight Piésold Ltd
Mary River Project .... the project
NSC .... North South Consultants
UTM .... universal transverse mercator

1 – INTRODUCTION

Baseline surface water and sediment quality sampling was conducted for the Mary River Project (the Project) in support of the Final Environmental Impact Statement (FEIS) completed by Baffinland Iron Mines Corporation (BIM) in 2012. An Aquatic Environment Monitoring Program (AEMP) Framework has been developed following submission of the FEIS. This field water and sediment sampling protocol supports the AEMP.

This document is intended to provide a detailed description of the baseline surface water and sediment quality field sampling methodologies that have been applied to date and that will be applied to the Project in the future.

The baseline sampling programs are conducted during the open-water season for streams and lakes in the Project area. Stream water quality is monitored during the spring, summer and fall, whereas, lake sampling takes places only during the summer and fall. Sediment sampling is done concurrently with the surface water sampling program during the fall campaign. The sampling methodologies within this protocol include details regarding:

- Equipment and sampling
- Field measurements and observations
- Quality assurance/quality control (QA/QC)
- Sample tracking (Chain of Custody) and shipping

2 – WATER QUALITY

2.1 GENERAL

Stream and lake water quality data were collected for the Mary River Project (the Project) by Knight Piésold Ltd. (KP) every year since 2005, with the exception of 2009 and 2010. Additional sampling was conducted by North/South Consultants Inc. (NSC) in 2007. The analytical suite of parameters included nutrients, total and dissolved metals, and major ions. A detailed list of water quality parameters is provided in Appendix A.

2.2 STREAM SAMPLING METHODOLOGY

2.2.1 Sampling Strategy

Consistent sampling methods have been applied throughout the stream water sampling programs. Stream samples are collected from flowing sections of the streams (unless otherwise noted) and are obtained by either wading into the stream or by collecting the sample from the bank. Samples are collected in an upstream direction, with bottles being placed beneath the surface (when possible) to reduce the amount of surface residue collected. Bottles with no acid preservative are rinsed three times before filling. For bottles where an acid preservative is required, the samples are transferred from a clean bottle into the bottle containing preservative.

2.2.2 Equipment and Sampling

The width of the stream at the sampling location is measured using range finders. If the stream is less than 5 metres (minimum distance for range finders), the width is estimated. Photos are taken upstream, downstream and across the sampling site.

The baseline water quality monitoring program includes as suite of analytical parameters (Appendix A). The laboratory typically provides nine sample bottles for these analyses (Table 2.1).

Table 2.1 Sample Bottle Summary

Sample Bottle Volume/Description	Analytical Parameter
1 L Amber glass	Chlorophyll *a*/Pheophytin
125 mL Plastic X 2	Total and Dissolved Metals
125 mL Plastic X 2 (pre-charged)	Nutrients
1 L Plastic	General/Routine
125 mL Amber glass X 2 (one pre-charged)	TOC, phenols, COD, etc.
250 mL Plastic	Chromium

The metals bottles require nitric acid preservative (blue label) that is provided in single dose vials by the laboratory (one vial per bottle). On occasion, the chromium sample bottle will not be provided pre-charged with preservative. In this case, a chromium preservative (green label) will be provided as required.

Prior to the addition of preservative, samples for dissolved metals and the other required parameters listed on the labels (e.g., dissolved organic carbon) are field filtered using Acrodisc® 32 mm Syringe Filters with 0.45 µm Supor® membrane filter. The syringes and filters are sealed in sterile packaging and should not be rinsed prior to use. The following steps outline the basic filtration technique that will be utilized:

- Attach the filter to the syringe prior to pulling the plunger out of the syringe (Note: pulling the plunger activates the filter media).
- Pull the plunger from the syringe, fill the syringe with sample water and then replace the plunger. Dispense the first 10 mL of water to the ground (not as sample).
- Filter the remaining sample directly into the appropriate container. Repeat the process until the sample bottle is full.
- Repeat the initial two steps if the water is particularly turbid and another filter is necessary prior to the sample bottle being full

2.2.3 Field Measurements and Observations

In-situ water quality measurements will be taken during the sample collection process, provided the multi-parameter probe (e.g., Quanta Hydrolab or YSI 600Q sonde) can be positioned downstream of the sample collection area. The following in-situ parameters are recorded (when available from the multi-parameter sonde):

- Water temperature (°C)
- Dissolved oxygen (mg/L and %)
- pH (pH units)
- Conductivity (µS/cm) and/or specific conductance ($\mu S/cm^n$) (both when possible)

Field observations around the sample area include:

- Description of the landscape (e.g., hilly, mountains, marsh, etc.)
- Vegetation
- Stream substrate (e.g., sand, cobble, boulder, bedrock)
- Stream flow description (e.g., strong-turbulent, slow-calm)
- Weather conditions
- Air temperature

All measurements and observations are recorded on the field record sheets included within Appendix B.

2.2.4 QA/QC

The QA/QC protocol aims to ensure the collection of reliable and accurate data. Using standard methods as outlined in this document provides control of sample collection, handling and shipping. While collection of duplicate samples ensures the laboratory results meet defined standards of quality, in addition to the internal laboratory QA/QC protocols required for analytical accreditation. Duplicate samples will be taken for 10 percent of the total number of samples. When possible, one field blank should be taken per sampling event.

2.2.5 Chain of Custody and Sample Shipment

An essential part of the QA/QC protocol is maintaining a record of the collected samples and the corresponding list of analytical parameters reported for those samples. A chain of custody (CoC) form will be completed digitally on the BIM environmental office laptop. An example of a completed CoC form is included as Appendix C. In order to start a new entry, the previous CoC should be opened and saved as a new file name beginning with the current sample date, followed by sample type (e.g., 13_07_24_COC_BWQ.pdf). The CoC is an editable pdf document that can be found using the following folder structure:

Mary River Project (\\10.20.1.253)(M:)
Environment
FINAL File System
14.0 LABORATORY ANALYTICAL RESULTS
2014 - Open last CoC and save as "YY_MM_DD_COC_BWQ.pdf"

The waybills for shipping coolers are provided by BIM in the environment office. One of the seasonal environmental staff or environmental coordinators will provide assistance in completing the required paperwork.

All coolers must have "this side up" arrows attached to either end of the cooler. These stickers are found on a roll in the BIM environment office. The laboratory shipping labels are also in the BIM environment office. Each cooler requires one laboratory shipping label affixed to the lid.

2.3 LAKE SAMPLING METHODOLOGY

2.3.1 Sampling Strategy

Consistent sampling methods have been applied throughout the lake water sampling programs. Wherever possible, water quality samples are collected from two isolated depths (approximately 1 m below surface and approximately 1 m above the bottom) at each of the lake water quality sites. Inflatable zodiac boats are used to access the lake sample locations and are anchored at the stations for the duration of the sampling and in-situ data collection. Some boat drift is inevitable due to wind and wave influence. The general procedures to be undertaken at each lake sampling station are detailed below.

2.3.2 Equipment and Sampling

The total depth of the water at each lake station is determined either using a portable fish finder, a weighted meter tape or the pressure sensor on the multi-parameter probe. The depth is recorded on the field record sheets. Windy conditions during sampling may result in variable depth measurements. The depth range, the estimated wind speed, and the estimated wind direction are always recorded.

The baseline water quality monitoring program includes a suite of analytes (Appendix A). As above (i.e., Table 2.1), the analytical laboratory typically provides nine sample bottles for these analyses.

A 2.2 L acrylic Kemmerer bottle with a graduated line is utilized to obtain water samples at the target depths. The Kemmerer bottle is set in the open position for sampling with the bottom sample valve in the closed position. The sampler is lowered to the desired depth and the messenger weight is released down the line to trigger the closing spring of the sampler. The Kemmerer bottle is retrieved and the retained water is discarded over the side of the boat.

Following this initial rinse, the Kemmerer bottle is deployed to the sample depth to obtain the analytical sample. Upon retrieval of the Kemmerer bottle, a small amount of water is purged out of the bottom sample valve. The remaining sample is discharged into the pre-labelled, laboratory sample containers (or into a field filter) via the sample valve. The remaining water is discarded over the side of the boat. This sampling process is then repeated for the next sample depth.

Bottles with no acid preservative are rinsed three times before filling. For bottles where acid preservative is required, samples are transferred from the Kemmerer bottle into the sample bottle containing preservative. Some samples will also require field filtration before adding preservatives. The filtration process is discussed in Section 2.2.2.

2.3.3 Field Measurements and Observations

Upon collection of the shallow and deep samples, in-situ lake profiling and secchi depths are completed at each sample station.

The profiling is undertaken using a measuring tape that is secured to a multi-parameter probe (e.g., Quanta Hydrolab or YSI 600Q sonde). The probe is lowered in 1 m increments and given time to stabilize prior to recording the in-situ parameters listed in Section 2.2.2.

Secchi depths are determined by attaching the measuring tape to the secchi disk and lowering the disk over the shaded side of the boat. Two depths are recorded: the depth at which the disk disappears while lowering the disk and the depth at which it reappears while raising the disk. The secchi depth is calculated from the average of these two depths and recorded on the field record sheets.

2.3.4 QA/QC

As with the stream samples, duplicate samples are to be taken for 10 percent of the total number of samples. When possible, one field blank per sampling event will be taken.

2.3.5 Chain of Custody and Sample Shipment

Information regarding the COC's and sample shipping methods are discussed in Section 2.2.5.

2.4 METHODOLOGY ADJUSTMENTS OVER TIME

There have not been any changes to the sampling methods for streams and lakes between 2005 and 2013, unless specific circumstances required alternative methods. These exceptions would be very rare, and any changes to methodology would be recorded on field record sheets. Field record sheets used by KP were updated in 2013 and are included in Appendix B. NSC used their own field sheets.

Equipment used for field measurements and lake sample collection have varied over time, based on the equipment available at the time. For lake sampling, the following samplers have been used:

- Beta bottle
- Van Dorn sampler
- Kemmerer bottle

It was decided in 2012 that the Kemmerer bottle would be the only sampler used for future sampling events in order to maintain consistency.

3 – SEDIMENT QUALITY

3.1 GENERAL

Stream sediment quality data were collected for the Project by KP every year since 2005, with the exception of 2009 and 2010. Lake sediment quality data were collected for the Project every year since 2006, with the exception of 2009 and 2010. Parameters analysed included nutrients, metals, major ions and particle size. A detailed list of parameters is provided in Appendix A.

Sediment quality monitoring is typically conducted as part of the benthic invertebrate community surveys for mining projects. These sampling programs typically focus on total organic carbon content, metals and particle size distribution (EC, 2012). The purpose of sediment monitoring at these sites is to identify any habitat differences that may contribute to changes in the invertebrate community. As such, sediment samples will be collected concurrently with benthic invertebrate samples.

3.2 STREAM SEDIMENT SAMPLING METHODOLOGY

3.2.1 Sampling Strategy

Consistent sampling methods have been applied throughout the stream sediment sampling programs. Stream samples are collected from flowing sections of the streams (unless otherwise noted) and are obtained by wading into the stream. The sampling equipment and collection protocol is discussed in the following section.

3.2.2 Equipment and Sampling

Equipment used for stream sediment sampling includes the following:

- Stainless steel bowl
- Stainless steel spatula
- Stainless steel spoon
- 500 mL Polyethylene (PET) bottle with open ends
- Four 250 mL amber glass sample jars
- Zip-top or Whirl-pak sample bag for archived sample

Stream sediment samples are collected as near as possible to the water sample location. Wherever possible, sediment samples are collected from the wetted area of the stream at water depths between 10 cm and 40 cm. Prior to collecting the sediment samples, all of the sampling equipment is rinsed in the stream water to ensure that trace sediments do not transfer between sample stations. Samples are collected by wading downstream to upstream. Where possible, sediment is collected from the surface of the stream bed. Up to 10 sub-samples can be taken where sufficient fine sediments (particles < 2 mm diameter) are present.

The following procedure for sampling stream sediments is followed at each sub-sample location:

- Insert the open-ended PET bottle 5 cm to 10 cm into the bottom substrate
- Slide the stainless steel spatula under the bottom of the PET bottle to trap the sediments inside
- Slowly raise the spatula and PET bottle out of the stream
- Place the contents of the PET bottle into a stainless steel bowl for compositing

The stainless steel bowl and sample is allowed to settle once sufficient sample has been obtained to fill the sample containers. Any excess water that forms on the surface of the sample is either poured-off or siphoned-off using a sterile syringe. Care must be taken during this process not to lose any fines. The sample is homogenized using a stainless steel spoon. The composite sample is then created by removing any large inorganic material (e.g., cobble). The sample is transferred to laboratory provided sample jars. This transfer is completed by adding a spoonful of sample to each of the jars and repeating until all the jars they are all full. This approach provides more consistent results than what would be obtained if each jar was filled in turn. Surplus sample will be put into a labeled Zip-top or Whirl-pak bag. Samples should be kept cool and in the dark until they can be shipped to the laboratory.

The field record sheet will record the number of jars and/or sample bags obtained at each station. A note on the field record sheet should also indicate if insufficient sample is available at a station.

3.2.3 Field Measurements and Observations

Field observations made during sediment sampling include sample characteristics, such as:

- Substratum composition
- Colour
- Odour
- Vegetation presence

3.2.4 QA/QC

As with the water samples, duplicate sediment samples will be taken for 10 percent of the total number of samples.

3.2.5 Chain of Custody and Sample Shipment

The required COC’s and sample shipping procedures are discussed in Section 2.2.5.

3.3 LAKE SEDIMENT SAMPLING METHODOLOGY

3.3.1 Sampling Strategy

Lake sediment samples have been collected using various methods as described in section 3.4. The methods defined below describe the collection of the lake sediment samples.

3.3.2 Equipment and Sampling

A sediment gravity core sampler (Figure 3.1) will be utilized to obtain lake sediment samples. The top two centimeters of sediment from the core samples will be retained for laboratory analysis.

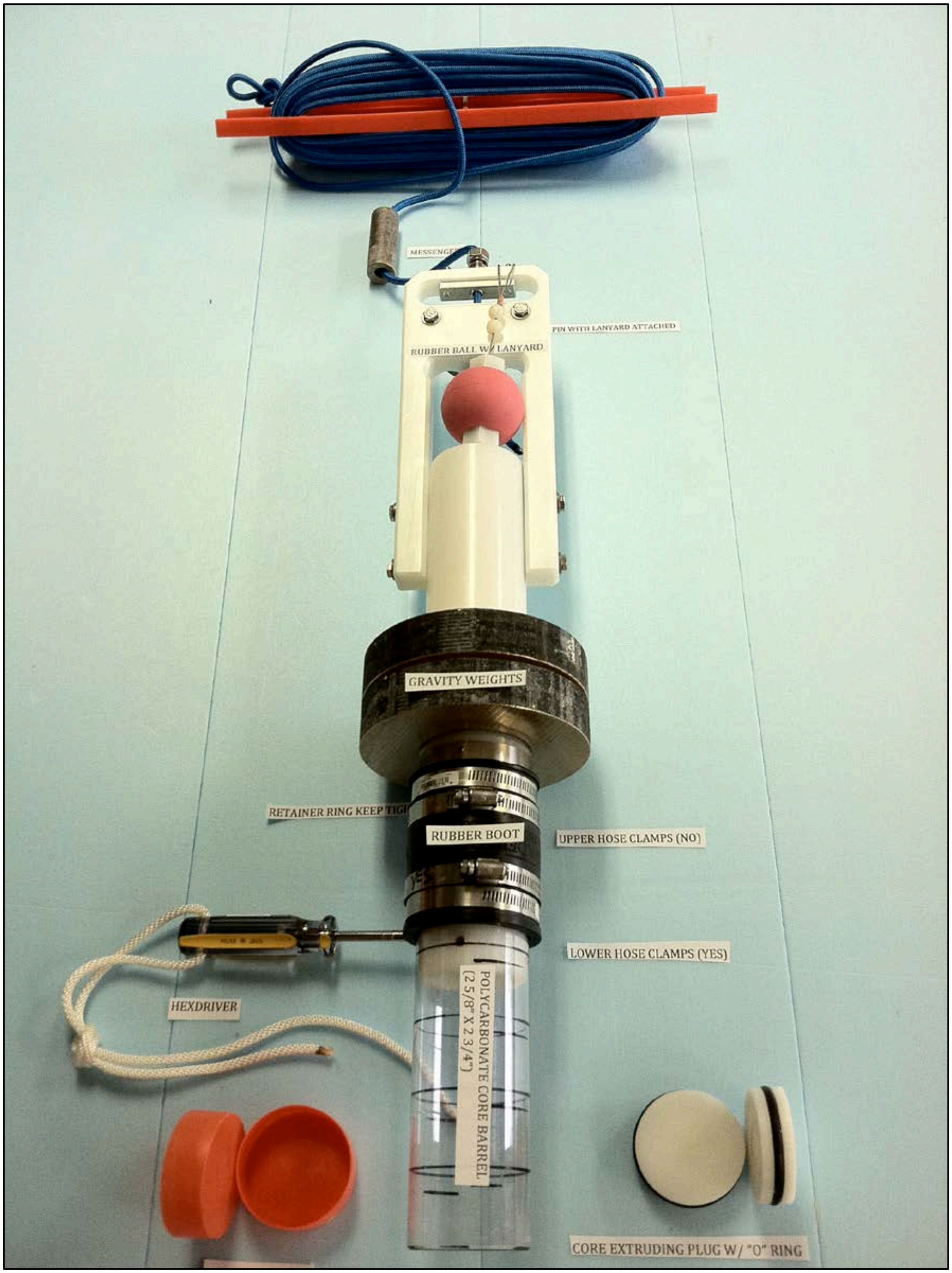


Figure 3.1 Sediment Gravity Core Sampler

3.3.3 Field Measurements and Observations

At each sampling site, the following information will be recorded during the collection of sediment samples.

- Site ID and UTM coordinates and location of any duplicate samples collected
- Sampling date and time
- Ambient weather conditions (e.g., wind speed, direction, wave action, current, air temperature)
- Sediment collection device
- General site description and observations (e.g., depth of water or ice)
- Sample properties (e.g., colour, texture, consistency, odour, presence of biota, estimate of quantity of recovered sediment)
- Deviations from standard operating procedures

Lake sediment samples will be collected using the sediment gravity corer and the following procedure.

- A clear polycarbonate core tube will be loaded into the corer and secured using a set of stainless steel hose clamps
- The corer (Figure 3.1) will be positioned perpendicular to the water surface prior to release. The penetration depth of the core tube is affected by the depth of water, angle of corer deployment and substrate type.
- Once the corer is embedded in the substrate, the stainless steel messenger will be sent down the corer rope to release the ball-type seal. This seal creates a vacuum in the core tube, retaining the sampled sediment.
- The corer will be retrieved vertically and at a constant speed to surface
- Upon retrieval, the bottom of the core tube will be plugged using an extruding plug prior to breaking the air-water interface. This procedure will prevent sample loss.
- Following placement of the core tube plugs, the hose clamps on the corer will be loosened to release the tube
- The visual characteristics of the core sample will be recorded on the field record sheets (e.g., colour, apparent horizons, aquatic vegetation, etc.)
- Overlying water within the tube will be described on field notes (e.g., clarity) prior to decanting. The decanting process should be undertaken carefully to ensure that no sediment sample is lost.

The sample is extruded out of the core tube and processed as follows:

- A suitable extruding apparatus, such as a PVC tube cut longer than core tube and with a slightly smaller outside diameter, will be used to force the extruding plug through the core tube. This process moves the sediment sample to the end. Care will be taken not to extrude the sediment, since the first two centimetres are the sample.
- The top two centimeters of sediment will be scooped out using a clean stainless steel spoon and placed in a clean stainless steel bowl
- A minimum of three core samples will be required per station. Limiting the amount of sampled sediment per tube (i.e., the top two centimeters) typically requires more sampling effort to obtain the required sample size.

- Samples within a station will be close to one another, but far enough apart to ensure that sampling disturbance from one grab does not affect another. Sampling from both sides of the boat and around the bow typically provides suitable spatial distribution within the station.
- After the top two centimeters are retained, the remaining, unused sediments within the core tube will be placed into a bucket and only released once sampling is complete at that particular station
- The core tube will be rinsed at surface and reloaded into the sampler in preparation for the next sample.

3.3.4 Sediment Sample Homogenization

Once sufficient sediments have been collected within the stainless steel bowl, the sample will be homogenized. Prior to homogenization, excess water will be decanted once the water has settled (to prevent loss of fines) and any large inorganic material (e.g., cobble) or debris will be removed. Once this step is complete, the sample will be thoroughly mixed using a newly gloved hand or stainless steel spoon until the sample has a homogeneous appearance. The sample containers will be filled by alternating aliquots between each of the containers. Once the containers are full, each sample will be transferred to an ice-packed cooler. Samples will be kept cool and in the dark until they can be shipped to the analytical laboratory.

3.3.5 QA/QC

All sampling equipment will be thoroughly cleaned between sampling stations and rinsed with ambient water prior to sampling. Duplicate samples will be taken for ten percent of the total number of samples.

3.3.6 Chain of Custody and Sample Shipment

The COC's and sample shipping methods are discussed in Section 2.2.5.

3.4 METHODOLOGY ADJUSTMENTS OVER TIME

Sediment sampling conducted prior to 2012 utilized a Petite Ponar grab sampler (231 cm^2) or an Ekman dredge sampler (523 cm^2). The sediment fraction collected for analysis was limited to the top 5 cm.

During review of the FEIS, BIM agreed to a recommendation from Environment Canada to carry out sediment sampling utilizing core in order to collect only the uppermost one to two centimetres. The rationale for this approach is that most infaunal organisms and the most recently introduced sediment (including contaminants of concern) are found in the upper two centimetres of the lake sediment. Arctic lakes experience low sedimentation rates and, therefore, collection of a thinner sample using a sediment coring instrument provides better resolution of changes in sediment quality.

Collection of thinner (1 cm to 2 cm) sediment samples was implemented by Baffinland starting in 2012. The top 2 cm of sediment from the core samples as described above will be retained for laboratory analysis.

4 – REFERENCES

Environment Canada (EC). 2012. *Environmental Effects Monitoring Technical Guidance Document*. National Environmental Effects Monitoring Office.

APPENDIX A

2014 SURFACE WATER AND SEDIMENT QUALITY PARAMETER LIST

(Pages A-1 to A-3)

Details of Quotation

Baseline - Cr III and VI

ANALYTE	METHOD REFERENCE	MDL	UNITS
Cr(VI)	Cr(VI) water M US EPA	0.05	mg/L
Cr(III)	Cr(VI) water M US EPA	0	mg/L

Baseline - Sediment

ANALYTE	METHOD REFERENCE	MDL	UNITS
Ca	Metals soil FAA - AMSFAAE2 M SM3111B-3050B	100	ug/g
Mg	Metals soil FAA - AMSFAAE2 M SM3111B-3050B	100	ug/g
Na	Metals soil FAA - AMSFAAE2 M SM3111B-3050B	100	ug/g
K	Metals soil FAA - AMSFAAE2 M SM3111B-3050B	100	ug/g
Al	ICP-MS SOIL PE6100 EPA 200.8	5	ug/g
Ba	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Be	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Cd	ICP-MS SOIL PE6100 EPA 200.8	0.5	ug/g
Cr	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Co	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Cu	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Fe	ICP-MS SOIL PE6100 EPA 200.8	5	ug/g
Pb	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Mn	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Mo	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Ni	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Ag	ICP-MS SOIL PE6100 EPA 200.8	0.2	ug/g
Sr	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Tl	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
V	ICP-MS SOIL PE6100 EPA 200.8	2	ug/g
Zn	ICP-MS SOIL PE6100 EPA 200.8	2	ug/g
As	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Sb	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Se	ICP-MS SOIL PE6100 EPA 200.8	1	ug/g
Hg	Hydride - Soil M SM3114C-3500C	0.1	ug/g
Sand (>0.050mm)	Particle Size C Ag Particle	1	%
Silt (>0.002-0.050mm)	Particle Size C Ag Particle	1	%
Clay (<=0.002mm)	Particle Size C Ag Particle	1	%
Moisture	MOISTURE C SM2540B	0.1	%
Total Kjeldahl Nitrogen	TKN soil/solids - AMTKNHX8 C SM4500-Norg-B	0.01	%
TOC	Organic matter Ag Soil	0.01	%
N-NO2	SOIL - Extractable N C 33-3 Methods of So	1	ppm
N-NO3	SOIL - Extractable N C 33-3 Methods of So	1	ppm
NO2 + NO3 as N	NO2/NO3 SKALAR - AMNOXSE1 C SM4500-NO3-F	0.1	mg/L
Boron (hot water extract)	Boron - hot water EXT Boron HWE	0.5	ug/g

Baseline - SW Chem

ANALYTE	METHOD REFERENCE	MDL	UNITS

pH	pH in water : Auto - AMAPCAE1 C SM4500-H+B	1	
Conductivity	Conductivity : Auto - AMAPCAE1 C SM2510B	5	uS/cm
Alkalinity as CaCO3	Alkalinity : Auto - AMAPCAE1 SM 2320B	5	mg/L
TDS (COND - CALC)	solids in water - AMSOLWE1 C SM2540	5	mg/L
Turbidity	Turbidity - AMTURBE1 C SM2130B	0.1	NTU
Phenols	Phenols 4-AAP - AMPHACE1 C SM5530D	0.001	mg/L
N-NH3	NH3 water low - AMNH3LE1 C SM4500-NH3D	0.02	mg/L
SO4	Anions by IC - DX-100 SM 4110C	3	mg/L
Cl	Anions by IC - DX-100 SM 4110C	1	mg/L
Br	Anions by IC - DX-100 SM 4110C	0.05	mg/L
N-NO2	Low NO2 - Technicon C SM4500-NO2-B	0.005	mg/L
N-NO3	NO2/NO3 SKALAR - AMNOXSE1 C SM4500-NO3-F	0.1	mg/L
NO2 + NO3 as N	NO2/NO3 SKALAR - AMNOXSE1 C SM4500-NO3-F	0.1	mg/L
TOC	TOC in water - AMDTOCE1 C SM5310C	0.5	mg/L
DOC	TOC in water - AMDTOCE1 C SM5310C	0.5	mg/L
Total Suspended Solids	solids in water - AMSOLWE1 C SM2540	2	mg/L
Total P	Low Total P C SM4500-PF	0.003	mg/L
Total Kjeldahl Nitrogen	TKN low water - AMTKNLE1 C SM4500-Norg-C	0.1	mg/L

Baseline Chlorophyll-Pheo

ANALYTE	METHOD REFERENCE	MDL	UNITS
Chlorophyll-a	Chlorophyll C SM10200H	0.2	mg/m3
Pheophytin-a	Chlorophyll C SM10200H	0.2	mg/m3

Baseline Dissolved Metals

ANALYTE	METHOD REFERENCE	MDL	UNITS
Ca	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
Mg	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	100	ug/L
Na	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
K	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
Al	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	3	ug/L
Sb	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
As	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Ba	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Be	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Bi	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
B	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	10	ug/L
Cd	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L
Cr	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Co	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Cu	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Fe	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	30	ug/L
Pb	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Li	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	5	ug/L
Mn	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Mo	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Ni	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Se	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	1	ug/L

Si	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
Ag	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L
Sr	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Tl	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Sn	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Ti	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	10	ug/L
U	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L
V	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	1	ug/L
Zn	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	3	ug/L
Hardness as CaCO3	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	500	ug/L
Hg	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L

Baseline Total Metals

ANALYTE	METHOD REFERENCE	MDL	UNITS
Ca	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
Mg	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	100	ug/L
Na	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
K	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
Al	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	3	ug/L
Sb	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
As	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Ba	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Be	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Bi	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
B	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	10	ug/L
Cd	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L
Cr	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Co	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Cu	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Fe	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	30	ug/L
Pb	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Li	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	5	ug/L
Mn	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Mo	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.05	ug/L
Ni	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.5	ug/L
Se	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	1	ug/L
Si	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	50	ug/L
Ag	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L
Sr	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Tl	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Sn	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.1	ug/L
Ti	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	10	ug/L
U	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L
V	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	1	ug/L
Zn	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	3	ug/L
Hardness as CaCO3	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	500	ug/L
Hg	ALS Low Level ICP-MS TOTAL Met ALS-OUTSIDE	0.01	ug/L

APPENDIX B

FIELD RECORD SHEET

(Page B-1)

SURFACE WATER QUALITY SAMPLING FIELD FORM

Knight Piésold CONSULTING

PROJECT NO.: ____________ *(i.e. NB102-102/10)*

SITE: ____________ *(i.e. BISSETT CREEK)* **DATE:** ____________ *(i.e.12MAR2013)*

STATION ID: ____________ *(i.e. SW12-01)* **STAFF:** ____________ *(i.e. SMR / DKK)*

SITE CONDITIONS

Air Temperature ____________ ºC **Wind** ____________ *(direction, speed)* **Weather** ____________ *(clear, o'cast, rain, etc.)*

SAMPLE DESCRIPTION/OBSERVATIONS

Sample ID: ____________ *(i.e. SW12-01)* **UTM mE** ____________ *(i.e. 558407)*

Sample Date / Time: ____________ *(i.e.12MAR2013/14:35)* **UTM mN** ____________ *(i.e. 7914885)*

No. of bottles ____________ **Zone / Datum** ____________ *(i.e. 17T / NAD83)*

Quote No. ____________ **Accuracy** ____________ *(± m)*

WATER BODY TYPE: ☐ Lake ☐ Pond ☐ Wetland ☐ Stream

FLOW: ☐ Stagnant ☐ Low ☐ Moderate ☐ High

ODOUR: ☐ None ☐ Describe: ____________ *(i.e. mineral, organic)*

COLOUR: ☐ None ☐ Describe: ____________ *(i.e. light tea, brown, black)*

TRANSPARENCY: ☐ Clear ☐ Translucent ☐ Opaque

SAMPLES FILTERED: ☐ None ☐ Yes, analytes incl.: ____________

IN-SITU WQ DATA

Water Temperature: ____________ ºC **pH:** ____________ pH **WQ INSTRUMENT:** *(i.e. Hanna/HI 98129, YSI 600QS)* ____________

Conductivity: ____________ µS/cm **Secchi:** ____________ m

Dissolved Oxygen: ____________ % ______ : ____________ Calibrated (Date / Time): ____________

Dissolved Oxygen: ____________ mg/L ______ : ____________ Calibration Check (Date / Time): ____________

PHOTOS: ☐ Upstream/Downstream ☐ None taken

QA/QC INFORMATION

Duplicate Collected: ☐ No ☐ Yes, ID: ____________ *(i.e. SW12-01-DUP)*

Field Blank Collected: ☐ No ☐ Yes, ID: ____________ *(i.e. SW12-01-FB)*

SITE SKETCH: *(i.e. stream, flow direction, road, culvert, north arrow, beaver dams, sample location, etc.)*

NOTES: *(i.e. additional WQ instrument calibration notes, water body name, photo notes, changes in site since last visit)*

APPENDIX C

EXAMPLE CHAIN OF CUSTODY

(Page C-1)

CHAIN OF CUSTODY RECORD

ACCUTEST LABORATORIES LTD.

☑ 146 Colonnade Rd., Unit 8
Ottawa, ON K2E 7Y1
Ph: (613) 727-5692 Fax: (613) 727-5222

☐ 608 Norris Court
Kingston, ON K7P 2R9
Ph: (613) 634-9307 Fax: (613) 634-9308

LABORATORY USE ONLY
Report #: ____________

Company Name: Baffinland Iron Mines Corporation	Address: Mary River	☐ Fax Results to:
Report Attention: Mr. Jim Millard/Allan Knight/Trevor Myers	City/Prov: via Iqaluit, NU Postal Code:	☑ E-mail Results to: Millard/Myers/Knight/mrsite.sd
Phone: 647-693-9447 Ext	Project # * Quotation # Baseline Water Quality	☑ Copy of Results to: salldred@knightpiesold.com
* Waterworks Name:	* Waterworks Number:	*Note that for drinking water samples, all exceedances will be reported where applicable legislation requires.*

Invoice to:
(if different from above)

____

____

SAMPLE ANALYSIS REQUIRED

⇦ Indicate: F=Filtered or P=Preserved

Sample ID	* Date/Time Collected	Sample Matrix i.e. Water, Soil, Paint	* Sample Type (see "Codes" below)	* MOE Reportable? Y = Yes N = No	# of Containers	** Service Required R=Rush S=Standard	Baseline Water Quality - Dissolved Metals Field Filtered							Criteria Required (i.e. Reg.170, Reg.153, CCME, PWQO etc.)	Laboratory Identification
BL0-05-B4	July 24, 2013, 14:35	Water	-	N	9	S	✔								
C0-01	July 24, 2013, 15:20	Water	-	N	9	S	✔								
C0-01-DUP	July 24, 2013, 15:25	Water	-	N	9	S	✔								
C0-10	July 24, 2013, 16:20	Water	-	N	9	S	✔								
C0-10-FB	July 24, 2013, 16:25	Water	-	N	9	S	✔								
E0-20	July 24, 2013, 17:10	Water	-	N	9	S	✔								
E0-21	July 24, 2013, 17:50	Water	-	N	9	S	✔								

Sample Type Codes for Drinking Water Systems: **RW** = Raw Water, **RWFC** = Raw Water For Consumption, **TW** = Treated Water at point of entry to distribution, **DW** = Distribution/Plumbing Water
"MOE Reportable" refers to the requirements under the SDWA for immediate reporting of results, which are indicators of adverse water quality, to the Owner/Operator, MOE, and MOH Medical Officer.

Sampled By: Shannon Alldred	Date/Time: July 24, 2013 19:00	Relinquished By: Allan Knight	Date/Time: July 25, 2013 08:00	Comments CN AWB 518-64071313	**Cooler Temp (°C) on Receipt**
Work Authorized By (signature):	Date/Time:	Received By Lab:	Date/Time:		

*** Indicates a required field.** If not complete, analysis will proceed only on verification of missing information. A quotation number is required, if one was provided.
**** There may surcharges applied to "Rush" service.** Please check with lab prior to submission of samples for rush analysis to confirm availability and pricing.

Page _____ of ______

AFCOCR.1 A-24 of 24

C-1 of 1

Copies: White – Sampler, Yellow – Laboratory, Pink – With Report
Please print and submit, to the laboratory, 2 copies of this form with your samples.

APPENDIX B

DETAILED REVIEW OF BASELINE LAKE WATER QUALITY

(Pages B-1 to B-98)

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DETAILED REVIEW OF BASELINE LAKE WATER QUALITY
NB102-181/33-1B

Rev	Description	Date
1	Issued in Final	May 30, 2014

Knight Piésold Ltd.
1650 Main Street West
North Bay,Ontario Canada P1B8G5
Telephone: (705) 476-2165
Facsimile: (705) 474-8095
www.knightpiesold.com

Knight Piésold
CONSULTING

TABLE OF CONTENTS

PAGE

TABLES

FIGURES

B – LAKE WATER QUALITY REVIEW

B.1 OVERVIEW

A detailed review of lake water quality within the mine site area was undertaken to facilitate the development of the Core Receiving Environment Monitoring Program (CREMP) for water and sediment quality. As stated in Section 1.2 of the main report, the objectives of the baseline review were as follows:

- Identify data quality issues
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water quality in the mine site area
- Understand the seasonal, depth (for lakes) and inter-annual variability of water quality
- Understand natural enrichment of the mine site area waters
- Determine the potential to pool data from multiple sample stations to increase the statistical power of the baseline water quality dataset
- Develop study designs for monitoring water quality in mine site streams and lakes
- Determine if changes to the existing water quality monitoring program are required to meet monitoring objectives

The focus of this review of lake water quality is the mine site area lakes: Camp Lake, Sheardown Lake NW, Sheardown Lake SE and Mary Lake.

Parameters of interest in the baseline review included water quality stressors of potential concern (SOPCs) identified on the basis of the existence of an established water quality guideline, as well as other factors such as Exposure Toxicity Modifying Factors (ETMF): pH, water hardness, dissolved organic carbon, etc., and indicator parameters (alkalinity, chloride, nitrate). Baseline water quality data was compared to Canadian Council of Ministers of the Environment (CCME) – Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-PAL). The focus was on total concentrations (versus dissolved) since CWQG-PAL guidelines are developed for total concentrations. The parameters of interest are displayed graphically in box plots. The box plots are used to portray natural ranges of selected parameters. Concentration data measured for the parameters of interest has been log transformed and further analyzed to investigate the possibility of aggregating data, bearing in mind:

- Seasonal variability (between summer, fall and winter samples)
- Inter-annual variability (from 2006 through 2008 and 2011 through 2013)

To assist in the development of study designs, parameter and station-specific a priori power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmark values were developed for the identified SOPCs that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 2.7.3 of the main report). Draft benchmarks were applied in the power analysis of the baseline presented in this detailed review.

The resultant study design for the monitoring of Project-related effects to water quality is presented in Section 2.7 of the main report.

B.2 BASELINE SUMMARY

B.2.1 Camp Lake

A total of 51 lake samples were collected over the baseline sampling period. Most sampling was completed during July and August. Late winter sampling (May) was carried out in 2007, 2008 and 2013. Three stations were monitored (Figures B.1 and B.2):

- JL0-01-S and JL0-01-D - Shallow and deep; centre and deepest part of the lake
- JL0-02-S and JL0-02-D - Near two main tributaries likely to be influenced by the Project
- JL0-09-S and JL0-09-D - Near the outlet of Camp Lake

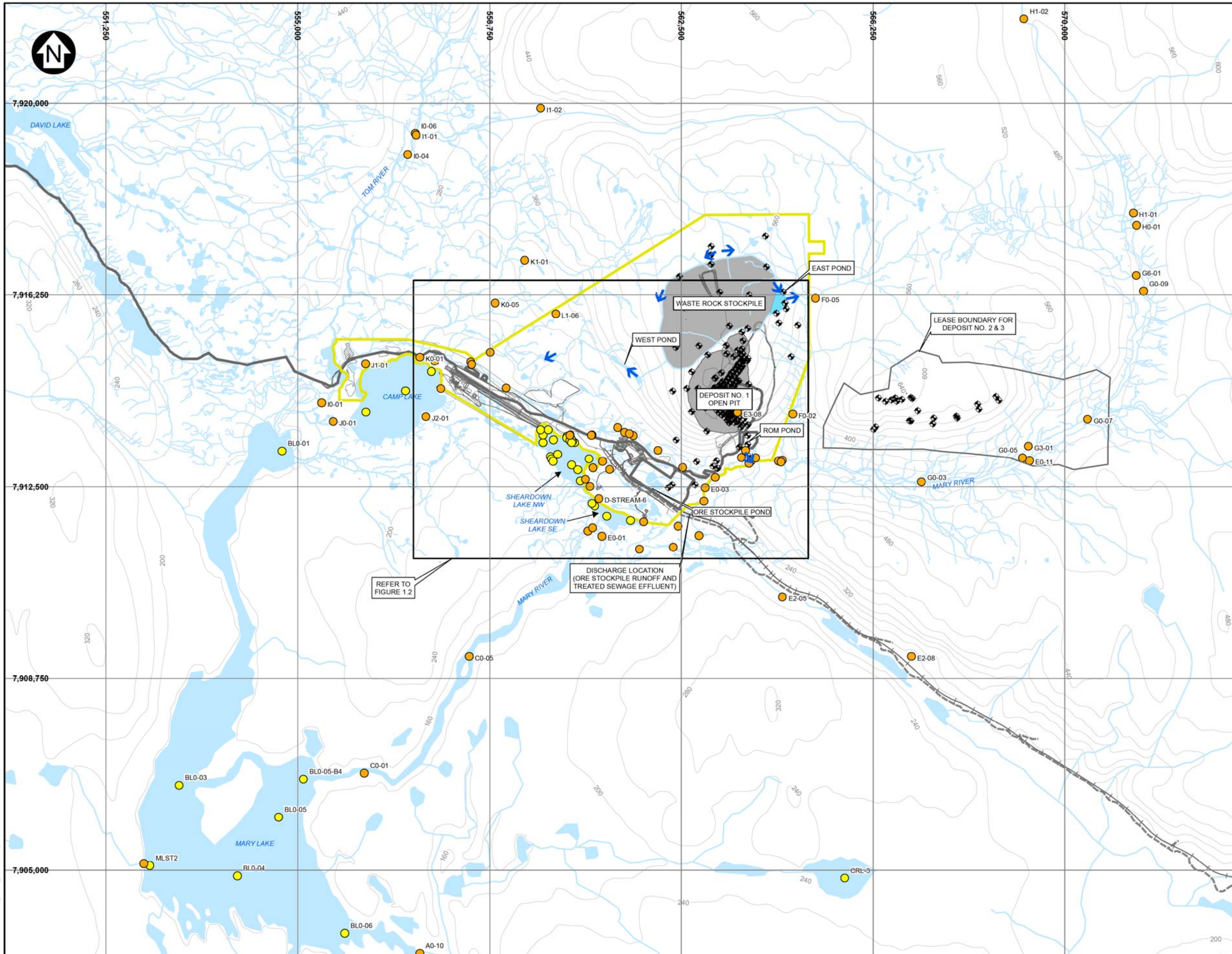
A summary of the data collected during each season are included in Table B.1. A graphical representation of the sampling events is provided in Figure B.3.

Table B.1 Camp Lake Sample Size

Year	Summer	Fall	Winter
2006	2	2	0
2007	6	6	6
2008	6	0	2
2011	4	0	0
2012	0	6	0
2013	5	6	2
Site	**Summer**	**Fall**	**Winter**
JL0-01-S	4	3	1
JL0-01-D	5	4	3
JL0-02-S	3	3	1
JL0-02-D	4	4	1
JL0-09-S	4	3	3
JL0-09-D	3	3	1

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30.
2. LAKE SAMPLING DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE.
3. NO SAMPLING OCCURRED DURING 2009 AND 2010.



LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS
MINE SITE AREA

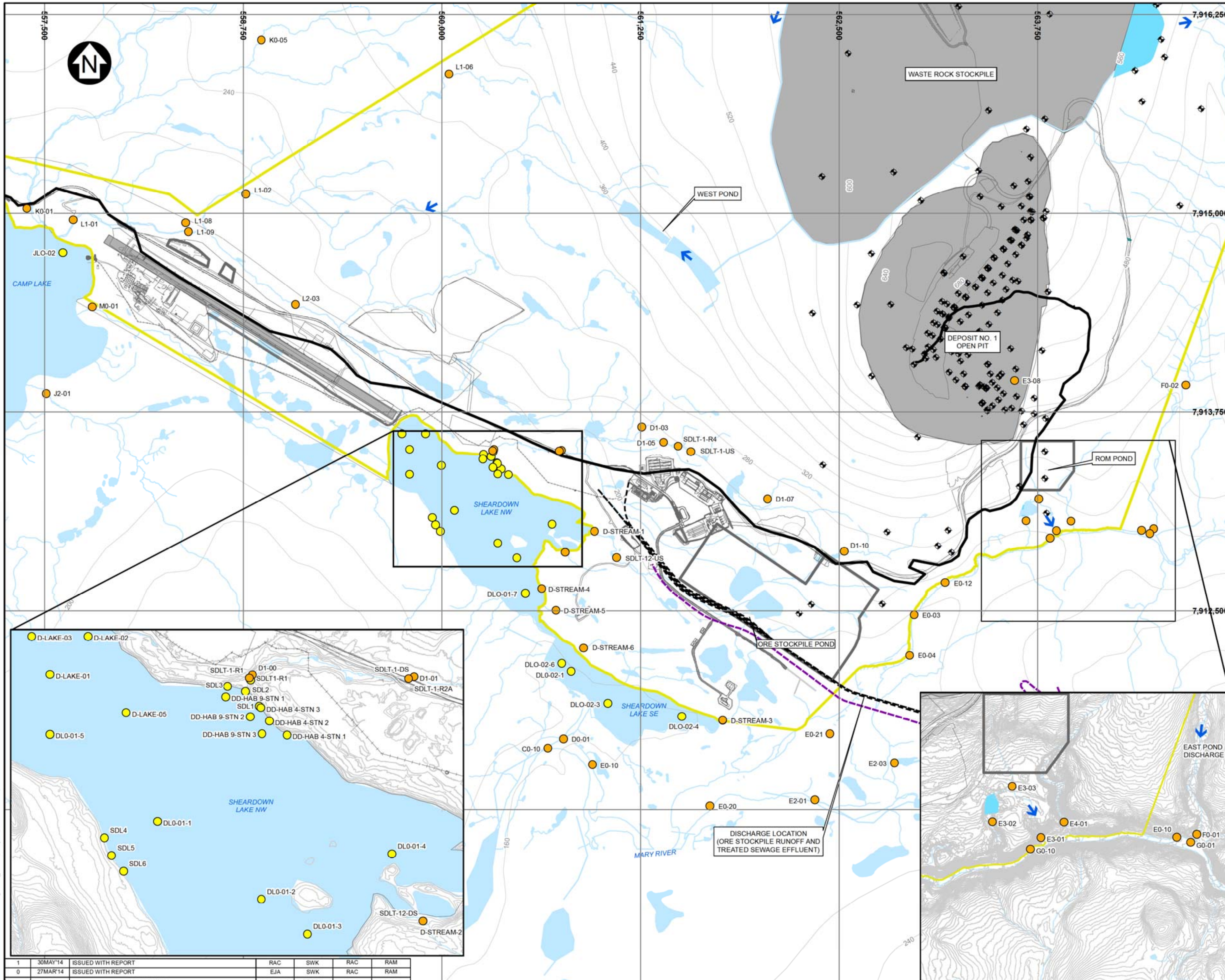
Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE B.1 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\B40_r1.mxd; May 30, 2014 1:11 PM; skozmick



LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 250 125 0 250 500 750 1,000 1,250 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS IMMEDIATE MINE SITE AREA

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE B.2 — REV 1

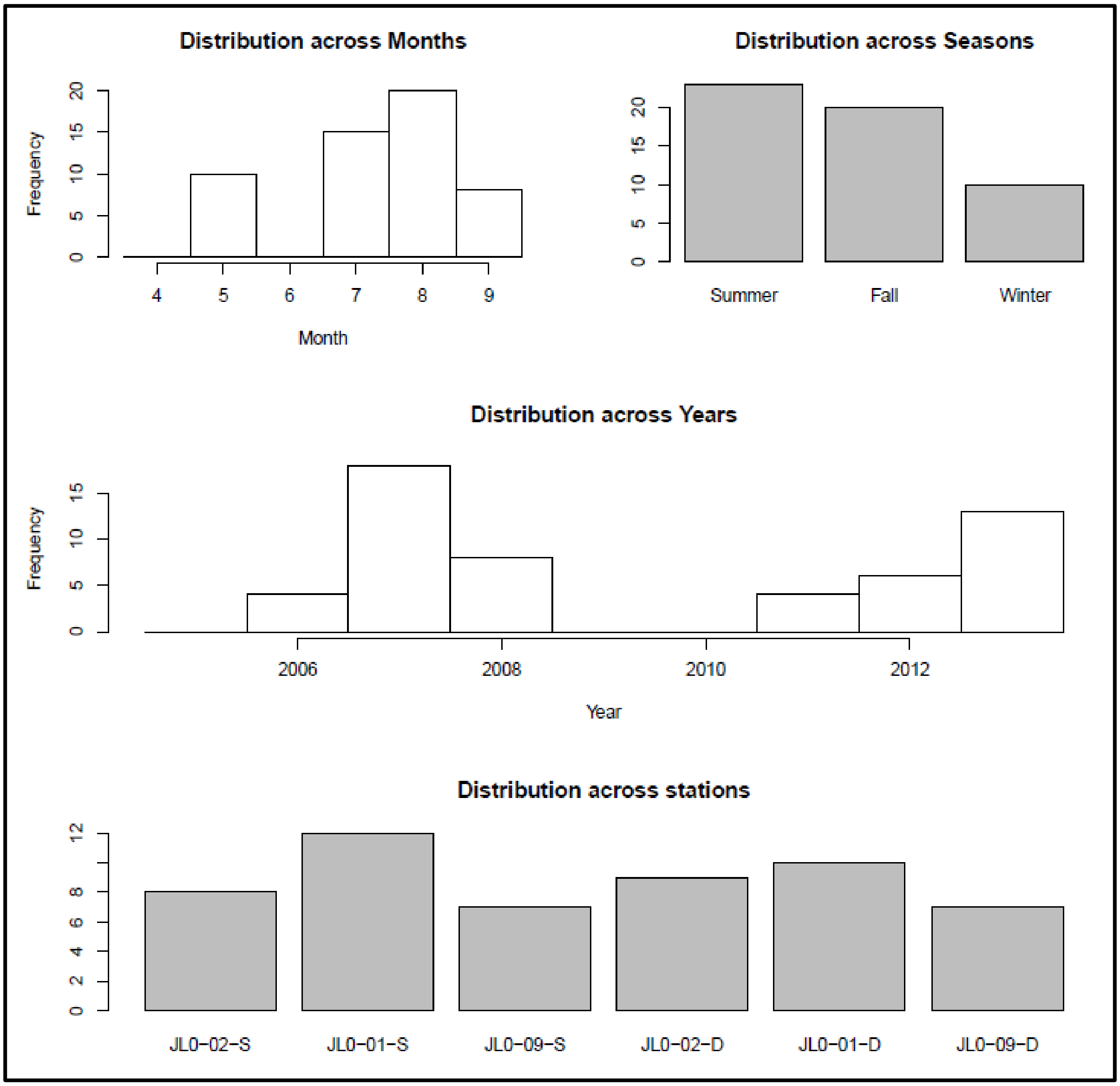


Figure B.3 Camp Lake - Graphical Summary of Sampling Events

The following summarizes the data review observations for the of the physical parameter data depicted in Figures B.4 and B.5.

pH (Figure B.4)

- Camp Lake is slightly alkaline, with total median pH of ~8.
- Measured median *In situ* pH at the deep stations (~7.6) was slightly lower compared to shallow samples (> 7.8).
- The lowest pH value was measured at the deep sample site JL0-01-D, located near the deepest portion of the lake.

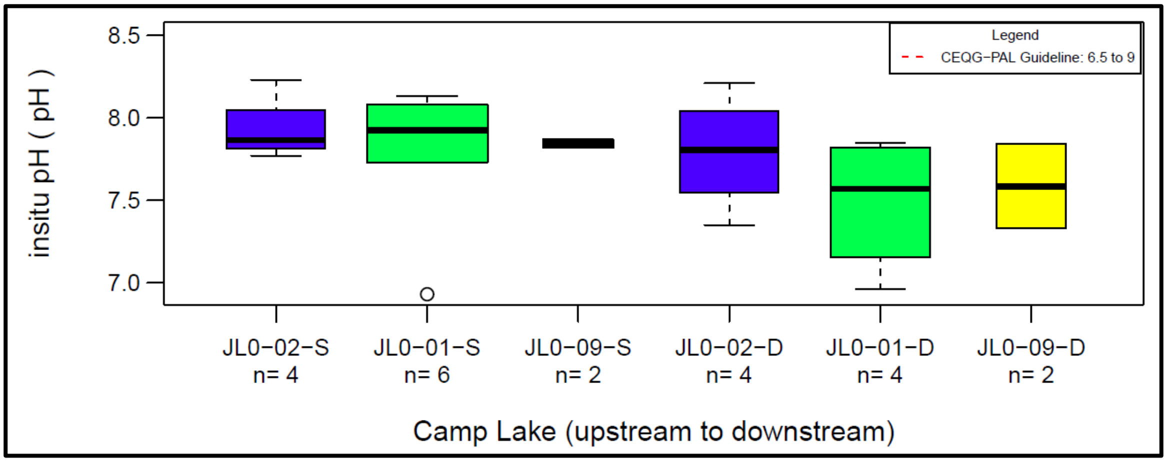


Figure B.4 Camp Lake – pH

Hardness (Figure B.5)

- Median hardness at stations within Camp Lake ranged from ~56 and 62 mg/L, classifying the lake water as "soft". One station, JL0-02-D had a median hardness concentration that classifies the lake water as "medium hardness".
- Hardness did not change meaningfully with depth, and portrayed trends very similar to alkalinity.
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

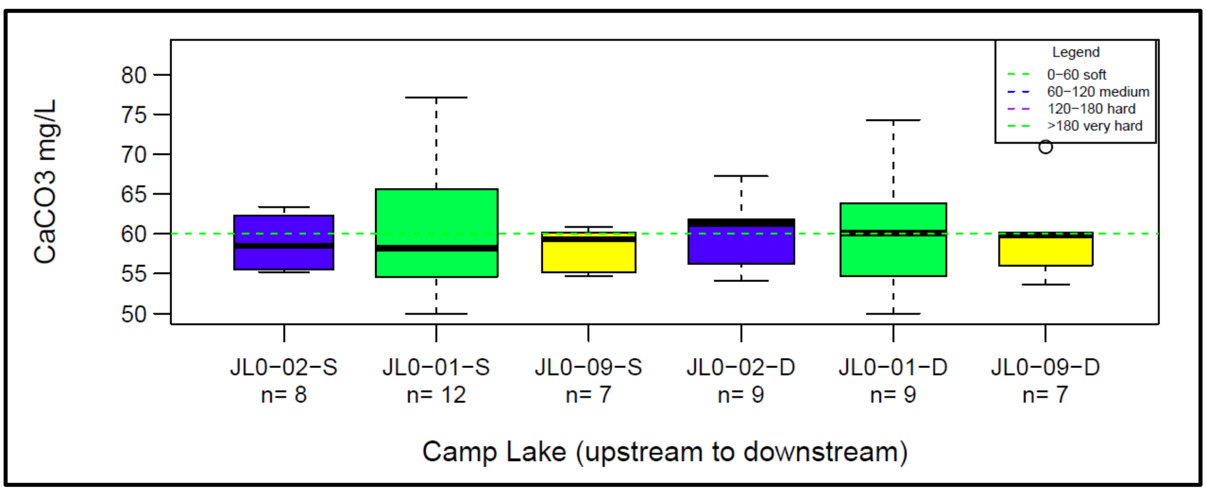
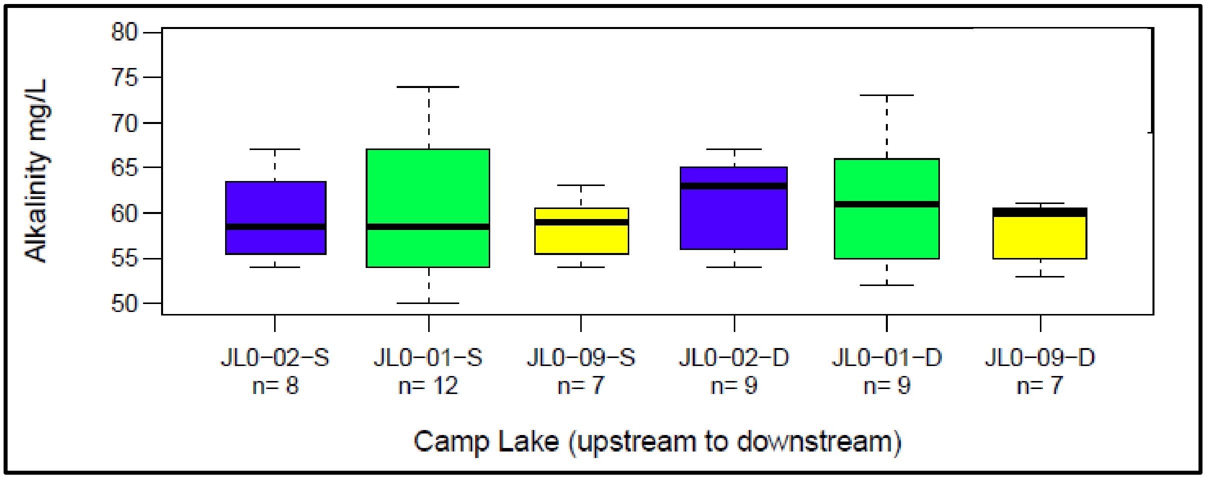


Figure B.5 Camp Lake – Hardness

Alkalinity (Figure B.6)

- Camp Lake sites have uniformly high median alkalinity values that range from 58 to 65 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.
- Discrete sites, regardless of depth, show similar measured alkalinity.



NOTES:

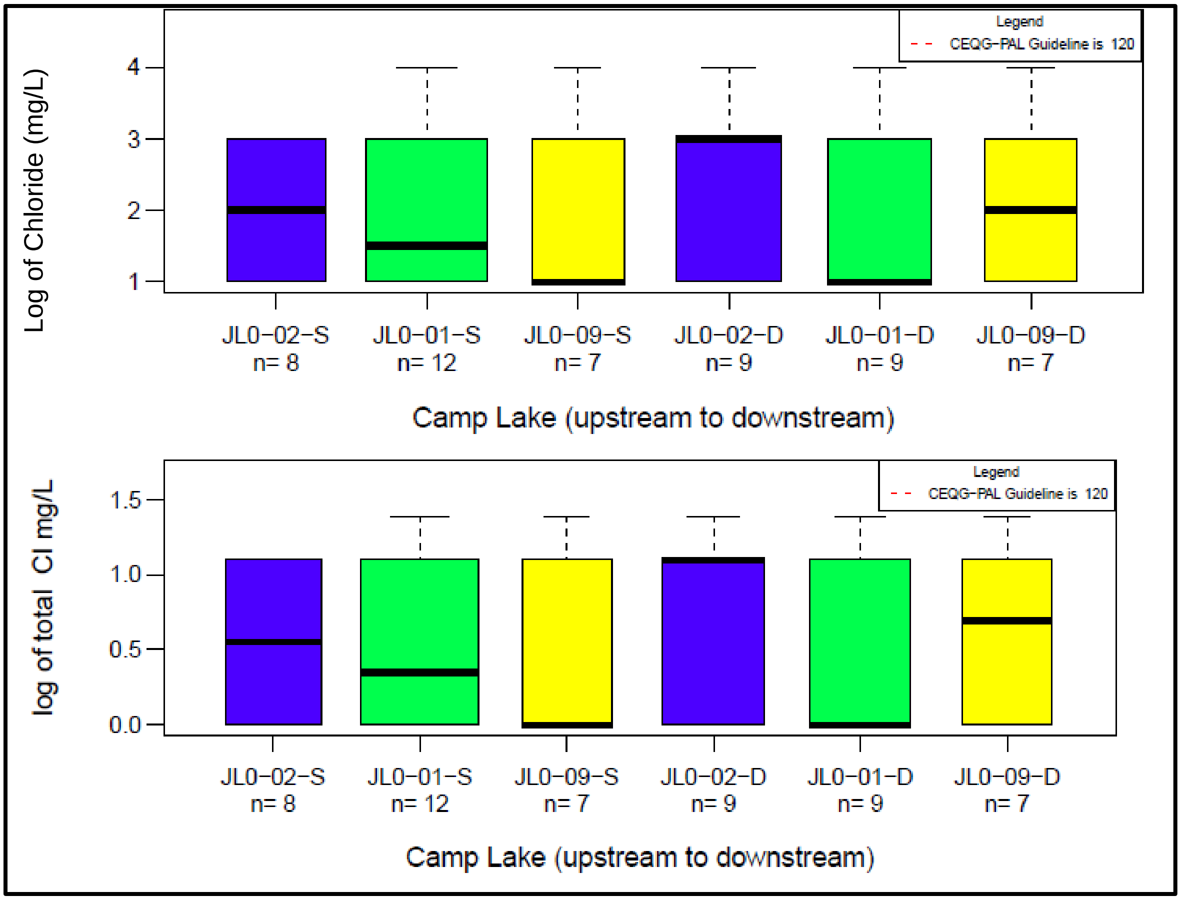
1. ALKALINITY VALUES BELOW 10 mg/L ARE HIGHLY SENSITIVE TO ACIDIC INPUTS; ALKALINITY VALUES BETWEEN 10 – 20 mg/L ARE MODERATELY SENSITIVE TO ACIDIC INPUTS AND ALKALINITY VALUES ABOVE 20 mg/L HAVE LOW SENSITIVITY TO ACIDIC INPUTS.

Figure B.6 Camp Lake – Alkalinity

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures B.7 and B.8)

The total sample size for chloride concentration samples collected ranges from seven to twelve, depending on the geographically distinct sampling site. Chloride concentrations are very low and range from maximum values of 4 mg/L to detection limit values of 1 mg/L (Figure B.7). These concentrations are far below the CWQG limit of 120 mg/L. All sites within Camp Lake have median values that range from 1 mg/L to 3 mg/L. No clear trends with respect to sample location are noted (Figure B.7). Raw data and log transformed data have identical distributions and therefore, chloride distributions remain unaffected by the lognormal data transformation.

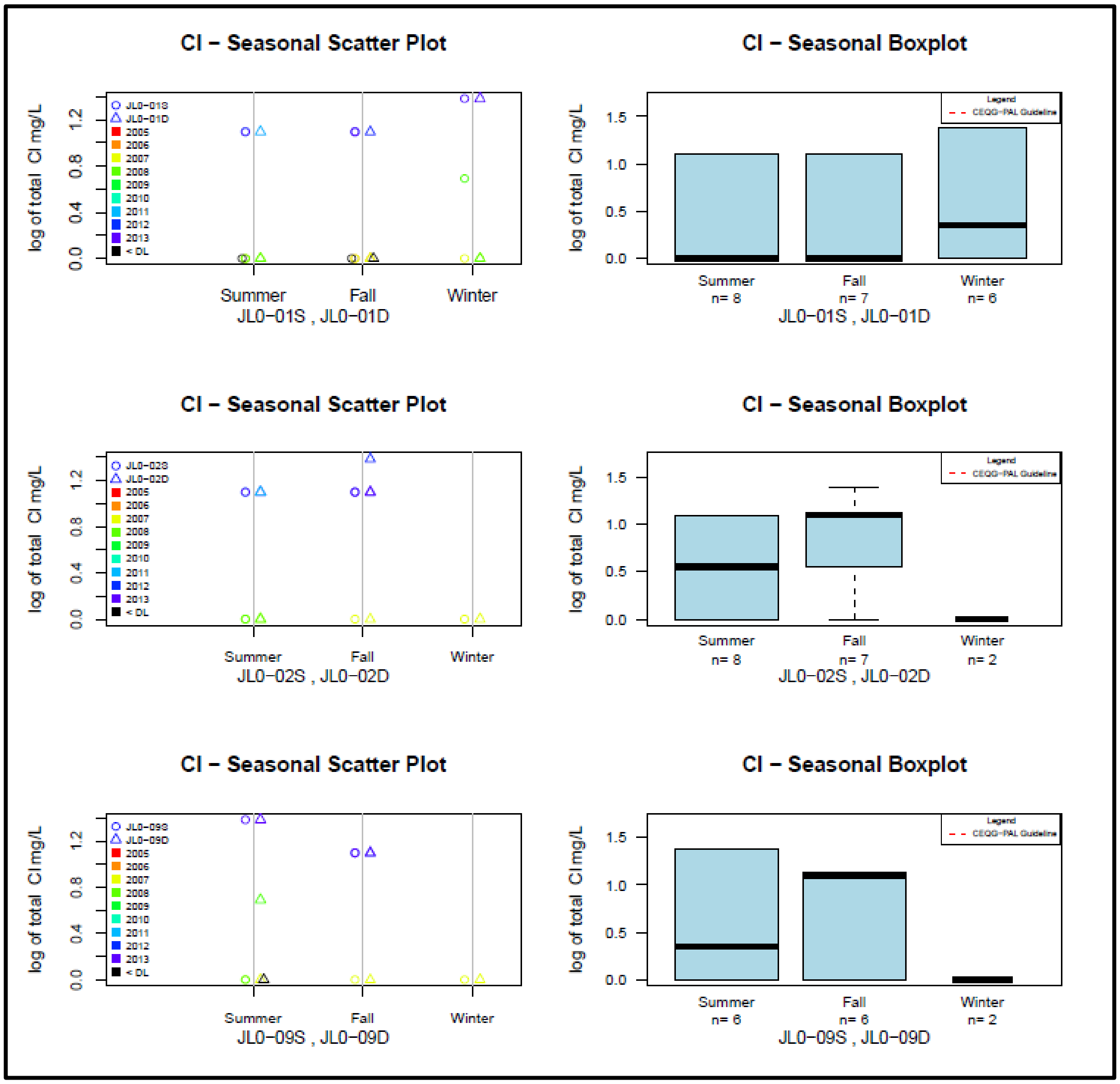


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.7 Camp Lake – Chloride Concentrations in Water

Seasonal scatterplots and boxplots (Figure B.8) show that deep and shallow samples taken during the same year often had similar concentration values, which does not support the assumption that chloride concentration changes with depth.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.8 Camp Lake – Variability of Chloride in Water

The absence of greater chloride concentrations at deep sites may be explained by the very low chloride concentrations or the lack of winter under ice samples, and does not necessarily indicate the absence of stratification. The seasonal scatterplots indicate that 2011 through 2013 chloride concentrations are elevated compared to 2005 to 2010 concentrations. No distinct seasonal trends are noted.

Nitrate

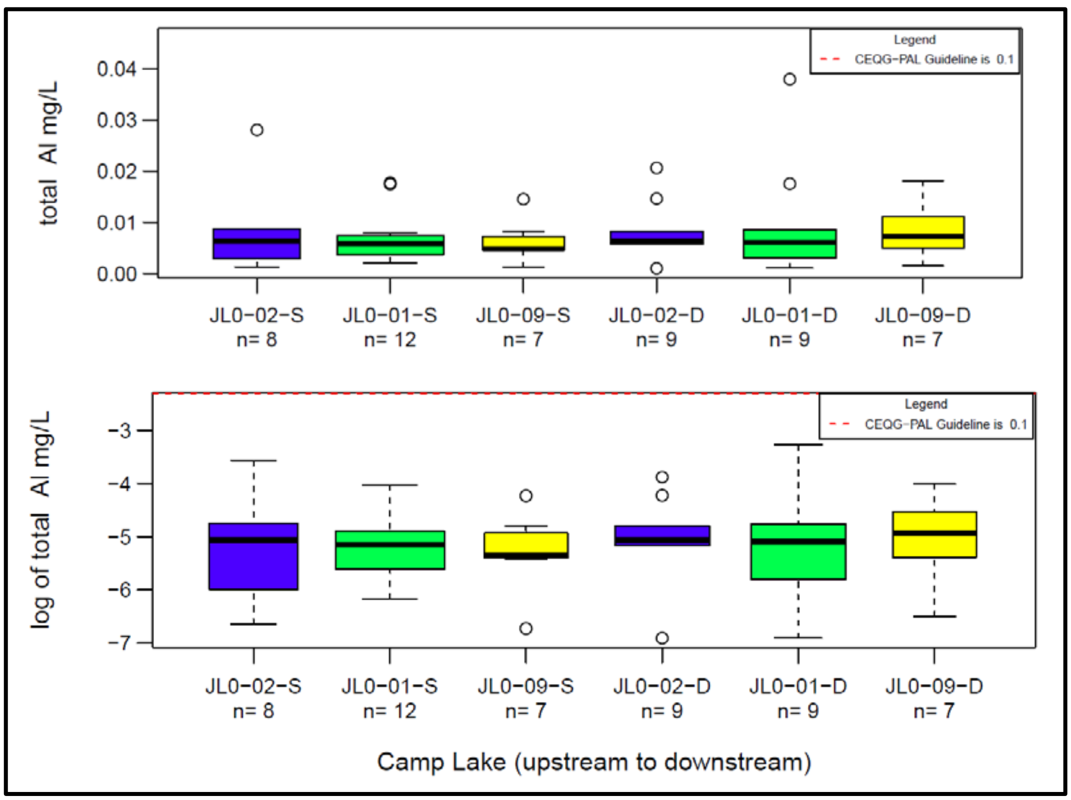
Fifty-two (52) nitrate concentration samples were collected at Camp Lake. All samples collected were at detection limit (0.10 mg/L) and occur well below the CWQG-PAL guideline (3 mg/L). Due to detection limit interference, no depth, seasonal or inter-annual variability is discernable and graphical depiction is not warranted.

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. Total metals concentrations for the parameters of interest have been presented on the basis that applicable guidelines are focused on total metals.

Total Aluminum (Figures B.9 and B.10)

Total aluminum values are uniformly above detection limits, but below the CWQG-PAL guideline across all sites in Camp Lake. Similar to nitrate and chloride, seasonal scatterplots and boxplots for aluminum show concentrations measured at deep and shallow samples taken during the same year have similar values (Figures B.9 and B.10).

Seasonal plots show higher median values of aluminum measured during the summer, lower aluminum concentrations measured in the fall and the lowest aluminum concentrations measured in the winter. Due to the log scale of these graphs, the actual magnitude variation is small. This seasonal trend may be explained by a combination of natural and anthropogenic factors. Elevated summer concentrations may occur as result of increase summer water temperature, increased aluminum mobilization from rocks, soils and sediments by running water during summer and fall seasons or as a result of drilling activities that have occurred in vicinity to Camp Lake during the summer.

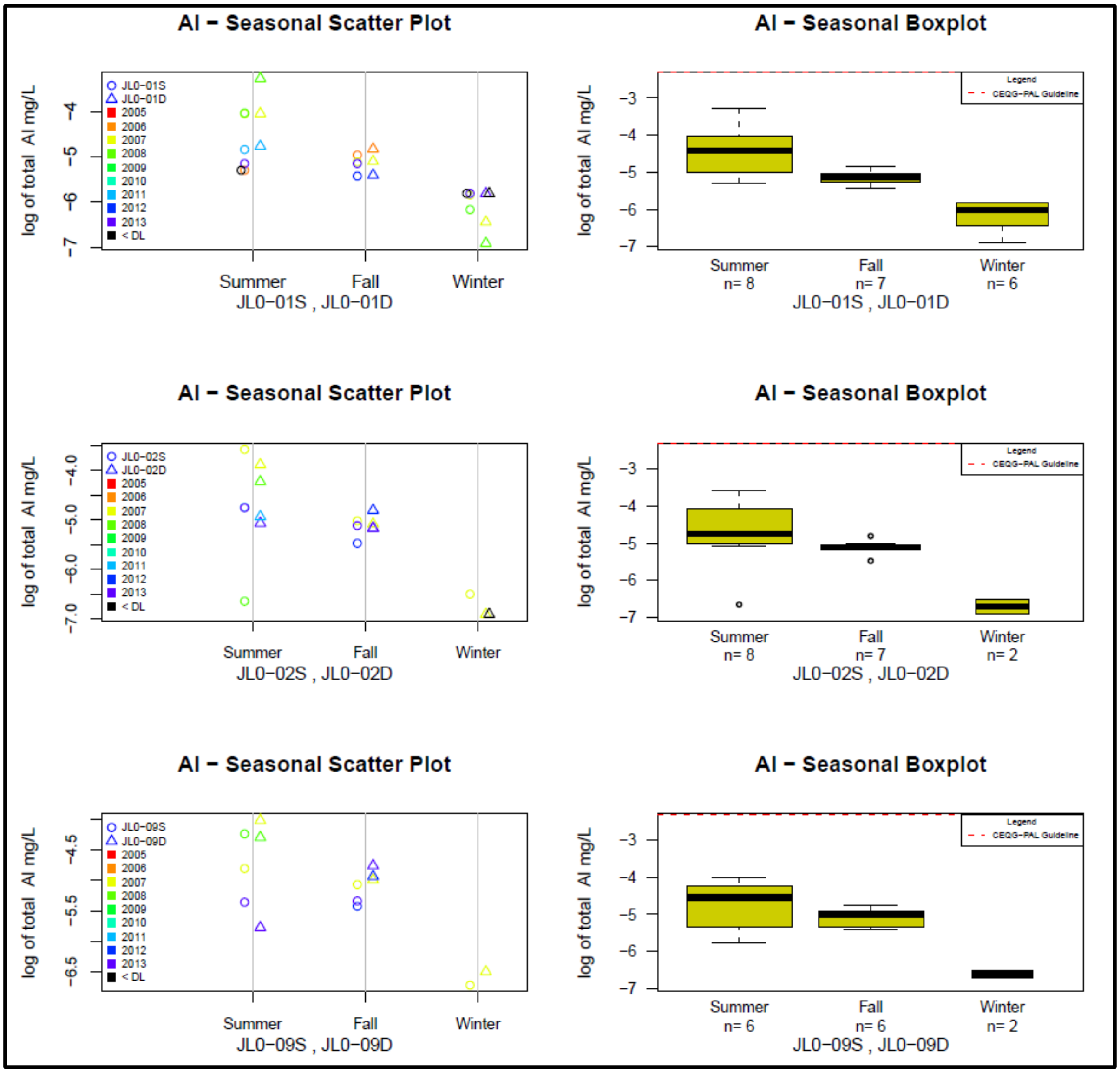


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.9 Camp Lake – Total Aluminum Concentrations in Water

Knight Piésold CONSULTING



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

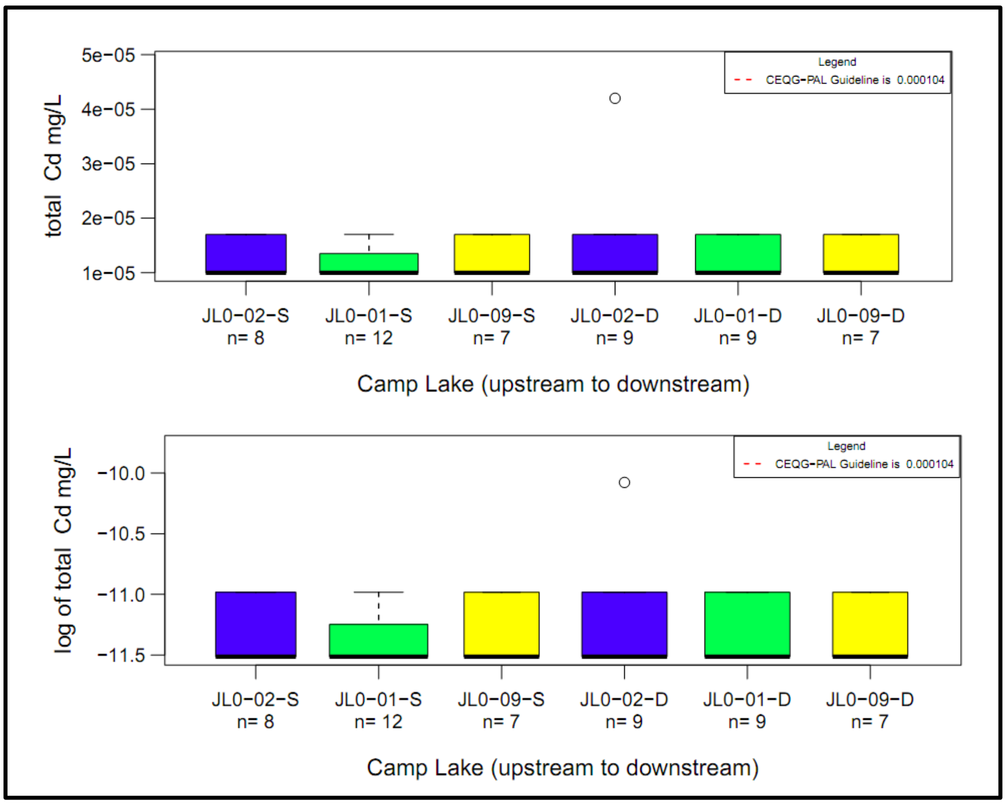
Figure B.10 Camp Lake – Variability of Total Aluminum in Water

Total Arsenic

Total arsenic concentrations were measured at the detection limit (0.0001 mg/L), consistently at all sampling locations within Camp Lake, throughout all seasons and during all years of sampling. As a result, graphical representation of data is not deemed necessary. The detection limit value is well below the appilcable CWQG-PAL guideline limit (0.005 mg/L).

Total Cadmium (Figures B.11 and B.12)

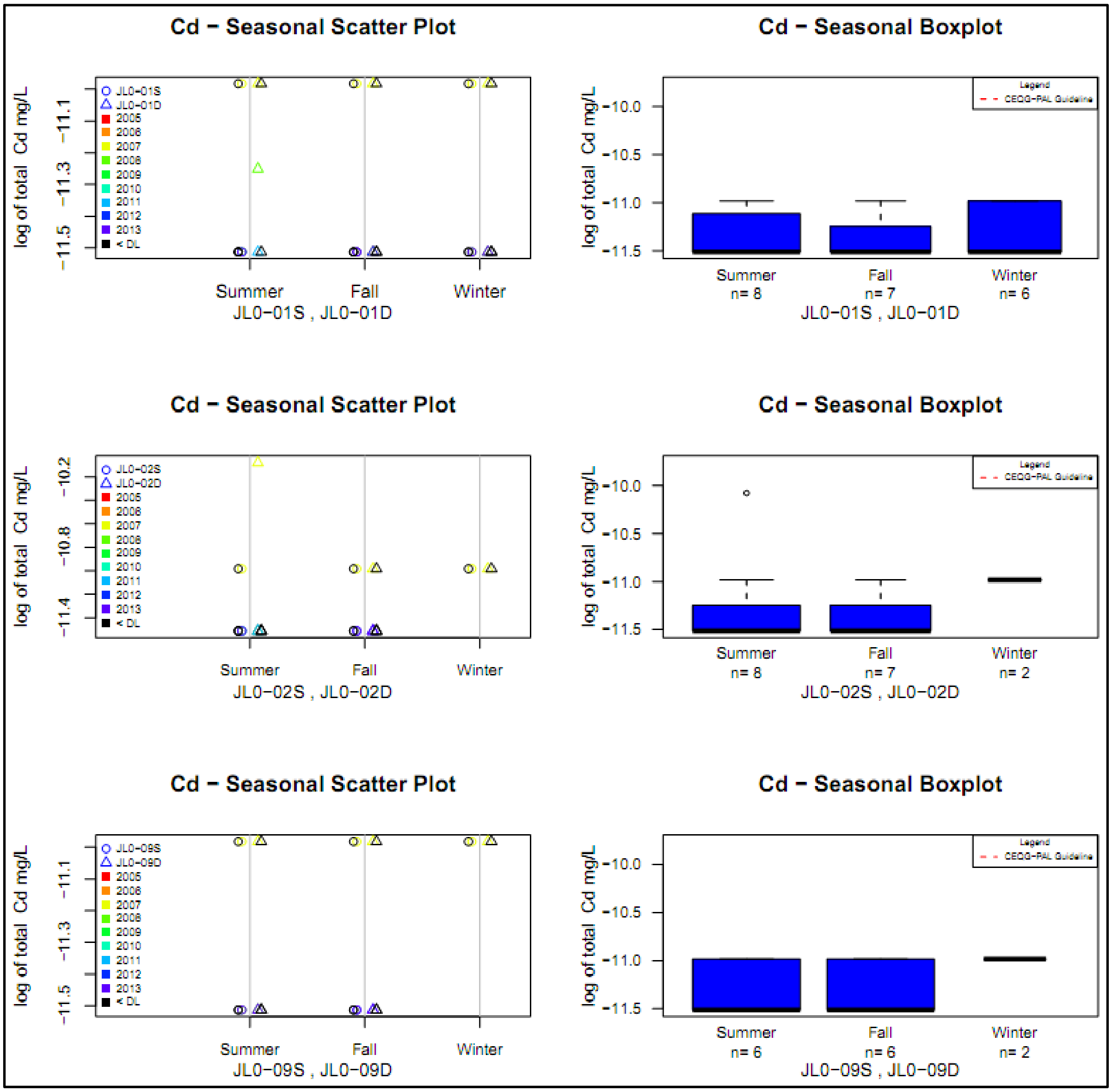
A total of 52 samples with measured cadmium concentrations were collected at Camp Lake, with seven to 12 samples collected at each of the sampling locations in Camp Lake (Figure B.11). Most total cadmium concentrations ranged from detection limit (0.00001 mg/L) to 0.00017 mg/L. One outlying value with a concentration of 0.00004 mg/L recorded in the summer, reported above the CWQG-PAL guideline (0.00018 mg/L, calculated using a median hardness of 50 mg/L $CaCO_3$). Seasonal scatter plots indicate that all measured cadmium concentrations are at a detection limit, with the exception of two data points. Seasonal box plots are obscured by artifact detection limits and do not show a consistent seasonal trend amoung the three sites sampled (Figure B.12). Definitive conclusions regarding depth and seasonal variability are obscured by artificially high detection limits.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.11 Camp Lake – Total Cadmium Concentrations in Water



NOTES:

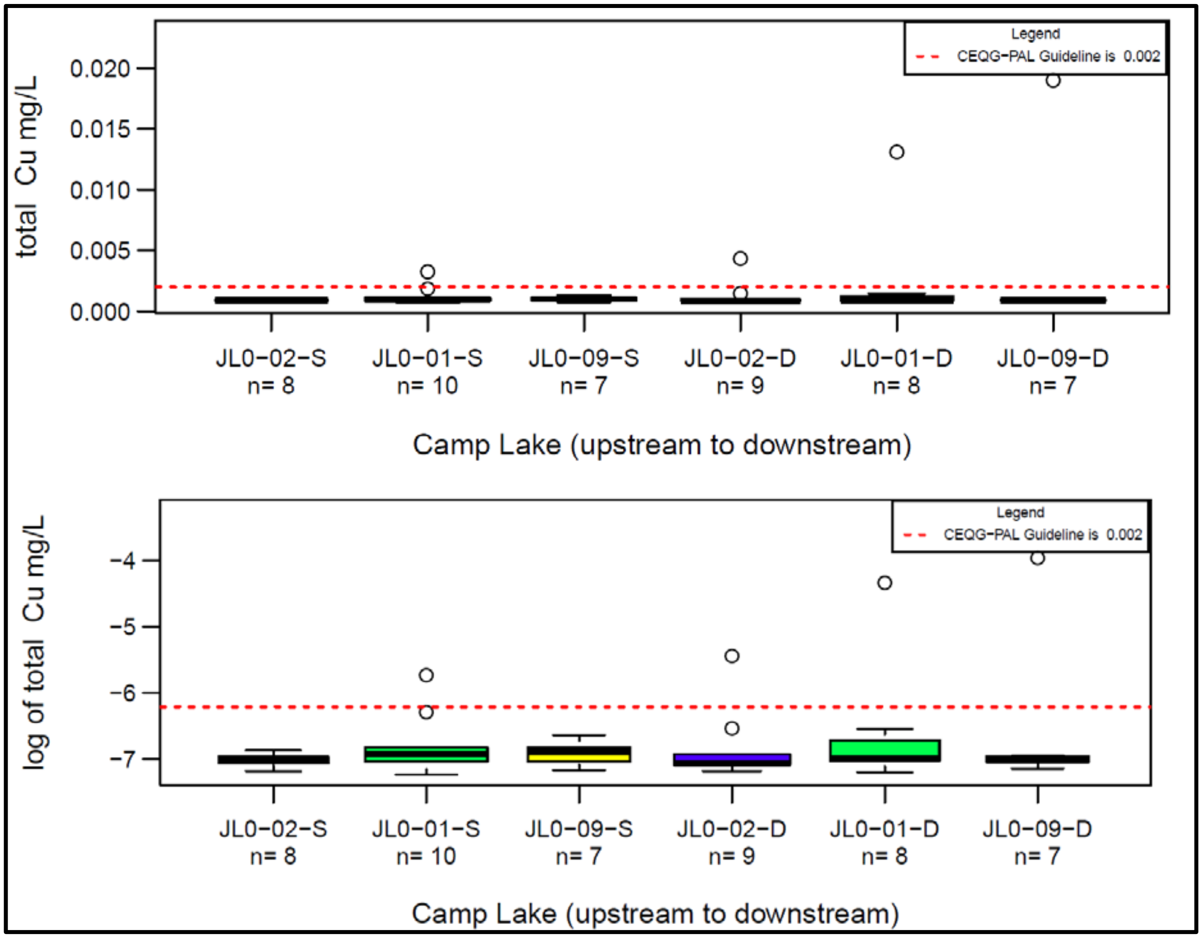
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.12 Camp Lake – Variability of Total Cadmium in Water

Total Copper (Figures B.13 and B.14)

The total sample size for copper samples in Camp Lake is 49, with between seven through ten samples collected at each sampling location. Median values for total copper at all sites occur below 0.002 mg/L (Figure B.13). Log values indicate a distribution of samples with low concentrations, below the guideline limit, that are not obscured by detection limits. Outlying values occur for several sites, to a maximum concentration of approximately 0.018 mg/L. Four outlying values exceed the CWQG-PAL guideline (0.002 mg/L).

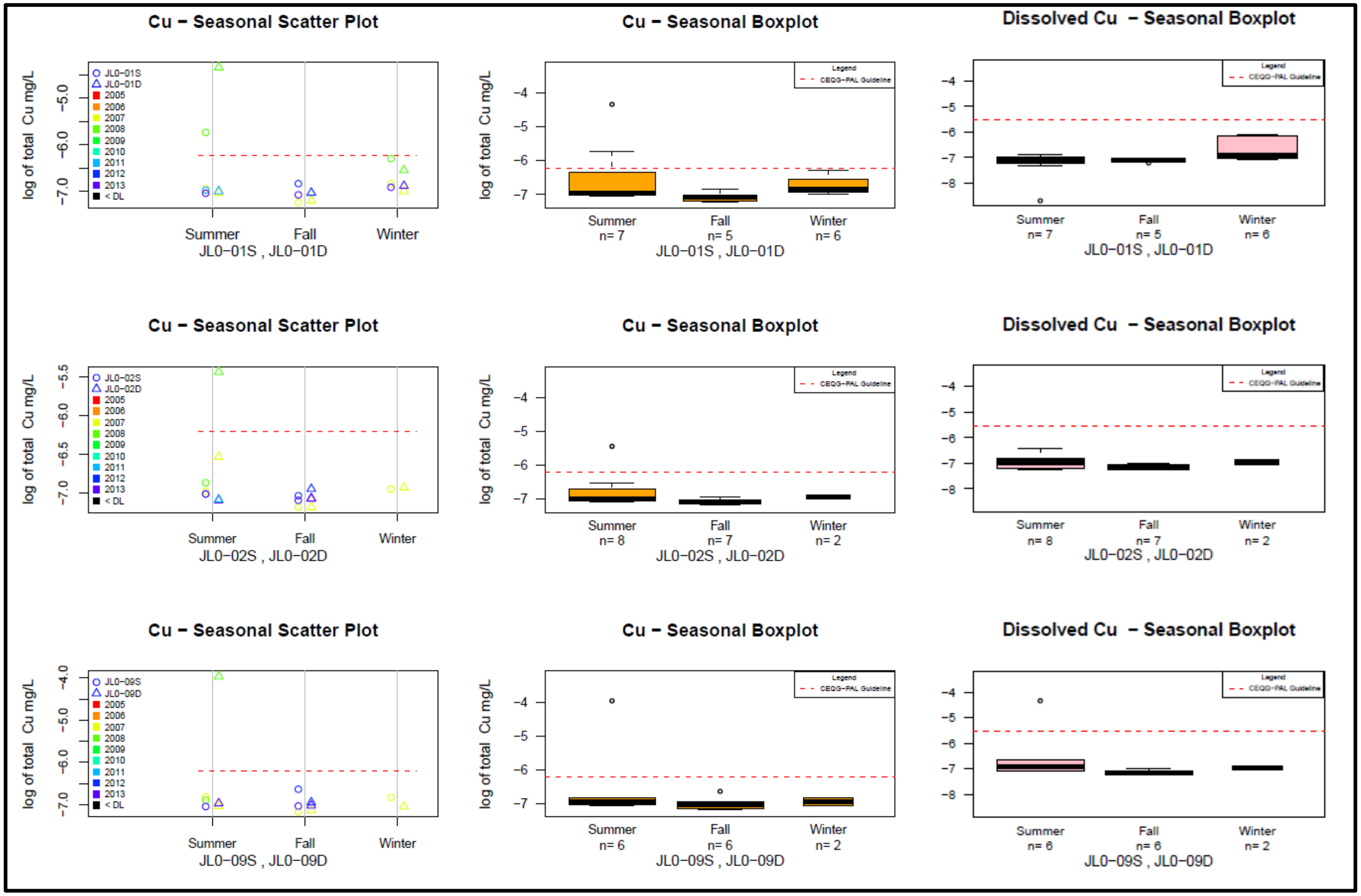
The seasonal copper scatterplot indicates that, with the exception of deep samples taken in 2008, shallow and deep concentrations are quite similar and do not show a consistent trend with depth (Figure B.14). In contrast to other parameters, seasonal trends indicates slightly higher concentrations are measured in summer and winter, when compared to fall. Further investigation into this seasonal trend revealed that winter total concentrations are almost entirely composed of the dissolved fraction, and not the particulate fraction (Figure B.14).



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.13 Camp Lake –Total Copper Concentrations in Water



NOTES:

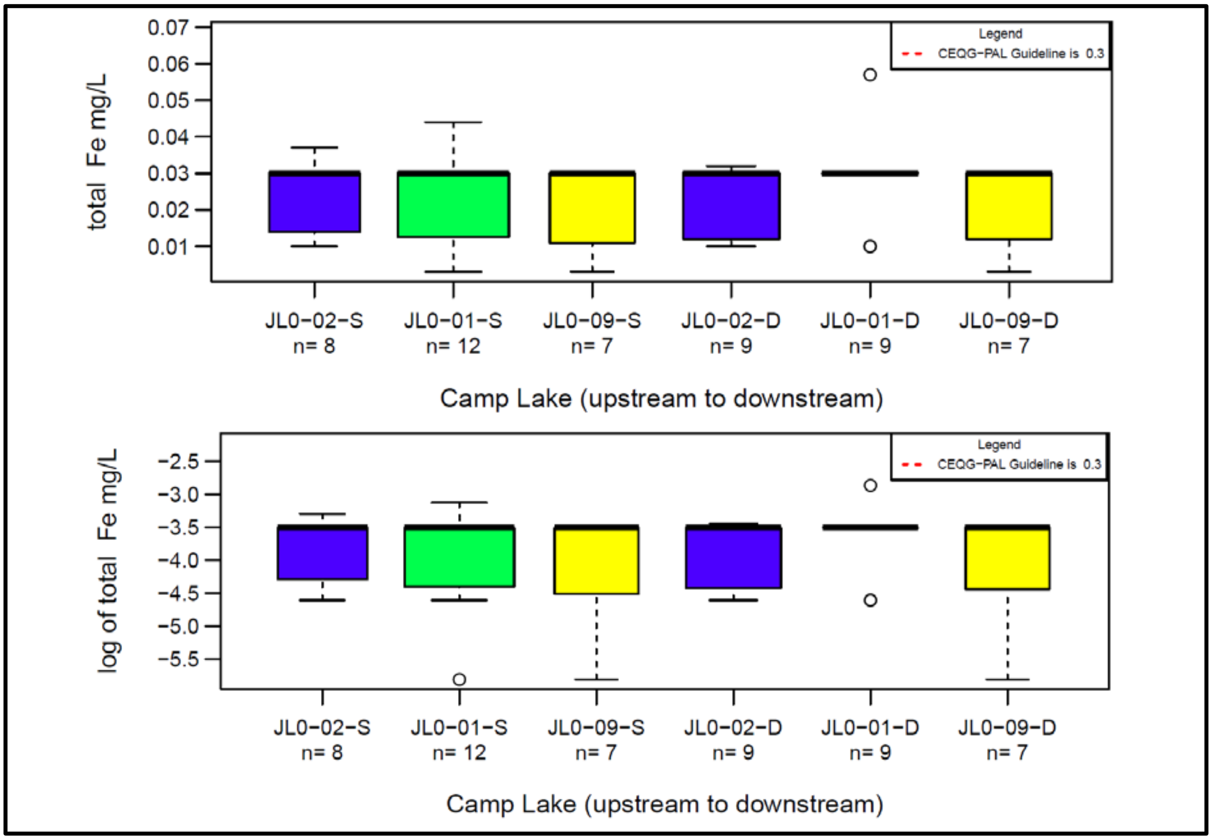
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.14 Camp Lake – Variability of Copper in Water

Total Iron (Figures B.15 and B.16)

Fifty-two (52) samples of total iron were taken within Camp Lake, with between 7 to 12 samples taken at each site within Camp Lake (Figure B.15). Median total iron concentrations at all sites was 0.03 mg/L, below the most stringent water quality guideline, CWQG-PAL at 0.3 mg/L (or the Interim SSWQO of 0.77 mg/L; see Section 2.4 of the main report). Raw and lognormal data show very similar trends, indicating that transformation may not be required for statistical tests and that graphical representation of outliers is not affected. Seasonal scatterplots of iron concentrations indicate that artificially elevated detection limits may be influencing the data and no distinct seasonal trends are noted.

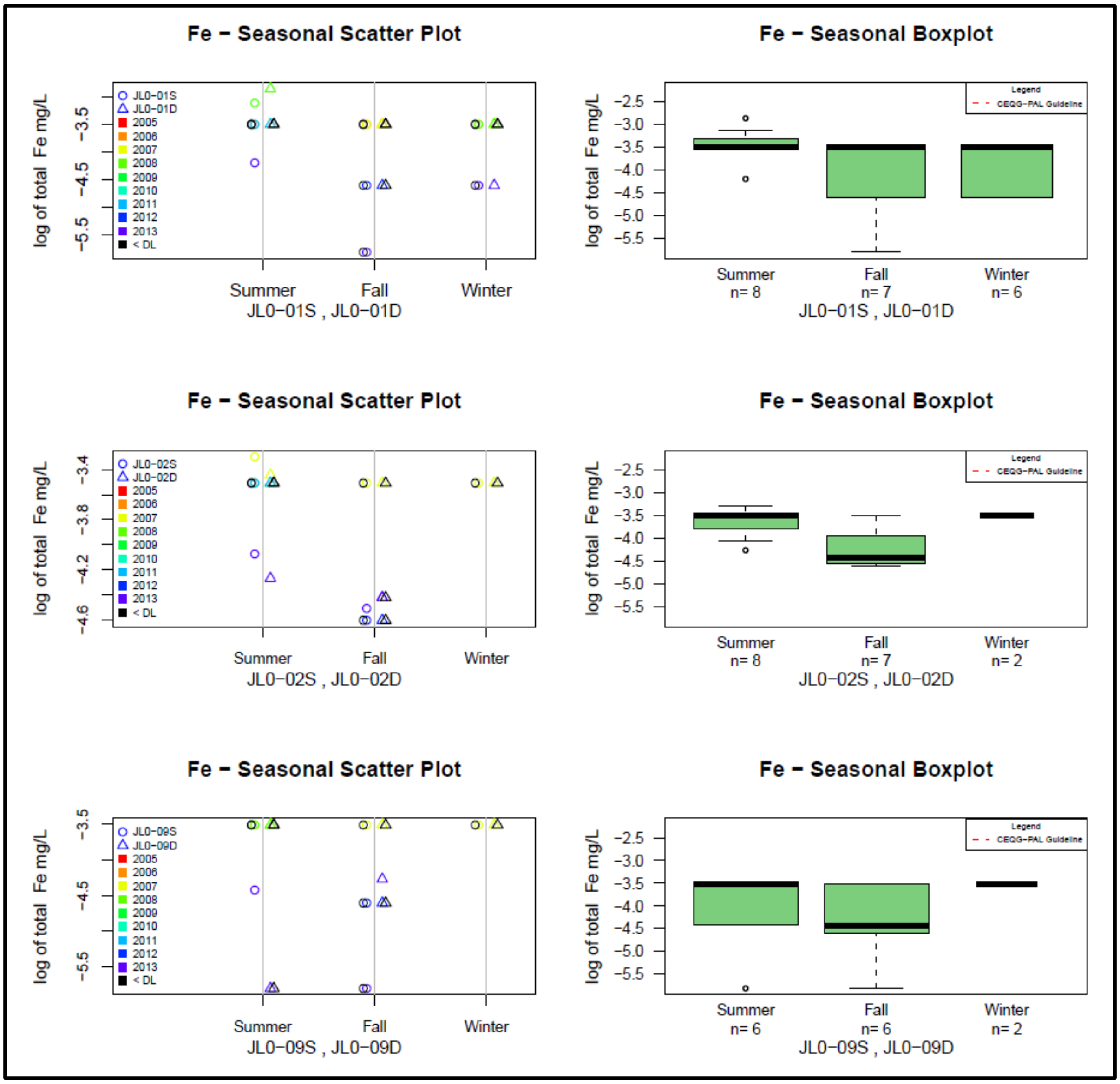
Due to interaction with detection limits during early years of sampling, definitive seasonal or depth trends are difficult to define (Figure B.16). Of note are the slightly lower iron concentrations during fall sampling events.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.15 Camp Lake – Total Iron Concentrations in Water



NOTES:

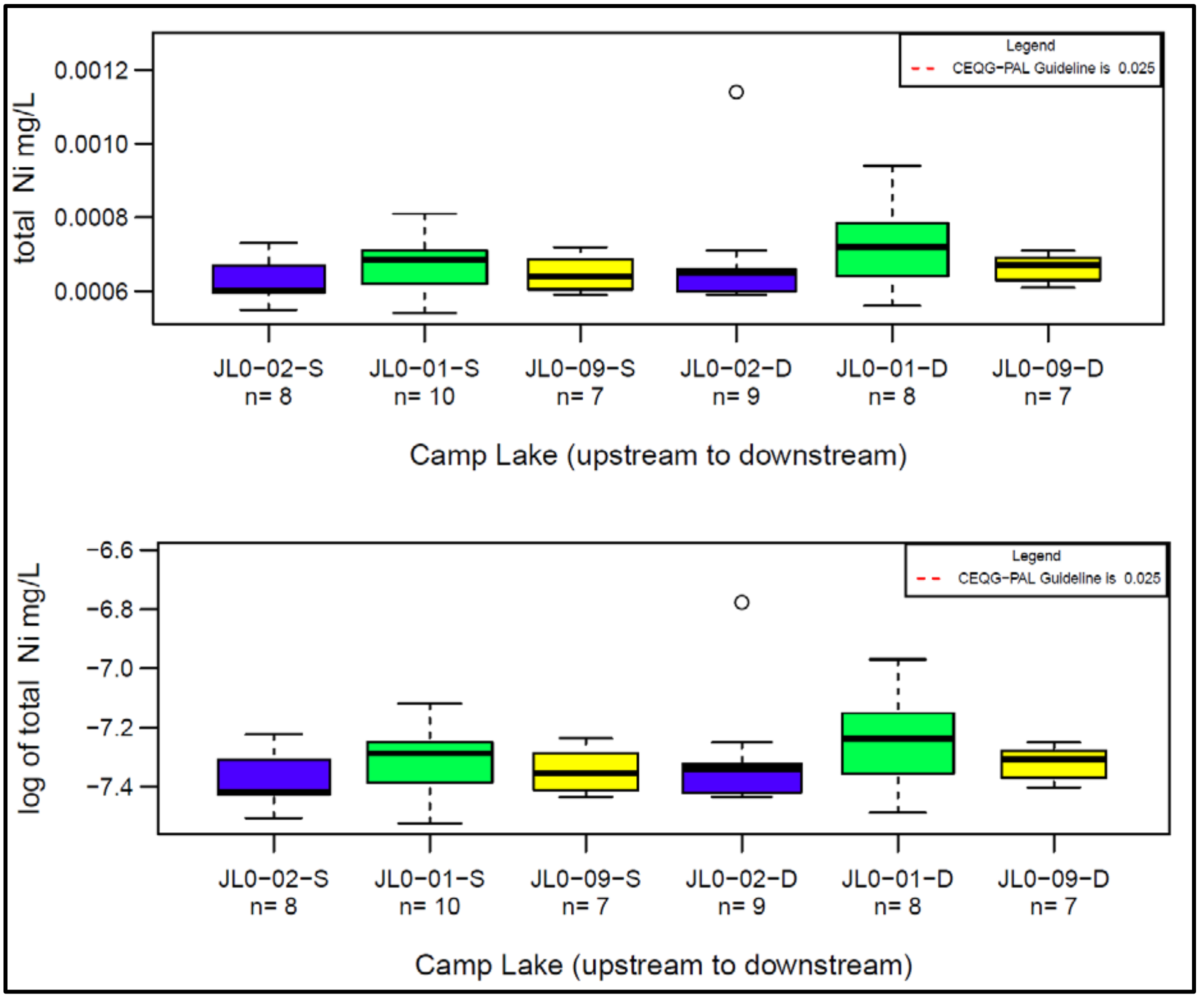
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.16 Camp Lake – Variability of Total Iron in Water

Total Nickel (Figures B.17 and B.18)

Forty-nine (49) nickel samples were collected at Camp Lake, with between seven to ten samples collected at each discrete sampling location. Median total nickel concentrations at each site are low and range from 0.0006 mg/L to 0.00075 mg/L (Figure B.17). All values are well below the CWQG-PAL guideline calculated to be 0.025 mg/L based on 50 mg/L $CaCO_3$ hardness.

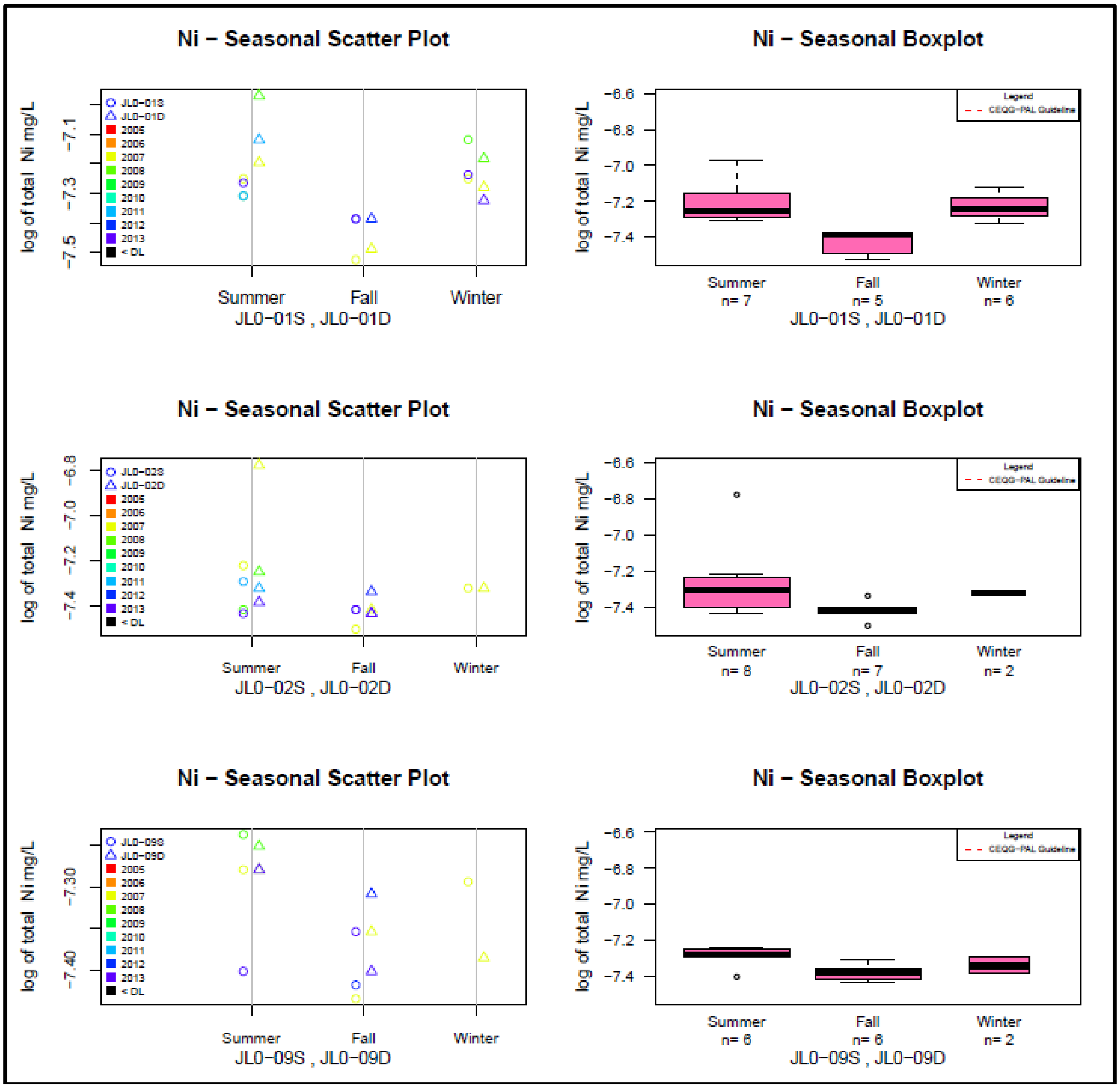
No distinct temporal trends over the course of yearly sampling are noted, although variation in site location is greater than variation as a result of depth (Figure B.18). JL0-01 has a very low magnitude elevation of nickel concentrations when compared to other sites. Seasonal trends are noted that are similar to those observed for copper, with very similar median summer and winter concentrations and lower fall sampling concentrations. Similar to copper, investigation into total versus dissolved concentration reveal that almost all total nickel is present in the dissolved form during the winter months, although summer and fall have more particulate data.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.17 Camp Lake – Total Nickel Concentrations in Water



NOTES:

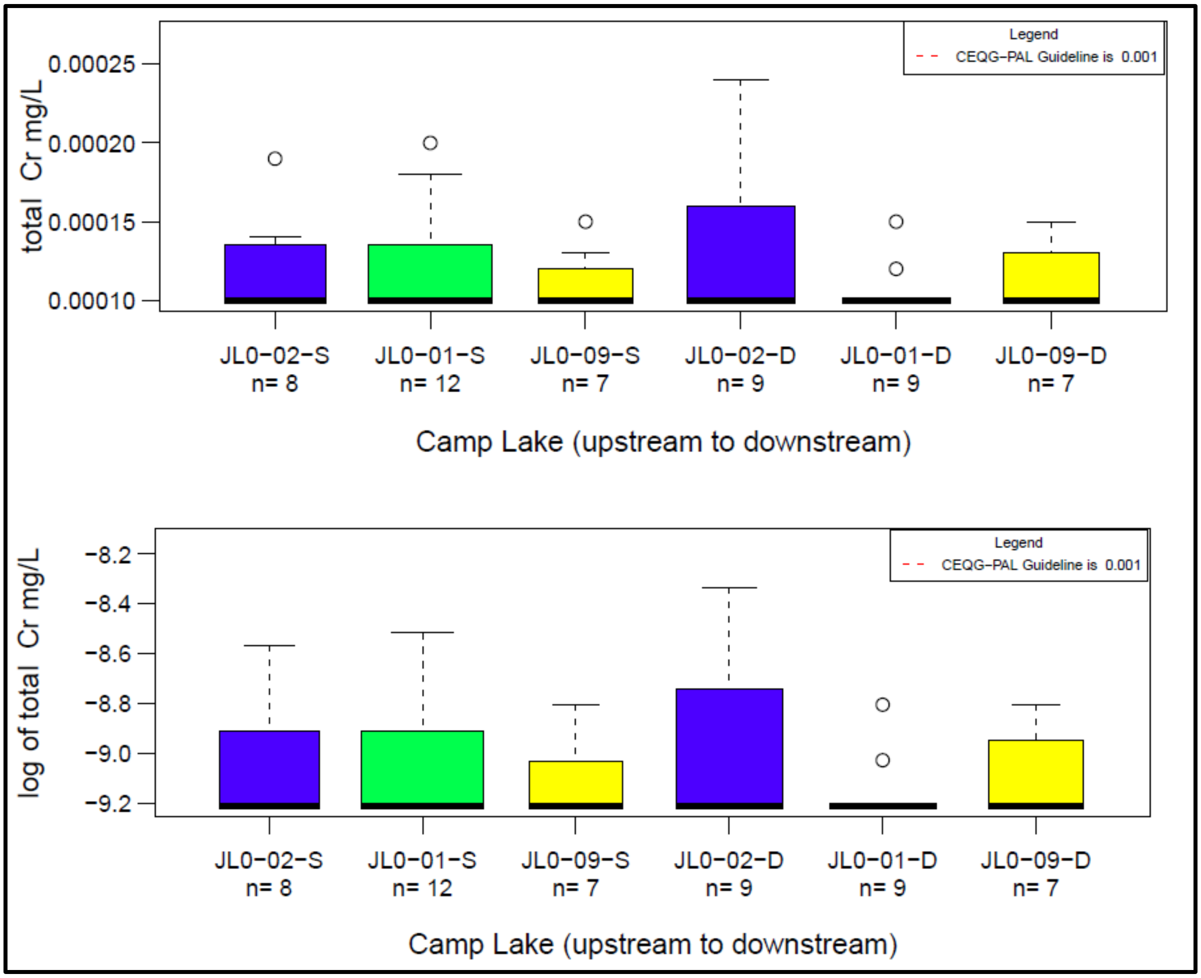
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.18 Camp Lake – Variability of Total Nickel in Water

Total Chromium (Figures B.19 and B.20)

Fifty-two (52) chromium samples were collected at Camp Lake, with between seven to twelve samples collected at each discrete sampling location. Median total chromium concentrations at each site are low and range from 0.0001 mg/L to 0.00024 mg/L (Figure B.19). All values are well below the CWQG-PAL guideline (0.001 mg/L).

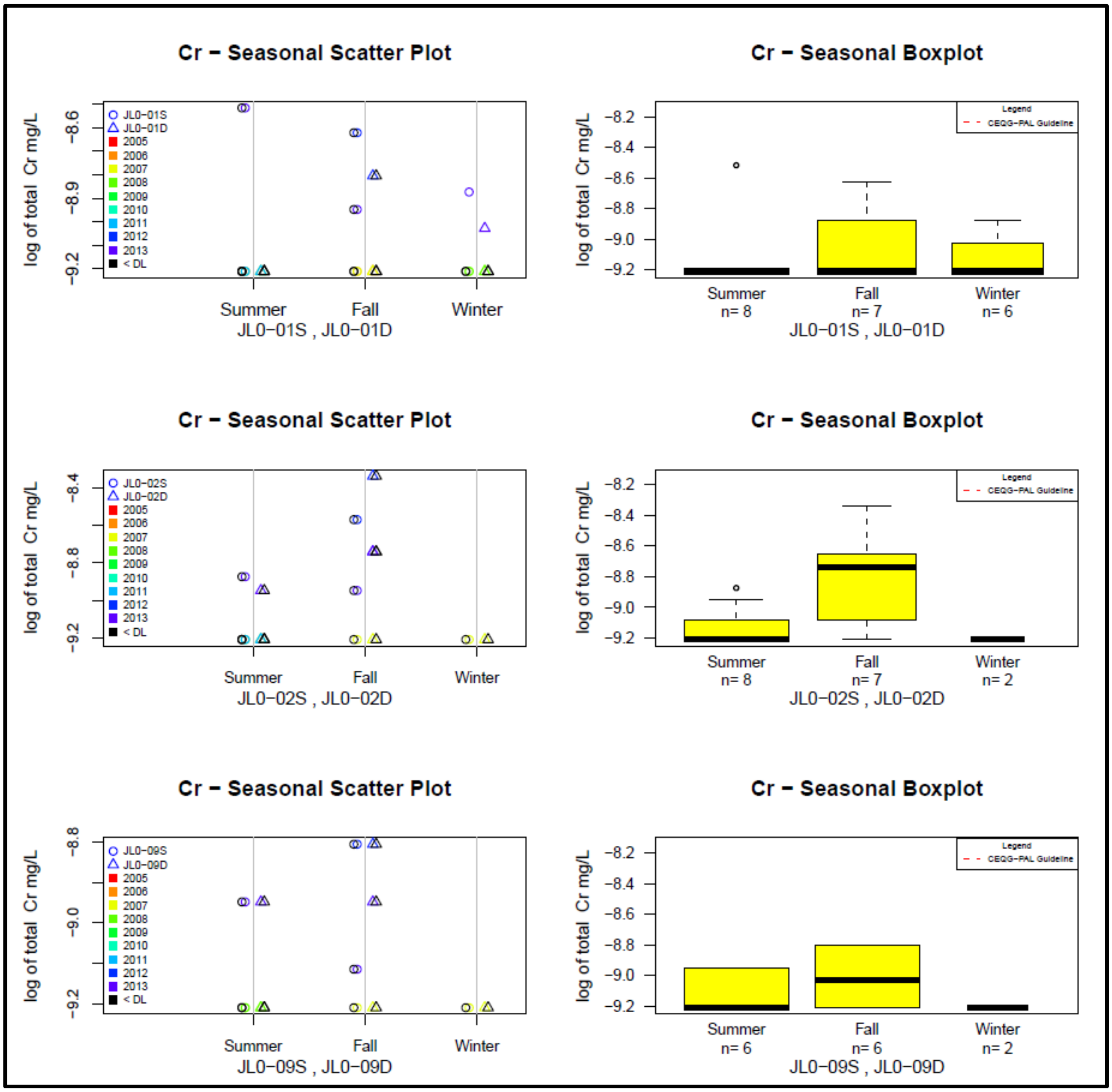
Samples from 2012 and 2013 are slightly elevated when compared to previous sampling years (Figure B.20). Slightly greater concentrations during the fall are noted for chromium



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.19 Camp Lake – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.20 Camp Lake – Variability of Total Chromium in Water

Summary of Camp Lake Water Quality

Summary of trends observed during review of Camp Lake baseline data:

- Distinct depth trends are not observed for Camp Lake, which suggests that the lake is completely mixed through much of the year. Review of data above suggests aggregation of deep and shallow sites may be appropriate.
- Geographic trends between discrete sampling sites were not observed for any parameters.

- With the exception of chloride and chromium, parameters did not show any distinct inter-annual trends/variability over the six year sampling history. Chloride and chromium concentrations in Camp Lake measured from 2011 through 2013 are elevated compared to earlier samples from 2005 to 2010.
- Parameters with MDL interference and/or that do not show seasonal trends include: cadmium, chloride, arsenic, iron and nitrate.
- Parameters that have maximum concentrations occurring in the summer: nitrate and aluminum. This is likely as a result of the spring runoff period caused by rapid melt of winter snowpack.
- Parameters that have maximum concentrations occurring in the winter: copper and nickel. Most of this concentration occurs in a dissolved form, not as particulate.
- Parameters that have maximum concentrations occurring in the fall: chromium.

B.2.2 Sheardown Lake

Sheardown Lake is separated into two basins, referred to as the northwest basin and southeast basin. Sheardown Lake NW has been the receiving water for treated sewage from the exploration camp. In addition, stockpiling and crushing of ore occurred in 2008 near the lake and the primary tributary to the lake. As such, the concentrations within the lake may have already been affected by construction and mining activities. Findings from both lakes will be discussed in the subsequent sections.

B.2.2.1 Sheardown Lake NW

A total of 92 lake samples were collected from the northwest basin of Sheardown Lake from 10 sampling stations over the sampling period. Most sampling was completed during the open water season, from July through September (summer and fall). Late winter sampling (May) was carried out only in 2007, 2008, 2012 and 2013. Ten stations are reported in detail (Figures B.1 and B.2):

- DL0-01-1-S and DL0-01-1-D - Shallow and deep; located in the centre of Sheardown Lake NW.
- DL0-01-2-S and DL0-01-2-D - Shallow and deep; located in the south centre of Sheardown Lake NW.
- DL0-01-4-S and DL0-01-4-D - Shallow and deep; located on the northeast bay within Sheardown Lake NW.
- DL0-01-5-S and DL0-01-5-D - Shallow and deep; located near the northwest shore within Sheardown Lake NW.
- DL0-01-7-S and DL0-01-7-D - Shallow and deep; located near the southern outlet of Sheardown Lake NW.

D-Lake-01, -02, -03, -04 and -05 were also established, but each has only one sampling point. A summary of the data collected during each season, with respect to year and site are included in Table B.2. A graphical representation of the sampling events within Sheardown Lake for the ten station reported in detail is provided in Figure B.21.

Table B.2 Sheardown Lake NW Sample Size

Year	Summer	Fall	Winter
2006	2	2	0
2007	10	10	4
2008	11	10	2
2011	6	6	0
2012	0	6	2
2013	13	8	6
Site	**Summer**	**Fall**	**Winter**
DL0-01-1-S	5	6	2
DL0-01-1-D	5	6	2
DL0-01-2-S	3	3	0
DL0-01-2-D	3	3	0
DL0-01-4-S	5	2	0
DL0-01-4-D	2	3	0
DL0-01-5-S	4	5	2
DL0-01-5-D	4	5	2
DL0-01-7-S	4	5	0
DL0-01-7-D	7	4	0

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30.
2. LAKE SAMPLING DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE.
3. DURING WINTER 2013, SAMPLES WERE COLLECTED WITHIN SHEARDOWN LAKE AT D-LAKE-05.

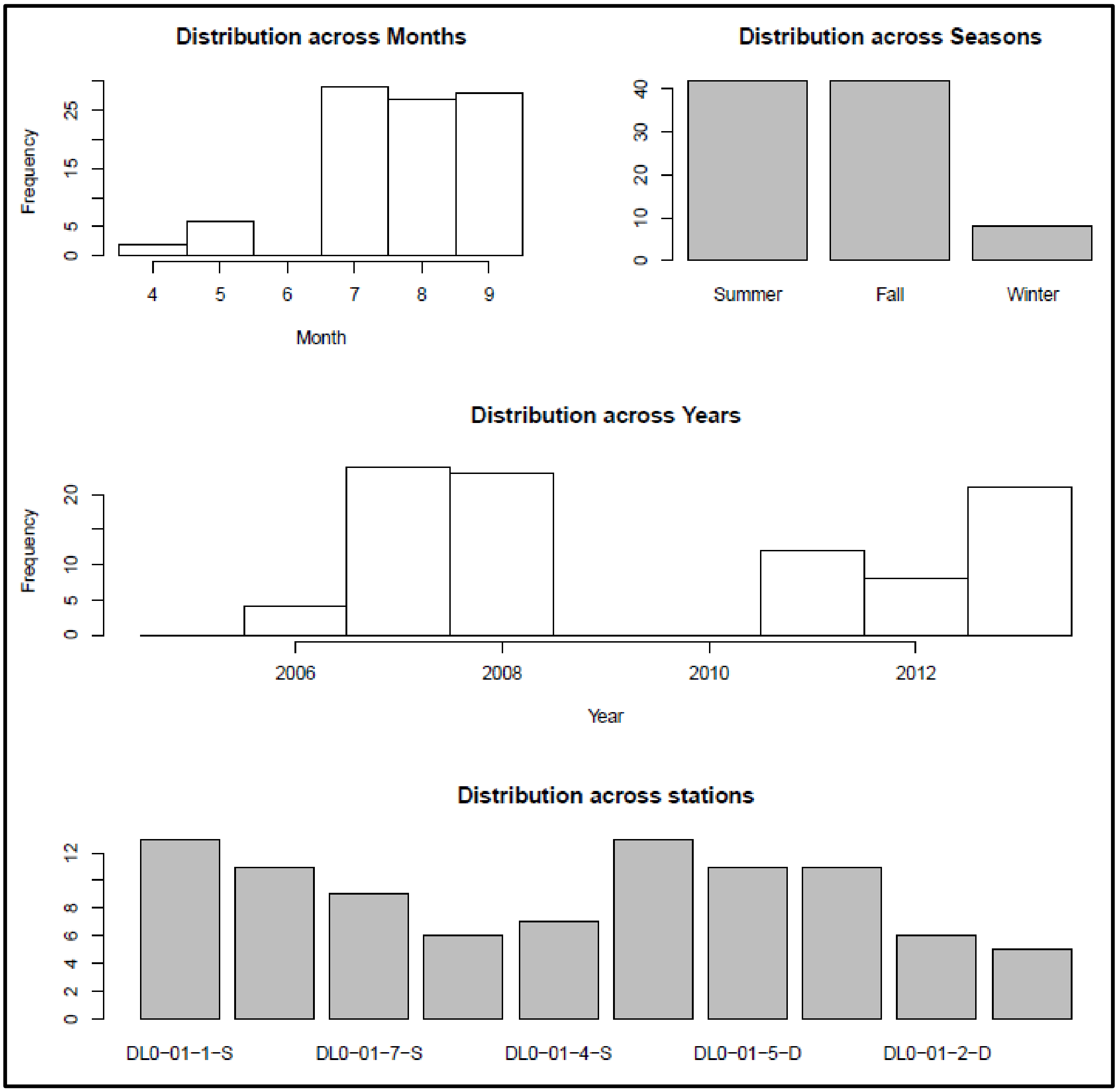


Figure B.21 Sheardown Lake NW – Graphical Summary of Sampling Events

The following summarizes the data review observations for Sheardown Lake NW.

pH (Figure B.22)

- Sheardown Lake NW is slightly alkaline with a median in-situ pH of ~7.6.
- A slight influence of depth on pH is observed with a measured median *in situ* pH at the deep stations is slightly lower compared to shallow stations.

Alkalinity (Figure B.22)

- Sheardown Lake sites are fairly uniform with median alkalinity values that range from 50 to 60 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.

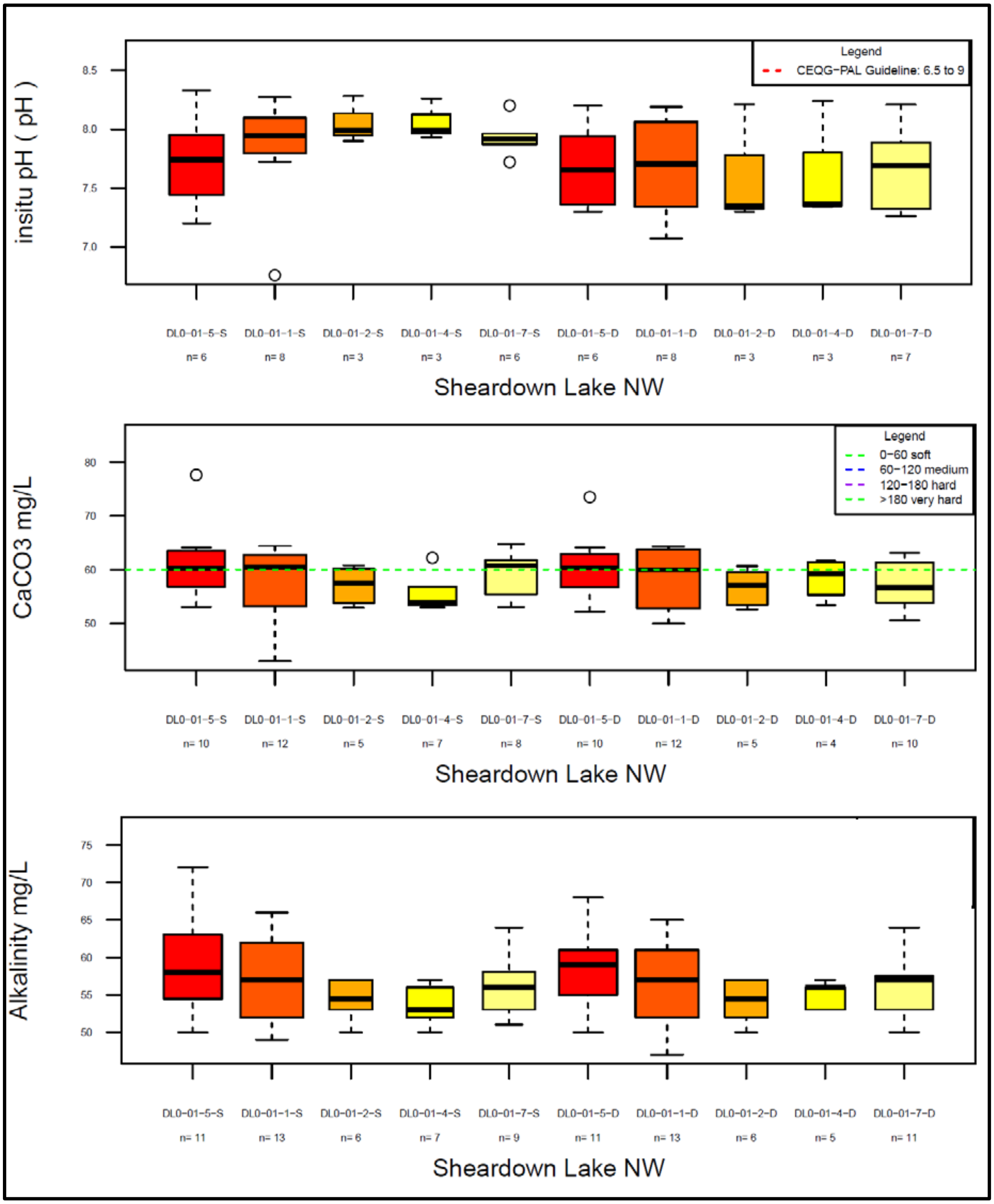


Figure B.22 Sheardown Lake NW – *In situ* pH, Alkalinity and Hardness

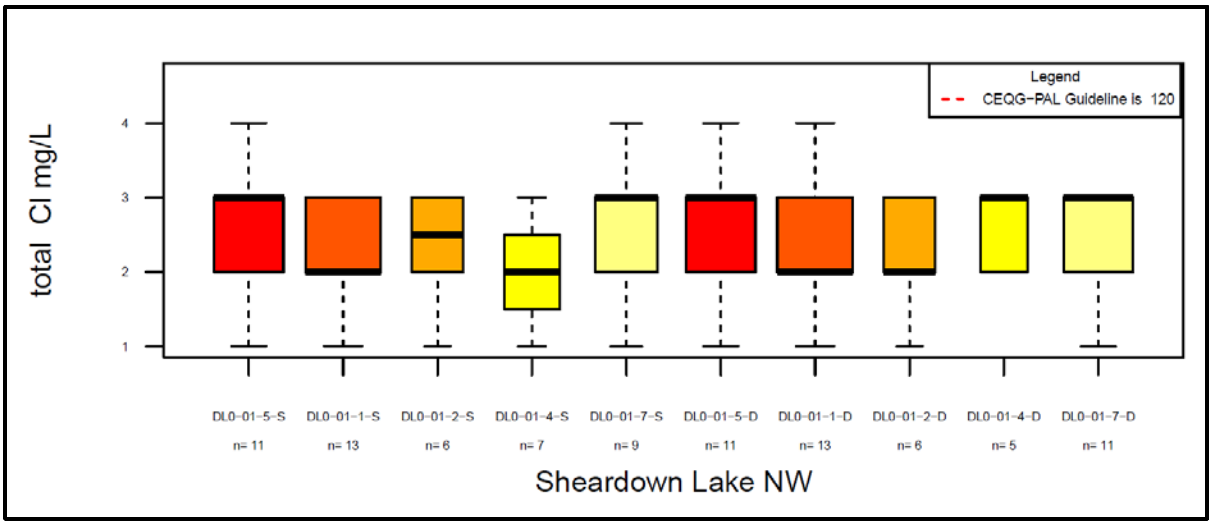
Hardness (Figure B.22)

- Median hardness ranged from 54 and 61 mg/L, putting Sheardown Lake NW right on the border of water that is considered “soft” or “medium” hardness.
- Hardness did not change meaningfully with depth, and showed more variation with station than with depth.
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures B.23 and B.24)

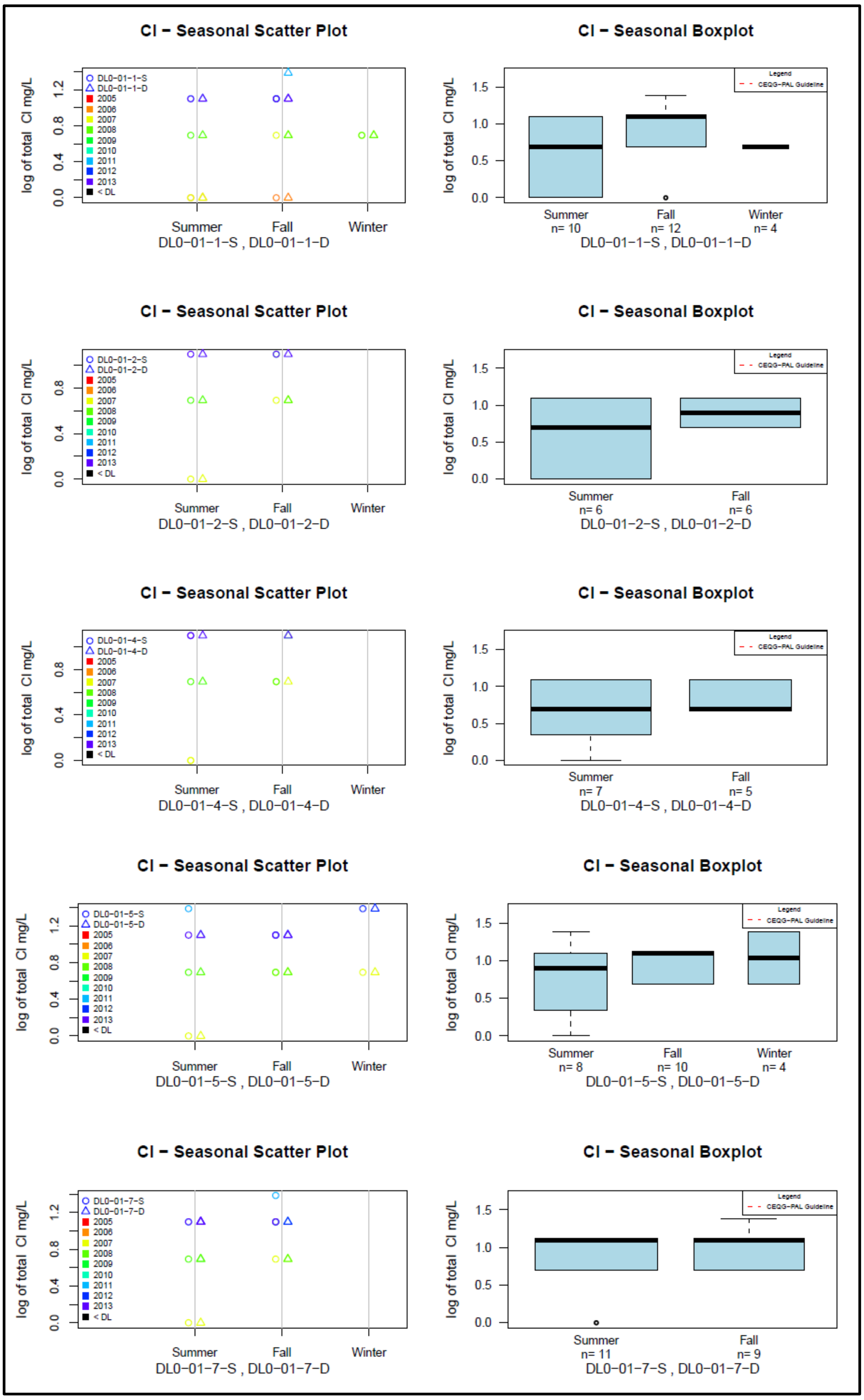
Ninety-two (92) chloride concentration samples were collected at Sheardown Lake NW. Chloride concentrations in Sheardown Lake NW are very low and have maximum values of 4 mg/L, well below the CWQG-PAL limit of 120 mg/L (Figure B.23). All sites within Sheardown Lake NW have very similar median chloride concentrations that range between 2 to 3 mg/L. Comparison of raw data and log values reveals the occurrence of low concentration outlying data, at a MDL. Seasonal scatterplots indicate that detection limit interference is occurring for chloride concentrations and that distinct trends with depth are not apparent (Figure B.24).



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.23 Sheardown Lake NW – Chloride Concentrations in Water



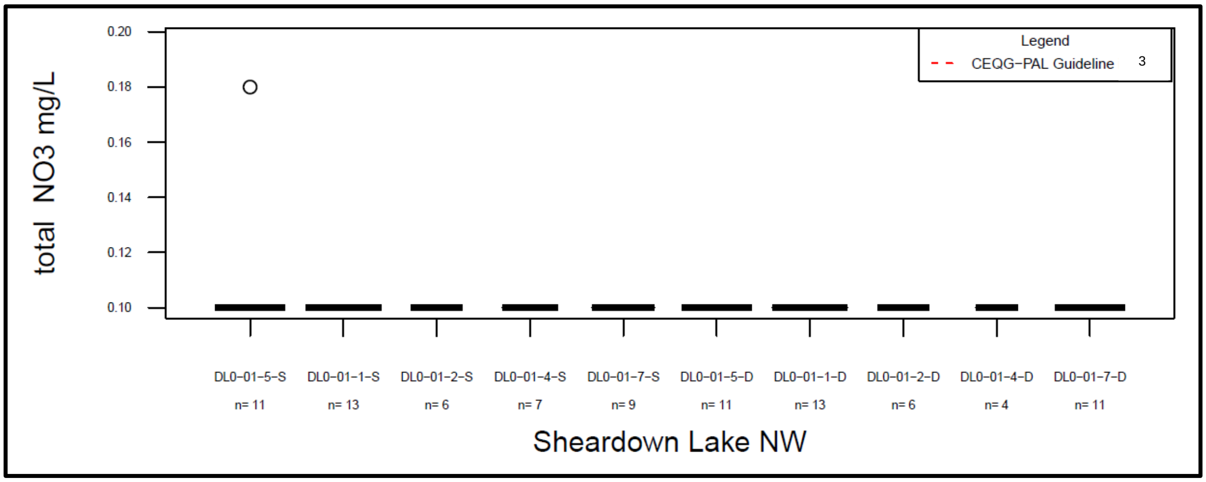
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.24 Sheardown Lake NW – Variability of Chloride in Water

Nitrate (Figure B.25)

Eighty-seven (87) nitrate concentration samples were collected from Sheardown Lake over the course of eight years. All nitrate concentrations were measured at the detection limit (0.10 mg/L), except for one outlying concentration equal to 0.18 mg/L (Figure B.25). As a result, no seasonal, inter-annual or depth variation can be determined.



NOTES:

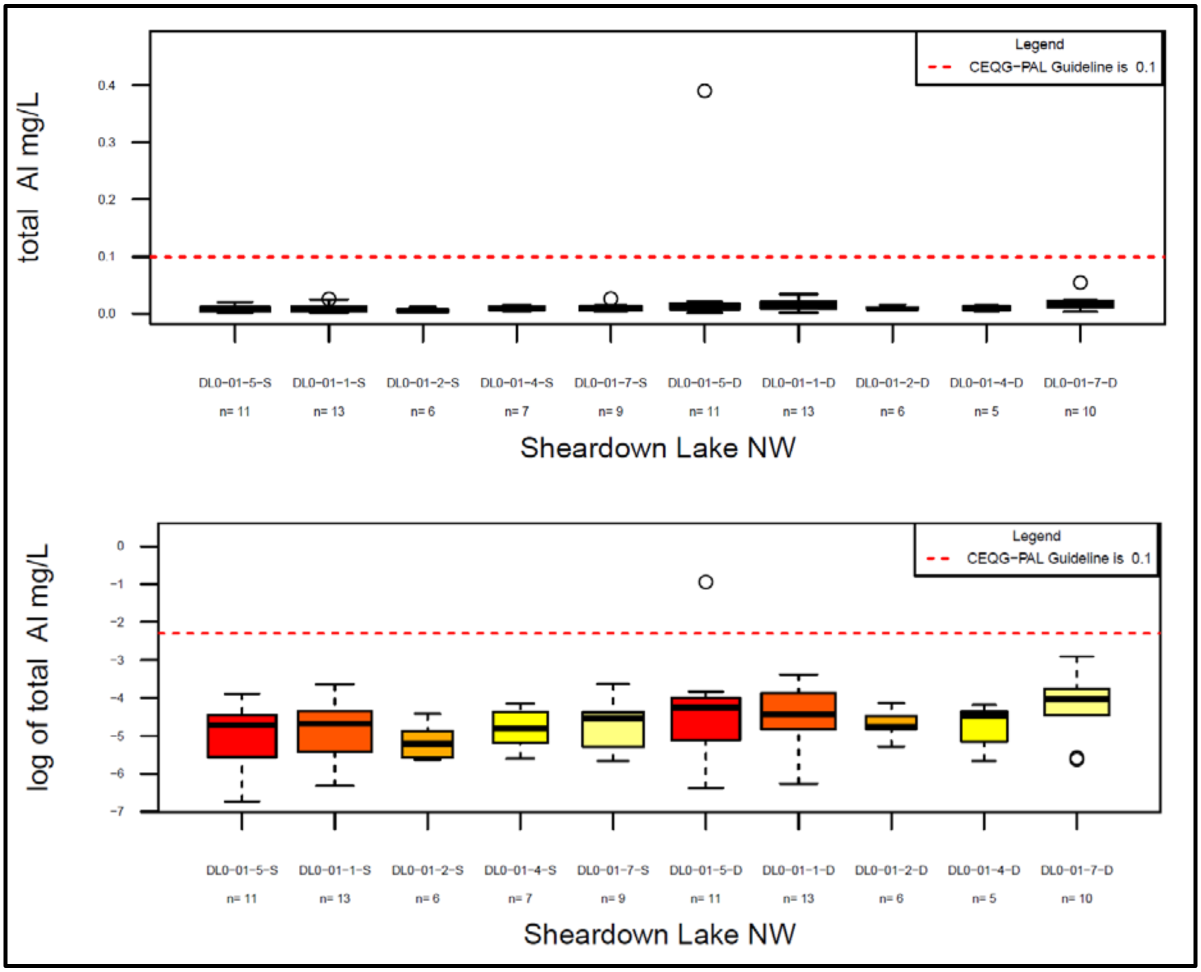
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.25 Sheardown Lake NW – Nitrate Concentrations in Water

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. All metals are discussed as total concentrations to match the relevant applicable guidelines.

Total Aluminum (Figures B.26 and B.27)

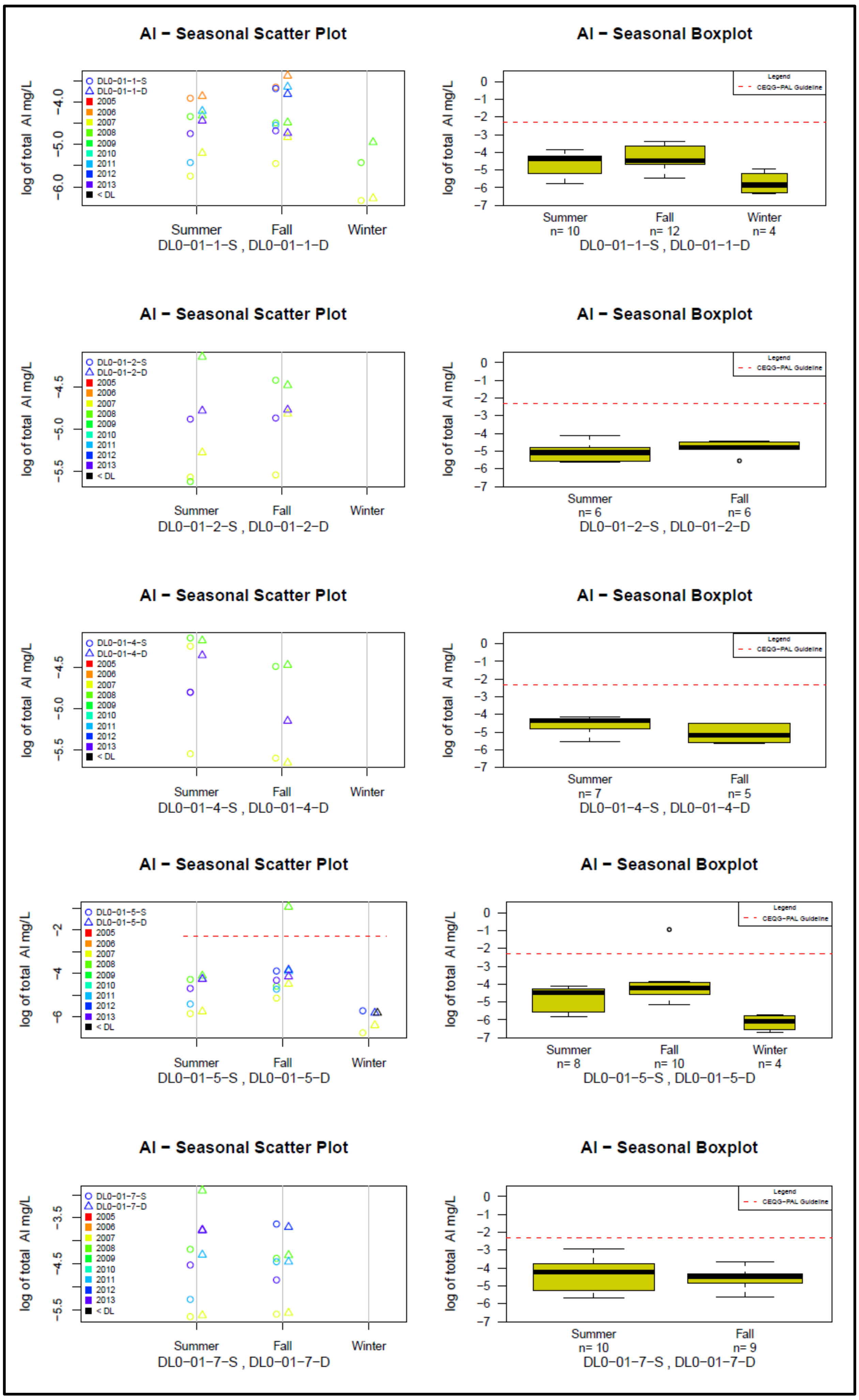
Ninety-one (91) total aluminum concentration samples were collected from Sheardown Lake NW over the course of eight years. Total aluminum concentrations consistently report above MDLs, and are consistently below the CWQG-PAL guideline, with the exception of one sample (Figure B.26). All stations within Sheardown Lake have similar median aluminum concentrations that are less than 0.05 mg/L. Deeper sampling stations show slightly elevated concentrations when compared to shallow stations. Comparison of raw data and log values reveals fewer outliers within the log transformed data, as expected. Seasonal scatterplots indicate that summer and fall concentrations of aluminum remain fairly elevated, while winter concentrations are reduced in comparison (Figure B.27).



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.26 Sheardown Lake NW – Total Aluminum Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.27 Sheardown Lake NW – Variability of Total Aluminum in Water

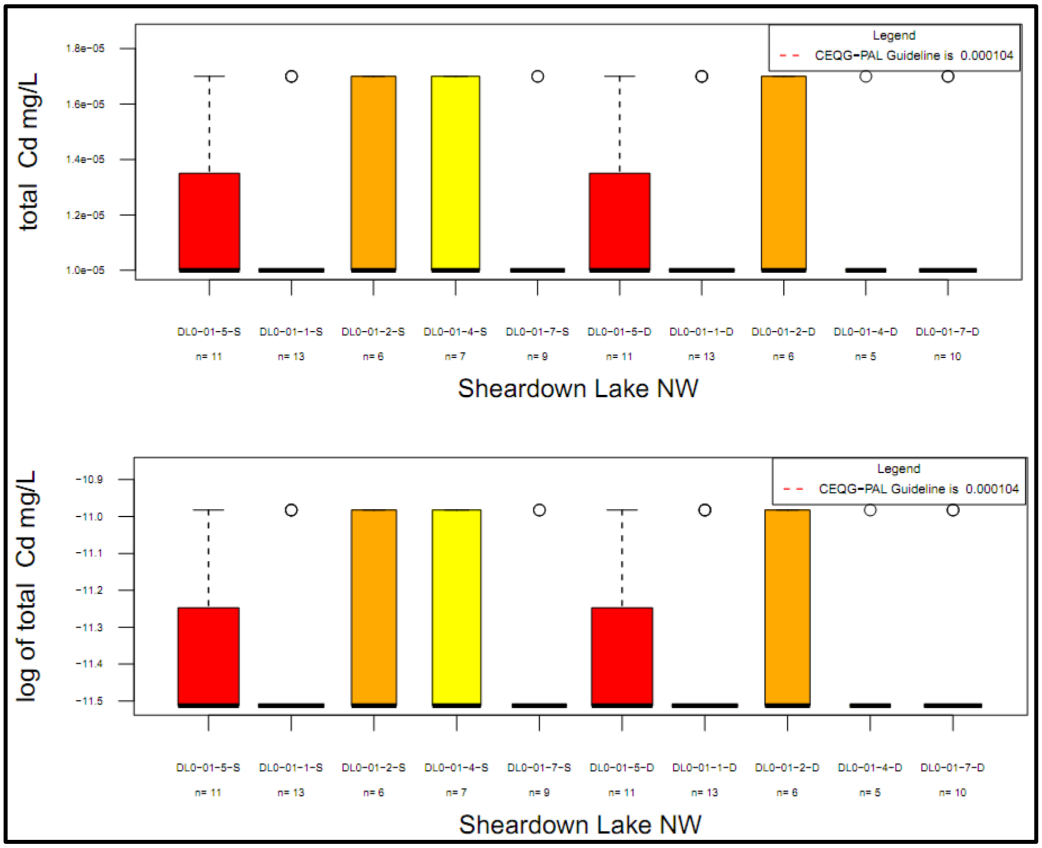
Total Arsenic

All (ninety-one) measured total arsenic levels report at detection limit and are therefore not not portrayed via graphical representation. The detection limit (0.00010 mg/L) is far below the CWQG-PAL guideline limit (0.005 mg/L).

Total Cadmium (Figures B.28 and B.29)

Ninety-one (91) total cadmium concentration samples were collected from Sheardown Lake over the course of eight years. Cadmium concentrations consistently report at or below MDLs, and are consistently below the CWQG-PAL guideline (Figure B.28). Although total boxplots of all data seem to indicate a range of values at each sampling point, this is as a result of two different detection limits. Seasonal scatterplots reveal that earlier data from 2007 had a detection limit of 0.000017 mg/L and later data from 2009 onwards had a detection limit of 0.00001 mg/L.

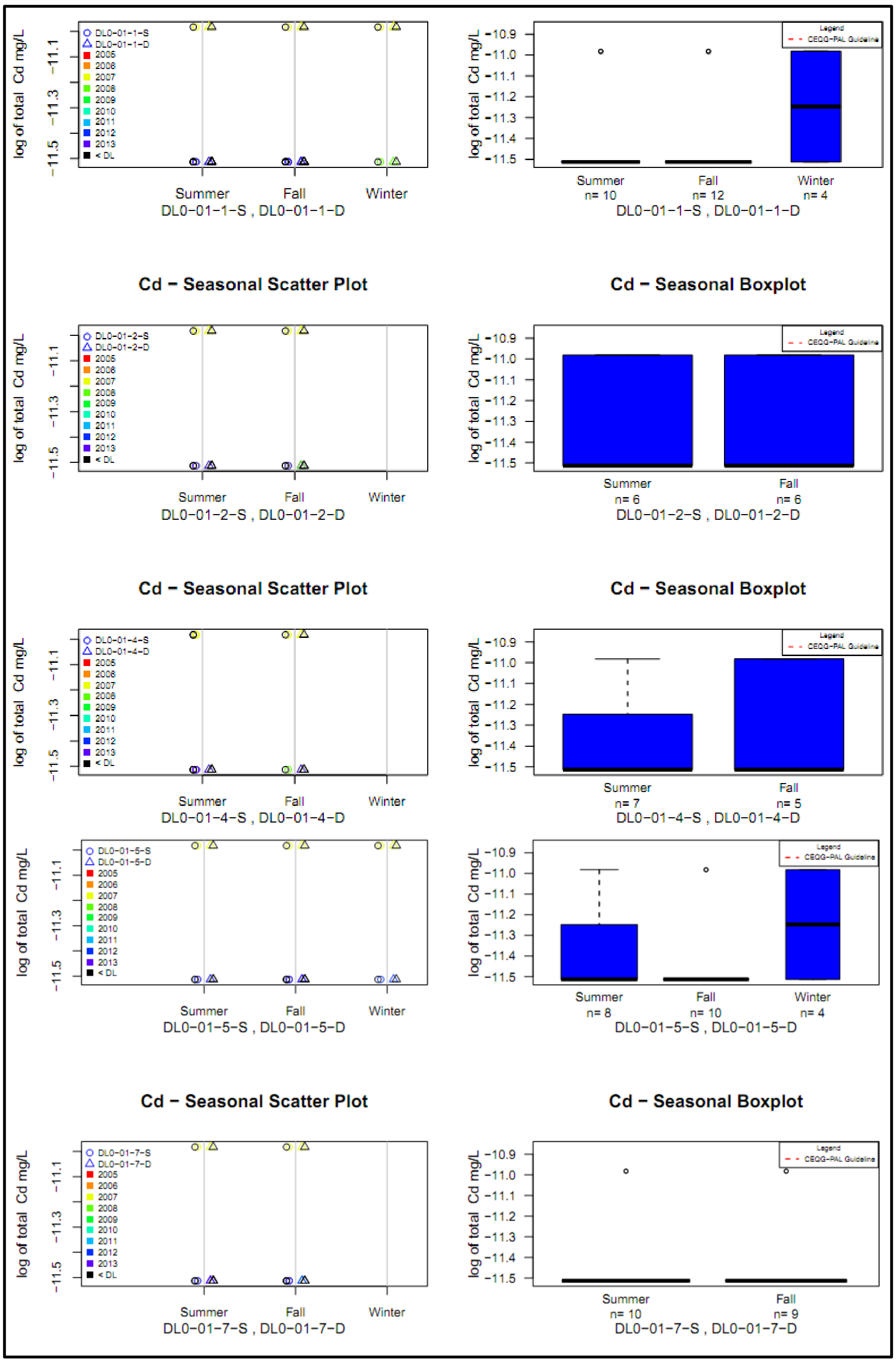
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations, as a result of MDL interference (Figure B.29). Similarly, seasonal differences are not noted as a result of MDL interference.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.28 Sheardown Lake NW – Total Cadmium Concentrations in Water



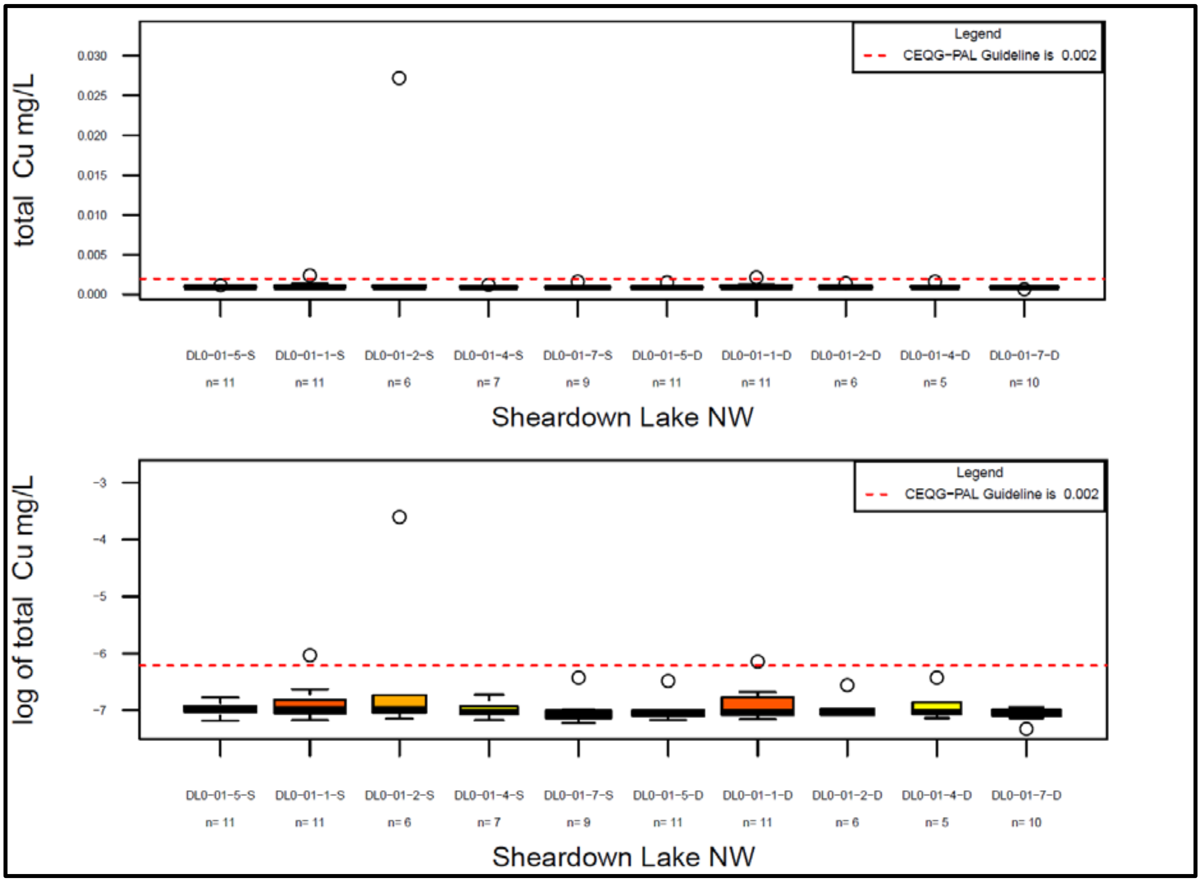
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.29 Sheardown Lake NW – Variability of Total Cadmium in Water

Total Copper (Figures B.30 and B.31)

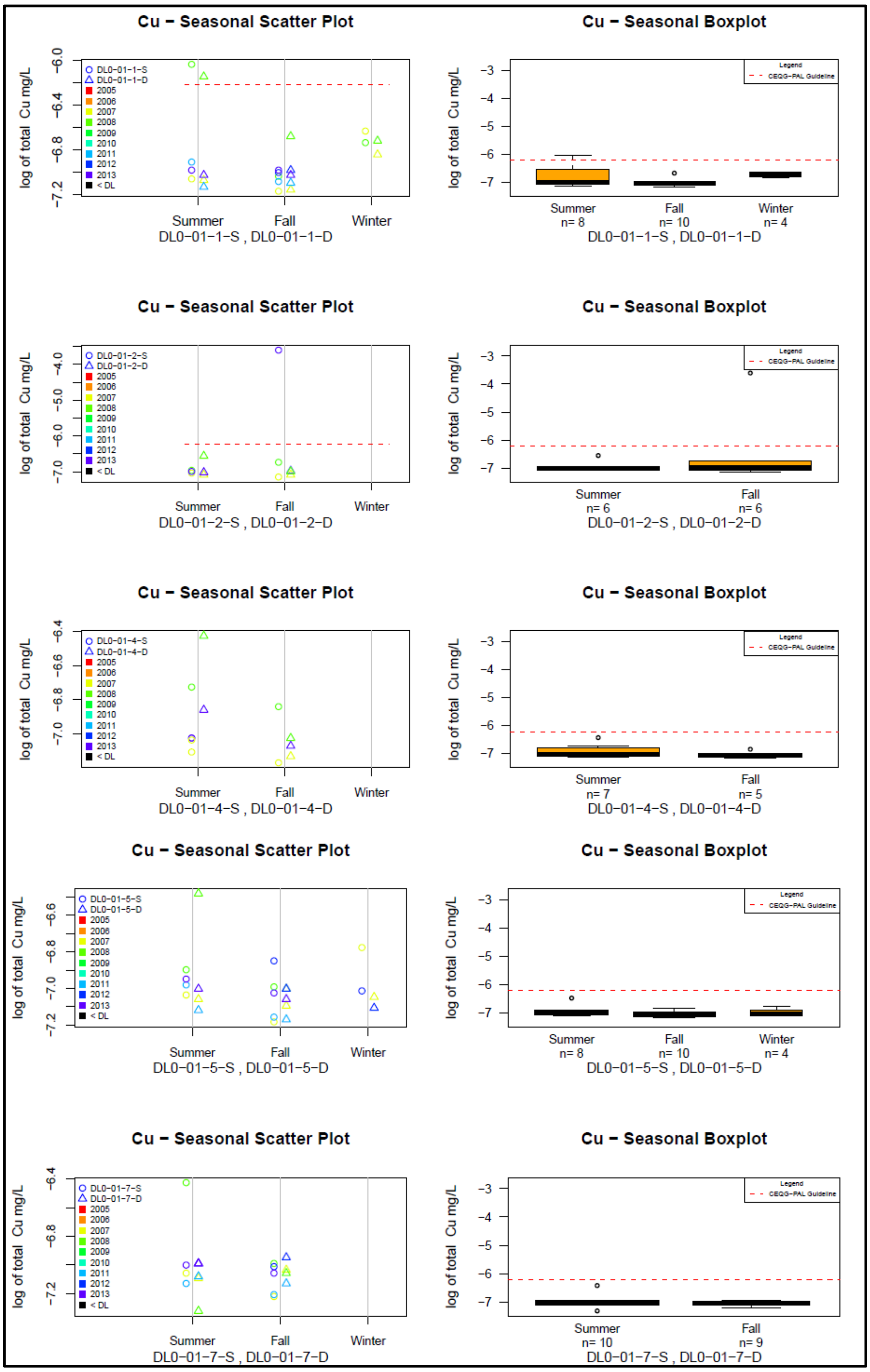
Eighty-seven (87) total copper concentration samples were collected from Sheardown Lake NW over the course of eight years. Total copper concentrations are slightly elevated, but usually below the CWQG-PAL guideline (Figure B.30). Seasonal scatterplots that combine data from deep and shallow sampling stations show little difference in values between the two stations (Figure B.31). No distinct seasonal differences are observed.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.30 Sheardown Lake NW – Total Copper Concentrations in Water



NOTES:

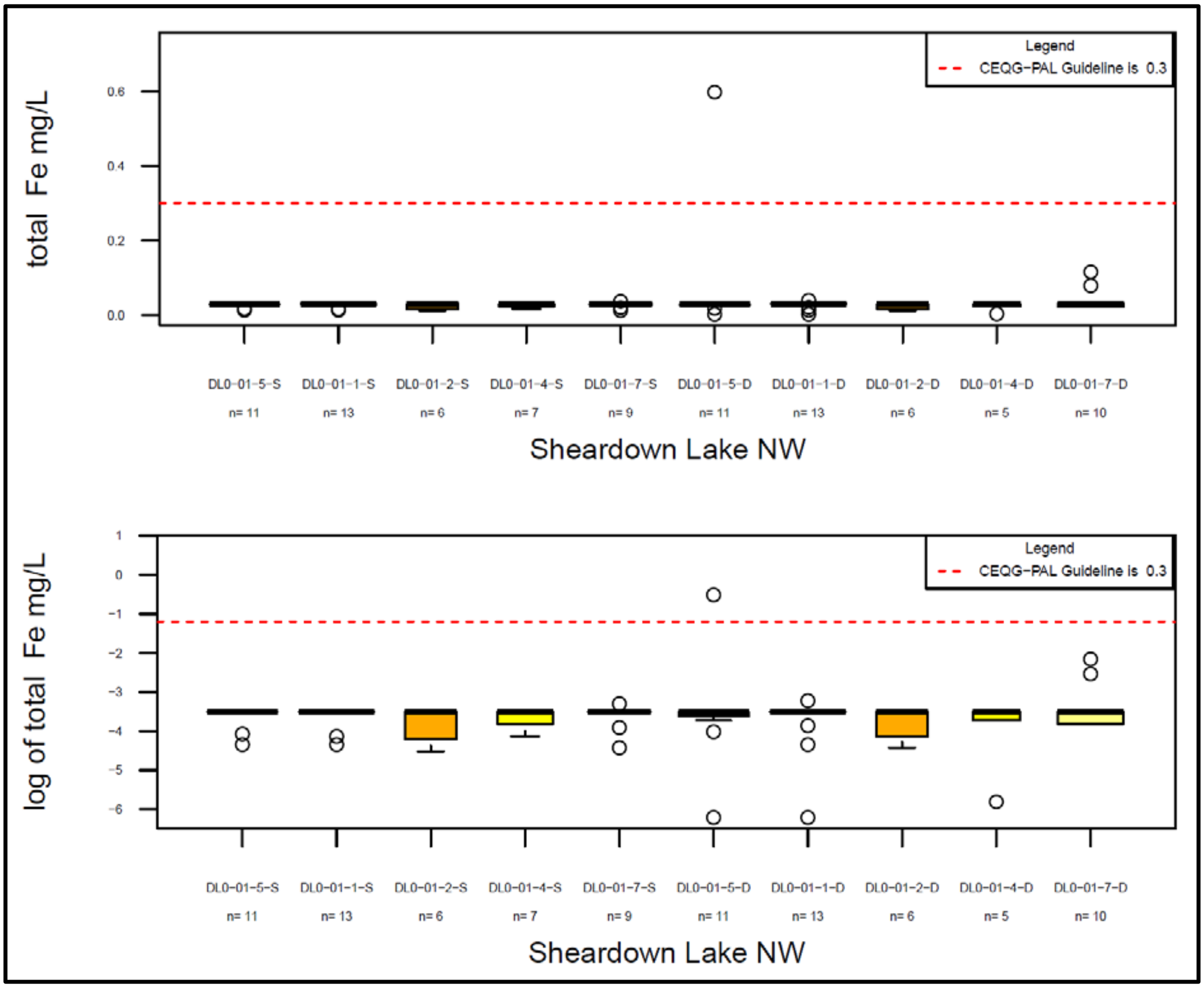
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.31 Sheardown Lake NW – Variability of Total Copper in Water

Total Iron (Figures B.32 and B.33)

Ninety-one (91) total iron concentration samples were collected from Sheardown Lake NW over the course of eight years. Total iron concentrations consistently report at or below MDLs, with the exception of one outlier (Figure B.32). Only one outlying data point, from DL0-01-5-D, reports above the CWQG-PAL guideline (0.002 mg/L). Seasonal scatterplots indicate samples prior to 2010 reported at or below the MDL. During 2013, detection limits were lowered and total iron concentrations consistently occurred below the 2010 MDL.

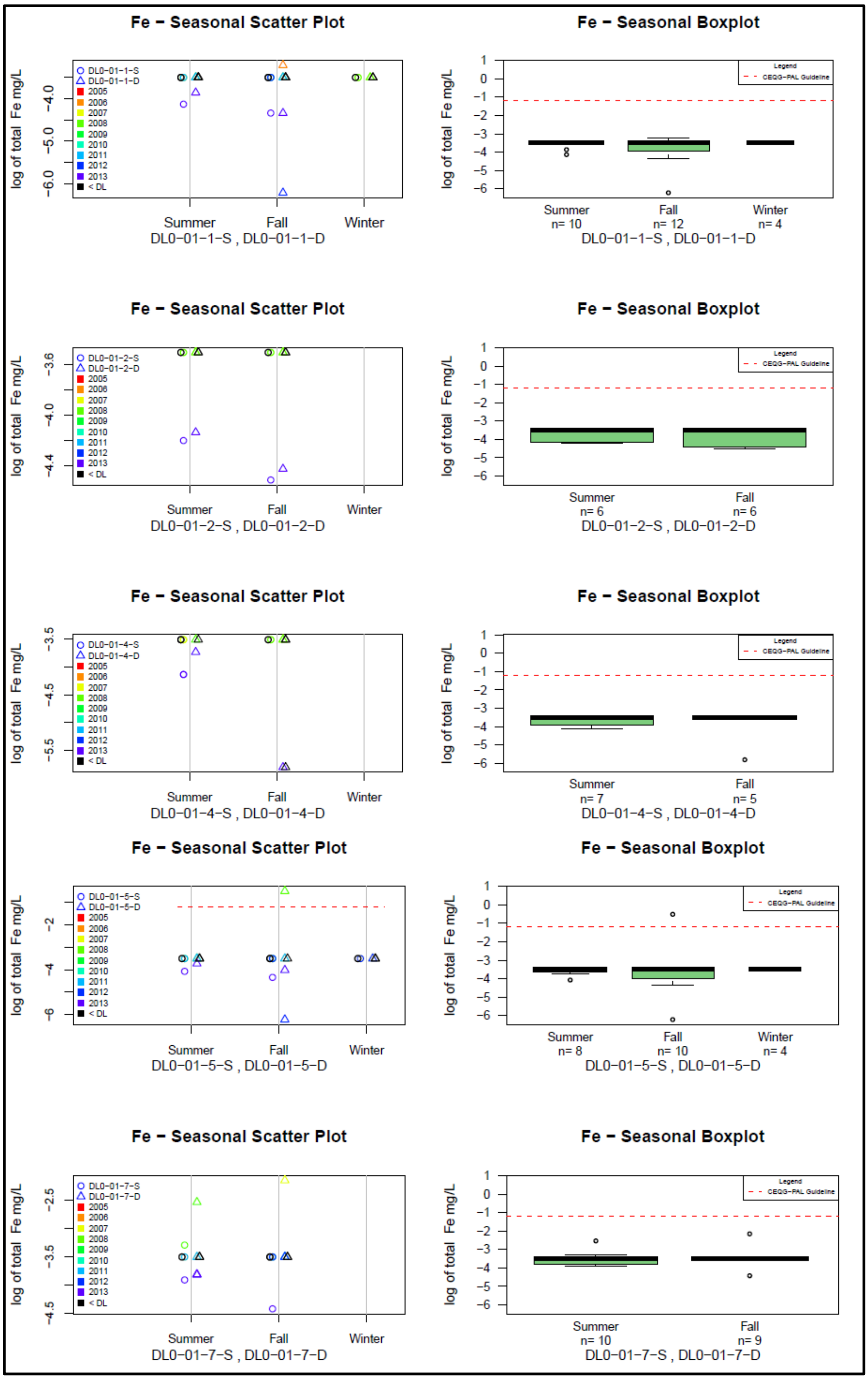
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations (Figure B.33). Seasonal differences are not noted as a result of MDL interference.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.32 Sheardown Lake NW – Total Iron Concentrations in Water



NOTES:

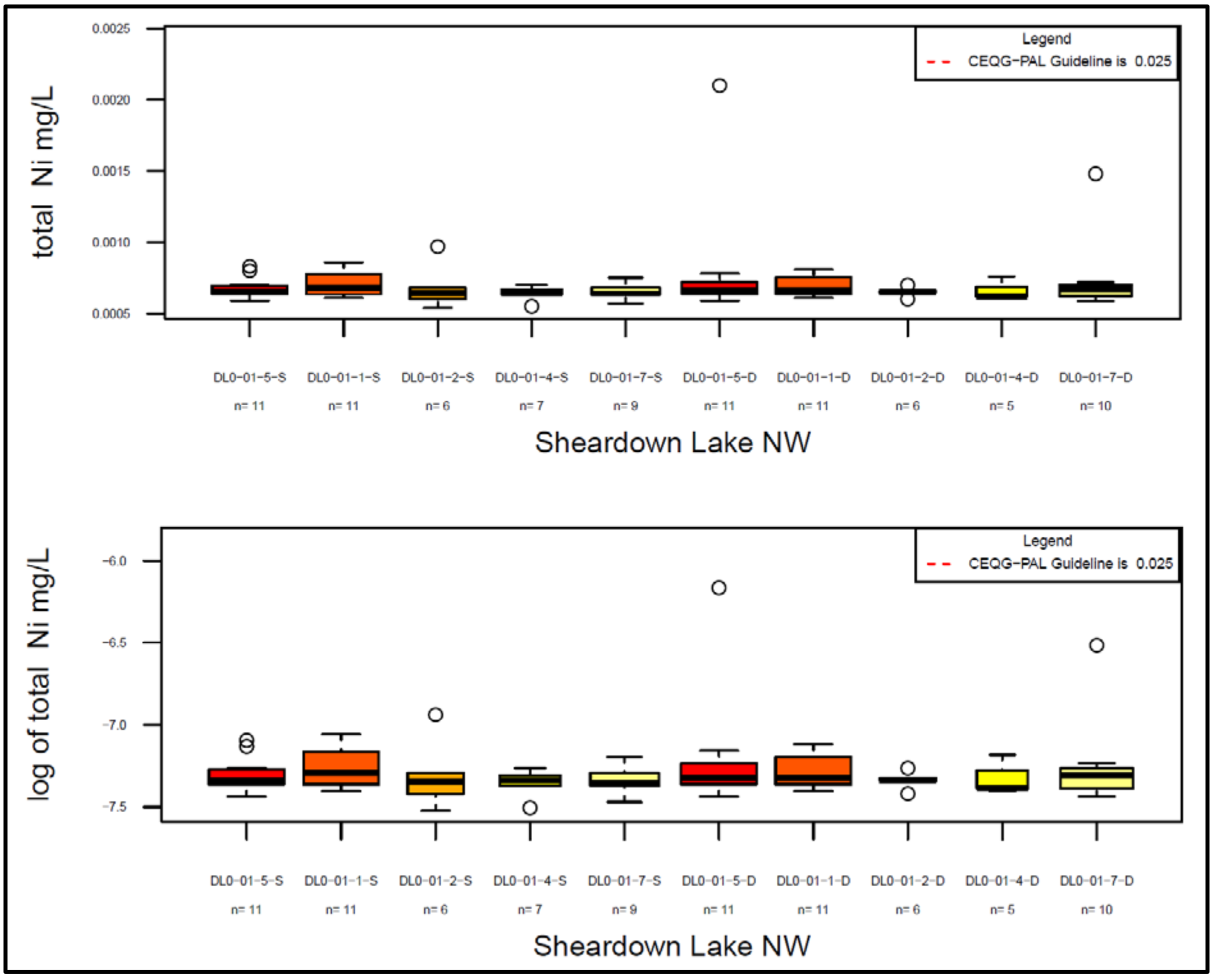
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.33 Sheardown Lake NW – Variability of Total Iron in Water

Total Nickel (Figures B.34 and B.35)

Eighty-seven (87) total nickel concentration samples were collected from Sheardown Lake NW over the course of eight years. Nickel concentrations consistently report above MDLs, but below the CWQG-PAL guideline (0.025 mg/L) (Figure B.34). Median total nickel concentrations are consistent throughout the geographically distinct sampling stations, and occur around 0.0007 mg/L; however, certain stations have a greater distribution of values. DL0-01-1-S and DL0-01-1-D show the greatest range of values, but also have the largest sample size.

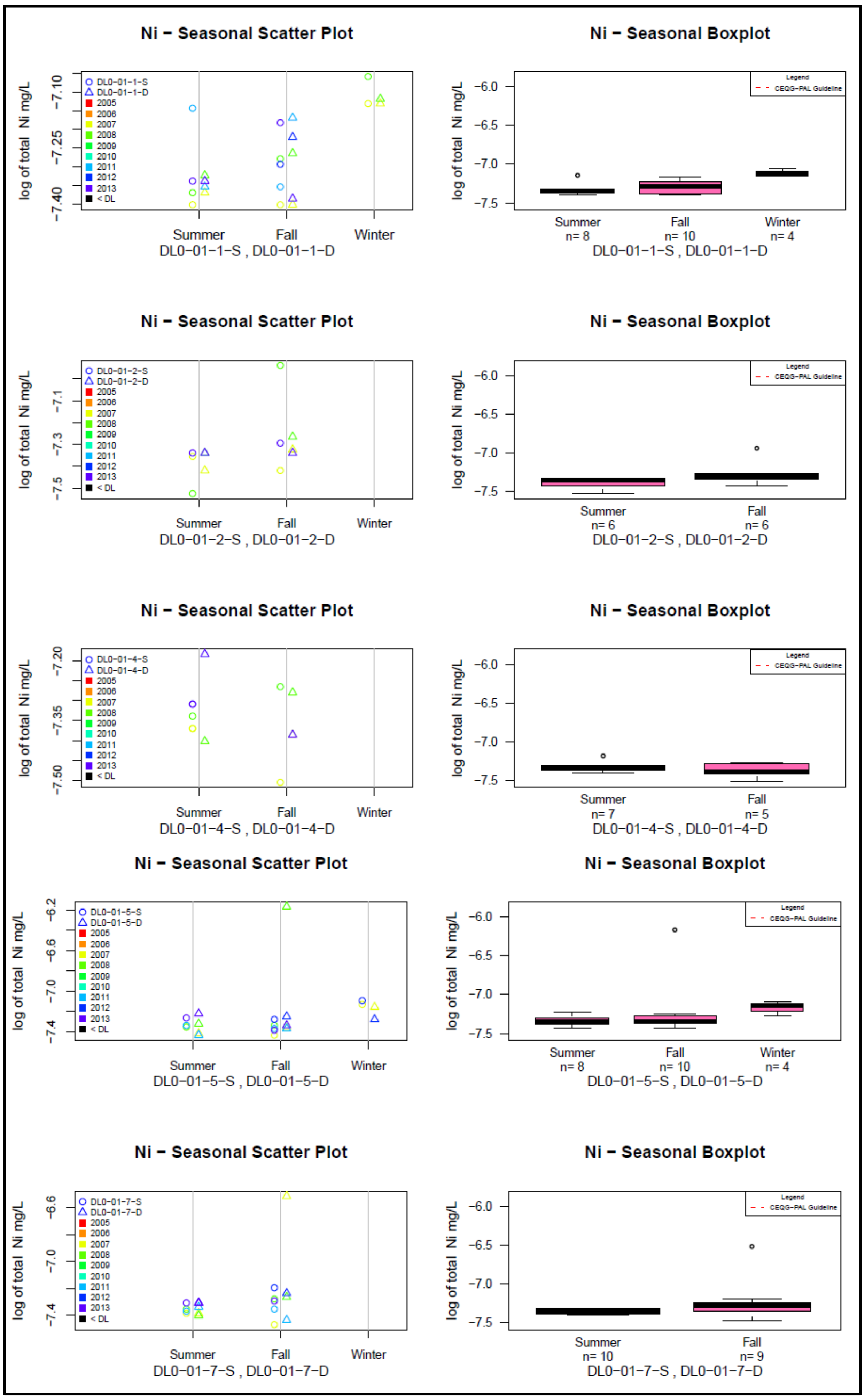
Seasonal scatterplots show that outlying data points tend to originate from sampling in 2008/2009 (Figure B.35). Seasonal boxplots show that the winter dataset for Sheardown lake nickel samples is limited. Historical summer and fall data have similar median values. The limited data collected for winter indicates winter samples have slightly higher concentrations; however, additional sampling is required to determine if this is a true trend.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.34 Sheardown Lake NW – Total Nickel Concentrations in Water



NOTES:

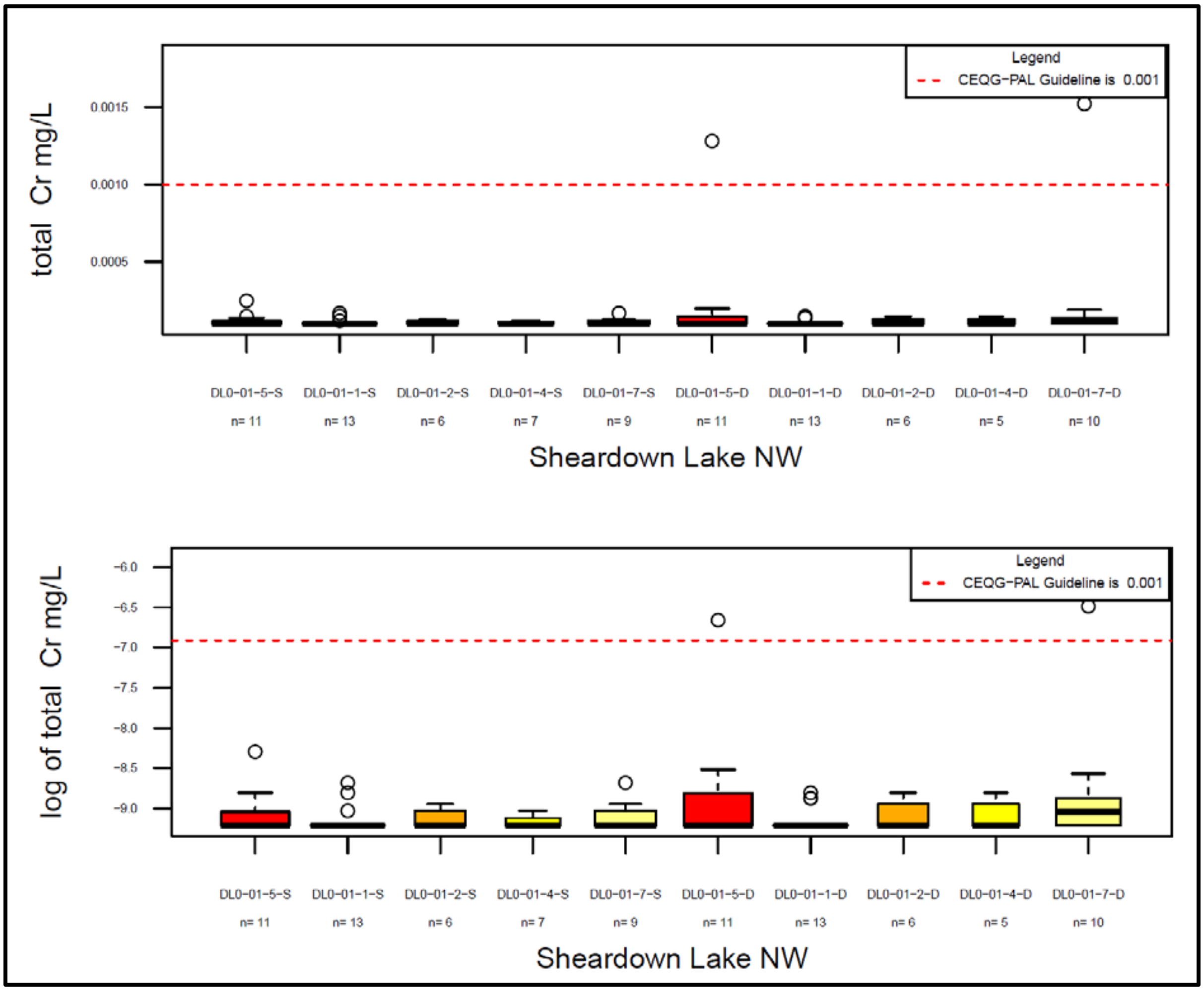
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.35 Sheardown Lake NW – Variability of Total Nickel in Water

Total Chromium (Figure B.36 and Figure B.37)

Ninety-one (91) total chromium concentration samples were collected from Sheardown Lake NW over the course of eight years. Chromium concentrations are low, with the exception of one outlier sampled at DL0-05-D (Figure B.36). Deep sites showed slightly elevated concentrations when compared with shallow samples.

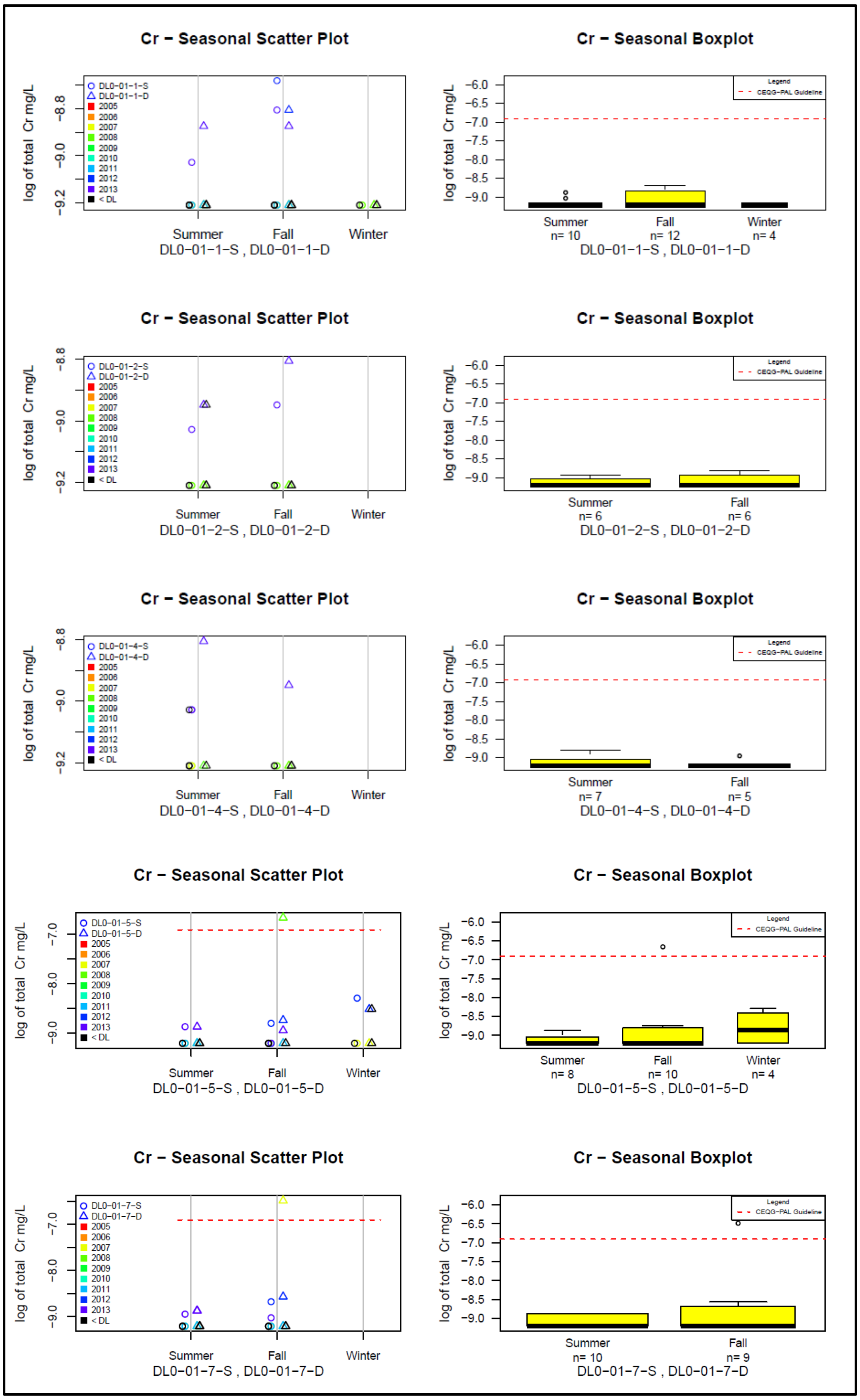
Seasonal scatterplots show 2012 and 2013 data is generally elevated when compared to older data (Figure B.37). Seasonal boxplots do not show a consistent seasonal trend.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.36 Sheardown Lake NW – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.37 Sheardown Lake NW – Variability of Total Chromium in Water

Summary of Sheardown Lake NW Water Quality

Summary of trends observed during review of Sheardown Lake NW baseline data:

- Deeper sampling stations show slightly elevated concentrations of aluminum. Distinct depth trends are not observed for other parameters within Sheardown Lake, which suggests that lake is completely mixed throughout the year, despite winter ice. As a result, aggregation of deep and shallow stations is appropriate for all parameters except aluminum.
- Detection limits decreased over the course of sampling and their decrease is particularly apparent in the copper and iron concentration data.
- Little variability was observed between geographically distinct sampling stations.
- Parameters below MDLs and/or do not show any seasonal trends: arsenic, cadmium, chloride, chromium, copper, nitrate and iron.
- Parameters with highest concentration occurring in the fall: aluminum.
- Parameters with highest concentrations occurring in the winter: nickel. The majority of the elevated nickel and copper total concentrations are as a result of dissolved metals.

B.2.2.2 Sheardown Lake SE

A total of forty-six (46) lake samples were collected from the southeast basin of Sheardown Lake from 8 sampling stations over the sampling period (Figures B.1 and B.2):

- DL0-02-1-S and DL0-02-1-D - Shallow and deep; located in west portion of Sheardown Lake SE.
- DL0-02-3-S and DL0-02-3-D - Shallow and deep; located in the centre of Sheardown Lake SE.
- DL0-02-4-S and DL0-02-4-D - Shallow and deep; located on the eastern lobe of Sheardown Lake SE.
- DL0-02-6-S and DL0-02-6-D - Shallow and deep; located in the most westerly portion of Sheardown Lake SE.

Most sampling was completed during the open water season, from July through September (summer and fall). Late winter sampling (May) was carried out only in 2007, 2008, 2012 and 2013. Six stations are reported in detail. Only one sample was taken at DL0-06-S and DL0-02-6-D, and therefore, these sites are excluded from graphical representation.

A summary of the data collected during each season, with respect to year and site are included in Table B.3. A graphical representation of the sampling events within Sheardown Lake for the six stations reported in detail is provided in Figure B.38.

Table B.3 Sheardown Lake SE Sample Size

Year	Summer	Fall	Winter
2006	1	1	0
2007	6	6	4
2008	8	6	2
2011	2	0	0
2012	0	2	2
2013	2	2	2
Site	**Summer**	**Fall**	**Winter**
DL0-02-1-S	3	2	1
DL0-02-1-D	5	3	1
DL0-02-3-S	3	4	3
DL0-02-3-D	3	4	3
DL0-02-4-S	3	2	0
DL0-02-4-D	2	2	0
DL0-02-6-S	0	0	1
DL0-02-6-D	0	0	1

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30TH.
2. LAKE SAMPLING DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE.
3. DURING WINTER 2013, SAMPLES WERE COLLECTED WITHIN SHEARDOWN LAKE AT D-LAKE-05.

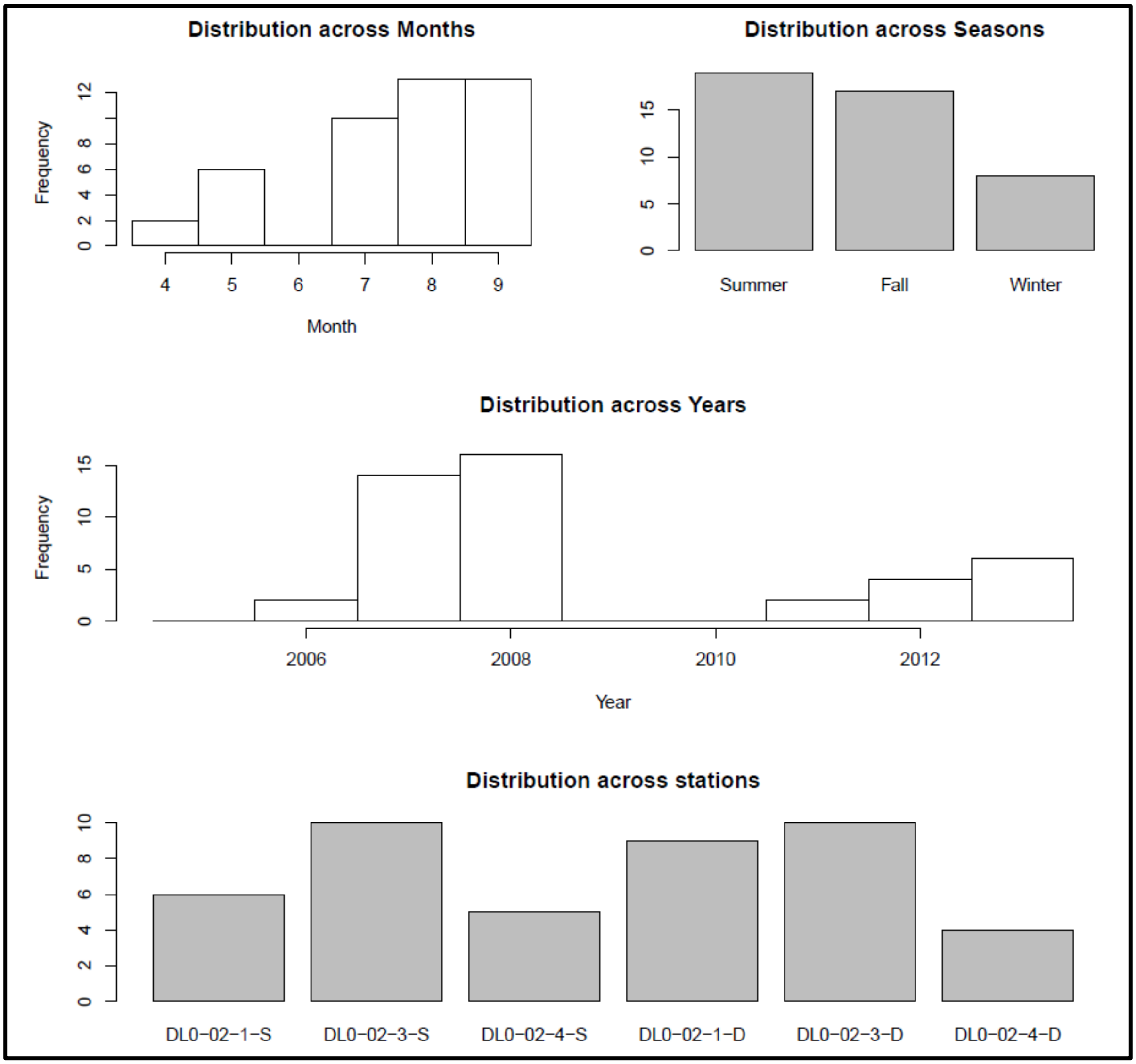


Figure B.38 Sheardown Lake SE – Graphical Summary of Sampling Events

The following summarizes the data review observations for Sheardown Lake NW.

pH (Figure B.39)

- Sheardown Lake NW is slightly alkaline with a median in-situ pH of 7.57 (range from 6.41 to 8.32).
- A slight influence of depth on pH is observed with a measured median in-situ pH at the deep stations of ~7.5, slightly lower compared to shallow samples (> 7.9).

Alkalinity (Figure B.39)

- Sheardown Lake sites are fairly uniform with median alkalinity values that range from 53 to 57 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.

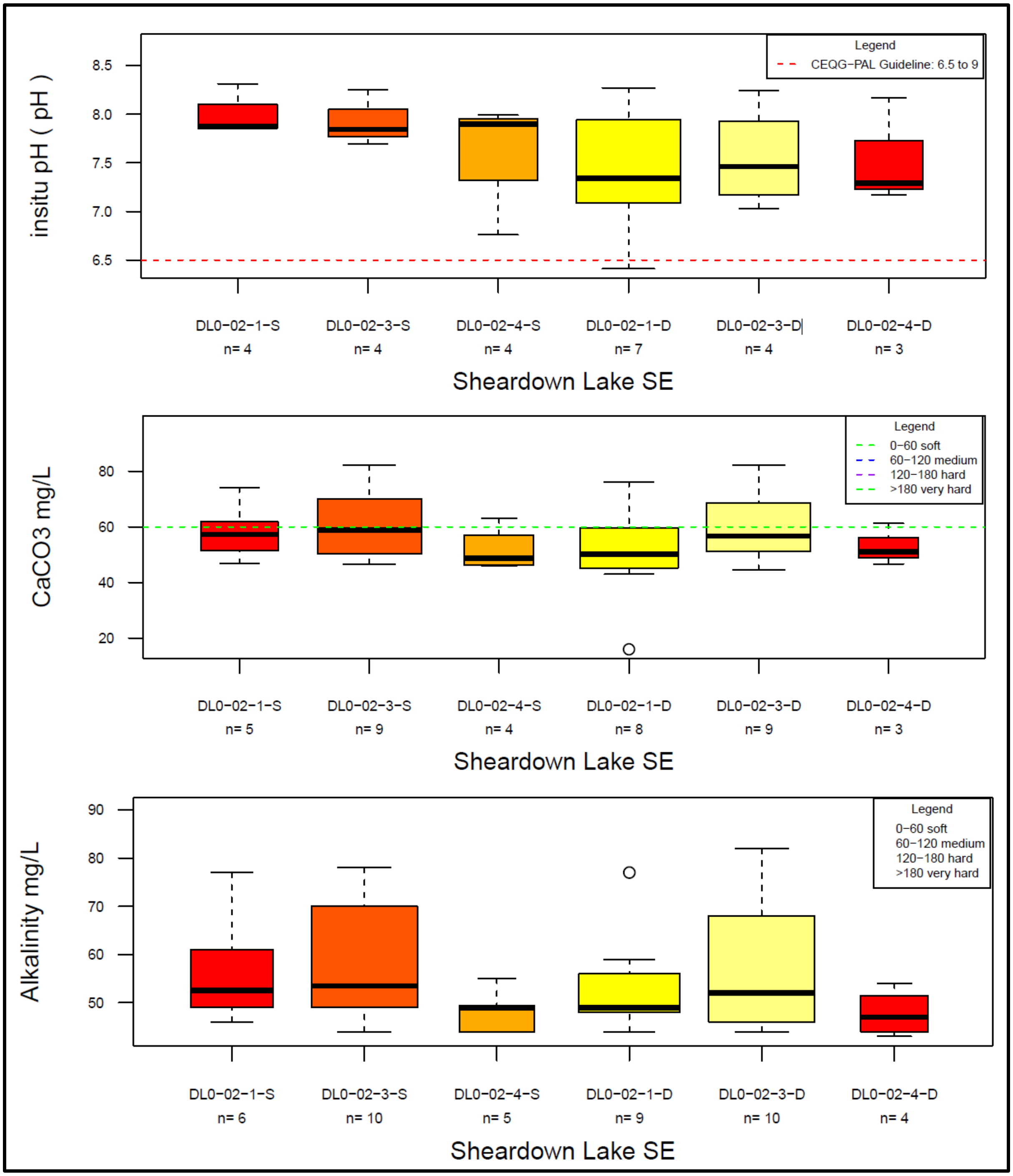


Figure B.39 Sheardown Lake SE – *In situ* pH, Alkalinity and Hardness

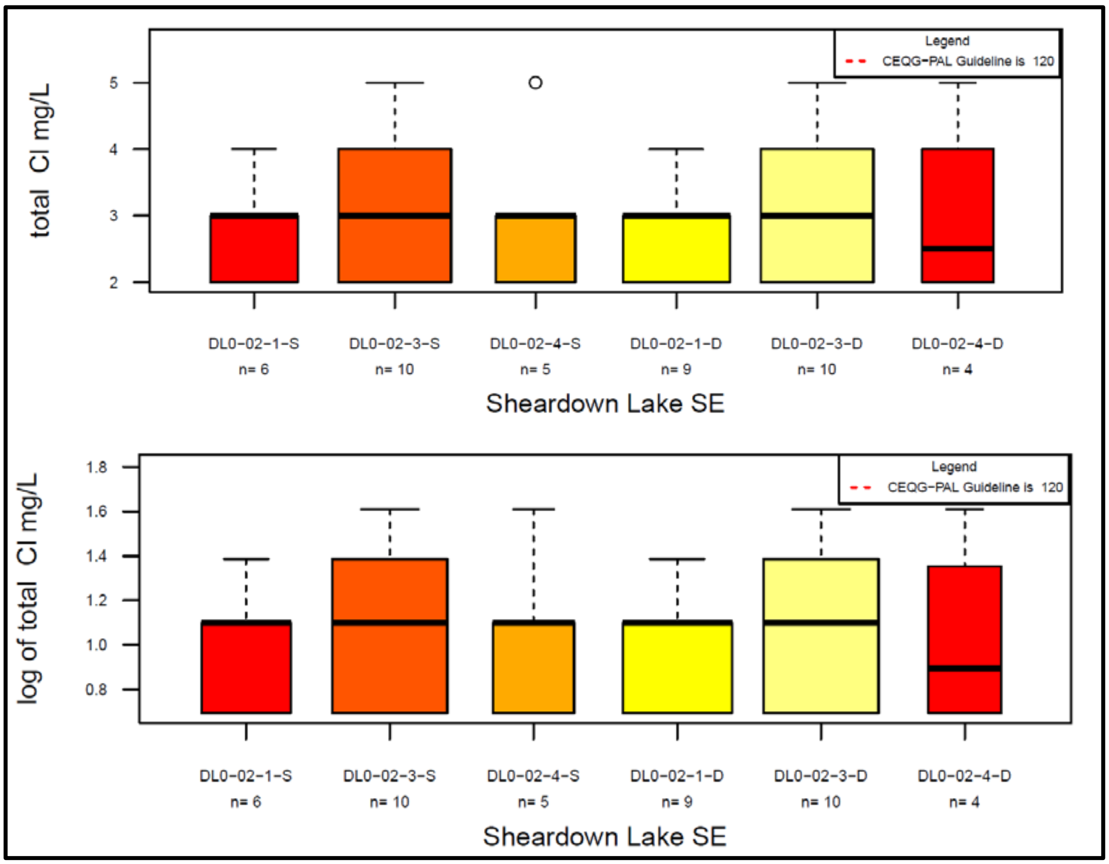
Hardness (Figure B.39)

- Median hardness ranged from 54 and 61 mg/L, classifying the lake water as "soft".
- Hardness did not change meaningfully with depth, and portrayed trends very similar to alkalinity.
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures B.40 and B.41)

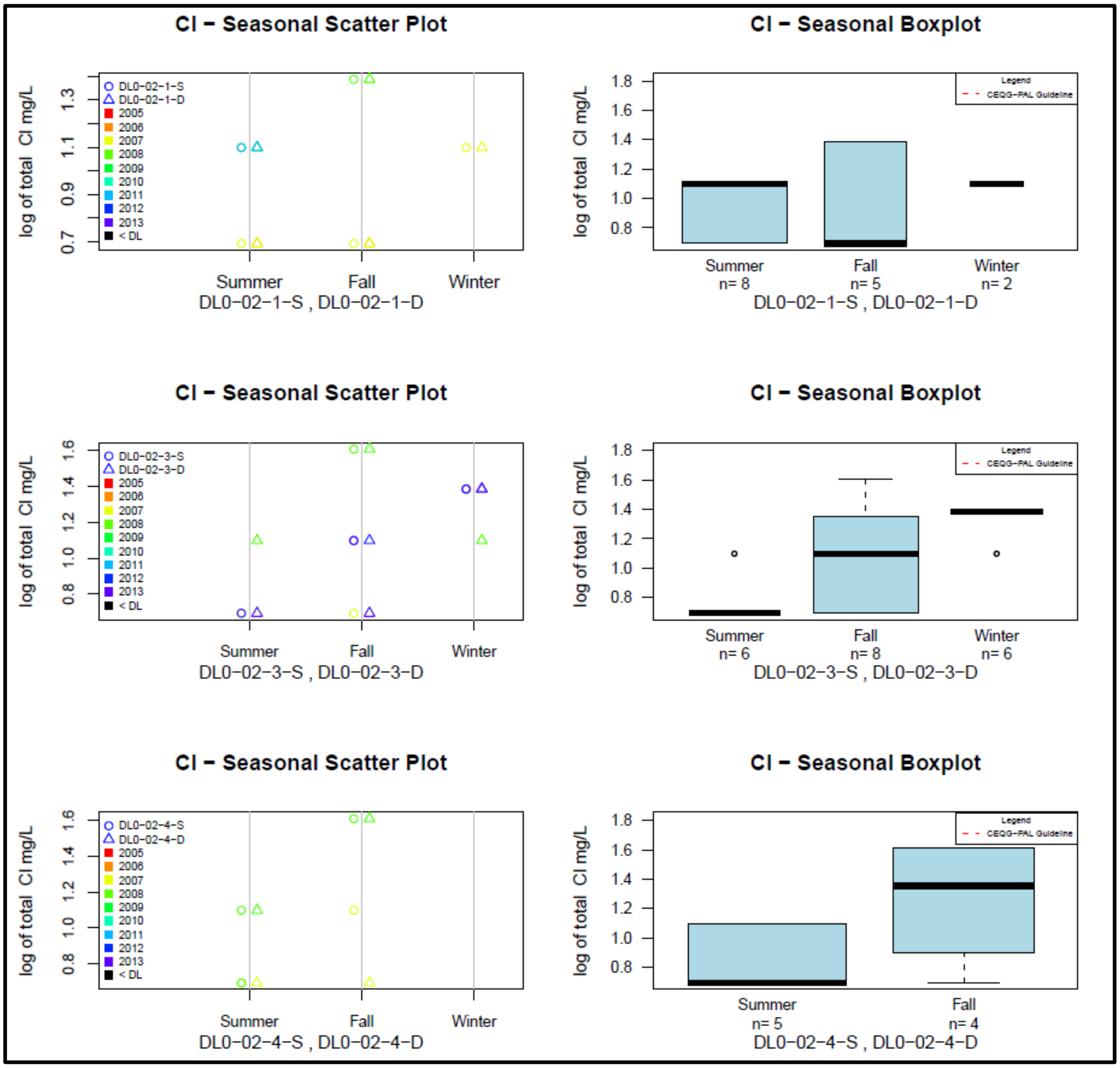
Forty-four (44) chloride concentration samples were collected at Sheardown Lake SE. Chloride concentrations in Sheardown Lake SE are very low and have maximum values of 5 mg/L, well below the CWQG-PAL limit of 120 mg/L (Figure B.40). All sites within Sheardown Lake SE have very similar median chloride concentrations that range between 0.9 mg/L to 1.1 mg/L. Log transformation does not reveal any outlying values in the data. Seasonal scatterplots indicate possible elevations of chloride concentrations in the winter. Additional baseline sampling will help to reveal this trend.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.40 Sheardown Lake SE – Chloride Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.41 Sheardown Lake SE – Variability of Chloride in Water

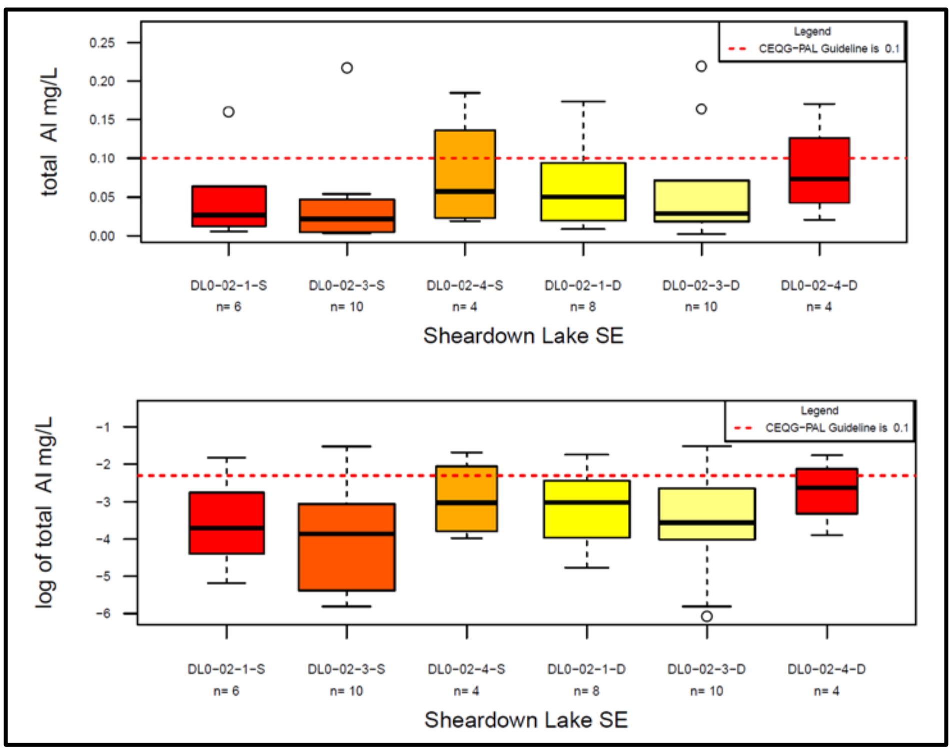
Nitrate

Forty-four (44) nitrate concentration samples were collected from Sheardown Lake SE over the course of eight years. All nitrate concentrations were measured at the detection limit (0.10 mg/L). As a result, no seasonal, inter-annual or depth variation can be determined and further graphical analyses are not warranted.

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. All metals are discussed as total concentrations to reflect the applicable guidelines.

Total Aluminum (Figures B.42 and B.43)

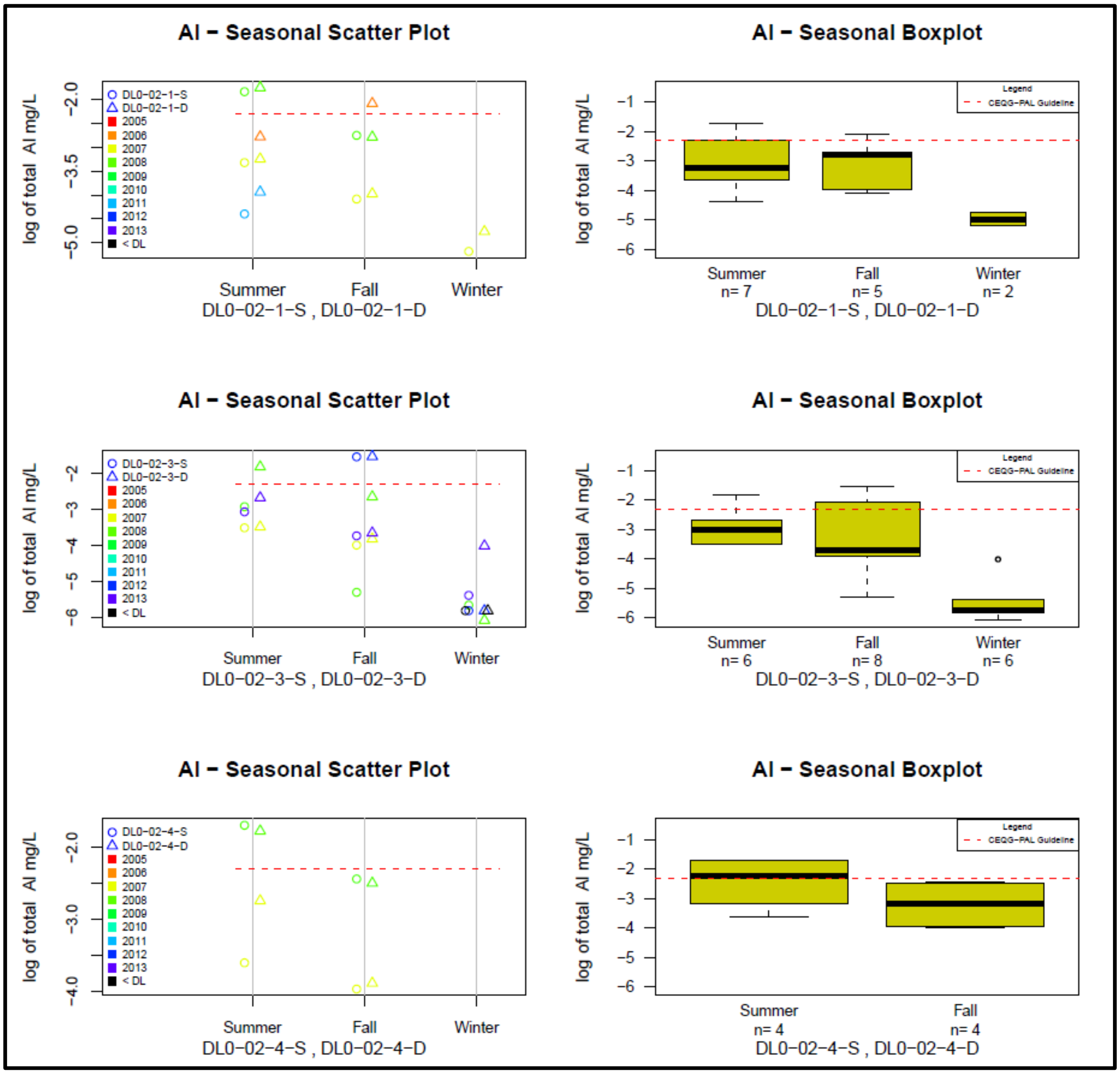
Forty-two (42) total aluminum concentration samples were collected from Sheardown Lake SE over the course of eight years. Total aluminum concentrations consistently report above MDLs and have 75th percentile values that exceed the CWQG-PAL guidelines of 0.1 mg/L (Figure B.42). All stations within Sheardown Lake have median aluminum concentrations that range from 0.02 mg/L to 0.06 mg/L. Deeper sampling stations show slightly elevated concentrations when compared to shallow stations. Comparison of raw data and log values reveals fewer outliers within the log transformed data, as expected. Similar to Sheardown NW, Sheardown SE data shows summer and fall concentrations of aluminum remain fairly elevated, while winter concentrations are reduced in comparison (Figure B.43).



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.42 Sheardown Lake SE – Total Aluminum Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.43 Sheardown Lake SE – Variability of Total Aluminum in Water

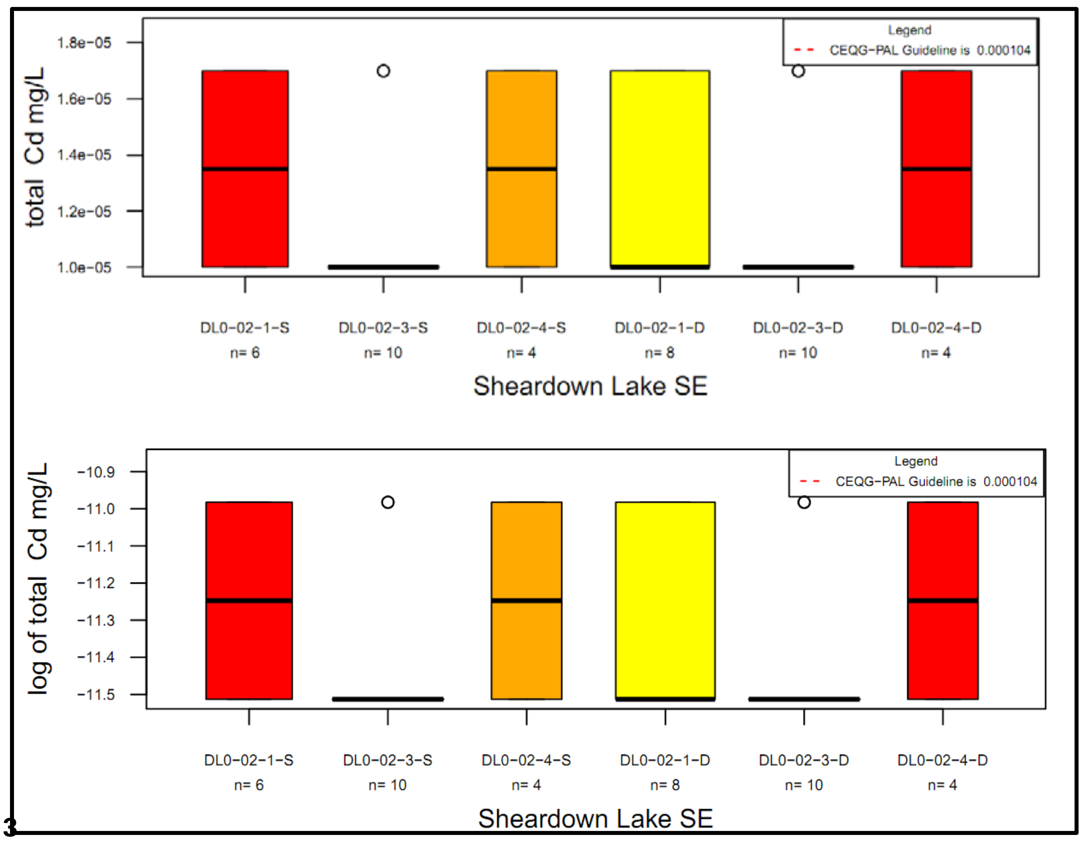
Total Arsenic

With the exception of one sample, the remaing (forty-one) measured total arsenic levels report at detection limit and are therefore not not portrayed via graphical representation. The detection limit (0.00010 mg/L) and the one outlying value (0.00011 mg/L) are far below the CWQG-PAL guideline limit (0.005 mg/L).

Total Cadmium (Figures B.44 and B.45)

Forty-two (42) total cadmium concentration samples were collected from six sites in Sheardown Lake SE over the course of eight years. Cadmium concentrations consistently report at or below MDLs, and are consistently below the CWQG-PAL guideline (Figure B.44). Although total boxplots of all data seem to indicate a range of values at each sampling point, this is as a result of two different detection limits. Seasonal scatterplots reveal that earlier data from 2007 had a detection limit of 0.000017 mg/L and later data from 2009 onwards had a detection limit of 0.00001 mg/L.

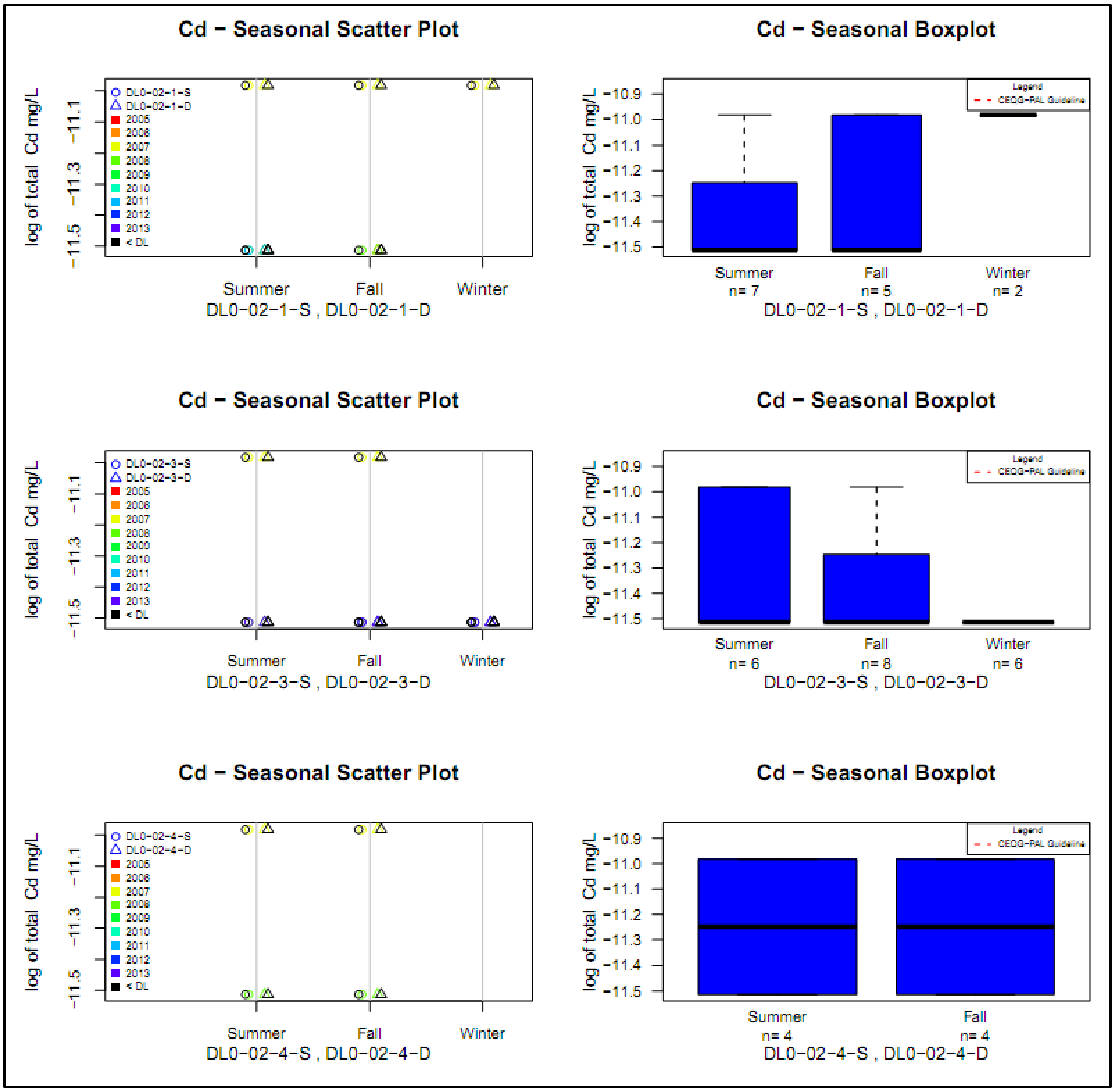
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations, as a result of MDL interference (Figure B.45). Similarly, seasonal differences are not noted as a result of MDL interference.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.44 Sheardown Lake SE – Total Cadmium Concentrations in Water



NOTES:

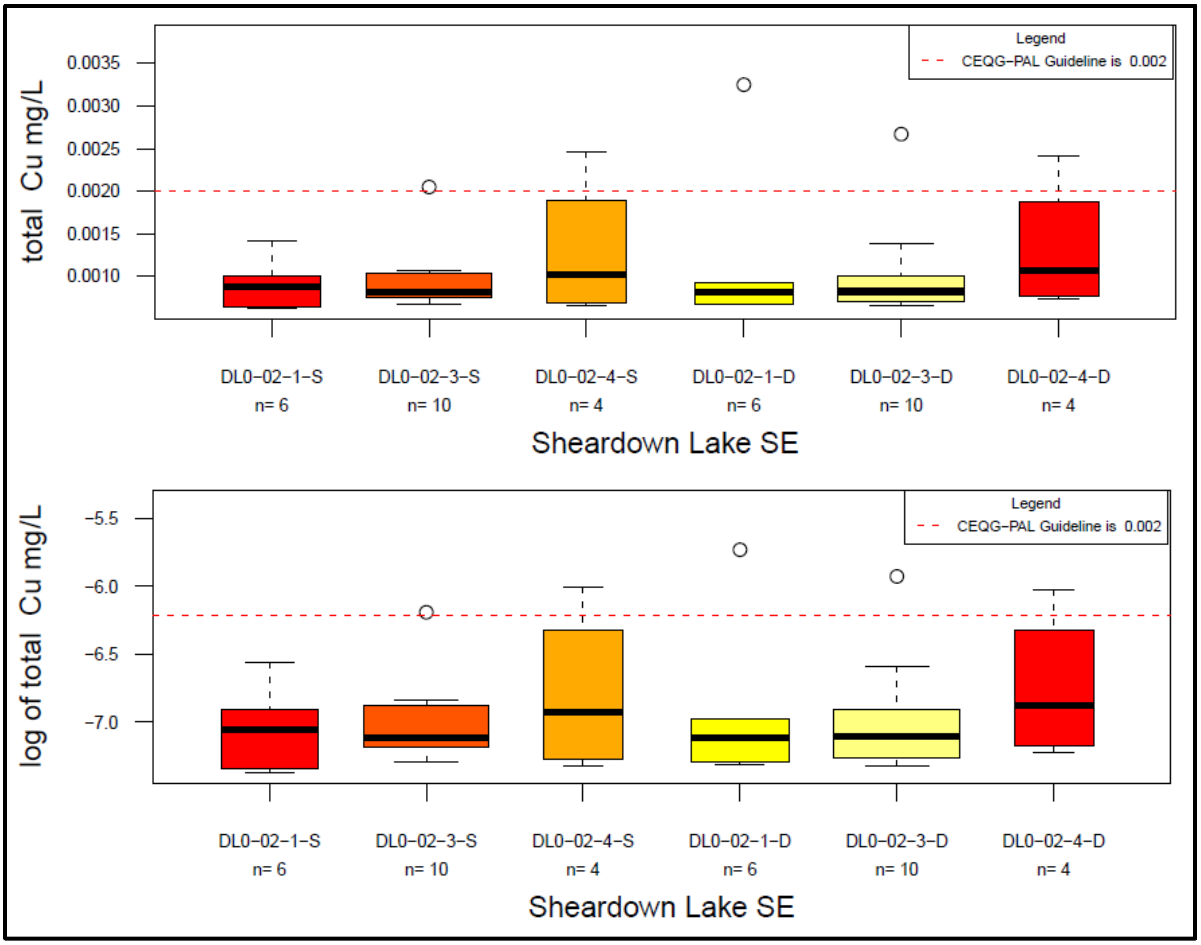
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.45 Sheardown Lake SE – Variability of Total Cadmium in Water

Total Copper (Figures B.46 and B.47)

Forty (40) total copper concentration samples were collected from six stations in Sheardown Lake SE over the course of eight years. Total copper concentrations consistently report above MDLs, and, with the exception of a few outliers, below the CWQG-PAL guideline (Figure B.46). Outliers at two deep and one shallow station just exceed the CWQG-PAL guideline of 0.002 mg/L, with a maximum outlying value of 0.0032 mg/L. Concentrations at DL0-02-4 are elevated compared to the other sites, which indicates inputs from D-Stream-3 might be higher in total copper concentrations than inputs from Sheardown NW. Log transformation of the data does not remove outliers observed in data.

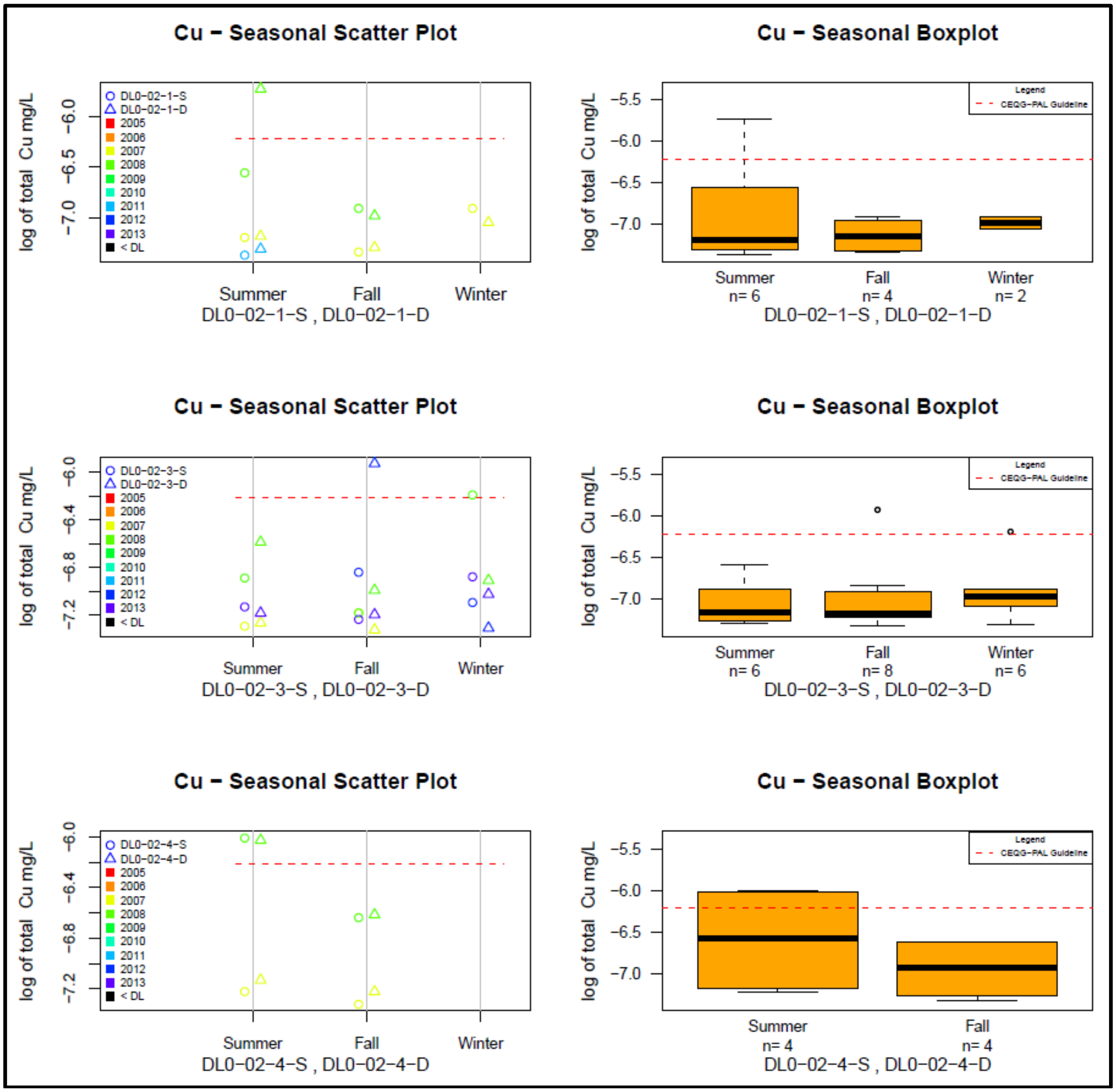
Seasonal scatterplots that combine data from deep and shallow sampling stations do not show a consistent trend across stations (Figure B.47). Data from 2008 appears to be slightly elevated when compared to later data. With the data available, distinct seasonal trends are not observed.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.46 Sheardown Lake SE – Total Copper Concentrations in Water



NOTES:

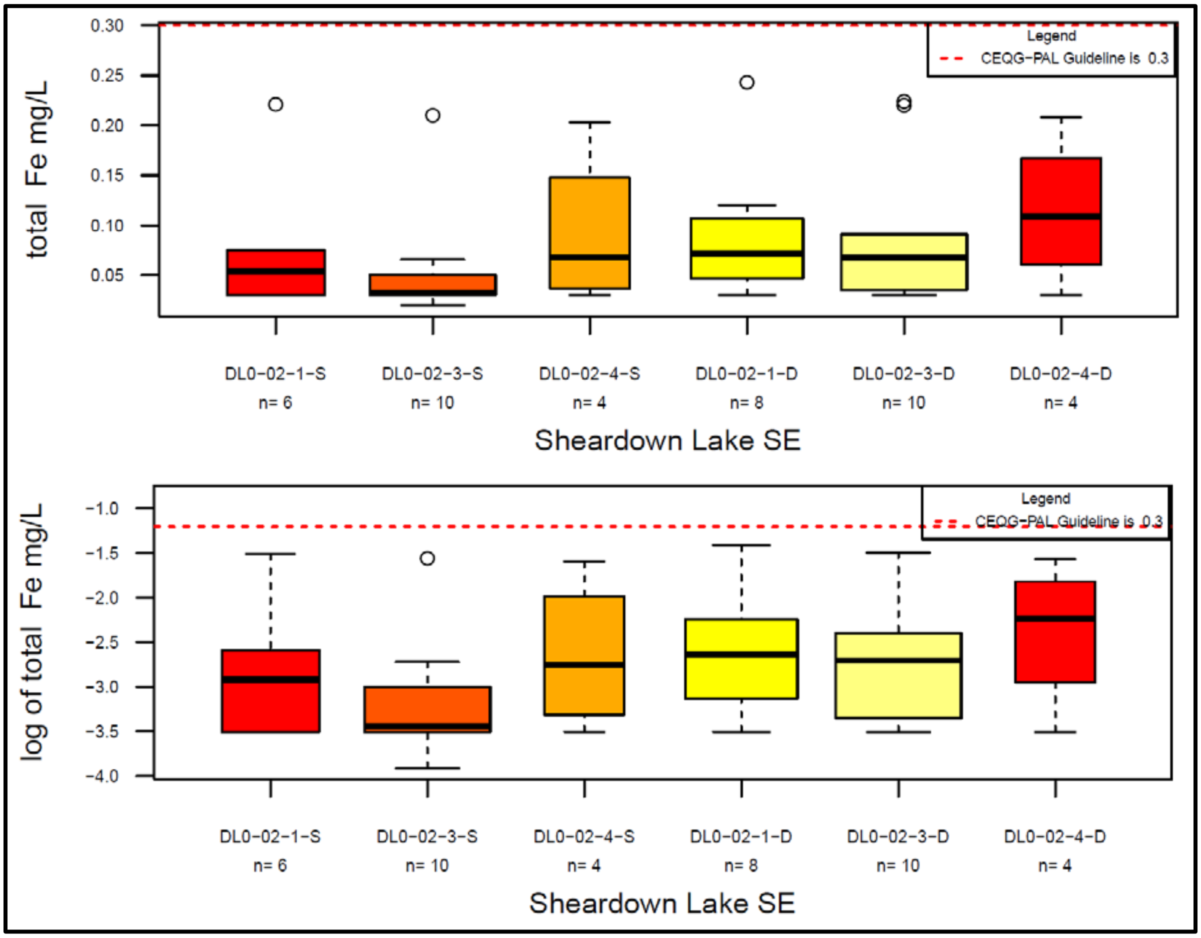
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.47 Sheardown Lake SE – Variability of Total Copper in Water

Total Iron (Figures B.48 and B.49)

Forty-two (42) total iron concentration samples were collected from Sheardown Lake SE at six stations over the course of eight years. The majority of total iron concentrations report above MDLs, band all samples report below the CWQG-PAL guideline of 0.3 mg/L (Figure B.48). Similar to copper, station DL0-02-4 has slightly elevated total iron concentrations when compared to the other stations in Sheardown Lake SE.

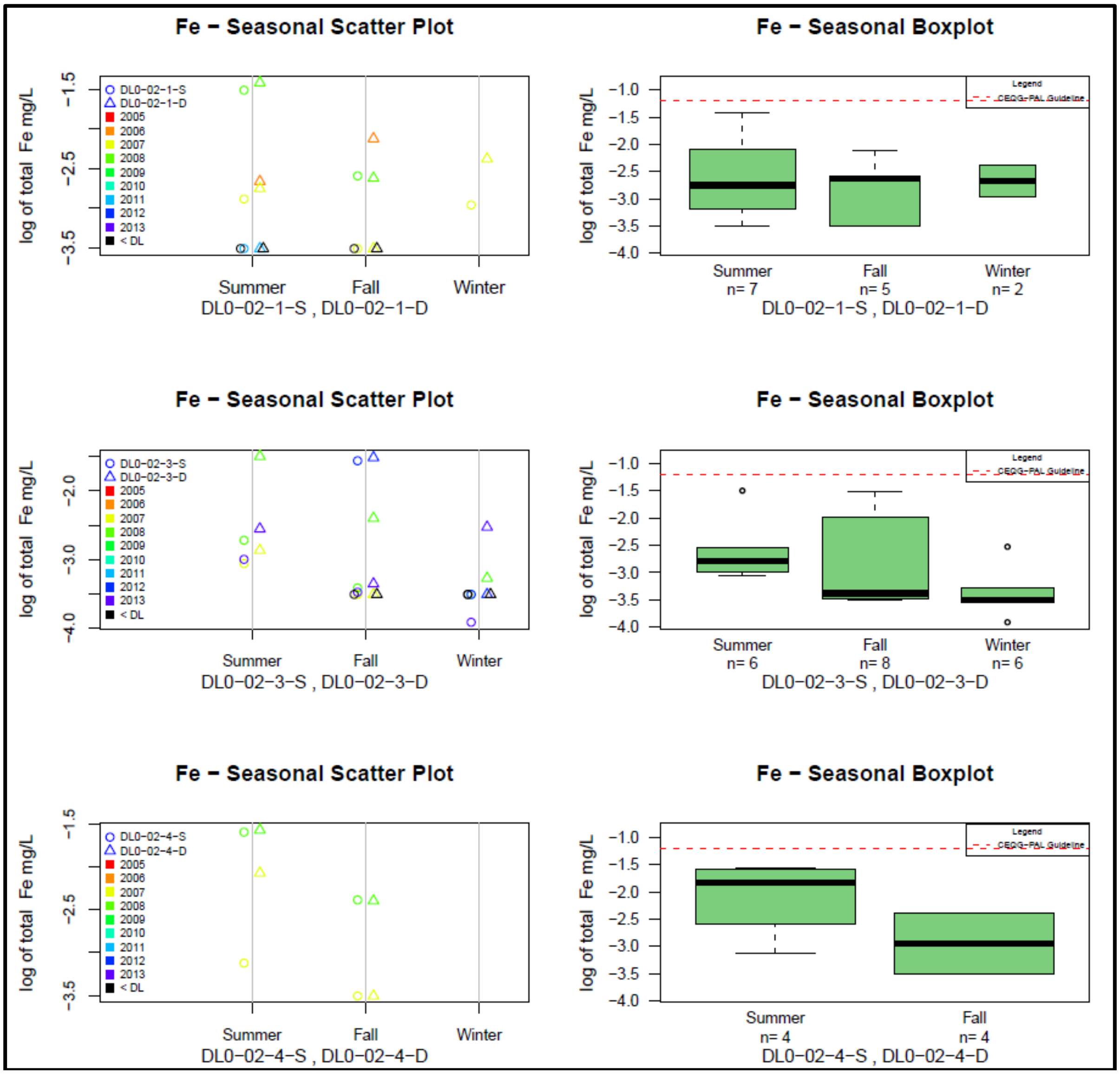
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations (Figure B.49). Slightly elevated summer concentrations are noted; however, more samples are required to understand magnitude of seasonal trend.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.48 Sheardown Lake SE – Total Iron Concentrations in Water



NOTES:

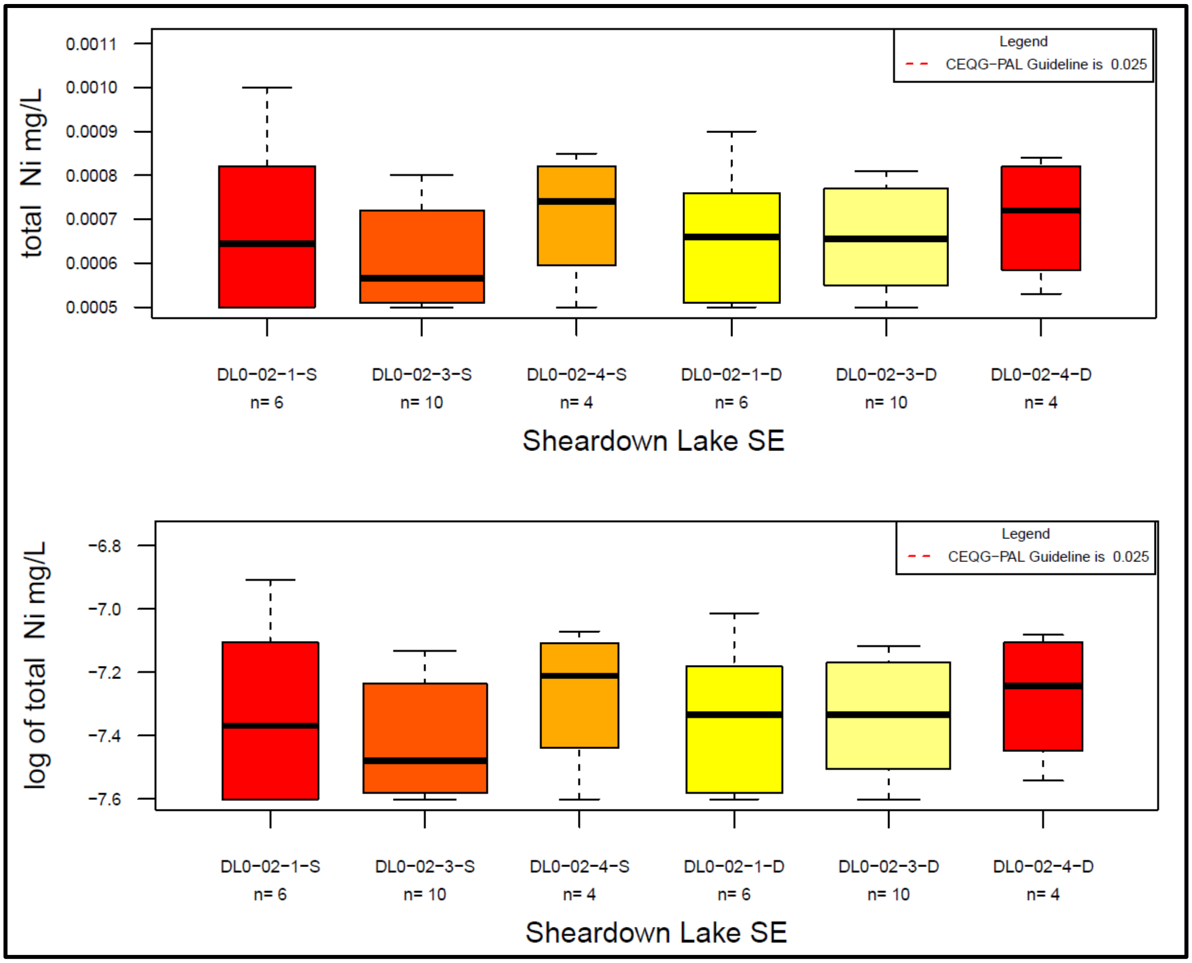
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.49 Sheardown Lake SE – Variability of Total Iron in Water

Total Nickel (Figures B.50 and B.51)

Forty (40) total nickel concentration samples were collected from Sheardown Lake SE at six sample stations over the course of eight years. Nickel concentrations consistently report above MDLs, but well below the CWQG-PAL guideline (0.025 mg/L) (Figure B.50). Median total nickel concentrations are consistent throughout the geographically distinct sampling stations and range from 0.00055 mg/L through 0.00075 mg/L. Similar to other iron, nickel concentrations are slightly elevated at the DL0-02-4 station.

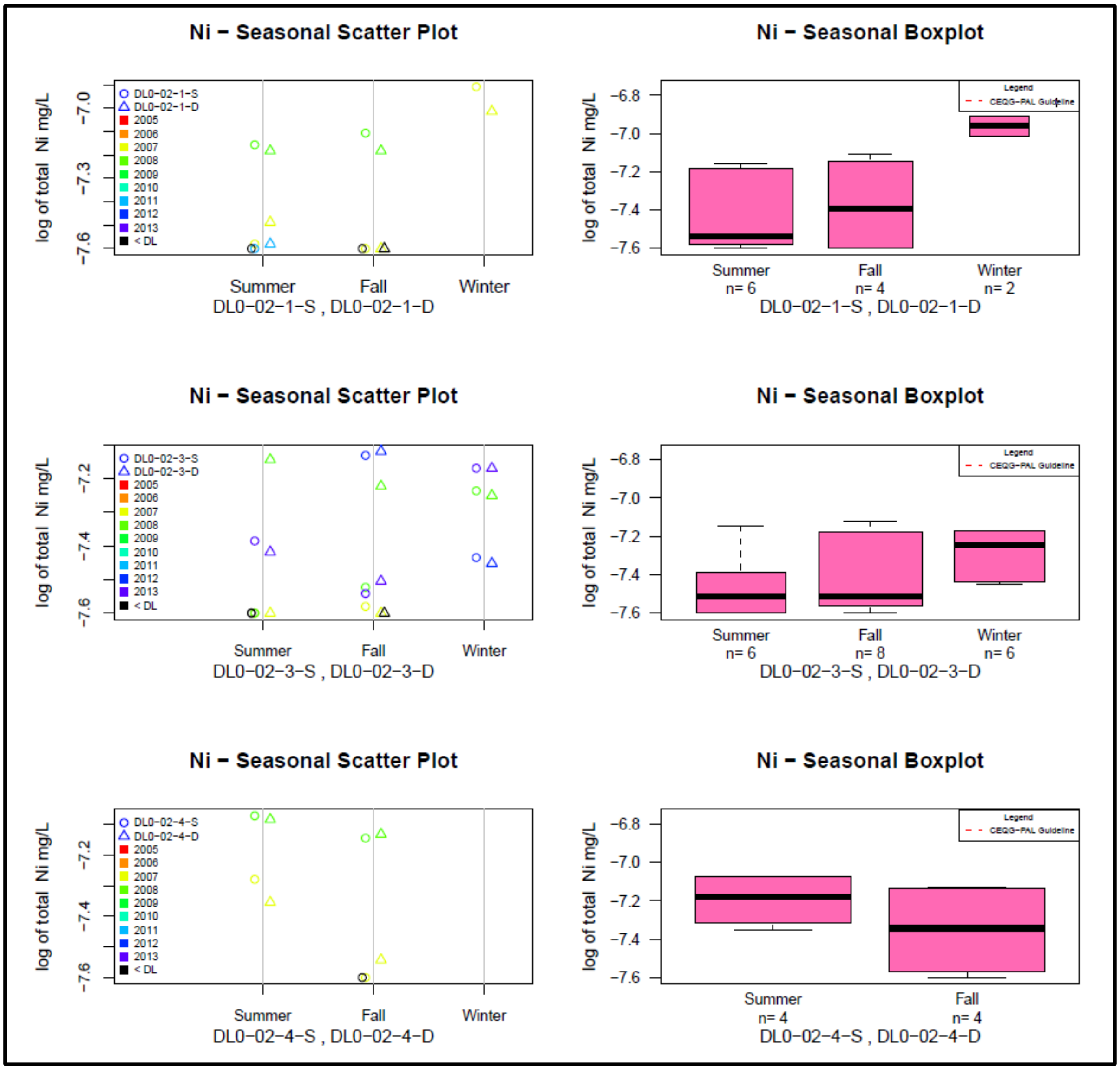
Seasonal scatterplots show that elevated concentrations are derived from early sampling (2007 and 2008), especially at DL0-02-1 and DL0-02-4 (Figure B.51). Although the winter dataset is limited, the current data indicates concentration peaks for nickel occur during the winter.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.50 Sheardown Lake SE – Total Nickel Concentrations in Water



NOTES:

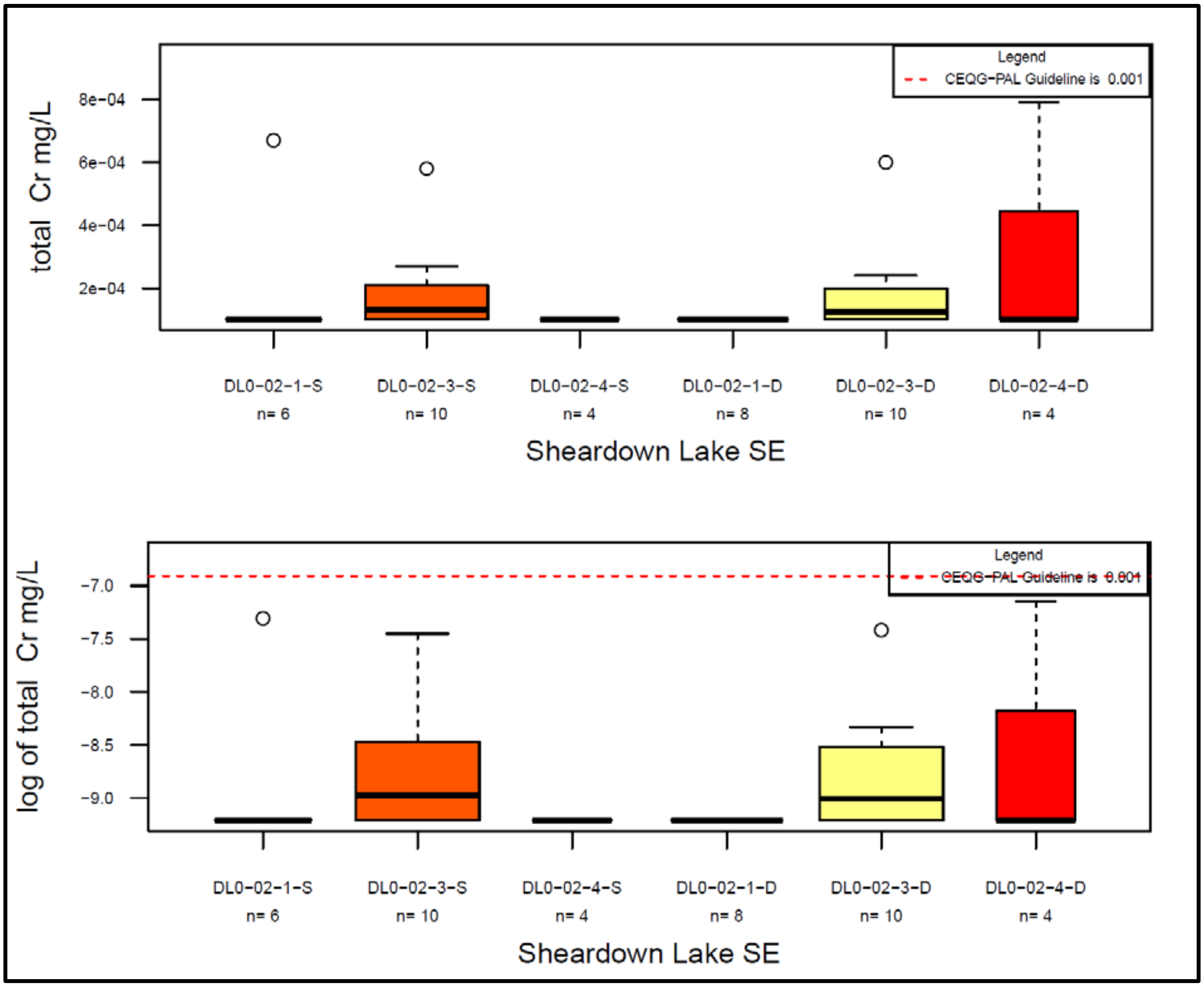
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.51 Sheardown Lake SE– Variability of Total Nickel in Water

Total Chromium (Figures B.52 and B.53)

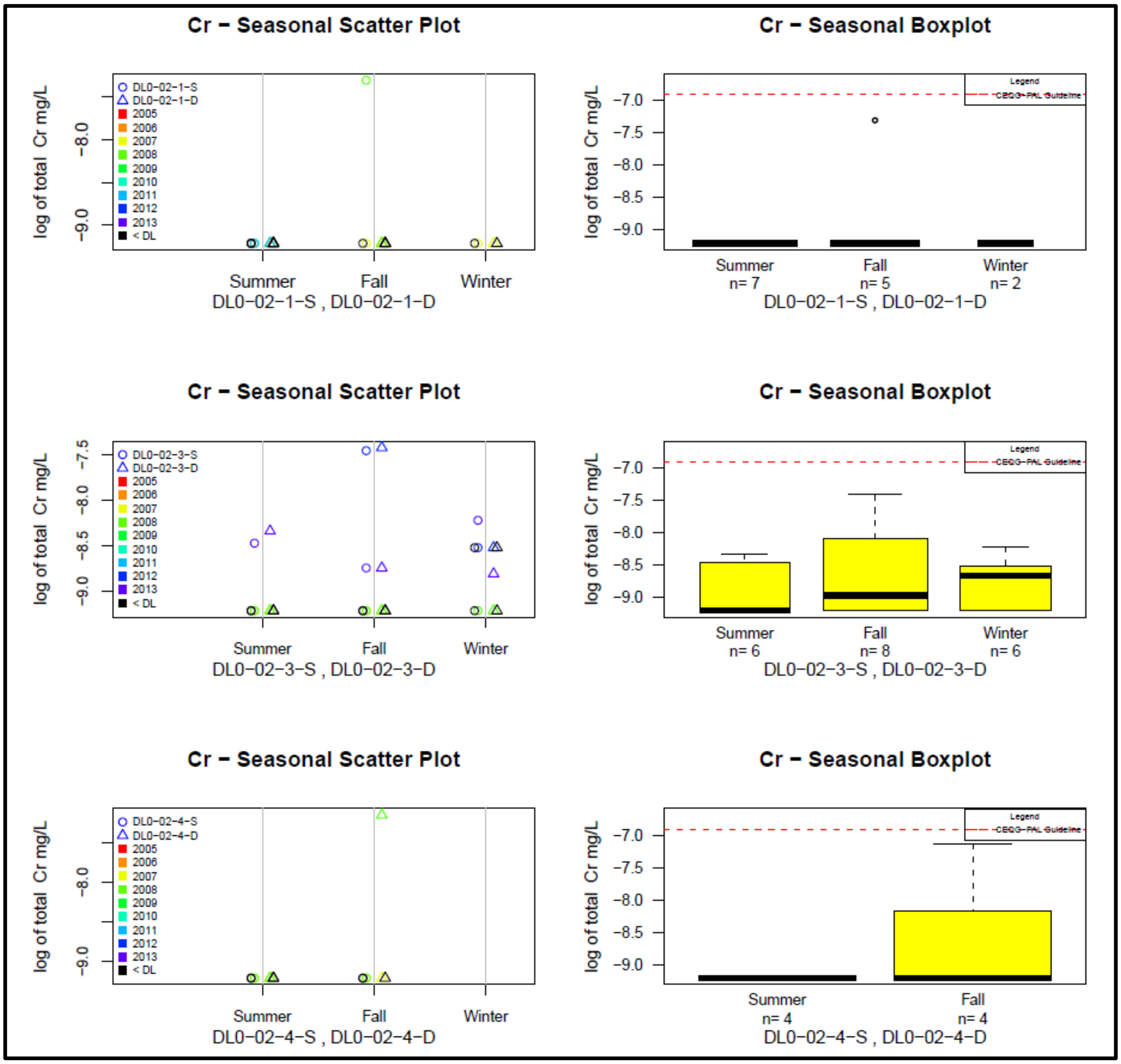
Forty-two (42) total chromium concentration samples were collected from Sheardown Lake SE at six sample stations over the course of eight years. Chromium concentrations are generally low, but concentrations are certain sites approach the CWQG-PAL guideline (0.001 mg/L) (Figure B.52). Samples from DL0-02-3/D and DL0-02-4-D are slightly elevated compared to the other stations with Sheardown Lake SE, but the trend is so muted, it is not considered important.

Seasonal scatterplots show that elevated concentrations at DL0-02-3-D are derived from recent sampling, during 2012 and 2013 (Figure B.53). No consistent seasonal trend was noted between sites.



NOTES:
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.52 Sheardown Lake SE – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.53 Sheardown Lake SE– Variability of Total Chromium in Water

Summary of Sheardown Lake SE Water Quality

Summary of trends observed during review of Sheardown Lake SE baseline data:

- Distinct depth trends are not observed for any parameters within Sheardown Lake SE, which suggests that lake is completely mixed throughout the year, despite winter ice.
- Elevated concentrations observed at DL0-02-4 compared to other sites: copper, iron and nickel.
- Early data (2007, 2008) appears elevated when compared to more recent data: copper and nickel.

- Parameters below MDLs and/or do not show any seasonal trends: nitrate, arsenic, cadmium, chromium and copper.
- Parameters with highest concentration occurring in the summer and/or fall: aluminum and iron.
- Parameters with highest concentrations occurring in the winter: chloride and nickel.

B.2.3 Mary Lake

A total of eighty-five (85) lake samples were collected at twelve stations over the eight-year sampling history at Mary Lake (Figures B.1 and B.2):

- BL0-01-D and S - Within a small basin at the north end of the northern arm of Mary Lake to which Camp Lake drains.
- BL0-03-D and S - Located at the centre of Mary Lake.
- BL0-04-D and S - Located in the centre of the main basin of Mary Lake.
- BL0-05-D and S - Located within the main basin of Mary Lake near the mouth of the Mary River.
- BL0-05-B4-D and S - Located at the inlet of Mary Lake.
- BL0-06-D and S - Located within the southern portion of Mary Lake.

Most samples were collected in 2007 and no samples were collected during 2009 and 2010. Most samples occurred in the summer, and the least number of samples were collected in the winter.

A summary of the data collected during each season, with respect to year and site are presented in Table B.4 and a graphical representation of the sampling events is provided in Figure B.54. Note that for the purposes of graphical analysis, data from BL0-05-B4 has been pooled with data from BL0-05.

Table B.4 Mary Lake Sample Size

Year	Summer	Fall	Winter
2006	8	4	0
2007	10	14	8
2008	10	0	4
2011	4	0	0
2012	0	2	0
2013	10	6	5
Site	**Summer**	**Fall**	**Winter**
BL0-01-S	4	3	2
BL0-01-D	4	2	4
BL0-03-S	4	2	1
BL0-03-D	4	2	1
BL0-04-S	4	2	2
BL0-04-D	4	2	2
BL0-05-S	5	5	2
BL0-05-D	5	5	2
BL0-05-B4-S	1	0	0
BL0-05-B4-D	1	0	0
BL0-06-S	3	2	0
BL0-06-D	3	2	0

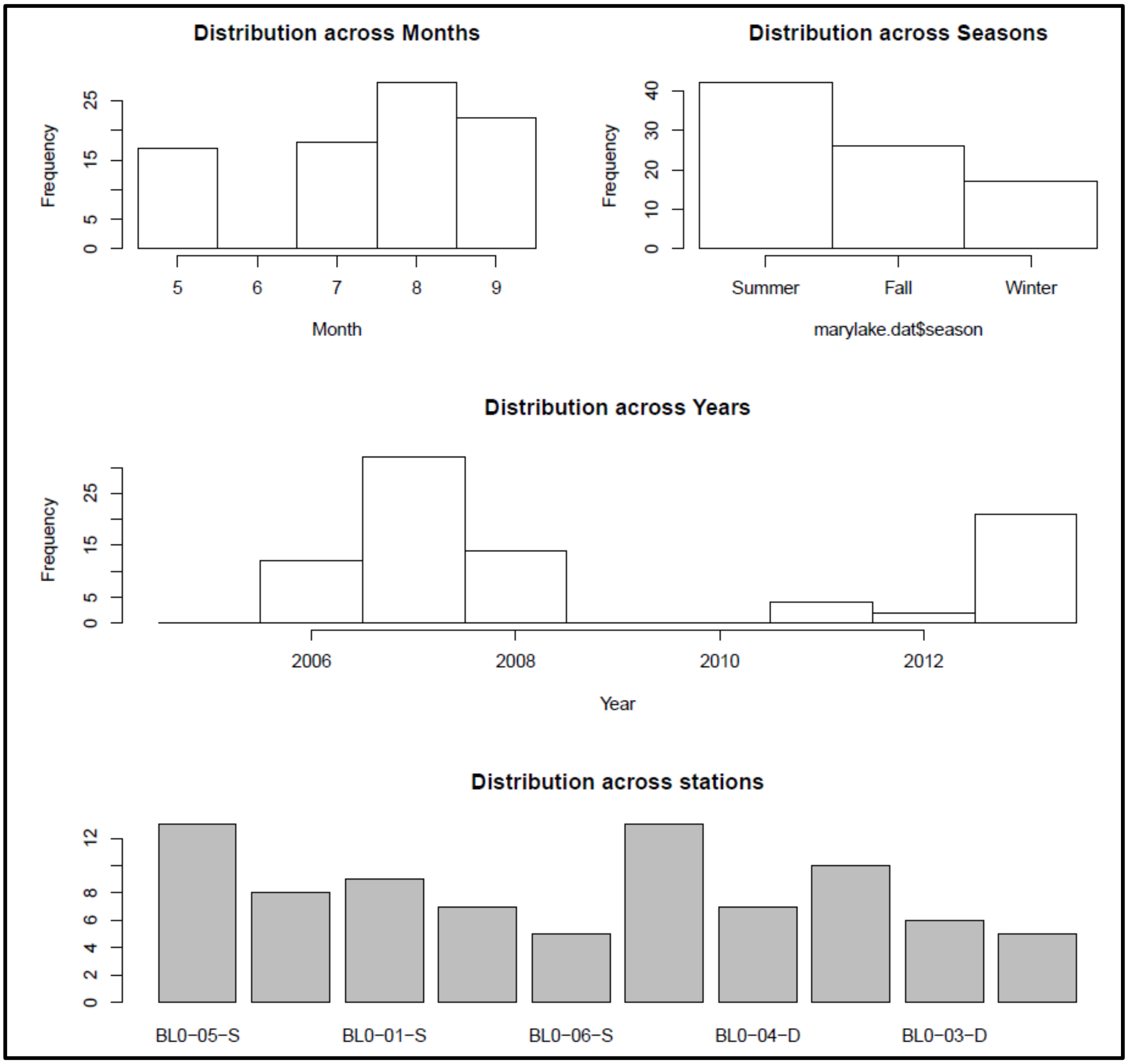


Figure B.54 Mary Lake – Graphical Summary of Sampling Events

The following summarizes the data review observations of the physical parameter data for Mary Lake.

pH (Figure B.55)

- The median pH from all samples collected in Mary Lake is ~7.5. Median values for pH at station within Mary Lake range from 6.6 to 8.3.

Alkalinity (Figure B.55)

- Mary Lake stations generally have alkalinity values that are below 40 mg/L $CaCO_3$; however, BL0-01-S/D show elevated median alkalinity values equal to approximately 70 mg/L $CaCO_3$.
- Differences between deep and shallow stations are not noted.

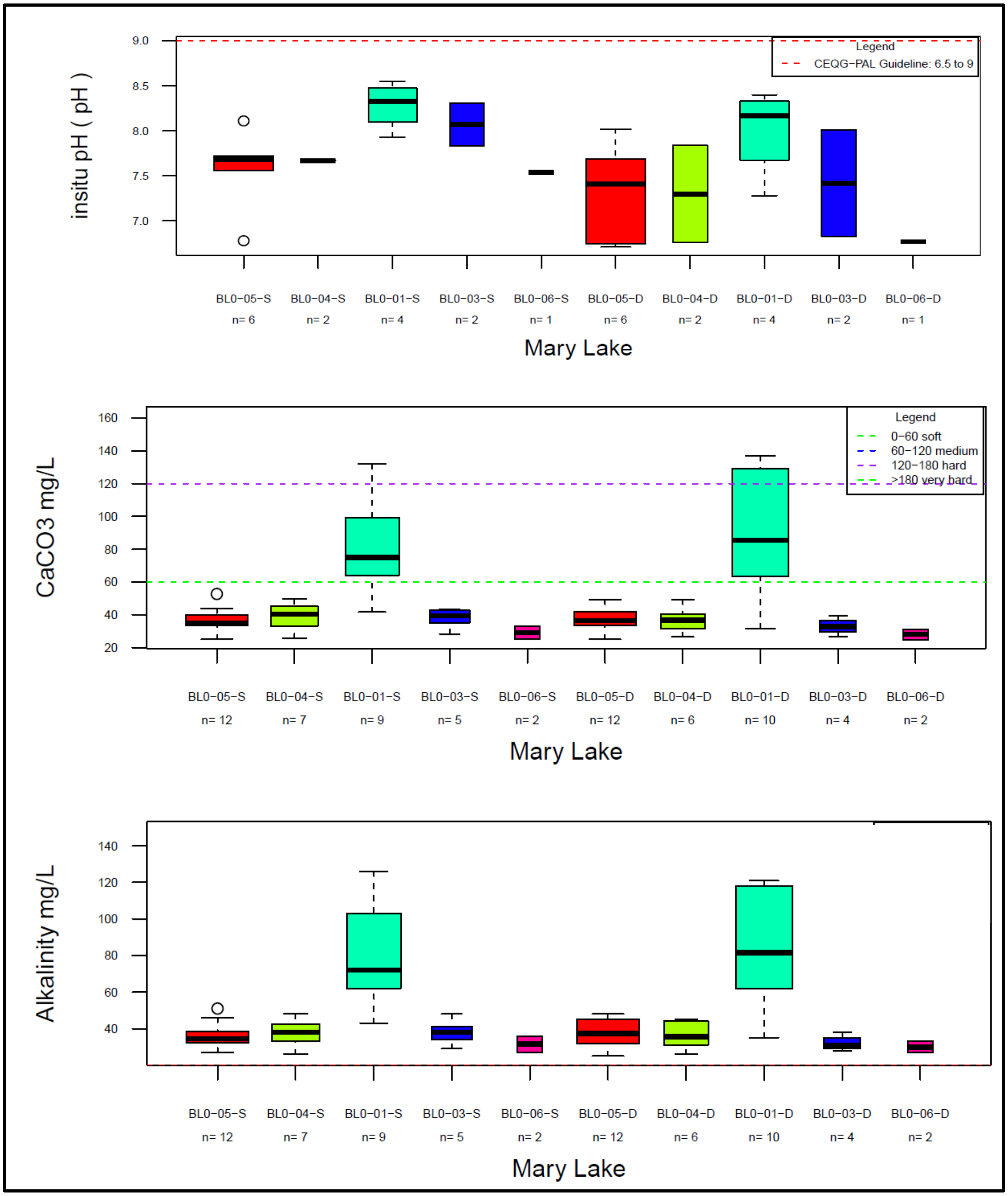


Figure B.55 Mary Lake – In-situ pH, Alkalinity and Hardness

Hardness (Figure B.55)

- Mary Lake stations have "soft water" and generally have alkalinity values that are below 40 mg/L hardness measured as $CaCO_3$, with the exception of BL0-01-S/D which has elevated median alkalinity values equal to ~80 mg/L $CaCO_3$.
- Differences between deep and shallow stations are not noted.
- Hardness portrayed trends very similar to alkalinity and suggests that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures B.56 and B.57)

Sixty-nine (69) chloride concentration samples were collected from Mary Lake over the course of eight years. Chloride concentrations are consistently low, and each geographically distinct site in Mary Lake has a median than ranges from 2 to 2.5 mg/L (Figure B.56). This is well below the CWQG-PAL limit of 120 mg/L. A comparison of total data and seasonal scatterplots reveals that deep and shallow stations located at the same location vary little in reported concentrations. BL0-01-S and BL0-01-D show the greatest variability and have the largest sample size. These stations have outlying values recorded around 11 mg/L to 14 mg/L. The BL0 sampling stations are located in a small basin at the north end of the north arm of the lake, which receives flows from Camp Lake as well as the Tom River (Figure B.1).

Seasonal boxplots show lower chloride concentrations occur in the summer and higher concentrations occur in the winter (Figure B.57).

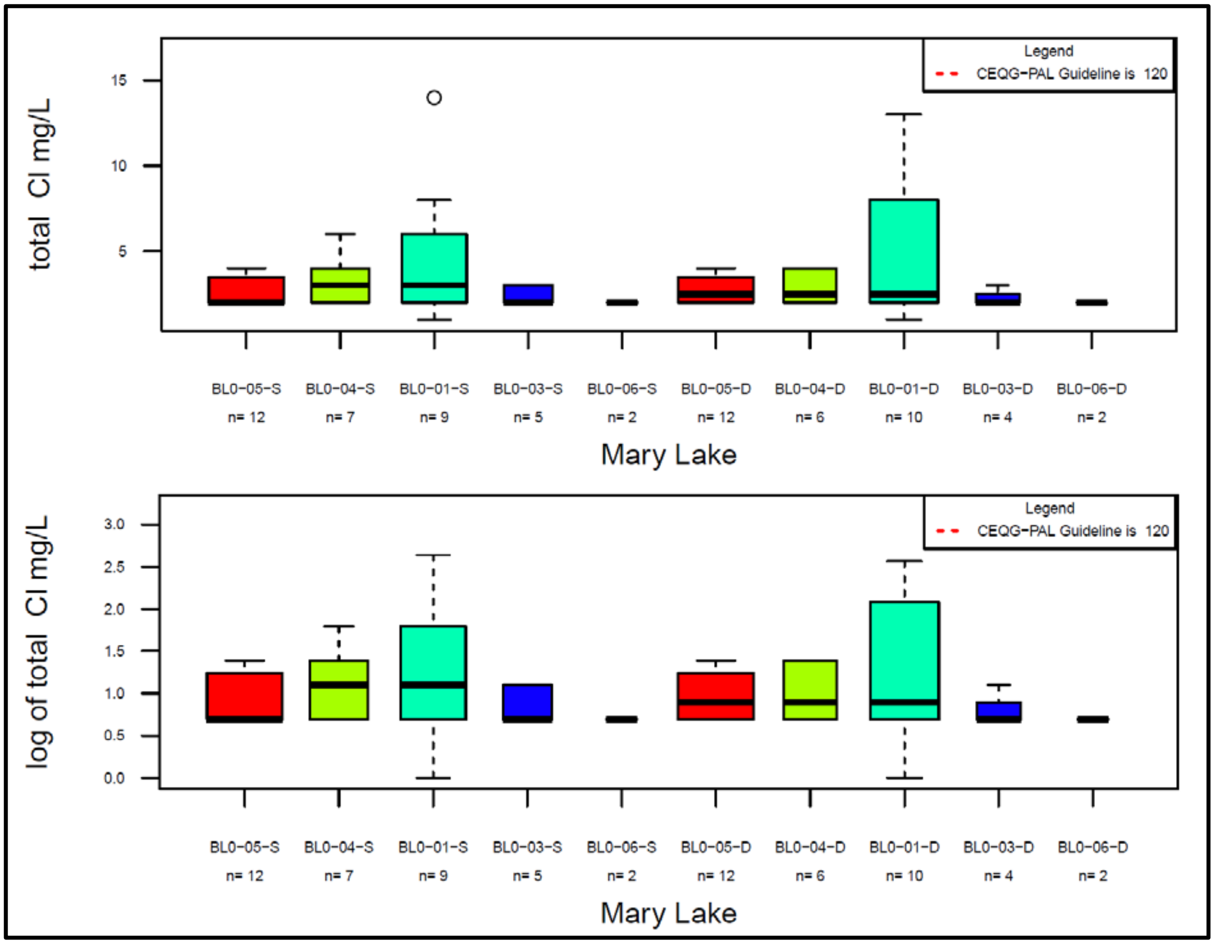
Nitrate

Sixty-nine (69) nitrate concentration samples were collected from Mary Lake over the course of eight years. All nitrate concentrations were measured at the detection limit (0.10), which is well below the CWQG-PAL limit (3 mg/L). As a result, no seasonal, inter-annual or depth variation can be determined and further graphical analyses are not warranted.

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. All metals are discussed as total concentrations instead of dissolved concentrations, to reflect both the total dissolved and particulate metal loading.

Total Aluminum (Figure B.58 and Figure B.59)

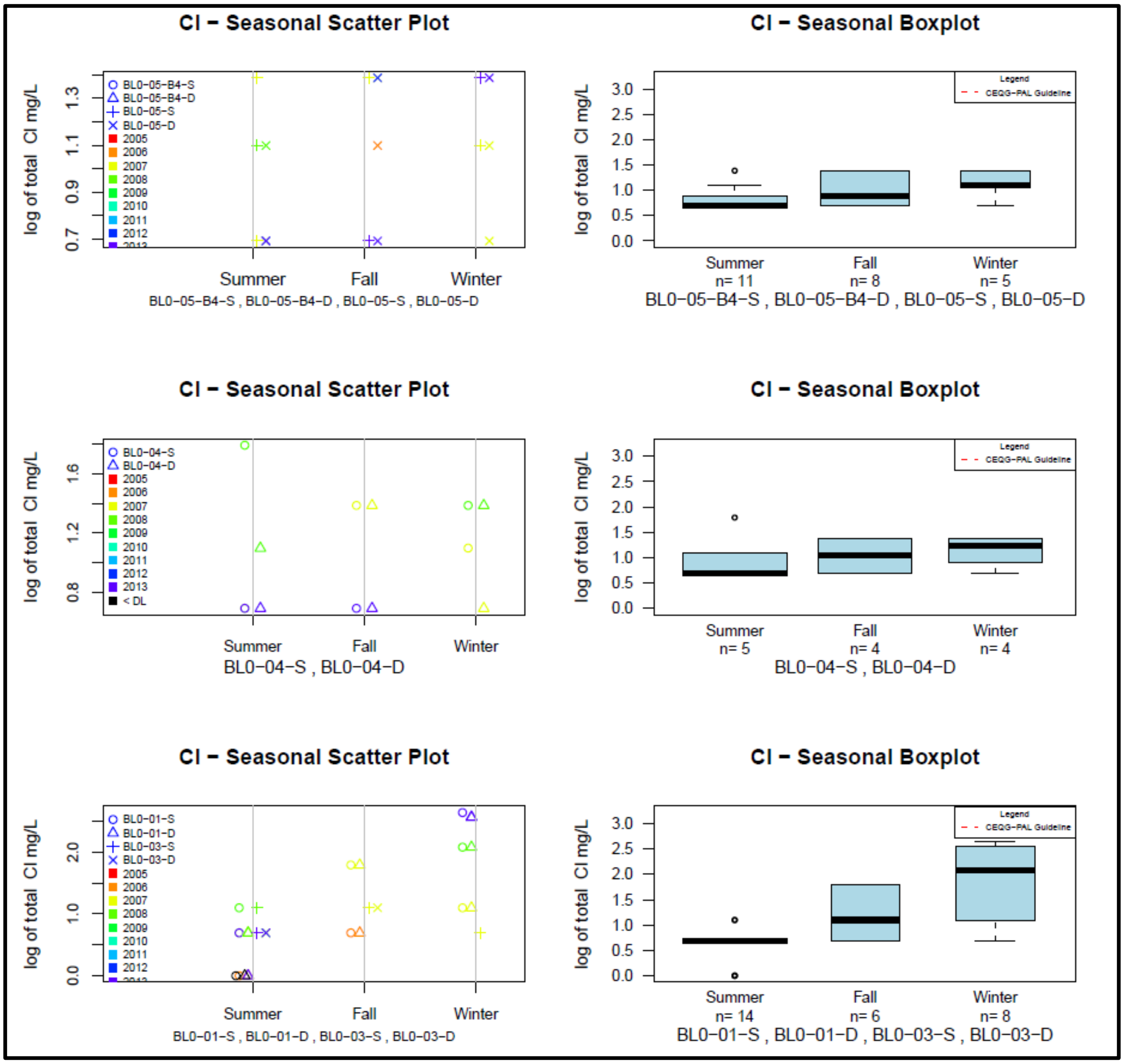
Sixty-nine (69) total aluminum concentration samples were collected from Mary Lake over the course of eight years. Total aluminum concentrations tend to occur above detection limits, and are elevated to concentrations above, or close to the CWQG-PAL limit (0.10 mg/L). Maximum aluminum concentrations exceed the CWQG-PAL limit at all sites except BL0-03-D/S and BL0-6S/D (Figure B.58). Median total aluminum concentrations at each geographically distinct sampling station in Mary Lake range from 0.03 mg/L to 0.06 mg/L. Sampling stations close to inlets, such as BL0-01 and BL0-05, show slightly higher aluminum concentrations when compared to other stations, indicating that upstream aluminum inputs may be occurring from waters flowing into the lake at these locations (the Mary River and Camp Lake). Elevated total aluminum concentrations measured in various watercourses across the mine site area.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.56 Mary Lake – Chloride Concentrations in Water

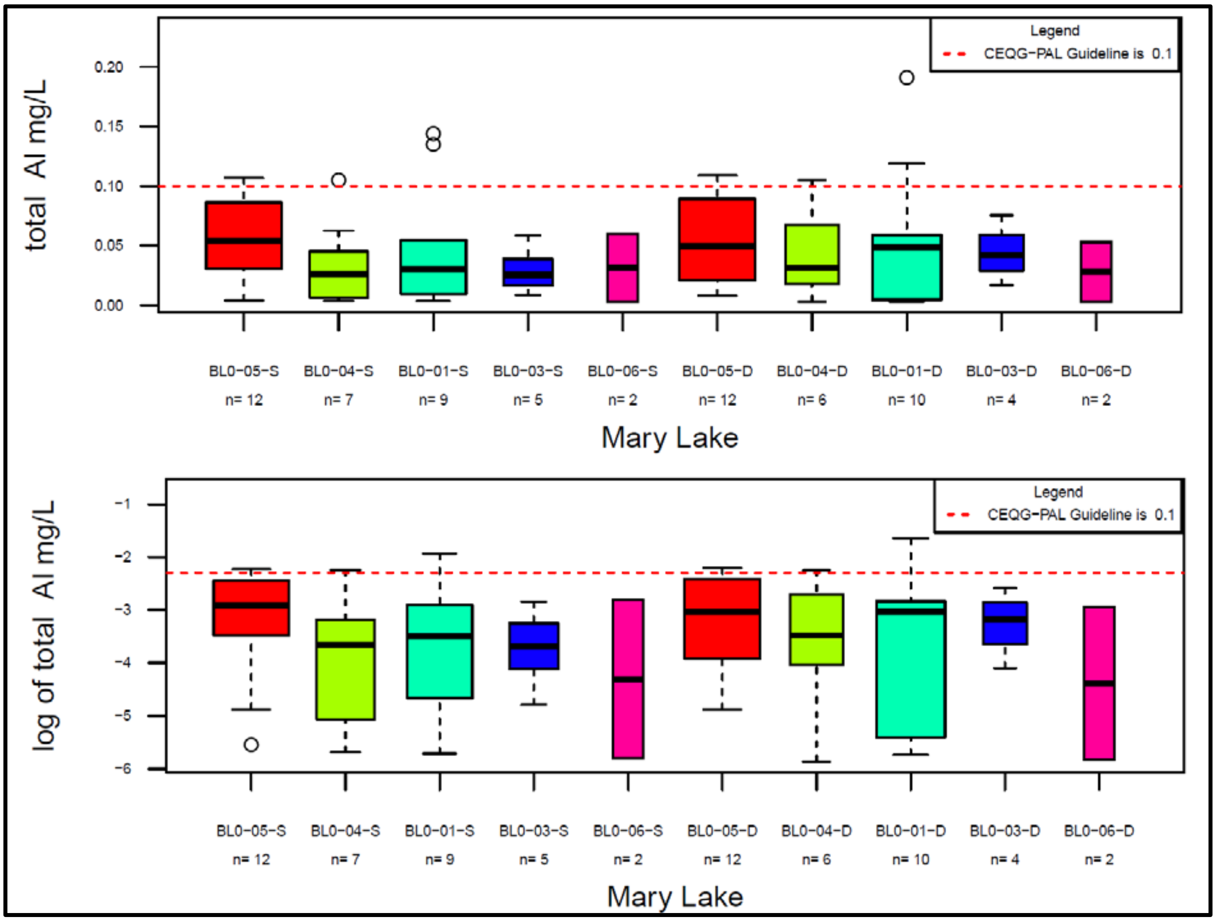


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.57 Mary Lake – Variability of Chloride in Water

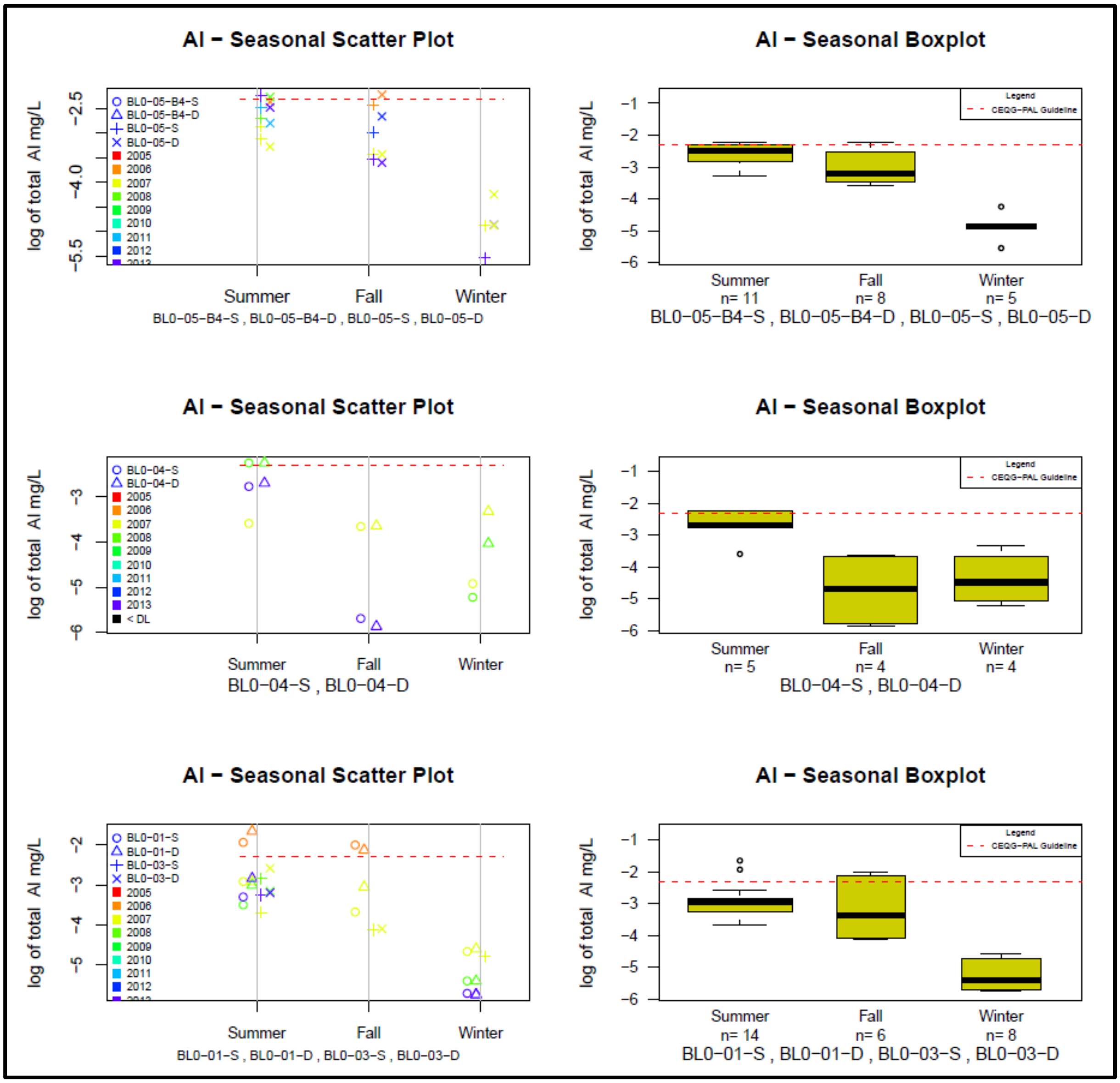
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be aggregated (Figure B.59). Distinct temporal trends over the eight-year sampling history are not noted.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.58 Mary Lake – Total Aluminum Concentrations in Water



NOTES:

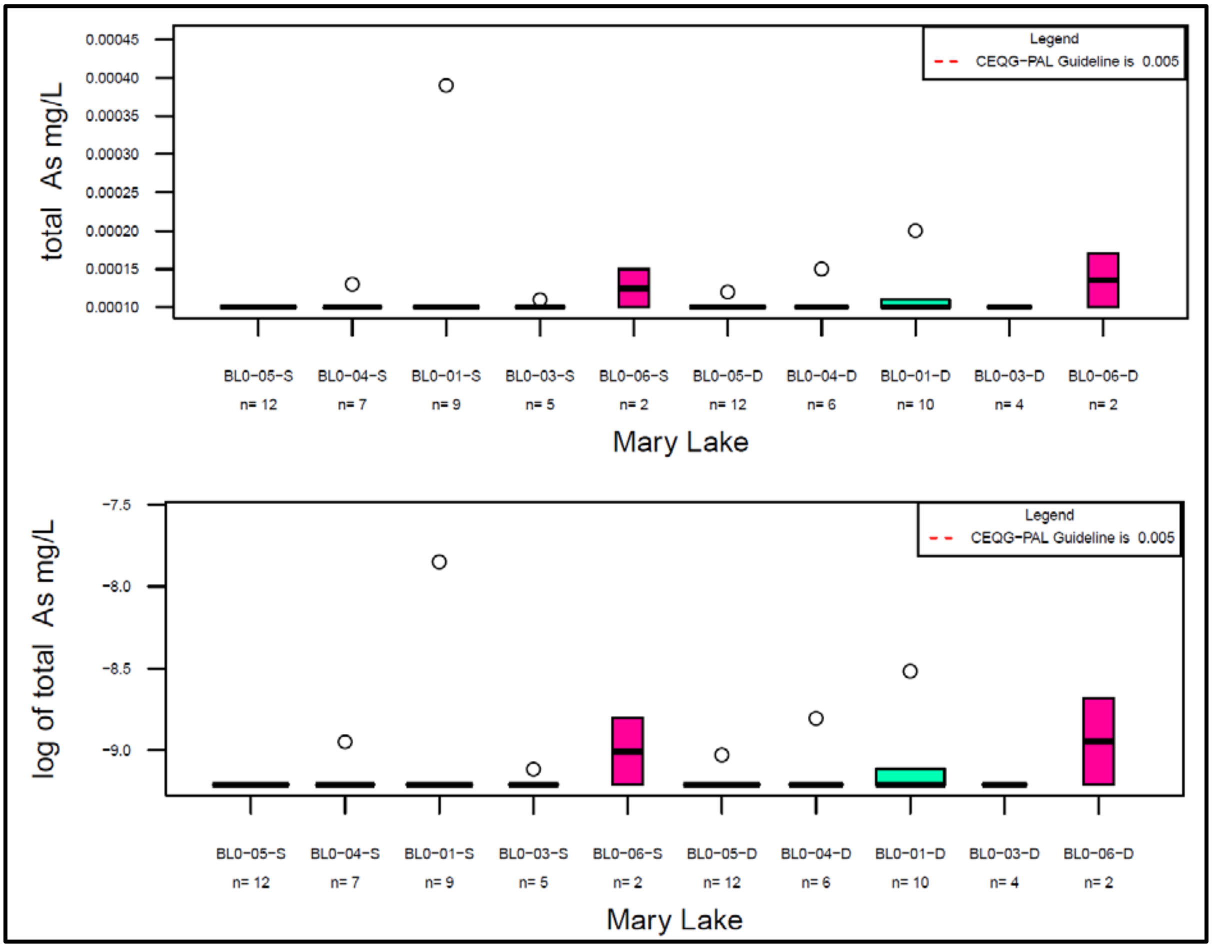
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.59 Mary Lake – Variability of Total Aluminum in Water

Seasonal boxplots show aluminum concentrations tend to be at their maximum in the summer, and decrease to their minimum value in the winter, with fall concentrations occurring somewhere in between. The only stations that do not show this trend are BL0-04-S/D and BL0-06-S/D. These stations show a cluster of low concentration values below 2007-2008 winter data. Similar to other locations within the mine site, seasonal box plots indicate that aluminum concentrations are highest in the winter and lowest in the summer.

Total Arsenic (Figures B.60 and B.61)

Sixty-nine (69) total arsenic concentration samples were collected from Mary Lake over the course of eight years. Arsenic concentrations tend to occur below detection limits, and below the CWQG-PAL limit (0.005 mg/L), with the exception of several outlying values (Figure B.60). All outlying values occur during the fall at BL0-05-S, BL0-04-S/D, and BL0-06-S/D in 2013; and at BL0-01-S/D in 2007. The highest outlying value (~0.0004 mg/L) remains below the CWQG-PAL limit. Samples from BL0-06-S/D, located at the outlet of Mary Lake, have slightly elevated median arsenic concentrations when compared to other stations.

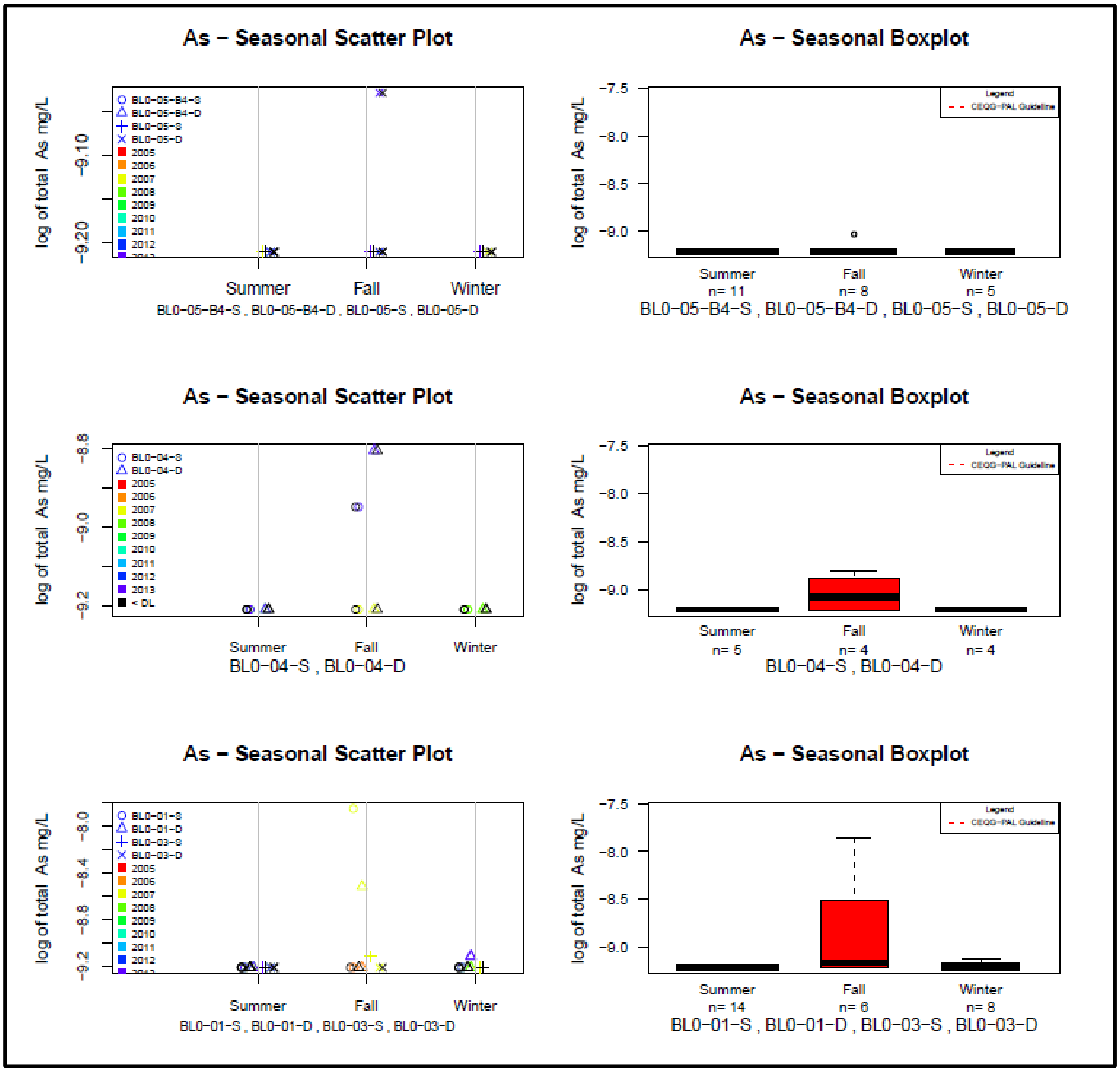


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.60 Mary Lake – Total Arsenic Concentrations in Water

Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together for calculation of benchmarks (Figure B.61). Seasonal boxplots show that all maximum arsenic concentration outliers occur during the fall, while summer and winter concentrations remain depressed in comparison.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

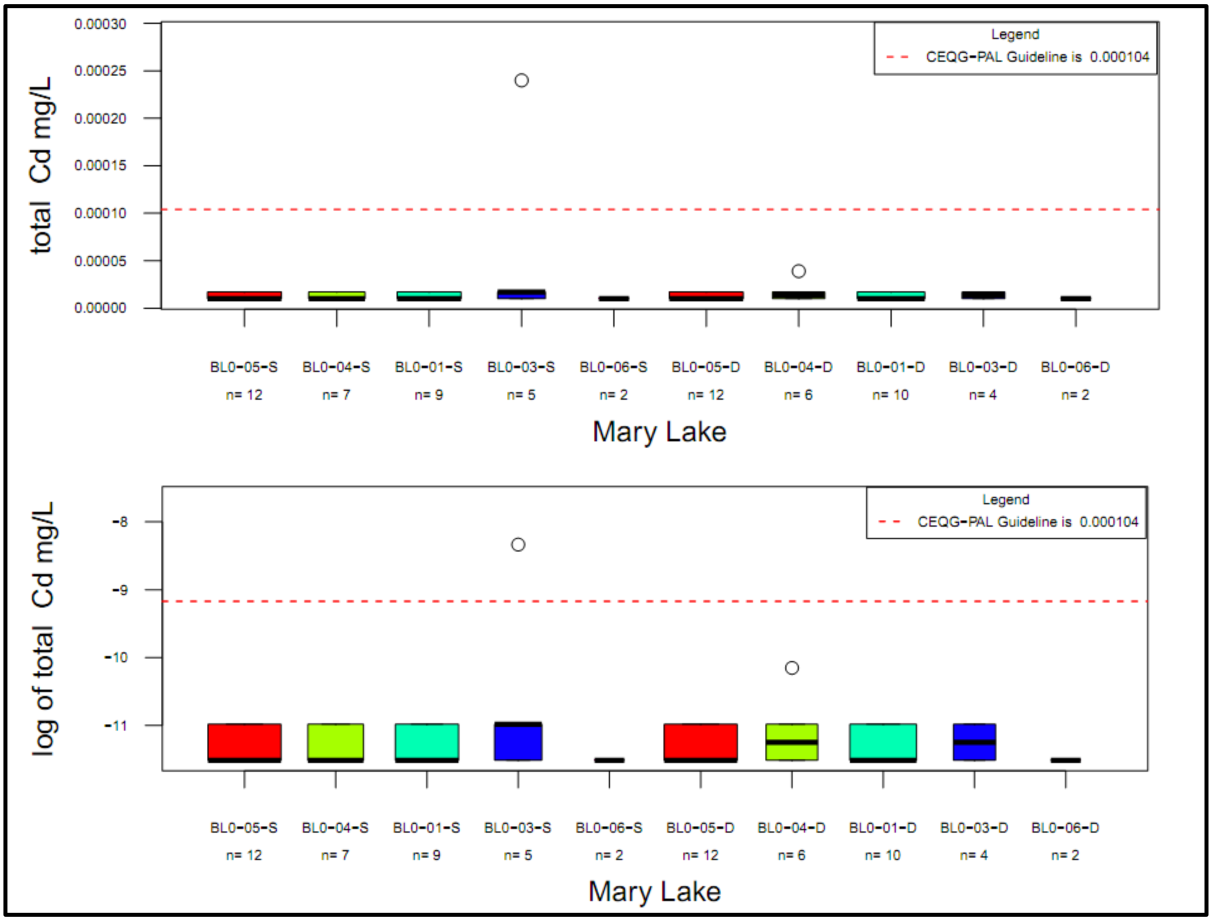
Figure B.61 Mary Lake – Variability of Total Arsenic in Water

Total Cadmium (Figures B.62 and B.63)

Sixty-nine (69) total cadmium concentration samples were collected from Mary Lake over the course of eight years. Cadmium concentrations tend to occur at or below detection limits, and just below the CWQG-PAL limit (0.000018 mg/L), with the exception of several outlying values (Figure B.62). BL0-04-D and BL0-03-S are the only stations where maximum concentrations exceed the

CWQG-PAL limit. All geographically distinct sample locations in Mary Lake have similar median values, with the exception of BL0-04-D and BL0-03-S, which have elevated median values.

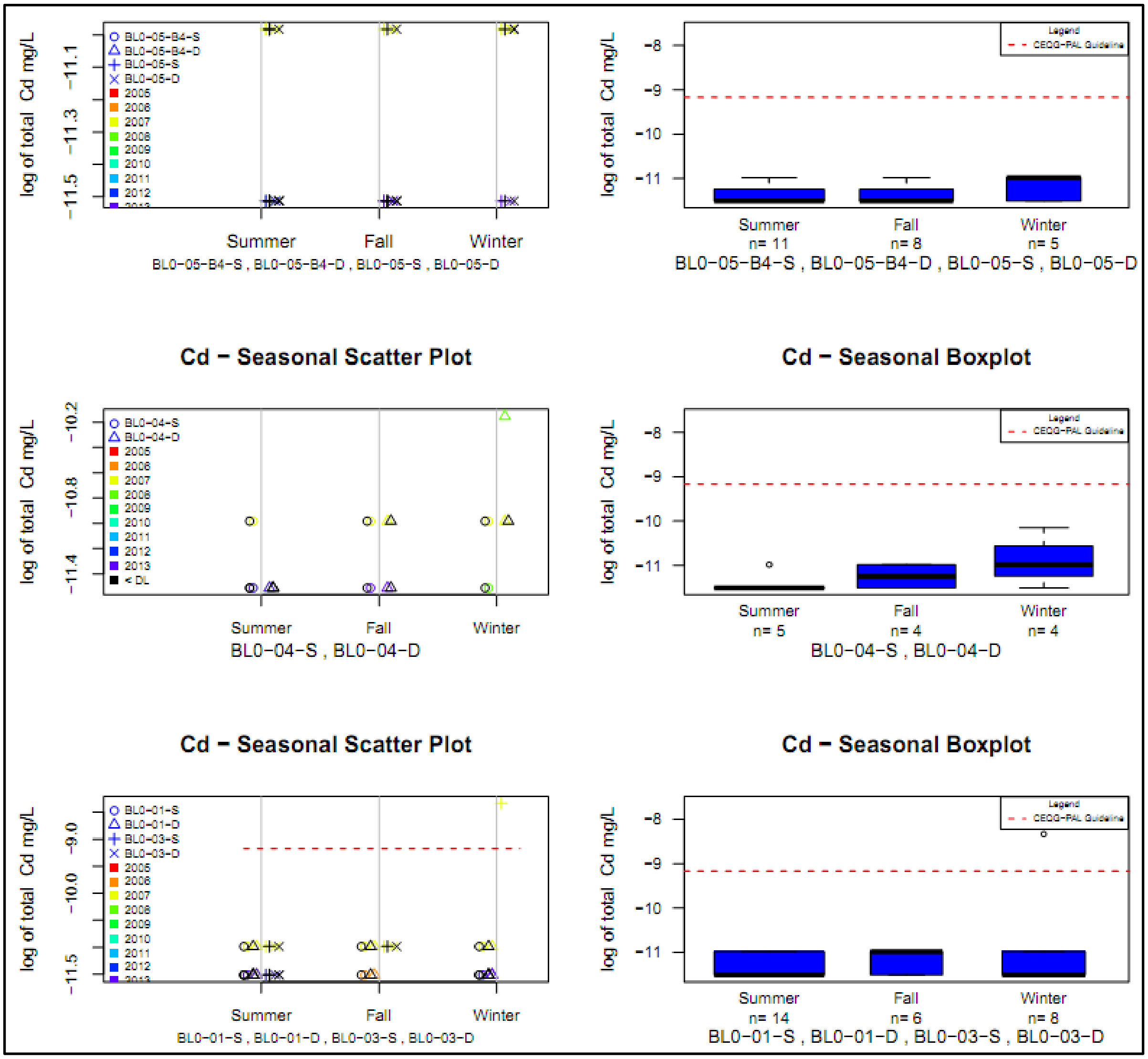
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to determine baseline trends (Figure B.63). Seasonal scatterplots indicate cadmium concentrations are slightly elevated in the winter, when compared to other seasons.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.62 Mary Lake – Total Cadmium Concentrations in Water



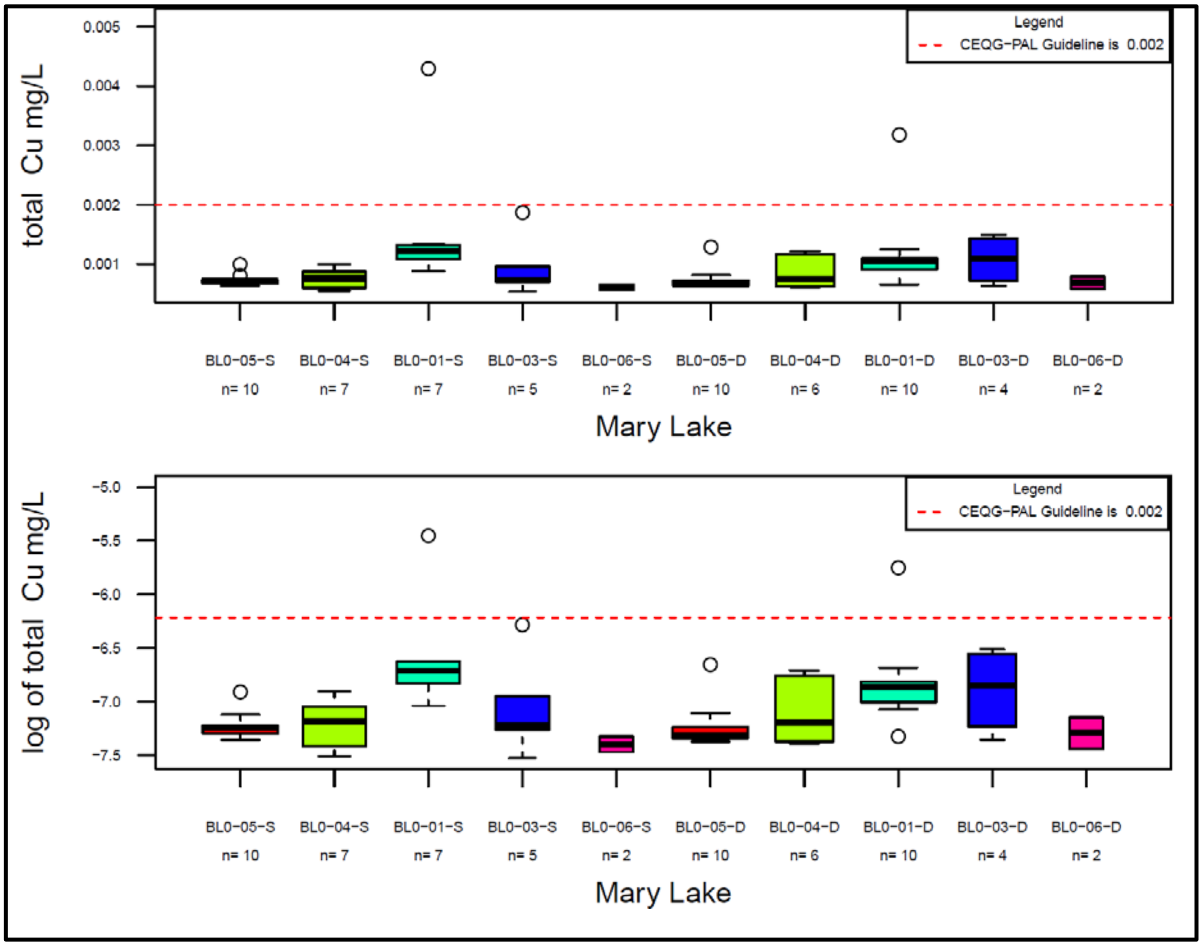
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.63 Mary Lake – Variability of Total Cadmium in Water

Total Copper (Figures B.64 and B.65)

Sixty-three (63) total copper concentration samples were collected from Mary Lake over the course of eight years. Copper concentrations tend to occur above detection limits, and below the CWQG-PAL limit (0.0002 mg/L), with the exception of two outlying values (Figure B.64). Samples from BL0-01-S/D and BL0-03-D are elevated in comparison to other stations. This indicates possible existing copper loading via inflows from I-tributary or J-tributary.

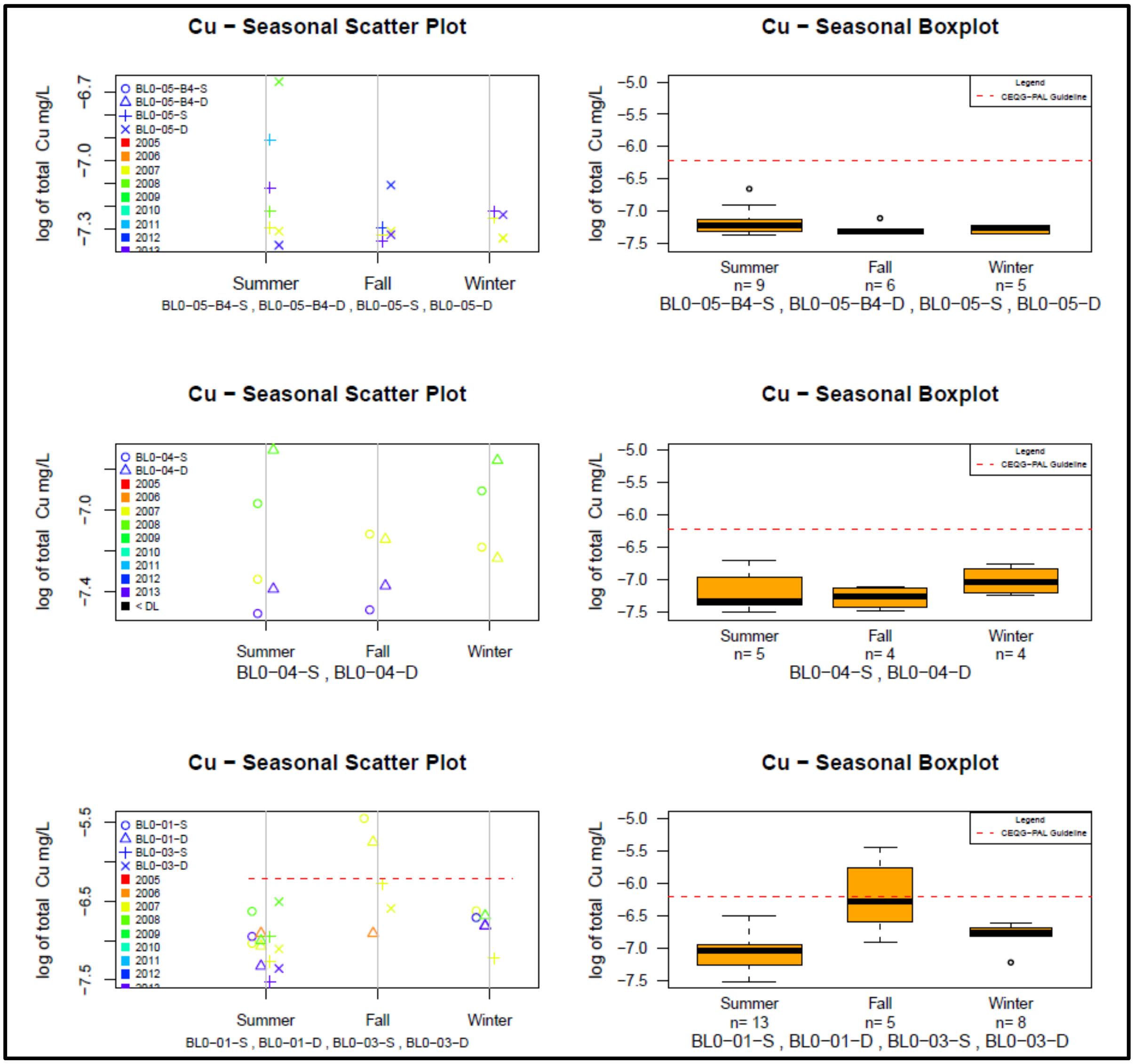


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.64 Mary Lake – Total Copper Concentrations in Water

Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to obtain an understanding of baseline concentrations (Figure B.65). Seasonal boxplots do not reveal a consistent trend among stations.



NOTES:

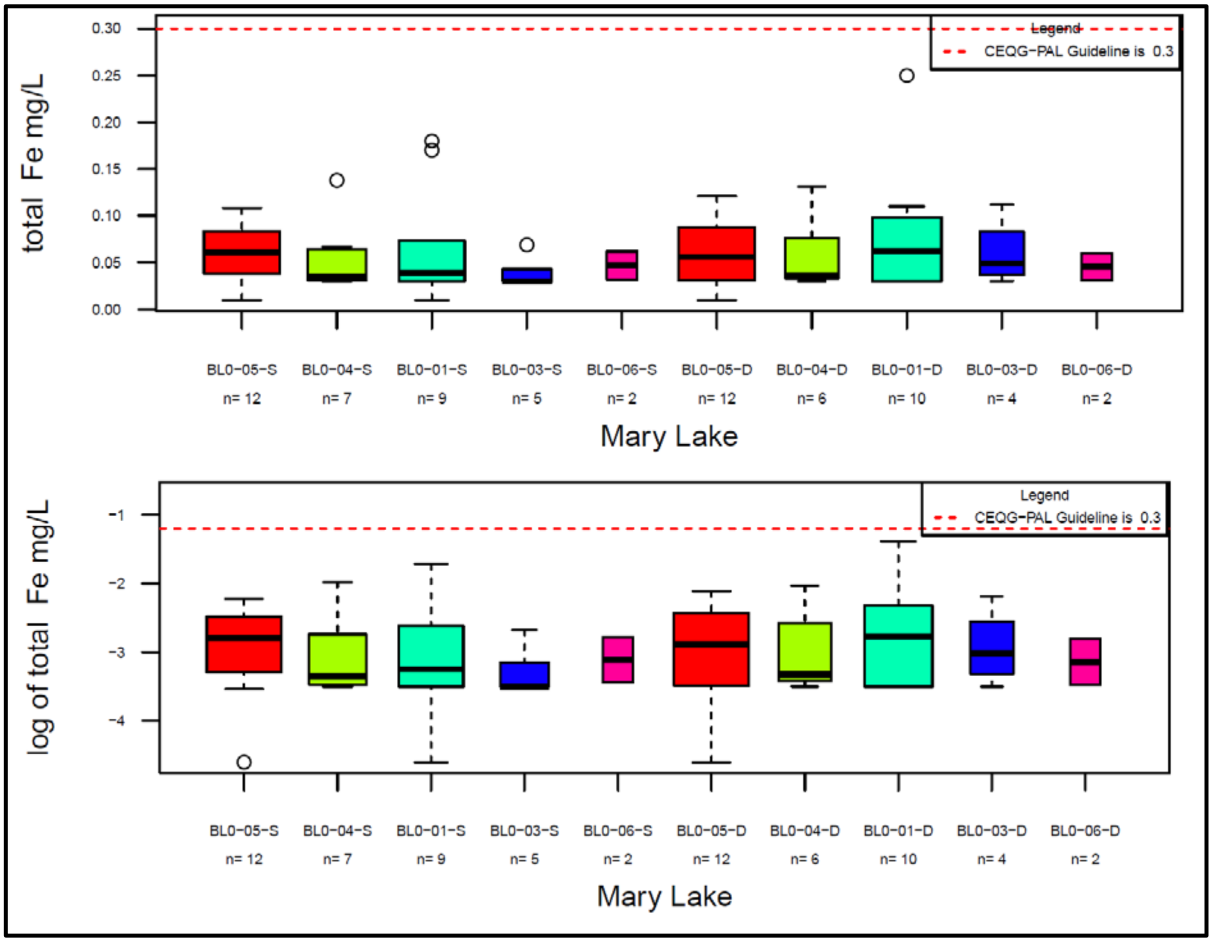
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.65 Mary Lake – Variability of Total Copper in Water

Total Iron (Figures B.66 and B.67)

Sixty-nine (69) total iron concentration samples were collected from Mary Lake over the course of eight years. Iron concentrations tend to occur above detection limits, and well below the CWQG-PAL limit (0.3 mg/L) (Figure B.66). Median iron concentrations range from 0.04 mg/L to 0.06 mg/L. BL0-05-S/D and BL0-01-D, both located at Mary Lake inlet locations, have elevated median iron concentrations. This indicates some amount of existing iron loading may be occurring from upstream sources.

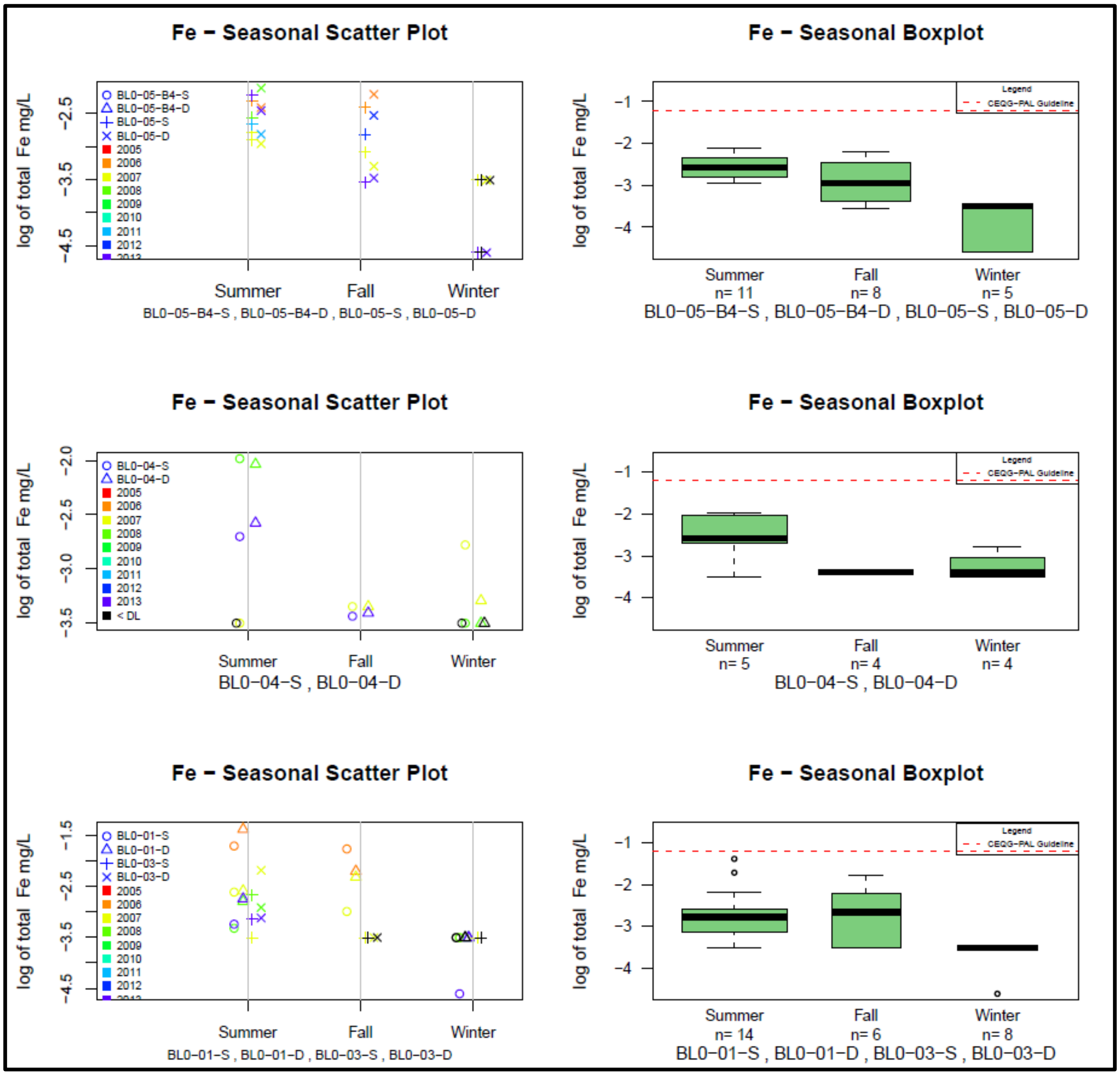
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to gain an understanding of baseline conditions (Figure B.67*).* Seasonal boxplots indicate summer concentrations are typically elevated, when compared to winter concentrations. Concentration trends for fall data are less consistent.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.66 Mary Lake – Total Iron Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

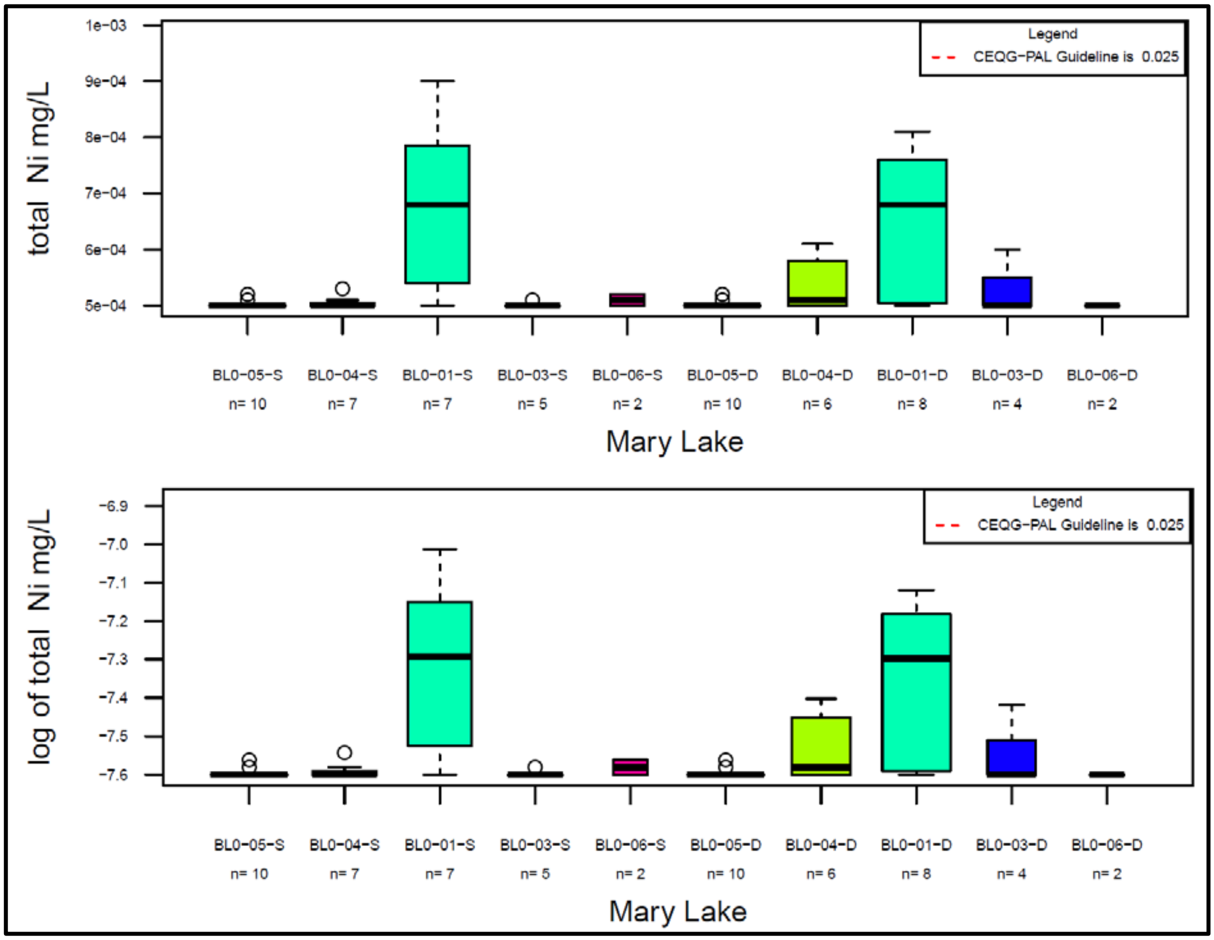
Figure B.67 Mary Lake – Variability of Total Iron in Water

Total Nickel (Figures B.68 and B.69)

Sixty-one (61) total nickel concentration samples were collected from Mary Lake over the course of eight years. Nickel concentrations are low and tend to occur at, below or slightly above detection limits, and well below the CWQG-PAL limit (0.025 mg/L) (Figure B.68). Median nickel concentrations at geographically distinct sampling stations tend to occur around 0.0005 mg/L. Samples from

BL0-01-S/D (north arm near the Camp Lake discharge) are elevated in comparison to other sample stations and have a median concentration ~0.0007 mg/L. This indicates some amount of existing nickel loading may be occurring from upstream sources.

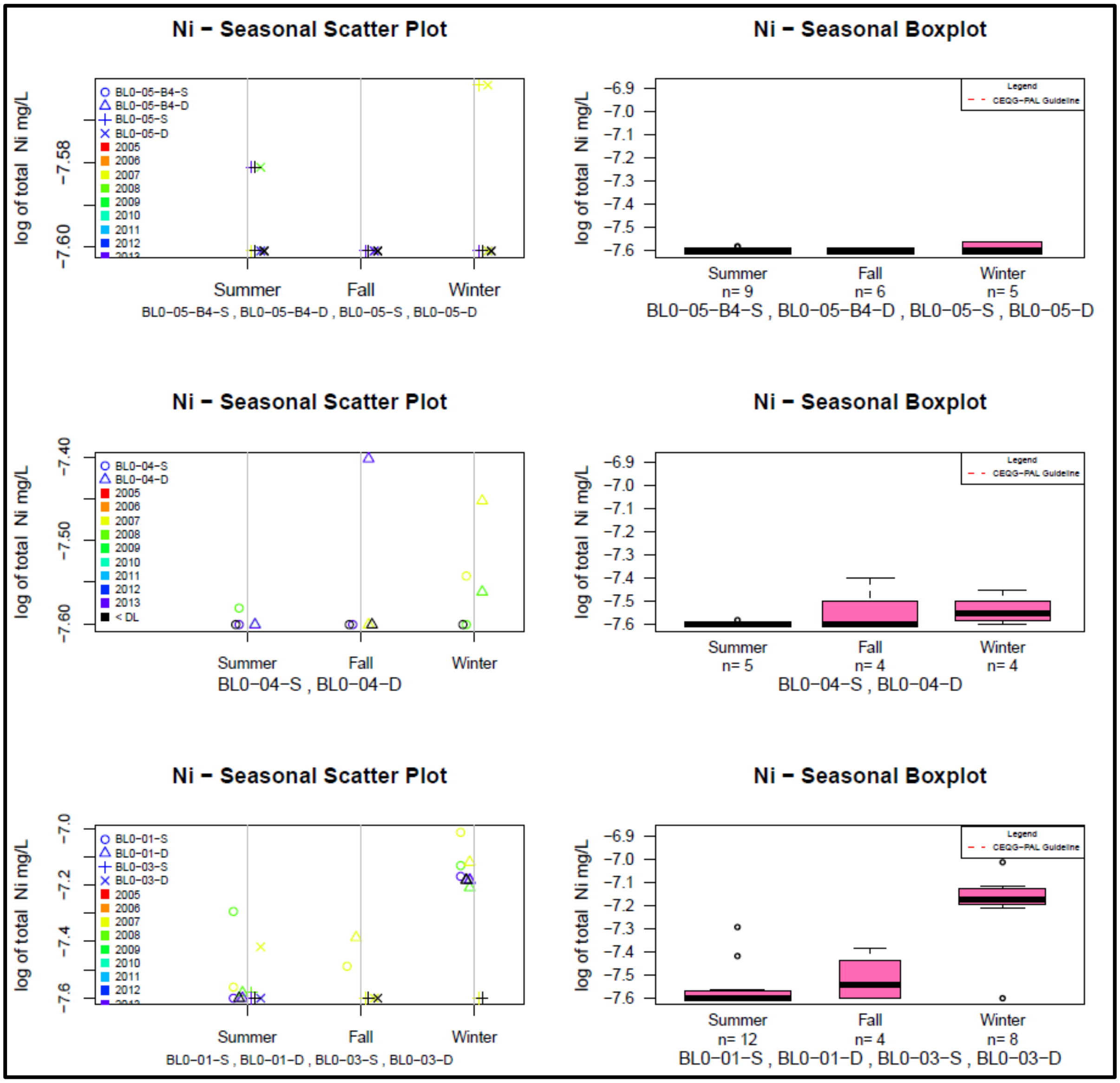
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized en mass to determine overall baseline trends (Figure B.69). Seasonal boxplots indicate summer concentrations are typically depressed when compared to winter concentrations.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.68 Mary Lake – Total Nickel Concentrations in Water



NOTES:

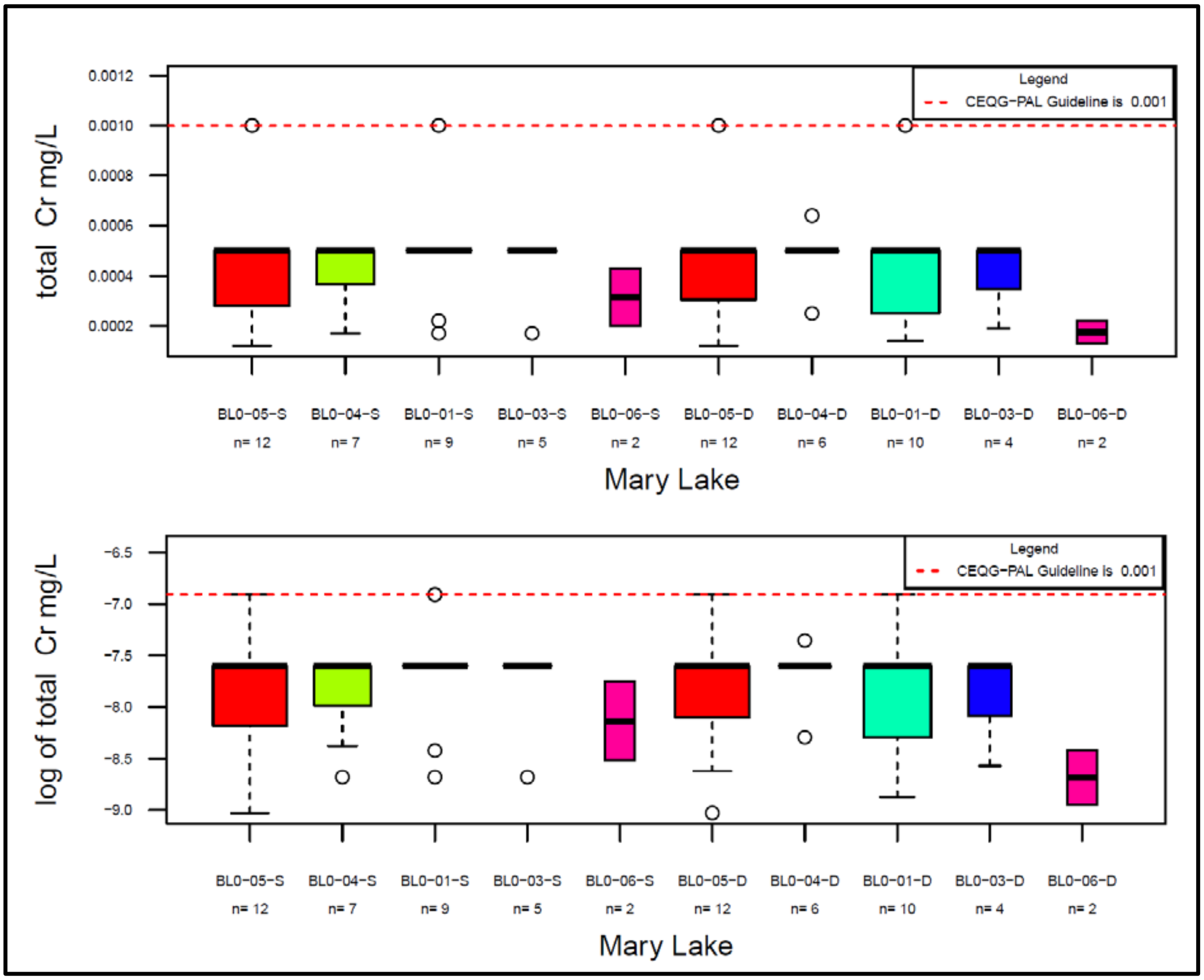
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.69 Mary Lake – Variability of Total Nickel in Water

Total Chromium (Figures B.70 and B.71)

Sixty-nine (69) total chromium concentration samples were collected from Mary Lake over the course of eight years. Total chromium concentrations are low and tend to occur at, below or slightly above detection limits, and well below the CWQG-PAL limit (0.001 mg/L) (Figure B.70). Maximum and outlying concentrations at BL0-05-S/D and BL0-01-S/D reach the guideline limit.

Seasonal scatterplots indicate show that detection limits are defined by applicable years (Figure B.71). Seasonal boxplots do not show any conserved trend throughout sites.

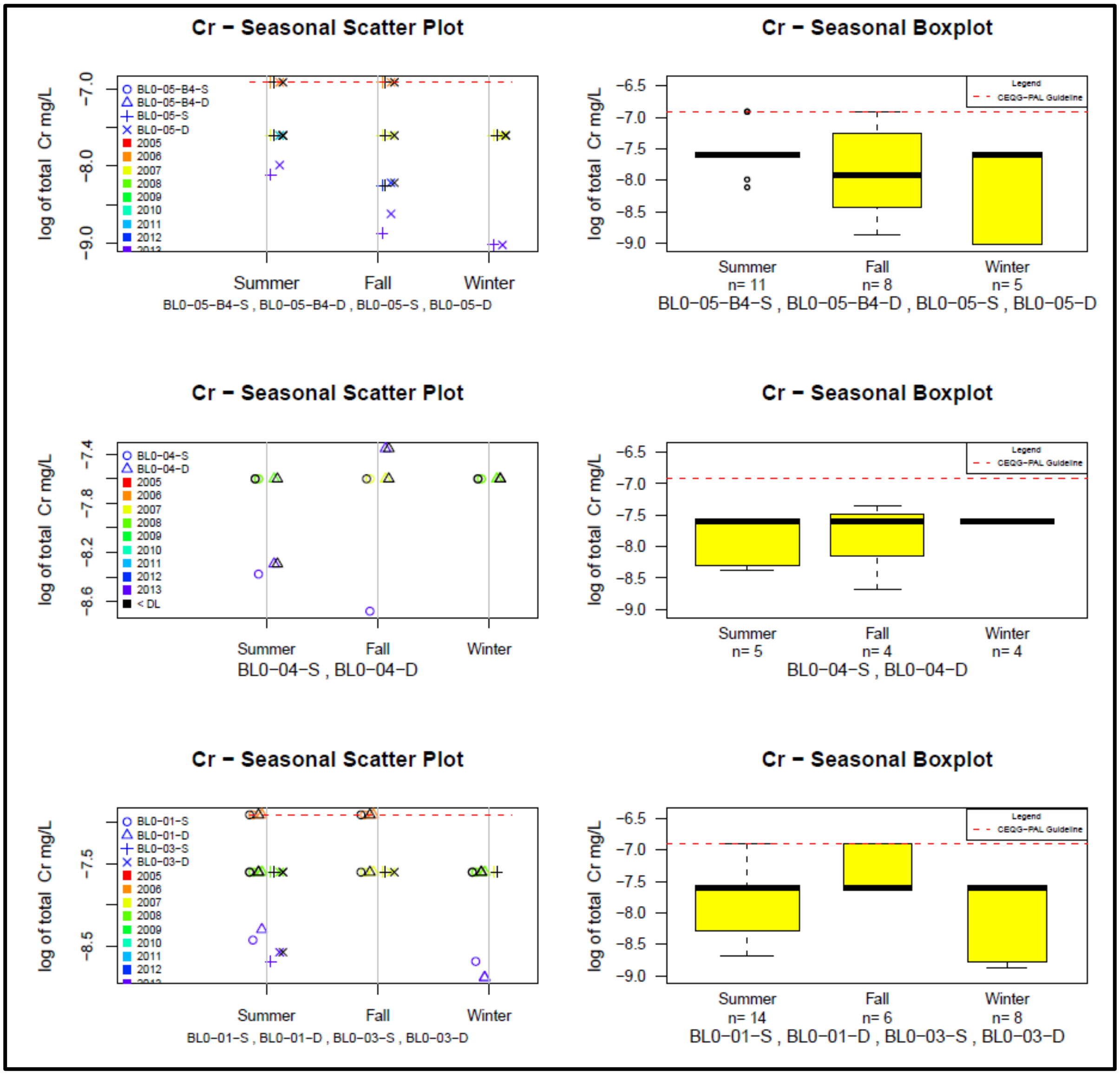


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.70 Mary Lake – Total Chromium Concentrations in Water

Knight Piésold CONSULTING



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.71 Mary Lake – Variability of Total Chromium in Water

Summary of Mary Lake Water Quality

Summary of trends observed during review of Mary Lake baseline water quality data:

- Distinct depth trends were not observed for any parameters within Mary Lake, which suggests complete mixing of the lake. As a result, both deep and shallow station data has been utilized to inform baseline trends in water quality.

- Inlet sampling shows elevated concentrations for certain samples, such as aluminum, chloride, copper, iron, hardness, chromium and nickel.
- Parameters that occur below MDL or do not show seasonal trends include: cadmium, copper, nitrate, and chromium.
- Parameters with the highest concentrations in the summer include: aluminum and iron.
- Parameters with the highest concentration during the fall include: arsenic.
- Parameters with the highest concentration during the winter: chloride, nickel and cadmium.

B.3 POWER ANALYSIS

B.3.1 Methods

Parameter and station-specific power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmark values have been developed for water quality contaminants of potential concern (COPCs) that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 2.7.3 of the main report). Sufficient statistical power is required to ensure that management action is triggered correctly, and this has necessitated the completion of a power analysis. Inputs to the power analyses include all baseline data sampled to date and the proposed benchmark values, which were calculated using the 97.5th percentile of the baseline data. For all lakes in the sampling program, no pre-mining reference data exists; therefore, a complete Before-After-Control-Impact (BACI) analysis cannot be completed. Instead a before-after (BA) design framework was used (Smith, 2002). Once additional baseline data from 2014 and post-mining data is collected, it is anticipated that a Linear Mixed Effects model will be used to test the differences between concentrations measured for pre-mining impact data, pre-mining baseline data, post-mining impact data and post-mining reference data.

The *a priori* power analysis determines, based on a given sample size, variability and effect size[1], the number of samples required to obtain a certain power at a certain alpha value or Type I error rate. Type I error quantifies the probability that a given statistical test will incorrectly reject the null hypothesis or provide a false positive/false alarm. Conversely, type II error occurs when the null hypothesis is false, but fails to be rejected. In other words, to miss something that is actually occurring. Type I and type II error are inversely related. Since the design of the sampling program is conservative and errs on the side of false alarm vs. miss, a greater alpha value (0.10) has been selected to increase power and consequently decrease the type II error. The power analyses presented here are do not account for multiple testing or use Bonferoni or other correction to adjust for experiment wise error rates. Correcting for multiple testing would result in lower nominal type I errors and reduced power for a given sample size.

The power analyses were run based on two effect sizes: 1) the difference between the station baseline mean and benchmark and 2) halfway between the station baseline mean and benchmark.

[1] Effect size is the magnitude of an effect. In a priori power analysis, the effect size quantifies the magnitude difference between two groups that the test will be able to determine.

The following parameters were selected for power analysis as they have a large number of detected values, have elevated concentrations during baseline conditions, are expected to be the most affected parameters during mine operation and are expected to require the largest sample sizes to detect change:

- Aluminum
- Arsenic
- Copper
- Iron
- Cadmium

A short list of sites was compiled from key sites in the proposed CREMP program. The following sites were selected for targeted power analysis:

- Camp Lake:
    - JL0-02-S
    - JL0-09-S
- Sheardown Lake NW:
    - DL0-01-1-S
    - DL0-01-5-S
- Sheardown Lake SE:
    - DL0-02-3-S
- Mary Lake:
    - BL0-01-S
    - BL0-05-S

Two different types of power analysis were run, depending on the proportion of data above MDL. Several modifications to each approach were taken, depending on availability of data at a specific site.

1) The power to detect a change in means was assessed for parameters with sufficient data above MDL (<15% of non-detected data). A before-after (BA) design was used when control data was not available and power analysis was carried out using a two sample t-test to compare means. This approach is less rigorous when compared to the BACI design and does not control for natural temporal changes.

   For the purposes of analysis, for parameters with <15% non-detected data, only detected data was analyzed. This method was selected due to a variety of detection limits present in the historic data. In some cases, imputation of detection limits occurred, as discussed in Section 2.2. Although all imputation assumptions were conservative; analysis of the detected data removes the possibility that data analysis was affected by imputation or elevated detection limits. To verify the use of the detected data to inform mean values for the power analysis, the mean values estimated with detected data are compared to the mean values estimated via Regression on Order (ROS) method. The Regression on Order (ROS) statistics method is recommended by the BC Ministry of Environment as a method to calculate statistics in data sets including non-detects and especially those affected by left-censored data (Huston and Juarez-Colunga, 2009). Both of these values are provided for each key parameter examined for the sake of comparison. In general, the mean estimate based on detected data is larger than the ROS estimate. This is conservative for the power analysis as a higher baseline mean corresponds to a smaller change to be detected post mining.

2) The power to detect a change in the proportion of values above MDL was assessed for parameters with a large proportion of values below MDL (>15% of non-detected data). For some parameters the baseline dataset is represented predominantly by values below MDL. This occurred for arsenic and cadmium at all stations. For these parameters, the exact magnitude of the parameters under baseline conditions is unknown. Although a full BACI analysis will be carried out for data analysis purposes, simplified designs were assumed for the power analysis. Two approaches were utilized for the test of proportions:

   a. BA designs were assessed using a test for two independent proportions (Agresti, 1990).

   b. McNemar's test (Agresti, 1990) was used to assess the power to detect a difference between the paired proportions at impact and control stations. As for continuous data, pairing allows exploitation of the fact that the variance of the difference between paired data is smaller than the variance of the difference between independent samples (Agresti, 1990). Under a full BACI design, the baseline and post-mining paired proportions can be compared to assess whether a change is mine related.

McNemar test for the equivalence of paired proportions (each impact sample paired with a correlated control sample collected at a comparable time) is carried out using the off-diagonal elements (p01 and p10) of a 2x2 contingency table. It is helpful to reference Table B.5 for discussions related to the analysis of proportions. This is a novel approach that enables the use of data highly affected by censored data, where a meaningful comparison of means is not possible and the utility of left-censored methods is limited. To our knowledge, this approach has not been used in other projects, but is supported within scientific literature as a valid method to deal with left-censored data (Agresti, 1990).

Table B.5 Proportion Labels for 2x2 Contingency Table

	Control		
Impact	<MDL	>MDL	Total
<MDL	p_{00}	p_{01}	p_{0+}
>MDL	p_{10}	p_{11}	p_{1+}
Total	p_{+0}	p_{+1}	p_{++}

For lakes, both shallow and deep sites were sampled at the same location at the same time. Although baseline results did not indicate stratification occurs in any of the lakes, the sampling program will continue to sample deep and shallow stations separately, with the hypothesis that mine-related effects could have different depth affects. Data from two depths will be analyzed separately. The power analysis presented here considers shallow stations. Sample size, median, mean, standard deviation and power were compared power between sites for a variety of lake sites. In general, sample sets that have a lower sample size, higher variability and a small difference from station baseline mean and benchmark have low power.

B.3.2 Results

Since the power analysis was completed on a site-specific and parameter-specific basis, the results were interpreted by identifying the sites and parameters that are most constraining. Table B.6 highlights the sites and parameters that are expected to constrain analysis. It is not unexpected that aluminum is a constraining factor across a number of sites since aluminum is the most enriched metal during baseline conditions. Analysis of Figure B.3 shows that sites identified as constraining factors for aluminum concentrations are those sites where the distribution of aluminum data occurs close to the benchmark. Subsequent discussion of each parameter follows individually in Section B.3.2.1 through Section B.3.2.3.

Table B.6 Lake Power Analysis – Constraining Sites and Parameters

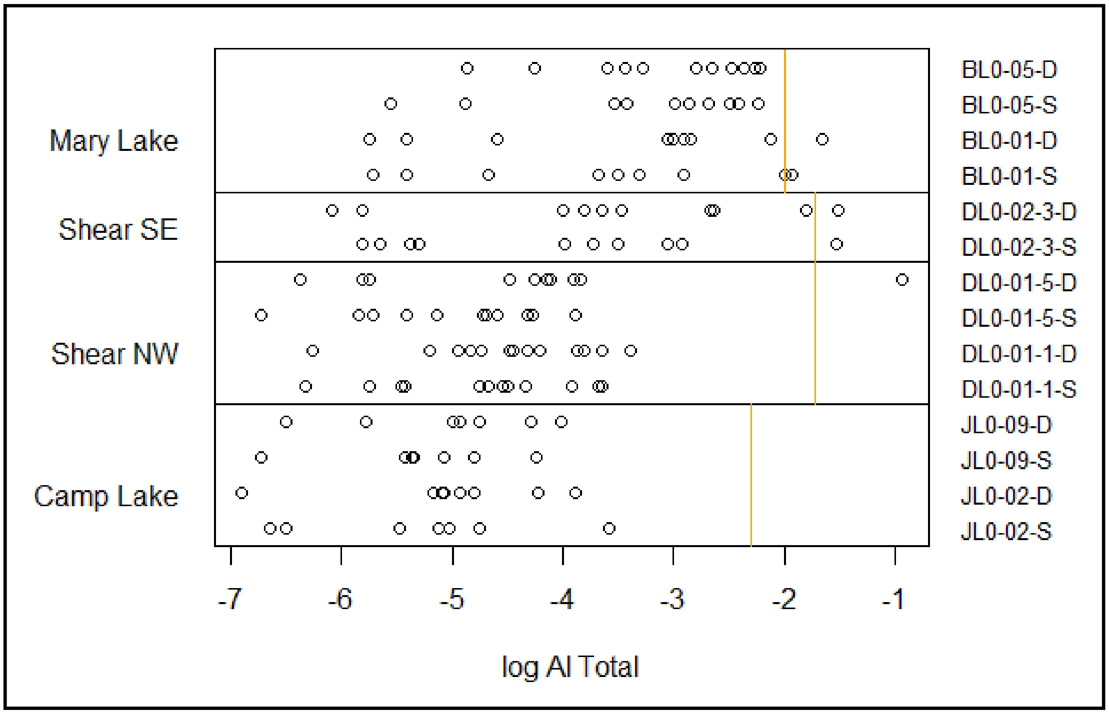
Parameter	Site	Waterbody	Power (given sample size of 10, alpha of 0.1)	Power (given sample size of 50)
Aluminum	DL0-02-3-S	Sheardown Lake SE	50%	78%
	BL0-01-S	Mary Lake	38%	58%
	BL0-05-S	Mary Lake	30%	58%
Copper	BL0-01-S	Mary Lake	30%	38%
Iron	BL0-01-S	Mary Lake	50%	75%

NOTES:

1. POWER IS CALCULATED BASED ON AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION BASELINE MEAN AND BENCHMARK.

B.3.2.1 Aluminum

Total aluminum values are elevated throughout the mine-site area and are noticeably elevated at sites within Sheardown Lake SE and Mary Lake (median aluminum ranges from 0.024 mg/L to 0.061 mg/L between individual sites) when compared to values in Camp Lake and Sheardown Lake NW (median aluminum ranges from 0.0059 mg/L to 0.0093 mg/L between individual sites). Sufficient power is expected to be obtained for sites examined within Camp Lake (JL0-1-S/D, JL0-2-S/D, JL0-09-S/D) and Sheardown Lake (DL0-01-1-S/D and DL0-01-5-S/D) with 5 samples. In contrast, approximately fifty (50) samples are expected to be required within Sheardown Lake SE and Mary Lake. Figure B.72 demonstrates that sites within Sheardown Lake and Mary Lake have a distribution of aluminum values very close to the benchmark. In contrast, Camp Lake and Sheardown Lake SW have a distribution of aluminum values further from the benchmark. Values in Table B.7 show that a higher standard deviation also characterizes data from Sheardown Lake SE and Mary Lake.



NOTES:

1. THE CAMP LAKE BENCHMARK FOR ALUMINUM IS 0.1 mg/L (LOG VALUE = -2.3).
2. THE SHEARDOWN LAKE BENCHMARK FOR ALUMINUM IS 0.179 mg/L (LOG VALUE = -1.72).
3. THE MARY LAKE BENCHMARK FOR ALUMINUM IS 0.137 mg/L (LOG VALUE = -1.99).

Figure B.72 Baseline Aluminum Values with Respect to the Benchmark

Table B.7 Results of Aluminum Power Analysis - Lakes

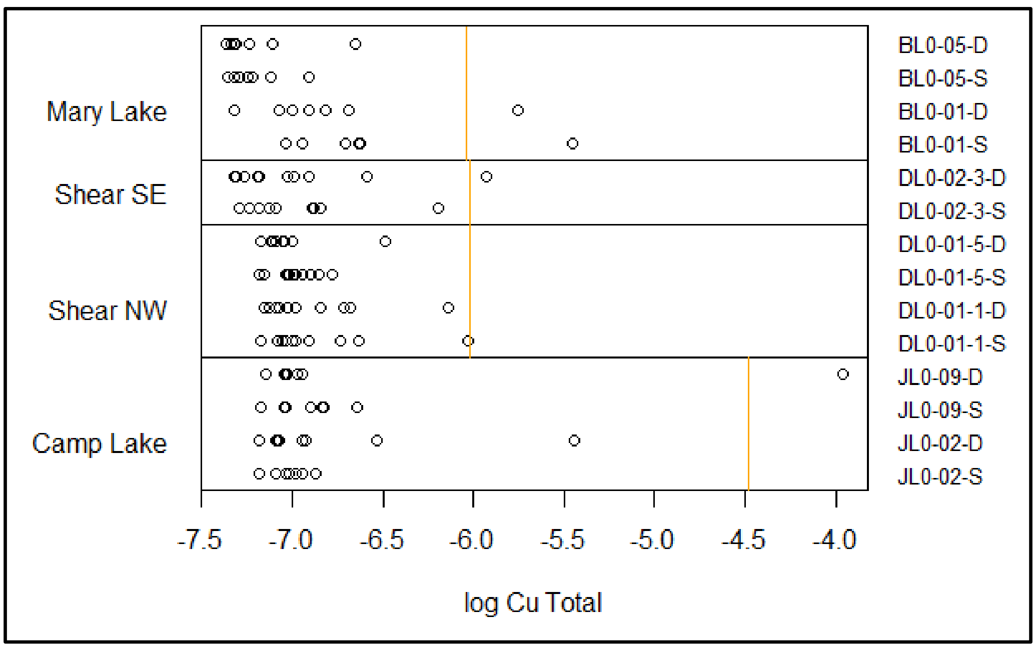
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	N Required	N Required (half benchmark)[1]
Camp Lake											
JL0-02-S	8	8	0.0063	0.01	-5.23	1.00	-5.23	0.1	-2.30	2.93	5
JL0-02-D	9	8	0.0068	0.01	-4.79	0.48	-4.91	0.1	-2.30	2.49	5
JL0-09-S	7	7	0.0048	0.00	-5.28	0.76	-5.28	0.1	-2.30	2.98	5
JL0-09-D	7	7	0.0072	0.01	-5.04	0.86	-5.04	0.1	-2.30	2.73	5
Sheardown Lake NW											
DL0-01-1-S	13	13	0.0093	0.01	-4.80	0.82	-4.8	0.18	-1.72	3.08	5
DL0-01-1-D	13	13	0.012	0.01	-4.47	0.76	-4.47	0.18	-1.72	2.75	5[2]
DL0-01-5-S	11	11	0.0089	0.01	-5.03	0.83	-5.03	0.18	-1.72	3.31	5
DL0-01-5-D	11	10	0.015	0.12	-4.20	1.42	-4.22	0.18	-1.72	2.48	5[2]
Sheardown Lake SE											
DL0-02-3-S	10	9	0.024	0.07	-3.89	1.36	-4.23	0.18	-1.72	2.17	50
DL0-02-3-D	10	9	0.031	0.07	-3.29	1.36	-3.40	0.18	-1.72	1.57	50[2]
Mary Lake											
BL0-01-S	9	9	0.030	0.05	-3.68	1.36	-3.68	0.14	-1.99	1.69	50
BL0-01-D	10	10	0.048	0.06	-3.71	1.53	-3.71	0.14	-1.99	1.72	50[2]
BL0-05-S	11	11	0.057	0.04	-3.21	1.09	-3.21	0.14	-1.99	1.22	50
BL0-05-D	11	11	0.061	0.04	-3.11	0.87	-3.11	0.14	-1.99	1.12	50[2]

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR SITES.

B.3.2.2 Copper

Total copper values are observed to be elevated site-wide and are particularly elevated within Mary River and Camp Lake tributary. Although total copper concentrations are reduced in lake sites compared to stream sites, certain sites remain elevated. The copper benchmark in Sheardown Lake and Mary is the same (0.0024 mg/L) and the Camp Lake benchmark is slightly higher (0.011 mg/L). Based on the existing baseline data, five baseline samples are expected to provide sufficient power to detect changes between baseline mean and halfway between baseline mean and the benchmark value (comparisons on log scale) at all sites within Camp Lake, at DL0-01-5-/S/D (Sheardown Lake NW) and DL0-02-3-S/D (Sheardown Lake SE) and BL0-05-S/D (Mary Lake). Ten post-mining samples are expected to be sufficient at DL0-01-1-S/D. As show on Figure B.73, the BL0-01-S/D site has a distribution of data which falls on either side of the benchmark. Due to the elevated median values and high variability, with the current baseline data it is estimated 50 samples would be required to show significance for the sites examined in Mary Lake; however, even with collection of 50 samples the power to detect change would only be 38%. With collection of additional baseline data in 2014, the power to detect change for copper is expected to increase.



NOTES:

1. THE CAMP LAKE BENCHMARK FOR COPPER IS 0.011 mg/L (LOG VALUE = -4.5).
2. THE SHEARDOWN LAKE BENCHMARK FOR COPPER IS 0.0024 mg/L (LOG VALUE = -6.0).
3. THE MARY LAKE BENCHMARK FOR COPPER IS 0.0024 mg/L (LOG VALUE = -6.0).

Figure B.73 Baseline Copper Values with respect to the Benchmark

Table B.8 Results of Copper Power Analysis - Lakes

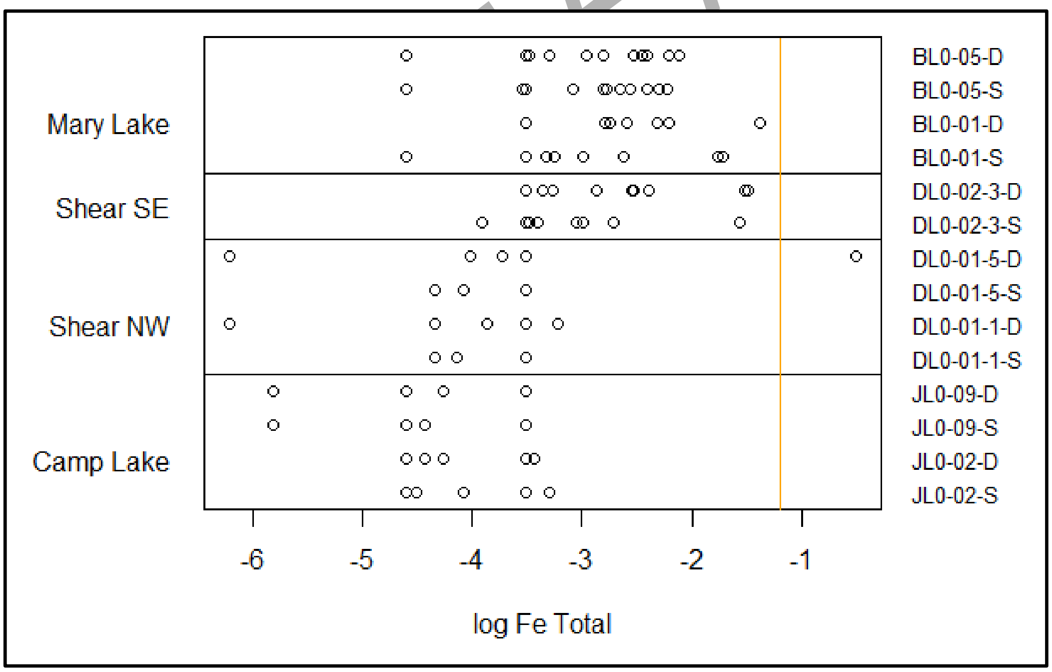
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	Benchmark Value (mg/L)	Log <Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
JL0-01-S	12	10	0	0.00076	-6.8	0.44	0.011	-4.5	2.3	5[2]
JL0-01-D	10	8	0	0.0043	-6.6	0.94	0.011	-4.5	2.1	5[2]
JL0-02-S	8	8	0	0.00008	-7.0	0.09	0.011	-4.5	2.5	5
JL0-02-D	9	9	0	0.0011	-6.8	0.55	0.011	-4.5	2.3	5[2]
JL0-09-S	7	7	0	0.00018	-6.9	0.18	0.011	-4.5	2.4	5
JL0-09-D	7	7	0	0.0068	-6.6	1.2	0.011	-4.5	2.1	5[2]
DL0-01-1-S	11	11	0	0.00046	-6.9	0.32	0.0024	-6.0	0.85	10
DL0-01-1-D	11	11	0	0.00040	-6.9	0.30	0.0024	-6.0	0.88	10[2]
DL0-01-5-S	11	11	0	0.00011	-7.0	0.12	0.0024	-6.0	0.97	5
DL0-01-5-D	11	11	0	0.00021	-7.0	0.18	0.0024	-6.0	0.99	5[2]
DL0-02-3-S	10	10	0	0.00040	-7.0	0.32	0.0024	-6.0	0.97	5
DL0-02-3-D	10	10	0	0.00061	-7.0	0.43	0.0024	-6.0	0.95	5[2]
BL0-01-S	7	7	0	0.0012	-6.6	0.53	0.0024	-6.0	0.55	50[6]
BL0-01-D	10	10	0	0.00071	-6.8	0.41	0.0024	-6.0	0.77	NA
BL0-05-S	9	9	0	0.00011	-7.2	0.13	0.0024	-6.0	1.2	5
BL0-05-D	9	9	0	0.00021	-7.2	0.23	0.0024	-6.0	1.2	5

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR SITES.
3. NA SITES WERE NOT ASSESSED.
4. TOTAL SAMPLE SIZE REPRESENTS THE NUMBER OF MEASURED SAMPLES AT EACH SITE (EXCLUDING NON-DETECTS).
5. THERE ARE NO NON-DETECT VALUES AT THIS SITE; THEREFORE, THE ROS LOG MEAN IS THE SAME AS THE LOG MEAN CALCULATED AND IS NOT PRESENTED.
6. SAMPLE SIZE REQUIRED FOR BL0-01-S IS AFFECTED BY OUTLIER VISIBLE IN FIGURE B.73.

B.3.2.3 Iron

Total iron concentrations are slightly elevated site-wide, but greater iron concentrations were observed in streams than rivers. There is a significant deficit of detection iron data at Camp Lake and Sheardown Lake NW. Due to the low numbers of detected samples, sample size cannot be estimated for Camp Lake and Sheardown Lake NW. Baseline sampling during 2014 is recommended to increase the sample size at these sites, or, alternately, an approach that considers non-detects is required. Approximately ten post-mining samples are expected to be sufficient to determine significant differences between baseline impact and post-mining impact sites within Sheardown Lake SE. The recommended sample size for Mary Lake is problematic, particularly for the BL0-01-S site. This site has among the highest mean and median iron values, in addition to elevated variability and relatively small sample size. Even with collection of fifty samples at BL0-01-S, power at this station does not exceed 75%. Similar to other parameters, additional baseline data from 2014 is expected to increase power for iron at this site.



NOTES:

1. THE BENCHMARK FOR IRON IN ALL LAKES IS 0.3 mg/L (LOG VALUE = -1.2).

Figure B.74 Baseline Iron Values with Respect to the Benchmark

Table B.9 Results of Iron Power Analysis - Lakes

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
Camp Lake											
JL0-02-S	8	3	0.017	0.014	-4.0	0.61	-4.5	0.3	-1.2	2.8	-
JL0-02-D	9	3	0.014	0.011	-4.0	0.53	-4.6	0.3	-1.2	2.8	-
JL0-09-S	7	1	0.012	NA	-4.4	NA	-4.4	0.3	-1.2	3.2	-
JL0-09-D	7	1	0.014	NA	-4.3	NA	-4.2	0.3	-1.2	3.1	-
Sheardown Lake NW											
DL0-01-1-S	13	5	0.030	0.009	-3.8	0.41	NA	0.3	-1.2	2.6	-
DL0-01-1-D	13	4	0.017	0.016	-4.4	1.3	-4.4	0.3	-1.2	3.2	-
DL0-01-5-S	11	4	0.024	0.009	-3.9	0.42	NA	0.3	-1.2	2.7	-
DL0-01-5-D	11	6	0.027	0.236	-3.6	1.8	NA	0.3	-1.2	2.4	-
Sheardown Lake SE											
DL0-02-3-S	10	7	0.047	0.066	-3.0	0.75	NA	0.3	-1.2	1.8	10
DL0-02-3-D	10	8	0.079	0.076	-2.5	0.70	-2.8	0.3	-1.2	1.3	10[2]
Mary Lake											
BL0-01-S	9	7	0.050	0.068	-2.9	1.00	NA	0.3	-1.2	1.7	50
BL0-01-D	10	8	0.070	0.071	-2.6	0.70	-3.0	0.3	-1.2	1.4	-
BL0-05-S	11	9	0.070	0.025	-2.7	0.41	-2.9	0.3	-1.2	1.5	5
BL0-05-D	11	11	0.060	0.036	-2.9	0.74	-2.9	0.3	-1.2	1.7	5[2]

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR SITES.
3. IF INSUFFICIENT SAMPLE SIZE IS AVAILABLE, NO VALUE FOR N WAS PROVIDED.

B.3.2.4 Cadmium, Arsenic and Iron Proportions

The proportion of data below MDL was determined for each of the target parameters at selected stations. Cadmium, Arsenic and iron were identified as requiring analysis of proportions (Figure B.10). A normal approximation has been used to estimate the width of the confidence interval on the proportion of values below (above) MDL for given sample sizes (Table B.10). For analysis purposes, when the proportion of non-detects is close to 100%, an exact test will be used.

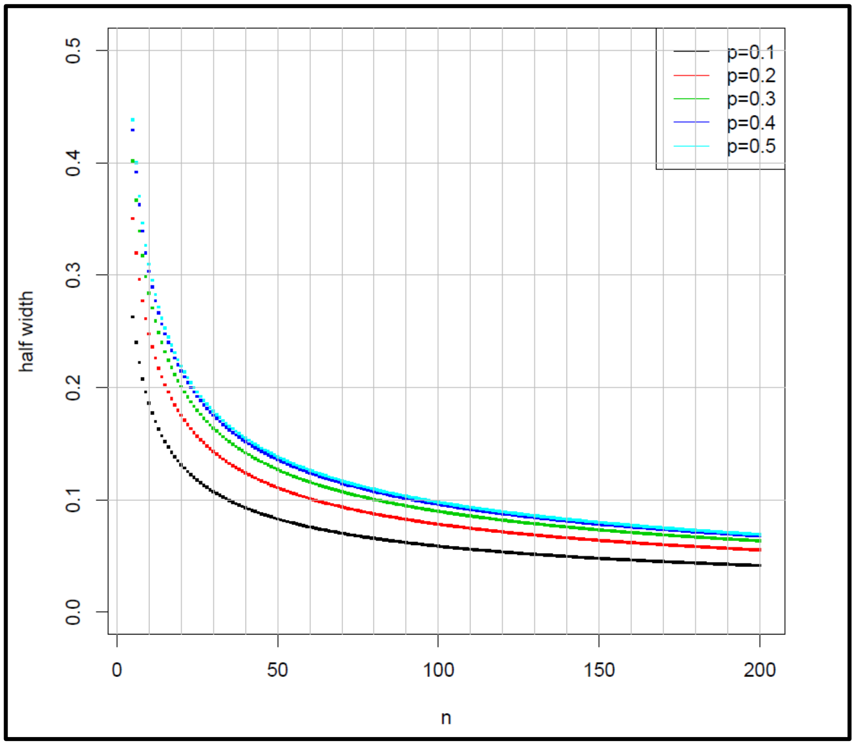
In order to assess statistical power to detect a change in the proportion of values below (or above) MDL from baseline to post-mining, we present a table of the sample sizes required. We see that a sample size of 12 is sufficient to show a change from 30% to 80%; a sample size of 8 is sufficient to show a difference between 20% and 80%.

Table B.10 Sample Size Required to Obtain 80% Power

	Proportion Above (below) MDL Post Mining				
Baseline Proportion Above (below) MDL	0.4	0.5	0.6	0.7	0.8
0.2	64	31	18	12	8
0.3	281	74	33	19	12
0.4	NA	305	77	33	18

NOTE:

1. Sample size required for baseline and post-mining to obtain 80% power with a two-sided type I error of 0.05 (or one-sided type I error of 0.05.



NOTES:

2. FOR THIS GRAPH, P = PROPORTION OF VALUES BELOW MDL/NON-DETECT.
3. THE CONFIDENCE INTERVAL WIDTHS ARE SYMMETRIC AROUND P=0.5. THERFORE P=0.1 AND 0.9; P=0.2 AND 0.8; P=0.3 AND 0.7; P=0.4 AND 0.6.

Figure B.75 Half 95% Confidence Interval Width

B.3.3 Recommendations

Power analysis completed for a subset of parameters at select areas is expected to be used to detect change at critical locations for most parameters. Parameters used here are indicator parameters, which are expected to have small effects sizes and represent the most number of samples required to be collected. There are two major factors that evidently constrain the power analysis for the lake samples. First, elevated aluminum concentrations create difficulties obtaining sufficient power, especially within Mary Lake and one site in Sheardown Lake SE. Second, the BL0-01-S site has high concentrations of aluminum, copper and iron, in addition to high variability. This site is predicted to have very low power, even with sample sizes as great as fifty.

As a result of these analyses, the following are recommended to augment the study design:

1. Increase the amount of baseline data (this will occur during the 2014 season of baseline data collection that will occur concurrently with mine construction but prior to mine effluent or dust emission);
2. Collect data at one more station within Sheardown Lake SE (recommend DL0-02-6)
3. Add two sites at the inlet location of Mary Lake near BL0-01 to ensure sufficient power to detect changes at this key location.

4. Add one additional site to the inlet location of Mary Lake near BL0-05 to ensure sufficient power to detect changes at this key location.
5. Add two to three lake reference sites for post-mining data collected. Ideally these sites should be consistent with the EEM reference sites.
6. Ensure that samples collected at all locations are collected as close to the same day and time as possible.
7. Three yearly samples are recommended to be collected during the first three-years of mine operation.

B.4 CONCLUSIONS

The only distinct depth trends are noted in Sheardown Lake for aluminum. The rest of the lake data gathered a lake stations suggests aggregations of deep and shallow stations is appropriate.

Table B.11 summarizes the trends observed in the data.

B.5 REFERENCES

Agresti, A, 1990. *Categorical Data Analysis*. Wiley Series, New York.

Huston, C. and Juarez-Colunga, E. 2009. Guidelines for computing summary statistics for data-sets containing non-detects. Written for the Bulkley Valley Research Center with assistance from the B.C. Ministry of Environment.

Intrinsik Environmental Sciences Inc., 2014. *Development of Water and Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project.* Intrinsik Project No. 30-30300.

Smith, E. 2002. BACI Design. Encyclopedia of Environmetrics. John Wiley and sons.1(141-148).

Table B.11 Summary of Trend Analysis in Area Lakes

Trend	Camp Lake	Mary Lake	Sheardown Lake NW	Sheardown Lake SE
Distinct depth trends	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate	Al slightly elevated in deeper samples, suggest lake completely mixed; aggregation of depth and shallow sites appropriate for all parameters except Al	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate
Geographic trends between discrete sampling sites	Not observed	Slightly elevated concentrations of Al, Cl, Cu, Cr, Fe, hardness and Ni observed at inlet; elevated As concentrations observed at outlet	Little variability	Cu, Fe and Ni (slightly elevated concentrations at DL0-02-4)
Distinct inter annual trends	Chloride and Cr (2011 to 2013 concentrations elevated compared early data)	Fe (2013 data slightly lower concentration than previous years) , Cd (detection limits decreased over course of sampling), Ni (elevated during 2007 winter)	Cd and Fe (decrease in detection limits over years)	Cu and Ni (early data from 2007-2008 elevated compared to more recent data)
Parameters below MDLs and / or do not show seasonal trends	Cl, Cd, As, Fe, nitrate	Cd, Cu, Cr, nitrate	As, Cd, Cl, Cr, Cu, nitrate, Fe	As, Cd, nitrate, Cr and Cu.
Parameters with maximum concentrations during summer	Al, nitrate	Al, Fe		Al (and fall), Fe
Parameters with maximum concentrations during fall	Cr	As	Al	
Parameters with maximum concentrations during winter	Cu (and summer), Ni (and summer)	Cl, Ni, Cd	Ni	Cl, Ni

APPENDIX C

DETAILED REVIEW OF BASELINE STREAM WATER QUALITY

(Pages C-1 to C-70)

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DETAILED REVIEW OF BASELINE STREAM WATER QUALITY
NB102-181/33-1C

Rev	Description	Date
1	Issued in Final	May 30, 2014

Knight Piésold Ltd.
1650 Main Street West
North Bay,Ontario Canada P1B8G5
Telephone: (705) 476-2165
Facsimile: (705) 474-8095
www.knightpiesold.com

Knight Piésold CONSULTING

TABLE OF CONTENTS

PAGE

TABLE

FIGURES

C – STREAM WATER QUALITY REVIEW

C.1 OVERVIEW

A detailed review of water quality within the mine site streams was undertaken to facilitate the development of the Core Receiving Environment Monitoring Program (CREMP) for water and sediment quality. The review adopted the same approach applied to the detailed review of lake water quality presented in Appendix B. As stated in Section 1.2 of the main report, the objectives of the baseline review were as follows:

- Identify data quality issues
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water quality in the mine site area
- Understand the seasonal and inter-annual variability of water quality
- Understand natural enrichment of the mine site area waters
- Determine the potential to pool data from multiple sample stations to increase the statistical power of the baseline water quality dataset
- Develop study designs for monitoring water quality in mine site streams and lakes
- Determine if changes to the existing water quality monitoring program are required to meet monitoring objectives

The focus of this review of stream water quality is the two main receiving waters of mine effluent, which are also close to the Project mining area that will be exposed to ore dust deposition: Camp Lake Tributary 1 (CLT-1) and the Mary River.

Parameters of interest in the baseline review included water quality stressors of potential concern (SOPCs) identified on the basis of the existence of an established water quality guideline, as well as other factors such as Exposure Toxicity Modifying Factors (ETMF): pH, water hardness, dissolved organic carbon, etc., and indicator parameters (alkalinity, chloride, nitrate). Baseline water quality data was compared to Canadian Council of Ministers of the Environment (CCME) – Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-PAL). The focus was on total concentrations (versus dissolved) since CWQG-PAL guidelines are developed for total concentrations. The parameters of interest are displayed graphically in box plots. The box plots are used to portray natural ranges of selected parameters. Concentration data measured for the parameters of interest has been log transformed and further analyzed to investigate the possibility of aggregating data, bearing in mind:

- Seasonal variability (between spring, summer and fall samples)
- Inter-annual variability (from 2006 through 2008 and 2011 through 2013)

To assist in the development of study designs, parameter and station-specific a priori power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmark values were developed for the identified SOPCs that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 2.7.3 of the main report). Draft benchmarks were applied in the power analysis of the baseline presented in this detailed review.

The resultant study design for the monitoring of Project-related effects to water quality is presented in Section 2.7 of the main report.

C.2 STREAM FLOW CHARACTERISTICS

Stream water quality sampling was completed within the drainages, streams and rivers in vicinity to the mine station from 2005 through 2008 and 2011 through 2013. The most comprehensive sampling was conducted in 2007.

The streams and rivers in the study area typically flow in early June and stop flowing in the second half of September. The hydrograph developed from the H6 stream gauge on the Mary River is presented as Figure C.1. Smaller creeks typically run dry and/or freeze earlier than the Mary River. Only the largest rivers in the area such as the Ravn River or the Rowley River flow during the winter.

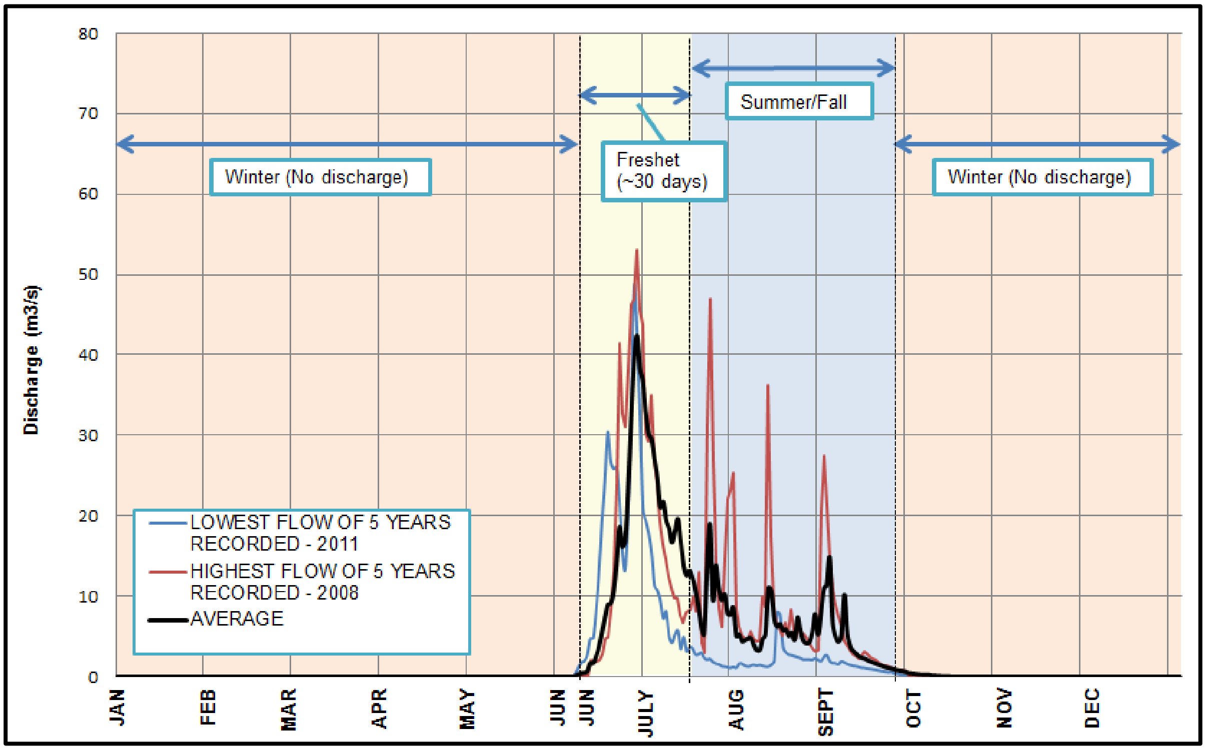


Figure C.1 Hydrograph of Stream Gauge H6 on the Mary River (2008-2011)

Understanding the flow regime at the station is an important backdrop to understanding the seasonal differences.

A review of the baseline data for each of the streams in vicinity to the mine site is provided below.

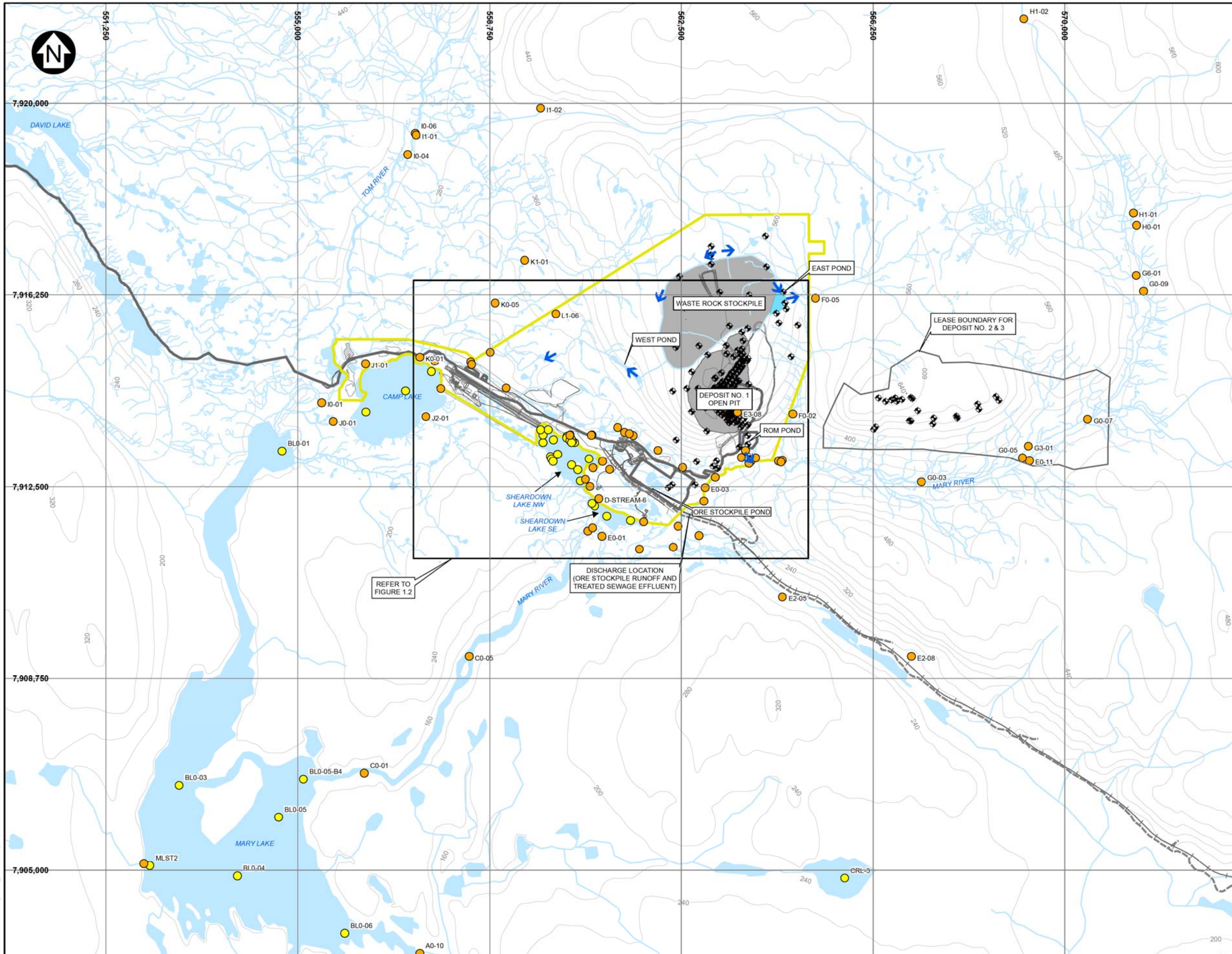
C.3 BASELINE SUMMARY

C.3.1 Mary River

Water quality samples within Mary River have been collected from 2005 through 2013, at a number of stations along the Mary River. The following 11 stations were selected as applicable for future CREMP monitoring and are discussed in detail below. A total of 351 samples from these 11 stations on Mary River were collected. Most sampling was completed during the summer season, from July through August. The greatest number of samples was collected during 2007 and 2008. Starting upstream of the mine station working downstream to Mary Lake, the sample stations are described below (Figures C.2 and C.3):

- G0-09: This is the most upstream station on the mainstem of the Mary River. This station will remain an upstream control station that will remain unaffected by mine-affected seepage or mine-affected dust particulate.
- G0-03: This station is on Mary River mainstem, downstream from G0-09, but upstream of any mine-related effluent effects.
- G0-01: This station is located on Mary River mainstem, immediately upstream of the confluence with the F-Tributary to which the east waste rock stormwater pond will discharge.
- E0-10: This station is located on the Mary River mainstem, immediately downstream of the F-tributary confluence. During operation of the proposed mine, seepage effects from the East Pond could potentially affect water quality at this station.
- E0-03: This station is located on the Mary River mainstem, downstream of the proposed ROM Pond discharge.
- E0-04: This station is located on the Mary River mainstem, downstream of the proposed ROM Pond discharge and immediately downstream of E0-03.
- E0-21: This station is located on the Mary River mainstem and is located downstream of all potential mine effects and is being considered as a “near-field” exposure station for the EEM program.
- E0-20: This station is located on the Mary River mainstem and is located downstream of all potential mine effects. The station is also located immediately downstream of station E0-21.
- C0-10: This station is located on the Mary River mainstem and is located downstream of all potential mine effects.
- C0-05: This station is located on the Mary River mainstem and is located downstream of all potential mine effects and is being considered as a “far-field” exposure station for the EEM program.
- C0-01: This station is located on the Mary River mainstem near the mouth, downstream of all potential mine effects. The station is being considered as an alternate “far-field” exposure station for the EEM program.

To simplify discussion and determine whether data aggregation would be appropriate, the stations above have been discussed in regard to seasonal and inter-annual variability, due to very similar water quality characteristics:



LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS MINE SITE AREA

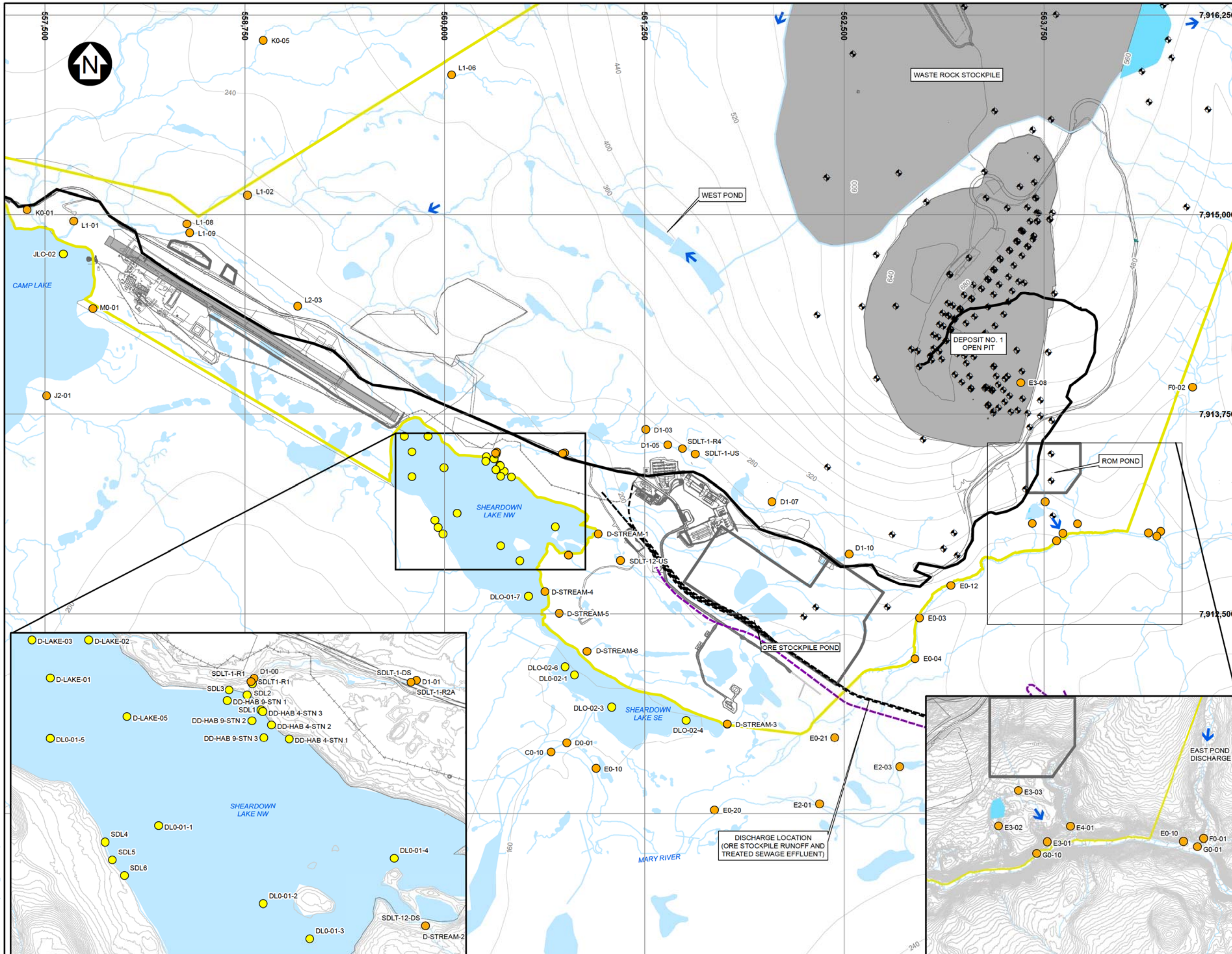
Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE C.2 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\B42_r1.mxd; May 30, 2014 1:15 PM; skozmick



LEGEND:

- LAKE SAMPLE LOCATION
- STREAM SAMPLE LOCATION
- DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- POTENTIAL DEVELOPMENT AREA (PDA)
- PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 250 125 0 250 500 750 1,000 1,250 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	EJA	SWK	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\B43_r1.mxd; May 30, 2014 1:21 PM; skozmick

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS IMMEDIATE MINE SITE AREA

Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE C.3 | REV 1

- G0-09, G0-03, E0-10 and G0-01: These stations represent upstream control stations that are expected to remain relatively unaffected by mine development (except perhaps by dust deposition). All stations, except E0-10 will also act as control stations once the proposed mine commences operation.
- E0-03, E0-21, E0-20: These stations have similar water quality and represent near-field exposure stations during operation of the proposed mine.
- C0-10, C0-05, C0-01: These stations have similar water quality and represent far-field exposure stations during operation of the proposed mine.

A summary of the data collected during each season, with respect to year and station are included in Table C.1. A graphical representation of the sampling events is provided in Figure C.4.

Table C.1 Mary River Sample Size

Year	Summer	Fall	Winter
2005	5	5	5
2006	16	31	17
2007	12	39	32
2008	6	50	33
2009	5	14	10
2010	0	4	4
2011	0	5	7
2012	8	9	8
2013	8	9	9
Station	**Summer**	**Fall**	**Winter**
G0-09	8	26	18
G0-03	7	16	13
G0-01	6	23	16
E0-10	7	26	15
Station	**Summer**	**Fall**	**Winter**
E0-03	10	28	21
E0-04	0	1	1
E0-21	2	2	3
E0-20	2	2	3
C0-10	10	27	21
C0-05	2	3	4
C0-01	6	12	10

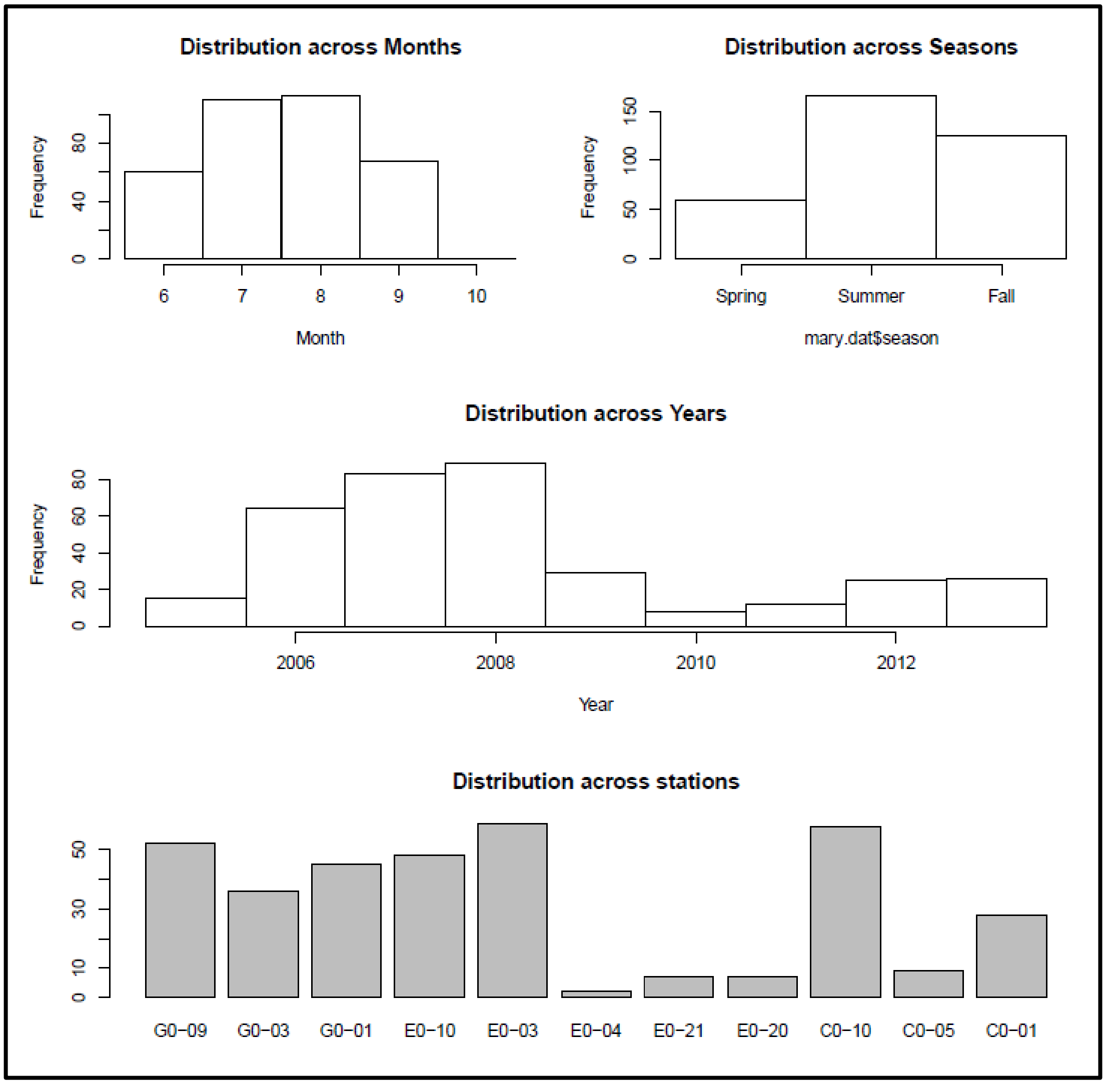


Figure C.4 Mary River – Graphical Summary of Sampling Events

The following summarizes the data review observations for the of the physical parameter data. Box plots that follow present upstream on the far left, moving downstream towards the right.

pH (Figure C.5)

- Mary River is slightly alkaline, with total median pH of 7.87 (range from 6.26 to 8.5).
- No distinct geographic trends were noted.

Alkalinity (Figure C.6)

- Mary River stations have uniformly high median alkalinity values that range from 40 to 50 mg/L $CaCO_3$, with maximum alkalinity values reaching close to 120 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.
- No distinct geographic trends were noted.

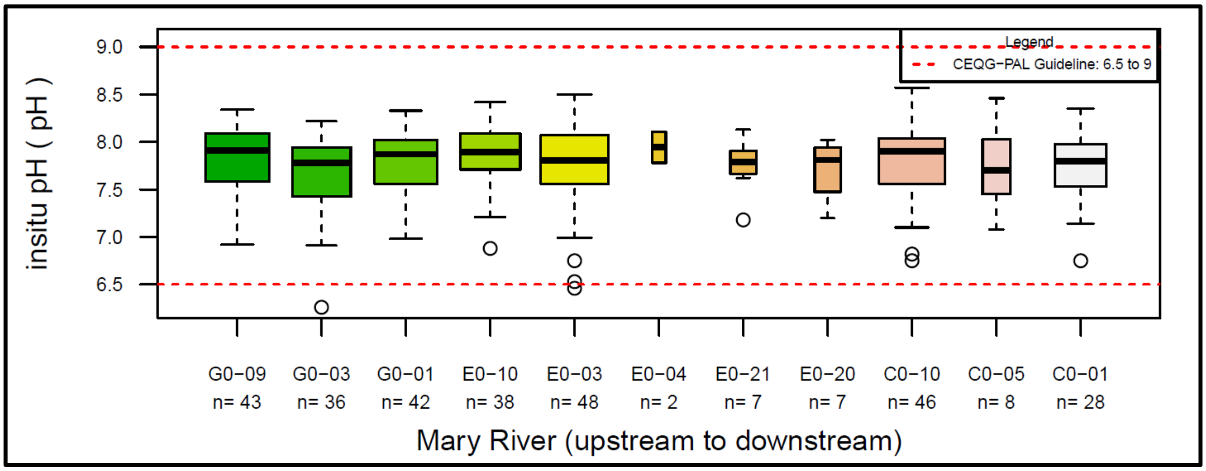


Figure C.5 Mary River – In Situ pH

Hardness (Figure C.6)

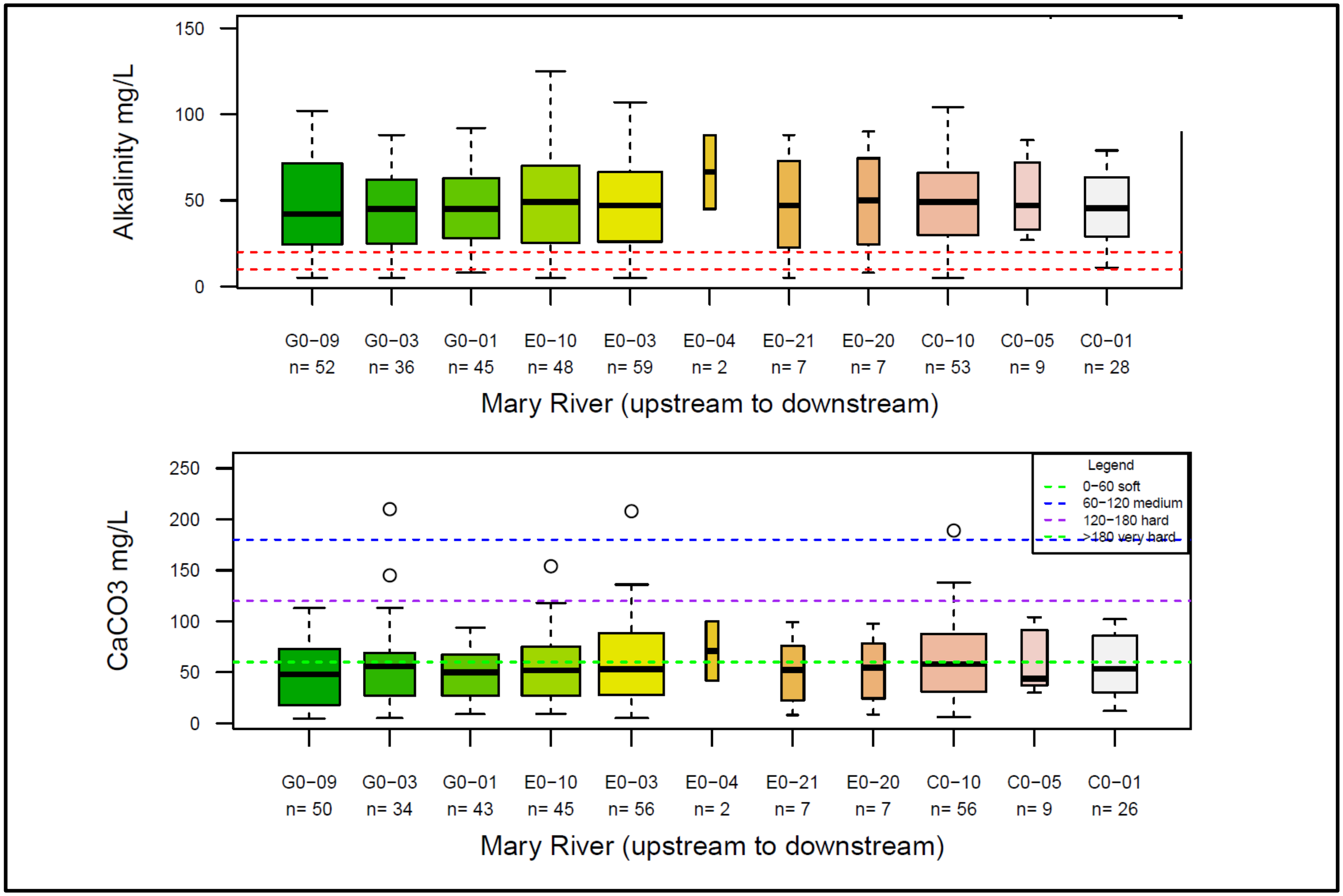
- Median hardness values at the stations in Mary River between 50 mg/L to 60 mg/L, classifying the river water as "soft". Only one station (E0-04) had median hardness values greater than 60 mg/L.
- Hardness portrayed trends very similar to alkalinity, although elevated values at E0-21 and E0-20 were reduced when compared with the alkalinity values.
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures C.7 and C.8)

The total sample size for chloride concentration samples collected in Mary River is 315, with between 2 and 51 samples collected at each geographically distinct station. Chloride concentrations are low and range from maximum values of 8 mg/L to detection limit values of 1 mg/L (Figure C.7). These concentrations are far below the CWQG-PAL guideline of 120 mg/L. Distinct geographic trends for chloride are not observed; however, measured chloride concentrations from upstream stations (G0-09, G0-03, G0-01 and E0-10) are slightly lower than concentrations observed at stations downstream of E0-10. This is expected to be the result of drilling salts that have been used during exploration in areas in vicinity to the open pit. Log transformed data has far fewer outliers and depicts geographic trends more clearly than the normal data.

Seasonal scatterplots and boxplots show a fairly conserved seasonal trend among different stations aggregated together: lowest measured concentrations occur in the spring (with the exception of C0-10, C0-05 and C0-01 data), slightly higher measured concentrations occur in the summer and the highest measured concentrations occur during the fall (Figure C.8). Seasonal scatter plots do not show consistent temporal trends over the years sampled, although seasonal scatterplots indicate the presence of one detection limit at ~1 mg/L.



NOTES:

1. ALKALINITY VALUES BELOW 10 mg/L ARE HIGHLY SENSITIVE TO ACIDIC INPUTS; ALKALINITY VLAUES BETWEEN 10 – 20 mg/L ARE MODERATELY SENSITIVE TO ACIDIC INPUTS AND ALKALINITY VALUES ABOVE 20 mg/L HAVE LOW SENSITIVITY TO ACIDIC INPUTS.

Figure C.6 Mary River – Alkalinity and Hardness

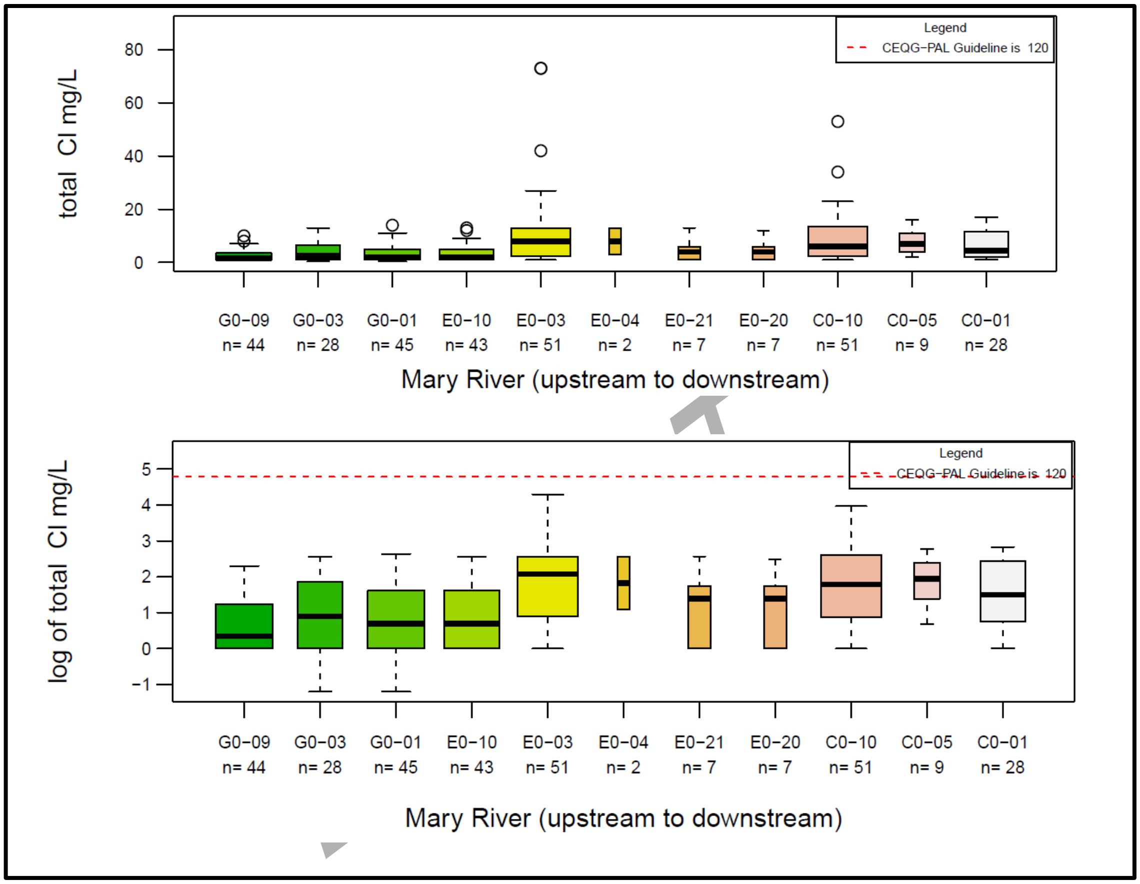
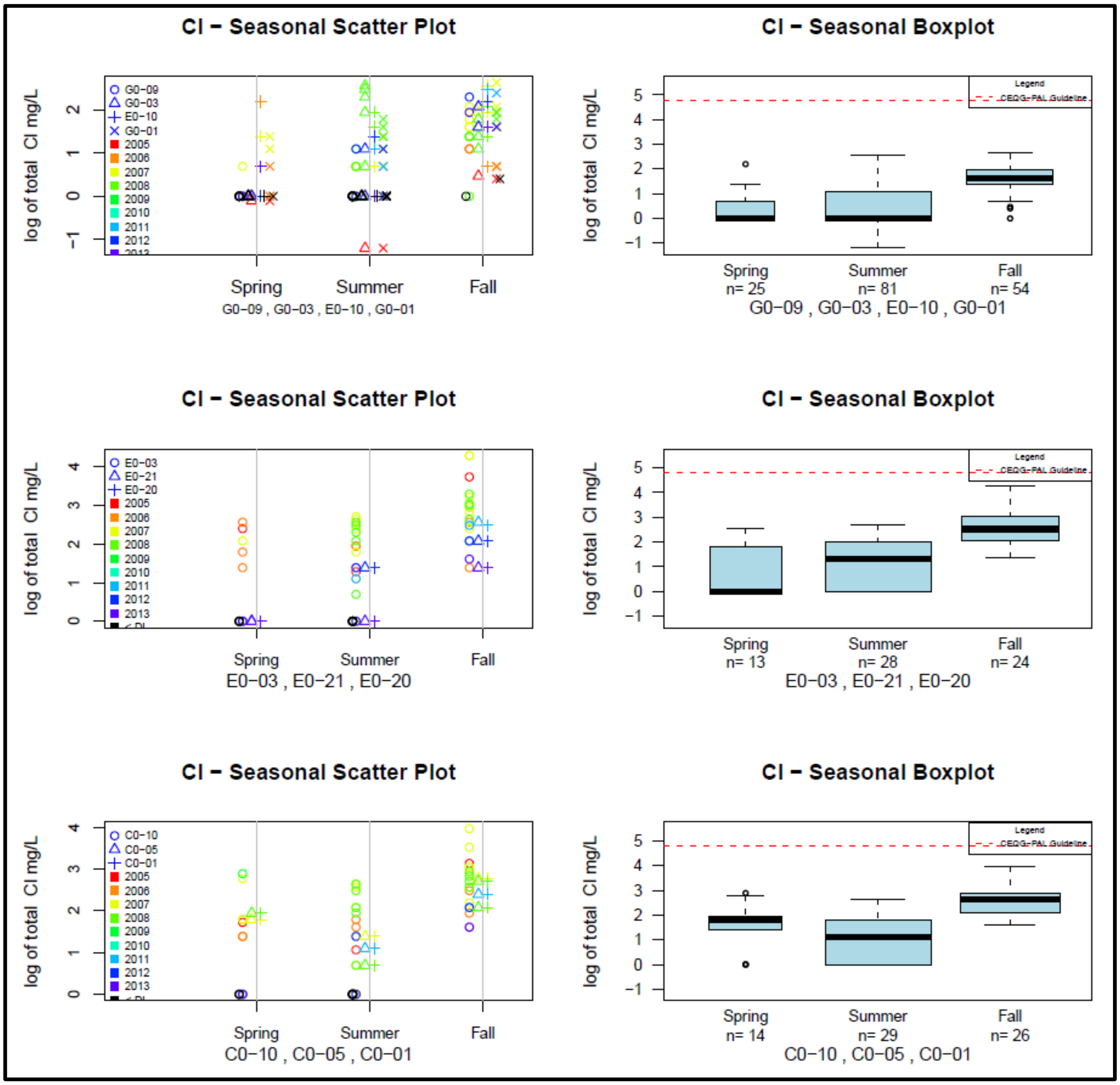


Figure C.7 Mary River – Chloride Concentrations in Water



NOTES:

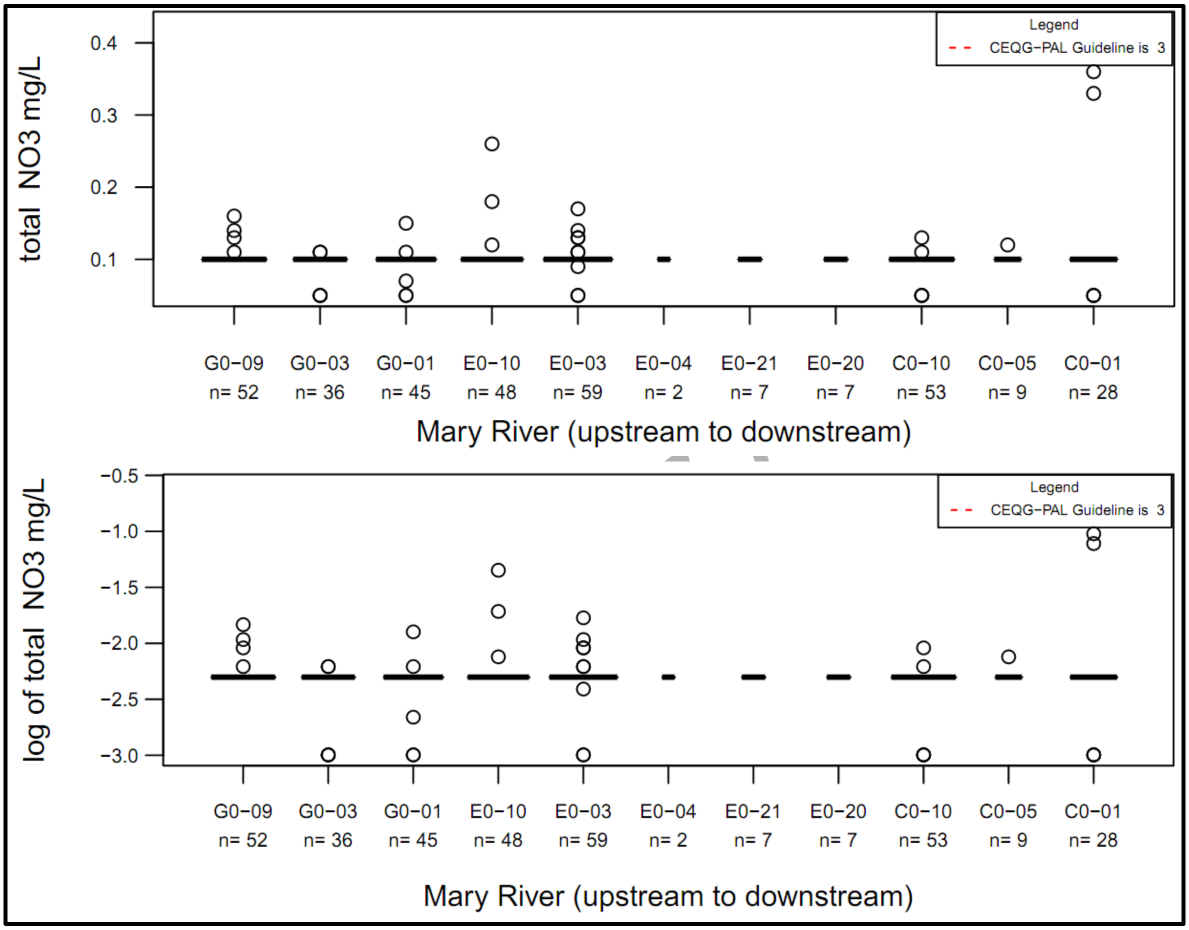
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.8 Mary River – Variability of Chloride in Water

Nitrate (Figures C.9 and C.10)

The total sample size for nitrate samples collected in Mary River is 346, with between 2 and 59 samples collected at each geographically distinct station on the Mary River. Nitrate concentrations generally occur at MDL level, and well below the CWQG-PAL guideline (3 mg/L), although, frequent outliers are noted (Figure C.9).

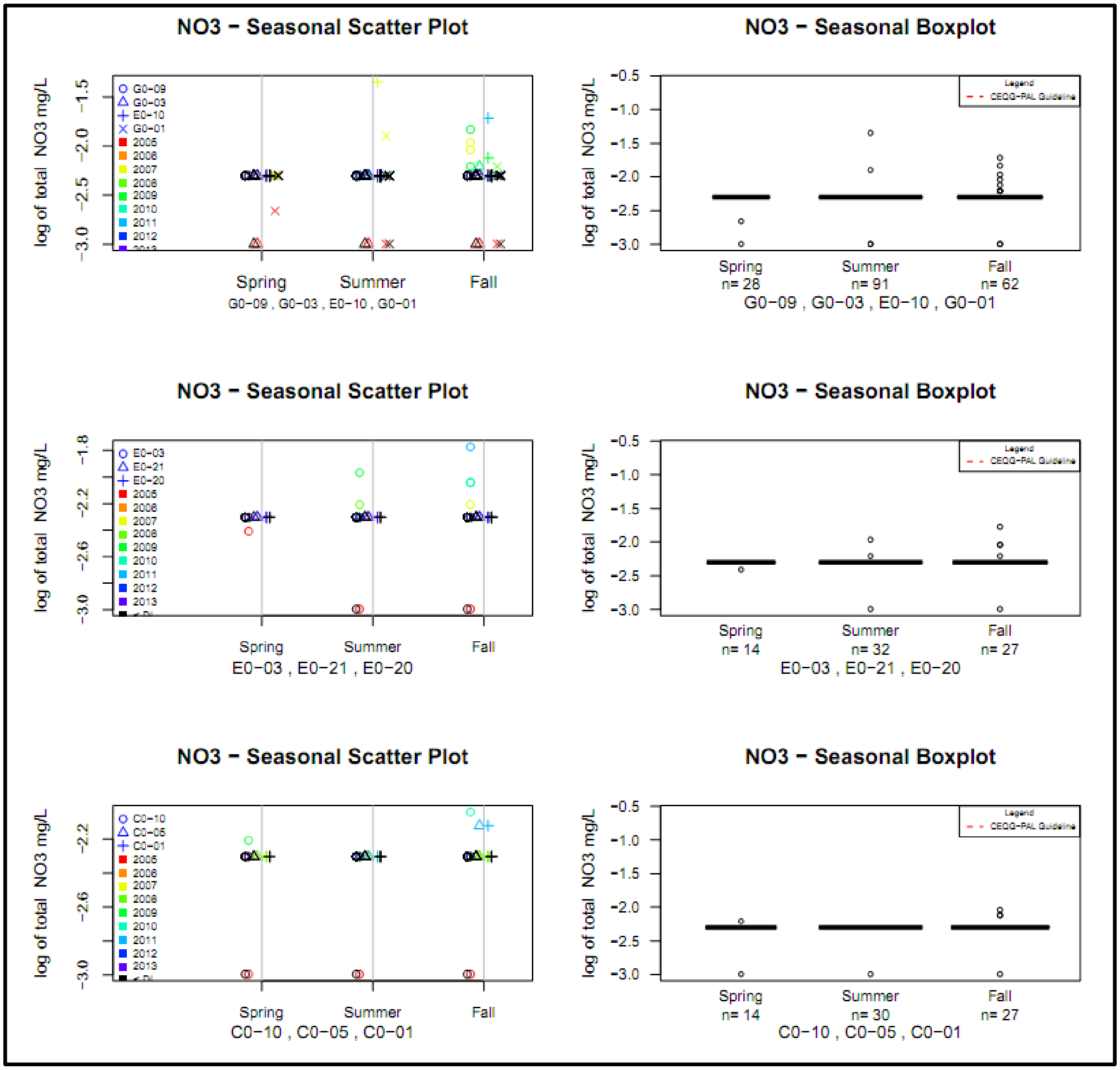
Seasonal scatterplots and boxplots show that the majority of outliers occur in the fall, and that data is subject to MDL interference. Seasonal scatterplots indicate that earlier data, from 2005, actually had a lower MDL than more recently collected data in 2012 (Figure C.10).



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.9 Mary River – Nitrate Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

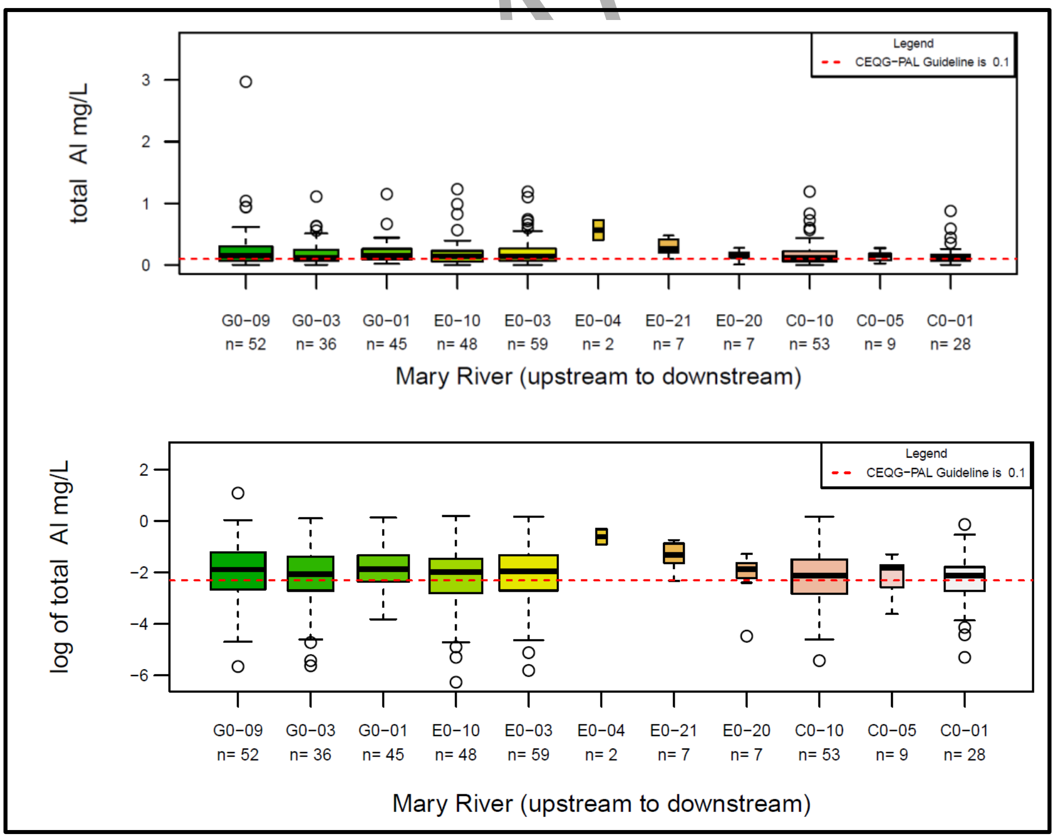
Figure C.10 Mary River – Variability of Nitrate in Water

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. All metals are discussed as total concentrations instead of dissolved concentrations, to reflect both the total dissolved and particulate metal loading.

Total Aluminum (Figures C.11 and C.12)

The total sample size for aluminum samples collected in Mary River is 346, with between one through 59 samples collected at each geographically distinct station on the Mary River (Figure C.11). Baseline total aluminum concentrations are elevated, and all stations sampled have median values greater than the CWQG-PAL guideline (0.1 mg/L) but below the Interim SSWQO[1] of 0.94 mg/L). The highest outlying value is 3 mg/L. Many outlying values are noted when box plots are created with raw data; however, when values are log transformed, fewer outliers are noted, and all occur below the calculated median value. Distinct geographic trends for aluminum are not observed, although slightly higher concentrations are noted at E0-04, E0-21 and E0-20. These observations are reliant are small amounts of data, and are therefore, not conclusive.

Seasonal scatterplots and boxplots do not show temporal effects during the eight year sampling program; however, seasonal trends are noted that are consistent between distinct Mary River stations (Figure C.12). Samples collected during summer show slightly higher seasonal concentrations, followed closely by fall concentrations, while spring concentrations occur at the lowest magnitudes.

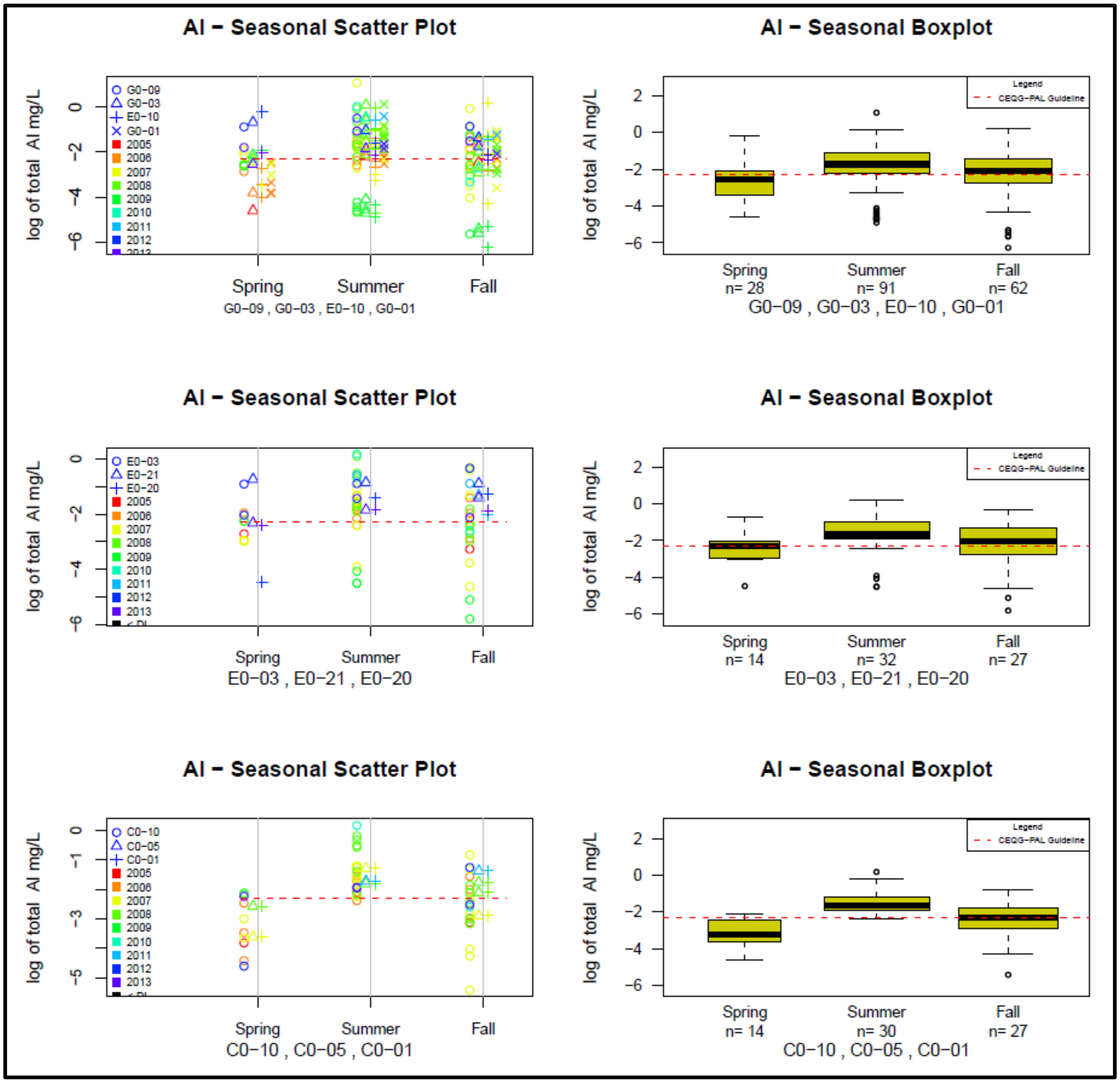


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.11 Mary River – Total Aluminum Concentrations in Water

[1] The SSWQO was based on the 95^{th} percentile of G0-09.



NOTES:

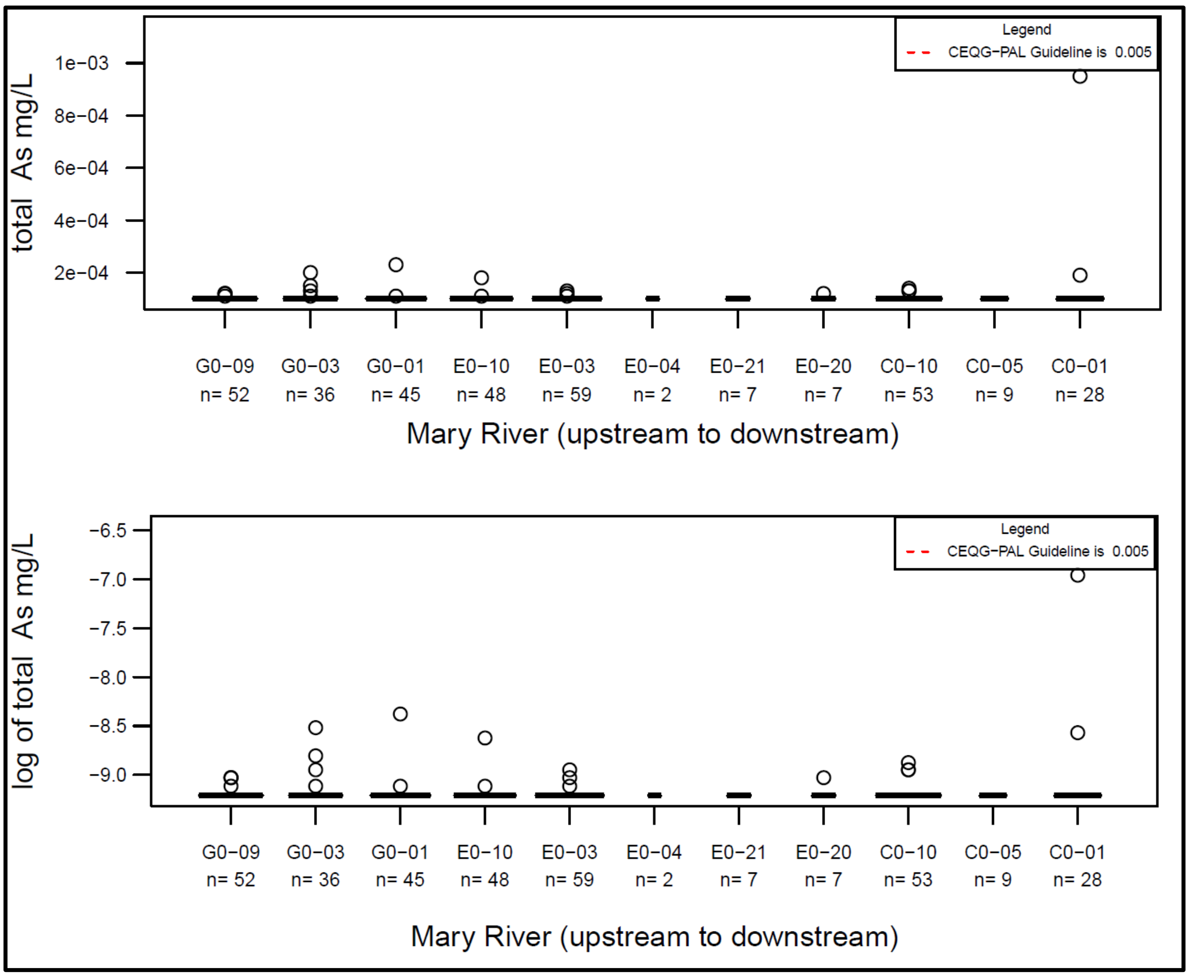
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.12 Mary River – Variability of Total Aluminum in Water

Total Arsenic (Figure C.13)

Total arsenic concentrations throughout Mary River generally occur at very low values or at the the laboratory MDLs, with the exception of some outlying values. Outlying values have been recorded at all stations except E0-04, E0-21 and C0-01, which all have smaller sample sizes than other stations (Figure C.13).

Median arsenic concentrations range from 0.0001 mg/L to 0.0002 mg/L. On average, 93% of data falls below the laboratory MDL. Station E0-03 has a median concentration slightly above MDL, with the 75th percentile concentration equal to approximately 0.001 mg/L. Ninety-five percent of data points occur below MDL. Station G0-01 also has the highest outlying value, recorded at ~0.0025 mg/L.

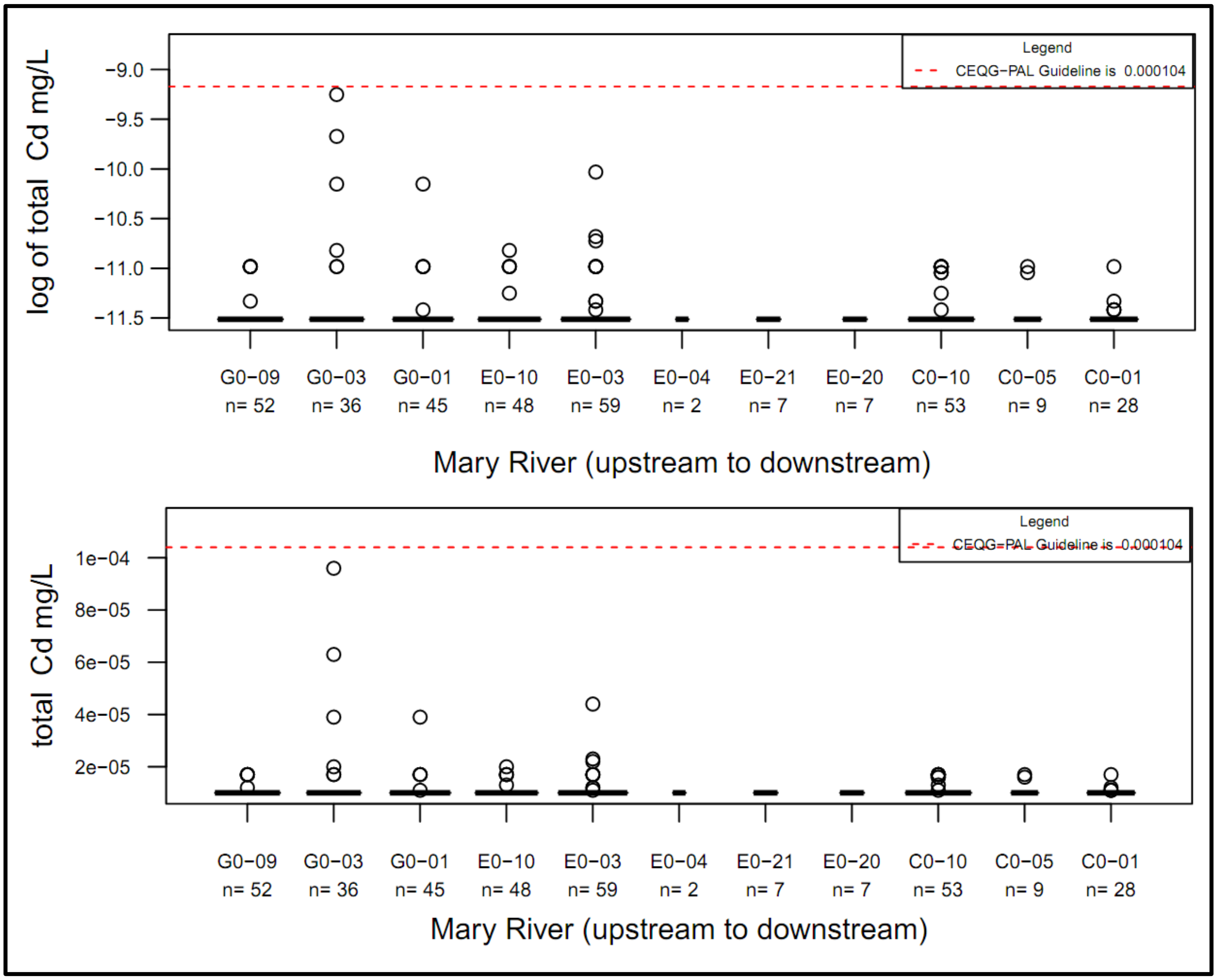


NOTES:
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.13 Mary River – Total Arsenic Concentrations in Water

Total Cadmium (Figure C.14)

The total sample size for cadmium samples collected in Mary River is 346, with between two through 59 samples collected at each geographically distinct station on the Mary River. Similar to arsenic, cadmium concentrations remain low or below the laboratory MDLs at most stations (Figure C.14). Median cadmium concentrations range from 0.00001 mg/L to 0.0001 mg/L. Based on all samples in Mary River, approximately 92% of samples fall below the laboratory MDLs.

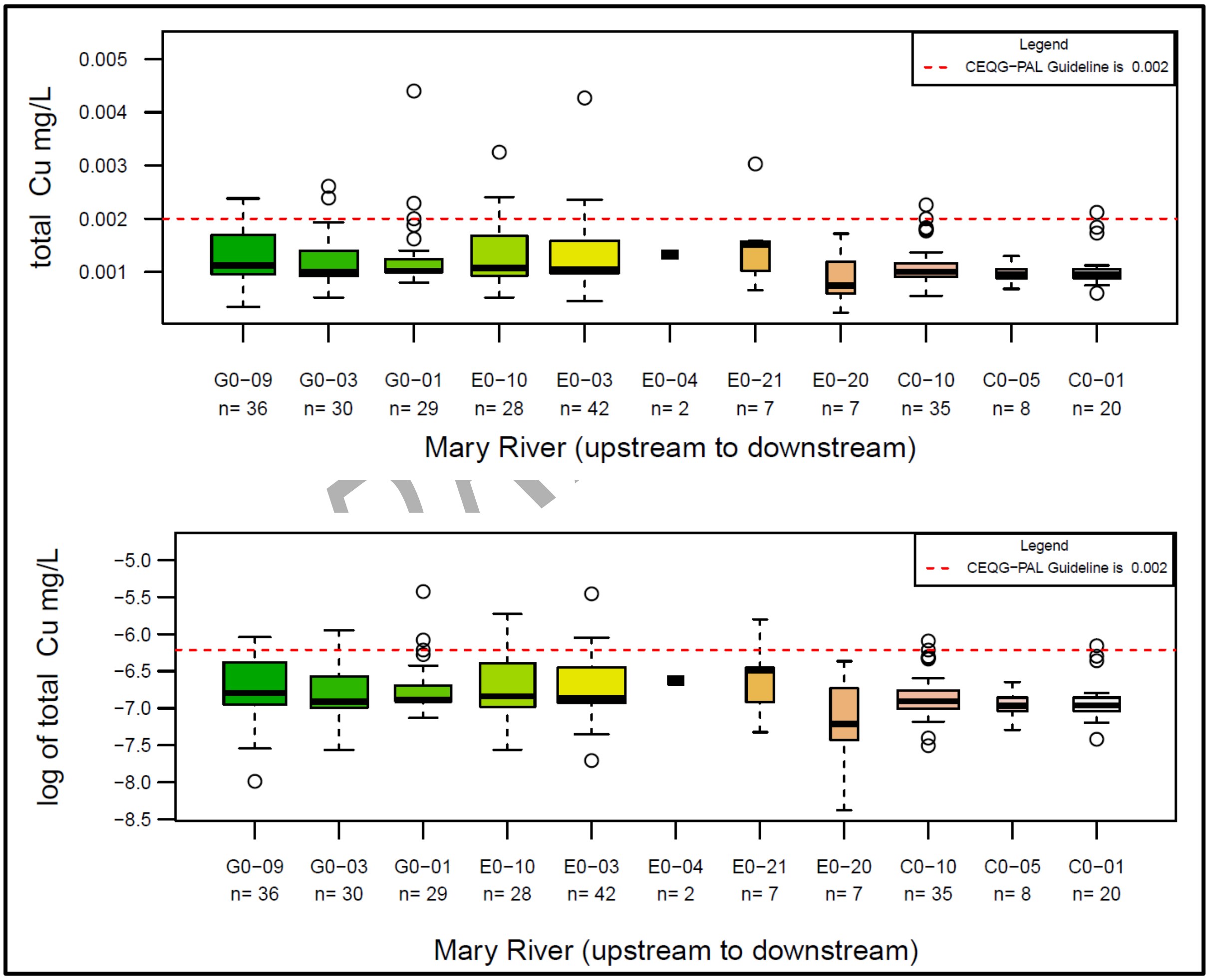


NOTES:
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.14 Mary River – Total Cadmium Concentrations in Water

Total Copper (Figures C.15 and C.16)

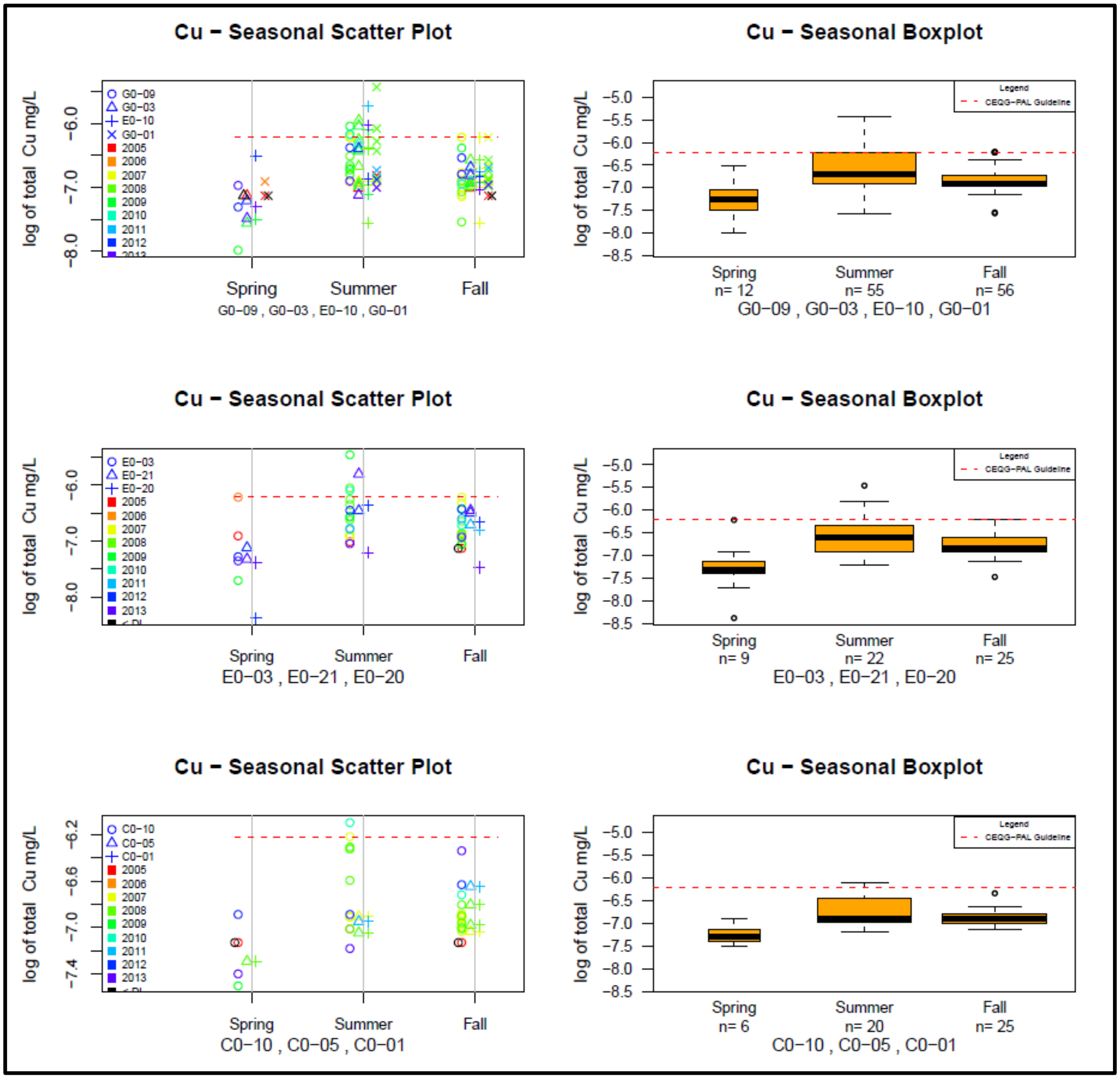
Between two through 59 total copper samples were collected at each geographically distinct station on the Mary River, for a total of 244 copper samplesa collected from the Mary River. Baseline total copper concentrations are slightly elevated. Although no median copper concentrations surpass the CWQG-PAL guideline (0.002 mg/L), naturally occuring maximum concentrations and 75th precentile concentrations do exceed this guideline (Figure C.15). The maximum copper concentration recorded within Mary River was slightly above 0.004 mg/L, which is twice that of the CWQG-PAL guideline limit. Distinct geographic trends are not noted within Mary River, as all stations have median values that are quite similar. Log transformed data shows slightly fewer outliers, but the data transformation does not affect the spread of data to a large extent.



NOTES:
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.15 Mary River – Total Copper Concentrations in Water

Seasonal scatterplots do not reveal a temporal trend over the eight year sampling history (Figure C.16). Seasonal scatterplots and boxplots do show, however, that all stations on Mary River show a consistent seasonal trend: with elevated, but similar concentrations occurring in summer and fall, and slightly lower concentrations occurring during spring. This trend is unique to copper.



NOTES:

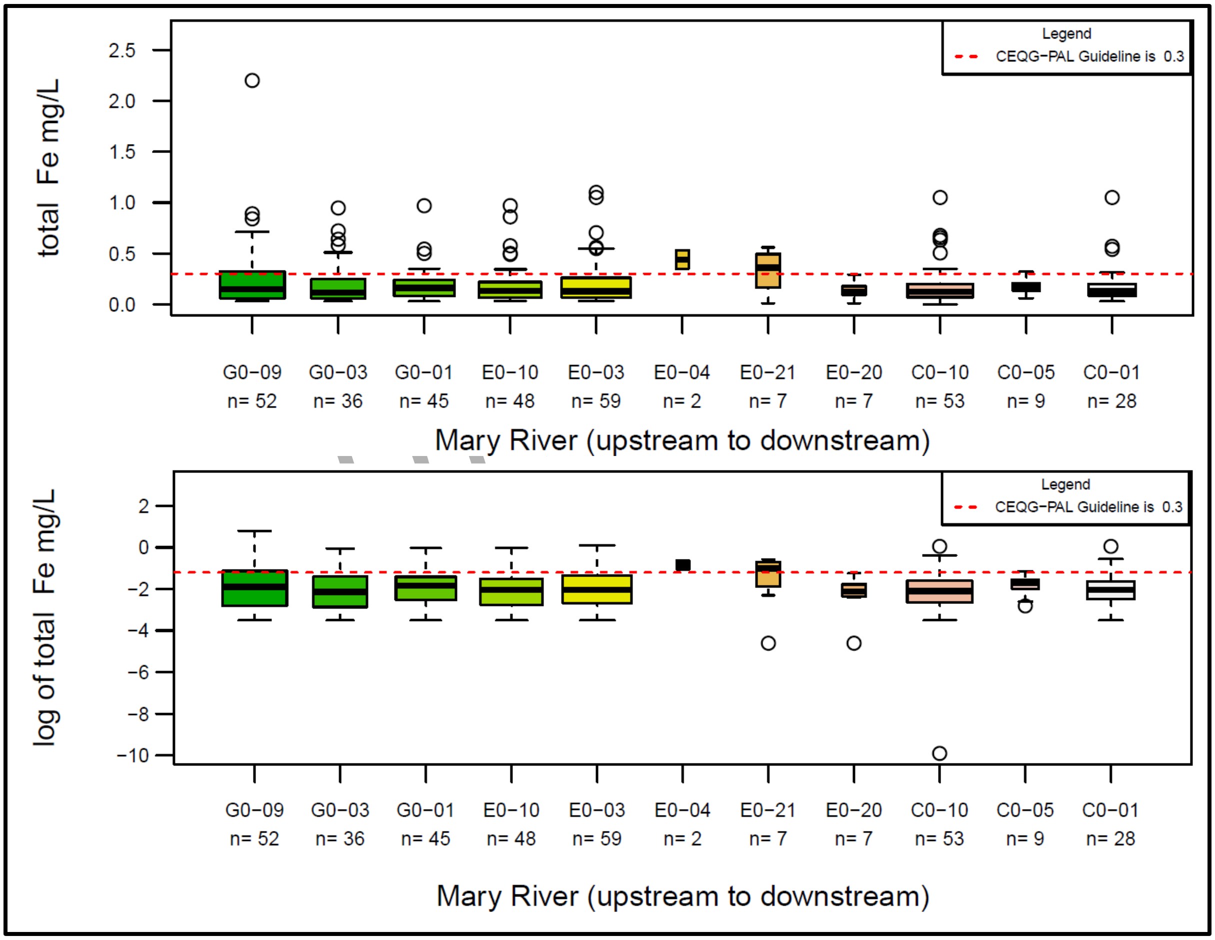
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.16 Mary River – Variability of Total Copper in Water

Total Iron (Figures C.17 and C.18)

The total sample size for total iron samples collected in Mary River is 346, with between two through 53 samples collected at each geographically distinct station on the Mary River. Baseline total iron concentrations are slightly elevated (Figure C.17).

Stations E0-21 and E0-04 have median iron concentrations that exceed the CWQG-PAL guideline (0.3 mg/L), but are based on a small sample size and are therefore inconclusive. The rest of the stations on Mary River have median values that fall below this guideline. Naturally occuring maximum concentrations and 75th percentile concentrations, however, do exceed the CWQG-PAL guideline and occur at a maximum, approximately six times the gudieline value. Plots of the log data indicate reduce the frequency of outliers significantly.

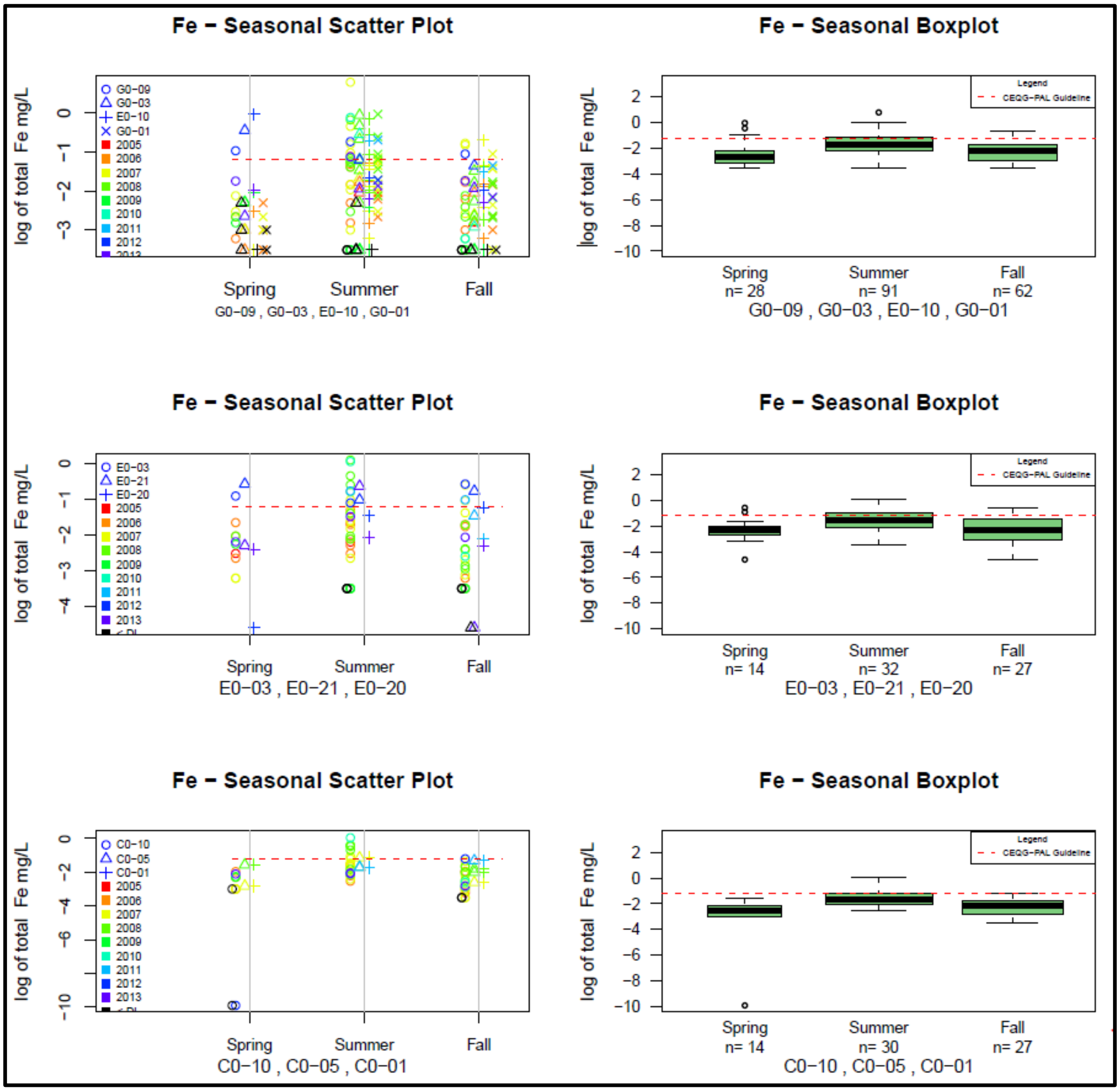


NOTES:

1. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.17 Mary River – Total Iron Concentrations in Water

Seasonal scatterplots do not reveal a temporal trend over the eight year sampling history (Figure C.18). Seasonal scatterplots and boxplots do show, however, that all stations on Mary River show a muted seasonal trend similar to the seasonal trend observed for aluminum. Summer total iron concentrations occur at slightly higher concentrations, with fall concentrations reporting slightly below summer concentrations, but above median spring concentrations.



NOTES:

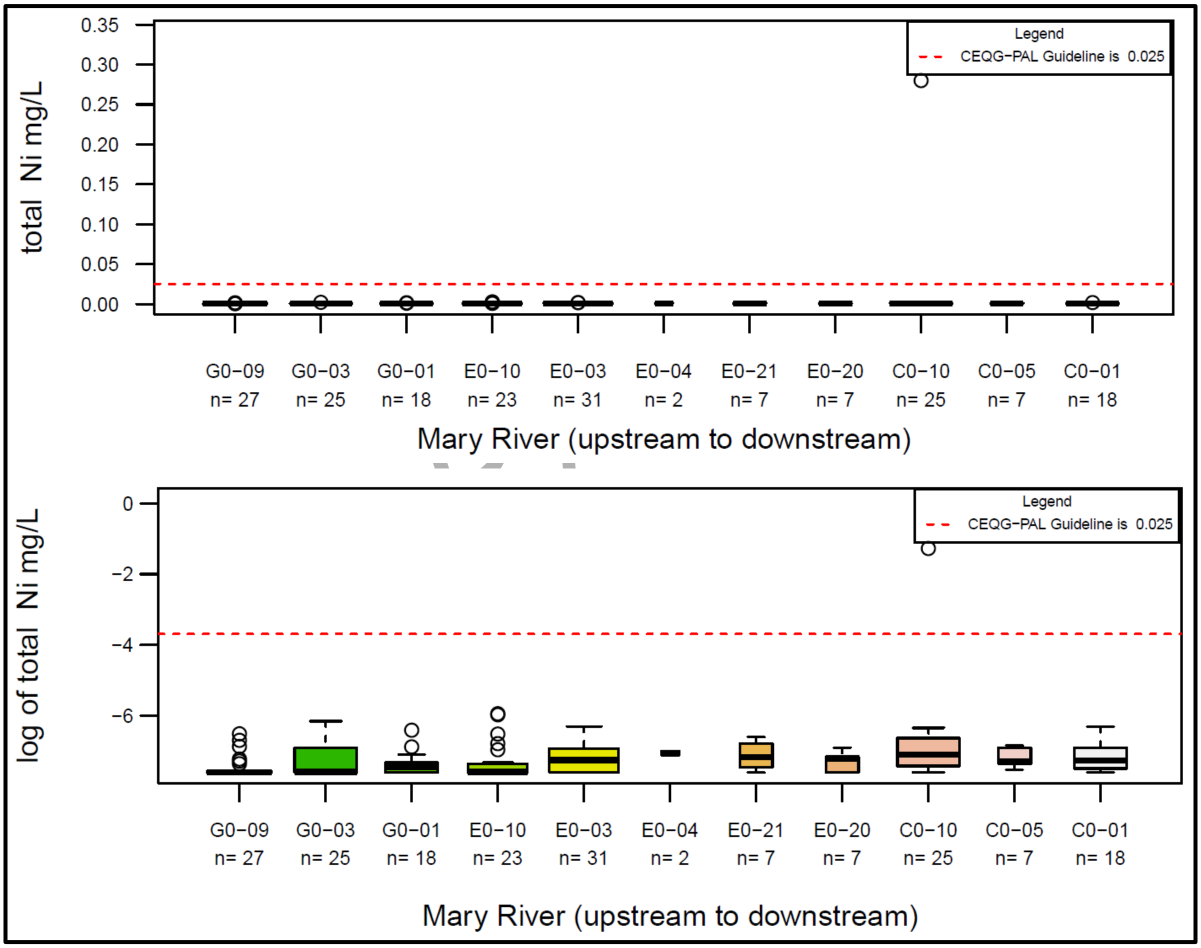
1. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.18 Mary River – Variability of Total Iron in Water

Total Nickel (Figures C.19 and C.20)

The total sample size for total nickel samples collected in Mary River is 190, with between two through 31 samples collected at each geographically distinct station on the Mary River. Baseline total nickel concentrations are low and occur consistently below the CWQG-PAL guideline (0.025 mg/L) (Figure C.19). Median values vary only slightly between stations, but do not appear to indicate any kind of geographic trend.

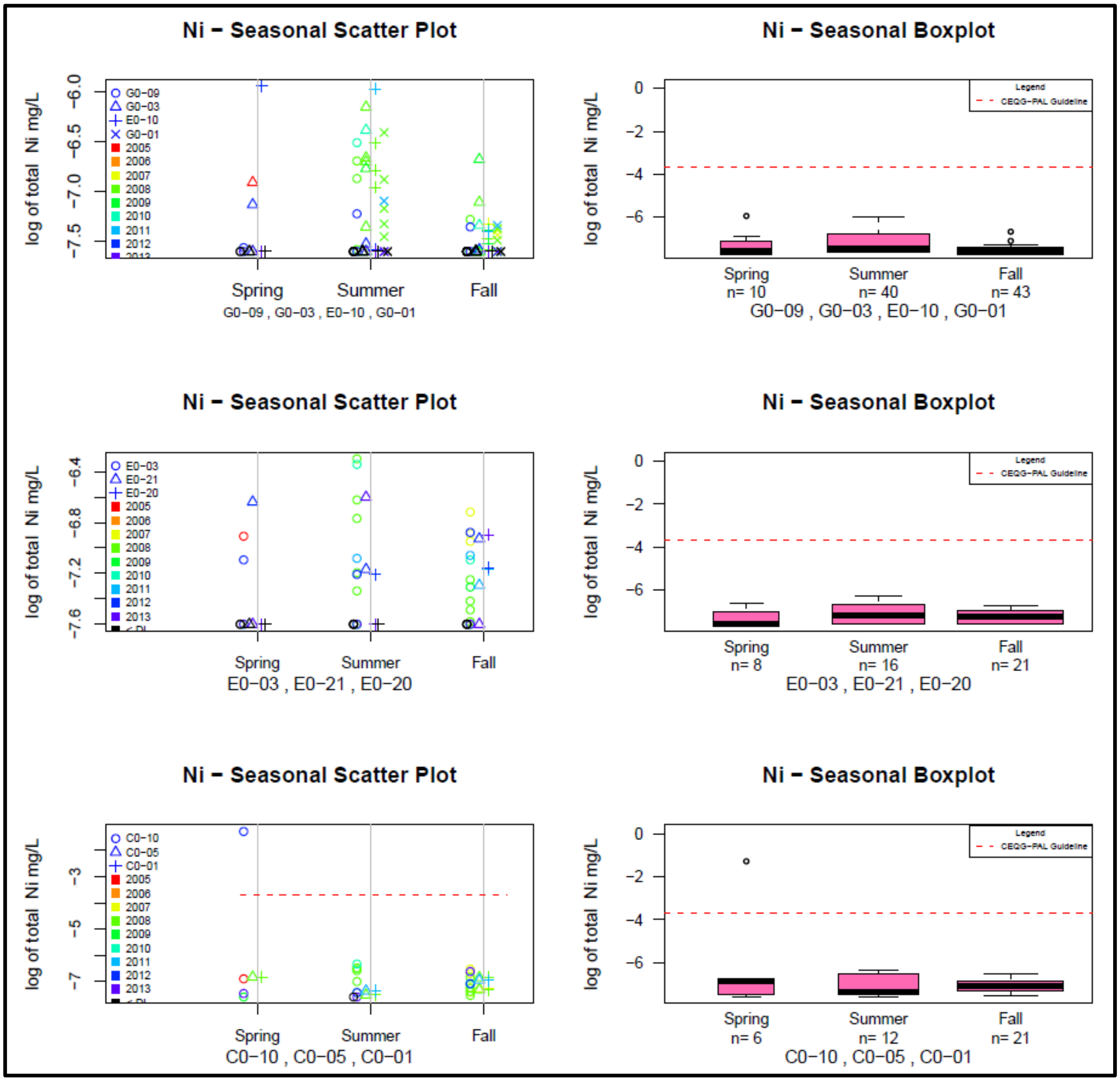
Seasonal scatterplots indicate data from 2008 and 2009 is slightly elevated compared to other data collected during the eight year sampling history (Figure C.20). Seasonal scatterplots and boxplots do not show any discernable seasonal trend, although it is possible summer concentrations are slightly higher than fall and spring concentrations.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.19 Mary River – Total Nickel Concentrations in Water



NOTES:

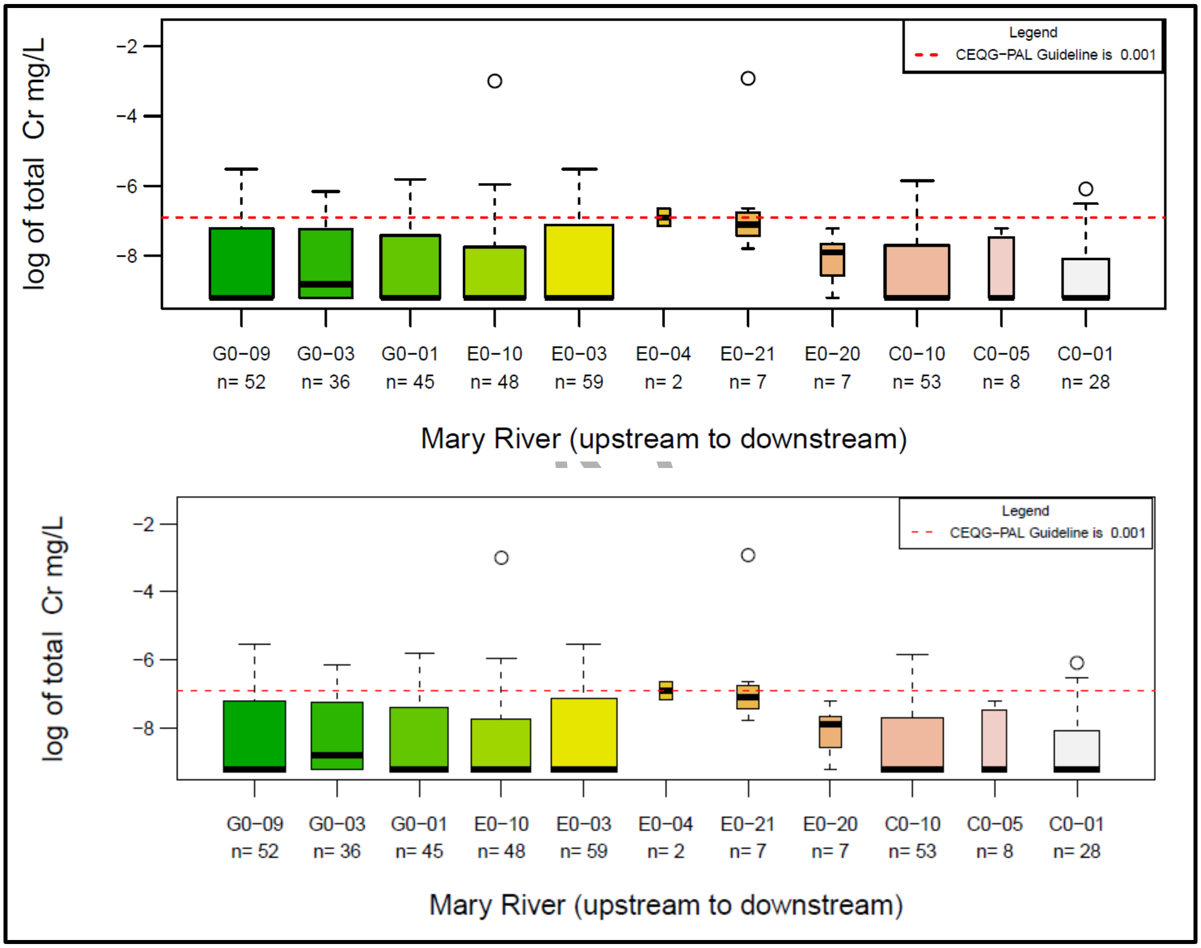
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.20 Mary River – Variability of Total Nickel in Water

Total Chromium (Figure C.21 and Figure C.22*)*

The total sample size for total chromium, samples collected in Mary River is 347, with between two through 59 samples collected at each geographically distinct station on the Mary River. Baseline total chromium concentrations are generally low but occur above the CWQG-PAL guideline (0.001 mg/L) at some stations (Figure C.21). Stations E0-04, E0-21 and E0-20 have elevated median concentrations compared to other stations.

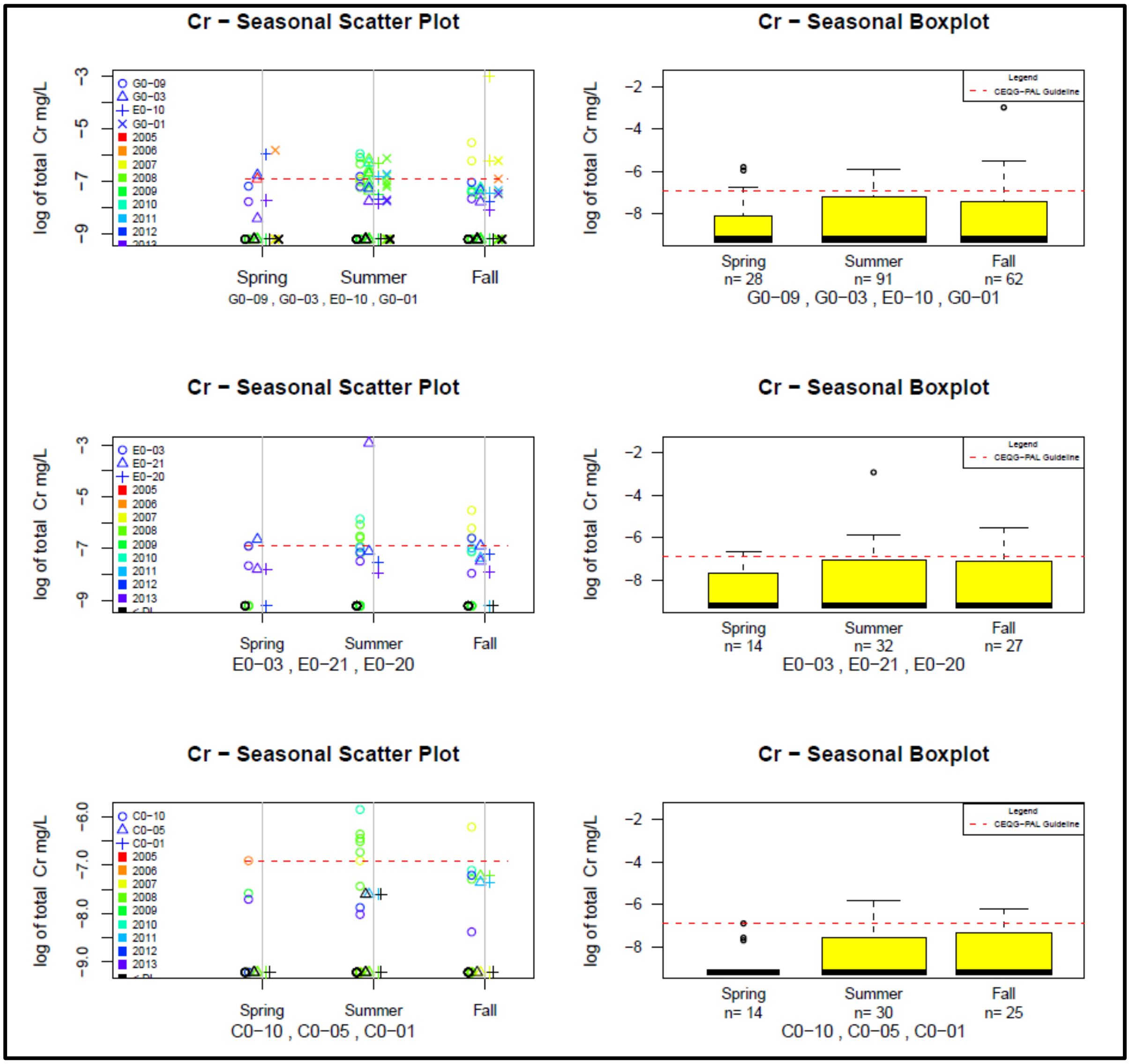
Seasonal scatterplots indicate data from summer of 2008 is slightly elevated compared to other data collected during the eight year sampling history (Figure C.22). Seasonal scatterplots and boxplots do not show any discernable seasonal trend.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.21 Mary River – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.22 Mary River – Variability of Total Chromium in Water

Summary of trends observed during review of Mary River baseline data:

- Geographic trends between discrete sampling stations were not observed for any parameters, with the exception of chloride, which showed slightly lower upstream concentrations. Concentrations at E0-04, E0-20 and E0-21 were often slightly elevated, but due to small sample size, this is not a conclusive trend.
- With the exception of nitrate and nickel, parameters did not show any distinct temporal trends over the sampling period.
- No seasonal trends were noted for nitrate, arsenic and cadmium due to detection limit interference. Although detection limit interference did not occur for nickel and chromium, these parameters do not also show consistent seasonal trends between sample stations.
- Aluminum, copper and iron (and muted trends observed for nickel) historically have their highest concentrations occurring during the summer.

C.3.2 Camp Lake Tributary

Water quality samples at five stations within the Camp Lake Tributary were collected from 2005 through 2013. A total of eighty-seven (87) samples were collected from the Camp Lake Tributary L0/L1 (Table C.2). Most sampling was completed during the spring and summer season, from June through August. The most number of samples were collected during 2007 and 2008. Variability in the Camp Lake Tributary samples is larger than variation observed within the other lakes samples. Although variability may be influenced by the relatively low sample size at all stations (15 to 22, with the exception of L0), variability is expected to also be as a result of sampling different tributaries.

- L0-01: Located on Tributary L0, this is the most downstream station on the Camp Lake Tributary, prior to discharge into Camp Lake and represents the most downstream point of entry of discharge from West Pond.
- L1-02: Located on Tributary L1, located immediately downstream of L1-08, prior to the confluence of Tributary L1 and L2.
- L1-08: Located on Tributary L1, within fish-bearing water, immediately below the West Pond discharge station and a large falls.
- L1-09: Located on Tributary L0, immediately downstream of the confluence of the L2 Tributary and the L1 tributary.
- L2-03: Located on Tributary L2, adjacent to the existing air strip. Tributary L2 converges with Tributary L1 to form Tributary L0.

Sampling locations are shown on Figures C.2 and C.3. A summary of the data collected during each season, with respect to year and station are included in Table C.2. A graphical representation of the sampling events is provided in Figure C.23.

Table C.2 Camp Lake Tributary Sample Size

Year	Summer	Fall	Winter
2005	4	3	3
2006	3	6	3
2007	2	7	5
2008	2	8	5
2011	0	3	3
2012	5	5	5
2013	5	5	5
Station	**Summer**	**Fall**	**Winter**
L0-01	9	23	15
L1-02	3	3	3
L1-08	4	4	4
L1-09	2	3	3
L2-03	3	4	4

The following summarizes the data review observations for the physical parameter data collected for the Camp Lake Tributary.

pH (Figure C.24)

- *In situ* pH values in the Camp Lake Tributary do not vary greatly, and slightly alkaline, with total median pH ~ 8.
- *In situ* pH is observed to increase slightly from upstream to downstream stations.

Alkalinity (Figure C.24)

- All Camp Lake Tributary stations have high alkalinity and are considered to have low sensitivity to acidic inputs. Median hardness is equal to 73 mg/L.
- The lowest alkalinity values are recorded at L1-08, the station located furthest upstream, and values increase to a maximum of approximately 95 mg/L at L2-03. This indicates the possibility that inputs may have occurred during exploration activities.

Hardness (Figure C.24)

- Median hardness for all stations within the Camp Lake tributary is 79 mg/L, classifying the river water as “moderately soft”; although, median hardness values at L1-08 and L1-02 are classified as “soft”.
- Hardness portrayed trends very similar to alkalinity, with the lowest measured concentration occurring at L1-08 (~48 mg/L) and increasing to a maximum value at L2-03 (~100 mg/L).
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

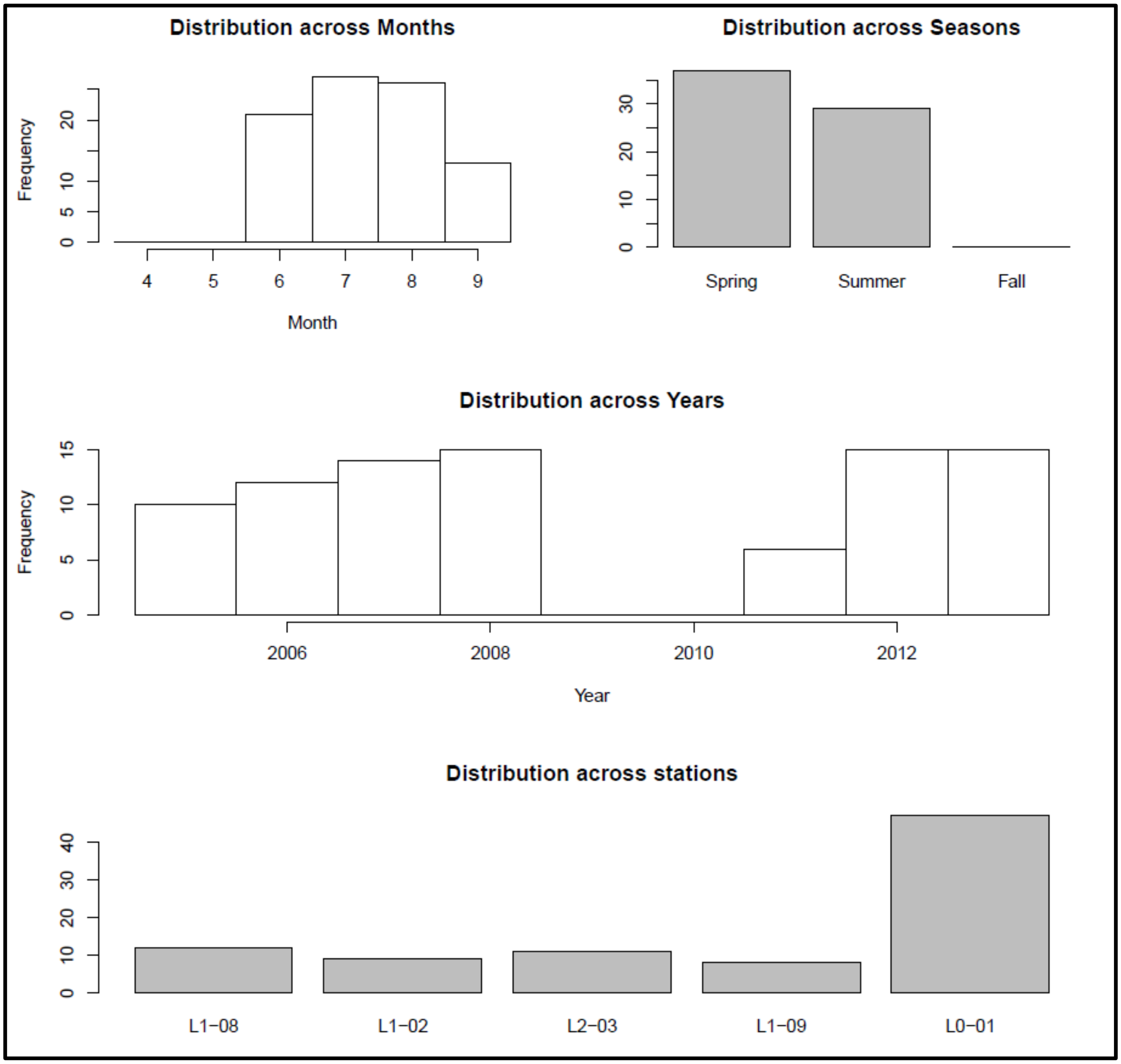
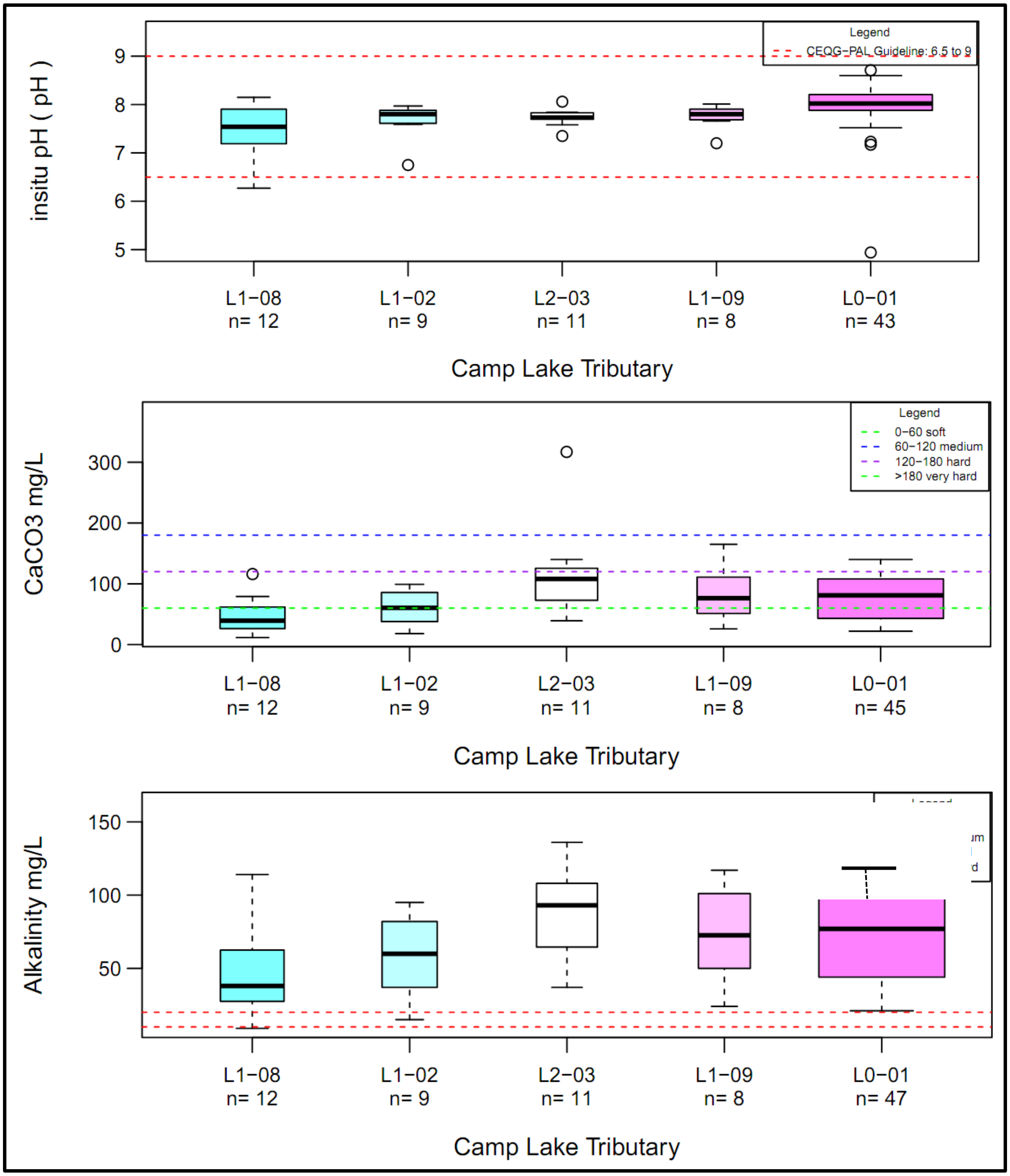


Figure C.23 Camp Lake Tributary – Graphical Summary of Sampling Events

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures C.25 and C.26)

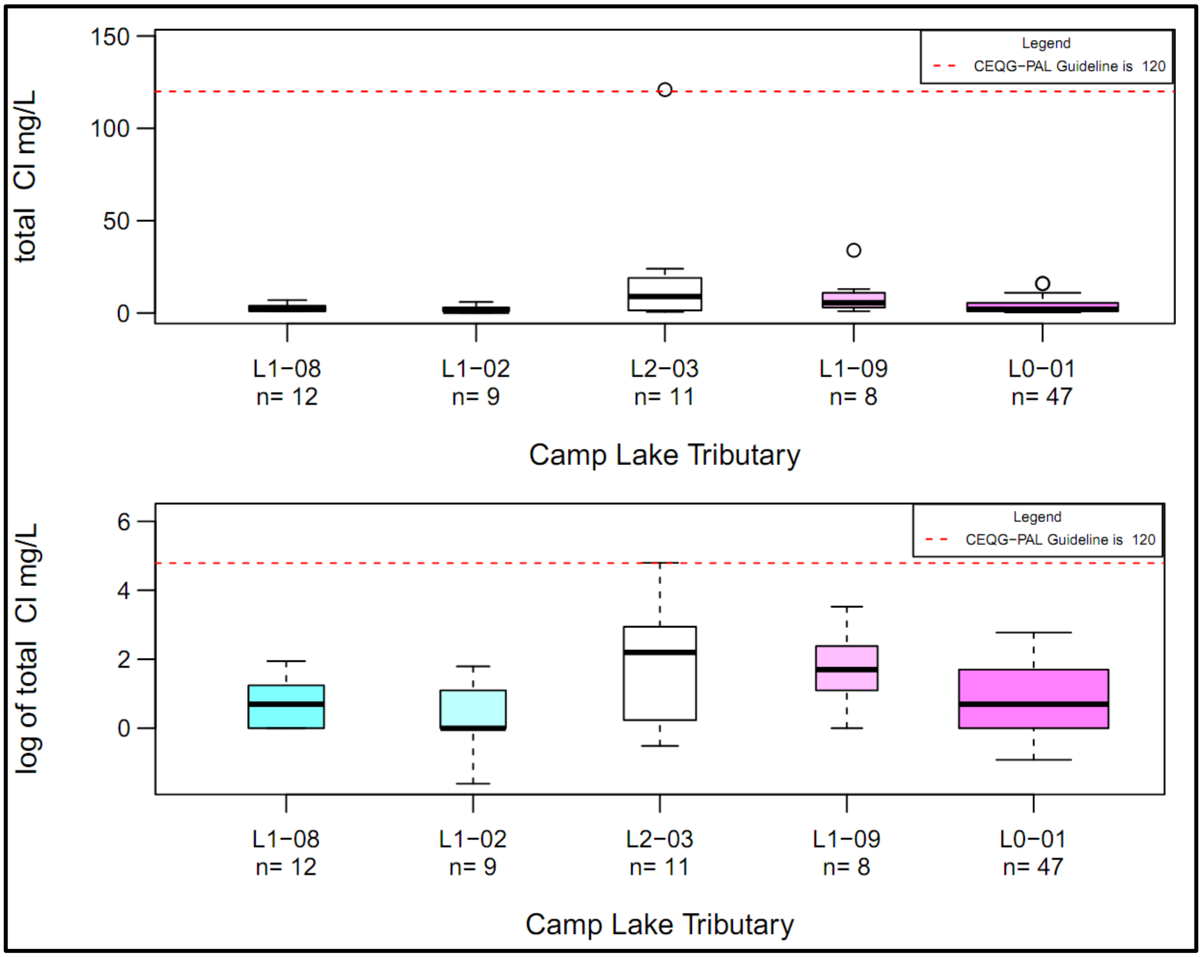
The total sample size for chloride concentration samples collected in the Camp Lake Tributary is eighty-seven (87) with 8 to 47 samples collected at each geographically distinct sampling station (Figure C.25). Chloride concentrations are low, with the exception of one outlier recorded at L2-03. Chloride concentrations generally range from the MDL to 20 mg/L, with the exception of one outlier recorded at 120 mg/L (at the CWQG limit). Chloride concentrations are marginally higher at L2-03, which samples a tributary adjcaent to the existing air strip, and are marginally lower at sampling point



NOTES:

1. ALKALINITY VALUES BELOW 10 mg/L ARE HIGHLY SENSITIVE TO ACIDIC INPUTS; ALKALINITY VLAUES BETWEEN 10 – 20 mg/L ARE MODERATELY SENSITIVE TO ACIDIC INPUTS AND ALKALINITY VALUES ABOVE 20 mg/L HAVE LOW SENSITIVITY TO ACIDIC INPUTS.

Figure C.24 Camp Lake Tributary – In-Situ pH, Alkalinity and Hardness

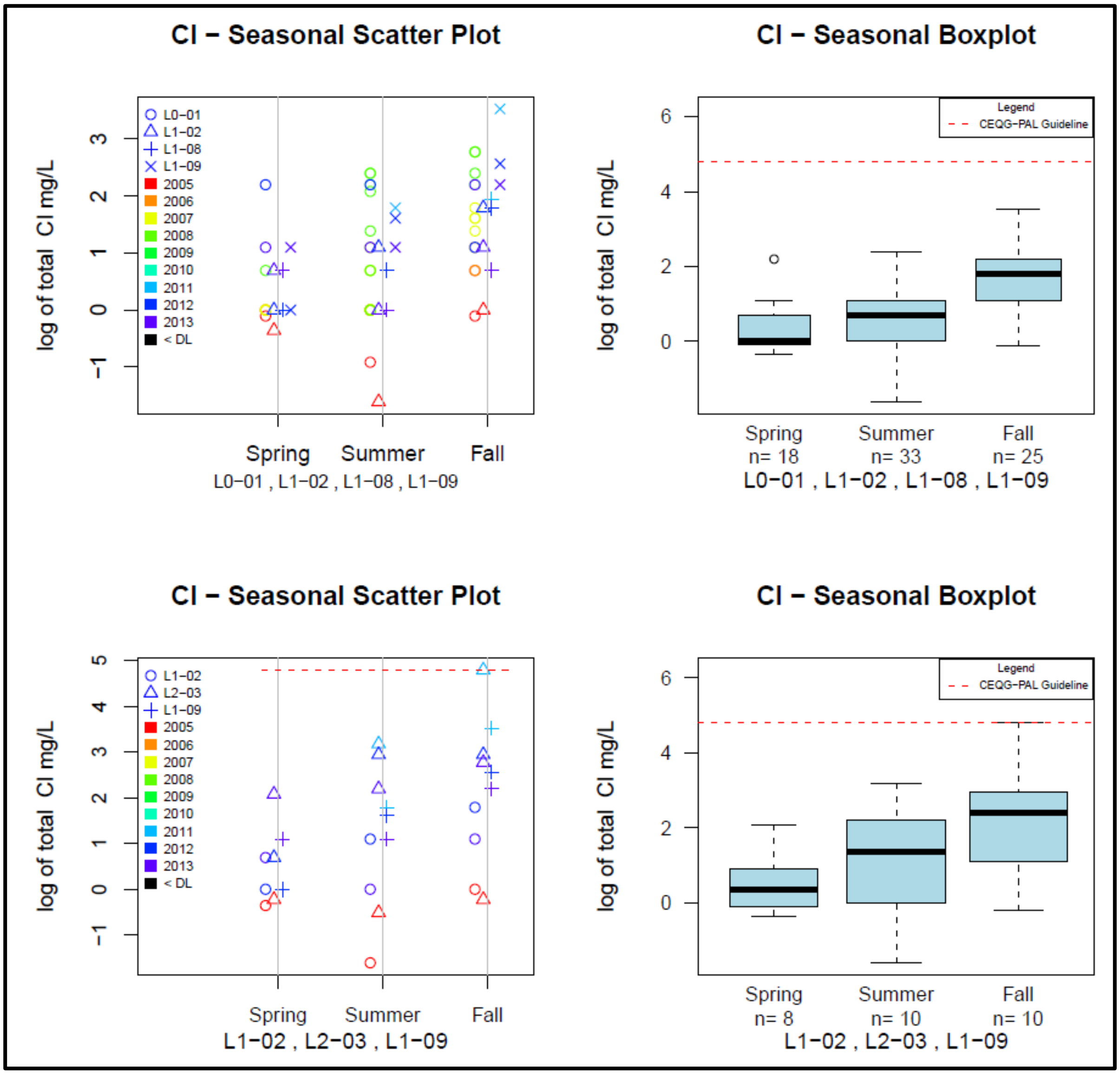


NOTES:
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.25 Camp Lake Tributary – Chloride Concentrations in Water

higher upstream in the catchment: L1-08 and L1-02. The small magnitude of this change is not conclusive enough to attribute significant change to this parameter as a result of exploration activities.

Temporal trends were not observed to have occurred within the seasonal scatter plots (Figure C.26). Seasonal boxplots for data within the Camp Lake Tributary show a conserved trend of: lower spring concentrations, slightly elevated summer concentrations, and highest seasonal concentrations occurring in the fall.



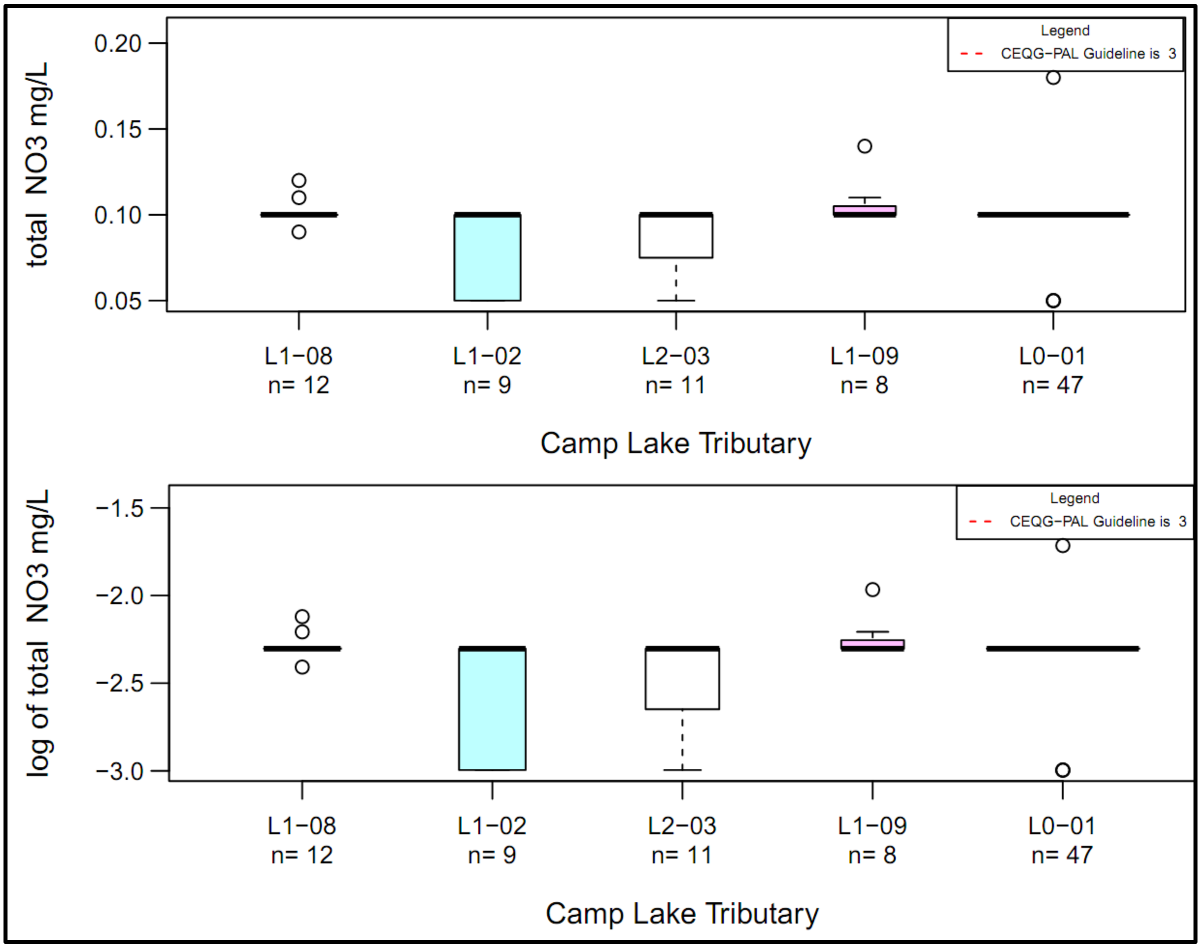
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.26 Camp Lake Tributary – Variability of Chloride in Water

Nitrate (Figure C.27)

Eighty-seven (87) nitrate samples were collected from the Camp Lake Tributary sampling area. At each geographically distinct sampling station, between 11 to 47 samples were collected. The vast majority of samples collected for nitrate are at MDLs (Figure C.27). Two distinct MDLs are noted: at 0.05 mg/L, and 0.1 mg/L. Due to detection limit interference, distinct geographic trends are difficult to discern. Seasonal trends are not observed due to detection limit interference.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

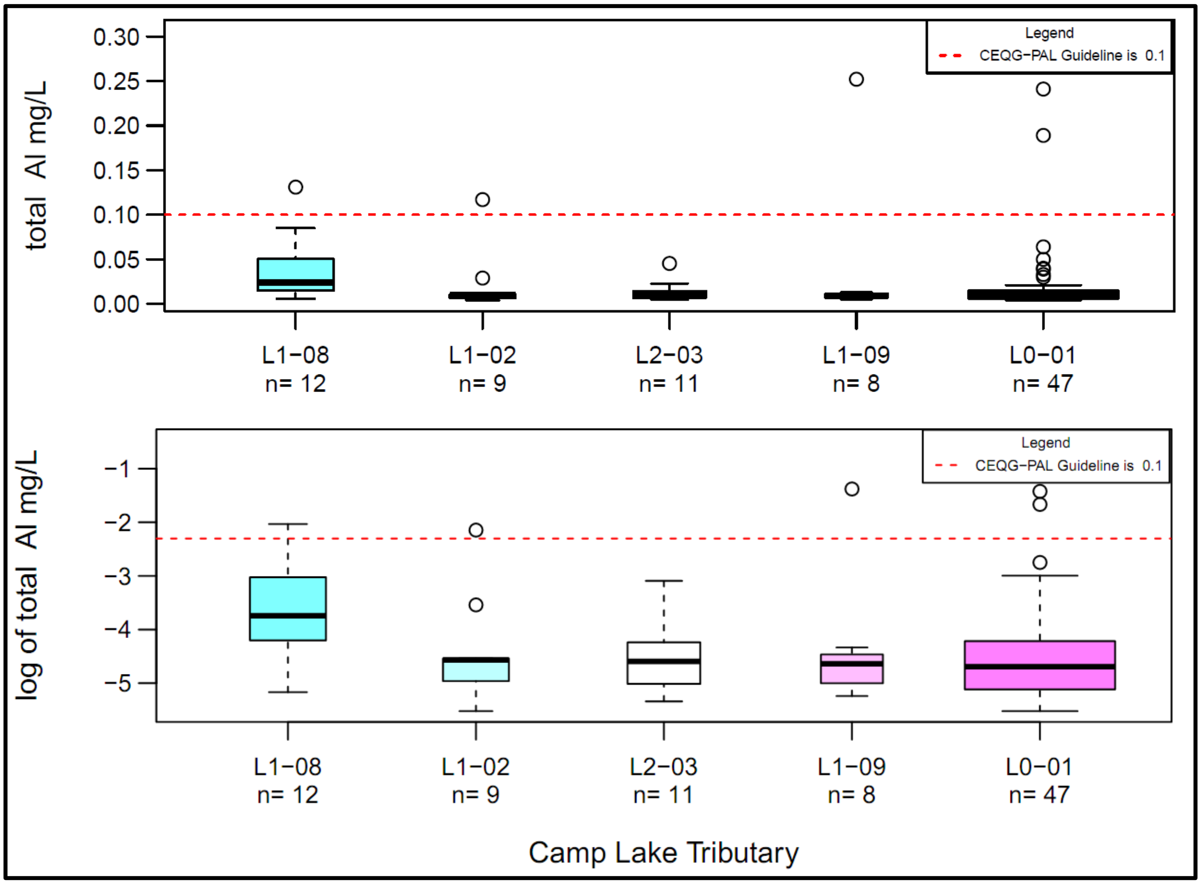
Figure C.27 Camp Lake Tributary – Nitrate Concentrations in Water

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel.

Total Aluminum (Figures C.28 and C.29)

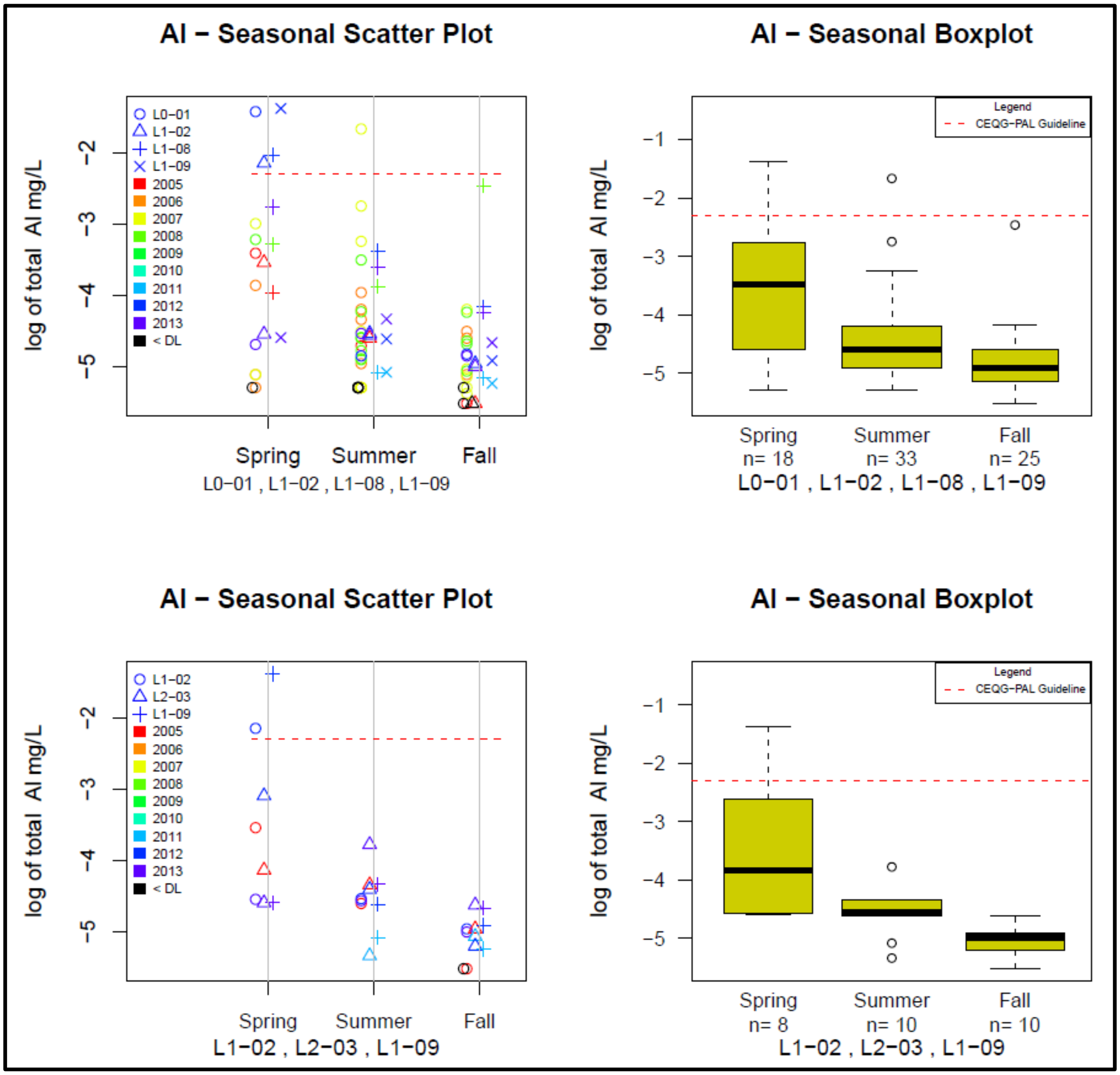
Eighty-seven (87) samples of total aluminum concentration were collected in the Camp Lake Tributary with 8 to 47 samples collected at each geographically distinct sampling station. Baseline aluminum concentrations occur consistently above MDL, but generally below the CWQG-PAL guideline (0.1 mg/L), except during the spring and summer (Figure C.28). During summer sampling, one outlying maximum aluminum concentrations occurs just above the CWQG-PAL limit and below the Interim SSWQO (0.94 mg/L). Aluminum concentrations at L1-08, the furthest upstream station, are slightly elevated when compared to other sampling stations.

Data from 2012 and 2013 tends to be slightly elevated when compared to other years of sampling (Figure C.29). As mentioned above, seasonal boxplots for the Camp Lake Tributary area show a conserved trend of highest concentrations occurring in the spring, with slightly lower summer concentrations and slightly lower concentrations again in the fall.



NOTES:
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.28 Camp Lake Tributary – Total Aluminum Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.29 Camp Lake Tributary – Aluminum Data Aggregation

Total Arsenic

Eighty-seven (87) total arsenic samples were collected in the Camp Lake Tributary area with 8 to 61 samples collected at each geographically distinct sampling station (47 samples were collected at L0-01 and between 8 to12 samples were collected at the remaining stations). Baseline arsenic concentrations occur consistently at MDL and do not change over time. Therefore, graphical analysis is not warranted.

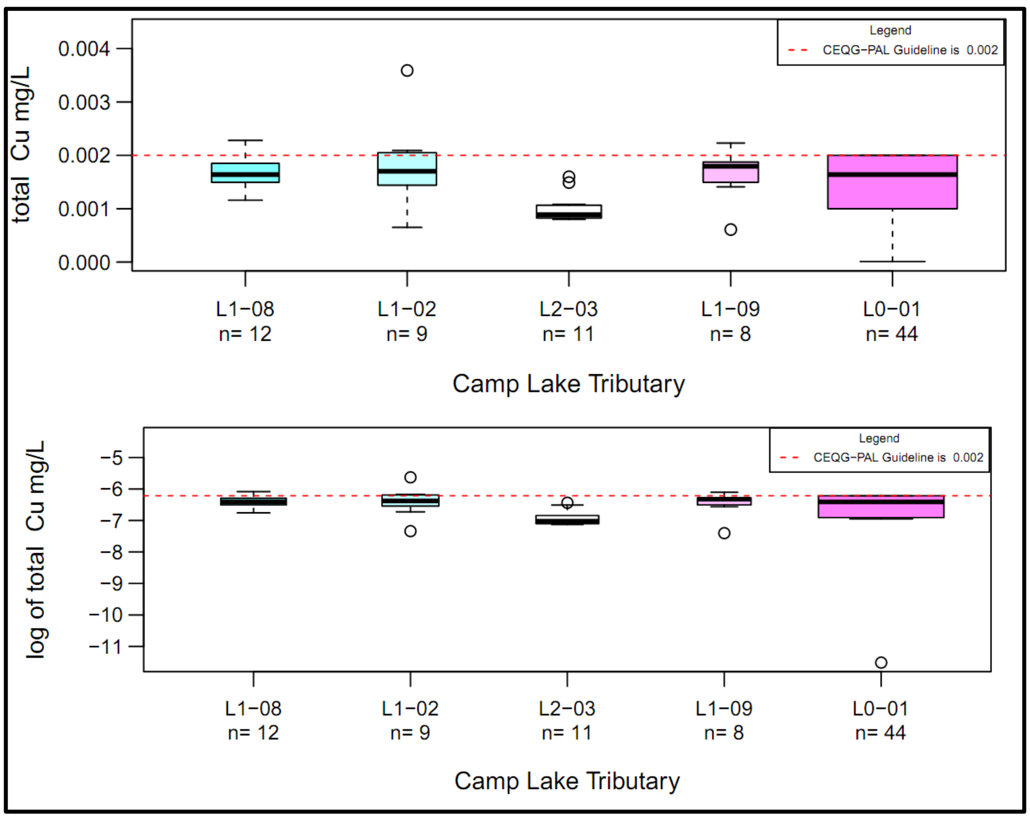
Total Cadmium

Eighty-seven (87) total cadmium samples were collected in the Camp Lake Tributary area with 8 to 47 samples collected at each geographically distinct sampling station (47 samples were collected at L0-01; 8 to 12 samples were collected at the remaining stations). Baseline cadmium concentrations occur consistently at MDL and do not warrant graphical analysis.

Total Copper (Figures C.30 and C.31)

Eight-four (84) copper samples were collected in the Camp Lake Tributary area with 8 to 44 samples collected at each geographically distinct sampling station. Baseline copper concentrations occur consistently above MDL, and close to or above the CWQG-PAL guideline (Figure C.30). Maximum and 75th percentile concentrations occur at or above the CWQG limit at L0-01, L1-02, L1-08, and L1-09. Total median copper concentrations remain at a consistent value for all stations, except L2-03, where copper concentrations are lower.

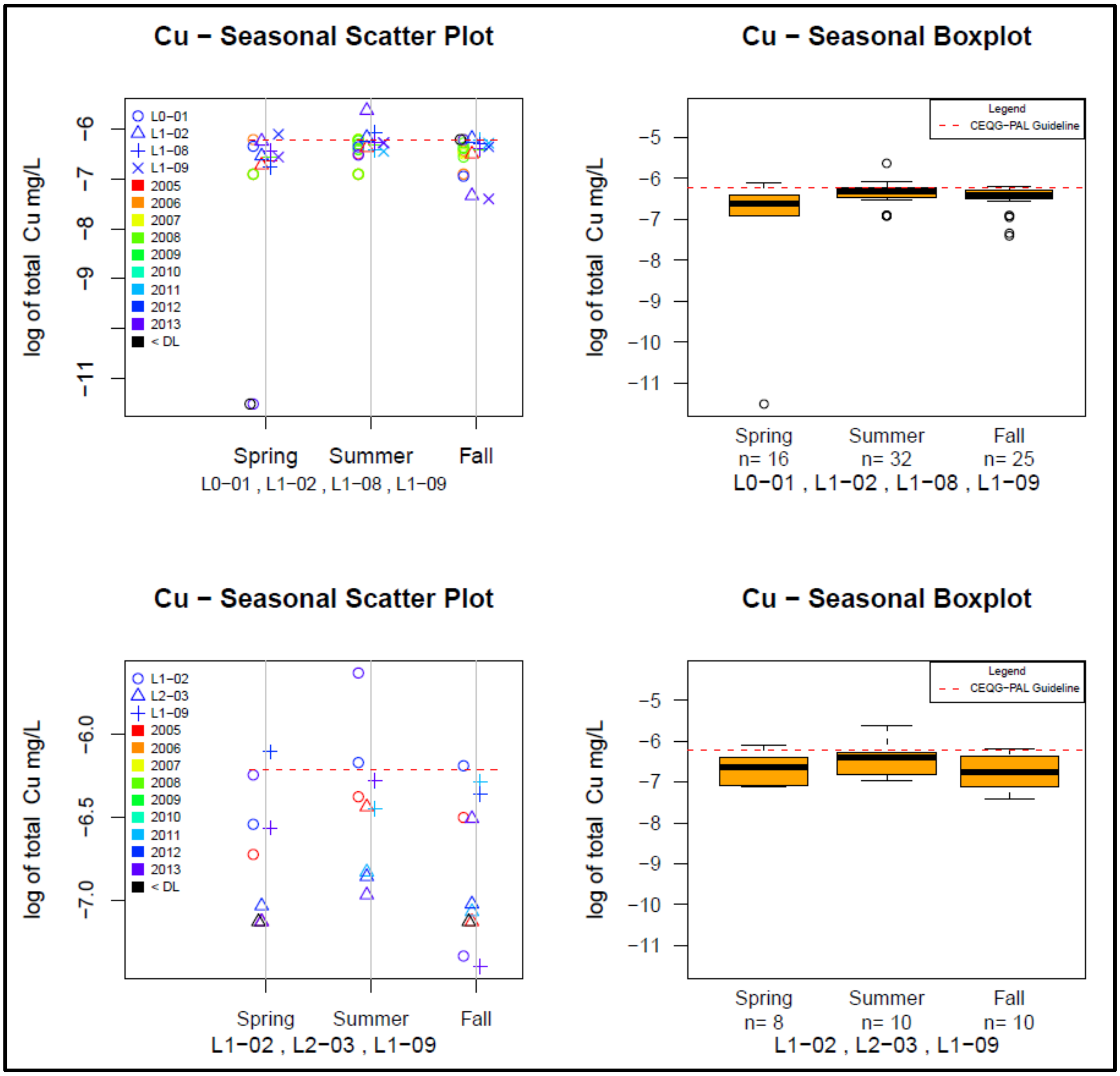
Large magnitude seasonal trends are not observed, but slightly elevated summer concentrations are observed (Figure C.31). No consistent temporal trends are noted over the eight-year sampling history.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.30 Camp Lake Tributary – Total Copper Concentrations in Water



NOTES:

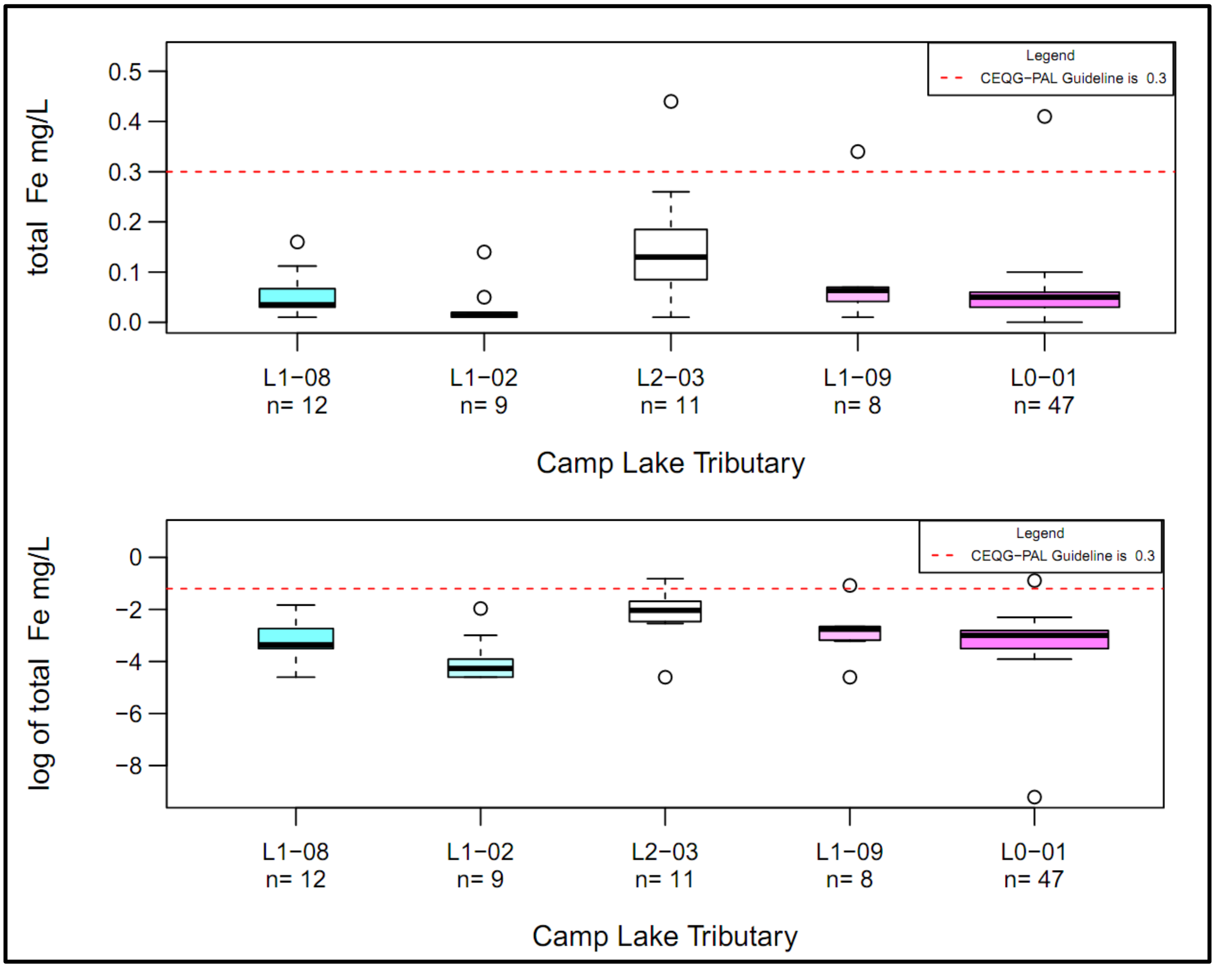
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.31 Camp Lake Tributary – Copper Data Aggregation

Total Iron (Figures C.32 and C.33)

Eighty-seven (87) total iron samples were collected in the Camp Lake Tributary area with 8 to 47 samples collected at each geographically distinct sampling station. Baseline iron concentrations occur consistently above MDL, with just 25% of all data collected in the Camp Lake Tributary occuring below MDL (Figure C.32). Total and seasonal median iron values occur consistently below the CWQG-PAL guideline; however, outlying concentrations occur at or above the CWQG limit at several stations (L2-03, L1-09 and L0-01). Iron concentrations at L2-03 are slightly elevated compared to other stations.

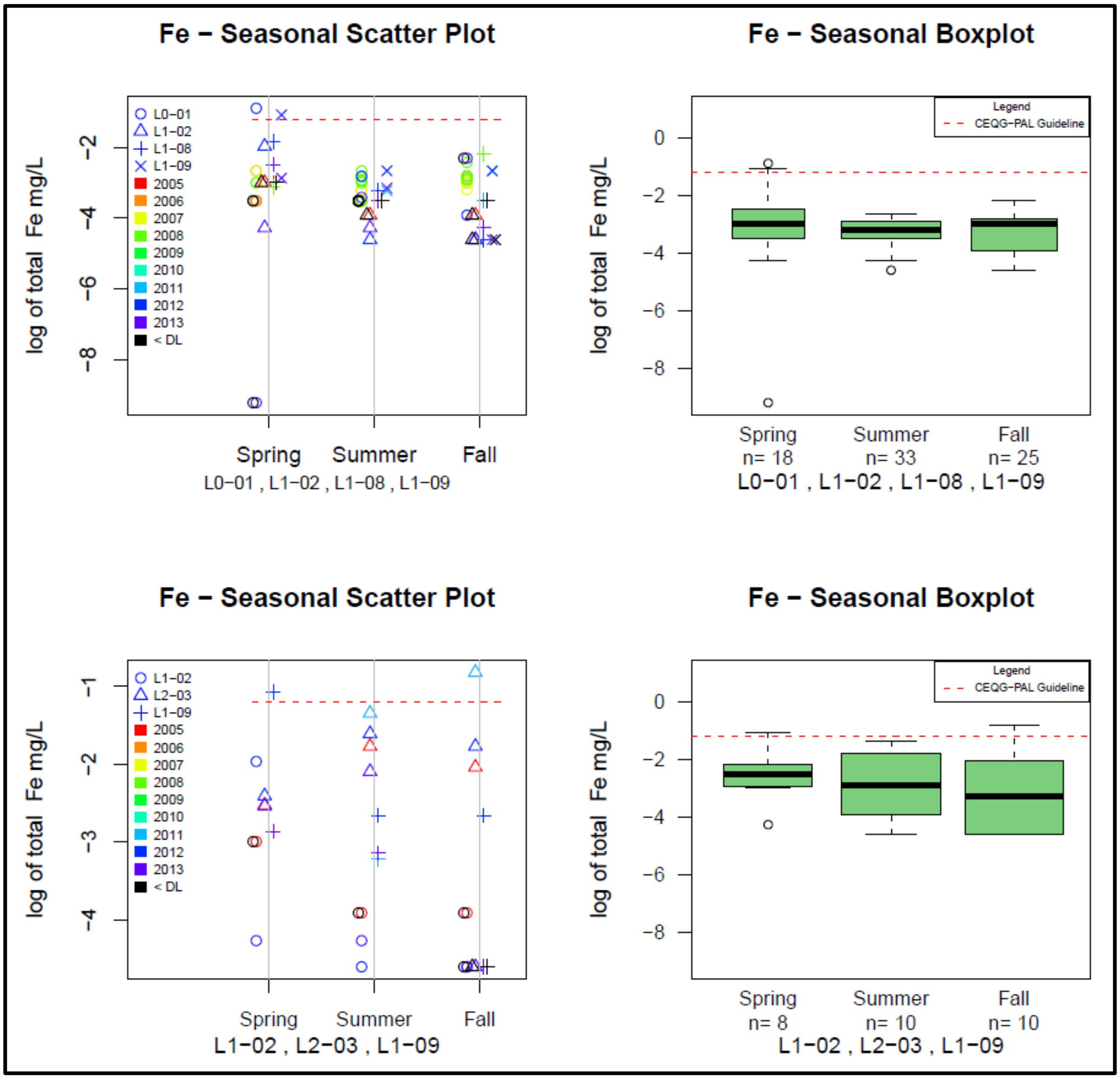
Seasonal box plots show fairly consistent median iron concentration, regardless of season (Figure C.33). In addition, no consistent temporal trends are noted over the eight-year sampling history.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.32 Camp Lake Tributary – Total Iron Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

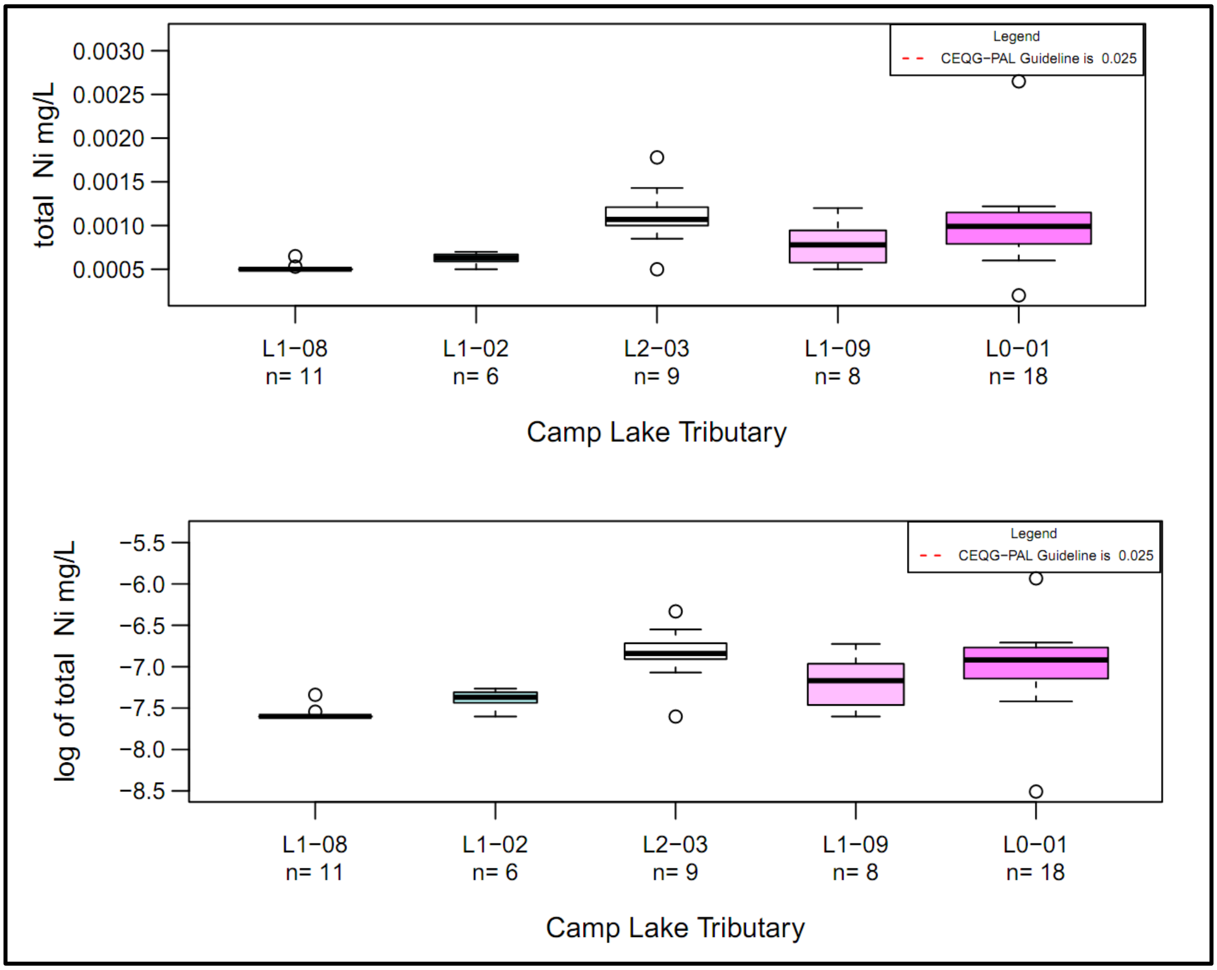
Figure C.33 Camp Lake Tributary – Variability of Total Iron in Water

Total Nickel (Figures C.34 and C.35)

Fifty-two (52) total nickel samples were collected in the Camp Lake Tributary area with 6 to 18 samples collected at each geographically distinct sampling station. Baseline nickel concentrations are consistently low, but occur above MDL (Figure C.34).

All measured concentrations of nickel occur well below the CWQG-PAL guideline, which is a hardness dependent guideline (calculated to be 0.025 mg/L with 50 mg/L $CaCO_3$). Similar to iron, nickel concentrations at L2-03 are slightly elevated compared to other stations, with concentrations at L0-01 occuring just behind those at L2-03.

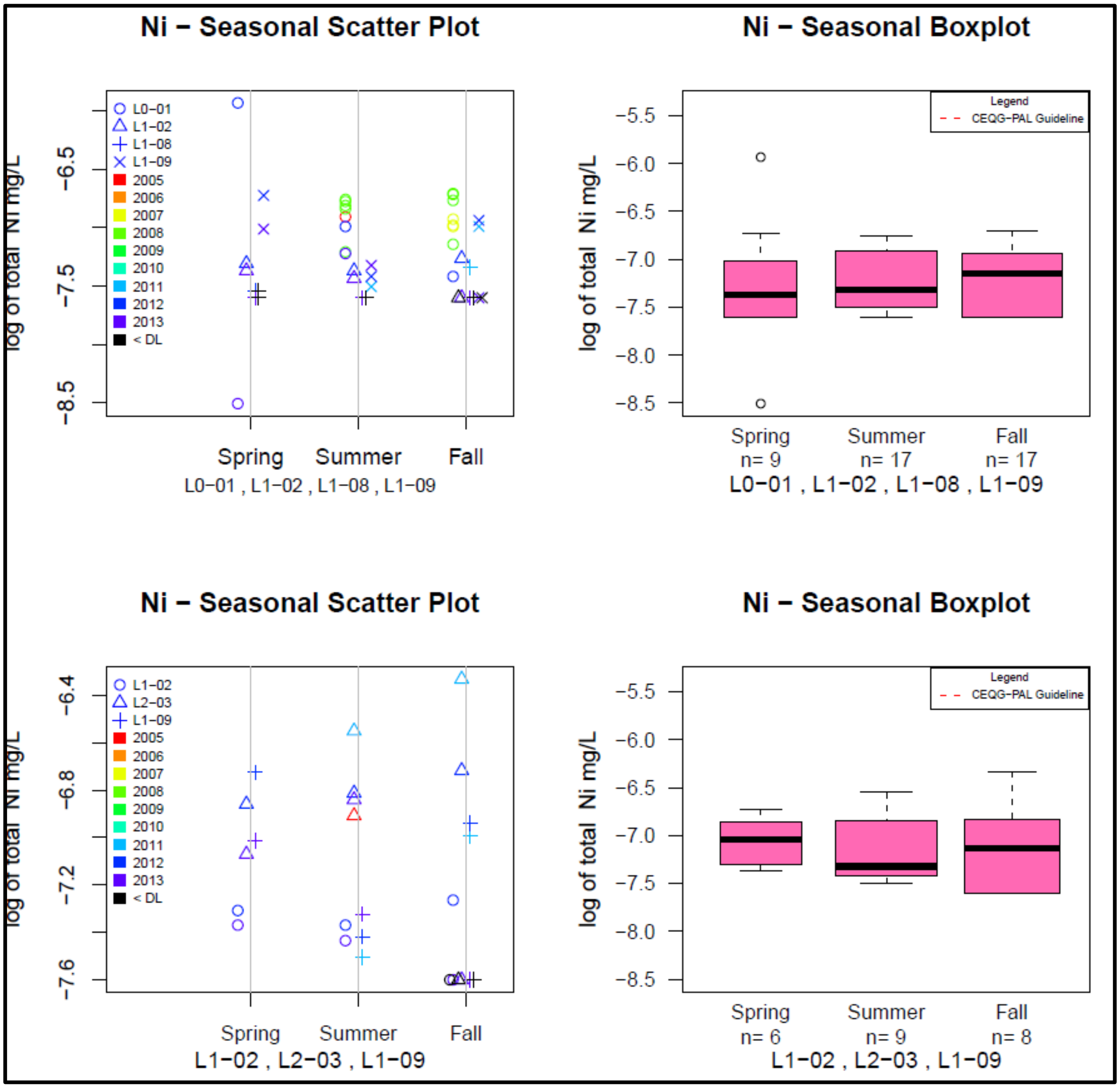
Seasonal box plots show consistent median iron concentration, regardless of season (Figure C.35). In addition, no consistent temporal trends are noted over the eight-year sampling history.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.34 Camp Lake Tributary – Total Nickel Concentrations in Water



NOTES:

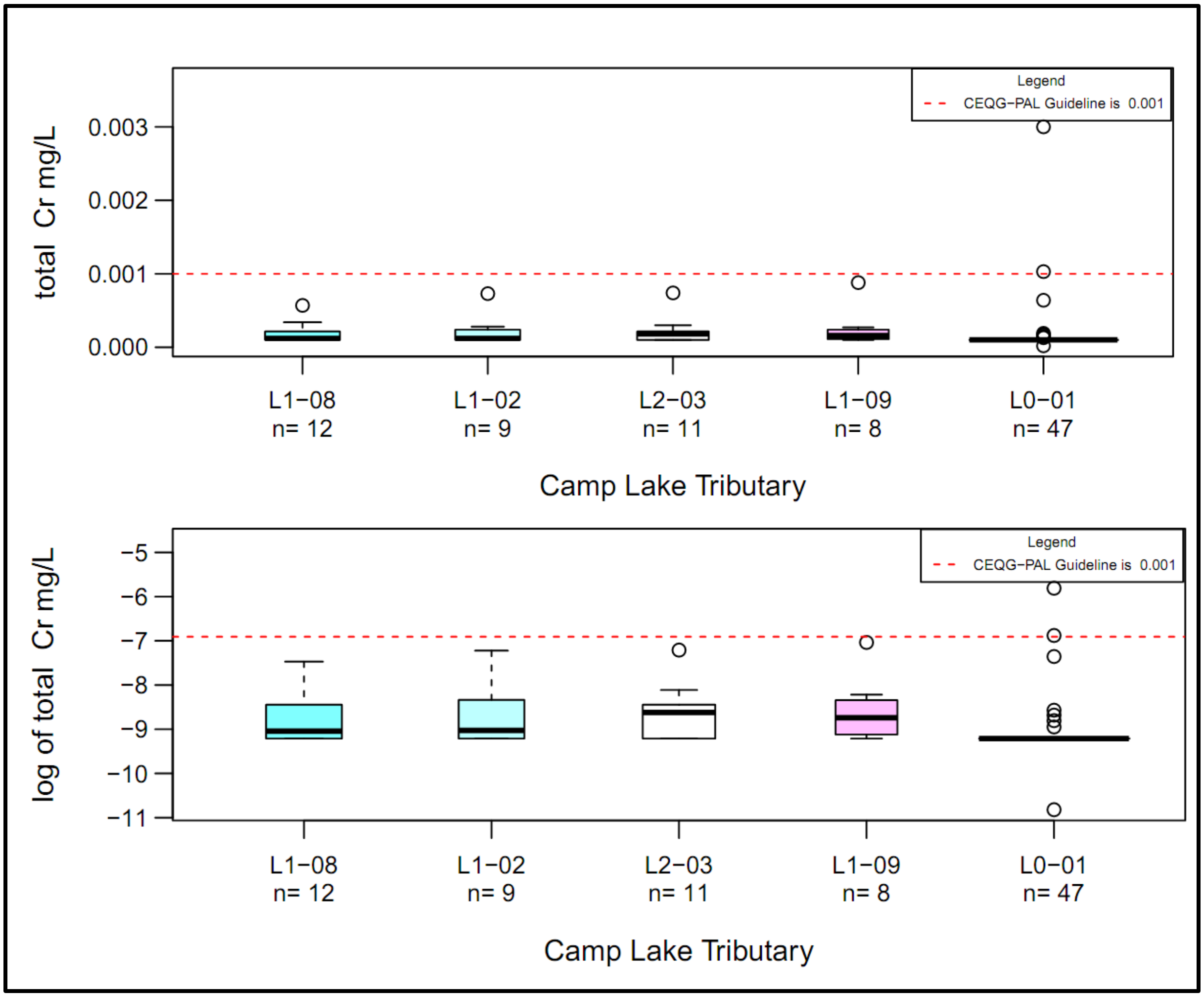
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.35 Camp Lake Tributary – Nickel Data Aggregation

Total Chromium (Figures C.36 and C.37)

Eighty-seven (87) total chromium samples were collected in the Camp Lake Tributary area with six to forty-seven samples collected at each geographically distinct sampling station. Baseline chromium concentrations are consistently elevated and occur close to the CWQG-PAL guideline (Figure C.36).

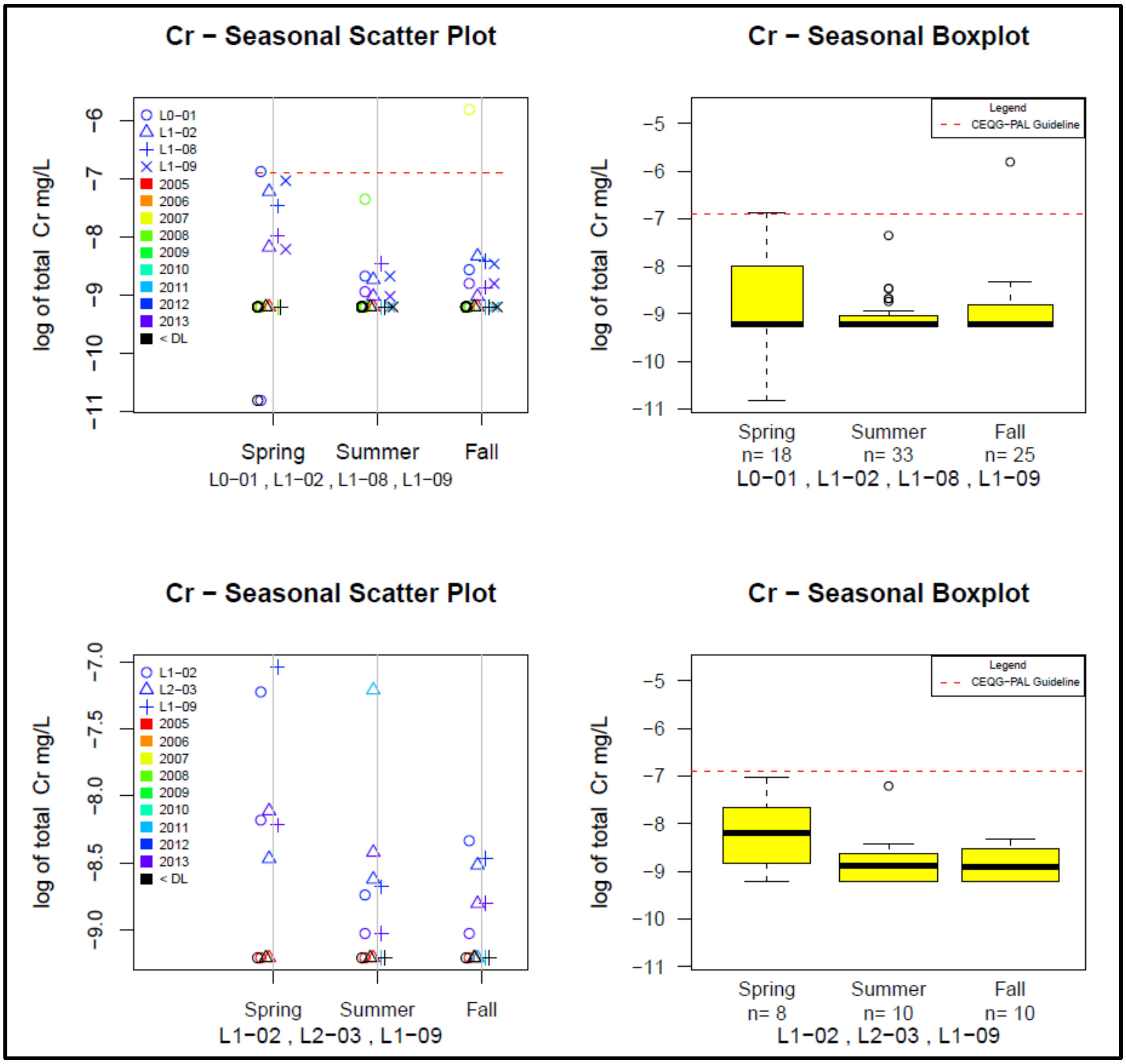
Seasonal box plots show consistent median chromium concentrations, regardless of season (Figure C.37). Data from 2012 and 2013 show slightly elevated values compared to previous years, but insufficient amount of data is avialable to prove this is the case.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.36 Camp Lake Tributary – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.37 Camp Lake Tributary – Chromium Data Aggregation

Summary of trends observed during review of Camp Lake Tributary baseline data:

- Station L0-01 has the greatest sample size, with sample size ranging from 30 to 61, depending on the parameter sampled.
- Aluminum and chromium data from 2012 and 2013 was observed to be slightly elevated when compared to other data.
- The L2-03 station recorded slightly higher concentrations of chloride, iron and nickel.

- Seasonal trends occurred for some parameters, and were specific to the parameter: baseline chloride concentrations were highest in the fall, lowest in the spring; aluminum concentration were highest in the spring, lowest in fall; nickel, chromium and iron had consistent median values, regardless of season and copper concentrations were highest in the summer, lowest in the spring.
- Nitrate, arsenic and cadmium were consistently measured to occur below MDLs and seasonal trends were not observed, due to detection limit interference.

C.3.3 River Summary

Since 2005, a variety of watercourses have been sampled as part of the baseline monitoring program. For the purposes of the CREMP, a subset of the total stations was selected that were deemed applicable for future monitoring. As a result, only two river/tributary systems were examined: Mary River and the Camp Lake Tributary. In general, similar station-wide and seasonal trends were noted for each parameter within rivers/tributary systems on the property. No distinct inter-annual trends were noted. Comparison of the general chemistry of the two systems indicates the general composition is quite similar: water is characterised as circum-neutral/slightly alkaline pH and high alkalinity/low sensitivity to acidic inputs. Hardness ranges from “soft” to “moderately soft” and is almost entirely carbonate hardness.

Chemical concentration trends were analysed with the knowledge that the intense spring runoff period resulting from winter snowpack melting characterizes the artic hydrologic cycle (Stewart and Lamoureux, 2011). Our data indicates highest trace metal concentrations occur during summer (and occasionally fall), and that spring concentrations are generally lowest. This indicates that the snowpack is acting as a fresh, diluting seasonal input.

Station-wide, nitrate, arsenic and cadmium general occur at detection limit. Chloride and nickel generally occur above MDL, but below guideline values. Chloride concentration increases through the seasons from the lowest recorded concentration in the spring to the highest recorded concentrations in the fall. In Mary River, the highest nickel concentrations occur in the summer; whereas, no seasonal trends are noted for nickel within the Camp Lake Tributary. Copper concentrations are consistently close to guideline value throughout the station, with highest concentrations occurring in the summer and fall.

Aluminum and iron show slightly different trends between stations within Mary River and the Camp Lake Tributary. Within Mary River, median total aluminium concentrations occur above CWQG-PAL guideline, but below the SSWQO and are highest during the summer. Within the Camp Lake Tributary, median total aluminum concentrations are generally low and below the CWQG guideline and are highest during the spring. Total iron concentrations within Mary River are consistently close to the guideline, with maximum values exceeding guideline and highest concentrations occurring in the summer. Within the Camp Lake Tributary, iron concentrations are consistently below guidelines, with maximum values occurring during the spring.

It is observed that the MDLs are higher for Cr (III) and Cr (VI) compared to total chromium. As such, 38% of samples in Mary River analyzed for total chromium were above MDL. Only 5% of Cr (III) and 2% of Cr (VI) samples were above MDLs. This supports the assumption that most chromium is in suspended particulate.

C.4 POWER ANALYSIS

Parameter and station-specific power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the AEMP Assessment Approach and Response Framework (Figure 2.12 in the main report), management action will be triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmarks have been developed as reference concentrations for comparison in the response framework (Intrinsik, 2014). Sufficient statistical power is required to ensure that management action is triggered correctly, and this has necessitated the completion of a power analysis. Inputs to the power analyses include all baseline data sampled to date and the benchmark values. The methodology used in the following sections follows closely the methodology used on lake water quality data in Appendix B.

The *a priori* power analysis determines, based on a given sample size, variability and effect size[2], the number of samples required to obtain a certain power at a certain alpha value or Type I error rate. The analysis utilized a two-sided alpha value of 0.10 (with an alpha of 0.05 on each side). The power analyses were run based on two effect sizes: 1) the difference between the station baseline mean and benchmark and 2) halfway between the station baseline mean and benchmark.

The following parameters were selected for power analysis as they have a large number of detected values, have elevated concentrations during baseline conditions and are expected to be the most affected parameters during mine operation:

- Aluminum
- Arsenic
- Cadmium
- Copper
- Iron

Two different types of power analysis were run, depending on the proportion of data above MDL. Several modifications to each approach were taken, depending on availability of data at a specific site.

1) The power to detect a change in means was assessed for parameters with sufficient data above MDL (<15% of non-detected data). A before-after-control-impact (BACI) design was used to assess the power to detect differences in log mean concentration values (using the methods of Stroup, 1999)[3]. A BACI design is rigorous in the sense that it shows a change in the difference between impact (exposure) and control (reference) stations from before to after the commencement of a potential environmental impact. This method accounts for background natural variation, such as seasonal trends, that may occur during the same period as the potential environmental impact. In order to utilize this design, sufficient baseline data is required at both control and impact sites.

---

[2] Effect size is the magnitude of an effect. In *a priori* power analysis, the effect size quantifies the magnitude difference between two groups that the test will be able to determine.

[3] Comparison of medians or log means are both supported methods to compare data sets. Median comparisons are more robust when distributions are non-normally distributed. Median or mean comparisons are equally robust when distributions are normally distributed. Log distribution of water quality data collected created a data set that was normally distributed. As a result, mean comparison was determined appropriate.

For the purposes of analysis, for parameters with <15% non-detected data, only detected data was analyzed. This method was selected due to a variety of detection limits present in the historic data. In some cases, imputation of detection limits occurred, as discussed in Section 2.2. Although all imputation assumptions were conservative; analysis of the detected data removes the possibility that data analysis was affected by imputation or elevated detection limits. To verify the use of the detected data to inform mean values for the power analysis, the mean values estimated with detected data are compared to the mean values estimated via Regression on Order (ROS) method. The Regression on Order (ROS) statistics method is recommended by the BC Ministry of Environment as a method to calculate statistics in data sets including non-detects and especially those affected by left-censored data (Huston and Juarez-Colunga, 2009). Both of these values are provided for each key parameter examined for the sake of comparison. In general, the mean estimate based on detected data is larger than the ROS estimate. This is conservative for the power analysis as a higher baseline mean corresponds to a smaller change to be detected post mining.

The following modifications to the complete BACI approach were taken, as dictated by the data available:

a. Before-after (BA) design was used when control data was not available. Under this design, power analysis was carried out using a two sample t-test to compare means. This approach is less rigorous when compared to the BACI design and does not control for natural temporal changes.

b. Control-impact (CI) design was assumed when very little baseline data was available. Under this design, power analysis for testing means was carried out using a paired t-test. This approach is less rigorous when compared to the BACI design does not control for natural geographic differences between the control and impact sites.

2) The power to detect a change in the proportion of values above MDL was assessed for parameters with a large proportion of values below MDL (>15% of non-detected data). For some parameters the baseline dataset is represented predominantly by values below MDL. This occurred for arsenic and cadmium at all stations. For these parameters, the exact magnitude of the parameters under baseline conditions is unknown. Although a full BACI analysis will be carried out for data analysis purposes, simplified designs were assumed for the power analysis. Two approaches were utilized for the test of proportions:

   a. BA designs were assessed using a test for two independent proportions (Agresti, 1990).

   b. McNemar's test (Agresti, 1990) was used to assess the power to detect a difference between the paired proportions at impact and control stations. As for continuous data, pairing allows exploitation of the fact that the variance of the difference between paired data is smaller than the variance of the difference between independent samples (Agresti, 1990). Under a full BACI design, the baseline and post-mining paired proportions can be compared to assess whether a change is mine related.

McNemar test for the equivalence of paired proportions (each impact sample paired with a correlated control sample collected at a comparable time) is carried out using the off-diagonal elements (p_{01} and p_{10}) of a 2x2 contingency table. It is helpful to reference Table C.3 for discussions related to the analysis of proportions. This is a novel approach that enables the use of data highly affected by censored data, where a meaningful comparison of means is not possible and the utility of left-censored methods is limited. To our knowledge, this approach has not been used in other projects, but is supported within scientific literature as a valid method to deal with left-censored data (Agresti, 1990).

Table C.3 Proportion Labels for 2x2 Contingency Table

Impact	Control		
	<MDL	>MDL	Total
<MDL	p_{00}	p_{01}	p_{0+}
>MDL	p_{10}	p_{11}	p_{1+}
Total	p_{+0}	p_{+1}	p_{++}

Stations were strategically selected to ensure sampling, and subsequent statistical testing would provide information regarding the source of the contaminants, if any, that arise during the course of mine development. Carrying out the power analysis for each station separately ensures sufficient power to detect change at each location. This is important as pooling data from near-field and far-field stations could potentially wash out effects at near field stations. By choosing stations located at various distances from a potential contaminant source, the spatial extent of potential impacts can be identified and the impact source(s) potentially isolated. These stations are specific to the water body.

C.4.1 Camp Lake Tributary

C.4.1.1 Methods

No pre-mining reference stations were available and the analysis was run assuming no control data, using a before-after (BA) design. Three key monitoring stations within the Camp Lake tributary were assessed. These stations also correspond to the Camp Lake tributary near-field and far-field exposure areas examined as part of the EEM.

- L0-01
- L1-09
- L1-02

Very few data points exist for L1-09 and L1-02, and the most number of samples at Camp Lake tributary were collected for L0-01. By assessing these key points, that also contain the smallest sample sizes, the study design is designed conservatively.

Metrics for sample size, median, mean and standard deviation will be used as a method to compare power between stations for a variety of lakes. In general, sample sets that have a lower sample size, higher variability and a small difference between station baseline mean and benchmark have low power.

C.4.1.2 Results

Since the power analysis was completed on a station-specific and parameter-specific basis, the results were interpreted by identifying the stations and parameters that are most constraining. Table B.5 highlights the stations and parameters that are expected to constrain power. Note that this power analysis is conservative because the effect size used is equal to halfway between the station baseline mean and the benchmark. It is not unexpected that aluminum is a constraining factor across a number of stations since aluminum is the most enriched metal during baseline conditions. Analysis of Table C.4 shows that stations identified as constraining factors for aluminum concentrations are those stations where the distribution of aluminum data occurs close to the benchmark. Discussion of each parameter follows.

Table C.4 Camp Lake Tributary Power Analysis – Constraining Stations and Parameters

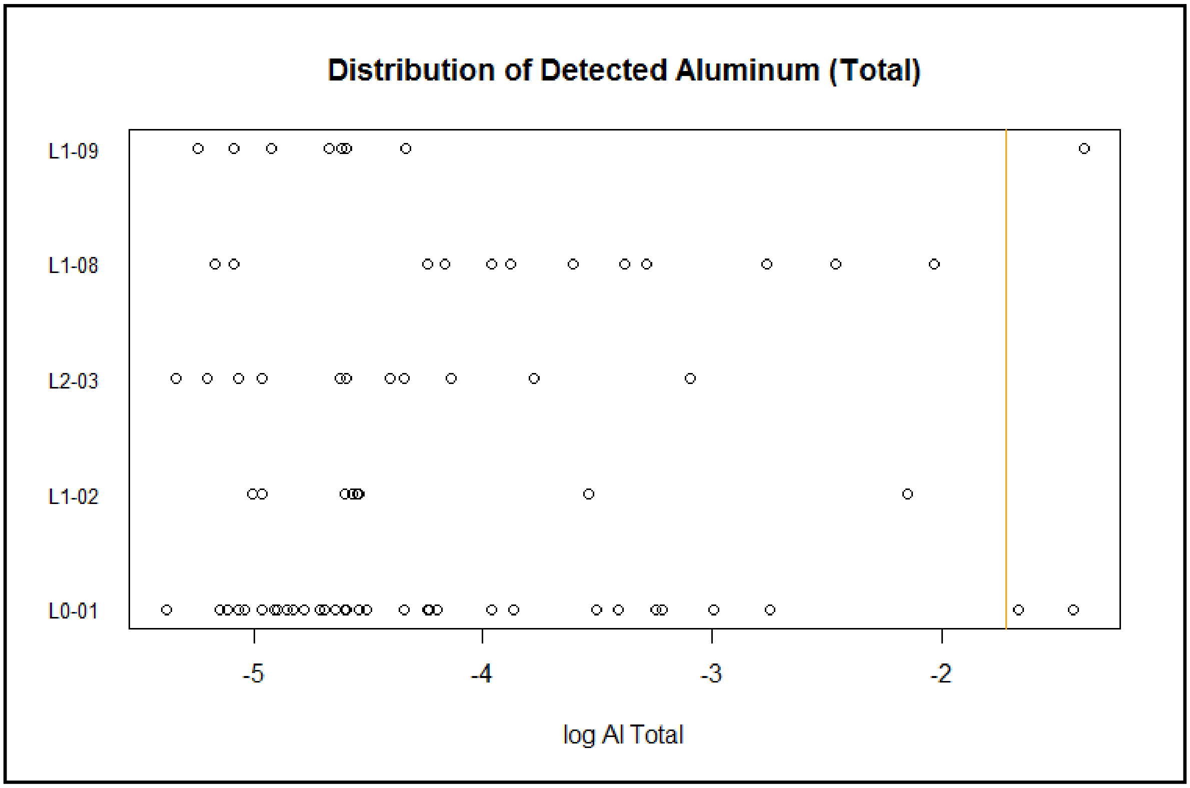
Parameter	Station	Waterbody	Power (given sample size of 10, alpha of 0.1)	Power (given sample size of 50)
Copper	L1-09	Camp Lake Tributary	58%	78%
	L1-02	Camp Lake Tributary	40%	58%
Iron	L1-09	Camp Lake Tributary	60%	80%
	L1-02	Camp Lake Tributary	65%	82%
Aluminum	L1-09	Camp Lake Tributary	70%	90%

NOTES:
1. POWER IS CALCULATED BASED ON AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION BASELINE MEAN AND BENCHMARK.

Aluminum

Total aluminum values are elevated throughout the mine site area but concentrations are significantly reduced in the Camp Lake Tributary when compared to the Mary River. Within the Camp Lake Tributary, measured baseline aluminum concentrations have several values that exceed the benchmark at L0-01 and L1-09 (Figure C.38). All measured concentrations at L1-08, L2-03 and L1-02 occur below the benchmark value. The benchmark for aluminum within the Camp Lake Tributary is 0.18 mg/L.

Five (5) samples are expected to be sufficient given an alpha value of 0.1 at all sites with the exception of L1-08 and L1-09, which are anticipated to require 5-10 and 20 samples, respectively.



NOTES:

1. THE CAMP LAKE TRIBUTARY BENCHMARK FOR ALUMINUM IS 0.18 mg/L (LOG VALUE = -1.7), DISPLAYED AS YELLOW LINE.

Figure C.38 Detected Total Aluminum Values in Camp Lake Relative to Benchmark

Table C.5 Results of Aluminum Power Analysis – Camp Lake Tributary Stations

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
L0-01	47	39	0.010	0.047	-4.3	0.91	-4.6	0.18	-1.7	2.6	5
L1-02	9	8	0.011	0.038	-4.2	1.0	-4.5	0.18	-1.7	2.5	5
L2-03	11	11	0.010	0.012	-4.5	0.67	-4.5	0.18	-1.7	2.8	~5[2]
L1-08	12	12	0.024	0.037	-3.7	0.96	-4.7	0.18	-1.7	1.9	~5-10[2]
L1-09	8	8	0.010	0.086	-4.4	1.2	-4.4	0.18	-1.7	2.6	20

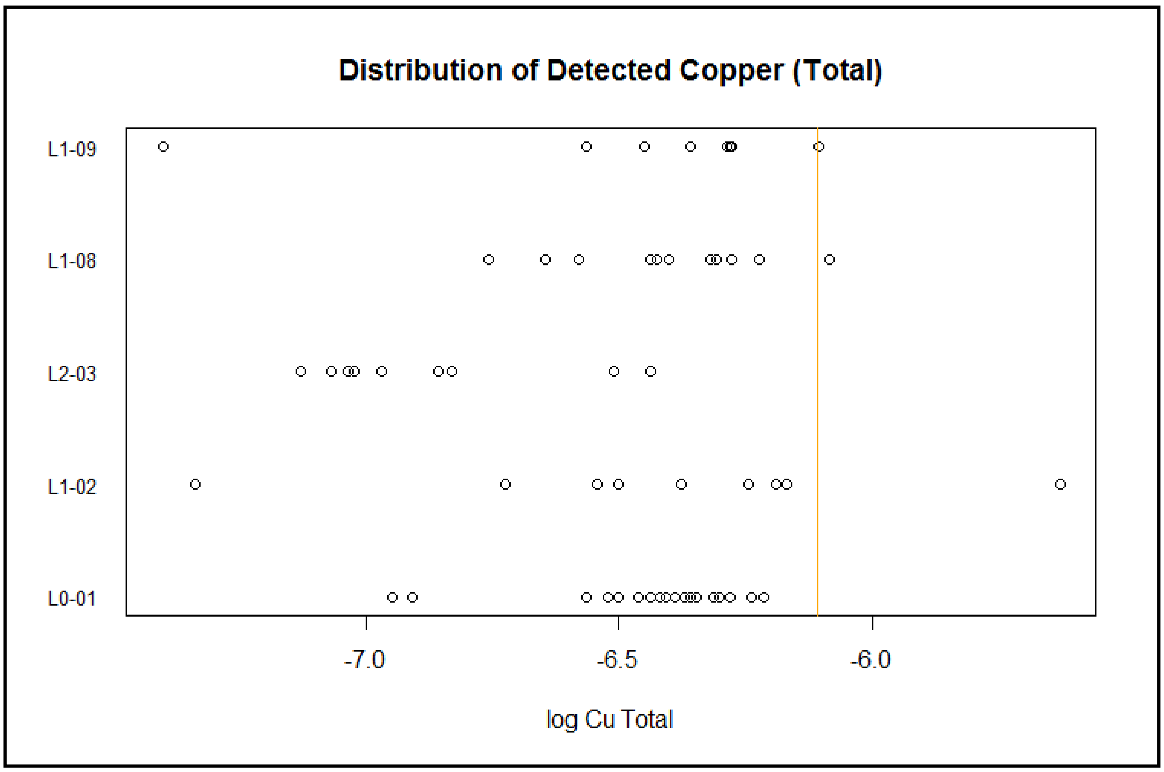
NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Copper

Total copper values are observed to be elevated site-wide and are particularly elevated within Mary River and Camp Lake tributary. Median copper values for stations within the Camp Lake tributary range from 0.00094 mg/L to 0.0016 mg/L. The CWQG-PAL guideline for copper is 0.002 mg/L and the benchmark value is 0.0022 mg/L (log value of -6.1). Figure C.39 shows that even though L0-01, L1-02 and L1-9 have median copper concentrations that vary slightly, the distribution of values are quite different.

L1-02 and L1-09 stations are problematic in obtaining adequate sample size to test for pre-mining and post-mining differences in copper. Even with the collection of fifty samples at these stations, the power obtained is still less than adequate (78% for L1-02 and 58% for L1-09) (Table C.6). The power analysis is constrained by the small baseline sample size, which is expected to increase after 2014 sampling.



NOTES:

1. THE CAMP LAKE TRIBUTARY BENCHMARK FOR COPPER IS 0.0022 mg/L (-6.1), DISPLAYED AS YELLOW LINE.

Figure C.39 Detected Total Copper Values in Camp Lake Tributary Relative to Benchmark

Table C.6 Results of Copper Power Analysis – Camp Lake Tributary Stations

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Bench mark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
L0-01	44	42	0.0016	0.00041	-6.5	0.29	-6.5	0.0022	-6.1	0.40	20
L1-02	9	9	0.0017	0.0008	-6.4	0.47	-6.4	0.0022	-6.1	0.30	50
L2-03	11	9	0.00094	0.00029	-6.9	0.25	-7.0	0.0022	-6.1	0.76	NA
L1-08	12	12	0.0016	0.00031	-6.4	0.19	-6.4	0.0022	-6.1	0.30	NA
L1-09	8	8	0.0018	0.00048	-6.5	0.40	-6.5	0.0022	-6.1	0.36	50

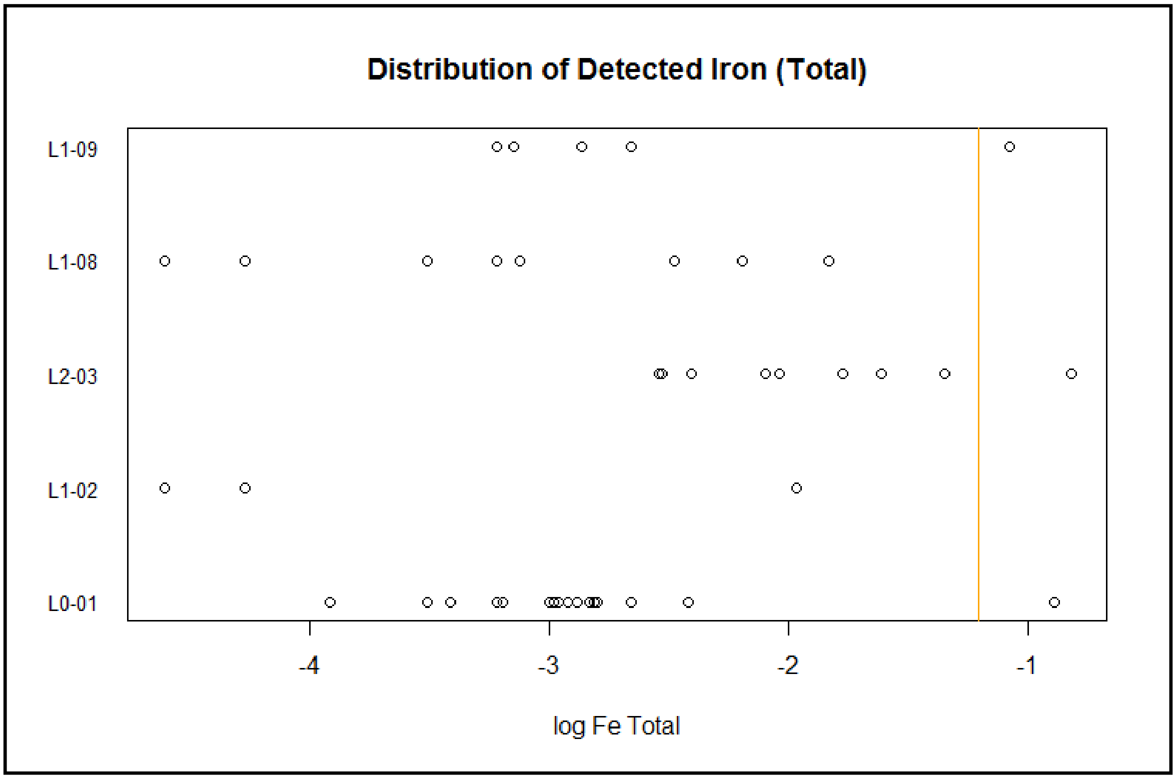
NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. NA STATIONS WERE NOT ASSESSED AND CANNOT BE ESTIMATED BASED ON ASSESSED STATIONS.
3. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Iron

Similar to aluminum and copper, iron concentrations are moderately elevated within the Camp Lake Tributary (Figure C.40). Median iron concentrations within the Camp Lake tributary range from 0.042 mg/L to 0.11 mg/L and the number of detectable samples ranges from 8 through 47.

As expected, the L0-01 station requires the least amount of samples post-mining to detect a statistical change (Table C.7). This is as a result of a high sample size for pre-mining data (36) and a low median iron concentration. Twenty post-mining samples are predicted to be required at L1-02, due mostly to the low sample size of pre-mining data. L1-09 proves to be a problematic station to determine significant differences for iron. This station has a low sample size and very high standard deviation. At L1-09, up to 50 samples are required to achieve 80% power. It is expected that the number of samples required at these stations will decrease after the completion of 2014 sampling; however, additional samples at L1-09 in particular key location is recommended to increase power.



NOTES:

1. THE BENCHMARK FOR IRON IN THE CAMP LAKE TRIBUTARY IS 0.3 mg/L (LOG VALUE = -1.2), DISPLAYED AS YELLOW LINE.

Figure C.40 Detected Total Iron Values in Camp Lake Tributary Relative to Benchmark

Table C.7 Results of Iron Power Analysis – Camp Lake Tributary Stations

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Bench mark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
L0-01	47	36	0.052	0.061	-2.9	0.46	-3.1	0.30	-1.2	1.7	5
L1-02	9	5	0.014	0.057	-3.9	1.1	-4.4	0.30	-1.2	2.7	20
L2-03	11	10	0.150	0.110	-1.9	0.55	-2.0	0.30	-1.2	0.7	NA
L1-08	12	8	0.042	0.053	-3.2	0.97	NA	0.30	-1.2	1.9	NA
L1-09	8	7	0.070	0.107	-2.6	0.7	-2.8	0.30	-1.2	1.4	50

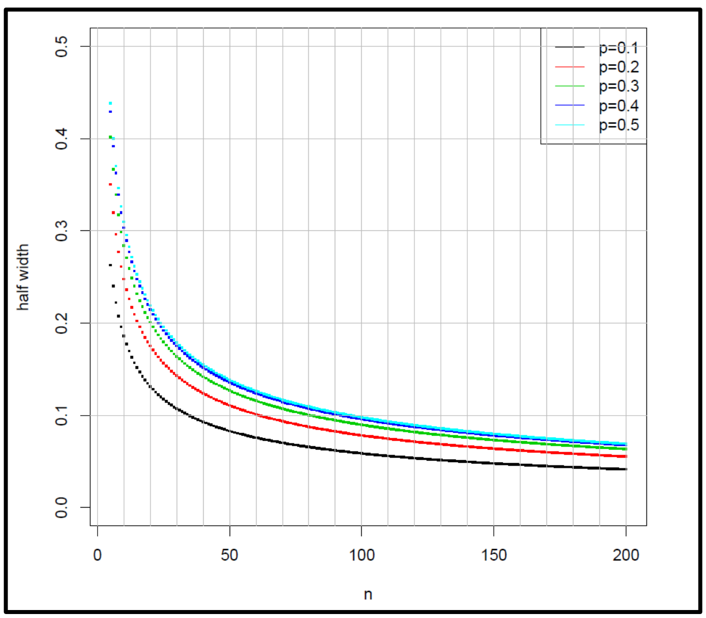
NOTES:

1. REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. NA STATIONS WERE NOT ASSESSED AND CANNOT BE ESTIMATED BASED ON EXISTING STATIONS.
3. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Arsenic and Cadmium

More than 90% of samples at each station in the Camp Lake Tributary have arsenic and cadmium concentrations that are below detection limits. As a result, assessment of the proportion of values above MDL was used for these parameters. A normal approximation to the binomial distribution was used to obtain the estimates of the width of confidence intervals for various proportions and sample sizes (based on a normal approximation) shown in Figure C.41. A statistically significant difference between proportions is equivalent to non-overlapping confidence intervals (CI) for the baseline and post-mining proportions. Figure C.41 can be used to determine the accuracy of the proportion estimates (CI) for various proportions and samples sizes. For arsenic and cadmium, the proportion of values below detection limits is greater than 90% (10% above); therefore, the p=0.1 line (black) is selected. For example, L0-01 has a baseline sample size of 47. Thus, a 95% CI on a proportion would be 0.1+/- 0.085 or (1.5%, 18.5%). The post-mining confidence interval for 50% above MDL with 20 samples would be 0.5 +/- 0.22 or (28%, 72%) and would be sufficient to detect such a change. The normal approximation does not hold for small sample sizes and extreme proportions but an exact confidence interval can be calculated. A sample size of 10 would produce a 95% baseline CI of (2%, 40%). Thus, only a large change to approximately 65% (CI = (44%, 86%)) above MDL would differ for a sample 20.

The power to detect a difference between independent samples can also be calculated. To detect a change from 10% to 50% approximately 20 samples are required at baseline and post-mining. With only 10 baseline samples and 10 post-mining samples, 80% power can be obtained for a larger change to 68% above MDL.



NOTES:
1. P EQUALS PROPORTION OF SAMPLES BELOW DETECTION LIMIT.

Figure C.41 Half 95% Confidence Interval Width for Proportions – L0-01

C.4.2 Mary River

C.4.2.1 Methods

Similar to the methods used for the Camp Lake Tributary power analysis, parameter and station-specific power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. In contrast to the method used for the Camp Lake Tributary power analysis, pre-mining reference and impact stations exist; therefore, a complete Before-After-Control-Impact (BACI) analysis is utilized.

The stations along the Mary River used in the power analysis were:

- E0-10
- E0-03
- E0-21 and E0-20 (pooled), and
- C0-10.

The best reference station for each impact station was considered to be the G0-09 value collected on the same day. Comparing data on the same day was considered optimal as it would minimize the effects of time. Since data from the same day was not always available, the data was infilled using the following alternatives, listed in order of priority and data proximity (0:29 with 0 indicating the best quality):

- 0-4: G0-09 same day, within 1 day, within 2 days, within 3 days, within 4 days
- 5-9: G0-03 same day, within 1 day, within 2 days, within 3 days, within 4 days
- 10-14: G0-01 same day, within 1 day, within 2 days, within 3 days, within 4 days
- 15-19: G0-09 within 5 days, within 6 days, within 7 days
- 20-24: G0-03 within 5 days, within 6 days, within 7 days, and
- 25-29: G0-01 within 5 days, within 6 days, within 7 days.

For future sampling, it is recommended that the timing of sampling for impact and control sites occur as closely as possible.

C.4.2.2 Results

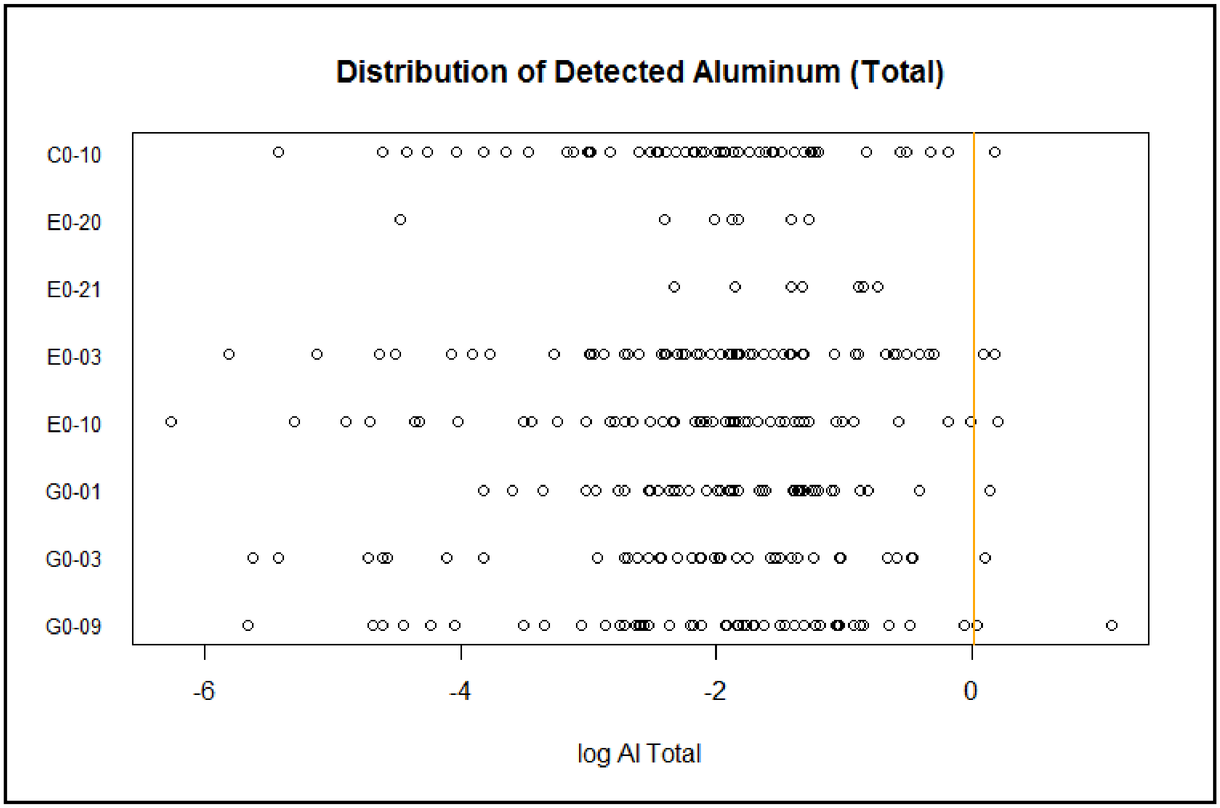
Since the power analysis was completed on a station-specific and parameter-specific basis, the results were interpreted by parameter and station. Unlike the Camp Lake Tributary, no particularly constraining stations or parameters were identified. Power analysis determined between five to ten samples are sufficient to provide 80% power at key stations within the Mary River. Discussion of each parameter individually follows.

Aluminum

Aluminum concentrations are elevated site-wide and are particularly elevated within Mary River. Median aluminum concentrations obtained from all stations in Mary River exceed the CWQG-PAL guideline (0.10 mg/L). The benchmark derived for aluminum is based on the 97.5th percentile of baseline concentrations, and is 1.01 mg/L, which is approximately one order of magnitude greater than the CWQG-PAL guideline. Median aluminum concentrations from the examined stations within Mary River range from 0.13 mg/L to 0.35 mg/L, and standard deviations range from 0.093 mg/L to

0.23 mg/L (Table C.8). Based on the existing baseline and reference data (from stations G0-09, G0-03 and G0-01), all key stations in the Mary River require between eight to ten samples to have adequate power to show significant differences in pre-mining and post-mining data. No “constraining” stations were identified, unlike the Camp Lake tributary (Section C3.1) or lakes assessment (Appendix B).

Figure C.42 shows that there is a strong correlation between aluminum concentrations at impact and control stations. For these stations, the standard deviation of the difference between the impact and control data is smaller than the standard deviation of either sample. The BACI design takes advantage of this correlation and is one of the reasons that relatively low sample sizes can achieve high power.



NOTES:

1. THE BENCHMARK FOR ALURMINUM IN MARY RIVER IS 1.01 mg/L (LOG VALUE = 0.01), DISPLAYED IN RED.

Figure C.42 Detected Total Aluminum Values in Mary River with Respect to Benchmark

Table C.8 Results of Aluminum Power Analysis – Mary River

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
G0-09	52	52	0.15	0.45	-2.1	-0.80	-2.1	1.01	0.01	2.1	NA
G0-03	36	36	0.13	0.23	-2.3	-1.46	-2.3	1.01	0.01	2.2	NA
G0-01	45	45	0.16	0.19	-1.9	-1.65	-1.9	1.01	0.01	1.9	NA
E0-10	48	48	0.14	0.25	-2.3	-1.40	-2.3	1.01	0.01	2.2	10
E0-03	59	59	0.14	0.25	-2.1	-1.37	-2.1	1.01	0.01	2.1	8
E0-21	7	7	0.27	0.14	-1.3	-1.93	-1.3	1.01	0.01	1.3	10
E0-20	7	7	0.15	0.09	-2.2	-2.41	-2.2	1.01	0.01	2.2	
C0-10	53	53	0.12	0.22	-2.2	-1.49	-2.2	1.01	0.01	2.2	8

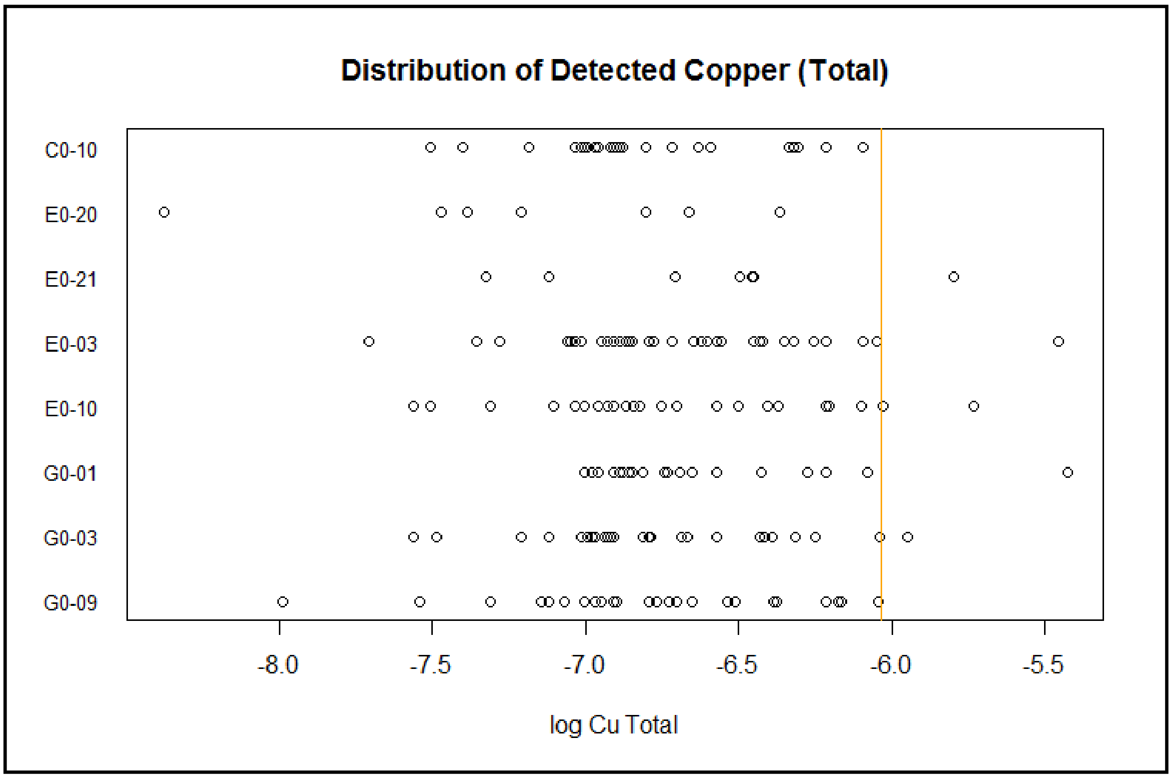
NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. NA STATIONS WERE NOT ASSESSED AND CAN NOT BE ESTIMATED BASED ON EXISTING STATIONS.
4. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Copper

Similar to aluminum, copper is elevated throughout the site. The CWQG-PAL guideline is 0.002 mg/L and the benchmark derived for Mary River is 0.0024 mg/L, which is only slightly above the CWQG-PAL guideline. Median copper values at key stations within Mary river range from 0.00074 mg/L to 0.0015 mg/L (Table C.9). The standard deviation of the baseline copper concentrations at stations along the Mary River are quite low and range from 0.0004 mg/L to 0.00071 mg/L.

Although certain stations have median concentrations that are relatively close to the benchmark (Figure C.43), most stations have median concentrations 50% less than the benchmark and have low standard deviations. As a result, between eight to ten samples are required at the key stations in the Mary River, to achieve 80% power to detect statistical change from baseline concentrations to half of the benchmark value. E0-03 and C0-10 required the least samples (5 and 8, respectively) and E0-20 and E0-21 required the most samples.



NOTES:

1. THE BENCHMARK FOR ALUMINUM IN MARY RIVER IS 0.0024 mg/L (LOG VALUE = -6.0), DISPLAYED IN RED.

Figure C.43 Detected Total Copper Values in Mary River with Respect to Benchmark

Table C.9 Results of Copper Power Analysis – Mary River

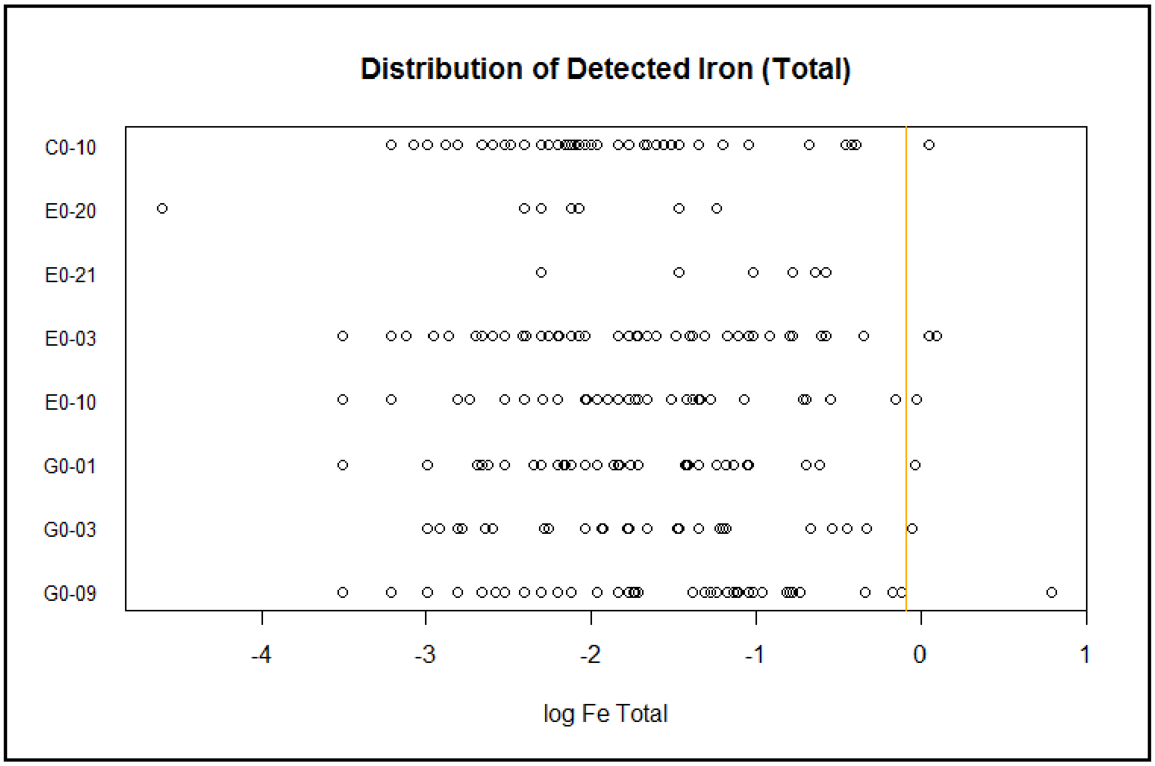
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
G0-09	36	36	0.0011	0.00051	-6.7	0.42	-6.7	0.0024	-6.0	0.71	NA
G0-03	30	29	0.0010	0.00050	-6.8	0.38	-6.8	0.0024	-6.0	0.76	NA
G0-01	29	27	0.0010	0.00071	-6.7	0.36	-6.8	0.0024	-6.0	0.68	NA
E0-10	28	28	0.0011	0.00065	-6.7	0.47	-6.7	0.0024	-6.0	0.71	10
E0-03	42	41	0.0011	0.00065	-6.7	0.40	-6.7	0.0024	-6.0	0.69	5
E0-21	7	7	0.0015	0.00078	-6.6	0.50	-6.6	0.0024	-6.0	0.59	10
E0-20	7	7	0.00074	0.00050	-7.2	0.66	-7.2	0.0024	-6.0	1.15	
C0-10	35	33	0.0010	0.00040	-6.8	0.32	-6.8	0.0024	-6.0	0.79	8

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. NA STATIONS WERE NOT ASSESSED AND CAN NOT BE ESTIMATED BASED ON EXISTING STATIONS.
4. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Iron

Iron concentrations are relatively elevated throughout the mine site area, and are particularly elevated within Mary River. Median iron levels at baseline range from 0.12 mg/L through 0.17 mg/L. The CWQG-PAL guideline for iron is 0.30 mg/L and the benchmark value (derived from the 97.5th percentile of baseline data) is 0.92 mg/L (log value of -0.088 mg/L). The power analysis was completed based on the statistical test determining a difference halfway between baseline mean and the 0.916 mg/L benchmark. Due to the high effect size, and the distribution of baseline values (Figure C.44), all key stations within Mary River only require between five to ten samples to obtain 80% power to detect the effect size required (Table C.10).



NOTES:

1. THE BENCHMARK FOR IRON IN MARY RIVER IS 0.92 mg/L (LOG VALUE = -0.880), DISPLAYED AS YELLOW LINE.

Figure C.44 Detected Total Iron Values in Mary River with Respect to Benchmark

Table C.10 Results of Iron Power Analysis – Mary River

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
G0-09	52	46	0.17	0.35	-1.8	0.97	-2.0	0.92	-0.088	1.7	NA
G0-03	36	27	0.17	0.23	-1.7	0.85	-2.2	0.92	-0.088	1.7	NA
G0-01	45	42	0.16	0.17	-1.9	0.70	-2.0	0.92	-0.088	1.8	~5
E0-10	48	41	0.14	0.20	-1.9	0.80	-2.2	0.92	-0.088	1.8	5
E0-03	59	52	0.17	0.23	-1.8	0.87	-2.1	0.92	-0.088	1.7	5
E0-21	7	6	0.41	0.18	-1.1	0.66	-1.3	0.92	-0.088	1.0	10
E0-20	7	7	0.12	0.093	-2.3	1.10	-2.3	0.92	-0.088	2.2	
C0-10	58	49	0.13	0.20	-2.0	0.76	-2.1	0.92	-0.088	1.9	5

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. NA STATIONS WERE NOT ASSESSED AND CAN NOT BE ESTIMATED BASED ON EXISTING STATIONS.
4. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Arsenic

Baseline concentrations of arsenic are very low site-wide. At each station in the Mary River, between 86% to 96% of arsenic samples at each station measured below detection limits. Median detected values for arsenic ranged from 0.00010 mg/L to 0.00017 mg/L. The benchmark for arsenic equals the CWQG-PAL guideline (0.005 mg/L). Table C.11 and Table C.12 list the proportions of samples above and below MDL at stations within the Mary River. Since baseline data was available for control sites in the Mary River, the power analysis was based on McNemar test for the difference between paired proportions. Based on a two-sided alpha value of 0.1 (0.05 on each side), for a power equal to 80%, to detect a difference in paired proportions indicated by: 10% of observations below MDL at impact and above MDL at control; 40% above MDL at impact and below MDL at control.

Table C.11 Number of Arsenic Samples Above and Below MDL at Mary River Stations

	E0-10		C0-10		E0-03	
	Control < MDL	Control > MDL	Control < MDL	Control > MDL	Control < MDL	Control > MDL
Impact < MDL	43	3	47	3	52	4
Impact > MDL	1	1	2	1	2	1

Table C.12 Proportion of Arsenic Samples Above and Below MDL at Mary River Stations

	E0-10		C0-10		E0-03	
	Control < MDL	Control > MDL	Control < MDL	Control > MDL	Control < MDL	Control > MDL
Impact < MDL	0.90	0.06	0.89	0.06	0.88	0.07
Impact > MDL	0.02	0.02	0.04	0.02	0.03	0.02

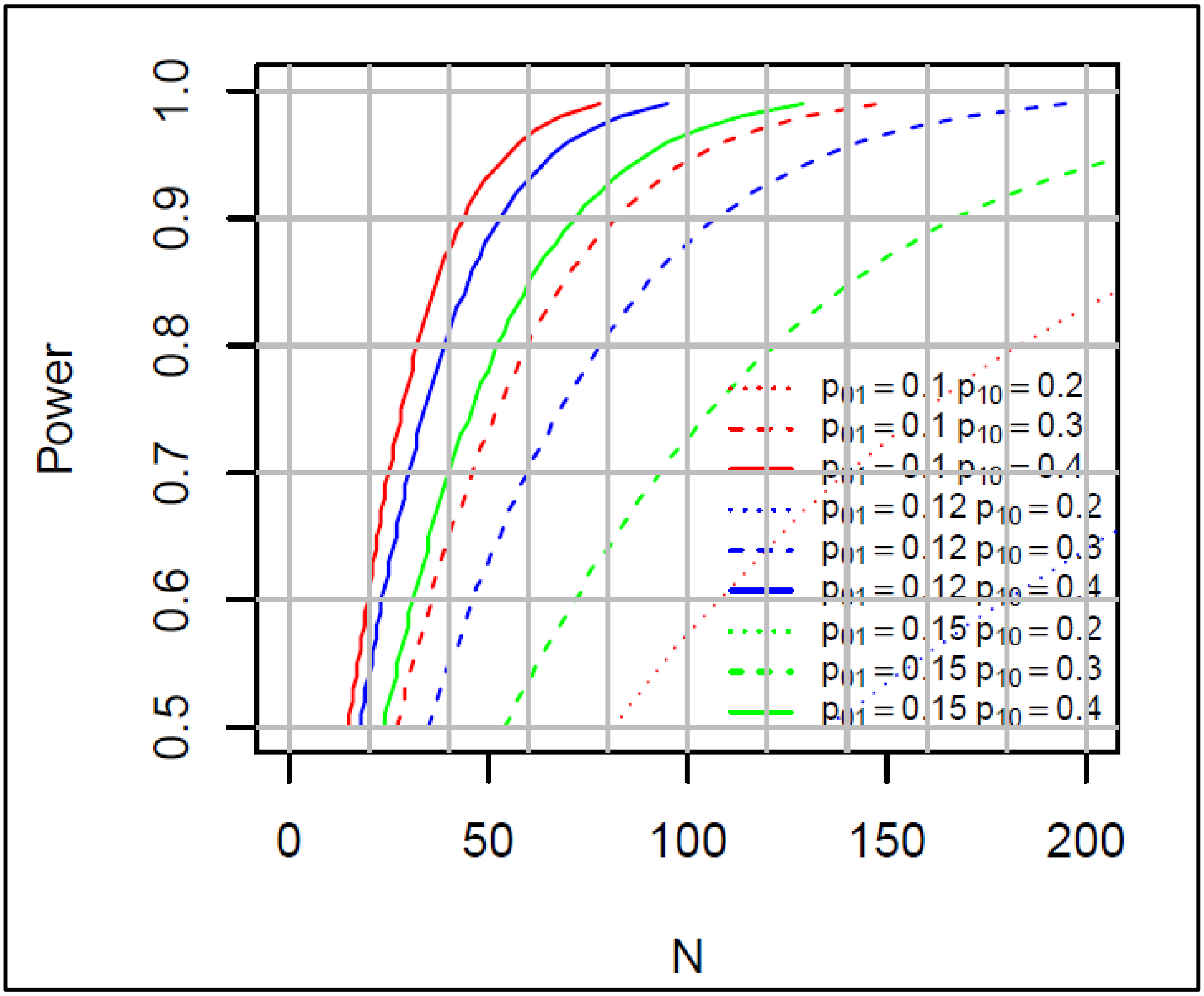


Figure C.45 Arsenic Sample Size Requirements for Equality of Proportions

Cadmium

Baseline concentrations of arsenic are very low site-wide. Between 86% to 100% of cadmium samples at each station in Mary River were below detection limits. Median detected values for cadmium ranged from 0.00001 mg/L to 0.0001 mg/L. The benchmark cadmium equals 0.0001 mg/L. Table C.13 and Table C.14 list the proportions of samples above and below MDL at stations within the Mary River. Based on the McNemar test (using an alpha value of 0.1, for a power equal to 80%), in order to detect a difference in paired proportions with pre-mining data composed of 10% of observations below MDL at impact site and above MDL at control site, requires 50% above MDL at impact and 50% below MDL at control site.

Table C.13 Number of Cadmium Samples Above and Below MDL at Mary River Stations

	E0-10		C0-10		E0-03	
	Control < MDL	Control > MDL	Control < MDL	Control > MDL	Control < MDL	Control > MDL
Impact < MDL	45	10	47	2	51	2
Impact > MDL	1	1	4	0	6	0

Table C.14 Proportion of Cadmium Samples Above and Below MDL at Mary River Stations

	E0-10		C0-10		E0-03	
	Control < MDL	Control > MDL	Control < MDL	Control > MDL	Control < MDL	Control > MDL
Impact < MDL	0.94	0.02	0.89	0.04	0.86	0.03
Impact > MDL	0.02	0.02	0.08	0.00	0.10	0.03

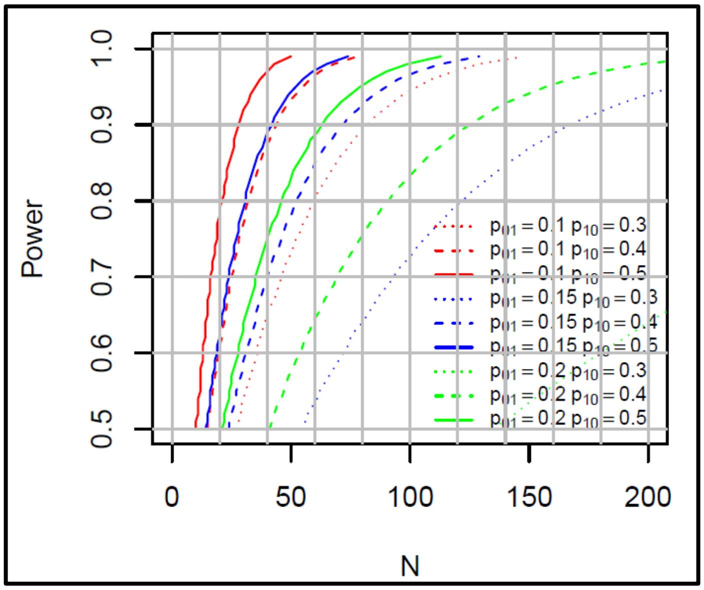


Figure C.46 Cadmium Sample Size Requirements for Equality of Proportions

C.4.3 Recommendations

Power analyses were run on key stations on both the Camp Lake Tributary and the Mary River for key parameters of concern, providing useful information to inform the study design and future power analyses on monitoring data. This analysis identified two major factors that evidently constrain the power analysis for the Camp Lake Tributary samples. First, elevated and variable copper concentrations create difficulties obtaining sufficient power at all stations. Second, the L1-09 and L1-02 station consistently have difficulty obtaining sufficient power with a sample size equal to ten. The Camp Lake Tributary analysis does show that between 5 to 20 samples will be adequate to have good power to detect changes in all parameters at L0-01 (far field EEM station). It is expected that additional sampling during 2014, concurrent to mine construction, but prior to discharge of mine effluents and dispersion of ore dust, will increase the available power.

The power analysis for Mary River identified fewer constraints for Mary River. Power analysis for copper, iron and aluminum concentrations measured during the baseline data collection within Mary River indicate that sufficient sample size can be obtained with between 5 to 10 samples. Parameters with a significant number of concentrations below detection limit might require more samples, although it is expected that additional baseline sampling in 2014 will moderate this requirement.

As a result of these analyses, the following are recommended to augment the study design:

1. Increase the amount of baseline data (this will occur during the one extra season of baseline data collection in 2014, concurrent to mine construction but prior to the discharge of mine effluents and the dispersion of ore dust);
2. Collect additional samples at L1-09 to improve baseline power;
3. Add an additional station in vicinity to L1-09 to provide enough statistical power to detect changes to near-field stations;

4. Recognize that our ability to detect changes to copper and iron are reduced at the Camp Lake Tributary.
5. Add reference station for Camp Lake samples on an adjacent tributary.
6. Four samples (one set of seasonal samples) is likely adequate for most parameters to determine significance. For parameters that require eight to ten post-mining samples, combining the analysis of data from stations with similar effluent additions is recommended.

C.5 REFERENCES

Agresti, A, 1990. Categorical Data Analysis. Wiley Series, New York.

Baffinland Iron Mines Corporation. 2013. *Mary River Project – Updated Aquatic Effects Monitoring Program Framework.* December 2013.

Huston, C. and Juarez-Colunga, E. 2009. Guidelines for computing summary statistics for data-sets containing non-detects. Written for the Bulkley Valley Research Center with assistance from the B.C. Ministry of Environment.

Smith, E. 2002. BACI Design. Encyclopedia of Environmetrics. John Wiley and Sons.1(141-148).

Stewart, K.A. and Lamoureux, S.F., 2011. Seasonal hydrochemical conditions and limnological response in adjacent High Arctic lakes: Cape Bounty, Melville Island, Nunavut. *Arctic* 64: 169-182.

Stroup, W.W., 1999. *Mixed Model Procedures to Assess Power, Precision, and Sample Size in the Design of Experiments*. Department of Biometry, University of Nebraska.

APPENDIX D

DETAILED REVIEW OF BASELINE SEDIMENT QUALITY

(Pages D-1 to D-37)

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DETAILED REVIEW OF BASELINE SEDIMENT QUALITY
NB102-181/33-1D

Rev	Description	Date
1	Issued in Final	May 30, 2014

Knight Piésold Ltd.
1650 Main Street West
North Bay, Ontario Canada P1B8G5
Telephone: (705) 476-2165
Facsimile: (705) 474-8095
www.knightpiesold.com

Knight Piésold CONSULTING

TABLE OF CONTENTS

PAGE

TABLES

FIGURES

D – SEDIMENT QUALITY REVIEW

D.1 OVERVIEW

A detailed review of sediment quality within the mine site area was undertaken to facilitate the development of the Core Receiving Environment Monitoring Program (CREMP) for water and sediment quality. As stated in Section 1.2 of the main report, the objectives of the baseline review were as follows:

- Identify data quality issues
- Understand natural enrichment of the mine site area waters and sediment
- Understand the inter-annual variability of sediment quality
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water or sediment quality in the mine site area
- Determine the potential to pool data from multiple sample stations to increase the statistical power of the baseline sediment quality dataset
- Develop a study design for monitoring sediment quality in mine site lakes and streams
- Determine if changes to the existing sediment quality monitoring program are required to meet monitoring objectives

The focus of this review of sediment quality is the mine site area lakes: Camp Lake, Sheardown Lake NW, Sheardown Lake SE and Mary Lake. As discussed in this review, characteristics of streams are such that metals accumulation is variable, and therefore measuring statistically-defensible change in stream sediment is challenging.

The relationship of metals accumulation with total organic carbon (TOC) and fines content in sediment is a focus of this review. Stressors of potential concern (SOPCs) in sediment are the focus of the review. SOPCs include these metals elevated in the iron ore to be produced at site, as well as those metals found to be naturally elevated in the mine site area (see Section 3.4 of the main report).

A review of sediment quality was completed by sediment SOPC, followed by a detailed review by lake and stream. Concentration data measured for the parameters of interest have been log transformed and presented on scatter plots to understand the spatial variability of metals concentrations in sediment. A detailed review of the relationship between metals accumulation and TOC and % sand is completed to identify cut-off values as a means to normalize the influence of each on metals accumulation.

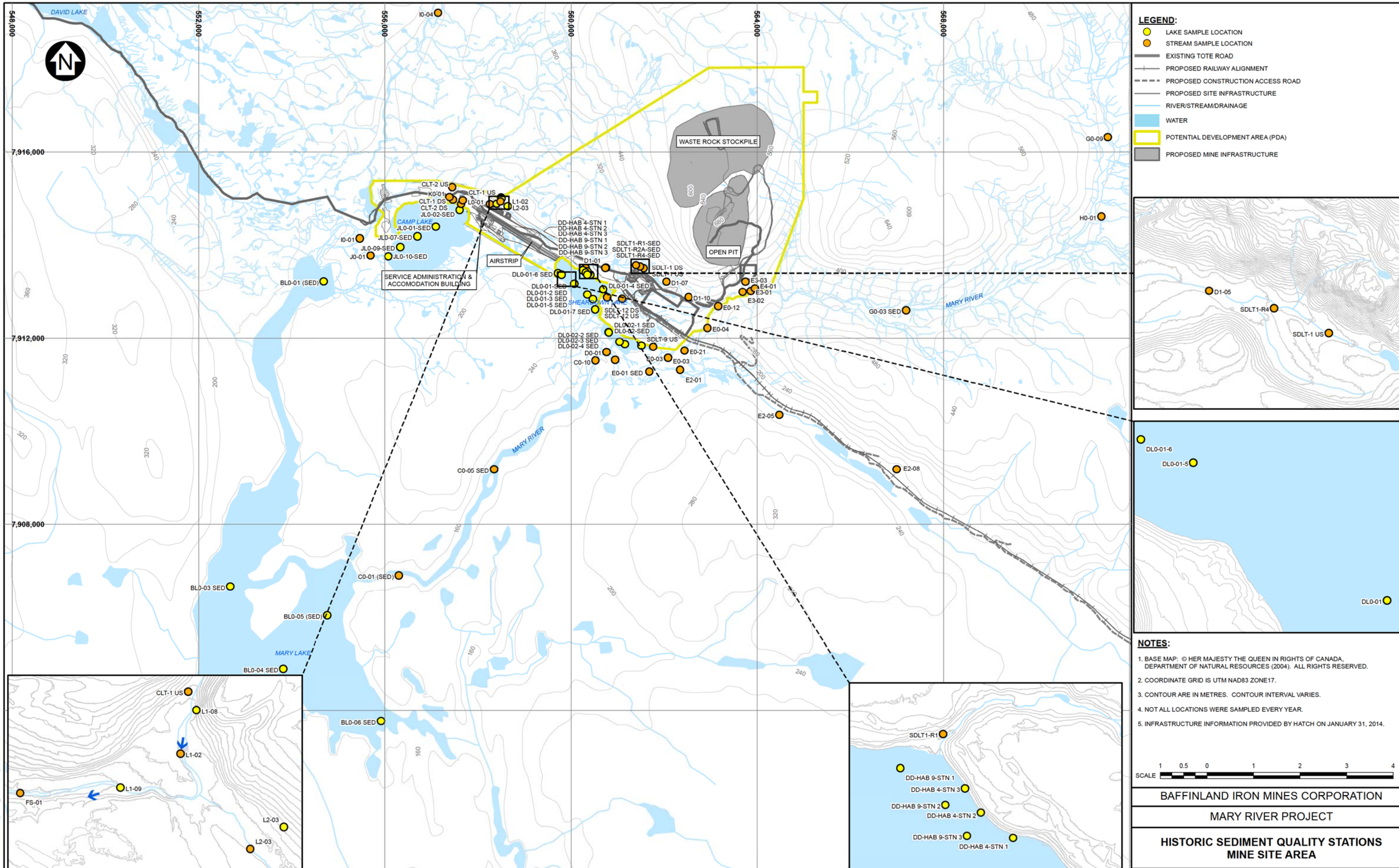
To assist in the development of study designs, parameter and station-specific a priori power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Interim area-wide benchmark values were developed for sediment SOPCs that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 3.6.3 of the main report). Interim area-wide benchmarks were applied in the power analysis of the baseline presented in this detailed review. The resultant study design for the monitoring of Project-related effects to sediment quality is presented in Section 3.6 of the main report.

D.2 REVIEW OF SEDIMENT QUALITY BY PARAMETER

Sediments comprise important habitat within the aquatic ecosystems and may also act as long-term reservoirs for particulate forms of a variety of contaminants. This appendix reviews the metal concentrations recorded within sediment samples taken throughout the Mary River Project's mine site area during baseline conditions. This assessment focuses on the parameters of interest, defined as those with federal sediment quality guidelines (Canadian Environmental Quality Guidelines; CEQG) and/or provincial sediment quality guidelines (Ontario Sediment Quality Guidelines; OSQG) as discussed in Section 3.1 of the report. Sediment quality guidelines provide general scientific reference points for evaluating the potential to observe adverse biological effects in aquatic ecosystems. The parameters of interest identified for the Project include: arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead and zinc.

Metal concentrations currently detected in the lakes and streams are related to the natural enrichment of the area; therefore, an exceedance of the generic sediment quality guidelines is not necessarily indicative of toxicity. There are a variety of physical factors that reduce the bioavailability of metals in the environment (e.g., speciation, availability of dissolved organic carbon, pH, alkalinity, hardness) and a variety of biological processes that modify or reduce toxicity naturally within biota (e.g., acclimation, adaptation). The observations and trends of the baseline data regarding concentrations of specific parameters of concern that have CSQG limits and/or PSQG limits are discussed below.

Historic sediment sampling locations are shown on Figure D.1. Concentrations are also shown graphically in relation to log TOC and percent sand on Figures D.2 through D.10 to understand the relationship between the concentration of a given metal and sediment TOC and fines content. The area of the plotted circle in these plots is proportional to the concentration of the given metal, and the color of the circle is indicative of the lake.



NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC SEDIMENT QUALITY STATIONS MINE SITE AREA

Knight Piésold CONSULTING

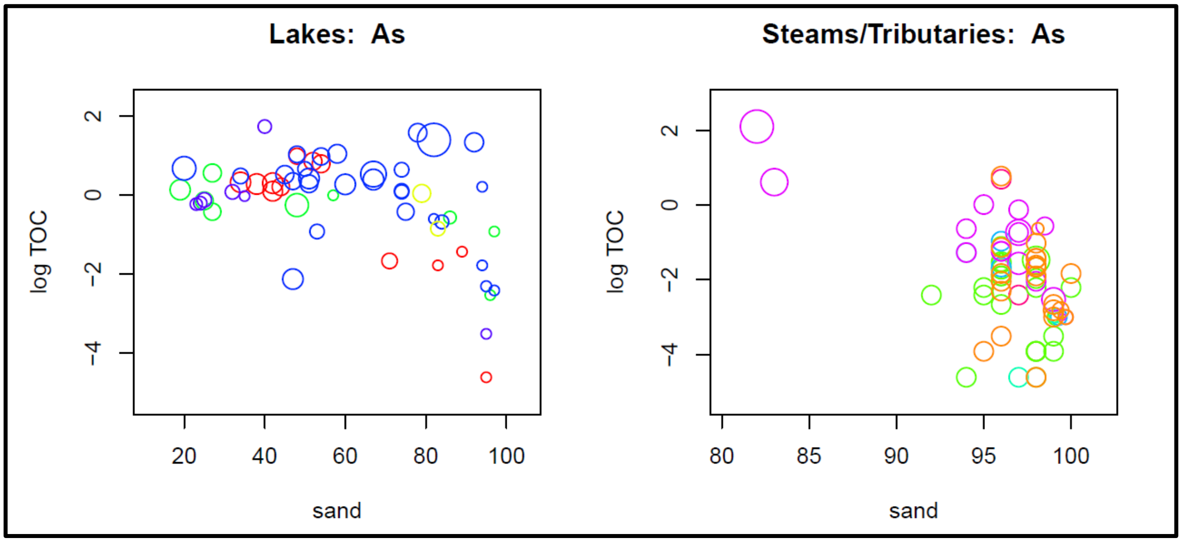
P/A NO.	REF NO.
NB102-181/33	1
FIGURE D.1	REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\B44_r1.mxd; May 30, 2014 1:28 PM; skozmick

Arsenic (Figure D.2)

- Lake sediment results show concentrations above the MDL in all areas, with exceedances of guidelines in Sheardown Lake NW. These concentrations exceed the CEQG-TEL guideline and PSQG-LEL guideline but neither exceed the CEQG-PEL or PSQG-SEL guideline.
- Most stream/tributary samples have low arsenic concentrations below MDL and high proportions of sand. Two Sheardown Lake tributary samples report slightly higher arsenic concentrations and a lower proportion of sands.
- No exceedances of sediment quality guidelines were detected in stream sediment samples.



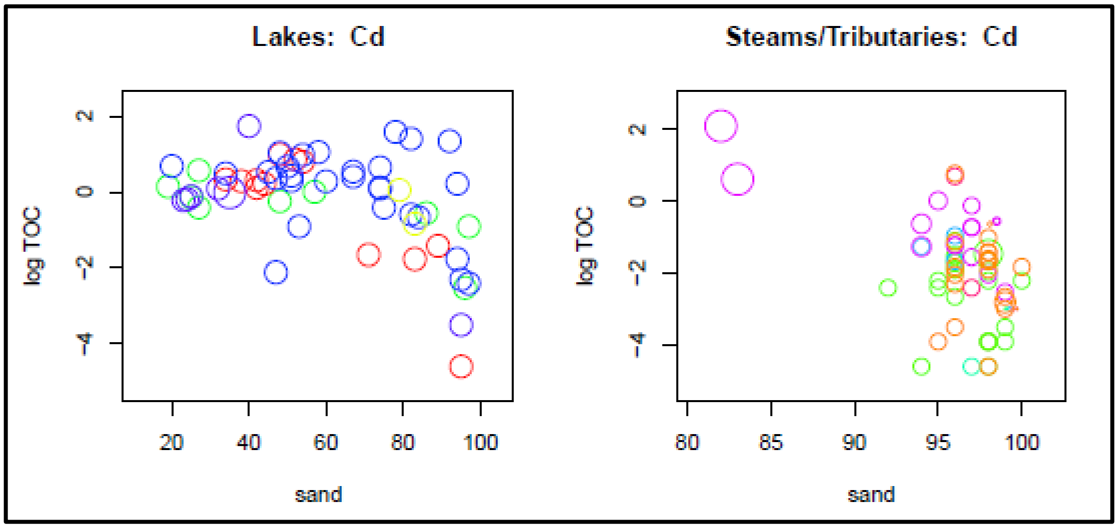
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.2 Arsenic in Sediment as a Function of Log TOC and Percent Sand

Cadmium (Figure D.3)

- All lake concentrations were near to or below the MDL.
- All stream area concentrations were below the MDL with the exception of a Sheardown Lake tributary (the two large circles in the top left) and one instance in a Camp Lake tributary.
- The large proportion of non-detect results for cadmium are evident by the circles being the same diameter for most of the samples (note the scale difference for percent sand between lakes and streams).



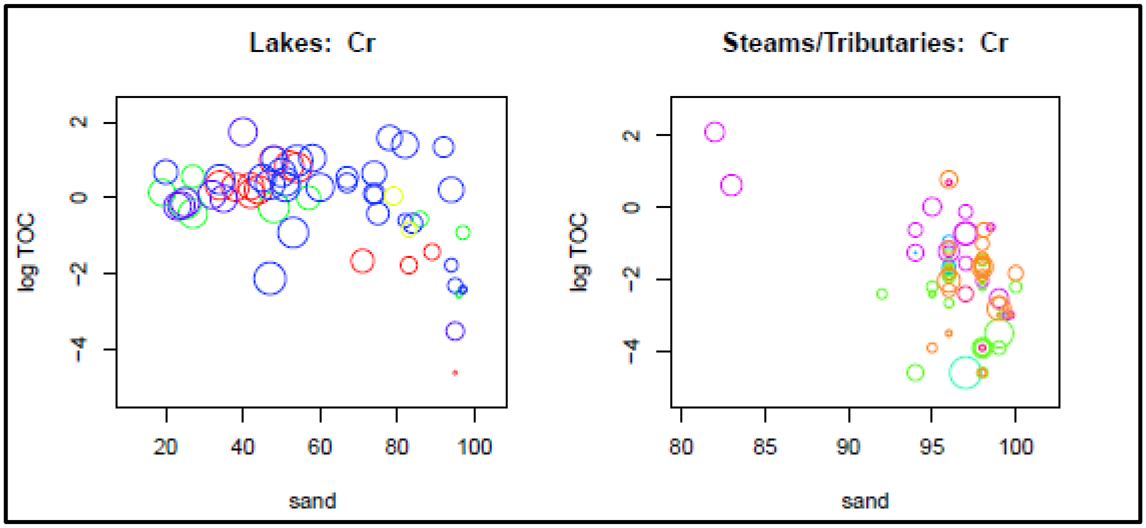
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.3 Cadmium in Sediment as a Function of Log TOC and Percent Sand

Chromium (Figure D.4)

- Each of the lake areas reported concentrations above sediment quality guidelines except the near shore dust monitoring stations in Sheardown Lake. The near-shore dust monitoring stations were not in a depositional environment according to low TOC and a low proportion of fines.
- All mine site streams and tributaries show concentrations above sediment quality guidelines except the Tom River and Phillips Creek.



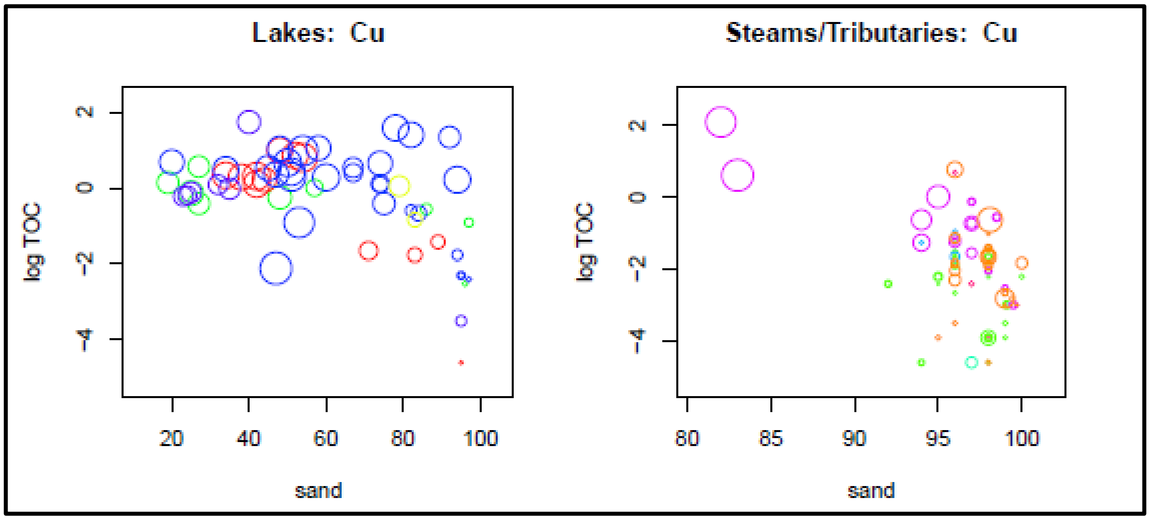
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.4 Chromium in Sediment as a Function of Log TOC and Percent Sand

Copper (Figure D.5)

- All lake area results show concentrations above guidelines except the near shore dust monitoring stations in Sheardown Lake (as mentioned above, not located in a depositional environment according to low TOC and a low proportion of fines).
- All stream sample concentrations were below the sediment quality guidelines with the exception of a Sheardown Lake tributary and the Camp Lake tributaries.



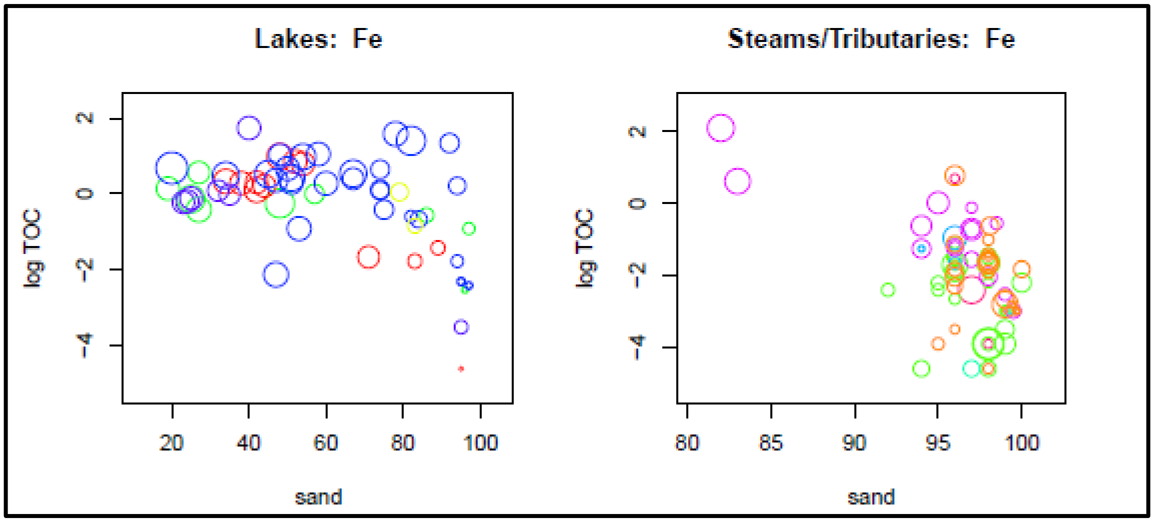
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.5 Copper in Sediment as a Function of Log TOC and Percent Sand

Iron (Figure D.6)

- All lake area results show concentrations above guidelines except the near shore dust monitoring stations in Sheardown Lake, and in David Lake located outside of the mine site area.
- Stream sample concentrations exceeded guidelines for at least one sample in most areas.
- Stream samples from the deposit drainage streams, Phillips Creek area and downstream of Mary Lake had concentrations below the guidelines.



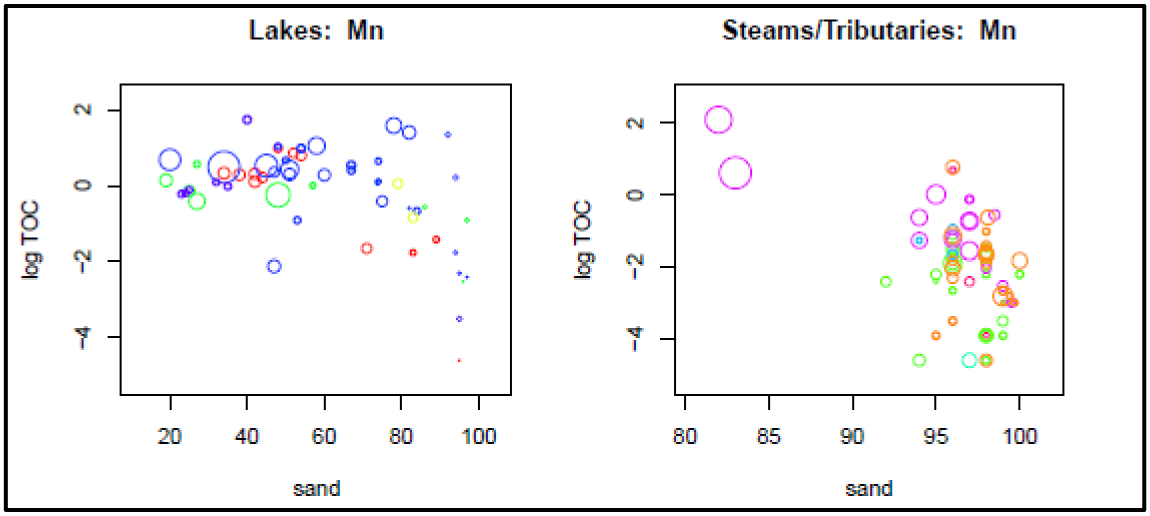
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.6 Iron in Sediment as a Function of Log TOC and Percent Sand

Manganese (Figure D.7)

- All lake areas results show concentrations above guidelines for at least one sample, except the near shore dust monitoring stations in Sheardown Lake.
- Stream sample concentrations were below the sediment quality guidelines for all but one sample (Sheardown Lake tributary).



NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

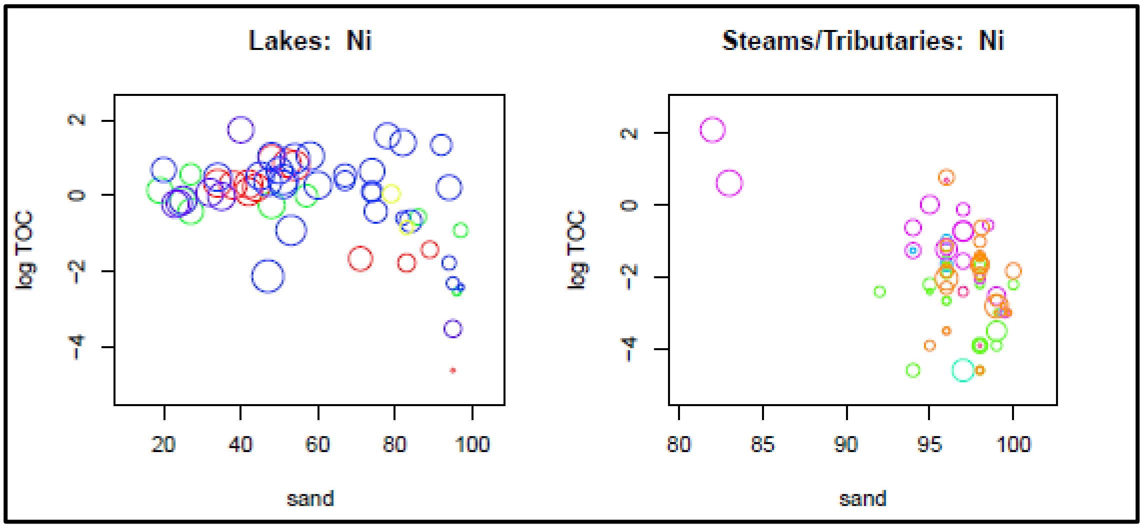
Figure D.7 Manganese in Sediment as a Function of Log TOC and Percent Sand

Mercury (no figure)

- All stream and lake concentrations were below the MDL.

Nickel (Figure D.8)

- Nickel concentrations exceeded the guidelines in each of the mine site lakes.
- Stream sample concentrations exceeded the guidelines for at least one sample in most areas.
- Stream samples from upstream of the deposit, the Tom River area and the Phillips Creek area had concentrations below the guidelines.



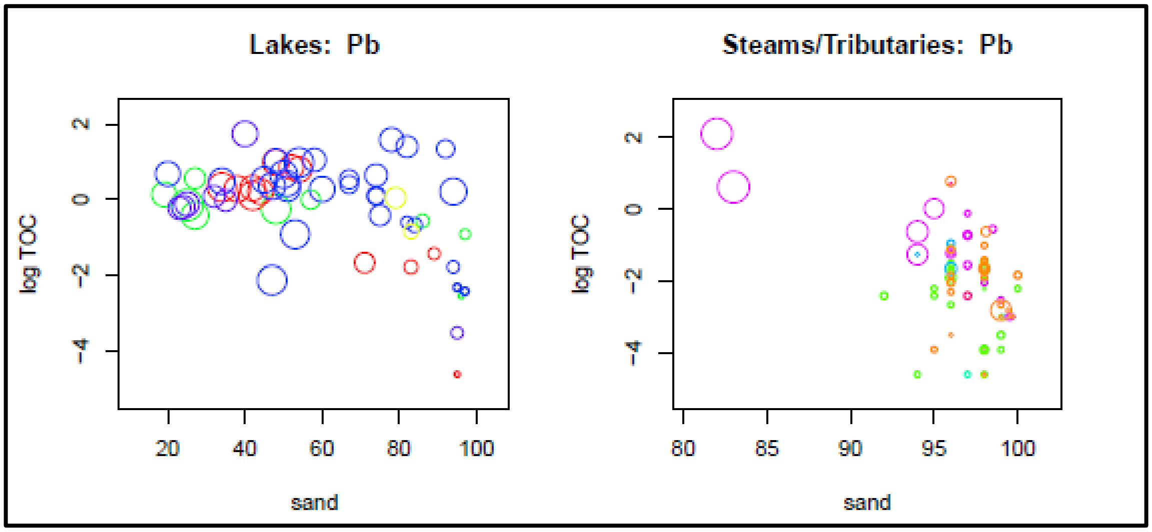
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.8 Nickel in Sediment as a Function of Log TOC and Percent Sand

Lead (Figure D.9)

- All lake sample concentrations were below the sediment quality guidelines.
- Most stream areas had low concentrations with only one sediment quality guideline exceeded (Sheardown Lake tributary).



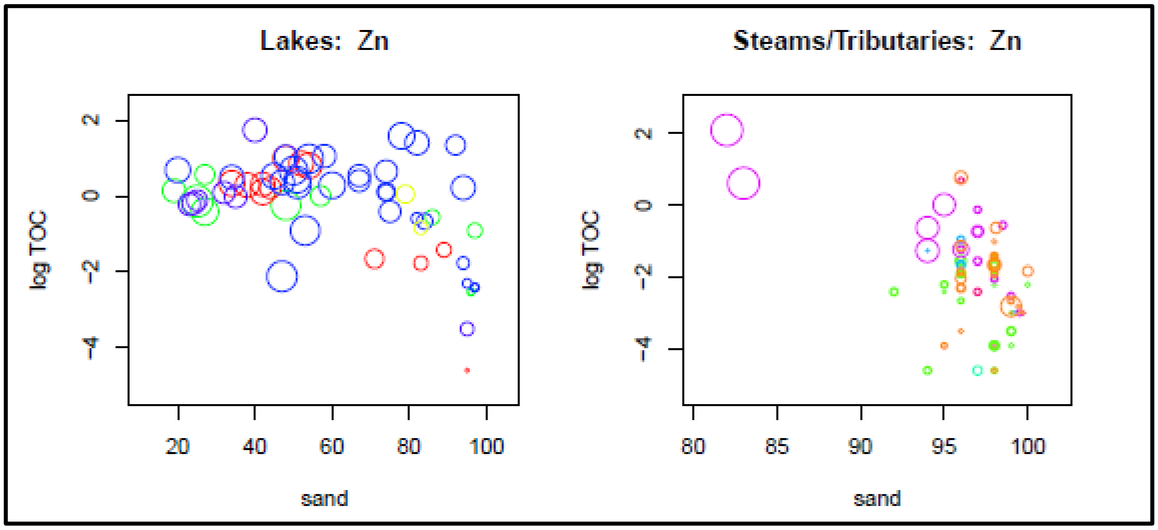
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.9 Lead in Sediment as a Function of Log TOC and Percent Sand

Zinc (Figure D.10)

- All lake samples tested for zinc were below guidelines.
- Stream sample concentrations were below the sediment quality guidelines for all but one sample (Sheardown Lake tributary).



NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.10 Zinc in Sediment as a Function of Log TOC and Percent Sand

Analytical results for the parameters of interest summarized above identify sediment quality guideline concentration exceedances in some areas. These areas have been discussed in the following section and are grouped by stream environments and lake environments.

D.3 SEDIMENT IN STREAM ENVIRONMENTS

Upstream of the Deposits

The three stations positioned upstream of the Project deposits are shown in Figure D.1: G0-09, H0-01 and G0-03. Surface runoff and natural loading contributes to the baseline parameter concentrations in the sediment of Mary River. There were five samples obtained at these stations between 2005 and 2013. Coarse grained sediment (e.g., sand) were the highest proportion of the particle size distribution analysis in this area (≥ 97%).

- **Station G0-09** - The sample results from 2006 show chromium and iron concentrations marginally above the PSQG-LEL criteria. The remaining sample results from this station and surrounding area stations did not show concentrations exceeding sediment quality guidelines.
- **Station H0-01** - One of the two sample results from this station have elevated levels of chromium and iron above their respective PSQG-LEL.
- **Station G0-03** - There is only one result for this station. Sample results from 2007 show elevated chromium and nickel concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. These concentrations were the highest detected in this area.

Downstream of the Deposits

These 14 stations are positioned in the Mary River downstream of the waterfall with the exception of Station G0-03 positioned approximately 2.5 km upstream of the waterfall (Figure D.1). The Mary River receives runoff from the deposits that contribute to baseline concentrations found in the stream sediments. There were 25 samples obtained from these stations between 2005 and 2013. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis in this area (≥ 97%). In general, concentrations of chromium, iron and nickel were found in elevated concentrations within this area as discussed below.

- **E-series Stations** - The sample results from the E-series of stations (E0-01, E0-03, E0-04 and E4-01) sampled between 2007 and 2012 show elevated chromium, iron and nickel concentrations. These concentrations were near to or marginally above their respective CSQG-ISQG and/or PSQG-LEL criteria.
- **Station C0-10** - The sample results from 2007 show elevated chromium and iron concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. This station is positioned on the Mary River, downstream of the confluence between the Mary River and the Sheardown Lake discharge channel.
- **Station C0-05** - The sample results from 2007 show elevated chromium concentrations close to the PSQG-LEL criteria and below the CSQG-ISQG criteria. This station is positioned on the Mary River, approximately half way between the Sheardown Lake confluence and the outlet to Mary Lake.
- **Station C0-01** - The sample results from 2007 show elevated concentrations of chromium, iron and nickel above their respective CSQG-ISQG and/or PSQG-LEL criteria. This station is positioned less than 2 km from the outlet of the Mary River into Mary Lake. The remaining sample results from this station 2005, 2012 and 2013 did not show concentrations exceeding sediment quality guidelines.

Background Tributary to Mary River

The E2 stream receives surface drainage from the surrounding landscape east of the deposits flows into the Mary River upstream of the confluence with the Sheardown Lake outlet channel (Figure D.1). This area was sampled at three stations to establish baseline sediment conditions outside of the immediate Mary River catchment area. There were four samples obtained between 2005 and 2012, with three of the four samples taken in 2012. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis in this area (≥ 94%). In general, concentrations of iron and nickel were found in elevated concentrations within this area as discussed below.

- **E2-series Stations** - The sample results from station E2-01 (2012) show elevated iron concentrations near to, but above the PSQG-LEL. Similarly, station E2-08 (2012) show elevated nickel concentrations slightly above the PSQG-LEL.

Downstream of Mary Lake

This station is positioned approximately 6 km downstream of the Mary Lake outlet, upstream of Angajurjualuk Lake. This station was sampled twice during the baseline program (2005 and 2007). Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis at this station (≥ 97%).

- **Station A0-01** - The sample results from 2007 show elevated chromium and nickel concentrations. Chromium concentrations were above the PSQG-SEL which was the highest reported chromium concentration in the baseline study. Nickel concentrations were above the PSQG-LEL criteria.

Sheardown Lake Tributaries

The Sheardown Lake tributary stations have various labels depending on the field program under which the samples were collected (Figure D.1). Sheardown Lake tributary 1 (SDLT1), historically identified as tributary D1 receives surface water and erosional material from the south slope of the deposit. Streams that receive drainage from the landscape, south of the deposit access road include SDL-Trib 9 and SDL-Trib 12. There were 18 samples obtained from these stations between 2005 and 2013. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis at this station (≥ 82%).

- **Station D1-01** - The sample results from 2012 show elevated chromium and nickel concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria.
- **Station D1-07** - The sample results from 2011 show elevated cadmium and chromium concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. Copper and nickel were measured above their respective PSQG-SEL criteria.
- **Station D1-10** - The sample results from 2011 show elevated total organic carbon (TOC), chromium and copper concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. Nickel was above the PSQG-SEL criteria.

- **Station D1-05 (SDLT1-R4 US)** - The sample results show elevated cadmium, chromium, copper, iron, manganese, nickel, lead and zinc concentrations. The 2012 and 2013 sample results had the highest number of sediment quality criteria exceedances, including the only CSQG-ISQG and PSQG-LEL exceedances of lead and zinc of the baseline study. The 2012 sample had the highest TOC concentration of the baseline study, which was above the PSQG-LEL criteria.
- **Station D1-01 (SDLT1-R2A and SDL-Trib 1 DS)** - The sample results show elevated chromium, copper and nickel concentrations. The 2012 chromium results were above the CSQG-ISQG and PSQG-LEL criteria. The 2008 copper results were equal to the PSQG-LEL criteria and below the CSQG-ISQG criteria. The 2008 and 2012 nickel results were above the PSQG-LEL criteria.
- **Station SDLT1-R1** - The sample results from 2008 show elevated chromium and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria.
- **Station SDL-Trib 9 US** - All sample results show elevated chromium and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria.
- **Station SDL-Trib 12 (US and DS)** - The sample results from 2007 show elevated chromium and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria.

Sample locations D1-10 and D1-05 in the Sheardown Lake tributary 1 are depositional environments that show similar metals accumulation to that of the mine site lakes. These sample locations represent good long-term sampling locations.

Camp Lake Tributaries

The 12 Camp Lake tributary stations have various labels depending on the field program under which the samples were collected (Figure D.1). Camp Lake tributary 1 (CLT-1), historically identified as tributary L1 receives surface water and erosional material from the deposit through the collection of surface water runoff and discharge through the West Pond. The L2 tributary is positioned parallel with the airstrip flowing into the L1 tributary upstream of the tote road. Downstream of the Tote Road, this stream is known as the L0 tributary where station CLT-1 DS is located. Camp Lake tributary 2 or K0 tributary receives runoff from the western portion of the deposit. The J0 station is located in the connecting channel between Camp Lake and the north branch of Mary Lake showing sediment conditions downstream of Camp Lake. A discussion of the sediment quality guideline exceedances has been presented below. There were 22 samples obtained from these stations between 2005 and 2013. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis at this station (≥ 82%).

- **Station CLT-1 US (L1 series)** - The results from 2005, 2007, 2012 and 2013 show elevated concentrations of cadmium, chromium, copper and nickel above the CSQG-ISQG and/or PSQG-LEL criteria. In addition, concentrations of iron were detected above the PSQG-LEL in 2007.
- **Station L2-03** - The results from 2011 to 2013 show all parameter concentrations of interest were below the CSQG-ISQG and/or PSQG-LEL criteria.
- **Station CLT-1 DS (L0 series)** - The results from 2007 show an elevated chromium concentration above the CSQG-ISQG and PSQG-LEL criteria, but below the upstream sample concentration. All other parameter concentrations were below criteria.

- **Station CLT-2 (K0)** - The results from 2013 show an elevated nickel concentration near to, but above the PSQG-LEL. The results from 2005 and 2012 do not show any concentrations above criteria.
- **Station J0-01** - The results from 2012 and 2013 show nickel concentrations near to, but above the PSQG-LEL. The results from 2005 do not show elevated nickel concentrations above criteria.

D.4 SEDIMENT IN LAKE ENVIRONMENTS

Camp Lake

The sample stations are positioned in a northeast to southwest transect across Camp Lake between the CLT-1 inflow stream and the J0-01 outlet stream (Figure D.1). These stations were selected for initial baseline assessments and ongoing monitoring programs. Fine grained sediment (e.g., silt and sand) were the highest percent particle size in the mid lake region, whereas sand was the highest component fraction in most of the other sample areas.

- **Station JL0-01** - This station is located mid-lake and is one of the proposed long-term monitoring stations. Four samples were obtained from this location, two were taken in 2007 and one was taken during the 2012 and 2013 sampling campaigns. The results from all sampling events show elevated TOC, chromium, copper, iron, manganese and Ni concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. The samples from this location had the highest manganese concentrations within Camp Lake.
- **Station JL0-02** - This station is positioned offshore from the CLT-1 outlet stream in the northeast corner of Camp Lake. Three samples were obtained from this location, one taken during each of the 2007, 2012 and 2013 sampling campaigns. The results of all samples had elevated TOC, chromium, copper, iron, manganese and nickel concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. The 2007 iron concentration was above the PSQG-SEL criteria and was the highest concentration within Camp Lake. This station also had the highest TOC concentrations likely attributable to the contribution of organic inputs from the CLT-1 stream.
- **Station JL0-07** - This station is positioned southwest of station JL0-01 in the main lake basin. One sample was obtained from this location (2007). The results show elevated TOC, chromium, copper, iron, manganese and nickel concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria.
- **Station JL0-09** - This station is positioned near the outlet channel, upstream of station JL0-10. Three samples were obtained from this location, one taken during each of the 2007, 2012 and 2013 sampling campaigns The results from 2007 show elevated TOC, chromium, copper, iron, manganese and nickel concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. The 2012 and 2013 results only show an elevated nickel concentration above the PSQG-LEL criteria. The difference in the number of criteria exceedances between 2007 and the 2012 and 2013 samples may be attributed to the high percent sand content in the recent samples (89% and 83% respectively).
- **Station JL0-10** - This station is located immediately upstream of the outlet channel in the southwest corner of Camp Lake. One sample was obtained from this location (2007). There were no elevated concentrations measured of any of the parameters of concern.

Sheardown Lake (NW Basin)

There were many stations established in the near shore and offshore environment to monitor pre-development sedimentation in these regions of the lake (Figure 3.2). Many stations are included in the ongoing monitoring program. This study will be used for post-Project comparison to baseline condition.

- **Station DL0-01-1** - This is a mid-lake sample station in the deepest area of the lake. Four samples were obtained from this location, one taken during each of the 2007, 2011, 2012 and 2013 sampling campaigns. The sample results from these years show elevated TOC, chromium, copper, iron, manganese and nickel concentrations. The chromium, copper and nickel concentrations were elevated above the respective CSQG-ISQG and/or PSQG-LEL criteria. All iron concentrations were above the PSQG-SEL criteria. The manganese results from 2011, 2012 and 2013 were above the PSQG-SEL, whereas the 2007 results were below this sediment quality guideline criterion. The nickel concentrations were all above the PSQG-LEL with the 2013 concentration also above the PSQG-SEL criteria. The particle size distribution results show a relatively equal proportion of fine grained sediment (e.g., silt and clay) and coarse grained sediment (e.g., sand) at this station.
- **Station DD-Hab 4 series** - There are three stations positioned in the shallow near shore area close to the SDLT-1 inflow stream. One sample was obtained from each station (2008), with one of these results showing elevated nickel concentration equal to the PSQG-LEL criteria. All other concentrations were reported below sediment quality guideline criteria. Particle size distribution data was not available for these samples.
- **Station DD-Hab 9 series** - The three stations in this series are positioned at offshore areas near the SDLT-1 inflow stream. Samples were obtained from each station during the 2008, 2012 and 2013 sampling campaigns. These results show elevated TOC, arsenic, chromium, copper, iron, manganese and nickel concentrations. The TOC concentrations from this series of stations were some of the highest in the lake, likely attributed to the contribution of organic inputs from the SDLT-1 stream. The 2008 arsenic concentration at DD-Hab-9-Stn 3 were reported above the CSQG-ISQG and PSQG-LEL criteria, which was the highest arsenic concentration detected in the lake. The majority of the chromium, copper, iron and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The 2008 manganese concentrations at DD-Hab-9-Stn 2 and DD-Hab-9-Stn 3 were above the PSQG-SEL criteria. The 2008 and 2012 results from DD-Hab-9-Stn 3 reported iron concentrations above the PSQG-SEL. In general, concentrations were higher in this deeper area compared to those reported from the shallow stations (DD-Hab 4 series). Particle size distribution data was not available for these samples.
- **Station DL0-01-5 and -6** - These stations are located in the northwest region of the lake, positioned near the treated sewage effluent outfall from the exploration camp. Four samples were obtained from station DL0-01-5, one taken during each of the 2007, 2008, 2011 and 2013 sampling campaigns, whereas only two samples were obtained from station DL0-01-6 (2007 and 2008). The results show some of the highest chromium, iron, manganese and nickel concentrations within the lake, which were above the CSQG-PEL and/or PSQG-SEL criteria. Copper was generally above the CSQG-ISQG and/or PSQG-LEL criteria. The highest TOC concentrations were measured at station DL0-01-5, which exceeded the PSQG-LEL criteria in 2007, 2008 and 2011. The particle size distribution results for

station DL0-01-5 show a relatively equal proportion of fine grained sediment (e.g., silt and clay) and coarse grained sediment (e.g., sand). The particle size distribution results from station DL0-01-6 show that sand was the dominant fraction in both samples (≥ 75%).

- **Station DL0-01-2 and -3** - These stations are located in the southeast region of this basin, positioned near the largest island in the lake. Three samples were obtained from station DL0-01-2, one taken during each of the 2007, 2008 and 2013 sampling campaigns, whereas only two samples were obtained from station DL0-02-3 (2007 and 2008). The results generally show elevated chromium, copper and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria. The 2008 results from station DL0-01-3 show an elevated arsenic concentration near to, but above the CSQG-ISQG and PSQG-LEL criteria. The manganese concentrations were generally above the PSQG-LEL and/or SEL criteria. All sample results show TOC concentrations above the PSQG-LEL criteria. The particle size distribution results for these stations show a range in the proportion of fine grained sediment (e.g., silt and clay) and coarse grained sediment (e.g., sand) between years. This range is likely due to the variability in substrate types near these stations.
- **Station DL0-01-4** - This station is positioned in a bay at the eastern end of the basin and receives inflow from the SDLT-12 stream. Three samples were obtained from this station one taken during each of the 2007, 2008 and 2013 sampling campaigns. The results show chromium, copper and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria. The results also show some iron and manganese concentrations above the CSQG-PEL and PSQG-SEL criteria. All sample results show TOC concentrations above the PSQG-LEL criteria and the highest concentration within the lake measured during 2008. The particle size distribution results show that sand was the dominant fraction in these samples (≥ 78%).
- **Station DL0-01-7** - This station is positioned near the outlet channel that connects the Sheardown Lake NW and SE basins. Five samples were obtained from this station, one taken during each of the 2007, 2008, 2011, 2012 and 2013 sampling campaigns. The results show elevated chromium, copper, iron, manganese and nickel concentrations generally above the CSQG-ISQG and PSQG-LEL criteria. The results from 2011 show nickel concentrations were the only parameter above the sediment quality guidelines. The results from 2008 reported the only manganese concentration above the PSQG-LEL criteria. All sample results show TOC concentrations above the PSQG-LEL criteria with the exception of 2011. The particle size distribution results show that sand was the dominant fraction in these samples (≥ 67 %).

Sheardown Lake (SE Basin)

There were four stations established in the near shore and offshore environment to monitor pre-development sedimentation in these regions of the lake (Figure 3.2). One of these stations (DL0-02-3) is included in the ongoing monitoring program. Silt was the highest percent particle size fraction in all but one sample (DL0-02-3 in September 2007). The highest concentrations of the parameters of concern were reported from the stations positioned in the deepest region of the southeast basin.

- **Station DL0-02-1** - This station is located in the northwest corner of this basin and is the first area to receive influent from the NW basin. This area may be subject to increased erosional flows from the NW basin channel during spring freshet that would transport material towards the main lake basin. Two samples have been obtained from this location, both taken during the 2007 sampling campaign. The results show elevated chromium, copper, iron, and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria.

- **Station DL0-02-2** - This station is located near the deepest area of the SE basin. One sample was obtained from this location (2007). The results show elevated chromium, copper, iron, and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria.
- **Station DL0-02-3** - This station is located mid-lake, nearest to the outlet channel that connects Sheardown Lake to Mary River. Three samples were obtained from this location, one taken during each of the 2007, 2012 and 2013 sampling campaigns. The 2007 results show elevated chromium and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria. The field sample record from 2007 indicates this material was obtained in a water depth of 1.8 m, which is significantly different than the sample depths in 2012 and 2013 (13 m and 14 m respectively). In addition, it is possible it might not have been obtained in the exact same location. The difference between the TOC results from 2007 (0.03%), 2012 (1.09%) and 2013 (0.98%) suggests the 2007 sample results may not be suitable for comparison to the 2012 and 2013 results. The 2012 and 2013 results show elevated chromium, copper, iron, and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria. In addition, the 2013 results also show an elevated manganese concentration above the PSQG-LEL criteria.
- **Station DL0-02-4** - This station is located in the southeast corner of the basin, in an area that receives influent from the SDLT-9 stream. A single sample was obtained from this location in 2007. The SDLT-9 stream is a source of organic material inputs as shown by the highest TOC concentration within the southeast basin. The results show elevated TOC, chromium, copper, iron, nickel, and manganese concentrations above the CSQG-ISQG and/or PSQG-LEL criteria.

Mary Lake

There are two main basins within Mary Lake (North and South). These basins will eventually receive water and sediment inputs from the mine site and upper reaches of the catchments as previously described. One monitoring station (BL0-01) is located in the north basin, whereas the remaining four stations are located in the south basin (Figure 3.3). The north basin receives influent water from Camp Lake which flows through a network of smaller basins and channels before reporting to the south Mary Lake basin. The majority of the Mary Lake south basin water comes from Mary River. Silt was the highest percent particle size fraction from all stations positioned in the south basin, except station BL0-05. Sand was the highest particle size fraction of the samples obtained from station BL0-01 and station BL0-05. These stations are positioned near the outlet of main streams (Camp Lake outlet and Mary River outlet) and also had the highest concentrations of TOC in Mary Lake.

- **Station BL0-01 (North)** - Two samples were obtained from this location, one taken during each of the 2006 and 2007 sampling campaigns. These results show elevated TOC, chromium, copper, iron and nickel concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. The 2007 results also show manganese concentration above the PSQG-SEL criteria.
- **Station BL0-03 (South)** - This station is located in the northwest corner of the Mary Lake south basin, downstream of Station BL0-01. One sample was obtained from this location (2007). These results show elevated chromium, copper, iron, manganese and nickel concentrations.

The copper and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The chromium, iron and manganese concentrations were above their respective CSQG-PEL and PSQG-SEL criteria. Station BL0-03 had the highest iron and manganese concentrations measured in Mary Lake.

- **Station BL0-04 (South)** - This station is located downstream of station BL0-03 and is positioned on the western edge of the deepest lake basin. One sample was obtained from this location (2007). These results show elevated chromium, copper, iron, manganese and nickel concentrations. The copper, iron and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The chromium and manganese concentrations were above their respective CSQG-PEL and/or PSQG-SEL criteria.
- **Station BL0-05 (South)** - This station is positioned at the outlet of Mary River. Two samples were obtained from this location, one taken during each of the 2006 and 2007 sampling campaigns. These results show elevated nickel concentrations above the PSQG-LEL criteria. Results from 2012 show elevated copper, iron and nickel concentrations above the PSQG-LEL criteria, with chromium concentrations above the CSQG-ISQG and PSQG-LEL criteria.
- **Station BL0-06 (South)** - This station is located in the southwestern corner Mary Lake, immediately upstream of the main lake outlet channel. One sample was obtained from this location (2007). These results show elevated chromium, copper, iron, manganese and nickel concentrations. Copper, manganese and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The chromium concentration was above the CSQG-PEL, but below the PSQG-SEL. The iron concentration was above the PSQG-SEL criteria.

David Lake

There were two stations sampled in 2012 to assess baseline sediment quality conditions prior to development. Sand was the highest percent particle size fraction at these locations, followed by silt.

- **Station DL-12-02** - This station is positioned at the western end of the lake in the main basin. The manganese and nickel concentrations were elevated above the PSQG-LEL criteria.
- **Station DL-12-03** - This station is located in the southeastern basin of the lake, near the main inflow stream. The inflow stream is a source of organic material inputs as shown by the high TOC concentration compared to the DL-12-02 station (1.05% and 0.43% respectively). The TOC, chromium, copper, manganese and nickel concentrations were elevated above their respective CSQG-ISQG and/or PSQG-LEL criteria.

D.5 INFLUENCE OF TOC AND FINES ON METALS ACCUMULATION

Metals concentrations in sediment are positively correlated with both finer grained particles as well as higher organic carbon content (Horowitz, 1991; EC, 2012). These relationships are observed within the sediment quality baseline dataset. Metals concentrations are consistently higher in depositional environments that generally have a higher proportion of organic carbon and fines in the substrate. Depositional environments were predominantly found within the mine site lakes, with the exception of select stations within the main tributary of Sheardown Lake (tributary 1). Streams at the mine site most often are high gradient, high energy and are not therefore depositional environments consisting of fine grained sediment or high organic carbon content.

For this reason, metals concentrations in lake sediment were consistently higher than sediment in streams. This is observed when reviewing mean concentrations of key metals as presented in Table D.1 (numbers have been rounded). Stream versus lake sediment sample groupings are shaded different colours.

Additionally, metals concentrations in depositional environments (higher TOC and/or fines) tended to be higher in the same metals. In the three mine site lakes, the mean concentrations of chromium, copper, iron, manganese and nickel exceeded applicable guidelines. Throughout the sediment quality dataset it is observed that depositional environments typically contain exceedances of most of these metals.

Metals concentrations in depositional lake samples are relatively consistent between samples, between sample stations within a given lake, as well as between each of the three mine site lakes (Camp, Mary, Sheardown). Sample location D1-05 within Sheardown Lake tributary 1 also exhibited the same substrate characteristics and elevated metals concentrations.

Conversely, metals concentrations in lake sediment and most stream sediment stations which were low in fines and/or TOC contained comparatively lower concentrations of metals and a high degree of variability in metals concentrations between sampling events between nearby sampling stations.

Table D.1 Mean Concentrations of Key Metals in Sediment at the Mine Site

Sample ID		As µg/g	Cd µg/g	Cr µg/g	Cu µg/g	Fe µg/g	Mn µg/g	Ni µg/g	Pb µg/g	Zn µg/g
CCME	ISQG	5.9	0.6	37.3	35.7				35	123
	PEL	17	3.5	90	197				91.3	315
Ontario Sediment Quality Guidelines	LEL	6	0.6	26	16	20,000	460	16	31	120
	SEL	33	10	110	110	40,000	1,100	75	250	820
	n									
Upstream of Deposits	4	0.9	0.4	12.8	1.9	9,446	41	5	1.6	5.9
Downstream of Deposits	22	<1	<0.5	22.9	4.5	11,795	83	13	2.4	8.5
Drainages Off the Deposits	10	<1	<0.5	28.3	12.8	9,688	135	21	2.9	15.1
Mary River Tributary E2	7	1.0	0.4	18.5	3.8	9,507	64	12	2.5	7.0
Mary River Downstream of Mary Lake	2	0.7	0.3	74.5	7.0	6,050	90	29	1.5	7.8
Sheardown Lake Tributaries	18	1.4	0.65	45.2	27.0	13,524	235	39	12.1	47.6
Camp Lake Tributaries	12	0.9	0.4	27.0	12.3	8,501	95	22	3.7	13.3
Tom River	4	<1	<0.5	14.5	2.3	6,993	48	7	1.5	5.8
Mary Lake	9	2.5	<0.5	54.6	21.7	27,469	1,099	40	13.4	51.6
Camp Lake	12	2.7	<0.5	60.2	33.2	27,748	700	52	14.7	48.8
Sheardown Lake NW	32	3.1	<0.5	59.6	36.8	30,687	1,149	54	14.6	56.6
Sheardown Lake SE	7	1.5	0.6	68.0	23.4	27,462	397	57	13.3	46.3

Therefore, further evaluation of the sediment quality database was undertaken to understand the relationship between TOC, the proportion of fines, and metals concentrations.

Figure D.11 shows clay, sand and silt plotted for the entire sediment quality dataset. Circle size represents the proportion of silt. Figure D.12 shows the same information in another way, plotting the proportion of clay/clay+silt by sand. The figures show the 3-way relationship between sand, silt and clay and the negative association between sand and clay.

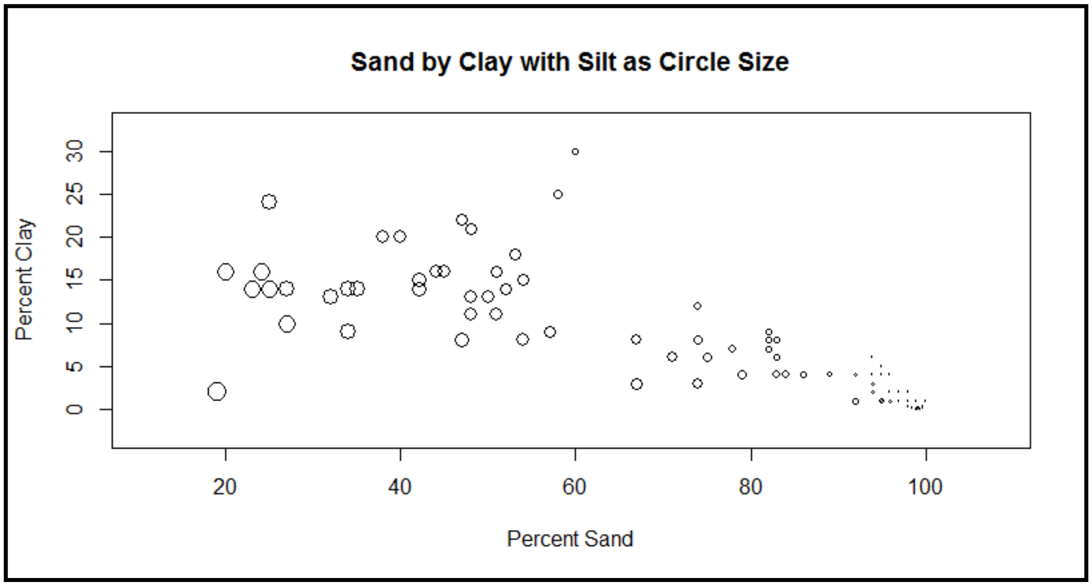


Figure D.11 Clay by Sand with Silt as Circle Size

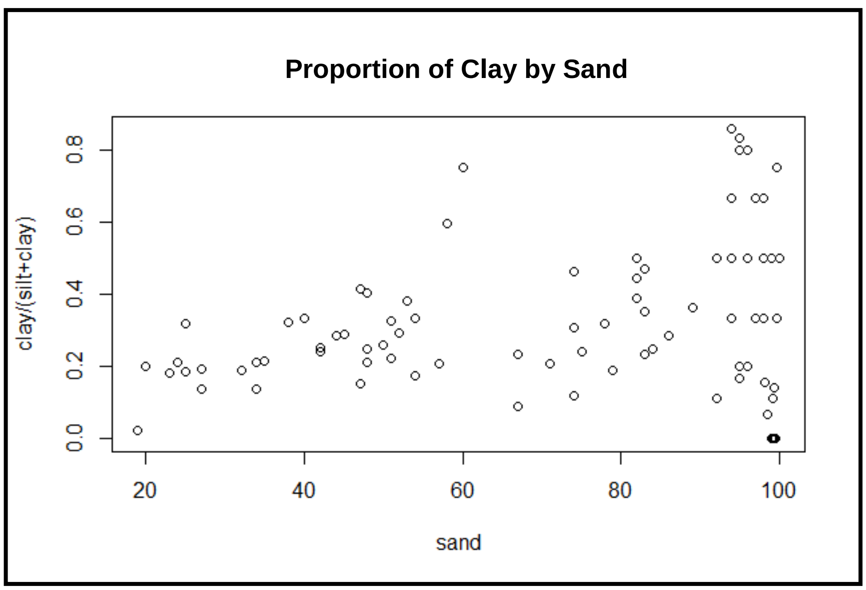


Figure D.12 Dependent Relationship between Sand, Silt and Clay in Sediment

Colored scatter plots (Figure D.13) show the relationship between TOC (or log TOC) and sand for lakes, streams and tributaries. Lakes are plotted using circles, streams and tributaries with triangles.

Colors are used to identify the specific water bodies. Note that the x axis limits for streams and tributaries were adjusted because all the stream data is clumped at high proportions of sand (minimum of 82%). The figure shows that the majority of lake sediment samples contain elevated TOC and higher proportions of fines (a lower proportion of sand), and conversely, the majority of stream samples are low in TOC and low in fines (predominantly sand).

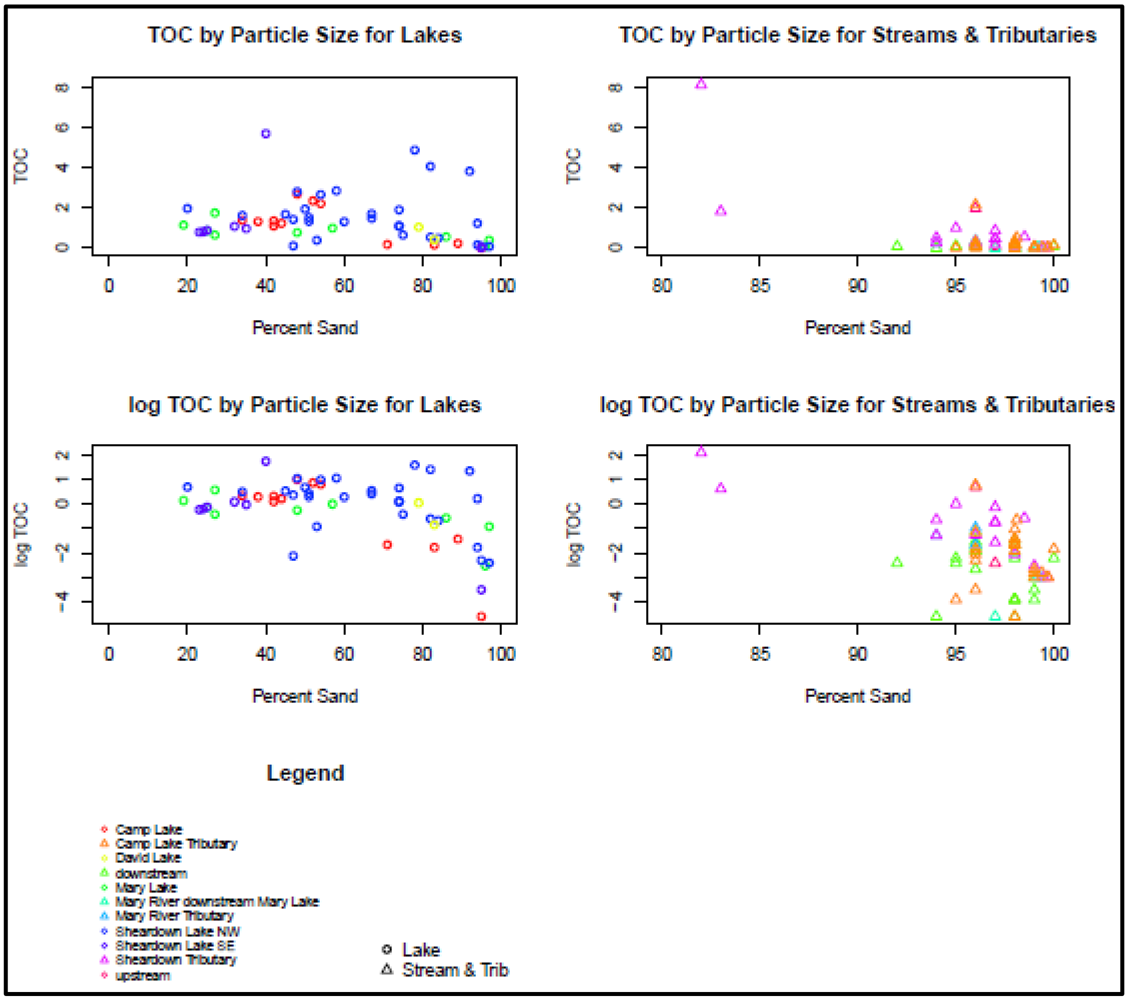


Figure D.13 Sediment TOC versus Particle Size for Lakes and Streams

A further evaluation was undertaken to identify cut offs in TOC and percent sand that could be applied to identify sediment samples in the baseline that can be used for comparison purposes, with the same cut off thresholds for TOC and percent sand applied to sediment samples collected for monitoring. In terms of long-term monitoring, it is recommended that sediment sampling stations in depositional environments be the focus of monitoring and the application of the assessment protocol identified in the AEMP Framework (e.g., detection of a change; establishing if the change is mine related; comparison to AEMP benchmark; undertaking a low or moderate action depending on the result compared to the AEMP benchmark). The high level of variability of metals concentrations within sediment samples characterized by high TOC (low proportion of sand) are likely to mask instead of allow for the detection of Project-related change, as the variability between samples may mask any project-related changes and collection of a sufficient number of samples to obtain statistical power is likely not possible.

D.6 STATISTICAL AND CUT POINT ANALYSIS

Percent sand and TOC are generally related to parameter concentrations. Deposition seems to be limited in sediment samples with high amounts of sand and very little TOC. For the AEMP, the focus of monitoring will be on identified mine-related changes in parameter concentrations. Variability due to TOC and particle size is a nuisance and introduces extraneous noise. In general, it is better to control confounding factors in the study design rather than adjust for them post hoc in the data analysis. Environment Canada (2012) recommends that normalized metal concentrations be used to account for the effects of particle size and organic carbon. This method was considered, but it was found that the best way to minimize the relationship to organic carbon and fines involved creating data cut-offs. Additionally, normalized metals concentrations do not reflect the actual toxicity exposure in the environment.

To identify sensitive depositional environments and minimize variability related to TOC and particle size the data were explored to determine appropriate TOC and particle size cut-offs. Regression analyses were used for 4 key parameters: arsenic, cadmium, iron and nickel.

Several arsenic samples, and many cadmium samples were below MDLs. For this analysis the MDL was used as the estimated concentration for samples below MDLs. Further analysis could be refined by using Tobit regression to account for the left censoring related to MDLs. However, methods to adjust for left censoring may not be appropriate when very large portions of the data are below MDLs as is the case for cadmium.

B-splines were used to obtain flexible, non-linear fits to explore the relationships between percent sand (Figure D.14) and TOC (Figure D.15) and each parameter. The fits using percent sand and TOC are shown in Figure D.16. These plots helped identify cut points in the vicinity of inflection points on the curves. The cut points were used in subsequent linear regression analyses to assess the linear relationship above and below the cut off points (black, green and red lines represent fits using 80%, 85% and 90% cut offs for sand or 0.2%, 0.6% and 1% TOC respectively).

The regression analyses were set up to accommodate separate, but connected, slopes on either side of the cut points. For sand, a cut point of 80% led to relatively gentle regression slopes below 80% and steep negative slopes above 80%. The cut points for TOC were not as clear. However, considering the size of the plotting symbols and the results of bivariate regressions, which include both TOC and percent sand (Figure D.16), defining cut points based on both percent sand and TOC was found to be useful.

A subset of the data was defined which excluded all samples with greater than 90% sand as well as samples with less than 0.6% TOC and greater than 80% sand (indicated in orange in Figure D.17). Alternatively, a cut off could be established such as the sloped black line in Figure D.17. It may be useful to carry out future research with additional data to develop such a rule. Figure D.18 shows the relationships between parameter concentrations and TOC and percent sand were generally negligible for the quantitatively defined subsets. The only exception is cadmium which has a large proportion of data below MDLs.

The selection criterion reduces variability associated with TOC and particle size. For post-mining data, using only samples which meet the criterion is expected to be a conservative approach since samples with more than 80% sand and low TOC tend to have the smallest parameter concentration.

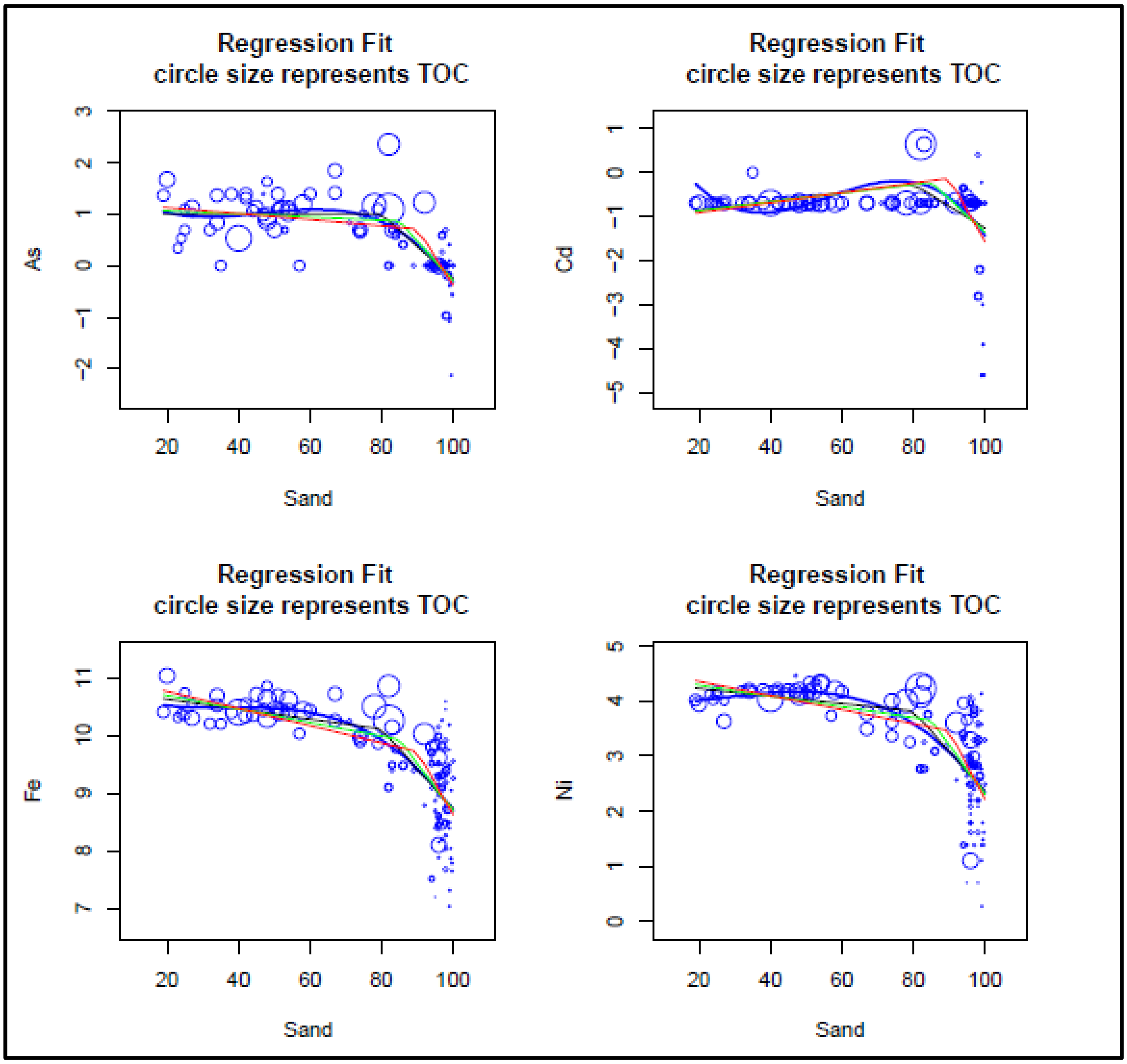


Figure D.14 Concentrations of As, Cd, Fe and Ni in Sediment Based on Percent Sand

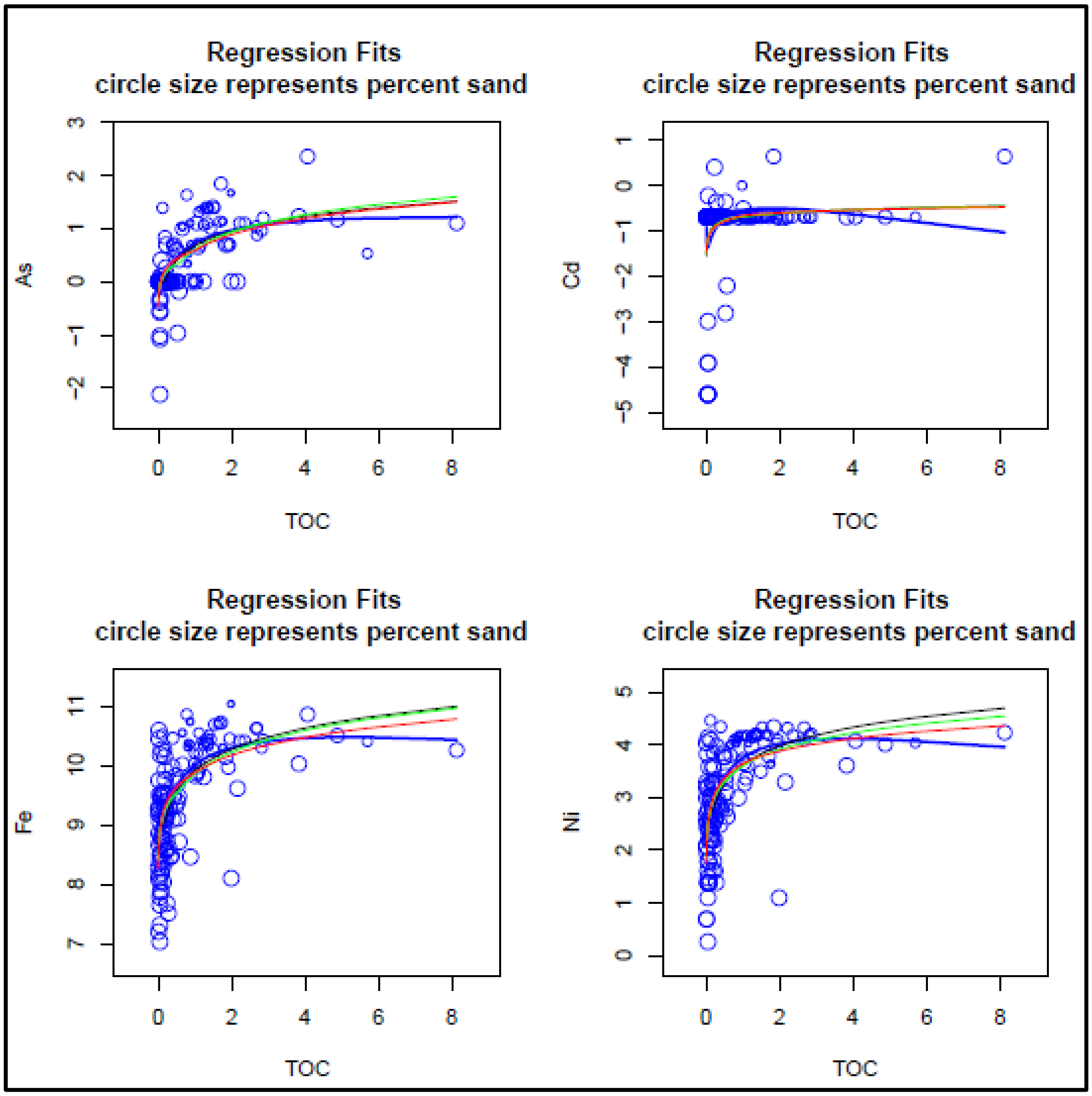


Figure D.15 Concentrations of As, Cd, Fe and Ni in Sediment Based on Percent TOC

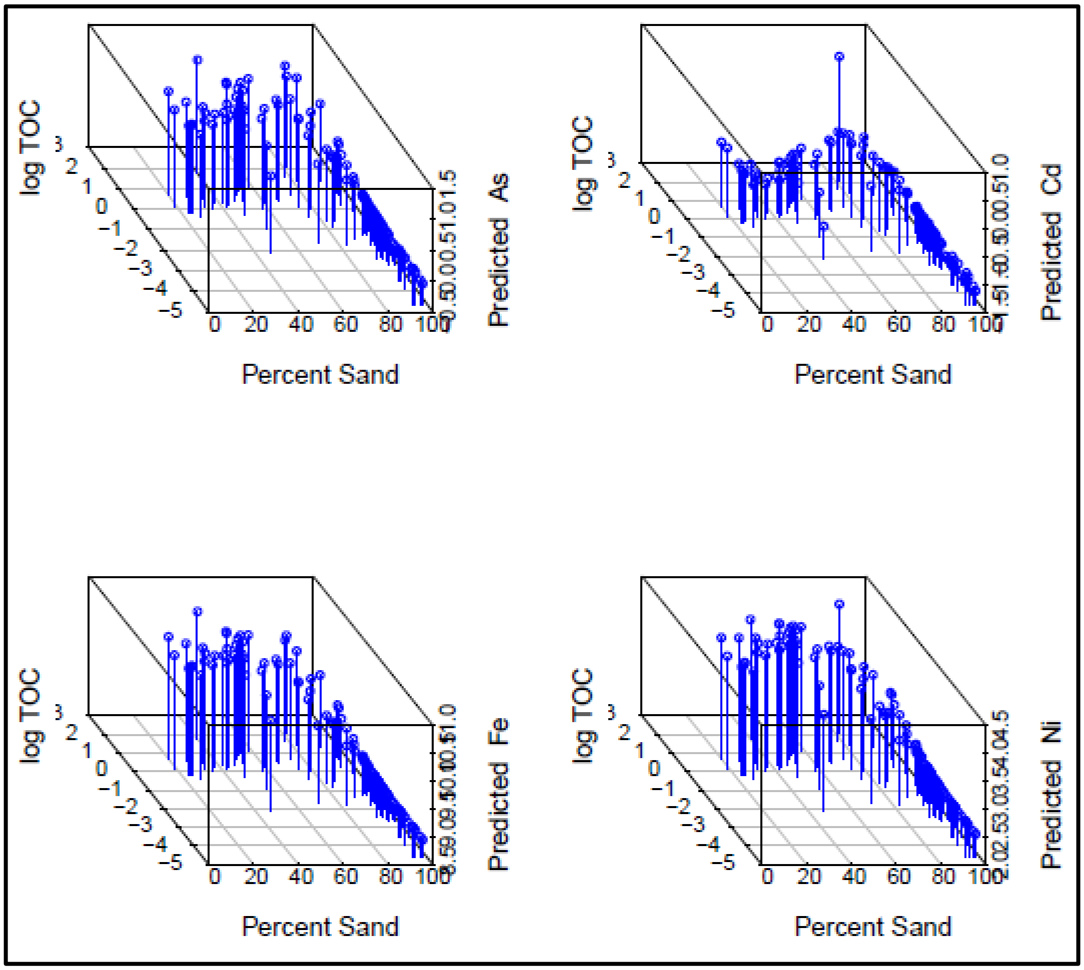


Figure D.16 Concentrations of As, Cd, Fe and Ni in Sediment Based on Log TOC and Percent Sand

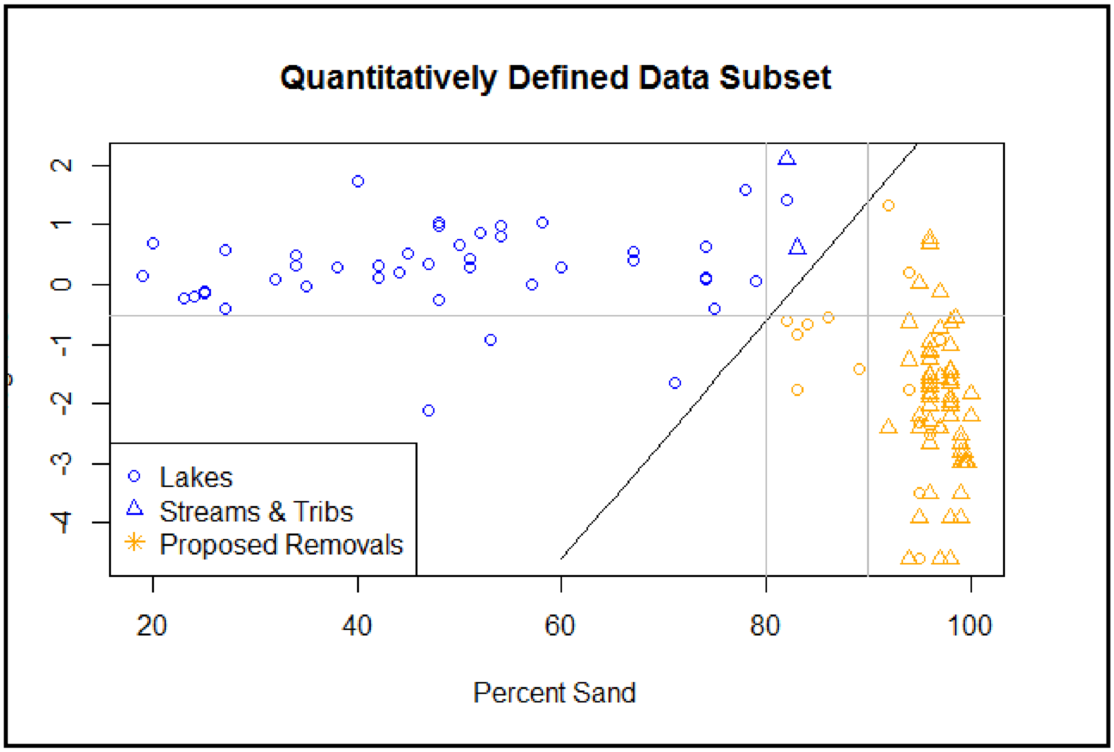


Figure D.17 Results of Cut Point Analysis for Sediment

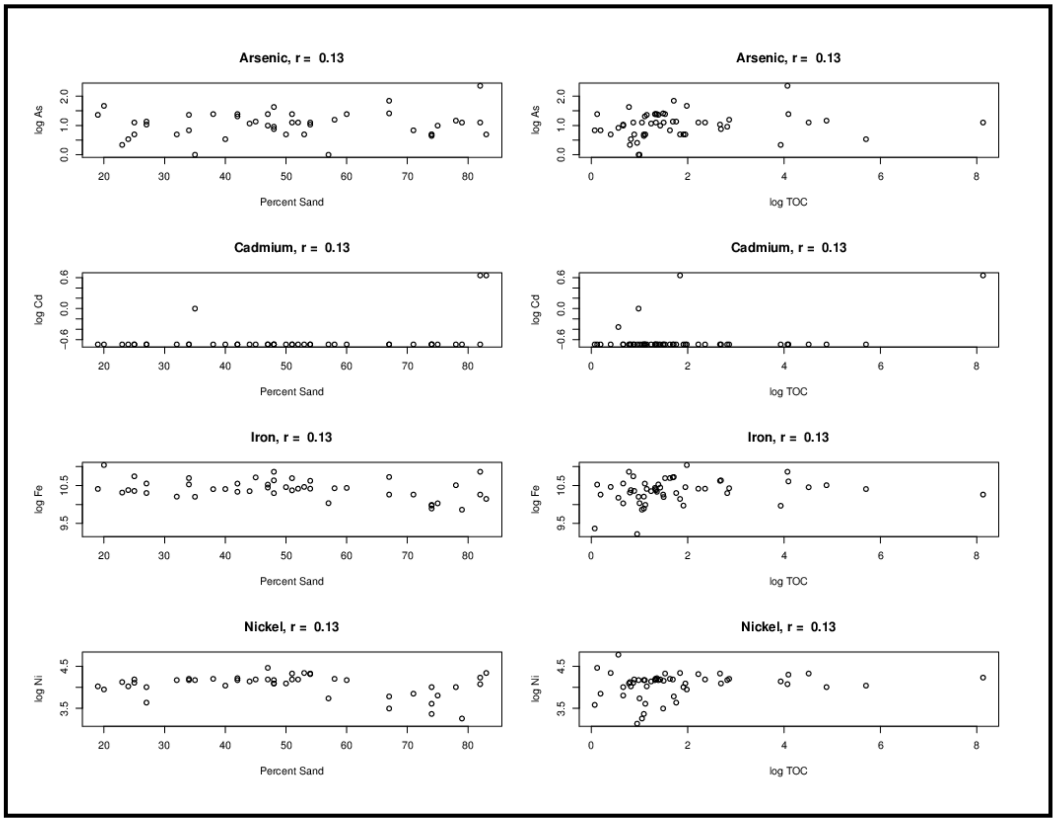


Figure D.18 Correlations between TOC and Percent Sand, and the 4 Key Parameters for the Subset Data, Second Stage Cuts in Blue

D.7 TEMPORAL AND SAMPLING EFFECTS

Sediment sampling from 2005 to 2008 was carried out using of a Petite Ponar dredge sampler to collect a maximum sample collection thickness of 5 cm. This depth is appropriate for monitoring studies where historical contamination is not a priority (Environment Canada, 2012). As a result of a recommendation from Environment Canada that the upper 1 to 2 cm of sediment be collected as part of Project monitoring, collection of a thinner (2 cm) core sediment sample was implemented by Baffinland starting in 2012. A comparison of the lake data from 2006 to 2013 was completed to determine if appreciable differences in sediment concentrations occurred as a result in the change of sampling techniques. Note that 2005 data was not included in the temporal sampling, since lake sampling did not occur in 2005. Review of Figures D.19 and D.20 indicate that significant inter-annual effects do not occur for any of the parameters of interest; however, certain parameters show slightly depressed concentrations in 2006 (chromium, lead, zinc and nickel). Due to the low sample size in 2006, the slightly depressed 2006 concentrations are considered to be influenced by sample size.

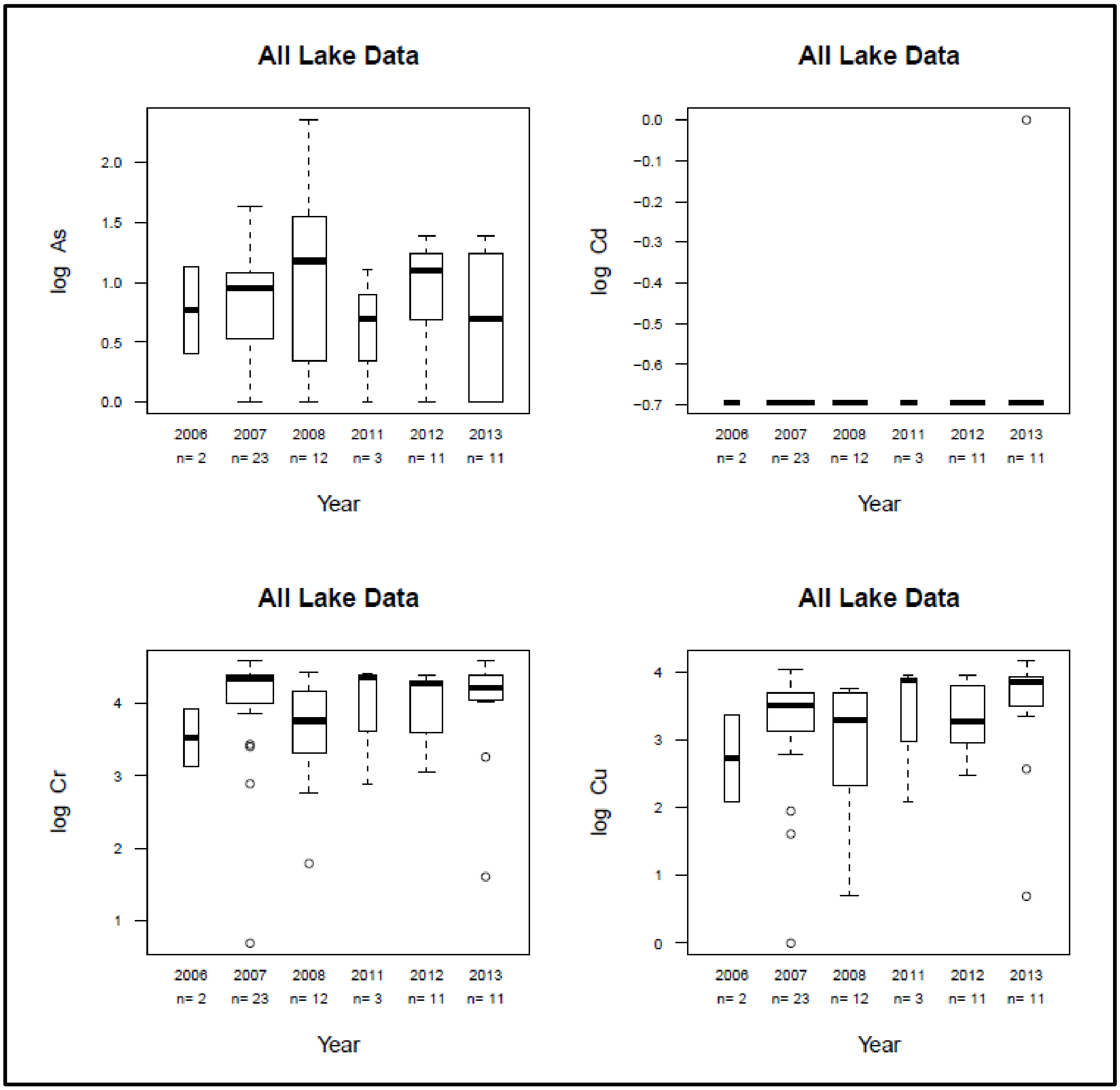


Figure D.19 Inter-Annual Variability for As, Cd, Cr and Cu in Sediment

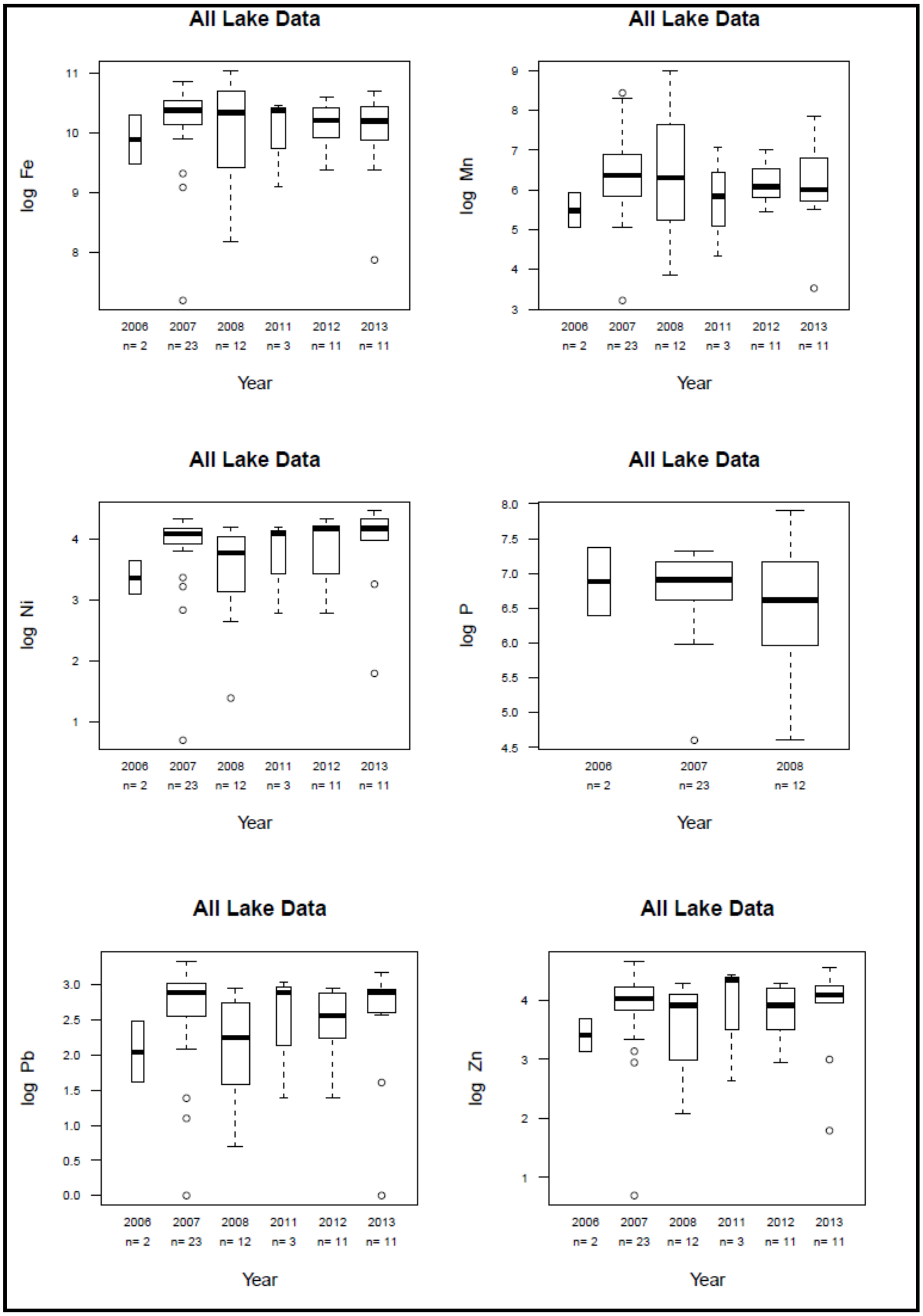


Figure D.20 Inter-Annual Variability for Fe, Mn, Ni, P, Pb and Zn in Sediment

D.8 POWER ANALYSIS

The baseline sediment quality monitoring program results from the stream and lake environments surrounding the Project site show naturally elevated concentrations above the lower sediment quality criteria concentrations for parameters of concern such as chromium, copper, iron, manganese and nickel. The iron and manganese concentrations were also typically above the severe effect levels in the lake environments.

After an initial exploratory analysis of the sediment baseline data, it was decided to retain fifty-two (52) samples that fit the criteria for TOC and percent sand. Sufficient power to detect a change from baseline values was desired for each station. Baseline data was not collected at reference stations and therefore, since baseline reference (control) data was not available, a full BACI design was not used for the power analysis. Instead, a before-after (BA) design was used. The power analysis was carried out using a two sample t-test which assumes independence between the before and after samples.

The sample sizes for each year, at each lake are presented in Table D.2. Further sampling carried out in 2014 will supplement this dataset and provide a better basis for refined power analysis. Here, instead of using highly variable estimates of station means from the limited baseline data, a generic analysis was used. Power to detect a change from a baseline mean to 97.5th percentiles for a normally distributed variable was used to get sample size estimates which apply to all sites and metals. This analysis will be refined for specific stations and metals after 2014 samples are collected and benchmarks have been finalized.

Table D.2 Sediment Sample Sizes for the Mary River Project

Area	**2006**	**2007**	**2008**	**2011**	**2012**	**2013**
Camp Lake	0	5	0	0	2	2
Mary Lake	1	4	0	0	1	0
Sheardown Lake NW	0	7	7	2	4	5
Sheardown Lake SE	0	4	0	0	1	1
David Lake	0	0	0	0	1	0

Site-wide preliminary benchmarks were developed by Intrinsik such that the benchmark was set to either the guideline value or the empirical estimate of the 97.5th percentile of the data, whichever was larger. In all cases, the 97.5th percentile was the lowest value. Therefore, the minimum power to detect a change from baseline mean to the benchmark can be obtained by considering this lower bound of the benchmark (97.5th percentile). For parameters where the benchmark is based on the guideline, the effect size is actually larger than considered here and thus the power will also be larger.

Further analysis was carried out to assess the sample size required to have sufficient power to detect smaller changes which act as early warning flags. The early warning value was set as half way between the baseline mean (or median) and the 97.5th percentile ($z = 1.96/2$; approximately the 84th percentile).

Using this approach, power can be calculated simultaneously for all variables and all sites as follows:

- Assume the data (log transformed) is normally distributed based on other analysis of other larger data sets

- Consider the standardized data; a z-score is obtained by subtracting the mean and dividing by the standard deviation
- For standardized normal data, the mean and median are equal with a z-score of 0; the 97.5th percentile has a z-score of 1.96
- The power to detect a before-after change from the baseline mean 0 (= median) to 1.96 (97.5th percentile) can be calculated using a 2 sample t-test
- Choose a one-tailed type I error of 0.05 or 0.01 since only increases in concentration are of interest

This approach allows a generic assessment of power for all parameters. The power for sample sizes of 5, 10, 15, 20 and 25 are shown for the 97.5th percentile and the mid-point value ($z = z_{97:5}$=2) half way between the median (z_{50} = 0) and 97.5th percentile ($z_{97:5}$ = 1:96). The following tables can be used to assess the sample size requirements for each station provided the 97.5th percentile estimates used for benchmark development is a reasonable estimate for each station. That is, provided the 97.5th percentile of the pooled data (from all stations) is representative of each individual station.

An alpha value of 0.05 was selected to examine the effects of varying the pre-mining and post mining sample size. In order to gain sufficient power, ideally either 15 pre-mining samples are taken and 25 post-mining are taken or 25 pre-mining samples are taken and 15 post-mining samples are taken to have sufficient power to detect early warning flags.

Table D.3 Power Predicted for Various Sample Sizes – Median to 95th Percentile

	N before = 5	N before = 10	N before = 15	N before = 25
N after = 5	0.77	0.89	0.92	0.95
N after = 10	0.97	0.97	0.99	1.00
N after = 15	0.99	0.99	1.00	1.00
N after = 25	1.00	1.00	1.00	1.00

NOTES:
1. ALPHA EQUALS 0.05.
2. THE EFFECT SIZE IS FROM MEDIAN TO THE 95TH PERCENTILE (1.65).

Table D.4 Power Predicted for Various Sample Sizes - Halfway from Median to 95th Percentile

	N before = 5	N before = 10	N before = 15	N before = 25
N after = 5	0.33	0.41	0.46	0.50
N after = 10	0.41	0.55	0.62	0.42
N after = 15	0.46	0.62	0.71	0.80
N after = 25	0.50	0.70	0.80	0.89

NOTES:
1. ALPHA EQUALS 0.05.
2. THE EFFECT SIZE IS HALFWAY FROM MEDIAN TO THE 95TH PERCENTILE (1.65/2).

D.9 RECOMMENDATIONS

The relationship between fine grained sediments and the accumulation of the parameters of concern suggests the sediment monitoring program should focus on the depositional lake environments, since they are the end receiver of stream sediments. Focusing the CREMP to include additional lake sediment monitoring stations and reducing the amount of stream sediment quality monitoring stations would increase the data coverage within the lake basins and strengthen the baseline data set. Stream sediment sampling will be conducted as part of the Environmental Effects Monitoring program required under the MMER in the Mary River and Camp Lake Tributary 1.

In order to achieve the sample sizes required, the following are recommended:

1. An additional year of baseline data collection.
2. Utilization of samples within one lake basin to achieve sufficient pre-mining sample size.
3. Recognition that there will not be sufficient power to complete site-based statistical testing.

D.10 REFERENCES

Environment Canada, 2012. *Metal Mining Technical Guidance for Environmental Effects Monitoring* .National Environmental Effects Monitoring Office.

Horowitz, Arthur J., 1991. *A Primer on Sediment-Trace Element Chemistry, 2nd Edition*. United States Geological Survey, Open File Report 91-76.

Intrinsik Environmental Sciences Inc., 2014. *Development of Water and Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project.* Intrinsik Project No. 30-30300.

Appendix C

Development of Water and Sediment Quality Benchmarks

Appendix C

Development of Water and Sediment Quality Benchmarks

SCIENCE INTEGRITY KNOWLEDGE

APPENDIX C

DEVELOPMENT OF WATER AND SEDIMENT QUALITY BENCHMARKS FOR APPLICATION IN AQUATIC EFFECTS MONITORING AT THE MARY RIVER PROJECT

June 26, 2014

Prepared For: Oliver Curran
Director Sustainable Development
Baffinland Iron Ore
2275 Upper Middle Road East Suite 300
Oakville ON
L6H 0C0

Sovereign Place, 5121 Sackville St, Suite 506, Halifax, NS, B3J 5Ri
Tel: 902-429-0278▪ Fax: 902-429-0279 ▪ www.intrinsik.com

DEVELOPMENT OF WATER AND SEDIMENT QUALITY BENCHMARKS FOR APPLICATION IN AQUATIC EFFECTS MONITORING AT THE MARY RIVER PROJECT

Table of Contents

Page

List of Tables

List of Figures

DEVELOPMENT OF WATER AND SEDIMENT QUALITY BENCHMARKS FOR APPLICATION IN AQUATIC EFFECTS MONITORING AT THE MARY RIVER PROJECT

C- 1.0 INTRODUCTION

As part of the Aquatic Effects Monitoring Program (AEMP) for the Mary River Project in Nunavut, Baffinland Iron Mines Corporation (Baffinland) requires development of benchmarks for comparison of surface water and sediment chemistry data which will be collected under the Core Receiving Environment Monitoring Program (CREMP).

Since the mine site occurs within an area of metals enrichment, generic water quality and sediment quality guidelines established for all areas within Canada may naturally be exceeded near the mine site. Therefore, the selection of appropriate benchmarks must consider established water and sediment quality guidelines, such as those developed by the Canadian Council of Ministers of the Environment (CCME), as well as site-specific natural enrichment, and other factors (such as Exposure Toxicity Modifying Factors (ETMF) including pH, water hardness, dissolved organic carbon, etc.), in the selection or development of final benchmarks for monitoring data comparison (CCME, 2003; 2007).

The assessment of surface water and sediment quality data over the life of the project will be on-going, and the recommended benchmarks of comparison throughout this process may change, as more data become available. For example, a generic water quality guideline established as a benchmark early on in the life of the mine may require updating over time to a Site Specific Water Quality Guideline, based on consideration of published literature and standardized protocols (CCME, 2007), or site specific toxicity tests conducted to further understand ETMF or resident species toxicity. In addition, sediment data will be collected in 2014 prior to mine-related discharge and is expected to be integrated into the baseline data, and will likely result in modifications to the suggested AEMP sediment benchmarks presented herein. The iterative, cyclical nature of modification of benchmarks under an AEMP is well established (MacDonald et al., 2009).

Section 5 of the AEMP outlines the proposed approach for development of the benchmarks. Briefly, the process involves the following steps:

- Determine, using the Final Environmental Impact Statement (FEIS), which substances are present at naturally elevated concentrations, and/or those that could be released at elevated concentrations as a result of mining activities, into the future;
- Evaluate baseline data, and determine a statistical metric of baseline levels which is considered representative of background for any naturally occurring substances (metals/metalloids);
- Evaluate CCME sediment and surface water quality guidelines, where available, or other relevant guidelines from other regulatory jurisdictions (such as Ontario or British Columbia), where appropriate. Appropriate guidelines could include Site-Specific Water

Quality Guidelines (SSWQGl) developed using CCME protocols, and data from the Mary River area, or from other northern Mine sites, where data are appropriate;

- Select the higher of either baseline or regulatory or SSWQGl as the benchmark for adoption in the AEMP.

This appendix outlines the benchmark selection process, and evaluation of data.

C- 2.0 SEDIMENT EVALUATION AND BENCHMARK DEVELOPMENT

C-2.1 Selection of Substances for Benchmark Development

Based on the baseline data collected between 2005 and 2013, and the outcomes of the FEIS, the following substances have the potential to be either naturally elevated in the environment, or elevated as a result of future mine site activities (see Table 2-1).

Table 2-1 Identification of Metals Naturally Elevated in Area, and Potentially Elevated as a Result of Facility Releases

Substance	***Sediment***	
	Naturally Enriched in Area, Relative to Sediment Quality Guidelines[a]	***Potential to be Elevated Due to Mine Site Releases***[b]
Arsenic	No	Yes
Cadmium	Yes	Yes
Chromium	Yes	Negligible
Copper	Yes	Negligible
Iron	Yes	Yes
Lead	No	Negligible
Manganese	Yes	Not determined
Mercury	No	Not determined
Nickel	Yes	Yes
Phosphorus	Yes	Not determined
Selenium	NGA	Not determined
Zinc	No	Negligible

Notes:
NGA = no guideline available
Bolded and shaded chemicals were carried forward for benchmark development based on natural enrichment, relative to guidelines, and consideration of future site contributions.
Bolded substances were carried forward as CCME sediment quality guidelines are available for these parameters.
[a] Determination based on baseline 97.5th percentile of all samples, relative to CCME sediment quality guidelines (ISQG) or Ontario sediment quality guidelines (LEL), where available
[b] Final FEIS, Volume 7; SWSQ-17-3; page 170; nickel concentrations were not predicted to exceed the PEL

Based on the information presented in Table 2-1, all bolded substances require benchmark development (*i.e.*, arsenic, cadmium, chromium, copper, iron, manganese, nickel and phosphorus). Three additional substances have CCME sediment quality guidelines, and were also included in the sediment chemistry assessment process (*i.e.*, lead, mercury and zinc).

C-2.2 Baseline Data Evaluation

Baseline sediment data were received from Knight Piésold. Data treatment conducted in the Baseline Integrity Review (Knight Piésold, 2014) involved the following steps:

- Removing all duplicate samples, to avoid "double counting" of data;
- All samples which were non-detect were assumed to equal the detection limit for statistical calculations; and
- Review of sediment quality laboratory detection limits.

The review of detection limits indicated that most were well below the relevant sediment quality guidelines, and that MDLs did not change meaningfully over the sampling years. The MDL reported for mercury is very close to the CSQG/ISQG, and the MDL for cadmium is 0.1 mg/kg less than the CSQG/ISQG. In both cases, increased resolution of detection limits in the future would be helpful in evaluating trends in the data over time, relative to guidelines and baseline.

C-2.2.1 Sediment Data Evaluation for Determining AEMP Benchmarks

Following completion of the data treatment steps present above, a detailed assessment of sediment chemistry was undertaken (Knight Piésold, 2014). Sediment data are available from 2005 through 2013, for various stations. The samples were all analyzed using a similar digest and analytical methodology, and hence are comparable. In addition, while the early sediment samples are all grab samples (ponar), more recent samples from some areas have included core samples (top 2 cm). Assessment of the data from these two approaches was conducted under the Baseline Integrity Review (Knight Piésold, 2014) and concluded the data are comparable, and therefore data from both sampling approaches were included in the data analysis.

A detailed evaluation of sediments was undertaken relative to depositional characteristics of sampling locations, to explore the relationships between depositional characteristics (such as Total Organic Carbon (TOC) (*e.g.*, high TOC represents a higher propensity to accumulate metals) and presence of sand (% sand; *e.g.*, high sand content would represent lower potential for accumulation of metals, due to lower binding potential), and metal concentrations. This analysis is presented within the Baseline Integrity Report (Knight Piésold, 2014; Appendix B). It concluded that all sediment sampling locations with TOC concentrations < 60% (0.6) and sand content of > 80% or those stations wherein sand alone was > 90% (irrespective of TOC) do not represent depositional zones, and these stations should no longer be included as potential monitoring stations. As such, these stations should be removed from the baseline chemistry calculations. Removal of these stations is justified since stations exhibiting these characteristics have a low potential to accumulate metals, and hence, will have a low likelihood of exhibiting substantial changes in chemistry in the future. In addition, including the data from these stations in the overall baseline percentile calculations results in considerable variability in the data, which would limit the potential to find statistically significant change over time, relative to future sediment monitoring and the current assessment framework (outlined in AEMP main report Figure 5.1).

The retained depositional stations were examined, and Log10 histograms of the dataset suggest that the data are largely log normally distributed (Figure 2-1), with the exception of cadmium, and mercury (not shown) due to the large number of non-detects, and phosphorus (which has a smaller number of samples, relative to other parameters).

In addition, Table 2-2 provides a summary of the number of sediment samples per year in each lake and depositional tributary area, and total number of samples for the entire area, relative to baseline metric development.

Table 2-2 Number of Sediment Samples Collected in Each Water Body by Year

Year	*Camp Lake*	*Mary Lake*	*Sheardown Lake NW*	*Sheardown Lake SE*	*Tributaries of Sheardown Lake*
2005	0	0	0	0	0
2006	0	1	0	0	0
2007	5	4	7	4	0
2008	0	0	7	0	3
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	2	0	0
2012	2	1	4	1	1
2013	2	0	5	1	1
Total	9	6	25	6	5

As can be seen in Table 2-2, there are limited samples in some of the area lakes. For the parameters of interest, Table 2-3 presents the total number of samples per lake, and the number of samples greater than the detection limit.

The data were evaluated using two approaches, based on the dataset as a whole (N=52), and also on an area-by-area basis, to determine if area-wide benchmarks could be established, or whether there were differences between lakes which would suggest a need for lake-specific AEMP benchmarks for selected lakes. With respect to possible approaches that can be taken to estimate background, guidance is available for soils and groundwater data from a variety of different regulatory jurisdictions, and is appropriate to apply to sediments. Ontario Ministry of Environment recommends that the 97.5th percent of baseline data be used (OMOE, 2011), whereas BC MOE (2005) suggests using a 95th percentile. US EPA suggests a 95th percentile for non-parametric datasets, or a 95th percentile Upper Prediction Limit (UPL) for datasets that are normally distributed (Singh and Singh, 2010). In several of these cases, consideration of potential outliers is suggested. With respect to other mining projects, the 95th percentile has been used as a baseline metric in the Meadowbank AEMP program (Agnico-Eagle, CREMP Design, 2012), whereas the maximum baseline value (or assessment against the range of baseline data) has been suggested in some other programs (Gahcho Kue Project; Golder, 2012).

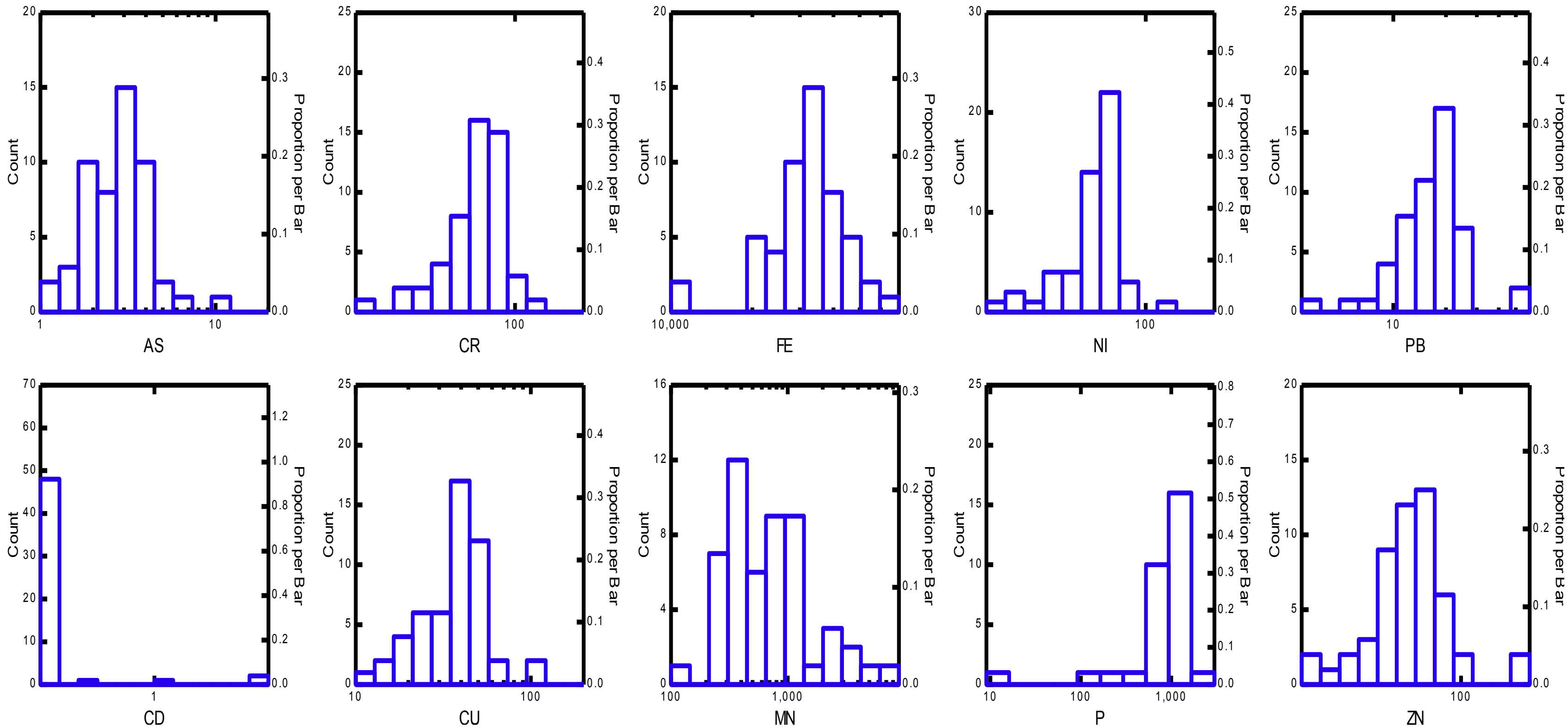


Figure 2-1 Log10 Histograms of Area-Wide Sediment Data (N=52), by Metal of Interest

Table 2-3 Number of Sediment Samples Greater Than Detection Limit by Water Body

Metal	***Camp Lake***		***Mary Lake***		***Sheardown Lake NW***		***Sheardown Lake SE***		***Tributaries of Sheardown Lake***	
	N	***Samples > DL***	***N***	***Samples > DL***	***N***	***Samples > DL***	***N***	***Samples > DL***	***N***	***Samples > DL***
As	9	9	6	6	25	25	6	6	5	5
Cd	9	1	6	0	25	0	6	5	5	3
Cr	9	9	6	6	25	25	6	6	5	5
Co	9	9	6	6	25	25	6	6	5	5
Cu	9	9	6	6	25	25	6	6	5	5
Fe	9	9	6	6	25	25	6	6	5	5
Hg	9	0	6	0	25	0	6	0	5	0
Mn	9	9	6	6	25	25	6	6	5	5
Ni	9	9	6	6	25	22	6	6	5	5
P	5	5	5	5	14	14	4	4	3	3
Pb	9	9	6	6	25	25	6	6	5	5
Zn	9	9	6	6	25	25	6	6	5	5

Notes:
N = number of samples
ND = not detected
> = greater than

Using the entire dataset (N=52) various statistical metrics were calculated to represent possible upper end of normal for the dataset (95th percentile and 97.5th percentile). UPLs were not explored at this time, as additional data collection is being recommended (see below) in light of the small number of samples available for several area lakes.

Sediment quality guidelines were also identified for comparison to baseline metrics. The CCME (2014) have sediment quality guidelines for only a limited number of metals. Where CCME guidelines were lacking, sediment quality guidelines from jurisdictions such as the British Columbia Ministry of Environment (Nagpal et al., 2006) and the Ontario Ministry of the Environment (OMOE, 2008) were reviewed and considered. Many of the British Columbia sediment guidelines are based on CCME values. Guidelines from US EPA (2014) were also reviewed and considered, and several of the guidelines draw on the Ontario guidelines. Where available, both low effect level guidelines [such as ISQGs (Interim Sediment Quality Guidelines) from CCME, and LEL (Lower Effect Level) from Ontario] are presented, as well as effect-level guidelines [such as PELs (Probable Effect Level) from CCME, and SEL (Severe Effect Level)]. It is critical to note the following with respect to the use of these generic benchmarks as comparison points for sediment data:

- Concentrations which are less than the more conservative guidelines (such as the ISQG from the CCME or LEL from Ontario) indicate that toxicity is not expected in the environment;
- Concentrations which are greater than the ISQG or LEL, suggest toxicity is possible;
- Concentrations which are greater than the PEL or SEL, suggest toxicity may be present, but is not certain, due to the number of possible modifying factors affecting toxicity.

Metals are naturally occurring substances, and in the vicinity of mining areas, it is commonplace that some metals may be present in elevated concentrations, relative to these guidelines. There are many site specific factors which play a significant role in modifying toxicity of metals in sediments which are not accounted for in these generic guidelines, most notable, site specific bioavailability of the metal/metalloid. Therefore, conclusions with respect to adverse effects need to be drawn based on site specific considerations and data, as opposed to comparisons to benchmarks alone. In general, CCME (2002) recommends that assessment of potential for adverse effects in biota related to sediment contamination involve the use of sediment quality guidelines, as well as other assessment tools, such as data on natural background concentrations of substances of interest, biological assessments (such as benthic community assessments), and/or other toxicity data (such as site-specific testing), as needed.

Table 2-4 presents the minimum, maximum, median, mean, 95th percentile and the 97.5th percentile for the compiled baseline sediment data for the entire region, relative to available sediment quality guidelines, for the metals/metalloids identified in Table 2-1.

Following this, an area by area assessment of data was conducted, to investigate potential differences between lakes, with respect to metals concentrations, relative to the 95th percentile of the entire dataset. Figure 2-2 illustrates box and whisker plots of the lake data (and tributaries of Sheardown Lake), with number of samples (represented by open circles on the figures).

Table 2-4 Baseline Statistical Calculations for Area-Wide Sediment Data Relative to Available Sediment Quality Guidelines (µg/g)

Jurisdiction and Statistical Metric	*Type of Guideline*	*Hg*	*As*	*Cd*	*Cr*	*Cu*	*Fe*	*Mn*	*Ni*	*P*	*Pb*	*Zn*
CCME	**ISQG**	0.17	5.9	0.6	37.3	35.7	NGA	NGA	NGA	NGA	35	123
	PEL	0.486	17	3.5	90	197	NGA	NGA	NGA	NGA	91.3	315
Ontario Sediment Quality Guidelines	**LEL**	0.2	6	0.6	26	16	20000	460	16	600	31	120
	SEL	2	33	10	110	110	40000	1100	75	2000	250	820
US EPA Sediment Quality Guidelines	**Screening**	0.18	9.8	0.99	43.4	31.6	20000	460	22	NGA	35.8	121
% of Samples Detected		0	100	18	100	100	100	100	100	100	100	100
Minimum		<0.1	1	<0.5	23	10	10,100	128	23	100	3	22
Maximum		<0.1	10.5	1.9	124	107	62,300	8,030	119	2700	52	171
Mean		NC	3.0	0.6	69	40	32,900	1,085	60	1042	18	65
Median		NC	2.3	0.5	72	40	33,100	649	64	1000	18	62
95th Percentile		NC	5.2	0.8	96	61	48,955	3,769	77	1550	26	100
97.5th Percentile		NC	6.0	1.7	98	87	52,200	4,452	84	1875	44	152

Note:
NC = not calculated because <5% of samples were detected; All metals had N= 52, with the exception of P, where N=31

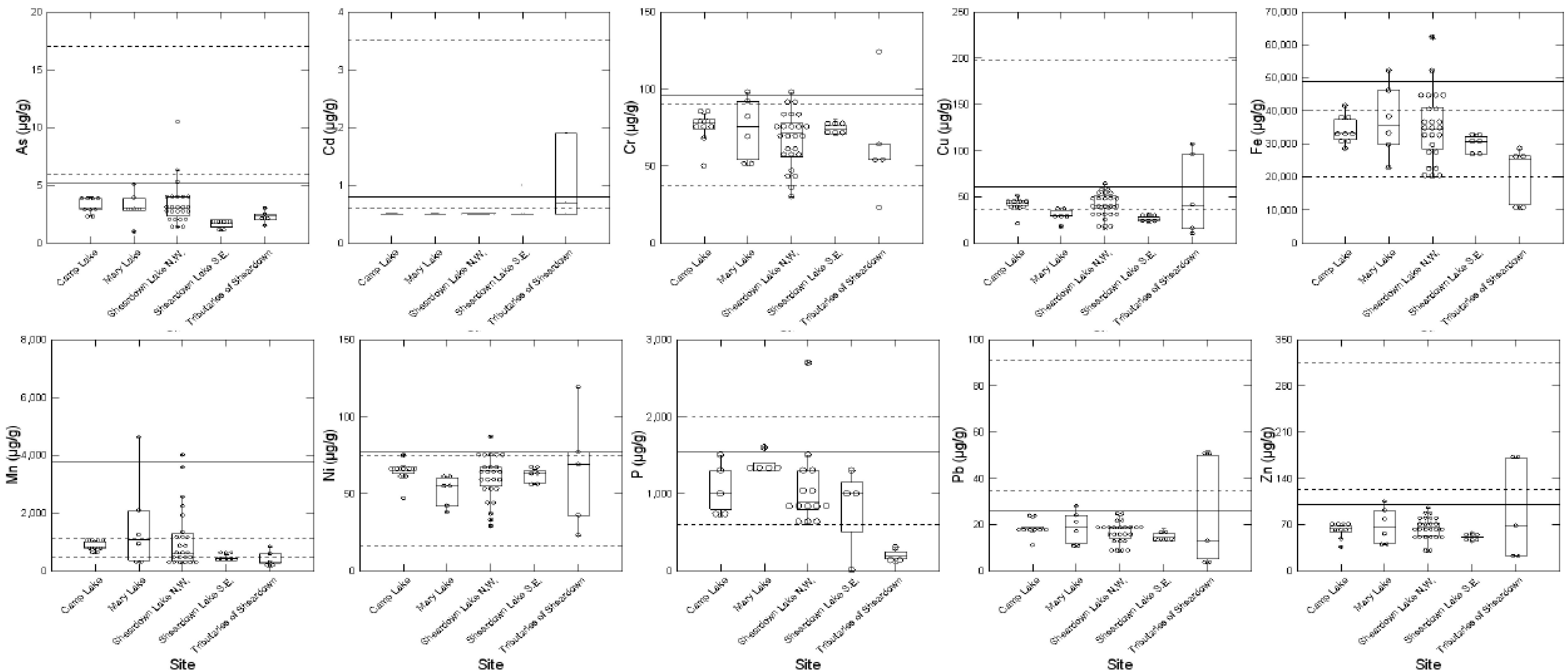


Figure 2-2 Box and Whisker Plots of Metal Concentrations by Area (Solid line represents 95th percentile of area-wide data; dotted lines represent ISQG/LEL and PEL/SEL sediment quality guidelines, respectively)

Median values are represented within each box as the central line, with the 25th and 75th percentiles of the data being represented by the lower and upper parts of the box. Upper and lower “whiskers” extend from the box, and represent the maximum data point within 1.5 interquartile range from the top (or bottom) of the box. Potential outliers are noted as symbols beyond the whiskers. Dotted lines in the figures represent CCME or Ontario ISQG/LEL and PEL/SEL guidelines. The solid line represents the 95th percentile of the area wide sediment data, for each metal.

These box and whisker plots clearly indicate that while there are similarities between some lakes for some metals (e.g., arsenic concentrations in Camp Lake, Mary Lake and, to a lesser extent, the Tributaries of Sheardown Lake), there are also large differences in some cases (e.g., iron and manganese in Sheardown Lake SE and Tributaries of Sheardown are very different from other lakes). Tributaries of Sheardown Lake appear to have some elevated values for cadmium, chromium, copper, lead, nickel, and zinc, relative to other area lakes. While Sheardown Lake NW has adequate sampling to be confident that baseline has been adequately characterized (n = 25), the small number of samples in Camp Lake (n= 9), Mary Lake (n = 6), Sheardown Lake SE (n = 6) and Tributaries of Sheardown Lake (n = 5), limit the understanding of baseline metals levels in these specific lakes.

In order to investigate whether there has been site-related influence over time, a visual temporal trend evaluation was conducted on Sheardown Lake NW, since it had adequate sampling size to conduct this type of analysis. Figure 2-3 illustrates the temporal trends for various metals/metalloids within this basin (mean +/- standard error).

Based on Figure 2-3, there are apparent upward trends in the data related to Cr, Ni and Cu, but less pronounced differences with respect to Pb and Zn, or other parameters. Data are too limited for P to examine trends, and statistical significance tests were not conducted at this time. Further data collection in 2014 will assist in evaluating whether data in this basin are trending upwards, or within natural variability. These trends will be discussed further below, relative to the selection of AEMP benchmarks.

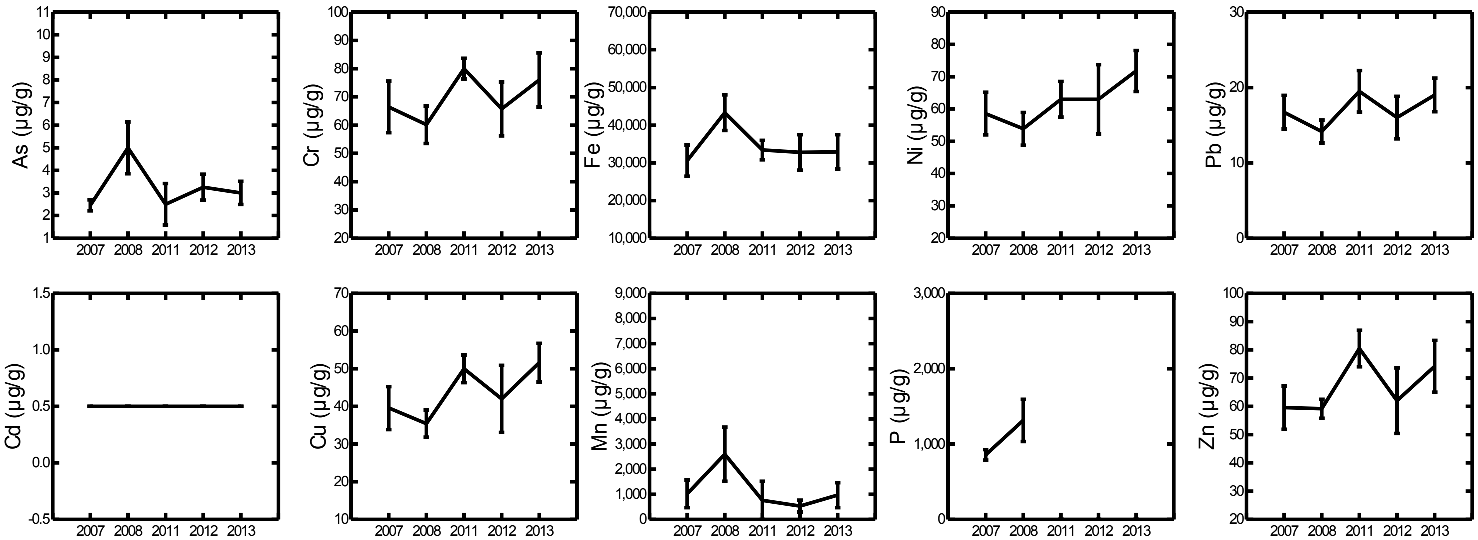


Figure 2-3 Temporal Trend Analysis for Sheardown Lake NW (n = 25) for Various Parameters (mean +/- std error)

C-2.3 AEMP Benchmark Derivation for Sediments

Based on the available data, final AEMP benchmarks were not derived at this time, as several of the lakes would benefit from an increased database to confirm adequate characterization of baseline (Camp Lake, Mary Lake, Tributaries of Sheardown Lake, Sheardown Lake SE). Therefore, the current proposed approach is to select an Interim AEMP sediment benchmark, which will be finalized once more sediment data are collected in the 2014 season.

The approach for selecting sediment AEMP benchmarks is outlined in Figure 2-4:

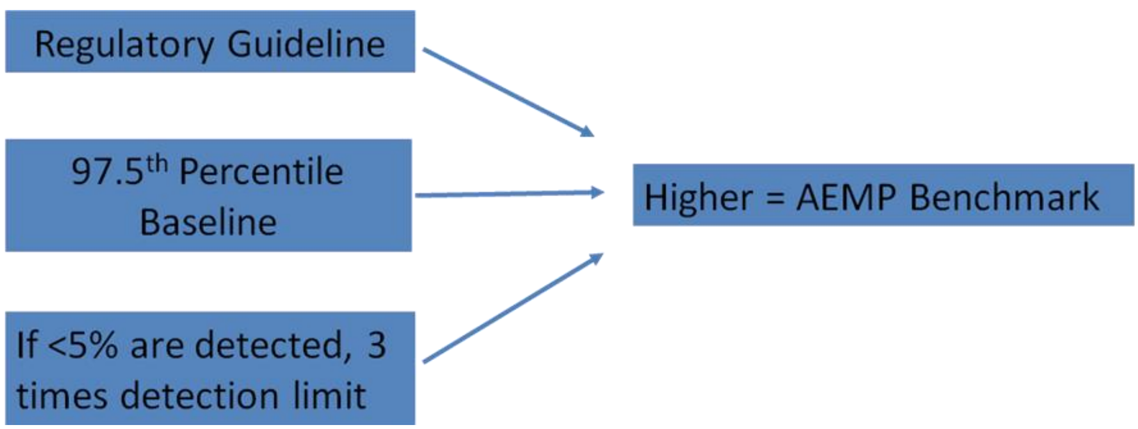


Figure 2-4 Approach for Selecting AEMP Benchmarks

For the AEMP benchmark, the 97.5th percentile was selected to represent the upper estimate "normal" or baseline concentration levels. Comparisons to the baseline range should be made in the overall exploratory data analysis stage (EDA) within Step 1 of the Assessment Approach and Response Framework (Section 5 of the AEMP; Baffinland, 2014), to provide added perspective on monitoring data. Based on the Assessment Approach and Response Framework established for Mary River Project, the 97.5thpercentile is considered to represent a reasonable Interim AEMP benchmark, when coupled with other Exploratory Data Analysis aspects of Step 1 of the framework, and the Low Action management responses, which occur if change is detected in Step 1, and the monitoring data are < AEMP benchmark (see AEMP main report; Figure 5.1).

Table 2-5 presents the 97.5th percentile of each metal/metalloid within each area (lake), compared to the relevant sediment quality guidelines and area-wide 95th and 97.5th percentile calculations. As noted in Table 2-5, the Tributaries of Sheardown Lake appear to have some of the higher 97.5th percentile values, which suggest some potential influence, or natural enrichment in this area. Data are too limited to conduct a temporal analysis of concentrations. In light of the elevations within this lake, area-wide calculations (95th and 97.5thpercentiles) are presented in Table 2-5 without the data from Tributaries of Sheardown Lake.

Proposed area-wide Interim AEMP benchmarks are also presented in Table 2-5, based on the higher of either 97.5th percentile of baseline, or sediment quality guidelines. In the case of Hg, Pb and Zn, the selected benchmark is the sediment quality guideline, as area-wide data were less than or equal to this value. The selection of the guideline at this time for these substances appears reasonable. Further sediment characterization in area lakes in 2014 may result in changes to this decision. In the case of As, Cr, Cu, Fe, Mn, Ni and P, the suggested area-wide Interim AEMP benchmark is the 97.5th percentile of baseline. The use of the area-wide percentiles as an interim benchmark appears reasonable, based on comparisons to both the existing guidelines, and characterization data for the lakes. As discussed earlier, further data collection will assist in better understanding baseline within the lakes, and will assist in final AEMP benchmark development. With respect to the temporal analysis conducted for Sheardown Lake NW, Cr, Cu, and Ni showed some increased trends over time in this basin (see Figure 2-3). Based on the 97.5th percentile calculations presented in Table 2.5 for this basin, these trends are not considered to substantially influence the outcome of the recommended interim AEMP benchmark. This issue will be re-assessed with 2014 data, for final benchmark development. For Cd, the data are largely non-detect, at an MDL of 0.5 mg/kg. The ISQG is 0.6 mg/kg, and due to the close proximity of the MDL to the ISQG, the 3 times MDL approach was applied for AEMP benchmark development.

Based on this analysis of the available data, the following are recommended:

- Additional sediment sampling should be conducted in all lakes (including Sheardown Lake NW), focusing on depositional areas, as per the analysis outlined in the CREMP to gather more data to characterize baseline prior to commencement of mining operations;
- 2014 data will be evaluated for temporal trends, and to determine whether lakes can be aggregated for some or all metals of interest with respect to AEMP benchmark development.

Final AEMP benchmarks will be established following analysis of the 2014 data.

Table 2-5 Comparison of Area-Specific Baseline Calculations to Overall Baseline Calculations, and Relevant Sediment Quality Guidelines (97.5th percentiles, by Area) (mg/kg; dw)

Jurisdiction, Type of Guideline and Statistical Metric		***Hg***	***As***	***Cd***	***Cr***	***Cu***	***Fe***	***Mn***	***Ni***	***P***	***Pb***	***Zn***
CCME (2014)	**ISQG**	0.17	5.9	0.6	37.3	35.7	NGA	NGA	NGA	NGA	35	123
	PEL	0.486	17	3.5	90	197	NGA	NGA	NGA	NGA	91.3	315
Ontario (OMOE, 2008)	**LEL**	0.2	6	0.6	26	16	20000	460	16	600	31	120
	SEL	2	33	10	110	110	40000	1100	75	2000	250	820
US EPA (2014)	**Screening**	0.18	9.8	0.99	43.4	31.6	20000	460	22	NGA	35.8	121
97.5th%iles of Each Lake Area (sample size)												
Tributaries of Sheardown Lake (5)		0.1	2.95	1.9	118	106	28,370	809	115	295	52	171
Mary Lake (6)		0.1	4.95	0.5	97	38	51,463	4,305	61	1580	28	103
Camp Lake (9)		0.1	4	0.5	83	50	40,920	1,057	74	1480	23	69
Sheardown Lake NW (25)		0.1	7.95	0.5	96	60	56,240	5,612	81	2310	24	92
Sheardown Lake SE (6)		0.1	2.0	0.9	80	32	32,988	547	66	1278	18	57
95th%ile of Area-Wide Data (47)[a]		NC	5.2	0.5	93	56	50,430	3,874	76	1565	24	91
97.5th %ile of Area-Wide Data (47)[a]		NC	6.2	0.5	97	58	52,200	4,530	77	1958	24	94
Proposed Interim AEMP Benchmark		**0.17[A]**	**6.2[B]**	**1.5[C]**	**97[B]**	**58[B]**	**52,200[B]**	**4,530[B]**	**77[B]**	**1958[B]**	**35[A]**	**123[A]**

Notes:

NC = not calculated as all values < MDL

[a =] Tributaries of Sheardown Lake data are not included in interim benchmark development due to elevated results in this area.

A = guideline is based on sediment quality guideline

B = guideline is based on 97.5th%ile of baseline data

C= guideline is based on 3 times MDL, the 97.5th%ile is equal to the MDL

Mercury was not detected in any samples; mercury detection limit is used to represent the 95th and 97.5th percentiles.

C- 3.0 SURFACE WATER EVALUATION AND BENCHMARK DEVELOPMENT

C-3.1 Selection of Substances for Benchmark Development: Lake Water and River/Streams

Based on the baseline data collected between 2005 and 2013, and the outcomes of the FEIS, substances having the potential to be either naturally elevated in the environment, or elevated as a result of future mine site activities in lake water were identified (see Table 3-1). In addition, metals regulated or which may be potentially regulated under MMER for base metal mines (as a result of the current re-evaluation of the MMER regulations) also were identified in Table 3-1. Any metal which was identified as being either naturally enriched, potentially elevated due to mine site released or regulated / potentially regulated under MMER were selected for benchmark development. The metals for which benchmarks will be developed in area surface waters are highlighted in Table 3-1.

In addition to metals, and regulated parameters, other substances, such as nutrients, major ions and conventional parameters are also important to include in benchmark development. Table 3-2 presents some of the nutrients, ions and conventional parameters for which analytical data are available and identifies those carried forward for benchmark development. In some cases, development of benchmarks was not considered necessary, and where appropriate, exploratory data analysis of the parameter is being recommended to assess trends, relative to baseline or reference. If change is noted in these parameters, benchmarks will be developed accordingly. All substances with AEMP benchmarks will also undergo exploratory data analysis (including statistical analysis) as part of the Assessment Approach and Monitoring Framework (AEMP main report Figure 5.1).

Table 3-1 Identification of Metals/Metalloids Naturally Elevated in Area Water, Regulated under MMER and/or Potentially Elevated as a Result of Facility Releases or Having Existing Water Quality Guidelines under CCME

Substance	*Naturally Enriched in Area, Relative to WQG*[a]	*Regulated or Potential to be Regulated Under MMER*	*Potential to be Elevated Due to Mine Site Releases* [a]	*CCME PAL?*
Aluminum	Yes	Potential	Yes [b]	Yes
Antimony	No	No	No	No
Arsenic	No	Yes	Yes	Yes
Barium	No	No	No	No
Beryllium	No	No	No	No
Bismuth	No	No	No	No
Boron	No	No	No	Yes
Cadmium	No	No	Yes [b]	Yes
Calcium	No	No	No	No
Chromium	Yes	No	Yes	Yes
Cobalt	No	No	Yes	No
Copper	Yes	Yes	Yes [b]	Yes
Iron	Yes	Potential	Yes	Yes
Lead	No	Yes	Yes [b]	Yes
Lithium	No	No	No	No
Manganese	No	No	No	No
Magnesium	No	No	No	No
Mercury[e]	No	Fish tissue only	No [c]	Yes
Molybdenum	No	No	No	Yes
Nickel	No	Yes	No	Yes
Phosphorus [d]	No	No	Yes	Yes [d]
Potassium	No	No	No	No
Selenium[e]	No	Potential	No [c]	Yes
Silver	No	No	Yes	Yes
Sodium	No	No	No	No
Strontium	No	No	No	No
Thallium	No	No	Yes [b]	Yes
Tin	No	No	No	No

Table 3-1	**Identification of Metals/Metalloids Naturally Elevated in Area Water, Regulated under MMER and/or Potentially Elevated as a Result of Facility Releases or Having Existing Water Quality Guidelines under CCME**			
Substance	***Naturally Enriched in Area, Relative to WQG[a]***	***Regulated or Potential to be Regulated Under MMER***	***Potential to be Elevated Due to Mine Site Releases [a]***	***CCME PAL?***
Titanium	No	No	No	No
Uranium[e]	No	No	No	Yes
Vanadium	No	No	Yes [b]	Yes
Zinc	No	Yes	Yes	Yes

Notes:
Bolded cell = indicates chemicals was identified as being either naturally enriched, potentially elevated due to mine site released and / or regulated / potentially regulated under MMER, or there was a CCME freshwater quality guideline available
Shaded cell **=** indicates chemicals was carried forward for benchmark development
WQG = water quality guideline; CCME PAL = Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines for the Protection of Aquatic Life
a. Determination based on Final FEIS, Volume 7; re-screened such that metals > 0.5 Hazard Quotient are listed above
b. These metals could potentially become elevated in receiving environments if dusting events were significant, as a result of dust runoff into aquatic receiving environments, based on Final FEIS, Volume 7. Therefore, these metals are included as potential Chemicals of Potential Concern (COPCs) requiring benchmark development.
c. The FEIS had identified potentially elevated mercury and selenium in both the baseline water quality and geochemical source terms attributable to laboratory detection limits. Subsequent testing of both metals at lower detection limits has confirmed that these metals are not expected to be elevated in either the baseline or in the mine effluent.
d. Total Phosphorus is inconsistent in area water courses, and hence, an alternative benchmark approach was developed (related to chlorophyll a) to evaluate potential for nutrient enrichment (see CREMP report)
e Mercury, selenium and uranium are not considered to become potentially elevated as a result of mine site releases, and therefore have not been included for AEMP benchmark development. Mercury will be monitored in mine effluent as part of the EEM Program, and a fish tissue study can be triggered under Part 2, Section 9c of the MMER if mercury in the effluent is found to exceed 0.1 µg/L.

Table 3-2 Selection of General Parameters and Nutrients for Benchmark Development or Exploratory Data Analysis				
General Parameters and Nutrients	***CCME PAL?***	***Included for Benchmark Development***	***Included for Exploratory Data Analysis***	***Comments***
pH	Yes	No	Yes	Exposure Toxicity Modifying Factor
Dissolved oxygen	Yes	No	Yes	
Conductivity	No	No	No	
Turbidity	Yes	No	Yes	
Hardness	No	No	Yes	Exposure Toxicity Modifying Factor
Total Dissolved Solids	No	No	Yes	TDS will be evaluated for statistical change
Total Suspended Solids (TSS)	Yes	No	Yes	TSS is considered to be a potential concern if storm water management is not implemented. It is carried forward for exploratory data analysis in light of this concern
Alkalinity	No	No	Yes	Exposure Toxicity Modifying Factor
Bromide (Br-)	No	No	No	
Chloride (Cl-)	Yes	Yes	Yes	Some chloride release has occurred related to exploration drilling activities (near stream environments), therefore it is being included for benchmark development
Sulphate (SO_4^{2-})	No	Yes	Yes	Can be associated with mining activities; recent BC MOE guideline available for sulphate (Meays and Nordin, 2013)
Ammonia (NH_3+NH_4^+)	Yes	Yes	Yes	Can be associated with mining activities; benchmark available
Nitrite (NO_2^-)	Yes	Yes	Yes	Can be associated with mining activities; benchmark available
Nitrate (NO_3^-)	Yes	Yes	Yes	Can be associated with mining activities; benchmark available
Magnesium	No	No	Yes	Associated with hardness and TDS; will be monitored for change
Phosphorus	Yes	No	Yes	Due to variability in natural waters, phosphorus will be included for Exploratory data Analysis; monitoring for eutrophication will be done using Chlorophyll a.
Potassium	No	No	Yes	
Total Organic Carbon (TOC)	No	No	Yes	Exposure Toxicity Modifying Factor
Dissolved Organic Carbon (DOC)	No	No	Yes	Exposure Toxicity Modifying Factor

Table 3-2 Selection of General Parameters and Nutrients for Benchmark Development or Exploratory Data Analysis				
General Parameters and Nutrients	***CCME PAL?***	***Included for Benchmark Development***	***Included for Exploratory Data Analysis***	***Comments***
Total Kjeldahl Nitrogen (TKN)	No	No	No	Assessment of monitoring data for Total ammonia, nitrite, nitrate and Chlorophyll a should provide adequate evaluation tools
Phenols	Yes	No	No	Not anticipated to be associated with facility releases

Notes:
Bolded text = selected for Exploratory Data Analysis only
Shaded text = selected for benchmark development (which will also include Exploratory Data Analysis as part of the Assessment Framework)

Based on the review of the metals, nutrients and general parameters selected for evaluation are provided in Table 3-3.

Table 3-3 List of Metals, Nutrients and Other Parameters Selected for Benchmark Development or Exploratory Data Analysis

Selected For Benchmark Development		***Selected for Exploratory Data Analysis***
Aluminum	Vanadium	pH
Arsenic	Zinc	Hardness
Cadmium		Total Dissolved Solids
Chromium		Total Suspended Solids (TSS)/Turbidity
Copper		Alkalinity
Cobalt	Ammonia (NH_3+NH_4)	Magnesium
Iron	Chloride	Phosphorus
Lead	Nitrite (NO_2^-)	Potassium
Nickel	Nitrate (NO3-)	Total Organic Carbon (TOC)
Silver	Sulphate	Dissolved Organic Carbon (DOC)
Thallium		Dissolved oxygen

Metals/non-metals and other key parameters not selected for benchmark develop will still undergo some degree of trend analysis within Step 1 of the Exploratory Data Analysis. If increasing trends are noticed, benchmark development will be undertaken.

C-3.2 Baseline Surface Water Data Evaluation for Determining AEMP Benchmarks

Baseline water quality data were received from Knight Piésold. Data treatment conducted in the Baseline Integrity Review (Knight Piésold, 2014) involved the following steps:

- Removing all duplicate samples, to avoid “double counting” of data;
- All samples which were non-detect were assumed to equal the detection limit for statistical calculations; and
- Where detection limits were elevated compared to later sampling events, they were substituted with lower detection limits (see Baseline Integrity Report; Knight Piésold, 2014).

Following completion of the data treatment steps present above, a detailed assessment of surface water quality was undertaken (CREMP Main Report and Appendix B; Knight Piésold, 2014). This detailed assessment included Camp Lake, Mary Lake and Sheardown Lake NW in addition to Mary River and Camp Lake Tributary. For Sheardown Lake, Knight Piésold (2014) focused their evaluation on the northwest basin since it is the closest to project activities, its tributary is important to juvenile char and it has been the most studied mainly due to treated sewage effluent discharges. The following sections provide a summary of trends observed in lakes and rivers, respectively in addition to how the data were treated for AMEP benchmark development.

C-3.2.1 Area Lakes (Camp Lake, Mary Lake, Sheardown Lake)

General water quality parameters in Camp Lake, Mary Lake and Sheardown Lake NW and SE were reported to be similar with all lakes being slightly alkaline (median pH values >7.5) and soft, with hardness being mainly carbonate hardness. A summary of the trends observed in Camp Lake, Mary Lake and Sheardown Lake NW and SE by Knight Piésold is provided in Table 3-4. For additional details, please refer to the CREMP Main Report and Appendix B (Knight Piésold, 2014).

Table 3-4 Summary of Trend Analysis of Area Lakes (Knight Piésold, 2014)

Trend	*Lakes*			
	Camp Lake	*Mary Lake*	*Sheardown Lake NW*	*Sheardown Lake SE*
Distinct depth trends	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate	Al slightly elevated in deeper samples, suggest lake completely mixed; aggregation of depth and shallow sites appropriate for all parameters except Al	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate
Geographic trends between discrete sampling sites	Not observed	Slightly elevated concentrations of Al, Cl, Cu, Cr, Fe, hardness and Ni observed at inlet; elevated As concentrations observed at outlet	Little variability	Cu, Fe and Ni (slightly elevated concentrations at DL0-02-4)
Distinct inter annual trends	Chloride and Cr (2011 to 2013 concentrations elevated compared early data)	Fe (2013 data slightly lower concentration than previous years) , Cd (detection limits decreased over course of sampling), Ni (elevated during 2007 winter)	Cd and Fe (decrease in detection limits over years)	Cu and Ni (early data from 2007-2008 elevated compared to more recent data)
Parameters consistently below MDL	As, Cd, nitrate,	As (except for outlet sites), Cd, nitrate,	As, Cd, Cl, nitrate, Fe	As, Cd, nitrate
Elevated parameters	Cu (outliers)	Al, Cu, Cr	Cu	Al, Cu
Parameters do not show seasonal trends	Cl, Cd, As, Fe, nitrate	Cd, Cu, Cr, nitrate	As, Cd, Cl, Cr, Cu, nitrate, Fe	As, Cd, nitrate, Cr and Cu.

Table 3-4 Summary of Trend Analysis of Area Lakes (Knight Piésold, 2014)				
Trend	***Lakes***			
	Camp Lake	***Mary Lake***	***Sheardown Lake NW***	***Sheardown Lake SE***
Parameters with maximum concentrations during summer	Al, nitrate	Al, Fe		Al (and fall), Fe
Parameters with maximum concentrations during fall	Cr	As	Al	
Parameters with maximum concentrations during spring	No sampling	No sampling	No sampling	No sampling
Parameters with maximum concentrations during winter	Cu (and summer), Ni (and summer)	Cl, Ni, Cd	Ni	Cl, Ni

As reported in Table 3-4, with the exception of aluminum in Sheardown Lake NW, distinct depth trends were not observed for Camp Lake, Mary Lake or Sheardown Lake SE and lakes were considered to be completely mixed (Knight Piésold, 2014). This implies that combining the shallow and deep datasets would be appropriate (with the exception of aluminum in Sheardown Lake), except that it constitutes pseudoreplication, since the shallow and deep samples were collected on the same day at the same site. In light of this, Knight Piésold ran a small statistical simulation in order to assess the effects of possible pseudoreplication on the estimation of the standard deviation and 95th percentile.

The statistical model assumes the data is generated in 2 steps:

1) Sample data from a normal distribution with a mean of zero and standard deviation of 1: x
2) Add replication error by adding a random error from a normal distribution with mean 0 and standard deviation of 0.1: y = x + e

In order to consider the data with and without pseudoreplicates, two datasets were created:

1) No pseudo replicates (sample size = n)
2) 3 pseudoreplicates (sample size = 3*n)

In order to test the effects of pseudoreplication, the possible effects of adding both the deep and shallow data on the calculation of standard deviation and the empirical 95th percentile were investigated. The 95th percentile indicates the value below which 95% of the observations in a group occur. Empirical 95th percentiles are indicates the value below which 95% of the observations in a group occur and is calculated using the actual recorded data. Table 1 indicates that the effects of pseudoreplication are small, even at small sample sizes; however, the empirical

95th percentile calculation has some drift with respect to the expected outcome (1.653) at small sample sizes.

Table 3-5 Statistical Model Results indicating effects of Pseudoreplication

Sample Size	*Data*	*Mean*	*Standard Deviation*	*Empirical 95th Percentile*
5	No pseudoreplicates	-0.00715	0.946	1.00
	Pseudoreplicates	-0.00787	0.877	1.2
10	No pseudoreplicates	-0.017	0.98	1.26
	Pseudoreplicates	-0.017	0.94	1.50
25	No pseudoreplicates	0.0067	0.99	1.65
	Pseudoreplicates	0.0056	0.98	1.62
100	No pseudoreplicates	0.0018	1.00	1.60
	Pseudoreplicates	0.0017	1.00	1.63

Note:
1. Based on 1000 simulations.
2. Mean should equal 0 and 95th percentile for normal distribution should equal 1.653

As such, surface and deep water samples for the lakes were combined for determining the AEMP benchmarks, for all lakes and chemicals with the exception of aluminum in Sheardown Lake, which was evaluated separately for surface and deep samples.

The number of water samples collected per year (shallow and deep combined) for each lake is provided in Table 3-6. In addition to Sheardown Lake NW, sample numbers are included for both Sheardown Lake SE and the Sheardown Lake near shore sampling programs, as these samples characterize the SE basin, and nearshore areas of the lakes.

Table 3-6 Number of Water Samples Collected in Area Lakes by Year

Year	*Camp Lake*	*Mary Lake*	*Sheardown Lake NW*	*Sheardown Lake SE*	*Sheardown Lake Near Shore*
2006	3	8	4	4	0
2007	18	24	26	16	0
2008	8	12	22	14	18
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	4	4	20	2	12
2012	6	2	16	4	4
2013	13	21	23	6	8
Total	52	71	111	46	42

Note: not all parameters or chemicals were analyzed for in each sample and as such, total number of samples for a specific parameter or chemical may be less than the values presented here

As can be seen in Tables 3-6, there are a reasonable number of samples obtained from each of the area lakes. As such, Camp Lake, Mary Lake and Sheardown Lake were evaluated separately for the purpose of AEMP development.

To determine if data for Sheardown Lake NW, SE and near shore could be combined, a comparison of select total and dissolved metal concentrations between the various Sheardown Lake sampling locations was conducted. The box and whisker plots in Figures 3-1 and 3-2 respectively show the comparisons of total and dissolved metal concentrations between various Sheardown Lake sampling locations (*i.e.*, nearshore, northwest and southeast). In the box and whisker plots, non-detectable values were replaced with detection limits.

Based on the comparisons in Figures 3-1 and 3-2, it was determined that the data for the various areas of Sheardown Lake were similar enough that they could be combined and assessed as a single water body.

Therefore for the purpose of AEMP benchmark development, Camp Lake, Mary Lake and Sheardown Lake (near shore, northwest and southeast data combined) were evaluated separately.

A summary of data for Camp Lake, Mary Lake and Sheardown Lake are provided in Tables 3-7 to 3-9 respectively.

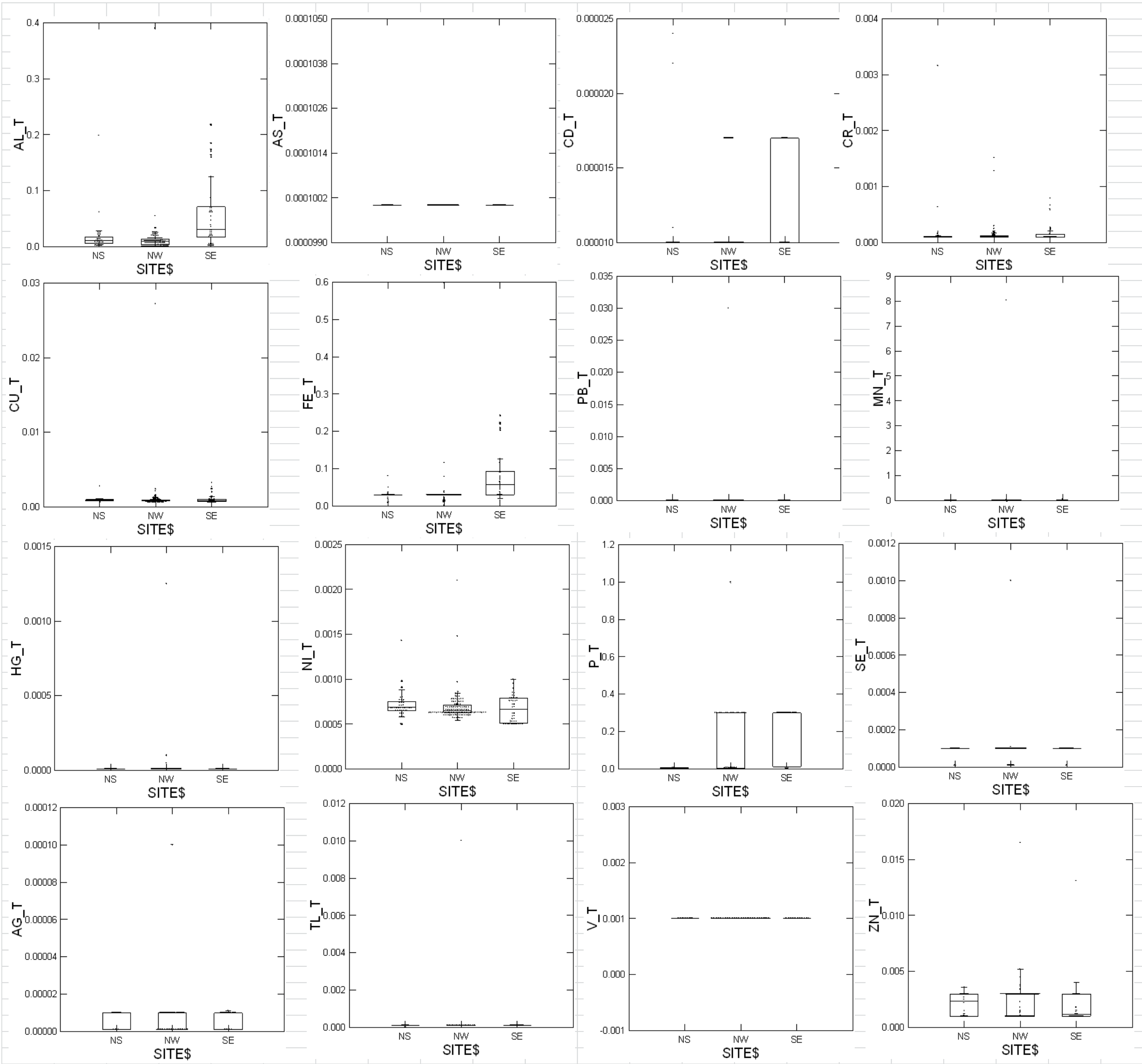


Figure 3-1 Total Metals (mg/L) Compared Between Various Sheardown Lake Sampling Locations (Nearshore (NS), Northwest (NW) and Southeast (SE)); T = total; Non-detectable values replaced with detection limit

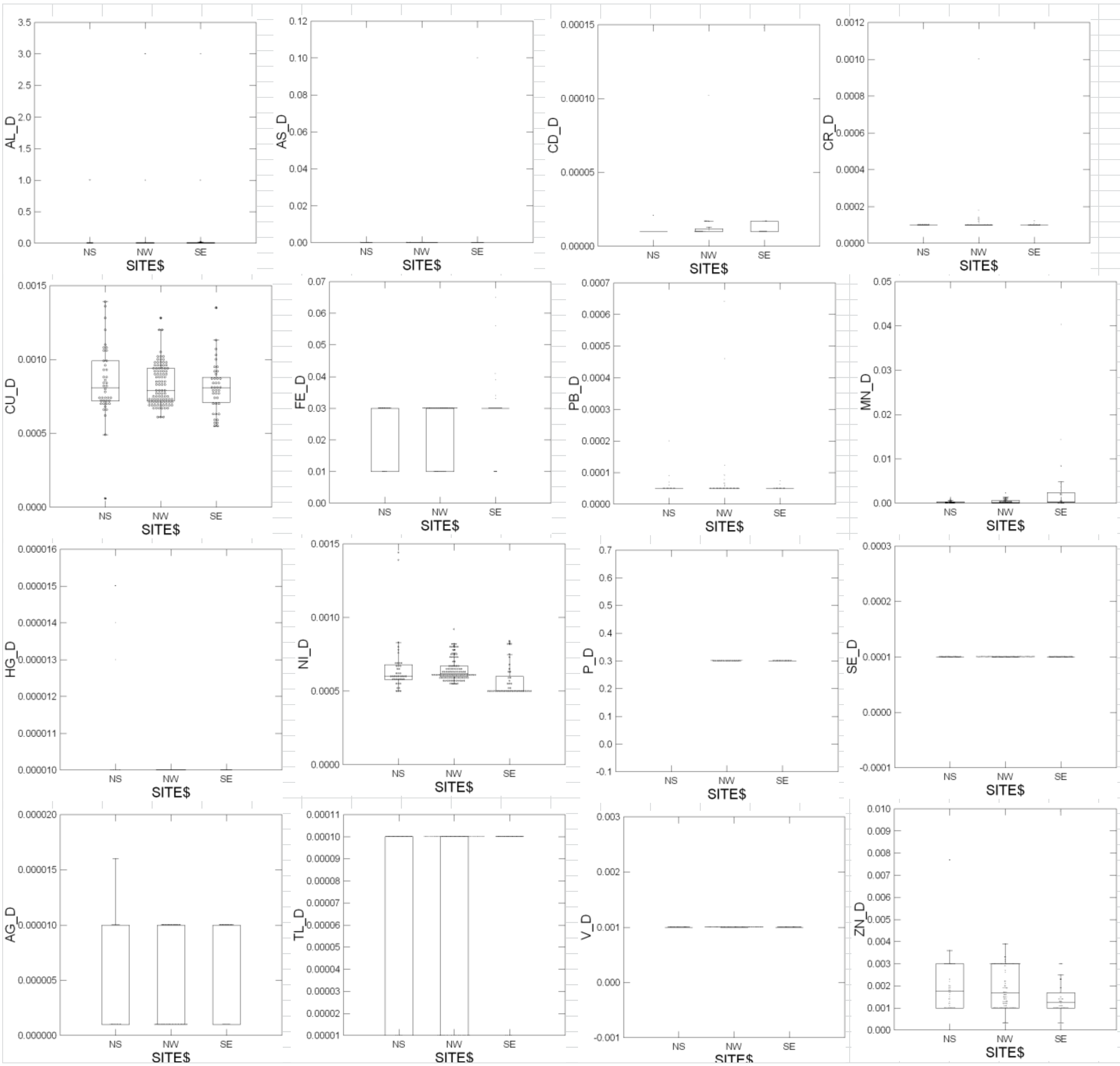


Figure 3-2 Dissolved Metals (mg/L) Compared Between Various Sheardown Lake Sampling Locations (Nearshore (NS), Northwest (NW) and Southeast (SE)); D = Dissolved; Non-detectable values replaced with detection limit

Table 3-7 Summary of Camp Lake Surface Water Analytical Data (Total Metals; 2006 to 2013)

Parameter	*Units*	*N*	*% Detect*	*Min*[b]	*Max*[c]	*Median*[d]	*95^{th} %ILE*[d]	*97.5^{th} %ILE*[d]	*Mean*[d]
Metals[a]									
Aluminium	mg/L	52	92	<0.001	0.0379	0.00615	0.0192	0.0260	0.00801
Arsenic	mg/L	52	0[e]	<0.0001	<0.0001	NC	NC	NC	NC
Cadmium	mg/L	52	4[e]	<0.00001	0.000042	NC	NC	NC	NC
Chromium	mg/L	52	4[e]	<0.0001	0.00014[g]	NC	NC	NC	NC
Chromium $^{+3}$	mg/L	19	0[e]	<0.001	<0.005	NC	NC	NC	NC
Chromium $^{+6}$	mg/L	15	0[e]	<0.001	<0.005	NC	NC	NC	NC
Cobalt	mg/L	52	0[e]	<0.0001	<0.0002	NC	NC	NC	NC
Copper	mg/L	49	100	0.00072	0.019	0.00092	0.00389	0.0113	0.00169
Iron	mg/L	52	23	<0.003	0.057	0.03	0.0343	0.0421	0.0238
Lead	mg/L	49	20	<0.00005	0.000429	0.00005	0.0002	0.000334	0.000074
Nickel	mg/L	49	100	0.00054	0.00114	0.00066	0.00081	0.000914	0.000672
Silver	mg/L	52	0[e]	<0.000001	<0.00001	NC	NC	NC	NC
Thallium	mg/L	49	0[e]	<0.000001	<0.0001	NC	NC	NC	NC
Vanadium	mg/L	52	0[e]	<0.001	<0.001	NC	NC	NC	NC
Zinc	mg/L	49	18	<0.001	0.0049	0.003	0.0032	0.0037	0.0022
Water Quality Parameters									
Chloride (Cl^-)	mg/L	52	27	<1	4	1	4	4	2.02
Ammonia (NH^3+NH^4)	mg N/L	52	92	<0.02	1.41	0.02	0.560	0.84	0.101
Nitrite (NO_2^-)	mg N/L	52	12	<0.002	0.012[e]	0.005	0.1	0.1	0.012
Nitrate (NO_3)	mg N/L	52	0[e]	<0.1	<0.1	NC	NC	NC	NC
Sulphate (SO_4^{2-})	mg/L	52	62	<1	3[e]	2	3	3	2.0
Major Toxicity Modifying Factors for Guideline Development									
pH	-	52	NA	6.8	8.3	7.5	8.3	8.3	7.6
Hardness	mg/L[f]	52	NA	50	77.1	59.7	69.5	73.4	59.4
Temperature	^oC	36	NA	0.9	9.0	7.1	8.7	8.9	6.2

Notes:
NC = not calculated; NA = not applicable; %ILE = percentile
a. Total metals unless otherwise noted
b. Minimum values is the lowest of all detected values or the lowest detection limit, whichever is less
c. Maximum values is the maximum detected value or, if no detected values were reported, indicates the maximum detection limit reported
d. For calculation of these summary statistics, non-detect values were replaced with the value of the detection limit
e. Less than 5% of samples were detected, therefore a median, 95^{th} percentile, 97^{th} percentile and mean were not calculated
f. mg/L as $CaCO_3$

Table 3-7	**Summary of Camp Lake Surface Water Analytical Data (Total Metals; 2006 to 2013)**								
Parameter	***Units***	***N***	***% Detect***	***Min***[b]	***Max***[c]	***Median***[d]	***95th %ILE***[d]	***97.5th %ILE***[d]	***Mean***[d]

g. Maximum detected value is less than highest detection limit. Maximum value selected is the highest detected value.

Parameter	Units	N	% Detect	Min[b]	Max[c]	Median[d]	95th %ILE[d]	97.5th %ILE[d]	Mean[d]
Table 3-8 Summary of Mary Lake Surface Water Analytical Data (Total Metals; 2006 to 2013)									
Metals [a]									
Aluminium	mg/L	71	100	0.00284	0.191	0.0387	0.114	0.137	0.0473
Arsenic	mg/L	71	10	0.0001	0.00039	0.0001	0.00015	0.000178	0.000109
Cadmium	mg/L	71	6	<0.00001	0.00024	0.00001	0.000017	0.000023	0.000016
Chromium	mg/L	71	25	0.00012[g]	0.00043[h]	0.0005	0.001	0.001	0.00047
Chromium $^{+3}$	mg/L	20	10	<0.005	0.005	0.005	0.005	0.005	0.005
Chromium $^{+6}$	mg/L	21	10	<0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	71	3[e]	<0.0001	0.0001[h]	NC	NC	NC	NC
Copper	mg/L	65	100	0.00054	0.00429	0.00079	0.00147	0.00239	0.000949
Iron	mg/L	71	82	<0.01	0.25	0.052	0.135	0.173	0.0619
Lead	mg/L	63	73	<0.00005	0.000149	0.00006	0.00013	0.00013	0.000068
Nickel	mg/L	63	51	<0.0005	0.0009	0.0005	0.00077	0.00080	0.00055
Silver	mg/L	69	3[e]	<0.000001	0.000001[h]	NC	NC	NC	NC
Thallium	mg/L	63	3[e]	<0.000001	0.000001[h]	NC	NC	NC	NC
Vanadium	mg/L	71	11	<0.001	0.0035	0.001	0.001	0.00146	0.00105
Zinc	mg/L	63	14	<0.001	0.003	0.0015	0.003	0.003	0.0020
Water Quality Parameters									
Chloride (Cl^-)	mg/L	71	65	<1	14	2	8	13	3.2
Ammonia (NH_3+NH_4)	mg N/L	71	97	<0.02	0.38	0.05	0.25	0.32	0.087
Nitrite (NO_2^-)	mg N/L	71	27	<0.002	0.1	0.005	0.055	0.1	0.0096
Nitrate (NO_3)	mg N/L	71	6	<0.1	0.14	0.1	0.1	0.11	0.10
Sulphate (SO_4^{2-})	mg/L	64	80	<1	8	3	5	7	2.7
Major Toxicity Modifying Factors for Guideline Development									
pH	-	71	NA	6.7	8.3	7.4	8.2	8.2	7.4
Hardness	mg/L[f]	71	NA	24.9	137	39.5	129	130.5	49.4
Temperature	°C	52	NA	0.6	14.1	7.4	12.9	13.6	6.9

Notes:
NC = not calculated; NA = not applicable; %ILE = percentile
a. Total metals unless otherwise noted
b. Minimum values is the lowest of all detected values or the lowest detection limit, whichever is less
c. Maximum values is the maximum detected value or, if no detected values were reported, indicates the maximum detection limit reported
d. For calculation of these summary statistics, non-detect values were replaced with the value of the detection limit
e. Less than 5% of samples were detected, therefore a median, 95th percentile, 97th percentile and mean were not calculated

Table 3-8	**Summary of Mary Lake Surface Water Analytical Data (Total Metals; 2006 to 2013)**								
Parameter	***Units***	***N***	***% Detect***	***Min***[b]	***Max***[c]	***Median***[d]	***95th %ILE***[d]	***97.5th %ILE***[d]	***Mean***[d]

f. mg/L as $CaCO_3$

g. Lowest detected value is less than the lowest non-detected value. Minimum value selected is the lowest detected value.

h. Maximum detected value is less than highest detection limit. Maximum value selected is the highest detected value.

Table 3-9 Summary of Sheardown Lake Surface Water Analytical Data (Total Metals; 2006 to 2013)									
Parameter	***Units***	***N***	***% Detect***	***Min***[b]	***Max***[c]	***Median*** [d]	***95th %ILE***[d]	***97.5th %ILE***[d]	***Mean*** [d]
Metals [a]									
Aluminium (Shallow)	mg/L	91	92	0.0012[g]	0.217	0.0092	0.0102	0.179	0.0223
Aluminum (Deep)	mg/L	90	91	0.001[g]	0.39	0.0134	0.146	0.173	0.030
Arsenic	mg/L	199	10	<0.0001	0.00012	0.0001	0.0001	0.0001	0.0001
Cadmium	mg/L	199	5	<0.00001	0.000024	0.00001	0.00002	0.000017	0.00001
Chromium	mg/L	199	31	<0.0001	0.00316	0.0001	0.0003	0.000641	0.0002
Chromium $^{+3}$	mg/L	47	4[e]	<0.001	0.005	NC	NC	NC	NC
Chromium $^{+6}$	mg/L	47	4[e]	<0.001	0.001	NC	NC	NC	NC
Cobalt	mg/L	199	10	<0.0001	0.00034	0.0001	0.0001	0.0002	0.0001
Copper	mg/L	187	98	0.00046 [g]	0.0272	0.0009	0.0016	0.00243	0.0011
Iron	mg/L	199	46	0.002 [g]	0.598	0.03	0.116	0.211	0.0437
Lead	mg/L	191	33	<0.00005	0.03	0.0001	0.0002	0.00026	0.0002
Nickel	mg/L	191	93	<0.0005	0.0021	0.0007	0.0009	0.000973	0.0007
Silver	mg/L	187	10	<0.000001	0.000011	0.00001	0.00001	0.0000104	0.000008
Thallium	mg/L	179	8	<0.000001	0.0001	0.000100	0.0001	0.0001	0.00012
Vanadium	mg/L	187	8	<0.001	0.001	0.001	0.001	0.001	0.001
Zinc	mg/L	179	26	<0.001	0.0165	0.0022	0.00322	0.00391	0.00220
Water Quality Parameters									
Chloride (Cl^-)	mg/L	202	98	<1	7	3	4	5	2.8
Ammonia (NH_3+NH_4)	mg N/L	201	45	<0.02	0.99	0.02	0.26	0.44	0.060
Nitrite (NO_2^-)	mg N/L	189	7	<0.002	0.009	0.005	0.1	0.1	0.014
Nitrate (NO_3)	mg N/L	201	1[e]	<0.1	0.18	NC	NC	NC	NC
Sulphate (SO_4^{2-})	mg/L	202	85	<1	5	3	4	5	2.7

Table 3-9 Summary of Sheardown Lake Surface Water Analytical Data (Total Metals; 2006 to 2013)									
Parameter	***Units***	***N***	***% Detect***	***Min***[b]	***Max***[c]	***Median***[d]	***95th %ILE***[d]	***97.5th %ILE***[d]	***Mean***[d]
Major Toxicity Modifying Factors for Guideline Development									
pH	-		NA	6.7	8.4	7.6	8.2	8.3	7.6
Hardness	mg/L [f]		NA	0.5	82.2	60.5	76.7	77.9	58.5
Temperature	^{o}C	142	NA	1.1	14.4	8.0	10.8	11.9	7.3

Notes:
NC = not calculated; NA = not applicable; %ILE = percentile
a. Total metals unless otherwise noted
b. Minimum values is the lowest of all detected values or the lowest detection limit, whichever is less
c. Maximum values is the maximum detected value or, if no detected values were reported, indicates the maximum detection limit reported
d. For calculation of these summary statistics, non-detect values were replaced with the value of the detection limit
e. Less than 5% of samples were detected, therefore a median, 95th percentile, 97th percentile and mean were not calculated
f. mg/L as $CaCO_3$
g. Lowest detected value is less than the lowest non-detected value. Minimum value selected is the lowest detected value.

C-3.2.2 Area Rivers (Mary River, Camp Lake Tributary)

Similar to the lakes, Mary River and the Camp Lake Tributary are slightly alkaline and are considered soft to moderately soft, with hardness being mainly carbonate hardness (Knight Piésold, 2014). The intense spring run-off acts to dilute seasonal input with lower metal concentration in spring and higher concentrations in summer. Nitrate, As and Cd concentrations are generally below the MDLs while chloride and Ni are generally above MDL but lower than guidelines. Mary River and the Camp Lake Tributary have slightly different trends for Al and Fe (Knight Piésold, 2014).

A summary of the trends observed in Mary River and the Camp Lake Tributary by Knight Piésold is provided in Table 3-10. For additional details, please refer to the CREMP Main Report and Appendix C (Knight Piésold, 2014). The number of water samples collected per year for Mary River and Camp Lake Tributary is provided in Table 3-11.

Table 3-10 Summary of Analysis of Area Rivers (Knight Piésold, 2014)

Trend	***Streams***	
	Mary River	***Camp Lake Tributary***
Distinct depth trends	NA	NA
Geographic trends between discrete sampling sites	Cl (slightly lower upstream concentrations);	Fe, Cl, Ni (slightly elevated concentrations at L2-03 compared to other sites); Cu (lower concentrations at L2-03).
Distinct inter annual trends	Nitrate (changes in MDL over time); Ni (early data elevated compared to more recent data)	Al (2012 and 2013 data slightly elevated compared to other years); Cr (2012 and 2013 data elevated compared to other years)
Parameters consistently below MDL	As, Cd, nitrate	As, Cd, nitrate
Elevated parameters	Al, Cu, Cr, Fe	Al (spring and summer outliers), Cu, Fe, Cr
Parameters do not show seasonal trends	As, Cd, nitrate (MDL interference, but outliers occur in the fall), Ni, Cr	Fe, Ni, Cr
Parameters with maximum concentrations during summer	Al, Cu (and fall), Fe	Cu (muted trend)
Parameters with maximum concentrations during fall	Cl	Cl
Parameters with maximum concentrations during spring		Al
Parameters with maximum concentrations during winter	No sampling	No sampling

Table 3-11 Number of Water Samples Collected in Area Rivers by Year		
Year	***Mary River***	***Camp Lake Tributary***
2005	15	11
2006	71	12
2007	80	14
2008	103	16
2009	35	0
2010	8	0
2011	16	6
2012	25	15
2013	26	15
Total	379	89

Note: not all parameters or chemicals were analyzed for in each sample and as such, total number of samples for a specific parameter or chemical may be less than the values presented

The samples numbers for Mary River and Camp Lake Tributary are sufficiently large such that these rivers were evaluated separately for the purpose of AEMP development. A summary of data for Mary River and Camp Lake Tributary are provided in Tables 3-12 to 3-13 respectively.

Table 3-12	**Summary of Mary River Surface Water Analytical Data (Total Metals; 2005 to 2013)**								
Parameter	***Units***	***N***	***% Detect***	***Min***[b]	***Max***[c]	***Median*** [d]	***95th %ILE***[d]	***97.5th %ILE***[d,i]	***Mean*** [d]
Metals [a]									
Aluminium	mg/L	381	100	0.0019	2.97	0.148	0.725	0.97	0.225
Arsenic	mg/L	381	7	<0.0001	0.00095	0.0001	0.00011	0.00013	0.0001
Cadmium	mg/L	381	8	<0.00001	0.00015	0.00001	0.000017	0.00002	0.00001
Chromium	mg/L	380	38	<0.0001	0.054	0.0001	0.002	0.0023	0.0007
Chromium $^{+3}$	mg/L	63	6	<0.001	0.003[h]	0.005	0.005	0.005	0.0041
Chromium $^{+6}$	mg/L	51	2	<0.0001	0.0015[h]	NC[e]	NC	NC	NC
Cobalt	mg/L	376	24	<0.0001	0.0006	0.0002	0.00031	0.0004	0.00018
Copper	mg/L	270	97	0.00023[g]	0.0044	0.0010	0.0022	0.0024	0.0012
Iron	mg/L	381	90	<0.01	2.2	0.14	0.64	0.874	0.213
Lead	mg/L	223	78	<0.00005	0.0013	0.00016	0.00056	0.00076	0.0002
Nickel	mg/L	211	69	<0.0005	0.0026	0.00063	0.0015	0.0018	0.00078
Silver	mg/L	376	6	<0.000001	0.0004	0.00001	0.0001	0.0001	0.000044
Thallium	mg/L	279	6	<0.000001	0.0002	0.0001	0.0002	0.0002	0.00009
Vanadium	mg/L	376	14	<0.0009	0.0035	0.001	0.0016	0.002	0.0011
Zinc	mg/L	236	44	<0.00033	0.0167	0.0028	0.01	0.01	0.003
Water Quality Parameters									
Chloride (Cl^-)	mg/L	350	74	0.3[g]	73	4	18	21.55	6.14
Ammonia (NH^3+NH^4)	mg N/L	330	44	<0.02	1.03	0.02	0.40	0.60	0.07
Nitrite (NO_2^-)	mg N/L	330	31	<0.002	0.05[h]	0.005	0.06	0.06	0.01
Nitrate (NO_3)	mg N/L	387	7	<0.05	0.36	0.1	0.11	0.14	0.102
Sulphate (SO_4^{2-})	mg/L	336	65	<0.05	9	3	6.2	8	3.1
Major Toxicity Modifying Factors for Guideline Development									
pH	-	339	NA	6.26	8.57	7.86	8.25	8.35	7.77
Hardness	mg/L [f]	374	NA	4.4	891	52.2	108.7	121.4	57.41
Temperature	^oC	338	NA	-0.1	17.07	6.05	13.36	14.12	5.91

Notes:
NC = not calculated; NA = not applicable; %ILE = percentile
a. Total metals unless otherwise noted
b. Minimum values is the lowest of all detected values or the lowest detection limit, whichever is less
c. Maximum values is the maximum detected value or, if no detected values were reported, indicates the maximum detection limit reported
d. For calculation of these summary statistics, non-detect values were replaced with the value of the detection limit
e. Less than 5% of samples were detected, therefore a median, 95th percentile, 97th percentile and mean were not calculated
f. mg/L as $CaCO_3$
g. Lowest detected value is less than the lowest non-detected value. Minimum value selected is the lowest detected value.
h. Maximum detected value is less than highest detection limit. Maximum value selected is the highest detected value.
i. One sample (outlier) containing chemical concentrations orders of magnitude above other values was not included in the calculations for Mary River.

Table 3-13 Summary of Camp Lake Tributary Surface Water Analytical Data (Total Metals; 2005 to 2013)

Parameter	*Units*	*N*	*% Detect*	*Min*[b]	*Max*[c]	*Median*[d]	*95th %ILE*[d]	*97.5th %ILE*[d]	*Mean*[d]
Metals [a]									
Aluminum	mg/L	88	90	<0.004	0.252	0.01	0.106	0.179	0.0247
Arsenic	mg/L	88	6	<0.0001	0.00554	0.0001	0.0001	0.00012	0.00016
Cadmium	mg/L	88	1[e]	<0.00001	0.000096[h]	NC	NC	NC	NC
Chromium	mg/L	88	36	0.000022[g]	0.003	0.0001	0.000699	0.000856	0.00020
Chromium +3	mg/L	30	0	<0.005	<0.005	NC	NC	NC	NC
Chromium +6	mg/L	30	0	<0.001	<0.001	NC	NC	NC	NC
Cobalt	mg/L	87	2	<0.0001	0.00013[h]	NC	NC	NC	NC
Copper	mg/L	85	95	<0.00001	0.00359	0.0016	0.00204	0.00222	0.00152
Iron	mg/L	88	75	<0.0001	0.44	0.05	0.190	0.326	0.0684
Lead	mg/L	56	20	<0.00005	0.00025[h]	0.00005	0.000268	0.000333	0.000094
Nickel	mg/L	52	75	0.000202[g]	0.00265	0.00077	0.00131	0.00168	0.00085
Silver	mg/L	87	0	<0.000001	<0.00001	NC	NC	NC	NC
Thallium	mg/L	71	14	<0.000001	0.00909	0.0001	0.0002	0.0002	0.00021
Vanadium	mg/L	86	1	<0.0009	0.001[h]	NC	NC	NC	NC
Zinc	mg/L	61	21	<0.00033	0.0104	0.003	0.0032	0.0035	0.00240
Water Quality Parameters									
Chloride (Cl^-)	mg/L	89	100	0.2[g]	121	2	17.8	23	6.06
Ammonia (NH^3+NH^4)	mg N/L	86	52	<0.02	0.8	0.02	0.475	0.60	0.087
Nitrite (NO_2^-)	mg N/L	86	15	0.002[g]	0.014[h]	0.005	0.06	0.095	0.015
Nitrate (NO_3)	mg N/L	89	9	<0.05	0.18	0.1	0.106	0.118	0.0961
Sulphate (SO_4^{2-})	mg/L	88	73	<0.5	8	3	5.7	6	2.8
Major Toxicity Modifying Factors for Guideline Development									
pH	-	84	NA	4.94	8.71	7.88	8.42	8.52	7.80
Hardness	mg/L [f]	87	NA	0.003	317	73.7	133.8	140	76.16
Temperature	^{o}C	85	NA	-0.17	17.81	6.05	14.15	17.33	6.52

Notes:
NC = not calculated; NA = not applicable; %ILE = percentile
a. Total metals unless otherwise noted
b. Minimum values is the lowest of all detected values or the lowest detection limit, whichever is less
c. Maximum values is the maximum detected value or, if no detected values were reported, indicates the maximum detection limit reported
d. For calculation of these summary statistics, non-detect values were replaced with the value of the detection limit
e. Less than 5% of samples were detected, therefore a median, 95th percentile, 97th percentile and mean were not calculated
f. mg/L as $CaCO_3$
g. Lowest detected value is less than the lowest non-detected value. Minimum value selected is the lowest detected value.
h. Maximum detected value is less than highest detection limit. Maximum value selected is the highest detected value.

C-3.3 AMEP Benchmark Derivation for Surface Waters

The focus of AEMP benchmark development was on Total Metals, since available Canadian water quality guidelines focus on Total Metals benchmarks, as opposed to dissolved metals data. Dissolved data will be assessed under the Assessment Approach and Response Framework in the Exploratory Data Analysis (Step 1 of Figure 5.1) to examine trends, and where deemed appropriate, based on assessment of both dissolved and total analyses, benchmarks will be considered for development if data are suggesting mine-related increases are occurring. Dissolved water quality guidelines are available for some parameters from the US EPA (http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable), as well as British Columbia Ministry of Environment, and these guidelines would be considered as a first point of comparison, in conjunction with baseline levels, as well as SSWQG, where appropriate.

For the total metals, and other selected parameters, the process used to select the AEMP benchmark was similar to that presented for sediments, in Figure 2-4. Briefly, the higher of either the 97.5th percentile, the CCME PAL, or 3 times the method detection limit were chosen to represent the AEMP benchmark.

To develop AEMP benchmarks for water quality parameters, appropriate guidelines were identified from the CCME freshwater aquatic life guidelines (CCME, 2014). Modifications were required based on site specific parameters, such as hardness or pH, the 25%ile hardness and 25%ile pH values for the water body in question was used in order to calculate a protective guideline. For ammonia, the 75th percentile temperature and pH were used to calculate the guideline. Where parameters are trending up towards these AEMP benchmarks, site-specific values should be substituted for comparison purposes (in Low Action).

Where no CCME guideline was available for a substance of interest, a BC MOE (Ministry of the Environment) Approved or Working guideline for the water column were used, where available (Nagpal et al, 2006). The guidelines selected for use in developing the AEMP benchmarks are provided in Table 3-14.

Table 3-14 Water Quality Guidelines Selected for Chemicals Carried Forward for Benchmark Development		
Chemical	***Freshwater Aquatic Life Guideline (mg/L)***	***Reference***
Aluminum (Al)	0.1[a]	CCME, 1987
Arsenic (As)	0.005	CCME, 1997
Cadmium (Cd)	Camp Lake = 0.0001[b] Mary Lake / Mary River = 0.00006 Sheardown Lake = 0.00009 Camp Lake Tributary = 0.00008	CCME, 2014
Chromium III (Cr)	0.0089	CCME, 1997
Chromium VI (Cr)	0.001	CCME, 1997
Cobalt (Co)	0.004 [e]	BC MOE (Nagpal, 2004)
Copper (Cu)	0.002 [c]	CCME, 1987
Iron (Fe)	0.3	CCME, 1987
Lead (Pb)	0.001 [d]	CCME, 1987
Nickel (Ni)	0.025 [f]	CCME, 1987
Silver (Ag)	0.0001	CCME, 1987
Thallium (Tl)	0.0008	CCME, 1999
Vanadium (V)	0.006 [g]	BCMOE (Nagpal et al., 2006)
Zinc (Zn)	0.030	CCME, 1987
Ammonia	Based on pH and temperature (look up table provided in CCME, on-line) [h]	CCME, 2011
Chloride	120	CCME, 2012
Nitrogen – Nitrite	0.060 NO_2 – N (equivalent to 0.197 mg nitrite / L)	CCME, 2001
Nitrogen – Nitrate	13	CCME, 1987
Sulphate	218[i]	BC MOE, (Meays and Nordin, 2013)

Notes:
25^{th} percentile pH: Camp Lake 7.3; Mary Lake 6.9; Sheardown Lake 7.3; Camp Lake Tributary 7.7; Mary River 7.6
25^{th} percentile hardness (as $CaCO_3$): Camp Lake 55.3; Mary Lake 33.2; Sheardown Lake 53.5; Camp Lake Tributary 41.0; Mary River 28.0
a. pH Guideline of 0.1 mg/L selected since 25^{th}%ile pH in all lakes and rivers was ≥ 6.5
b. Cadmium guideline based on 25%ile water hardness and following equation: *CWQG (mg/L) =* $[10^{\{0.83(\log[hardness]) - 2.46\}}] / 1000$.
c. Copper guideline based on 25th%ile water hardness and following equation: *CWQG (mg/L) =* $[0.2 * e^{\{0.8545[\ln(hardness)]-1.465\}}] / 1000$.
d. Lead guideline based on 25^{th}%ile water hardness and following equation: *CWQG (mg/L)=* $[e^{\{1.273[\ln(hardness)]-4.705\}}] / 1000$
e. 30 day average; approved guideline
f. Nickel guideline based on 25^{th}%ile water hardness and following equation: *CWQG (mg/L) =* $[e^{\{0.76[\ln(hardness)]+1.06\}}] / 1000$.
g. Working guideline; reported as Ontario's water quality objective
h. Based on pH and temperature (look up table provided in CCME, on-line); calculated based on 75%ile temperature data, to be conservative, and 75%ile pH of 7.5. These values equate to a pH of 8 and a temperature of 10 degrees C, in the summary table, which yields a guideline of 0.855 mg/L total ammonia-N.
i. 30-day average (minimum of 5 evenly-spaced samples collected in 30 days); Approved guideline

The selected water quality guidelines were then compared to baseline data to determine an AEMP benchmark for each of the selected chemicals. As per the sediment benchmark evaluation approach, a statistical representation of baseline concentrations was calculated to determine an upper estimate of natural concentrations. As per sediment AEMP benchmarks, the 97.5th percentile concentration was used as the statistical metric. A comparison of the selected water quality guidelines to the 97.5th percentile concentrations in each water body are provided in Tables 3-15 and 3-16 for area lakes and rivers, respectively, with the recommended parameter-specific AEMP benchmark. The basis of the recommended AEMP benchmark is identified in Tables 3-15 and 2-16 as follows:

- Method A: Water Quality Guideline was higher than 97.5%ile, and therefore was selected
- Method B: 97.5%ile was higher than the Water Quality Guideline, and therefore was selected; or
- Method C: Parameter has < 5% detected values, and either the Water Quality Guideline was selected (if available), or 3 * MDL was used to derive benchmark

If Method B was selected, additional assessment of the data was conducted to ensure the percentile calculations were not being driven by elevated detection limits, or other factors.

In most cases, the recommended AEMP benchmarks are consistent between lakes and rivers, with the vast majority of selected benchmarks being regulatory water quality guidelines. A summary table is presented (Table 3-17). Where natural concentrations varied, and exceeded available water quality guidelines, or < 5% of values were detected, recommended AEMP benchmarks varied (see Tables 3-15 and 3-16 and 3-17).

As discussed in the CREMP, some parameters have been shown to exhibit some changes in concentrations with season. For those parameters, Step 1 of the assessment framework should include an evaluation of seasonality trends relative to the AEMP benchmark and baseline. AEMP benchmarks may need to be re-visited for these compounds, and SSWQG can be considered.

Several water quality guidelines established by the CCME are currently under revision (i.e., lead and iron) or have been released in draft form for comments (silver). Once finalized, these revised benchmarks should be evaluated, using the benchmark selection process outlined, and AEMP benchmarks updated accordingly.

Table 3-15 Comparison of 97.5th Percentile Concentrations in Area Lakes to Water Quality Guidelines and Selection of AEMP Benchmarks

Parameter	*Units*	*Water Quality Guideline*	*Camp Lake*	*Mary Lake*	*Sheardown Lake*	*Selected AEMP Benchmark*	*Benchmark Method*
Metals [a]							
Aluminium	mg/L	0.1	0.026	0.137	0.179 (Shallow) 0.173 (Deep)	CL = 0.1 ML = 0.13; SDL shallow/deep = 0.179/0.173	A (CL), B (ML/SDL)
Arsenic	mg/L	0.005	NC	0.00018	0.0001	0.005	A
Cadmium	mg/L	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	NC	0.000023	0.000017	0.0001 (CL) 0.00006 (ML) 0.00009 (SDL)	A
Chromium	mg/L	NGA	NC	0.001	0.000641	0.0003 (CL) (ML) = 0.0005[f] (SDL) = 0.000642[g]	B (ML/SDL), C (CL)
Chromium +3	mg/L	0.0089	NC	0.005	NC	0.0089	A
Chromium +6	mg/L	0.001	NC	0.001	NC	0.003 – 0.015 (CL)[c] 0.003 (ML/SDL)[c]	C
Cobalt	mg/L	0.004	NC	NC	0.0002	0.004	A
Copper	mg/L	0.002	0.0113	0.00239	0.00243	(CL) = 0.004[e] (ML) = 0.0024 (SDL) = 0.0024	B
Iron	mg/L	0.3	0.0421	0.173	0.211	0.3	A
Lead	mg/L	0.001	0.000334	0.00013	0.00026	0.001	A
Nickel	mg/L	0.025	0.000941	0.00080	0.000973	0.025	A
Silver	mg/L	0.0001	NC	NC	0.0000104	0.0001	A
Thallium	mg/L	0.0008	NC	NC	0.0001	0.0008	A
Vanadium	mg/L	0.006	NC	0.00146	0.001	0.006	A
Zinc	mg/L	0.030	0.0037	0.003	0.00391	0.030	A
Water Quality Parameters							
Chloride (Cl^-)	mg/L	120	4	13	5	120	A
Ammonia (NH_3+NH_4)	mg total ammonia-N/L	0.855[b]	0.84	0.32	0.44	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.1[d]	0.1[d]	0.1[d]	0.060	A

Table 3-15 Comparison of 97.5th Percentile Concentrations in Area Lakes to Water Quality Guidelines and Selection of AEMP Benchmarks

Parameter	***Units***	***Water Quality Guideline***	***Camp Lake***	***Mary Lake***	***Sheardown Lake***	***Selected AEMP Benchmark***	***Benchmark Method***
Nitrate (NO_3)	mg N/L	13	NC	0.11	NC	13	A
Sulphate	mg/L	218	3	7	5	218	A

Notes:
NGA = no guideline available; NC = Not Calculated; TBD = To Be Determined; Guideline still under development; CL = Camp Lake; ML = Mary Lake; SDL = Sheardown Lake
Method A = Water Quality Guideline from CCME/B.C. MOE; Method B = 97.5%ile of baseline; Method C = 3* MDL
a. Total metals unless otherwise noted
b. Assumes temperature at 10 degrees C, and pH of 8
c. The 2013 detection limit for Cr^{6+} increased in 2013 from 0.001 to 0.005, hence this affects the 3* MDL calculation for the benchmark in Camp Lake. Efforts will be made to reduce this MDL in 2014, and comparisons to the lower of the 2 benchmarks would then be applied in Camp Lake. If detection limits improve, Method A (selection of the guideline) may be implemented.
d. These values are elevated detection limits, and hence, the guideline has been selected as the AEMP benchmark
e. The maximum value of 0.0113 mg/L copper was removed to calculate the 97.5th percentile, as this value appears to be an outlier.
f. An elevated detection limit of 0.001 mg/L was removed from the dataset and calculations, and the AEMP selected was the 97.5th percentile, which is 0.0005 mg/L.
g. Several detected values ranging from 0.00079 – 0.00316 mg/L Cr have been reported in the dataset for SDL, and hence, these values were considered to represent baseline, and were included in the 97.5th percentile calculation.

Table 3-16 Comparison of 97.5th Percentile Concentrations in Area Rivers to Water Quality Guidelines and Selection of AEMP Benchmarks

Parameter	*Units*	*Water Quality Guideline*	*Camp Lake Tributary*	*Mary River*[a]	*Selected AEMP Benchmark*	*Benchmark Method*
Metals [b]						
Aluminum	mg/L	0.1	0.179	0.97	CLT = 0.179 MR = 0.966	B
Arsenic	mg/L	0.005	0.00012	0.00013	0.005	A
Cadmium	mg/L	0.00008 (CLT) 0.00006 (MR)	NC	0.00002	CLT = 0.00008 MR = 0.00006	A
Chromium	mg/L	NGA	0.000856	0.0023	CLT = 0.000856 MR = 0.0023	B
Chromium $^{+3}$	mg/L	0.0089	NC	0.005	0.0089	A
Chromium $^{+6}$	mg/L	0.001	NC	NC	0.003[c]	C
Cobalt	mg/L	0.004	NC	0.0004	0.004	A
Copper	mg/L	0.002	0.00222	0.0024	CLT = 0.0022 MR = 0.0024	B
Iron	mg/L	0.3	0.326	0.874	CLT = 0.326 MR = 0.874	B
Lead	mg/L	0.001	0.000333	0.00076	0.001	A
Nickel	mg/L	0.025	0.00168	0.0018	0.025	A
Silver	mg/L	0.0001	NC	0.0001	0.0001	A
Thallium	mg/L	0.0008	0.0002	0.0002	0.0008	A
Vanadium	mg/L	0.006	NC	0.002	0.006	A
Zinc	mg/L	0.030	0.0035	0.01	0.030	A
Water Quality Parameters						
Chloride (Cl^-)	mg/L	120	23	21.55	120	A
Ammonia (NH_3+NH_4)	mg total ammonia-N/L	0.855[d]	0.60	0.60	0.855	A
Nitrite (NO_2^-)	mg N/L	0.060	0.095[e]	0.06	0.060	A
Nitrate (NO_3)	mg N/L	13	0.118	0.14	13	A
Sulphate	mg/L	218	6	8	218	A

Notes:
NGA = no guideline available; NC = Not Calculated; TBD = To Be Determined; Guideline still under development; MR = Mary River; CLT = Camp Lake Tributary
Method A = Water Quality Guideline from CCME/B.C. MOE; Method B = 97.5%ile of baseline; Method C = 3* MDL
a. One sample (outlier) containing chemical concentrations orders of magnitude above other values was not included in the calculations for Mary River.
b. Total metals unless otherwise noted
c. Efforts will be made to reduce this MDL in 2014, and comparisons to the higher of the Method A or C would then be applied as the AEMP benchmark
d. Assumes temperature at 10 degrees C, and pH of 8.0
e. 97.5th percentile is being driven by elevated detection limit, therefore, the guideline was selected

C- 4.0 REFERENCES

Agnico-Eagle, 2012. Core Receiving Environment Monitoring Program (CREMP): Design Document 2012 Meadowbank Mine. Prepared for Agnico-Eagle Mines Limited. Baker Lake, Nunavut. Prepared by: Azimuth Consulting Group Inc., Vancouver, B.C.

CCME (Canadian Council of Ministers of the Environment), 2002. Canadian sediment quality guidelines for the protection of aquatic life: Introduction.

CCME (Canadian Council of Ministers of the Environment). 2003. Canadian water quality guidelines for the protection of aquatic life: Guidance on the site-specific application of water quality guidelines in Canada: Procedures for deriving numerical water quality objectives. In: Canadian environmental quality guidelines, 1999. Winnipeg, MB.

CCME (Canadian Council of Ministers of the Environment). 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December 2007. In: Canadian environmental quality guidelines, 1999. Winnipeg, MB.

CCME (Canadian Council of Ministers of the Environment). 2014. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table. http://ceqg-rcqe.ccme.ca/

CCME, 1987. Water Quality for the Protection of Aquatic Life. Guidelines for Aluminium, Copper, Iron, Lead, Nickel, Silver, Zinc, and Nitrogen-Nitrate. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 1997a. Sediment Quality for the Protection of Aquatic Life. Guidelines for Cadmium and Mercury. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 1997b. Water Quality for the Protection of Aquatic Life. Guidelines for Arsenic, Chromium III, and Chromium VI. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 1998. Sediment Quality for the Protection of Aquatic Life. Guidelines for Arsenic, Chromium, Copper, Lead and Zinc. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 1999. Water Quality for the Protection of Aquatic Life. Guidelines for Thallium. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 2001. Water Quality for the Protection of Aquatic Life. Guidelines for Nitrogen-Nitrite.Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 2011. Water Quality for the Protection of Aquatic Life. Guidelines for Ammonia. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 2012. Water Quality for the Protection of Aquatic Life. Guidelines for Chloride. Summary Table http://ceqg-rcqe.ccme.ca/

CCME, 2014. Water Quality for the Protection of Aquatic Life. Guidelines for Cadmium. Summary Table http://ceqg-rcqe.ccme.ca/

Golder, 2012. Water Quality Objectives (WQO) and Sediment Quality Objectives (SQO) for the Proposed Gahcho Kue Project – Recommendations. Technical Memorandum. September 14, 2012. To: Veronica Chisholm, De Beers Canada, Inc. From: Peter M. Chapman.

Knight Piésold, 2014. Appendix B, AEMP. Water and Sediment Quality Review and CREMP Study Design. Knight Piésold Ltd. 1650 Main Street, North Bay, Ontario.,

MacDonald. D.D., B. Zajdlik, and INAC Water Resources. 2009. Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories. Overview Report. Version 1, June 2009.

Meays, C., and R. Nordin, 2013. Ambient Water Quality Guidelines for Sulphate. Technical Appendix Update. 2013. Ministry of Environment, Province of British Columbia. Water Protection & Sustainability Branch. http://www2.gov.bc.ca/assets/gov/topic/C61AC40F96CC4628C24A5C95F5E09E1F/sulphate_final_guideline_april_2013.pdf

Nagpal, N.K. 2004.Technical Report – Water Quality Guidelines for Cobalt. Water Protection Section. Water, Air and Climate Change Branch. Ministry of Water, Land and Air Protection, British Columbia. (http://www.env.gov.bc.ca/wat/wq/BCguidelines/cobalt/cobalt_tech.pdf)

Nagpal, N.K., L. W. Pommen, L. G. Swain. 2006. A Compendium of Working Water Quality Guidelines for British Columbia (http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html#table1)

OMOE, 2008. Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An Integrated Approach. May, 2008. R. Fletcher, P. Welsh, and T. Fletcher.Standards Development Branch. PIBS 6658e.

OMOE (Ontario Ministry of Environment). 2011. Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario. PIBS 7386e01. http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_086518.pdf. Accessed January 28th, 2013.

Singh and Singh 2010. ProUCL Version 4.1.00 Technical Guide (Draft), EPA/600/R-07/041

US EPA, 2014. Freshwater Sediment Screening Benchmarks. Accessed in February, 2014. http://www.epa.gov/reg3hscd/risk/eco/btag/sbv/fwsed/screenbench.htm

Appendix D

Freshwater Biota CREMP Study Design

Appendix D

Freshwater Biota CREMP Study Design

Mary River Project

June 2014

Core Receiving Environment Monitoring Program: Freshwater Biota

North/South Consultants Inc.
Aquatic Environment Specialists

Core Receiving Environment Monitoring Program: Freshwater Biota

June, 2014

Prepared by

North/South Consultants Inc.

For

Baffinland Iron Mines Corporation

North/South Consultants Inc.
Aquatic Environment Specialists

83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca

Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Program
ANOVA	Analysis of variance
ANCOVA	Analysis of covariance
ANFO	Ammonium nitrate fuel oils
BMI	Benthic macroinvertebrate(s)
CALA	Canadian Association for Laboratory Accreditation Inc.
CES	Critical effect size
CPUE	Catch-per-unit-effort
CREMP	Core Receiving Environment Monitoring Program
DELTs	Deformities, erosion, lesions, and tumours
DO	Dissolved oxygen
EC	Environment Canada
EEM	Environmental Effects Monitoring
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statements
INAC	Indian and Northern Affairs Canada
MMER	Metal Mining Effluent Regulations
NSC	North/South Consultants Inc.
OECD	Organization for Economic Cooperation and Development
QA/QC	Quality assurance/quality control
SD	Standard deviation
SE	Standard error of the mean
TP	Total phosphorus
TN	Total nitrogen
TSS	Total suspended solids
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
YOY	Young-of-the-year

1.0 INTRODUCTION

The following describes the general background, approach, and methods for biological monitoring under the Core Receiving Environment Monitoring Program (CREMP) for the Baffinland Iron Mines Corporation Mary River Iron Ore Mine Project. Monitoring components include phytoplankton, benthic macroinvertebrates (BMI), and Arctic Char (*Salvelinus alpinus*).

This document was prepared, and the CREMP was designed, with baseline information available at the time of preparation of this report. As not all results of baseline sampling conducted in 2013 were available at the time of preparation of this report, recommendations for modification to the CREMP may be made upon receipt and analysis of these additional data.

A desktop technical review of freshwater biota baseline data was conducted in 2013 to provide a preliminary review of the adequacy of existing baseline data for the CREMP component of the overall Aquatic Effects Monitoring Program (AEMP) for the Mary River Project Mine site (North/South Consultants Inc. [NSC] 2013). This initial report was based on available baseline data for the period of 2006 through 2012 and identified data gaps and recommendations for additional baseline sampling for the 2013 field season.

The initial technical review document was subsequently updated in 2014 to incorporate additional information acquired in 2013 and to reflect further development of the CREMP (e.g., selection of benchmarks). The revised document is provided as Appendix 1. These baseline review reports were used as the foundation for the development of the biological programs for the CREMP. Key conclusions and findings of this review have been considered and integrated into the present CREMP document.

2.0 PHYTOPLANKTON

The following section provides a description of monitoring of phytoplankton under the CREMP. The program focuses on monitoring lakes in the Mine Area, where potential for eutrophication is greatest.

2.1 PATHWAYS OF EFFECT AND KEY QUESTIONS

Key questions were developed for the CREMP to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. These questions and metrics focus upon key potential effects identified in the Final Environmental Impact Statement (FEIS) and the Addendum to the FEIS for the Early Revenue Phase (ERP), as well as metrics commonly applied for characterizing phytoplankton communities.

The key pathways of potential effects of the Project on phytoplankton communities include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area).

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources on phytoplankton abundance in Mine Area lakes?

The primary issue of concern with respect to the phytoplankton community is related to nutrient enrichment and eutrophication, though effects on water clarity (e.g., changes in TSS) could also affect primary productivity. As such, the CREMP and the baseline data review focused upon waterbodies most at risk to eutrophication in relation to pathways of effect for the Project; in general, lakes (rather than streams) are most vulnerable to eutrophication in the Mine Area. Sheardown Lake NW has received treated sewage effluent discharge during the construction phase and may also be affected by dust deposition, stream diversions, and non-point sources during operation. Although treated sewage effluent will be discharged to the Mary River during the operation phase, Mary Lake is the ultimate receiving environment for all point sources in the Mine Area, including discharge of treated sewage effluent, and is more vulnerable to effects of nutrient enrichment due to its lacustrine nature.

2.2 PARAMETERS AND METRICS

The key metric for phytoplankton monitoring will be chlorophyll *a*. Chlorophyll *a* is the most widely used indicator of phytoplankton abundance and is relatively easy to sample. It is also associated with lower analytical variability and is more cost effective than biomass and community composition metrics. Further, biological benchmarks for phytoplankton community metrics have not been developed to the same extent as for chlorophyll *a* and phytoplankton indices are not as strongly linked to primary drivers of eutrophication (i.e., nutrients). While this parameter is associated with relatively high variability in the lakes currently, the variability is largely a function of low concentrations and in particular, a relatively high frequency of censured values (i.e., below detection; Appendix 1).

Although chlorophyll *a* will be the key metric for this component, samples will also be collected and archived for potential analysis of phytoplankton biomass and taxonomy during the CREMP. These samples will provide the ability to conduct additional analyses should monitoring of water quality, chlorophyll *a*, and/or other biological components indicate that effects to primary productivity may be of concern and would benefit from these additional data.

In addition, as phytoplankton monitoring is intended to address the potential for eutrophication effects in Mine Area lakes, analysis of monitoring data will also consider related/supporting variables including nutrients (phosphorus and nitrogen), measures of water clarity (i.e., TSS, turbidity, Secchi disk depth), and temperature in the data analysis and reporting phase.

2.3 BENCHMARKS

As noted in Section 2.1, phytoplankton abundance either may be increased by the Project through nutrient enrichment or may be decreased by the Project through changes in other factors such as water clarity. Therefore, the phytoplankton monitoring component is intended to monitor for either increases or decreases in algal abundance. However, owing to the particular concern related to nutrient enrichment and potential for eutrophication in Mine Area lakes related to phosphorus additions, the benchmark for the CREMP was developed to address potential increases in chlorophyll *a*. In addition, decreases in chlorophyll *a* relative to current (baseline) conditions would be difficult to measure owing to the low concentrations and high frequency of censured values.

Other recent/ongoing monitoring programs in northern Canada have identified effects sizes and/or benchmarks for phytoplankton using different approaches. Azimuth (2012) recommended the application of a 20% effect size as a monitoring "trigger" and a 50% effect size as a monitoring "threshold" for phytoplankton community metrics (i.e., total biomass and number of species), where effect size refers to a change or difference relative to before-after-control-impact (BACI). Under this program, the mean of three months of monitoring is compared to the trigger and threshold. The authors note that the terms "threshold" and "trigger" are intended to be applied less strictly for biological variables, relative to chemical variables such as water or sediment quality, due to the inherent high natural variability in biological parameters and the need to consider the cause of any observed statistical "changes" in the biological communities. The rationale provided for the identification of the 20% and 50% criteria is "to maintain a transparent (fixed) effect size that is more likely to be ecologically relevant." Inherent to this discussion, is the importance of considering the variability in existing data in identifying appropriate critical effects sizes (CESs).

A revised AEMP was recently issued for the Diavik Diamond Mines Inc. (DDMI) operation at Lac de Gras, NT, which includes a specific monitoring component related to eutrophication in Lac de Gras (Golder Associates 2014). The key metric identified was chlorophyll *a*, which is sampled once in the open-water season. The assessment approach includes a number of action levels defined based on magnitude of changes in chlorophyll *a* concentrations and in consideration of the spatial extent of the effects. The lowest action level is considered to be exceeded where the 95th percentile of chlorophyll *a* concentrations (defined based on pooled data for the open-water season sampling period) is higher than the "normal range". The normal range is defined as the mean ± 2 x standard deviation (SD) of reference area values (open-water season). Additional action levels compare monitoring results to a benchmark value. The benchmark value was based on maintaining an oligotrophic status in the lake, using trophic boundaries defined in the scientific literature. Specifically, the benchmark (4.5 µg/L) was defined as the average concentration of the upper limit of the oligotrophic boundary and the lower limit of the mesotrophic boundary from the literature. A higher action level (termed an "effects threshold") is identified in concept but has not been defined quantitatively; this step would be undertaken in the future if lower action levels were exceeded.

With respect to the Mary River Project, development of benchmarks or CESs for phytoplankton that are adequately sensitive and ecologically appropriate for Mine Area lakes considered:

- Natural variability in existing phytoplankton community metrics;
- Limitations associated with the existing data set - specifically issues associated with chlorophyll *a* concentrations being below the analytical detection limits;
- Relationships between nutrients (notably phosphorus) and phytoplankton metrics for Mine Area lakes;
- Lake trophic categorization schemes and trophic status of the Mine Area lakes; and
- Literature in which CESs for phytoplankton have been identified or adopted, such as AEMPs for the Diavik Diamond Mine and the Meadowbank projects.

While there are no established benchmarks for phytoplankton metrics for application in monitoring programs, there is an extensive literature base regarding the issue of eutrophication of freshwater ecosystems as well as numerous trophic categorization schemes for lakes and several for freshwater streams. Mine Area lakes are currently oligotrophic based on several different lake trophic categorization schemes using chlorophyll *a* (Table 2-1). While a significant relationship was found between total phosphorus (TP) and chlorophyll *a* in Mine Area lakes (Appendix 1), the relationship is weak and cannot be used to construct a predictive model linking nutrient concentrations to phytoplankton. Therefore, a benchmark for chlorophyll *a* was derived based on existing baseline data and in consideration of approaches applied in other recent/ongoing arctic AEMPs and trophic categories/status.

The benchmark for chlorophyll *a* for the Mary River Project (3.7 µg/L) is based on maintaining the trophic status (i.e., oligotrophic) of Mine Area lakes. The benchmark was derived using a similar approach and rationale as was recently applied for the DDMI Project. Specifically, the benchmark represents the average of the upper and lower ranges of trophic boundaries for lakes based on chlorophyll *a*, as designated and/or adopted in the scientific literature (Table 2-2). This value is lower than the benchmark adopted by DDMI due to some differences in the literature incorporated in this calculation. Two of the literature sources utilized for the DDMI benchmark derivation

(United States Environmental Protection Agency [USEPA] 1974 and 1988) were omitted due to the age of the documents and because the USEPA has applied a different trophic status categorization scheme in a more recent report (USEPA 2009). The values applied in USEPA (2009) were included in the calculation instead. In addition, the values presented in CCME (2004) were omitted since these values are reproductions of the Organization for Economic Cooperation and Development (OECD 1982) values, which are already included in the data set. Similarly, Alberta Environment (2013) also applies the same boundaries as the OECD (1982) but this was not included as a separate entry in the calculations for the same reason. Lastly, the trophic categorization scheme applied by the Swedish EPA (2000) was also included in the calculation.

As previously noted, the benchmark (3.7 µg/L) for Mary River lakes is lower than the recently developed benchmark for Lac de Gras in relation to the Diavik Diamond Mines Project. Lac de Gras has a similar background concentration of chlorophyll *a* than Sheardown Lake NW but a lower concentration than other Mine Area lakes (Table 2-3); the "normal range" of chlorophyll *a* in Lac de Gras (mean±2 x SD) was identified as 0.89 µg/L and the mean was 0.52 µg/L for the open-water season (Golder Associates 2014).

2.4 MONITORING AREA AND SAMPLING SITES

The monitoring area for phytoplankton includes Mine Area lakes, specifically Camp and Mary lakes, and Sheardown Lake NW and SE, and selected streams (Figure 2-1). In addition, monitoring will be conducted at a minimum of one reference lake.

Five sites will be monitored for chlorophyll *a* in Camp, Sheardown NW and Sheardown SE lakes during each sampling period; six sites will be monitored in Mary Lake. Samples will also be collected at these same locations for phytoplankton biomass and taxonomy but will be archived following collection. Sites will be consistent with water quality sampling sites to provide supporting information for interpretation and analysis of results (e.g., nutrient concentrations and water clarity).

Chlorophyll *a* will also be monitored at stream locations in conjunction with water quality monitoring (see Figure 2-1 for locations). Monitoring will include several sites on the Mary River, including sites upstream and downstream of effluent discharges, and small tributaries to Sheardown Lake NW and SE and Camp Lake.

An *a priori* power analysis was conducted using existing baseline data for chlorophyll *a* for Sheardown Lake NW and Mary Lake to advise on the power of the existing dataset and to identify sample sizes for the CREMP (see Appendix 1 for details); these two lakes represent the range of baseline conditions for the Mine Area lakes as a whole. Power analyses indicate relatively high power to detect a change of the magnitude of the benchmark for each sampling season in each lake (Table 2-4). Power is greater for Sheardown Lake NW owing to the lower baseline concentrations of chlorophyll *a* than Mary Lake. A sample size of five for Sheardown Lake NW and similar lakes including Sheardown Lake SE and Camp Lake, and a sample size of six for Mary Lake, are associated with high power in relation to the benchmark. Power was also evaluated for an effects size of 2 x the mean; relatively high power (0.7 for Mary Lake and 0.8 for Sheardown Lake NW) is associated with detecting this level of change.

2.5 SAMPLING FREQUENCY AND SCHEDULE

Sampling will be conducted annually during the initial years of operation but sampling frequency should be regularly evaluated (i.e., each year) to determine if modifications are warranted. Sampling in lakes would consist of two open-water periods (summer and late summer/fall) and once in late winter. Streams will be sampled three times in the open-water season. These sampling frequencies are consistent with baseline sampling programs conducted in the Mine Area to date.

Sampling will be conducted in conjunction with the water quality sampling program to provide data for supporting indicators, including TP, total nitrogen (TN), and water clarity. Dissolved oxygen (DO) profiles will also be collected at each sampling site to evaluate potential for DO depletion (i.e., a eutrophication response variable).

2.6 FIELD AND LABORATORY METHODS

Chlorophyll *a* samples will be collected at a depth of approximately 1 m below the water surface with a sampling device (i.e., van Dorn or Kemmerer), transferred to sample bottles provided by the analytical laboratory, kept cool and in the dark and submitted to a laboratory accredited under the Canadian Association for Laboratory Accreditation (CALA) Inc. Additional information will be recorded at the time of sampling including:

- Field crew;
- Site coordinates (universal transmercator units [UTMs]);
- Date and time of sampling;
- Sampling depth/methods and any deviations from the sampling protocol;
- Total water depth (and ice thickness in winter); and

- Site conditions/observations.

As chlorophyll *a* will be sampled at the same sites and times and using the same collection methods as other water quality parameters, additional water quality data, including nutrients, will be collected concurrently to assist with data analysis. *In situ* profiles of DO, temperature, pH, and conductivity and Secchi disk depths (average of two measurements) will also be measured at each site. For information on water quality sampling, see Appendix B of the AEMP.

Samples for phytoplankton taxonomy and biomass will be collected as depth-integrated samples using a tube-sampler. The sampling depth will be calculated as 3 x the average Secchi disk depth (i.e., an estimate of the euphotic zone depth), to a maximum of 10 m. Due to the high water clarity of Mine Area lakes, euphotic zone depths may exceed 10 m in some sampling periods at some sites. Where this occurs, a second sample should be collected from the 10 m depth to the estimated depth of the euphotic zone. Samples will be transferred to sample bottles and preserved with Lugol's solution. Following collection, samples will be archived for potential future analysis.

2.7 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The QA/QC program will include the following components:

- Development and use of sampling protocols;
- Incorporation of field QA/QC samples; and
- Review of data for transcription errors, omissions, and outliers.

The field QA/QC program will include:

- Collection of replicate samples for chlorophyll *a* and phytoplankton biomass and taxonomy; and
- Analysis of field and trip blanks for chlorophyll *a*.

2.8 STUDY DESIGN AND DATA ANALYSIS

As existing baseline data for candidate reference lakes are minimal, the monitoring program will focus upon before-after comparisons of the key metric (i.e., chlorophyll *a*) within the Mine Area waterbodies, with an emphasis on Mine Area lakes. Trends will also be examined over time to determine if phytoplankton abundance indicates increasing or decreasing concentrations over a number of years. Lastly, frequency of detection of chlorophyll *a* will also be calculated and compared to baseline data as a further means of assessing change.

Chlorophyll *a* data collected in reference lakes and streams will also be considered within the interpretation of the monitoring data at the Mine Site. Specifically these data will assist with determining if observed changes in Mine Area lakes and streams are Project-related or a function of regional natural variability. Once sufficient data are acquired for the reference waterbodies, statistical comparisons to Mine Area waterbodies may be undertaken under the CREMP.

Results reported below the analytical detection limit will be assigned a value equal to the detection limit for subsequent data analyses. Statistical comparisons (spatial and/or temporal) will be conducted by an analysis of variance (ANOVA) where data meet the assumptions of equal variance and normality or by non-parametric methods (i.e., Kruskal-Wallis test followed by the Dunn's multiple pairwise comparisons procedure or the Mann-Whitney test) where the assumptions are not met. Transformations of data (e.g., log transformations) will be explored where applicable to attempt to meet the assumptions of ANOVA. Where the qualitative review of the monitoring results indicates a potential increase in chlorophyll *a*, one-tailed statistical analyses will be conducted. Statistical comparisons (before –after) will be done on a lake-wide basis for each sampling season. All tests will be assessed with a significance level of 0.05.

Additional analyses may be conducted including correlation analyses and/or regression analyses examining relationships between the key metric (chlorophyll *a*) and other related variables such as nutrients. These regressions, where significant, may be used as a tool for projecting long-term trends in chlorophyll *a* and/or to assist with delineating cause(s) of observed changes in chlorophyll *a*.

2.9 ASSESSMENT FRAMEWORK

Monitoring data will be assessed during each year of monitoring and would follow the assessment framework as outlined in Figure 2-2 and described below.

2.9.1 Step 1: Initial Data Analysis

Step 1 of the assessment will include initial review, screening, QA/QC, and exploratory analyses of the data set and determination if the data indicate potential increases or decreases in chlorophyll *a* concentrations relative to baseline conditions. Data will be summarized graphically and/or in tabular format and will include generation of summary statistics and graphing of data for evaluating temporal trends. Data will also be compared to the benchmark to identify if conditions indicate further analysis of the data is warranted.

Section 2.4 provides a description and rationale for the identification of a benchmark for chlorophyll *a* (3.7 µg/L). The mean chlorophyll *a* concentration measured during each sampling period in each lake will be compared to this benchmark. If Step 1 indicates exceedance of a benchmark, statistically significant differences relative to baseline conditions, and/or qualitative review of the data suggest that the Project could potentially have resulted in a change in the indicator, the analysis would proceed to Step 2. If it is concluded that there is no evidence of change, no management response would be required.

2.9.2 Step 2: Determine if Change is Mine Related

Step 2 involves determining if the changes in chlorophyll *a* are due to the Project or due to natural variability or other causes. This question will be addressed through several possible approaches:

- Evaluating spatial patterns in chlorophyll *a* results for the Mine Area as a whole, including Mine Area lakes and streams, to evaluate if changes are widespread or specific to certain waterbodies, and to identify the spatial extent and pattern of observed changes. This exercise would assist with identifying potential stressors/pathways of effects;

- Comparing data from Mine Area lakes to reference lake(s) and potentially data from Mine Area streams to reference streams. This would further assist with determining whether the observed changes were due to natural variability or the Project;

- Evaluating monitoring results for nutrients, notably phosphorus, in Mine Area waterbodies (lakes and streams) to assess whether nutrients have similarly changed and in the same spatial pattern/magnitude as observed for chlorophyll *a*;

- Evaluating other factors that affect phytoplankton abundance such as water clarity and temperature; and

- Evaluating Project activities with the potential to alter nutrients and/or conditions that may affect phytoplankton. This may include evaluating effluent quality, discharge regime/rates, and loading, notably in relation to sewage effluent, dust deposition, and other point/non-point sources as required.

If the Step 2 analysis concludes that the changes in chlorophyll *a* are, or are likely, due to the Project, the assessment would proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response would be required.

2.9.3 Step 3: Determine Action Level

Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark. If the benchmark is not exceeded, a low action response would be undertaken and may include:

- Evaluate temporal trends: this will be a qualitative exercise and consist of graphical presentation of data over time to evaluate increasing or decreasing trends. It is important to note that several years of data will be required to begin to assess temporal trends;
- Investigate and summarize potential causes and pathways of effect of the observed changes;
- Review and summarize monitoring results for other metrics of relevance to phytoplankton (i.e., drivers) and eutrophication including nutrients, water clarity, and DO. Trend analysis results for these metrics, notably phosphorus, will also be considered in the interpretation of phytoplankton monitoring results;
- Review/assess the benchmark with acquisition of data (note: this will be undertaken over the course of monitoring). This may include updating the regression analysis relating chlorophyll *a* to TP concentrations with additional data to generate a site-specific model; and
- Based on the above evaluations, determine next steps.

If the benchmark is exceeded and it is concluded to be due to, or likely due to, the Project, a moderate action level response would be undertaken and may include the following:

- Evaluate indicators of nutrient enrichment (i.e., nitrogen and phosphorus) and other eutrophication response indicators (i.e., dissolved oxygen, Secchi disk depth) to assess overall trophic status and relationships between nutrients and chlorophyll *a*;
- Evaluate chemical, biological, and physical monitoring results collectively with chlorophyll *a* monitoring results to evaluate effects on the ecosystem. Key metrics would be evaluated to determine if increases in chlorophyll *a* are

adversely affecting other biota, specifically BMI and Arctic Char. It is anticipated that BMI metrics would be the most sensitive for evaluating these linkages;

- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP;
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required; and
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the high action level response has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in chlorophyll *a* on the lakes as a whole and because the benchmark may need to be revised in consideration of ongoing monitoring results. Increases in nutrients and primary productivity may lead to increased productivity in other trophic levels, such as fish, which is an effect that can be perceived as positive. The precise relationships between nutrients, phytoplankton, and higher trophic levels is difficult to predict and it is therefore suggested that actions undertaken under the moderate action level response will attempt to explore these relationships to advise on overall effects to the ecosystem. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) include:

- Analysis of phytoplankton samples collected from Mine Area lakes for biomass and taxonomy (i.e., samples will be collected and archived under the CREMP). This information would provide additional data regarding phytoplankton abundance (i.e., biomass) as well as information to characterize the community composition. Derived metrics such as diversity, richness, and evenness could be examined to evaluate shifts in the phytoplankton communities that may trigger cascading effects across trophic levels. This information may be useful in exploring causes or pathways of effects across higher trophic levels if they are observed (e.g., changes in BMI communities);
- Implementation of increased monitoring to confirm effects and/or define magnitude and spatial extent of effects if warranted; and
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response.

3.0 BENTHIC MACROINVERTEBRATES

The following section provides a description of monitoring of BMI under the CREMP, with an emphasis upon monitoring of lakes in the Mine Area, where potential for sedimentation and eutrophication is greatest and where Arctic Char overwinter.

3.1 PATHWAYS OF EFFECT AND KEY QUESTIONS

Key questions were developed for the CREMP to guide the review of baseline data adequacy (see Appendix 1 for details) and, ultimately, design of the monitoring program. These questions and metrics focus upon key potential effects identified in the FEIS, as well as metrics commonly applied for characterizing the BMI community.

The key pathways of potential effects of the Project on the BMI community include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (Mine Area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Changes in sediment quality due to effluent discharge and/or dust deposition;
- Dust deposition in aquatic habitat (i.e., sedimentation); and
- Effects of the Project on primary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, aquatic habitat loss or alteration, sedimentation, and changes in primary producers on BMI abundance and community composition in Mine Area lakes?

3.2 COMMUNITY METRICS

The review of existing baseline data (through 2011; see Appendix 1) evaluated a number of BMI metrics for inclusion in the CREMP, including: abundance (total macroinvertebrate density [individuals/m^2±SE])); composition (Chironomidae proportion [% of total density], Shannon’s Equitability [evenness], and the Simpson’s Diversity Index); and richness metrics (total taxa and Hill’s Effective richness, both at the genus level); Magurran 1988, 2004). The variability of the BMI metrics measured during the baseline studies program were evaluated and described to assist with identifying the most robust metrics for further statistical exploration and consideration under the CREMP. The least variable metrics identified for both Mine Area lakes and streams through this process were:

- Chironomidae proportion;
- Shannon’s Equitability;
- Simpson’s Diversity Index; and
- Total Taxa Richness.

Total macroinvertebrate density was associated with a relatively high variability in all lake habitat types and stream reaches. However, this metric was retained as it is one of the most commonly used indicators of the status of benthic macroinvertebrate communities in waterbodies.

3.3 BENCHMARKS

Unlike water or sediment, where protection of aquatic life guidelines may be used to develop triggers or thresholds for effects assessment, there are no universal benchmarks for biological variables such as abundance or diversity. Rather, the magnitude of change or difference relative to expected conditions is typically used to establish CESs for biological variables.

Environment Canada (EC 2012) identifies CESs for a BMI metric as multiples of within-reference-area standard deviations (i.e., ±2 SD]). As for fish, confirmed effects are based on the results of two consecutive surveys.

Recent and ongoing monitoring programs in northern Canada have identified effects sizes and/or benchmarks for BMI using different approaches. For the Diavik Diamond Mine, a significant adverse effect as it relates to aquatic biota was defined in the Environmental

Assessment as a change in fish population(s) that is greater than 20% (Government of Canada 1999). This effect must have a high probability of being permanent or long-term in nature and must occur throughout the receiving environment (Lac de Gras). The “Significance Thresholds” for this AEMP, therefore, are related to impacts that could result in a change in fish population(s) that is greater than 20% (Golder 2014).

Azimuth (2012) recommended the application of a 20% effect size as a monitoring “trigger” and a 50% effect size as a monitoring “threshold” for BMI metrics for the Meadowbank Mine Project (i.e., total abundance and richness), where effect size refers to a change or difference relative to BACI. They further note that the terms “threshold” and “trigger” are intended to be applied less strictly for biological variables, relative to chemical variables such as water or sediment quality, due to the inherent natural variability in biological parameters and the need to consider the cause of any observed statistical “changes” in the biological communities. The rationale provided for the identification of the 20% and 50% criteria is “to maintain a transparent (fixed) effect size that is more likely to be ecologically relevant.” Where natural variability is high, use of two standard deviations for benthic invertebrate metrics could potentially mean that large and ecologically-relevant effects could occur to some endpoints without being higher than the CES. On the other hand, the limitation of using percentage change to define the CES for a metric when variability is high is reduced statistical power to detect change. Integral to this discussion is the importance of considering the variability in existing data in identifying appropriate CESs.

With respect to the Mary River Project, development of a benchmark(s) or CES(s) for the BMI that is adequately sensitive and ecologically appropriate considered:

- Natural variability in existing BMI metrics;
- the available baseline data set (i.e., baseline BMI community sampling has only been conducted once or twice at the majority of Mine Area lakes/streams and/or aquatic habitat types); and
- Literature in which benchmarks or CESs for BMI metrics have been adopted or identified, such as AEMPs for the Diavik Diamond Mine and Meadowbank projects.

The benchmark for the BMI program that will be conducted under the CREMP is a change of ± 50% in the mean of key metrics. A preliminary assessment of the statistical power of baseline data (see Appendix 1) indicated that the power of the data sets for a representative lake (Sheardown Lake NW) and stream (Sheardown Lake Tributary 1, Reach 4) to be able to detect a post-Project change in the mean of ± 50% was, with the exception of total macroinvertebrate density, high for the majority of metrics investigated (Tables 3-1 and 3-2). More sensitive metrics to change were identified and these include Chironomidae proportion, Shannon’s Equitability, Simpson’s Diversity Index, and total taxa richness. In before-after comparisons of metrics, the power to detect differences is greater when there are more monitoring events in the before and after periods included in the analysis. Overall, it is expected that the CREMP will be capable of detecting larger impacts in a short time period, but will require longer time periods to detect more subtle effects (i.e., as more data are acquired).

3.4 MONITORING AREA AND SAMPLING SITES

The monitoring area for BMI includes Mine Area lakes, specifically Camp, Sheardown NW and SE, and Mary lakes (Figure 3-1), and Sheardown Lake tributaries 1, 9, and 12, several sites on the Mary River located upstream and downstream of effluent discharges, and Camp Lake tributaries 1 and 2 (Figure 3-2). Although monitoring will be conducted in areas of the Mary River and Camp Lake Tributary 1 under the Metal Mining Effluent Regulations (MMER) Environmental Effects Monitoring (EEM) program (Appendix A of the AEMP), additional monitoring in these waterbodies is proposed under the CREMP to augment the EEM monitoring program. In addition, monitoring will be conducted at a minimum of one reference lake and one reference stream.

3.4.1 Lakes

Based on habitat types identified from previous field studies, Habitat Type 9 (5 nearshore replicate stations) and Habitat Type 14 (5 offshore replicate stations) will be sampled in each of the Mine Area and reference lakes (total of 10 replicate stations per lake; Figure 3-1). Each replicate station will consist of five benthic macroinvertebrate field sub-samples/grabs. Replicate stations will be consistent with sediment quality sampling locations where feasible to provide supporting information for interpretation and analysis of results (e.g., metals concentrations).

Field crews will verify the aquatic habitat attributes of replicate stations (i.e., appropriate water depth, substrate type, and presence/absence of aquatic macrophytes) prior to sample collection.

3.4.2 Streams

Five replicate stations separated by approximately three wetted stream widths will be sampled in each stream reach (Figure 3-2). Each replicate station will consist of five benthic macroinvertebrate field sub-samples. Sub-samples will be collected moving in an upstream direction and, whenever possible, they will be collected from representative microhabitats across the stream.

3.5 SAMPLING FREQUENCY AND SCHEDULE

Sampling will be conducted in the first three years of operation during the ERP of the Project; subsequent sampling and sampling frequency will be evaluated following completion of the first 3 years of monitoring and in consideration of the current plans for mining activities at that time (e.g., will mine production be increased or remain at a similar level). Sampling frequency will be evaluated (i.e., each year of monitoring) to determine if modifications are warranted.

Timing of sampling will be concentrated within a single sampling season (i.e., late summer/fall). Benthic invertebrate sampling has been consistently conducted in the Mine Area in late summer/fall, which is an ecologically relevant time for sampling and is most appropriate considering the effluent discharge regime (i.e., discharge during the open-water season only), hydrology (i.e., streams/rivers freeze solid), and dust deposition (i.e., introduction during the open-water season).

3.6 FIELD AND LABORATORY METHODS

Sampling methods for BMI and supporting variables are indicated below. BMI samples will be submitted to an analytical laboratory for processing and taxonomic identification. Laboratory methods for BMI samples will be in accordance with guidance provided in EC (2012). Samples for analysis of supporting sediment variables (i.e., particle size, TOC) will be submitted to an analytical laboratory accredited under CALA.

3.6.1 Lakes

By EEM definition, a replicate station is a specific, fixed sampling location within an area/polygon that can be recognized, re-sampled and defined quantitatively (e.g., UTM position and a written description). The geographic extent of each replicate station will be minimally 10 m x 10 m and separated from other replicate stations by at least 20 m. Within each habitat type(s), a replicate station will consist of five randomly collected benthic invertebrate sub-samples. Field sub-samples will be collected using a random number table and from designated sampling locations around an anchored boat within the 10 m x 10 m replicate station area.

For each field sub-sample/grab:

1. The petite Ponar (area of opening 0.23 m^2) will be slowly lowered until it rests on the bottom to prevent shock waves that could physically move or disturb organisms and sediment from beneath the sampler.

2. The petite Ponar will be closed using a messenger.

3. The petite Ponar will be slowly raised, to minimize turbulence, and the sample will be immediately placed into a pail.

4. An acceptable sample requires that the jaws be completely closed upon retrieval.

5. If the jaws are not completely closed the sample will be discarded into a bucket (and disposed of once sampling is completed) and the procedure will be repeated.

6. The depth of penetration of each successful sample will be recorded; grab sample penetration of approximately 6-8 cm substrate-depth will be considered an acceptable sample.

All sampling equipment will be rinsed before sampling at the next replicate station.

Benthic invertebrate samples will be carefully sieved through a 500 µm mesh rinsing bucket. All materials, including invertebrates, retained by the screen will be transferred to labelled plastic jars and fixed with 10% buffered formalin. Fixed and labelled samples will be shipped to the analytical laboratory for processing and archiving.

3.6.2 Streams

Five replicate stations separated by approximately three wetted stream widths will be sampled in each stream reach. Each replicate station will consist of five benthic macroinvertebrate field sub-samples. Sub-samples will be collected moving in an upstream direction and, whenever possible, they will be collected from representative microhabitats across the stream.

Each sub-sample will be collected by placing a Surber sampler (the sampling equipment used during the baseline field programs) on a flat area of the streambed, facing upstream. The surface area sampled by the Surber sampler is equivalent to 0.097 m^2. Macroinvertebrates will be collected over a two minute time period by rubbing the rocks and disturbing the sediment in the substrate area framed by the Surber net. All sub-samples will be rinsed from the netting into a 500 µm sieve. Forceps will be used to collect any macroinvertebrates remaining on the netting after rinsing. The sample will then be washed, transferred into a sample jar, and fixed as soon as possible in 10%

buffered formalin. Fixed and labelled samples will be shipped to the analytical laboratory for processing and archiving.

3.6.3 Supporting Environmental Variables

Supporting environmental variables will be measured in order to link aquatic habitat attributes with benthic invertebrate community metrics. Supporting environmental variables measured at each replicate station will include:

- Sample date and start/end sample time;
- UTM position (using a hand-held GPS receiver);
- Water transparency (using a Secchi disk; lakes only); and
- Water temperature (using a hand-held thermometer for water surface measurement).

Supporting environmental variables measured/recorded at each sub-sample/grab site will include:

- Water depth (using a hand-held depth sounder or metered petit Ponar rope);
- Presence/absence of aquatic macrophytes in sub-sample;
- Substrate composition (visual description e.g., % cobble, gravel, silt, etc.) and compaction (soft, medium) of sub-sample. A visual description of benthic grab samples should be recorded to describe sediment colour, odour, texture (e.g., % sand, silt, clay, etc.) and debris content (e.g., woody debris, aquatic macrophyte, etc.); and
- Depth of penetration (cm) of each successful sub-sample/grab.

One grab sample will be collected for sediment from each replicate station for a total of five sediment samples per aquatic habitat type (lakes, streams where feasible). Each sediment grab will be sub-sampled with a 5 cm diameter core tube (0.002 m^2 surface area) to provide a sample of approximately 100 mL of sediment for the analysis of supporting variables (i.e., total organic carbon and particle size). Additionally, DO, pH, conductivity, temperature, and turbidity will be measured *in situ* near the sediment-water interface at each replicate station (lakes, streams where feasible).

3.7 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC procedures for benthic macroinvertebrate field operations, laboratory operations (sorting efficiency, sub-sampling), and data handling will conform to current EEM recommendations provided in EC (2012).

3.8 STUDY DESIGN AND DATA ANALYSIS

As existing baseline data for potential reference lakes and streams are minimal, the monitoring program will focus upon before-after comparisons of key metrics within the Mine Area waterbodies. The overall objective of this program is to collect habitat-based abundance, composition, and distribution information for the BMI community across a range of habitat types in the Mine Area lakes and streams.

For Sheardown Lake NW, Sheardown Lake SE, Camp, Mary, and reference lakes, major nearshore and offshore habitat types (5 replicate stations per habitat type) will be sampled. Based on habitat types identified from previous field studies, one nearshore and one offshore habitat type would be sampled in each of the Mine Area lakes (total of 10 replicate stations per lake) to provide information on habitat-based abundance, composition, and distribution of benthos. For Sheardown Lake tributaries 1, 9, and 12, Camp Lake tributaries 1 and 2, and the Mary River, representative stream reaches (5 replicate stations per reach) will also be sampled.

To prepare the data for analysis, the abundance of macroinvertebrates in each replicate will be converted to density (number of invertebrates per square meter [individuals/m^2]) by dividing the total number of invertebrates per sample by the bottom area of the sampling device (0.023 m^2 for Ekman and petit Ponar dredge; 0.97 m^2 for Surber sampler). Benthic invertebrate metrics will be calculated for each replicate and included in statistical analyses to describe the community. Metrics will be plotted as box plots to visually assess the occurrence of extreme outliers and to provide a preliminary visual assessment of potential spatial and/or yearly differences. Summary statistics (n, mean, median, SD, standard error [SE], minimum, maximum, and 95^{th} percentile) for each metric will be derived for each lake by aquatic habitat type and by year, and for each stream by reach and by year to examine spatial and inter-annual differences. Efforts will be made to include as many taxa as possible in the analysis; however, Diptera, Chironomidae and Empididae pupae will be excluded from metric calculations where genus level identifications are used (e.g., evenness, Simpson's Diversity Index). Taxonomic richness (i.e., the number of taxa) is determined at the genus level. If a group is identified to a higher level (e.g., class or order), then it will be assumed that only one genus is represented and this may result in a conservative estimate of the number of taxa; pupae will not be included in the determination of richness.

Additionally, the number of field sub-samples (i.e., grabs) per replicate station that would provide an estimate with 20% precision (i.e., an acceptable level of variance) for each metric will be determined for each lake by aquatic habitat type and year. The number of field sub-samples will be calculated as follows:

$n = s^2 / D^2 * X^2$

where:

X = the sample mean

n = the number of field sub-samples

s = the sample variance

D = the index of precision (i.e., 0.20)

Inter-annual differences in macroinvertebrate metrics will be assessed statistically for each lake by habitat type and for each stream by reach (where multiple years of data are available). All data will be tested for normality prior to statistical analysis and data that are normally distributed will be assessed using parametric statistics while non-normally distributed data will be analysed using non-parametric tests. Differences between years (and before-after comparisons) will be assessed using the t-test (parametric) or Mann-Whitney U-test (non-parametric) when two years of data are available; ANOVA with Bonferroni pairwise comparison (parametric) or Kruskal-Wallis test followed by multiple pairwise comparison (Dunn's procedure) (non-parametric) will be used when three years of data are available. All tests will be assessed with a significance level of 0.05.

3.9 ASSESSMENT FRAMEWORK

BMI data will be assessed during each year of monitoring and would follow the assessment framework as outlined in Figure 2-2 and described below.

3.9.1 Step 1: Initial Data Analysis

Section 3.3 provides a description and rationale for the development of a benchmark for BMI metrics (change in the mean of ± 50%). As existing baseline data for potential reference lakes and streams are minimal, the monitoring program will focus upon before-after comparisons of key metrics within the Mine Area waterbodies, with an emphasis on Mine Area lakes. As additional data are acquired from reference waterbodies, comparisons to these datasets may also be undertaken in the future.

Step 1 will involve preparing the BMI data for analysis (i.e., convert number of macroinvertebrates to density), calculating metrics for each replicate station, preliminary review of data through graphical presentations (e.g., box plots) to visually assess the occurrence of extreme outliers and potential spatial and/or yearly differences, calculation of summary statistics, and statistical comparisons between baseline data and monitoring data for each lake by aquatic habitat type, and each stream by reach (and by year when data are available). Summary statistics for each metric will be derived for each lake by aquatic habitat type, and each stream by reach.

Statistical comparisons will be done by metric based on data collected in each aquatic habitat/reach pre- and post-Project for each Mine Area lake/stream. Data would then be compared to the benchmark (change in the mean of ± 50% as described in Section 3.3). If there is no evidence of change for any metric, no management response would be required; however, spatial and temporal analyses would be continued. In this instance, more robust metrics would be plotted graphically or in table format to facilitate visual analysis of changes over time and assessment of whether there is an upward or downward change that may suggest mounting effects. If there is evidence of a change for any metric, the assessment would proceed to Step 2 to determine if the change is Mine-related.

3.9.2 Step 2: Determine if Change is Mine-Related

Step 2 involves determining whether the evidence of change in a BMI metric(s) is related to the Project, other causes, or natural variability. This question will be addressed through several possible approaches:

- Evaluating spatial patterns for metric results for the Mine Area as a whole, including Mine Area lakes and streams (CREMP and EEM results), to evaluate if changes are widespread or specific to certain waterbodies (i.e., identify the spatial extent and pattern of observed changes). This exercise would assist with identifying potential stressors/pathways of effects;
- Comparing data from Mine Area lakes to reference lake(s) and potentially data from Mine Area streams to reference streams. This would further assist with determining whether the observed changes were related to natural variability or the Project;

- Evaluating other factors that may affect the BMI community such as water quality, sediment quality, and physical habitat attributes; and
- Evaluating Project activities with the potential to alter water quality and/or other conditions that could ultimately affect the benthic macroinvertebrate community. This may include evaluating effluent quality, discharge regime/rates, and loading, notably in relation to sewage effluent, dust deposition, and other point/non-point sources as required.

If the Step 2 analysis concludes that the changes in one or more BMI metrics are, or are likely, related to the Project, the assessment would proceed to Step 3. If it is concluded that it is unlikely that the changes are related to the Project, no management response would be required; spatial and temporal analyses would be continued as in Step 1.

3.9.3 Step 3: Determine Action Level

Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark (change in the mean of ± 50% as described in Section 3.3). If the benchmark is not exceeded the assessment would proceed to a low action level response; if it is equalled or exceeded, the assessment would proceed to a moderate action level response.

If the benchmark is not exceeded, a low action level response would be undertaken and may include:

- Conduct a spatial and temporal analysis – this will be a qualitative exercise and consist of graphical presentation of data for each lake (by aquatic habitat type) and over time within a lake (by aquatic habitat type) to evaluate differences among lakes and changes within a lake over time. It is important to note that several years of data will be required to begin to assess temporal trends;
- Investigate and summarize potential relationships to the Project and pathways of effect for the observed changes;
- Review and summarize monitoring results for other metrics of relevance to the BMI community, including nutrients, water clarity, DO, and sediment quality (including sedimentation). Spatial and temporal analysis results for these metrics, notably eutrophication and sedimentation, will also be considered in the interpretation of BMI monitoring results;
- Review/assess benchmark with acquisition of data (note: this will be undertaken over the course of monitoring). This may include performing a power analysis to assess the power of the current data set for detecting post-Project change (i.e.,

Before-After comparisons) and explore samples sizes (i.e., number of replicate stations within an aquatic habitat type) required for detecting pre-defined levels of change; and

- Based on the above evaluations, determine next steps.

If the benchmark is met or exceeded, a moderate action level response would be undertaken and may include the following:

- Evaluate chemical, biological, and physical monitoring results collectively with BMI monitoring results to evaluate effects on the ecosystem. For example, key metrics would be evaluated to determine if any observed increases in chlorophyll *a* are adversely affecting other biota, specifically BMI and Arctic Char;

- Evaluate the need for additional monitoring (e.g., targeted studies to confirm monitoring results) and/or modifications to the CREMP;

- Consider results of the temporal analysis (i.e., analysis indicates a substantive change) to determine if management/mitigation is required;

- Evaluate the benchmark to determine if it should be modified, as described above; and

- Identify next steps based on the above analyses. Next steps may include those identified for a high action level response.

A quantitative trigger (i.e., threshold) for a high action level response has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed changes in BMI metrics on the lakes and streams as a whole and because the benchmark may need to be revised in consideration of ongoing monitoring results. For example, increases in nutrients and primary productivity (i.e., eutrophication) may lead to increased productivity in other trophic levels, such as BMI and fish, which may be perceived as a positive effect. The precise relationships between nutrients, phytoplankton, and higher trophic levels is difficult to predict and it is therefore suggested that actions undertaken under a moderate action level response attempt to explore these relationships to advise on overall effects to the ecosystem. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) include:

- Implement increased monitoring to confirm effects and/or define magnitude and spatial extent of effects if warranted; and

- Implement mitigation measures or other management actions that may be identified in a moderate action level response.

4.0 ARCTIC CHAR

The following section provides a description of monitoring of Arctic Char under the CREMP.

4.1 PATHWAYS OF EFFECT AND KEY QUESTIONS

Key questions were developed for the CREMP to guide the review of baseline data adequacy and, ultimately, design of the fish monitoring program. These questions and metrics focus upon key potential effects identified in the FEIS, as well as metrics commonly applied for characterizing fish populations (growth, reproduction, condition and survival) and recommended by EC (2012).

The key pathways of potential residual effects of the Project on Arctic Char include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (Mine Area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Dust deposition (i.e., sedimentation) in Arctic Char spawning areas (habitat) and on Arctic Char eggs; and
- Effects of the Project on primary and secondary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, sedimentation, habitat loss or alteration, and changes in primary or secondary producers on Arctic Char in Mine Area lakes (Sheardown Lake NW and SE, Camp Lake, and Mary Lake)?

Arctic Char will be monitored downstream of discharges of ore and waste rock stockpile runoff (i.e., Camp Lake Tributary 1 and the Mary River) under the MMER EEM program. A description of the MMER EEM program is provided in Appendix A of the AEMP and is not considered here. The CREMP provides a description of Arctic Char monitoring that will be conducted in addition to the MMER EEM program. The objective of the CREMP fish program is to augment monitoring in time and/or space beyond that captured by the EEM program to address all key effects pathways. For example, EEM monitoring will occur exclusively in streams, but Mine Area lakes, which provide overwintering and spawning habitat and support a broader range of age classes than streams, may be affected by the Project differently than streams.

4.2 PARAMETERS AND METRICS

The Mine Area streams and lakes support only two fish species: land-locked Arctic Char; and, Ninespine Stickleback (*Pungitius pungitius*). Of these, abundance and distribution of Ninespine Stickleback are relatively limited and highly localized while Arctic Char are overwhelmingly the most abundant and widely distributed fish species in the area. As Mine Area streams freeze solid during winter, overwintering habitat is provided exclusively by lakes.

EC (2012) recommends monitoring of sexually mature individuals of a minimum of two fish species for EEM programs and use of invasive sampling (i.e., lethal) if acceptable. Alternative study designs include non-lethal sampling methods for fish populations/communities, as well as studies of juvenile fish if appropriate and/or required.

Given that there are only two fish species present in the area, fish monitoring in the Mine Area would be limited to successful capture of sufficient numbers of both of these fish species in the exposure areas. In most lakes and streams in the exposure area, Arctic Char are sufficiently abundant that successful capture of enough fish for monitoring purposes is possible. In contrast, Ninespine Stickleback are absent or uncommon in a number of waterbodies. It is unlikely, even with extensive effort, that sufficient numbers of Ninespine Stickleback could be captured for monitoring purposes from either the receiving environments or from prospective reference areas. For these reasons only a single species, Arctic Char, will be targeted under the CREMP program.

Non-lethal sampling methods will be used to the extent possible to minimize impacts of monitoring on the Arctic Char populations. As a result, metrics that can be reliably obtained from live fish will be included in CREMP. Metrics will include indicators of fish growth, condition, and reproduction.

EC (2012) recommends that non-lethal sampling should include fork length for fish with a forked caudal fin (± 1 mm), total body weight (± 1.0%), assessment of external condition (i.e., deformities, erosion, lesions, and tumours [DELTs]), external sex determination (if possible), and age (where possible; ± 1 year). Metrics based on these measurements that will be examined under the CREMP are indicated in Table 4-1. In addition, catch-per-unit-effort (CPUE) will be calculated and examined in the analysis and reporting as a general indicator of abundance.

4.3 BENCHMARKS

Although there are no established benchmarks for biological variables (e.g., abundance), including fish, that can be readily adopted or considered for monitoring effects on freshwater biota, CESs for selected biological metrics are prescribed in the MMER EEM Guidance Document (EC 2012) and have been proposed and applied in other recent monitoring programs that fall outside of MMER EEM requirements, such as the DDMI project (Golder Associates 2014).

A revised AEMP was recently issued for the DDMI Project at Lac de Gras, NT, which includes lethal monitoring of the fish community (Golder Associates 2014). Effects and subsequent action levels associated with the fish community monitoring represent a range, as follows (note action level 4 is not defined):

- statistical differences relative to reference areas (action levels 1 and 2) where effects indicate a toxicological response;
- metrics beyond the normal range (action level 3); and
- benchmark of "indications of severely impaired reproduction or unhealthy fish likely to cause a > 20% change in fish population(s)" (action level 5).

The MMER identifies CESs for a fish population as a percentage of change from the "reference mean" (Table 4-2). As noted by Indian and Northern Affairs Canada (INAC 2009), "these effect sizes do not reflect the method recommended by Environment Canada (2004); namely effect sizes that correspond with unacceptable ecological changes." INAC (2009) also notes that Environment Canada (2008) identified these CESs "in the absence of clear scientific understanding of the long-term implications of these effects". However, as further noted by INAC (2009) these CESs "may serve as a starting point for discussions on acceptable effect sizes that occur during AEMP development".

As it is not possible to identify a level of change in Arctic Char population metrics that would be indicative of long-term effects or "unacceptable ecological changes" for the Mine Area fish populations, the CREMP will initially apply the recommended benchmarks developed for MMER EEM (Table 4-2). However, it is recommended that the applicability/appropriateness of these benchmarks be reviewed on a regular basis and, if appropriate, modified as the CREMP progresses. The management response framework should also be regularly reviewed and adjusted over time to ensure the program is effective, sensitive, and ecologically meaningful.

4.4 MONITORING AREA AND SAMPLING SITES

The monitoring area for Arctic Char includes Mine Area lakes, specifically Camp and Mary lakes, and Sheardown Lake NW and SE. Monitoring of lakes is a key component of the CREMP because the Mine Area lakes provide overwintering and spawning habitat, support the full range of age classes, and because they may be affected differently than streams. In addition, monitoring will be conducted at a minimum of one reference lake.

4.5 SAMPLING FREQUENCY AND SCHEDULE

Sampling will be conducted in the first three years of operation during the ERP of the Project; subsequent sampling and sampling frequency will be evaluated following completion of the first 3 years of monitoring and in consideration of the current plans for mining activities at that time (e.g., will mine production be increased or remain at a similar level). Sampling frequency should be regularly evaluated (i.e., each year of monitoring) to determine if modifications are warranted. Monitoring will be conducted in late summer/fall near the end of the growing season.

4.6 FIELD METHODS

4.6.1 Lakes

The lake-based Arctic Char sampling program is designed to be non-lethal and is based upon Environment Canada's EEM survey design (EC 2012). As such, the lake-based sampling program is focused upon obtaining measures of metrics for Age 1+ and young of the year (YOY) fish using standardized sampling methods (i.e., standard gang index gillnetting and shoreline backpack electrofishing). The program will include sampling in major habitat types in each of the lakes defined in terms of water depth and substrate as follows:

- Deep (> 12 m)/hard;
- Deep/soft;
- Shallow (2-12 m)/hard; and
- Shallow/soft.

Capture of smaller fish (age 0+ and 1+) will be conducted through targeted sampling in nearshore habitats. Gear will include standard gang index gill nets and nearshore backpack electrofishing to obtain the required minimum target sample size (100 fish) and range of fish ages/sizes. Small mesh nets (i.e., Swedish nets) may also be employed, but based on field programs conducted to date, are not anticipated to be a key gear type for this program.

Fish will be identified to species, enumerated by location, and measured for fork length (±1 mm), round weight (±1%), examined for (DELTs, and where possible, sex and maturity. Metadata that will be recorded will include site UTMs, date and time of net deployment and retrieval (or start and end time of electrofishing), and water temperature. Mortalities will be retained and examined internally to determine sex and state of sexual maturity (i.e., had never spawned, preparing to spawn in the current year, had just completed spawning in the current year, or had spawned in a previous year but would not be spawning in the current year), where possible.

The preferred structure for ageing Arctic Char is the otolith (Baker and Timmons 1991). However, where non-lethal sampling methods are employed, fish are typically aged with pectoral fin rays. The results of a study comparing pectoral fin rays and otoliths for ageing Arctic Char in the mine area indicates that the former method underestimates fish ages (NSC 2014). Based on this study, pectoral fin rays will be collected from live fish but a sub-sample of Arctic Char will be sacrificed for collection of otoliths for age validation. Additional comparison of these two ageing structures may be undertaken to determine if a conversion factor can be developed for application in future monitoring.

4.7 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The QA/QC program will include the following components:

- Application of established sampling protocols;
- Review of data for transcription errors, omissions, and outliers; and
- QA/QC of fish ageing data.

A minimum of 10% of fish ageing structures will be aged by a second technician.

4.8 STUDY DESIGN, DATA ANALYSIS, AND SAMPLE SIZE

The study design is a non-lethal fish survey, which would consist of a lake-based program in late summer/fall using a combination of gear types.

Review of baseline data for Arctic Char was conducted in 2013 to advise on a study design for the CREMP (NSC 2013). This review indicated that the recommended sample size of 100 fish in the EEM Guidance Document (EC 2012) would be more than adequate to detect low levels of change in Arctic Char length, weight, and condition factor.

Arctic Char metrics will be statistically assessed against baseline data in the initial years of operation. Once sufficient data are acquired for the reference waterbody, statistical comparisons to Mine Area waterbodies may be undertaken under the CREMP. Trends will also be examined over time to determine if fish metrics are increasing or decreasing.

Data analysis methods will follow guidance provided by EC (2012) and will include preliminary review of data for identification of outliers, calculation of summary statistics, and conduct of statistical comparisons to baseline data. Statistical analyses will vary depending on the metric but will include ANOVA, analysis of covariance (ANCOVA), and the Kolmorgorov-Smirnov test. If required, data transformations and/or non-parametric methods will be employed. All tests will be assessed with a significance level of 0.05.

4.9 ASSESSMENT FRAMEWORK

Monitoring data will be assessed during each year of monitoring and would follow the assessment framework as outlined in Figure 2-2 and described below.

4.9.1 Step 1: Initial Data Analysis

Step 1 would involve collation and QA/QC review of data, preliminary review of data through graphical presentations to assist with identification of outliers, calculation of summary statistics, statistical comparisons to baseline and/or reference area data, and comparison to the benchmarks. Statistical comparisons between pre- and post-Project data (i.e., before-after comparisons) will be undertaken initially. However, as data are acquired at the reference lake(s), comparisons may also be made in the future to reference areas. If this analysis indicates a statistically significant or qualitative difference between pre- and post-Project data, the assessment would proceed to Step 2. If there is no indication of change, no management response would be required.

4.9.2 Step 2: Determine if Change is Mine Related

Step 2 involves determining if the observed change in a fish metric is due to the Project or due to natural variability or other causes. This question will be addressed through several possible approaches:

- Evaluating observed changes in all of the fish metrics collectively to assist with interpretation of the results;
- Evaluating spatial patterns in results for the Mine Area as a whole to evaluate if changes are widespread or specific to certain waterbodies, and to identify the spatial extent and pattern of observed changes. This exercise would assist with identifying potential stressors/pathways of effects;
- Comparing data from Mine Area lakes to a reference lake(s). This would further assist with determining whether the observed changes were due to natural variability or the Project;
- Evaluating monitoring results from other components monitored under the CREMP including water quality, sediment quality, benthic macroinvertebrates, phytoplankton, water levels/flows, and dust deposition/sedimentation; and
- Considering supporting information such as climatological factors (e.g., length of growing season) and water temperature.

If the observed differences are not attributable to the Project, no management response would be required. If the results of this analysis indicate the changes are due or likely due to the Project, the assessment would proceed to Step 3.

4.9.3 Step 3: Determine Action Level

Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark. If the benchmark is not exceeded, a low action level response would be undertaken and may include:

- Conduct a temporal trend analysis: this will be a qualitative exercise and consist of graphical presentation of data over time to evaluate increasing or decreasing trends. It is important to note that several years of data will be required to begin to assess temporal trends;
- Investigate and summarize potential causes and pathways of effect of the observed changes;

- Review and summarize monitoring results for other metrics of relevance to Arctic Char (i.e., drivers) such as water levels and flows, water temperature, and/or chemical and other biological metrics;

- Review/assess benchmarks with acquisition of data (note: this will be undertaken over the course of monitoring); and

- Based on the above evaluations, determine next steps.

If a benchmark is exceeded, a moderate action level response would be undertaken and may include the following:

- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP;

- Consider results of the trend analysis (i.e., trend analysis indicates an upward or downward trend) to determine if management/mitigation is required;

- Consider if effects are indicative of nutrient enrichment (i.e., increased growth or productivity) or due to either a toxicological response or a physical effect such as changes in habitat; and

- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

Actions should consider whether the statistical differences and benchmark exceedances are observed in two consecutive monitoring periods to confirm the effects.

A quantitative trigger for the high action level response has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed changes and because the benchmarks may need to be revised in consideration of ongoing monitoring results and the ecological significance of the results. For example, increases in nutrients and primary productivity may lead to increased productivity in other trophic levels, such as fish, which is an effect that can be perceived as positive. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) include:

- Implement increased monitoring to confirm effects and/or define magnitude and spatial extent of effects if warranted; and

- Implement mitigation measures or other management actions that may be identified under the moderate action level response.

5.0 LITERATURE CITED

Alberta Environment. (updated 2013). Lake water trophic status. http://environment.alberta.ca/01715.html. Accessed February 22, 2014.

Baker, T.T., and L.S. Timmons. 1991. Precision of ages estimated from five bony structures of Arctic char (*Salvelinus alpinus*) from the Wood River System, Alaska. Can. J. Fish. Aquat. Sci. 48: 1007-1014.

Carlson R.E. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22: 361-369.

Environment Canada (EC). 2012. Metal mining technical guidance for Environmental Effects Monitoring. ISBN 978-1-100-20496-3.

EC. 2004. Canadian guidance framework for the management of phosphorus in freshwater systems. Ecosystem Health: Science-based Solutions Report No. 1-8. National Guidelines and Standards Office, Water Policy and Coordination Directorate, Environment Canada. 114 p.

Galvez-Cloutier R. and M. Sanchez. 2007. Trophic status evaluation for 154 lakes in Quebec, Canada: monitoring and recommendations. Wat. Qual. Res. J. Can. 42: 252-268.

Golder Associates. 2014. Diavik Diamond Mines aquatic effects monitoring program study design Version 3.4. Prepared for Diavik Diamond Mines Inc. by Golder Associates Ltd., Calgary, AB, January 2014. 318 p.

Government of Canada. 1999. The Canadian Environmental Assessment Act Comprehensive Study Report. Diavik Diamonds Project. June 1999.

Indian and Northern Affairs Canada (INAC). 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories. Yellowknife. June 2009. Volumes 1-6.

Magurran, A. E. 2004. Measuring biological diversity. Blackwell. Malden Massachusetts.

Magurran, A.E.1988. Ecological diversity and its measurement. Princeton University Press. New Jersey.

North/South Consultants Inc. (NSC). 2014. Arctic Char ageing structure comparison. Technical Memorandum prepared for Baffinland Iron Mines Inc., May 24, 2014.

NSC. 2013. Preliminary review of baseline data for freshwater biota: Mary River Mine Site. November 2013.

Nürnberg G.K. 1996. Trophic state in clear and colored, soft and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake Reserv. Manage. 12: 432-447.

Organization for Economic Cooperation and Development (OECD). 1982. Eutrophication of waters. Monitoring, assessment and control. Final report, OECD cooperative programme on monitoring of inland waters (eutrophication control), Environment Directorate. OECD, Paris. 154 p.

Ryding., S.-O. and W. Rast. 1989. *The Control of Eutrophication of Lakes and Reservoirs.* Vol. 1. UNESCO, Paris and the Parthenon Publishing, United Kingdom. 314 p.

Swedish Environmental Protection Agency (EPA). 2000. Environmental quality criteria. Lakes and watercourses. Swedish EPA Report 5050. 102 p.

University of Florida, Florida Lakewatch. 2002. Trophic state: a waterbody's ability to support plants, fish and wildlife. Gainesville, FL, USA.

United States Environmental Protection Agency (USEPA). 2009. National lake assessment: A collaborative survey of the nation's lakes. EPA 841-R-09-001. USEPA, Office of Water and Office of Research and Development, Washington, D.C.104 p.

USEPA. 1988. The lake and reservoir restoration guidance manual. 1st Ed. Prepared by the North American Lake Management Society under EPA cooperative agreement No. CR813531-0, Corvallis, OR, USA.

USEPA. 1974. National Eutrophication Survey Methods for Lakes Sampled in 1972. National Eutrophication Survey Working Paper No. 1. U.S. Environmental Protection Agency, National Eutrophication Research Program, Corvallis, OR, USA.

Wetzel, R.G. 2001. Limnology. Lake and river ecosystems. Third Edition, Elsevier Academic Press, San Diego, CA.1006 p.

Table 2-1. Lake trophic classification schemes based on chlorophyll *a* and mean concentrations in Mine Area lakes.

Lake Trophic Status: Chlorophyll *a* (µg/L)						Comments	Reference
Ultra-oligotrophic	**Oligotrophic**	**Mesotrophic**	**Meso-eutrophic**	**Eutrophic**	**Hypereutrophic**		
<1	<2.5	2.5-8		8-25	> 25	International; Alberta	OECD (1982) and AENV (2014)
	Mean: <1.7 Range: 0.3-4.5	Mean: 4.7 Range: 3-11		Mean: 14.3 Range: 3-78	Range: 100-150	International Lakes and Reservoirs (modified from Vollenweider 1979)	Wetzel (2001)
-	< 3.5	3.5-9	-	9.1-25	> 25		Nürnberg (1996)
	<2.6	2.6-6.4	6.4-20	>20			Carlson (1977)
≤2	2-5	5-12		12-25	>25	Sweden	Swedish EPA (2000)
	<2	2-7		7-30	>30	US	USEPA (2009)
	<3	3-7		7-40	>40	Florida	University of Florida (2002)
	1-3	3-8		8-25		Quebec	Galvez-Cloutier R. and M. Sanchez. 2007
Mean: <1 Max: 2.5	Mean: <2.5 Max: 8	Mean: 2.5-8 Max: 8-25		Mean: 8-25 Max: 25-75	Mean: >25 Max: >75	International	Ryding and Rast (1989)
Sheardown Lake NW Mean: 0.35							
Sheardown Lake SE Mean: 0.78							
Camp Lake Mean: 0.57							
Mary Lake Mean: 1.18							
All Lakes Mean: 0.67							

Table 2-2. Derivation of the benchmark for chlorophyll *a*.

Reference	**Chlorophyll *a* (µg/L)**	
	Maximum Oligotrophic	**Minimum Mesotrophic**
OECD (1982) and AENV (2014)	2.5	2.5
Wetzel (2001)	4.5	3
Nürnberg (1996)	3.5	3.5
Carlson (1977)	2.6	2.6
Swedish EPA (2000)	5	5
USEPA (2009)	2	2
University of Florida (2002)	3	3
Galvez-Cloutier R. and M. Sanchez. (2007)	3	3
Ryding and Rast (1989)	8	8
Mean	**3.79**	**3.62**

Table 2-3. Summary of baseline chlorophyll *a* concentrations in Mine Area lakes.

	Sheardown Lake NW			Sheardown Lake SE			Camp Lake			Mary Lake			All Lakes
	All Data (2007, 2008, 2013)	Summer	Late Summer/Fall	All Data (2007, 2008, 2013)	Summer	Late Summer/Fall	All Data (2007, 2008, 2013)	Summer	Late Summer/Fall	All Data (2007, 2008, 2013)	Summer	Late Summer/Fall	2007, 2008, and 2013
Mean	0.35	0.42	0.29	0.57	0.60	0.54	0.57	0.60	0.52	1.18	1.06	1.39	0.68
Median	0.20	0.30	0.20	0.20	0.20	0.30	0.25	0.20	0.30	1.05	1.20	0.90	0.20
Minimum	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Maximum	0.90	0.90	0.90	2.10	2.10	1.70	2.10	2.10	1.70	3.50	2.10	3.50	3.50
SD	0.24	0.28	0.19	0.60	0.67	0.54	0.59	0.67	0.51	1.00	0.80	1.33	0.73
SE	0.04	0.07	0.05	0.14	0.20	0.19	0.13	0.20	0.17	0.22	0.22	0.50	0.08
n	30	15	15	19	11	8	20	11	9	20	13	7	86
95th Percentile	0.90	0.90	0.62	1.74	1.80	1.46	1.72	1.80	1.42	1.80	2.04	3.35	2.10
97.5th Percentile	0.90	0.90	0.76	1.92	1.95	1.58	1.91	1.95	1.56	3.26	2.07	3.43	2.28
% Detections	50	67	33	53	45	63	55	45	67	70	69	71	53
COV (%)	69	66	67	105	111	100	104	111	97	85	76	96	108
Mean + 2 x SD	0.84	0.97	0.67	1.78	1.93	1.62	1.74	1.93	1.54	3.17	2.67	4.05	2.14
2 x Mean	0.71	0.84	0.57	1.15	1.20	1.08	1.13	1.20	1.04	2.35	2.12	2.77	1.35
Mean + 50%	0.53	0.63	0.43	0.86	0.90	0.81	0.85	0.90	0.78	1.76	1.59	2.08	1.02

Table 2-4. Summary of power analysis results for phytoplankton chlorophyll *a*.

Waterbody	Effect Size	Power			
		Summer		Fall	
		n = 5	n = 6	n = 5	n = 6
Sheardown Lake NW	Benchmark	1	1	1	1
	2 x Mean of Baseline	0.80	0.83	0.82	0.85
Mary Lake	Benchmark	0.94	0.68	0.77	0.67
	2 x Mean of Baseline	0.95	0.69	0.77	0.69

Table 3-1. Power of existing BMI data in Sheardown Lake NW to detect pre-defined levels of change.

Metric	Habitat Type 4 (2008; n = 8)		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	0.247	0.148	0.123
Chironomidae proportion	0.957	0.536	0.402
Shannon's Equitability	1.000	0.935	0.813
Simpson's Diversity Index	1.000	0.982	0.938
Total taxa richness	1.000	1.000	1.000
Metric	**Habitat 9 (2007 and 2008; n = 22)**		
	Mean +/-50%	**Mean +/-25%**	**Mean +/-20%**
Total macroinvertebrate density	0.807	0.387	0.282
Chironomidae proportion	1.000	1.000	1.000
Shannon's Equitability	1.000	1.000	0.999
Simpson's Diversity Index	1.000	1.000	1.000
Total taxa richness	1.000	0.992	0.943
Metric	**Habitat Type 14 (2007, 2008, 2011; n = 12)**		
	Mean +/-50%	**Mean +/-25%**	**Mean +/-20%**
Total macroinvertebrate density	0.441	0.170	0.154
Chironomidae proportion	1.000	1.000	1.000
Shannon's Equitability	0.990	0.681	0.495
Simpson's Diversity Index	0.892	0.446	0.317
Total taxa richness	1.000	0.866	0.712

Table 3-2. Power of existing BMI data in Sheardown Lake Tributary 1, Reach 4 to detect pre-defined levels of change.

Metric	**2007, 2008, 2011; n = 9**		
	Mean +/-50%	**Mean +/-25%**	**Mean +/-20%**
Total macroinvertebrate density	0.564 [1]	0.248 [2]	0.209 [3]
Chironomidae proportion	1.000	1.000	1.000
Shannon's Equitability	1.000	0.791	0.602
Simpson's Diversity Index	1.000	0.750	0.578
Total taxa richness	1.000	0.844	0.651

[1] metric not normally distributed: -50%, 0.785

[2] metric not normally distributed: -25%, 0.276

[3] metric not normally distributes: -20%, 0.109

Table 4-1. Summary of fish metrics and statistical analysis methods recommended under EEM (EC 2012). Metrics indicated with an asterisk are endpoints used for determining effects under EEM, as designated by statistically significant differences between exposure and reference areas. Other endpoints may be used to support analyses.

Effect Indicators	Fish Effect Endpoint	
	Non-Lethal Survey	Statistical Test
Growth	*Length of YOY (age 0) at end of growth period	ANOVA
	*Weight of YOY (age 0) at end of growth period	ANOVA
	*Size of 1+ fish	ANOVA
	*Size-at-age (body weight at age)	ANCOVA
	Length-at-age	ANCOVA
	Body Weight	ANOVA
	Length	ANOVA
Reproduction	*Relative abundance of YOY (% composition of YOY)	Kolmorgorov-Smirnov test performed on length-frequency distributions with and without YOY included; OR proportions of YOY can be tested using a Chi-squared test.
	OR relative age-class strength	
Condition	*Condition Factor	ANCOVA
Survival	*Length-frequency distribution	2-sample Kolmorgorov-Smirnov test
	*Age-frequency distribution (if possible)	2-sample Kolmorgorov-Smirnov test
	YOY Survival	

Table 4-2 MMER EEM Critical Effects Sizes (CES) for Fish Populations Using Non-Lethal Sampling.

Effect Indicators	Fish Effect Endpoint	CES[1]
Growth	Length and weight of YOY (age 0) and age 1+ at end of growth period	± 25%
Reproduction	Relative abundance of YOY (% composition of YOY) OR relative age-class strength	± 25%
Condition	Condition Factor	± 10%
Survival	Length or age frequency distribution	± 25%

[1] CESs are expressed as a percentage of the reference means.

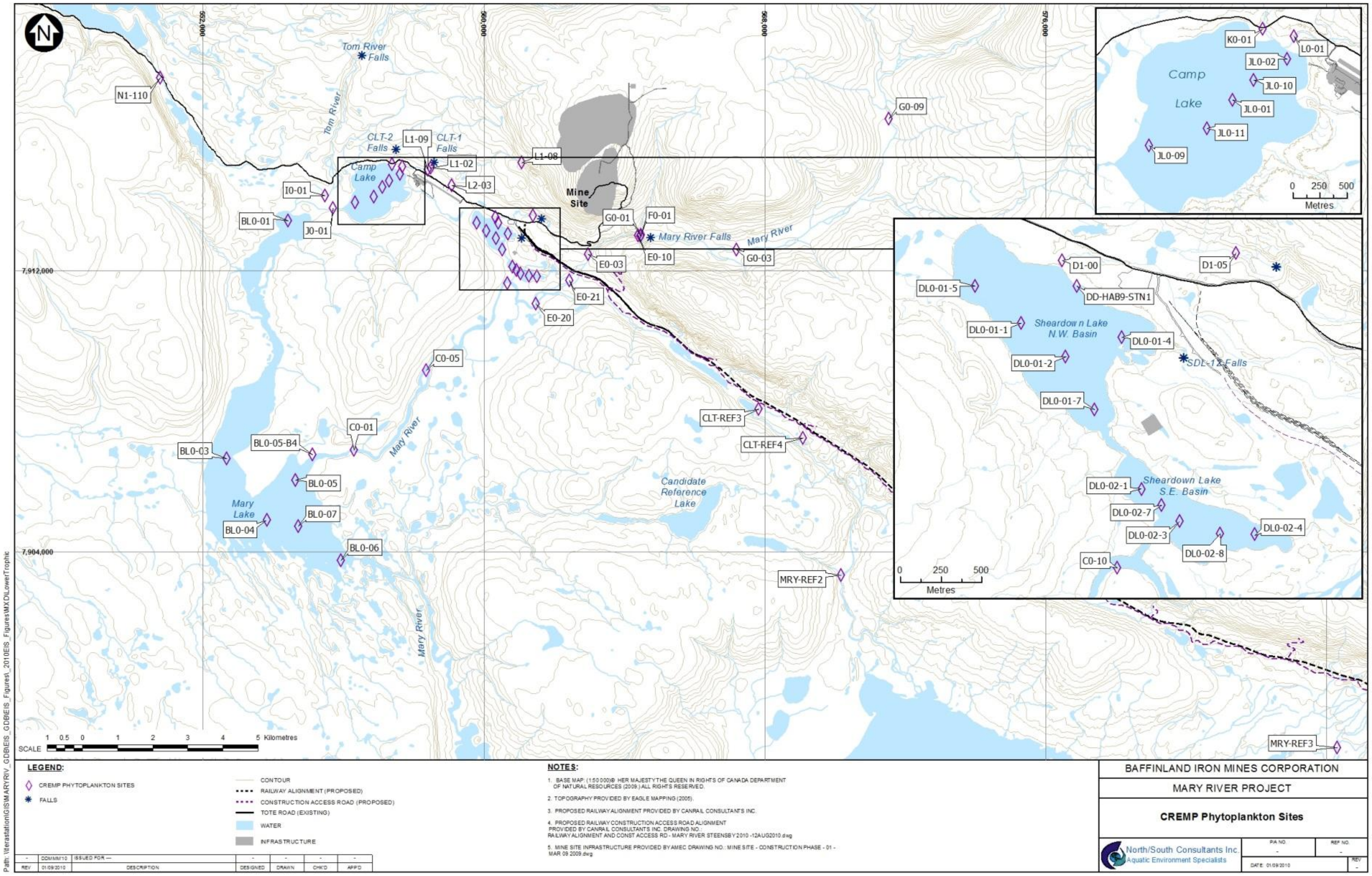
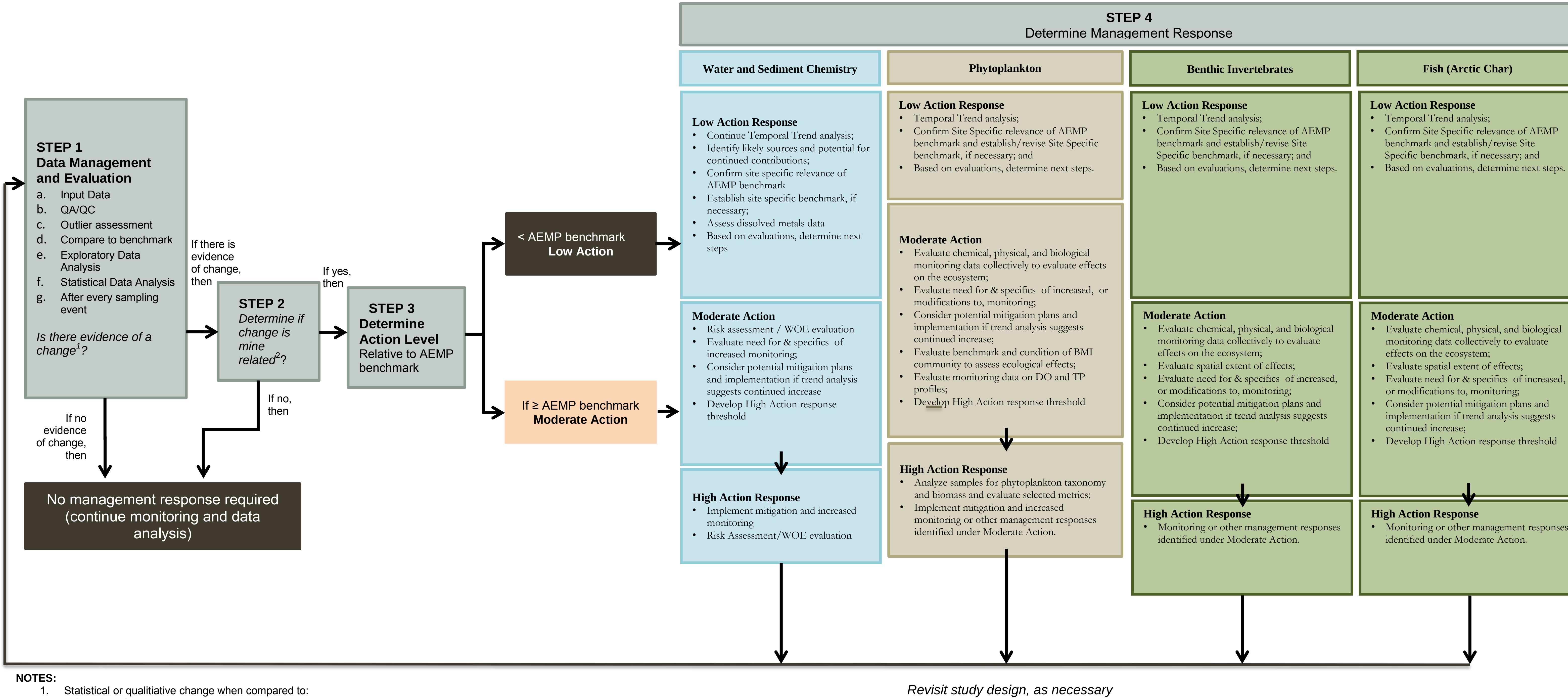


Figure 2-1. Locations of phytoplankton monitoring sites under CREMP.



NOTES:

1. Statistical or qualitiative change when compared to:
   a) benchmark,
   b) baseline values,
   c) temporal or spatial trends

2. Mine related changes are a result of the mine and associated facilities including but not limited to effects from effluent discharges and dust deposition that are distinguished from natural causes or variation

Figure 2-2. Assessment approach and response framework.

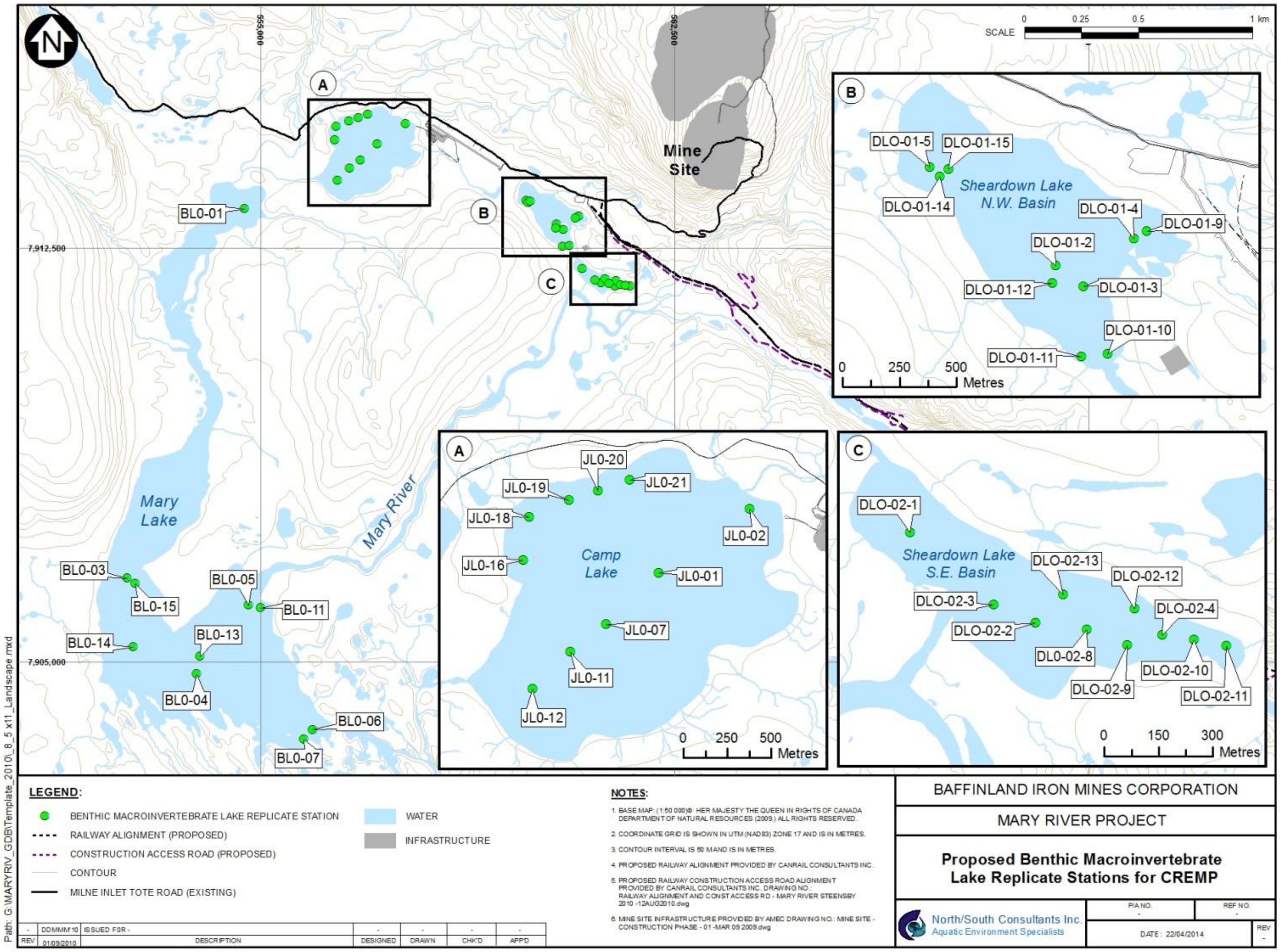


Figure 3-1. Locations of lake benthic macroinvertebrate sampling sites under the CREMP.

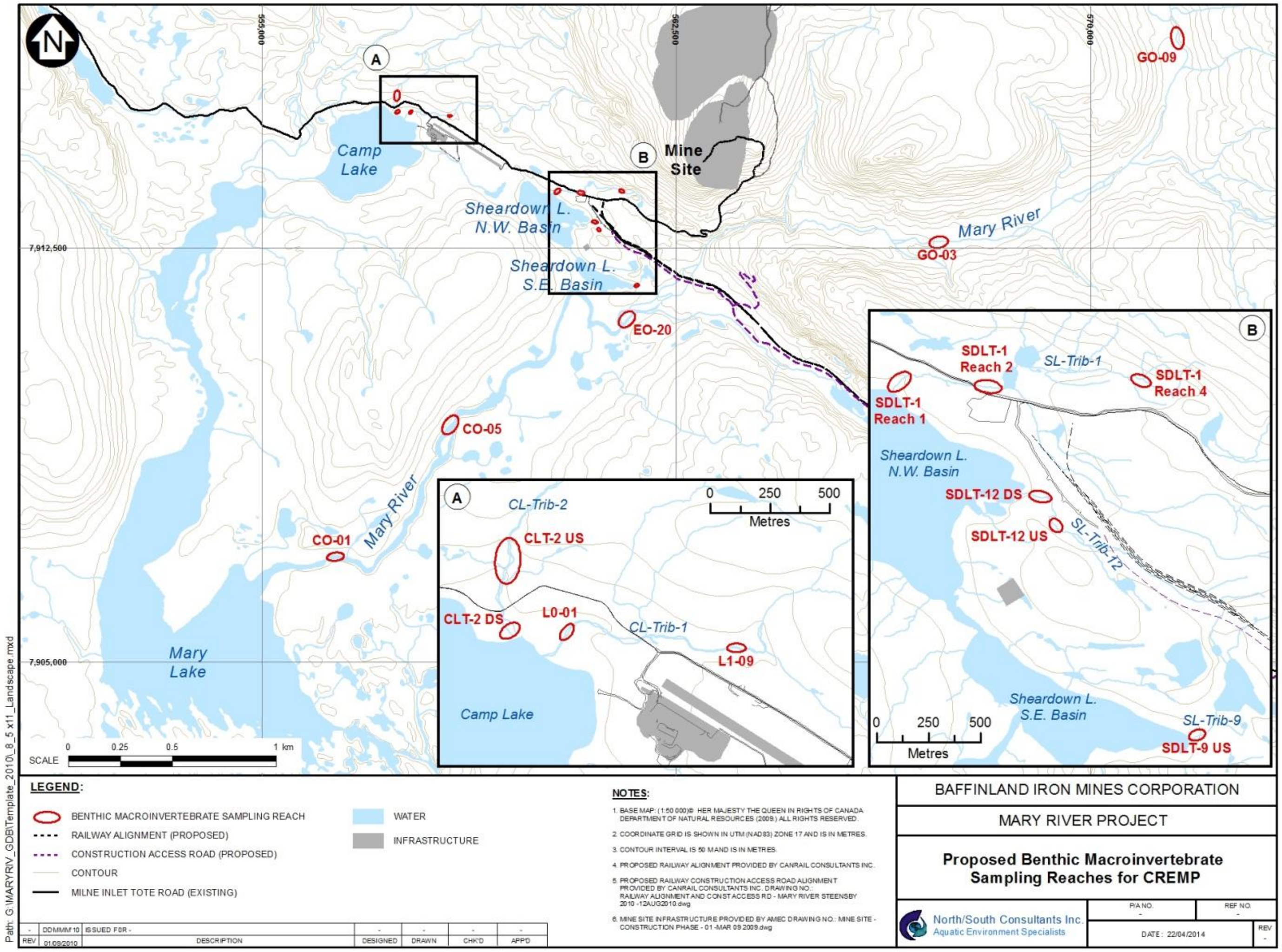


Figure 3-2. Locations of stream benthic macroinvertebrate sampling sites under the CREMP.

APPENDIX 1. REVIEW OF BASELINE DTA FOR FRESHWATER BIOTA: MARY RIVER MINE SITE.

Mary River Project

June 2014

Review of Baseline Data for Freshwater Biota:

Mary River Mine Site

North/South Consultants Inc.
Aquatic Environment Specialists

Review of Baseline Data for Freshwater Biota: Mary River Mine Site

June, 2014

Prepared by

North/South Consultants Inc.

For

Baffinland Iron Mines Corporation

North/South Consultants Inc.
Aquatic Environment Specialists

83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca

Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Program
ANOVA	Analysis of variance
ANCOVA	Analysis of covariance
ANFO	Ammonium nitrate fuel oils
BIM	Baffinland Iron Mines Corporation
BMI	Benthic macroinvertebrate(s)
CES	Critical effect size
COV	Coefficient of variation
CPUE	Catch-per-unit-effort
CREMP	Core Receiving Environment Monitoring Program
DELTs	Deformities, erosion, lesions, and tumours
EC	Environment Canada
EEM	Environmental Effects Monitoring
EF	Electrofishing
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statements
GPS	Global positioning system
INAC	Indian and Northern Affairs Canada
MMER	Metal Mining Effluent Regulations
NSC	North/South Consultants Inc.
OECD	Organization for Economic Cooperation and Development
QA/QC	Quality assurance/quality control
SD	Standard deviation
SE	Standard error of the mean
TP	Total phosphorus
TN	Total nitrogen
TSS	Total suspended solids
UTM	Universal Transverse Mercator

YOY	Young-of-the-year
ZEAS	Zaranko Environmental Assessment Services

1.0 INTRODUCTION

A desktop technical review of freshwater biota baseline data was conducted in 2013 to provide a preliminary review of the adequacy of existing baseline data for the Core Receiving Environment Monitoring Program (CREMP) component of the overall Aquatic Effects Monitoring Program (AEMP) for the Mary River Project at the mine site (North/South Consultants Inc. [NSC] 2013). This initial report was based on available baseline data for the period of 2006 through 2012 and identified data gaps and recommendations for additional baseline sampling for the 2013 field season.

This report represents an updated version of the initial baseline data review and includes results of additional data analyses undertaken during the development of the CREMP. Overviews of the field programs completed in 2013 are also provided to document additional data collected since the initial baseline review.

Biotic components reviewed included phytoplankton, benthic macroinvertebrates (BMI), and fish. The main tasks completed included:

- An inventory of sampling methods and baseline data;
- A summary of key pathways of potential effects (i.e., linkages) and development of key questions to advise on study design for the CREMP;
- A review existing baseline data, including variability of the datasets and sampling design (i.e., sampling sites, frequency, and methods):
- Identification of key metrics for consideration under the CREMP and for exploratory statistical analysis;
- Exploratory power analyses of baseline data for key areas and key metrics to assist with:
    - Evaluation of the power of the existing data for post-Project comparisons;
    - Identification of sample sizes for the CREMP;
    - Identification of the most sensitive metrics for the CREMP; and
    - Development and evaluation of critical effects sizes (CESs) or “benchmarks” for the CREMP.

- Identification of issues that could affect use of data for post-Project monitoring; and
- A review of sampling design and methods.

Sampling methods and baseline data inventories were prepared for Mine Area lakes and streams based on all sampling completed through 2013. However, the detailed review of baseline data (i.e., statistical analyses) focused primarily upon the period of 2007-2012; most results of sampling conducted in 2013 were not available for analysis at the time of preparation of this report. Data collected in 2013 included in this review are restricted to results for chlorophyll *a* sampling conducted in Mine Area lakes and streams.

2.0 PHYTOPLANKTON

The following sections provide an inventory of available baseline phytoplankton data, a description of key pathways of effect and key questions respecting the Project, a detailed examination of baseline phytoplankton data, a review of sampling sites, methods, and frequency, and a summary of sampling completed in 2013.

2.1 INVENTORY OF FRESHWATER BASELINE DATA

The following sections provide an inventory of existing baseline data for phytoplankton in the Mine Area to assist with evaluating the existing dataset and advising on future sampling and monitoring. Specifically, the following provides:

- an overview of the sampling methods employed for collection and analysis of phytoplankton in the Mine Area waterbodies; and
- an inventory of existing baseline phytoplankton data for Mine Area waterbodies.

2.1.1 Sampling Methods

Chlorophyll *a* samples were collected using the same methods as applied for water quality sampling. Specifically, in lakes, chlorophyll *a* samples were collected approximately 1 m below the water surface ("near-surface samples") and from approximately 1 m above the sediments ("bottom samples") using a Kemmerer water sampler. Sample bottles provided by the analytical laboratory were then filled and the samples were submitted to EXOVA Laboratories for analysis. Replicate samples and field blanks were incorporated into the sampling program in 2007, 2008, and 2013 as a component of the Quality Assurance/Quality Control (QA/QC) program.

Samples for taxonomic identification and enumeration were collected in the 2007, 2008, and 2013 open-water seasons as depth-integrated samples of surface water collected across the euphotic zone (estimated as three times the Secchi Disk depth measured at the time of sampling, Cole 1983). A depth-integrated sample of water was collected from across the euphotic zone using a 10-m long tube sampler (up to a maximum depth of 10 m). Where the euphotic zone was calculated to exceed depth at a site, samples were collected by lowering the tube sampler to a depth 1 m from the bottom of the lake (to a maximum of 10 m).

Sample bottles provided by the analytical laboratory were then filled and a sufficient quantity of Lugol's solution was added to render the sample "tea coloured". The sample was then mixed and additional Lugol's was added on site or at the end of the day as required. Samples were submitted to ALS Laboratories, Winnipeg, MB for taxonomic identification and enumeration. Only samples collected in 2007 and 2008 have been analysed; 2013 samples have been archived.

2.1.2 Baseline Data Inventory

Baseline field studies included collection and analysis of surface water samples for characterization of phytoplankton in Mine Area lakes and streams. Specifically, chlorophyll *a* (sestonic) was measured at selected sites in lakes and streams and phytoplankton biomass and community composition was measured in Mine Area lakes. The following provides an inventory of baseline phytoplankton data for lakes and streams separately.

2.1.2.1 Lakes

Samples were collected for analysis of phytoplankton community composition and biomass and chlorophyll *a* from Mine Area lakes in the open-water seasons of 2007, 2008, and 2013. The sampling program was conducted in conjunction with and, therefore, at the same locations and times, as the water quality sampling program (Figure 2-1). These locations included:

- Mary Lake;
- Sheardown Lake Northwest;
- Sheardown Lake Southeast; and
- Camp Lake.

Sampling for phytoplankton was conducted twice each year (2007, 2008, and 2013), though not all sites were sampled in fall 2008 or 2013, as follows:

- August 7-14, 2007, July 29-August 6, 2008, and July 25-28, 2013 (summer sampling); and
- September 13-20, 2007, September 2, 2008 (fall sampling – Sheardown Lake only), and August 24-29, 2013.

Nearshore sampling for analysis of chlorophyll *a* was also conducted at six sites in Sheardown Lake NW in 2008 in spring (June 25, 2008), summer (July 31 and August 7, 2008), and fall (September 14, 2008). In addition, chlorophyll *a* was measured at four sites in Sheardown Lake NW and one site in Sheardown Lake SE following discharge of treated sewage effluent in August 2009.

Water sampling locations where chlorophyll *a* and phytoplankton samples were collected and periods sampled for the Mine Area are presented in Tables 2-1 and 2-2, respectively. As described in Section 2.1.1, during most sampling events, chlorophyll *a* was measured in near surface (1 m below water surface) and bottom (1 m above the sediments) samples. Table 2-1 presents the total number of near-surface samples collected from lakes.

2.1.2.2 Streams

A number of streams, including the Mary and Tom rivers and tributaries to Sheardown Lake, Camp Lake and Mary Lake, were sampled for analysis of chlorophyll *a* during the conduct of the water quality sampling program in 2007, 2008, and 2013 (Table 2-3, Figure 2-1). A total of 138 samples were collected over this period, with approximately half of them collected from the Mary River.

2.2 PATHWAYS OF EFFECT AND KEY QUESTIONS

Key questions were developed to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. The adequacy of baseline data to address these key questions is addressed in Section 2.3. These questions focus upon key potential residual effects identified in the Final Environmental Impact Statement (FEIS; Baffinland Iron Mines Corporation [BIM] 2012) and the Addendum to the FEIS for the Early Revenue Phase (ERP; BIM 2013).

The key pathways of potential residual effects of the Project on phytoplankton communities include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and total suspended solids [TSS]) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition); and
- Water quality changes due to non-point sources, such as site runoff and use of Ammonium nitrate fuel oil (ANFO) explosives (Mine Area).

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources on phytoplankton abundance in Mine Area lakes?

The primary issue of concern with respect to the phytoplankton community is related to nutrient enrichment and eutrophication, though effects on water clarity (e.g., changes in TSS) could also affect primary productivity. As such, the CREMP and the baseline data review focused upon waterbodies most at risk to eutrophication; in general, lakes (rather than streams) are most vulnerable to eutrophication in the Mine Area. Sheardown Lake NW has received treated sewage effluent discharge during the construction phase and may also be affected by dust deposition, stream diversions, and non-point sources during the operation period. Although treated sewage effluent will be discharged to the Mary River during the operation phase, Mary Lake is the ultimate receiving environment for all point sources in the Mine Area, including discharge of treated sewage effluent, and is more vulnerable to effects of nutrient enrichment due to its lacustrine nature.

2.3 EVALUATION OF DATA FOR POST-PROJECT MONITORING

2.3.1 Description of Existing Data

2.3.1.1 Data Analysis

To explore the robustness of various potential metrics for phytoplankton for the CREMP, several metrics were derived as indicated in Table 2-4. A number of community metrics were calculated to describe the richness and diversity of the communities sampled. Calculations followed those in Hill (1973), Magurran (1988), and Begon et al. (1996), and included:

- Species richness (S);
- Simpson's diversity index (D = 1-G);
- Simpson's evenness ($E_D = 1/G \times 1/S$);
- Shannon's heterogeneity ($H = -\sum P_i \times [\ln P_i]$);
- Shannon's evenness ($E_H = H/\ln[S]$);
- Hill's effective richness (e^H); and
- Hill's evenness (e^H/S).

Where G is Simpson's diversity for sampling with no replacement ($[\sum n_i(n_i-1)]/[N(N-1)]$), P_i is the proportional contribution of species i to the total biomass, n_i is the number of individuals of the i^{th} species, and N is the total number of individuals. Diversity and evenness metrics range for 0 to 1, with values close to 0 having low diversity/evenness and values close to 1 having high diversity/evenness.

Metrics were plotted as box plots to visually assess the occurrence of extreme outliers and to provide a preliminary visual assessment of potential spatial and/or seasonal differences. However, owing to the inherently high variability of the phytoplankton dataset, no data points were removed from the analysis as outlier identification is complicated by the high natural variability.

Summary statistics (mean, median, standard error [SE], standard deviation [SD], minimum, maximum, n, coefficient of variation [COV], and 95^{th} percentile) were derived for each lake using data from all sites sampled in that waterbody (i.e. sites pooled). Summary statistics were also derived for Sheardown Lake NW by sampling period and by year to examine seasonal and interannual differences. Chlorophyll *a* values reported as below the measurement detection limit (0.2 µg/L; i.e., 'censured values') were assigned a value equal to the detection limit. Duplicate samples were averaged and the mean was used for all data analyses.

COV was calculated as SD/mean x 100; COV facilitated comparisons of the variability of various datasets to assist with identifying the most robust metrics as well as to assist with advising on sampling design. The variability of the metrics examined was then described to facilitate identification of those metrics with the lowest natural variation for further consideration and statistical analysis.

Correlation analyses were conducted for phytoplankton metrics, including chlorophyll *a*, biomass, and evenness and richness indices to assist with identifying the most suitable metrics for monitoring. Spearman rank correlations ($\alpha = 0.05$) were conducted for all phytoplankton data collected in all Mine Area lakes in summer and late/summer fall for the years 2007, 2008, and 2013 collectively. The broader dataset was used for this analysis to augment the number of data points. Note that the only additional data available from 2013 for this analysis were chlorophyll *a*, total nitrogen (TN), and total phosphorus (TP).

Statistical comparisons between lakes and between seasons and years for Sheardown Lake NW were undertaken to advise on spatial and temporal variability in the environment. For parameters exhibiting a normal distribution, analyses were conducted using an analysis of variance (ANOVA) and a Tukey's test ($\alpha = 0.05$). For parameters not meeting the assumptions of a normal distribution (normality was tested on raw, untransformed data and log-transformed data), analyses were performed using the non-parametric Kruskal-Wallis test followed by the Dunn's multiple pairwise comparisons procedure (two-tailed; $\alpha = 0.05$).

In addition, although this report focused upon review of biological metrics, correlation and linear regression analyses were also conducted between phytoplankton metrics and TP as the primary pathway of potential effects relates to nutrient enrichment, and nutrient ratios indicate that phosphorus is the limiting nutrient.

2.3.1.2 Results

Chlorophyll a

Chlorophyll *a* concentrations are relatively low in Mine Area lakes (Mean of 0.66 µg/L and range of <0.2 – 3.5 µg/L) and a relatively high proportion of measurements were below the analytical detection limit of 0.2 µg/L in 2007, 2008, and 2013 (Table 2-5). As a result, the data exhibited high variability and were not normally distributed. Based on a commonly applied trophic categorization scheme for lakes (Organization for Economic Cooperation and Development [OECD] 1982), chlorophyll *a* concentrations indicate oligotrophic conditions (i.e., chlorophyll *a* < 2.5 µg/L) based on mean or maximum chlorophyll *a* concentrations measured across the lakes.

Data collected from Sheardown Lake NW were examined in greater detail as a representative waterbody for the Mine Area. Considering only offshore sites, there was no seasonal (i.e., comparisons to summer and late/summer fall periods) or interannual patterns observed for this lake (Figure 2-2; Table 2-6). The COVs were similarly high when derived by sampling season or for the whole year combined, though the lowest variability was observed for the 2013 dataset.

Concentrations of chlorophyll *a* measured in nearshore areas in 2008 (water depths of 1.2 m) were generally higher than offshore sites and inclusion of these data increased the overall means and maximums for the lake as a whole (Figure 2-3). In particular, higher concentrations of chlorophyll *a* were measured in nearshore areas in late summer/fall of 2008. Sampling in nearshore areas was undertaken as a component of a study examining potential effects of localized dust deposition and may not be representative of the lake as a whole. Therefore, data collected from the nearshore areas were excluded from power analyses described in Section 2.3.2.

Considering all Mine Area lakes collectively, there did not appear to be a consistent seasonal or annual pattern in chlorophyll *a* concentrations across all of the lakes (Figure 2-4). Conversely, chlorophyll *a* was statistically lower in Sheardown Lake NW than Mary Lake over the baseline sampling period (Figure 2-5). Due to this observed difference, exploratory power analyses for chlorophyll *a* were conducted for both Sheardown Lake NW and Mary Lake (see Section 2.3.2).

Phytoplankton Biomass

Phytoplankton biomass varied across sampling periods and years in Mine Area lakes and was highest in fall 2008 in lakes where sampling occurred (Figure 2-6). Open-water season means for the 2007-2008 period were highest in Sheardown Lake NW, however, Camp and Mary lakes were not sampled in fall 2008, when the biomass was highest in Sheardown Lake NW (Table 2-7, Figure 2-6). COVs for total biomass, which ranged from 60 to 89% across the Mine Area lakes, were lower than COVs observed for chlorophyll *a* (Table 2-7). This likely reflects the relatively high frequency of measurements of chlorophyll *a* below the analytical detection limit.

Within Sheardown Lake NW, biomass was significantly higher in 2008 than 2007 but no significant differences were observed between the summer and late summer/fall sampling periods (Table 2-8). COVs were greater between sampling periods than between years (Table 2-8).

Phytoplankton Taxonomic Metrics

Metrics of phytoplankton diversity and evenness were relatively similar between Camp Lake, Sheardown Lake NW, and Sheardown Lake SE (Table 2-9). These metrics were lower in Mary Lake. Species richness, Simpson’s diversity indices, and Shannon’s evenness indices yielded the lowest COVs for Sheardown Lake NW and for all lakes combined, all of which were less than 40%. Seasonal and interannual differences were evident for some lakes and periods (Figures 2-7 to 2-12).

Within Sheardown Lake NW, all taxonomic metrics yielded a COV of less than 40% when both years of baseline data were considered collectively (Table 2-10). The least variable metrics were species richness, Simpson’s diversity index, and Shannon’s evenness. All phytoplankton taxonomic metrics had lower variability (expressed as COVs) than either chlorophyll *a* or phytoplankton biomass.

All taxonomic metrics were significantly higher in 2007 than 2008 in Sheardown Lake NW. Conversely, of the phytoplankton taxonomic metrics examined, only Simpson's Evenness was significantly higher in summer relative to the fall period (Table 2-10).

Correlations and Regressions

Correlations between phytoplankton metrics were explored to assist with identifying metrics most suitable for monitoring effects of nutrient enrichment. Additionally, as noted in Section 2.3.1.1, relationships between phytoplankton metrics and TP were also explored to assist with identification of the most suitable metrics for monitoring effects of nutrient enrichment (i.e., phosphorus enrichment).

Spearman rank correlations indicated significant correlations between total biomass and a number of taxonomic parameters (Table 2-11); biomass of diatoms (r = 0.96), green algae (r = 0.46), chrysophytes (r = 0.53), cryptophytes (r = 0.32), and dinoflagellates (r = 0.30) were positively correlated to total biomass while several metrics of evenness and diversity were negatively correlated to total biomass including Simpson's diversity index (r = -0.60), Simpson's evenness (r = -0.71), Shannon's evenness (r = -0.65), Hill's effective richness (r = -0.55), and Hill's evenness (r = -0.71). Biomass was not significantly correlated to either species richness or chlorophyll *a*.

The conventional paradigm for lakes is a positive relationship between TP and chlorophyll *a* – though the relationship is not necessarily linear – and typically, phosphorus is the limiting nutrient in freshwater ecosystems. TN:TP molar ratios for Mine Area lakes indicate strong phosphorus limitation.

As introduction of phosphorus from discharge of treated sewage effluent and subsequent eutrophication is a potential concern in the Mine Area, regression analyses were conducted between chlorophyll *a* and TP measured in Mine Area lakes. Spearman correlations indicated no significant relationship between TP and total biomass but did indicate a weak but significant relationship with chlorophyll *a* (r = 0.29).

Due to the relatively low frequency of detection, chlorophyll *a* was only weakly significantly correlated with TP for all lakes combined or within Sheardown Lake NW only (Figure 2-13). However, regressions were stronger when only chlorophyll *a* measurements that exceeded the analytical detection limit in Sheardown Lake NW were included in the analysis (Figure 2-13).

2.3.1.3 Chlorophyll a in Streams

Though this review and the phytoplankton component of the CREMP focuses on Mine Area lakes, some exploratory analyses of baseline chlorophyll *a* data for streams was undertaken to inform selection of stream monitoring sites and sampling periods for the CREMP. Specifically, data collected from the Mary River were examined visually with boxplots for spatial and seasonal differences. Available data suggest chlorophyll *a* is somewhat higher at downstream sites relative to the headwaters of the Mary River (Figure 2-14). There is also some indication of seasonal differences, though the differences do not appear to be consistent between all sites (Figure 2-15).

2.3.2 Power Analysis

2.3.2.1 Methods

Power analysis was conducted following general guidance provided in the Environment Canada (EC) Metal Mining Environmental Effects Monitoring (EEM) Guidance Document (EC 2012), though it is noted that the EEM program does not discuss monitoring of phytoplankton. Specifically, values for α (Type I error) and β (Type II error) were set at 0.1 as advised in EC (2012). Datasets were tested for normality for all phytoplankton metrics prior to the conduct of the power analyses. All metrics were normally distributed excepting chlorophyll *a*.

Power analysis by simulation was implemented using PopTools (Hood 2010).Two types of power analyses were used one based on a t-test (parametric) and one based on the Mann-Whitney (nonparametric) U-test.

The power of existing baseline data to be used for demonstrating changes in the various metrics was explored for a range of effects sizes. Using the dNormalDev(mean, SD) function, random data were generated for the observed baseline and hypothetical monitoring scenarios. The Excel formula for a t-test was used keeping the first row fixed. This process was iterated 1000 times by Monte Carlo simulation to determine the frequency of a realised t-probability greater than α (Type I error). This provided an estimate of β (Type II error) with the power of the test being $1-\beta$. Both α and β were set at 0.10 for a power of 90% following the EEM Guidelines (EC 2012).

For nonparametric tests, the same process was used, but baseline data were first fit to a distribution and then, using the appropriate functions (e.g., dLogNormalDev(Mean, SD)), random deviates were generated. The test was iterated 1000 times to estimate β Type II error. As in the parametric tests, the theoretical shifts were assessed as percent changes from baseline.

Phytoplankton Taxonomy and Biomass

The most robust taxonomic/biomass metrics identified through review of the baseline data for further statistical exploration and consideration under the CREMP were subject to a power analysis to:

- Provide a preliminary analysis of the power of the existing dataset to be used as the foundation for detecting post-Project change (i.e., Before-After comparisons);
- Explore samples sizes (i.e., number of sites within a waterbody or area of a waterbody) required for detecting pre-defined levels of change;
- Advise on key metrics for consideration under the CREMP; and
- Advise on the need for collection of additional baseline data and/or modifications to future sampling programs (i.e., number of sites for the CREMP).

Evaluation of power of the existing baseline data was conducted using data collected from Sheardown Lake NW as a representative data set.

The variability of numerous phytoplankton metrics measured during the baseline studies program was evaluated and described in Section 2.3.1 to assist with identifying the most robust metrics for further statistical exploration and consideration under the CREMP. Metrics that were subject to a power analysis included:

- Total biomass;
- Species Richness;
- Simpson's diversity index; and
- Shannon's evenness.

COVs for the taxonomic metrics were less than 20% for the whole baseline dataset (2007 and 2008 combined) in Sheardown Lake NW and were therefore identified for further analysis. COVs for total biomass were high but this metric was retained as it is one of two metrics used to describe phytoplankton abundance.

CESs utilized for power analysis were selected based on the Metal Mining EEM Guidance document (EC 2012), scientific literature, and other recent/current AEMPs and/or guidance documents (Azimuth 2012, Indian and Northern Affairs Canada [INAC] 2009, Munkittrick et al. 2009). Where initial power analyses indicated low power associated with the CESs identified *a priori*, larger CESs were explored.

Power analyses were conducted using all data collected in the open-water seasons of 2007 and 2008 (i.e., summer and late summer/fall sampling) in Sheardown Lake NW, as well as for the fall datasets alone. The latter was conducted to explore the additional power achieved with two sampling periods as opposed to sampling only in the fall.

Chlorophyll a

Power analyses for the key metric for phytoplankton (i.e., chlorophyll *a*) were conducted to determine if the power of the baseline data is sufficient to detect a change relative to the benchmark identified for the CREMP and to advise on sample sizes for the CREMP (see Section 2.3 of the main body of the CREMP for details). Power analyses for this parameter were conducted for both Sheardown Lake NW and Mary Lake since, as noted in Section 2.3.1, chlorophyll *a* was statistically significantly different between these lakes.

Power analyses were conducted using all data collected in the open-water seasons of 2007, 2008, and 2013 (i.e., summer and late summer/fall sampling) in Sheardown Lake NW and Mary Lake. Power analyses were based on one-tailed Mann-Whitney U-test conducted for each season and lake using the benchmark (3.7 µg/L) and a lower CES equal to two times the mean. For datasets with a high frequency of values below the analytical detection limit (i.e., censured values), data were assumed to follow a true distribution below detection limit. There were two assumptions associated with this method for censured values: (1) the data between zero and the analytical detection limit were part of a 'real' distribution; and (2) that the effect sizes tested were shifting from the fitted baseline to one more representative of what would be expected with a 'real' trophic shift.

2.3.2.2 Results

Phytoplankton Taxonomy and Biomass

Minimum sample sizes identified through the exploratory power analyses are presented in Table 2-12. As expected, power is greatest for the phytoplankton community metrics, owing to the relatively low COVs for these parameters. Power analysis indicated that a reasonably small sample size (i.e., n = 3) would be required to detect changes in phytoplankton community metrics on the order of 20-50% relative to baseline conditions, if sampling consisted of two sampling periods. A similar level of effort (i.e., n = 3-4) would be required for detecting these levels of change with sampling the fall period only.

The power associated with the total biomass dataset is lower than for the community metrics (Table 2-12). The existing baseline dataset would be sufficient to detect change on the order of 100% with a relatively small number of samples (8 samples for the entire dataset and 6 samples for the fall dataset). Smaller levels of change would require a prohibitively high number of samples to be detected. Because the fall dataset is slightly less variable than the entire dataset, there is greater power associated with the former and a slightly smaller number of samples would be required to demonstrate changes from baseline conditions.

Chlorophyll a

Power analyses indicate relatively high power to detect a change of the magnitude of the benchmark for each sampling season in each lake (Figure 2-16). Power is greater for Sheardown Lake NW owing to the lower baseline concentrations of chlorophyll *a* than Mary Lake. A sample size of five for Sheardown Lake NW and a sample size of six for Mary Lake are associated with high power in relation to the benchmark. Power was also evaluated for an effects size of 2 x the mean; relatively high power (0.7 for Mary Lake and 0.8 for Sheardown Lake NW) is also associated with this level of change.

2.3.3 Sampling Sites and Areas

The Project will result in introduction of nutrients to Mine Area waterbodies which may stimulate primary productivity, but may also adversely affect primary productivity through changes in water clarity and water chemistry. A sample size of 5 for Sheardown Lake NW and SE and Camp Lake and a sample size of 6 for Mary Lake has been identified for the CREMP.

2.3.4 Sampling Methods

Chlorophyll *a* samples have been collected from Mine Area lakes using the same methods as the water quality sampling program (i.e., samples collected with a water sampler at 1 m below the water surface and 1 m above the sediments). While this methodology ensures consistency with supporting water quality variables, notably nutrients such as TP, it may under or over represent phytoplankton density across the water column. Chlorophyll *a* should continue to be analysed in grab samples (near surface samples) in the future to maintain continuity with the methods used for the existing datasets.

Conversely, samples for measurement of phytoplankton taxonomy and biomass have been collected from across the euphotic zone of lakes which generally provides a more accurate representation of phytoplankton in lacustrine environments. The depth of lake euphotic zones was estimated as 3 x the average Secchi disk depth, to a maximum of 10 m. Due to the high water clarity of Mine Area lakes, euphotic zone depths were calculated to exceed 10 m (the length of the sampling tube) in some sampling periods at some sites.

2.3.5 Sampling Frequency

The results of the power analyses on Sheardown Lake NW phytoplankton data indicate similar levels of power for detecting changes associated with sampling during two periods as sampling only in the fall period. This suggests that one sampling period may be adequate for monitoring purposes. However, it is recommended to retain two rounds of sampling in Mine Area lakes for the initial years of monitoring. The results of the CREMP should be reviewed regularly to determine the need for two sampling periods.

2.4 OVERVIEW OF 2013 SAMPLING

Sampling for analysis of chlorophyll *a* and phytoplankton taxonomy and biomass was undertaken in Mine Area lakes in the open-water season of 2013. In addition, chlorophyll *a* was measured at selected stream sampling sites. Sampling sites are presented in Figure 2-17 and summaries of sampling completed in lakes and streams in 2013 is provided in Tables 2-13 and 2-14, respectively. Due to inclement weather, not all sites were resampled during each sampling period. As previously noted, samples were analysed for chlorophyll *a* and the results were incorporated into this review. Samples for phytoplankton taxonomy and biomass have been archived.

3.0 BENTHIC MACROINVERTEBRATES

The following sections provide an inventory of available baseline benthic macroinvertebrate data, a description of key pathways of effect and key questions respecting the Project, a detailed examination of baseline BMI data, a review of sample size, sampling sites, methods, and timing, and taxonomic analyses, and an overview of sampling completed in 2013.

As the results from the 2013 sampling were not available at the time of completion of this review, the review of baseline benthic macroinvertebrate data provided in Section 3.3 is restricted to data collected over the period of 2006 through 2011. Section 3.1 (inventory of freshwater baseline data) refers to all sampling completed through 2013.

3.1 INVENTORY OF FRESHWATER BASELINE DATA

The following sections provide an inventory of existing baseline data (through 2013) for BMI in the Mine Area to assist with evaluating the existing dataset and advising on future sampling and monitoring. Specifically, the following provides:

- An overview of the sampling methods employed for collection and analysis of benthic macroinvertebrates (i.e., benthos) in the Mine Area waterbodies; and
- An inventory of existing baseline BMI sampling completed for Mine Area lakes and streams.

3.1.1 Sampling Methods

3.1.1.1 Lakes

Lake BMI samples were collected using either an Ekman dredge (2006) or a petit Ponar dredge (2007, 2008, 2011, 2013) sampling device (each with a sampling area of 0.023 m^2; Table 3-1). Sample characteristics, which included substratum composition, colour, odour, sample depth, and Universal Transverse Mercator (UTM) coordinates for each replicate site, were documented.

In 2006, 2007, and 2011, three replicate samples were collected at each sampling site while in 2008 three to seven replicate stations were sampled for each habitat type investigated in Sheardown Lake NW. In 2013, five replicate stations were sampled in each of two habitat types in the Mine Area lakes; an additional replicate station was collected in a third habitat type in Camp Lake.

At most sites and times, each replicate sample was a composite of five grabs (i.e., five sub-samples were combined per replicate site); sub-samples were preserved separately in 2013. However, each replicate sample was composed of only a single grab due to equipment malfunction in Mary Lake in 2007 and at Sheardown Lake in 2011 the three replicates were composed of one, three, and one grabs, respectively, due to poor weather conditions and time restrictions during the field program.

At each sampling location, the dredge was slowly lowered until it rested on the bottom to prevent shock waves that could physically move or disturb organisms and sediment from beneath the sampler. Following completion of a grab, the dredge was slowly raised, to minimize turbulence, and the sample was immediately placed into a pail. An acceptable sample required that the jaws be completely closed upon retrieval. If the jaws were not completely closed the sample was discarded into a bucket (and disposed of once sampling was completed) and the procedure was repeated.

For each replicate collected in 2006 and 2007, five sub-samples approximately 1 m apart were collected from the same side of the boat. The three replicate samples were separated by approximately 10 m. For each habitat type sampled in 2008, 2011, and 2013 three to seven replicate stations were sampled, each resulting in a single composite sample consisting of one to five benthic macroinvertebrate field sub-samples/grabs; sub-samples were preserved separately in 2013. The geographic extent of each replicate station was at least 10m x 10m and replicate stations were separated by at least 20 m.

Samples were taken to shore and sieved through a 500 µm sieve bucket. A weed sprayer was sometimes used on a gentle setting to help break down clay. Samples were then rinsed into labelled sampling jars and fixed in 10% formalin. Sodium bicarbonate (’baking soda’) was used to buffer samples where molluscs/shells were present. Sampling equipment was rinsed on shore before the next site was sampled.

Benthic macroinvertebrate samples were submitted to Zaranko Environmental Assessment Services (ZEAS) Inc. (Nobleton, ON) for processing and identification; laboratory methods were consistent over the study period.

3.1.1.2 Streams

As benthic samples were collected at or near habitat assessment sites in the Mine Area streams, site characteristics were noted extensively. Three replicate samples separated by approximately three wetted stream widths were collected at each sampling site in 2006 through 2008, and 2011; only one replicate sample was collected at each sampling site in

2005 (Table 3-2). In 2013, two to three replicate stations were collected at each sampling site (Table 3-2). Within each replicate site, five sub-samples were combined into one large sample in all years excepting 2013. In 2013, two to five sub-samples were collected and preserved separately, with the exception of Sheardown Lake, Tributary 1 Replicate Stations B1, B2, and B3 where sub-samples were composited. Sub-samples were collected moving in an upstream direction and, whenever possible, they were collected from representative microhabitats across the stream.

Each sub-sample was collected by placing a Surber sampler on a flat area of the streambed, facing upstream. The surface area sampled by the Surber sampler was equivalent to 0.097 m^2. Macroinvertebrates were collected over a two minute time period by rubbing the rocks and disturbing the sediment in the substrate area framed by the Surber net. With the exception of 2005 when a 250 µm mesh size was used, all sub-samples were rinsed from the netting into a 500 µm sieve. Forceps were used to collect any macroinvertebrates remaining on the netting after rinsing. The sample was washed, transferred into a sample jar, and fixed as soon as possible in 10% formalin.

Benthic macroinvertebrate samples were submitted to ZEAS Inc. for processing and identification; laboratory methods were consistent over the four years of investigation.

3.1.2 Baseline Data Inventory

Benthic macroinvertebrate community sampling was initiated in 2005 in the Mine Area, and initially included sampling of streams only. The program was expanded in 2006 to include lakes and additional stream sampling sites. The following sub-sections provide an inventory of baseline BMI samples collected from lakes and streams.

3.1.2.1 Lakes

Benthic macroinvertebrate sampling in lakes was conducted in fall (August 31 and September 5, 2006; August 31 to September 20, 2007; September 8-12, 2008; September 3, 2011; September 5-8, 2013) from Camp (2007, 2013), Sheardown NW (2007, 2008, 2011, and 2013), Sheardown SE (2007, 2013), and Mary (2006, 2007) lakes (Table 3-3). Inclement weather reduced the length of the fall sampling season in 2008, which prevented the completion of the full planned program for Sheardown Lake NW. Inclement weather also prevented sampling of Mary Lake in 2013. Sampling of BMIs in Sheardown NW in September, 2011 was limited to a single site. Locations of BMI sampling sites and sampling dates are presented in Table 3-4 and Figure 3-1.

3.1.2.2 Streams

BMI sampling in streams was conducted in summer 2005 (August 6-17, 2005) and fall 2006-2008, 2011, and 2013 (August 23 to September 1, 2006; August 31 to September 5, 2007; September 10-11, 2008; August 28 to September 4, 2011; August 29-31, 2013) from the Mary (2005, 2006, 2007, 2011) and Tom (2006, 2007) rivers, and Camp Lake (2005, 2007, 2011) and Sheardown Lake (2005, 2007, 2008, 2011, 2013) tributaries (Table 3-3). Locations of benthic macroinvertebrate sampling sites and sampling dates are presented in Table 3-5 and Figure 3-2.

3.2 PATHWAYS OF EFFECT AND KEY QUESTIONS

Key questions were developed to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. The adequacy of baseline data to address these key questions is addressed in the Section 3.3. These questions and metrics focus upon key potential residual effects identified in the FEIS (BIM 2012) and the Addendum to the FEIS for the ERP (BIM 2013), as well as metrics commonly applied for characterizing the BMI community.

The key pathways of potential effects of the Project on BMIs include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);
- Water quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (Mine Area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Dust deposition in aquatic habitat (i.e., sedimentation); and
- Effects of the Project on primary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, aquatic habitat loss or alteration, sedimentation, and changes in primary producers on BMI abundance and community composition in Mine Area lakes and streams?

Overall, effects on lower trophic level biota are primarily related to the introduction of dust to surface waters, discharge of treated sewage effluent to Sheardown Lake NW and the Mary River, release of wasterock and ore stockpile runoff to surface waters (Camp Lake Tributary 1, Mary River), general non-point sources in the Mine Area, and release of pit water during the post-closure phase. The baseline data review focused upon waterbodies most at risk to sedimentation and eutrophication and that are not captured under the Metal Mining Effluent Regulation (MMER) EEM program as follows: Camp Lake; Sheardown Lake NW; Mary Lake; and tributaries to Sheardown Lake (specifically, Tributary 1). Dust is predicted to be deposited directly on surface waters in the Mine Area, including Sheardown and Camp lakes, portions of the Mary River, and numerous small tributaries to these waterbodies. Sheardown Lake NW has received treated sewage effluent discharge during the construction phase and may also be affected by dust deposition, stream diversions, and non-point sources during Project operation. Although treated sewage effluent will be discharged to the Mary River during the operation phase, Mary Lake is the ultimate receiving environment for all point sources in the Mine Area, including discharge of treated sewage effluent and is considered more vulnerable to effects of nutrient enrichment due to its lacustrine nature.

3.3 EVALUATION OF DATA FOR POST-PROJECT MONITORING

The following provides a description and critical review of baseline data for the period of 2005 through 2011.

3.3.1 Description of Existing Data

3.3.1.1 Data Analysis

To explore the ability of various BMI community metrics to detect change as part of the CREMP, several were derived as outlined in Table 3-6. Methods for the derivation of these calculated metrics are described below.

Locations in Mine Area lakes sampled for BMIs were classified according to aquatic habitat types based on water depth and light availability, substrata type, and the presence or absence of rooted aquatic vegetation (Table 3-7).

To prepare the data for analysis, the abundance of BMIs in each replicate was converted to density (number of macroinvertebrates per square meter [individuals/m^2]) by dividing the total number of macroinvertebrates per sample by the bottom area of the sampling device (0.023 m^2 for the Ekman and petit Ponar dredges; 0.97 m^2 for the Surber sampler). Benthic macroinvertebrate metrics were calculated for each replicate and included in statistical analyses to describe the community. Metrics included: abundance (total macroinvertebrate density [individuals/m^2±SE])); composition (Chironomidae proportion [% of total density], Shannon's Equitability [evenness], and the Simpson's Diversity Index); and richness metrics (total taxa and Hill's Effective richness, both at the genus level; Magurran 1988, 2004).

Evenness measures the similarity of population sizes of different species, with values closer to 1 indicating that macroinvertebrates of different species are more similar in abundance and values of 0 indicating that only one species is present. A diversity index provides an estimate of the probability that two individuals in a sample belong to the same species. The higher the index (0 to 1), the less likely it is that two individuals belong to the same species (i.e., likely the higher the diversity; Magurran 1988, 2004). However, it is important to consider that this index is not itself a true estimate of diversity and it is highly nonlinear. Diversity indices attempt to summarize the relative abundance of various taxa. An index may provide more succinct information about benthic macroinvertebrate communities than abundance or richness alone. Simpson's Diversity index de-emphasizes rare taxa, while highlighting common taxa and evenness among taxa (i.e., similarity of population sizes of different species; Mandaville 2002). Hill's Effective Richness provides an indication of the number of genera that contribute to the majority of the community represented in the sample collected. For example, if total richness = 28 and effective richness = 11, then of the 28 genera identified in the sample, 11 taxa are considered dominant.

Metrics were plotted as box plots to visually assess the occurrence of extreme outliers and to provide a preliminary visual assessment of potential spatial and/or yearly differences (for lakes only). However, owing to the inherently high variability of the benthic macroinvertebrate dataset, no data were removed from the analysis as outlier identification is complicated by the high natural variability of biotic data.

Metrics were calculated for each replicate sample and summary statistics (n, mean, median, SD, SE, minimum, maximum, COV, and 95th percentile) were derived for each lake by aquatic habitat type and each stream reach to examine spatial differences. Summary statistics were also derived for Sheardown Lake NW by aquatic habitat type and by year and Sheardown Lake NW Tributary 1 by reach and by year to examine inter-annual differences. Efforts were made to include as many taxa as possible in the analysis; however, Diptera, Chironomidae and Empididae pupae were excluded from metric calculations where genus level identification was used (e.g., evenness, Simpson's Diversity Index). Taxonomic richness (i.e., the number of taxa) was determined at the genus level. If a group was identified to a higher level (e.g., class or order), then it was assumed that only one genus was represented and this likely resulted in a conservative estimate of the number of taxa; pupae were not included in the determination of richness.

Additionally, the number of field sub-samples (i.e., grabs) per replicate station that would provide an estimate with 20% precision (i.e., an acceptable level of variance) for each metric was determined for Sheardown Lake NW by aquatic habitat type and year and Sheardown Lake NW Tributary 1 by reach and by year; these results are discussed in Section 3.3.4. The number of field sub-samples was calculated as follows:

$n = s^2 / D^2 * X^2$

where:

X = the sample mean

n = the number of field sub-samples

s = the sample variance

D = the index of precision (i.e., 0.20)

COV was calculated as SD/mean x 100; COV facilitated comparisons of the variability of various datasets to assist with identifying the most robust metrics as well as to assist with advising on sampling design. The variability of the metrics examined was then described to facilitate identification of those metrics with the lowest natural variation for further consideration and statistical analysis.

Detailed statistical analyses were conducted on the Sheardown Lake NW dataset as a representative lake dataset for the Mine Area. The baseline dataset is largest for this waterbody and would conceptually therefore provide the most robust pre-Project database for use in post-Project monitoring. Inter-annual differences in macroinvertebrate metrics were assessed statistically for each habitat type in Sheardown Lake NW (where multiple years of data were available). Similarly, Sheardown Lake NW Tributary 1 was explored in detail as the representative data set for Mine Area streams, as the baseline dataset is largest for this stream, particularly Reach 4.

All data were tested for normality prior to statistical analysis and data that were normally distributed were assessed using parametric statistics while non-normally distributed data were analysed using non-parametric tests. Differences between years were assessed using the t-test (parametric) or Mann-Whitney U-test (non-parametric) when two years of data were available; ANOVA with Bonferroni pairwise comparison (parametric) or Kruskal-Wallis test followed by multiple pairwise comparison (Dunn's procedure) (non-parametric) was used when three years of data are available. All tests were assessed with significance level of 0.05; analyses were performed using XLStat Version 2007.4.

3.3.1.2 Lake Results

Abundance

Total macroinvertebrate density was variable among Mine Area lakes and among habitat types sampled within waterbodies, ranging from a mean of 14 individuals/m^2 (Camp Lake, Habitat Type 4) to 18,562 individuals/m^2 (Sheardown Lake SE, Habitat Type 10; Table 3-8). The data exhibited relatively high variability (COVs up to 173%), but were normally distributed with the exception of Sheardown Lake NW, Habitat Type 9. COVs of samples collected were somewhat lower from deeper water depths (Profundal Zone, Habitat Type 14) in comparison to shallower water depths (particularly the Shoreline Zone, Habitat Type 4). This may reflect the more variable nature of the shallower areas of the lakes (i.e., strongly affected by water level fluctuations and wave energy, increased substrate heterogeneity, and potentially affected by anthropogenic factors).

For the representative waterbody (i.e., Sheardown Lake NW), there were notable differences in total density among habitat types and between years within the same habitat type, with no clear pattern among habitat types (Figure 3-3).The COVs were somewhat higher at shallower water depths in comparison to deeper water habitat, with the lowest variability being observed in Habitat 14 in 2007 (Table 3-9). Within Habitat Type 9, total density was significantly lower in 2008 in comparison to 2007, and within Habitat Type 14, each year was significantly different from the other with total density being the lowest in 2008 and highest in 2011.

Composition

The proportion of Chironomidae contributing to the total macroinvertebrate density was relatively similar among Mine Area lakes within the same habitat type (Table 3-10). The exception to this was Camp Lake, Habitat Type 4, where Chironomidae only made up 7% of the total in comparison to 66% in Sheardown Lake NW and 55% in Sheardown Lake SE. Differences among habitat types within a lake were evident, with the proportion of Chironomidae observed in samples increasing with water depth (Figure 3-4). The data exhibited less variability (lower COVs) in comparison to total BMI density, and were normally distributed, with the exception of Mary Lake habitat types 9 and 14. As the proportion of Chironomidae increased with water depth, the corresponding COV declined. Within Sheardown Lake NW, COVs were less than 15% when each habitat type was considered annually, with the exception of Habitat Type 4 (28%; 2008 only), and declined with increasing water depth (Table 3-11). No significant differences were observed between years within habitat types 9 and 14.

Within a habitat type, evenness and diversity indices tended to be somewhat similar among Mine Area lakes, more so than among habitat types within a lake (Tables 3-12 and 3-13). As with the proportion of Chironomidae, differences among habitat types within a lake were evident for these two indices. Both indices decreased with increasing water depth, particularly for the Profundal Zone (Habitat Type 14; Figure 3-5 and 3-6). An exception to this was the diversity index for Camp Lake; however, the sample size for determining this metric in Habitat Type 4 was reduced to 1 due to the lack of macroinvertebrates in two of the three replicates. Data for these two indices were normally distributed, with the exception of diversity in Sheardown Lake NW, Habitat Type 9, and Mary Lake, Habitat Type 14. COVs for these two metrics were less than or equal to 40%, with the exception of diversity in Mary Lake, Habitat Type 14 (46%). Within a lake, COVs for both indices tended to increase with increasing water depth, particularly for the Profundal Zone; an exception to this was evenness in Sheardown Lake SE.

Within Sheardown Lake NW, COVs ranged between 20 and 33% for evenness and 10 and 41% for diversity when each habitat type was considered annually and both were notably higher in the Profundal Zone (Tables 3-14 and 3-15). No significant differences were observed between years within habitat types 9 and 14 for either evenness or diversity indices.

Richness

COVs for total and effective metrics were less than 40%, with the exception of total richness in Camp Lake Habitat Type 4 (173%) and Mary Lake Habitat Type 14 (64%), and effective richness in Sheardown Lake SE Habitat Type 4 (46%).

Within a lake, COV for total richness increased with increasing water depth (Table 3-16); an exception to this was Camp Lake. The pattern of COV for effective richness within a lake was inconsistent (Table 3-17). Data from Sheardown Lake NW demonstrated that there were differences in both richness metrics among habitat types and inter-annually within the same habitat type; however, both tended to decrease with increasing water depth (Figures 3-7 and 3-8). COVs ranged between 7 and 28% for total richness and 19 and 28% for effective richness when each habitat type was considered annually (Tables 3-18 and 3-19). COVs tended to be somewhat higher for effective richness in comparison to total richness in an aquatic habitat for any given year. Within Habitat Type 9, total richness was significantly higher in 2008 in comparison to 2007. No other significant differences were observed.

3.3.1.3 Stream Results

Abundance

Total macroinvertebrate density was higher in the furthest upstream reach and declined in downstream reaches, ranging from a mean of 3,332 individuals/m^2 in Reach 4 (furthest upstream) to 299 individuals/m^2 in Reach 1 (furthest downstream; Table 3-20). The data exhibited relatively high variability (COVs ranged from 25% to 97%), with the exception of Reach 1 (COV 18%). COVs of samples collected were somewhat higher in the furthest upstream reach in comparison to those collected from the middle and, particularly, the downstream reach; this may reflect increased heterogeneity of aquatic habitat in further upstream stream reaches. There were no statistically significant inter-annual differences in reaches 2 (2007, 2008) and 4 (2007, 2008, 2011).

Composition

Similar to total BMI density, the proportion of Chironomidae contributing to the macroinvertebrate community was higher in the furthest upstream reach and declined in downstream reaches, ranging from a mean of 91% in Reach 4 (furthest upstream) to 69% in Reach 1 (furthest downstream; Table 3-21). The data exhibited less variability (lower COVs) in comparison to total macroinvertebrate density, with the exception of Reach 2 in 2007 (COV of 36% for 2007 samples). There were no statistically significant inter-annual differences in reaches 2 and 4 (Table 3-21).

Evenness and diversity indices were both somewhat lower in the furthest upstream reach in comparison to more downstream reaches (Tables 3-22 and 3-23). Data for these two indices were normally distributed and COVs were well below 20%, with the exception of samples collected from Reach 4 in 2007 (COV 29% and 31% for evenness and diversity, respectively). No significant differences were observed between years with stream reaches 2 and 4 for either evenness or diversity indices.

Richness

Total taxa richness was slightly higher in the furthest upstream reach in comparison to more downstream reaches; however, effective richness was similar among the three reaches (Tables 3-24 and 3-25). Data for these two metrics were normally distributed and COVs were below 20%, with the exception of total taxa richness in Reach 4 in 2007 (COV 29%) and effective richness in Reach 4 in 2007, 2008, and 2011 (COV 51%, 34%, and 32%, respectively). No significant inter-annual differences were noted for either reach 2 or 4 for either richness metric.

3.3.2 Power Analysis

3.3.2.1 Data Analysis Methods

The most robust metrics identified through review of the baseline data for further statistical exploration and consideration under the CREMP were subject to a power analysis to:

- Provide a preliminary analysis of the power of the existing dataset to be used as the foundation for detecting post-Project change (i.e., Before-After comparisons);
- Explore samples sizes (i.e., number of replicate stations within a waterbody or area of a waterbody) required for detecting pre-defined levels of change; and
- Advise on the need for collection of additional baseline data and/or modifications to future sampling programs (i.e., number of replicate stations).

Power analysis was conducted following general guidance provided in the EC Metal Mining EEM Guidance Document (EC 2012). Specifically, values for α (Type I error) and β (Type II error) were set at 0.1 as advised in EC (2012); resulting power is 0.900. Evaluation of power of the existing baseline data for BMI community metrics was conducted using data collected from Sheardown Lake NW (evaluated by habitat type for pooled years of data) and Sheardown Lake Tributary 1, Reach 4 (also for pooled years of data). As noted previously, Sheardown Lake NW and its tributaries could be affected by a number of pathways of effects including effects on water clarity (dust, sewage discharge, and runoff), effects on other water quality parameters, and/or effects on hydrology. Additionally, Tributary 1 provides important juvenile Arctic Char rearing habitat.

Metrics that were subject to a power analysis included:

- Total macroinvertebrate density;
- Chironomidae proportion;
- Shannon's Equitability;
- Simpson's Diversity Index; and
- Total Taxa Richness.

COVs for the composition and richness metrics were typically less than 20% for each habitat type in Sheardown Lake NW and Tributary 1, Reach 4 and were therefore identified for further analysis; exceptions included Chironomidae proportion (Habitat 4), and Shannon's Equitability, Simpson's Diversity Index, and total taxa richness for Habitat 14 in Sheardown Lake NW (Tables 3-11, 3-14, 3-15, and 3-18). COVs for total macroinvertebrate density were high in all lake habitat types and Reach 4, but this metric was retained as it is one of the most commonly used indicators of the status of the BMI community in waterbodies.

CESs utilized for power analysis of Sheardown Lake NW and Tributary 1, Reach 4 are summarized in Tables 3-26 and 3-27, respectively. The CESs were selected based on the Metal Mining EEM Guidance document, scientific literature, and other recent/current AEMPs (see Section 3.3 of the main body of the CREMP for details). For metrics with a non-normal distribution (total taxa richness, Habitat Type 4; total macroinvertebrate density and Simpson's Diversity Index, Habitat Type 9; total macroinvertebrate density, Reach 4), all distributions were fitted to a log-normal prior to analyses; for Simpson's Diversity Index, it was truncated at 1. Analyses were run using PopTools version 3.2 (build 5) add-in for Microsoft Excel 2010. See Section 2.3.2 for additional details regarding power analysis methods.

3.3.2.2 Lake Results

Total Macroinvertebrate Density

The power of the existing total BMI density dataset from Sheardown Lake NW for detecting a pre-defined level of change (i.e., mean ± 50%, mean ± 25%, mean ± 20%) tends to be low for all scenarios explored and varies depending on the aquatic habitat type (Table 3-28). The aquatic habitat type with the highest power for detecting change post-Project is Habitat Type 9, with a power of 0.807 for detecting a change in the mean of ±50%.

Sample sizes (i.e., the number of replicate stations within an aquatic habitat type) required for detecting pre-defined levels of change in the density metric were high for all aquatic habitat types, likely related to the high variability in the existing dataset (COVs up to 94%; Table 3-29). A total of 31, 43, and 64 replicate stations would be required in habitat types 9, 14, and 4, respectively, to detect a change in the mean of ±50% (power of 0.900).

Chironomidae Proportion

The power of the existing dataset for the Chironomidae proportion metric to be able to detect a pre-defined level of change is high for all change scenarios explored in habitat types 9 and 14 (power of 1.000), but somewhat lower for Habitat Type 4 (Table 3-28). The power in Habitat Type 4 ranges from a high of 0.957 (mean ± 50%) to a low of 0.402 (mean ± 20%).

Sample sizes required for detecting pre-defined levels of change in the Chironomidae proportion metric were notably lower than those determined for the total macroinvertebrate density metric and varied by habitat type (Table 3-29). A total of 6, 22, and 37 replicate stations would be required in Habitat Type 4 to detect a change in the mean of 50%, ±25%, and ±20%, respectively (power of 0.900). Corresponding sample sizes in Habitat Type 9 were calculated to be 2, 4, and 6. Due to the low variability of this metric in Habitat 14, a sample of size of 1 would be sufficient to detect a change in the mean of ±20%.

Shannon's Equitability

The power of the existing dataset for the evenness metric (Shannon`s equitability) to be able to detect change post-Project is high for Habitat Type 9 for all scenarios examined (power of 1.000; Table 3-28). The power is high in habitat types 4 and 14 to be able to detect a change in the mean of ±50% (power of 1.000 and 0.990, respectively), but declines for changes in the mean of ±25% and ±20%.

With respect to required sample sizes, Habitat Type 9 is estimated to require 2, 4, and 6 replicate stations to be able to detect changes in the mean of ±50%, ±25%, and ±20%, respectively (Table 3-29). The number of replicate stations required in habitat types 4 and 14 for corresponding changes in the mean are higher, ranging between 3 and 10, and 7 and 37, respectively.

Simpson's Diversity Index

The power of the diversity index metric dataset to be able to detect change is high for habitat types 4 and 9 for all scenarios examined (Table 3-28). The power is also high in Habitat Type 14 to be able to detect a change in the mean of ±50% (power of 0.892), but declines for changes in the mean of ±25% and ±20%.

To detect a ±50% change in the mean, habitat types 4, 9, and 14 are estimated to require 3, <5, and 12 replicate stations, respectively (Table 3-29). The number of replicate stations required in Habitat Type 14 to be able to detect smaller changes in the mean increases notably in comparison to the other two habitat types.

Total Taxa Richness

The power of the existing total taxa richness dataset from Sheardown Lake NW for detecting a pre-defined level of change is high for all change scenarios and habitat types explored (Table 3-28). However, power is somewhat lower in Habitat Type 14 in comparison to the other habitat types to be able to detect a change in the mean of ±25% and ±20% (power of 0.866 and 0.712, respectively).

To detect a ±50% change in the mean, habitat types 4, 9, and 14 require <<3, 4, and 4 replicate stations, respectively (Table 3-29). The number of replicate stations required in habitat types 9 and 14 to be able to detect smaller changes in the mean increases similarly for both in comparison to Habitat Type 4.

3.3.2.3 Streams Results

Total Macroinvertebrate Density

The power of the existing total BMI dataset from Sheardown Lake Tributary 1, Reach 1 for detecting a pre-defined level of change (i.e., mean ± 50%, mean ± 25%, mean ± 20%) is low for all change scenarios explored (Table 3-30). The highest power of 0.785 is for a change in the mean of -50% (0.564: +50%) and the lowest is 0.109 for -20% (0.209: +20%).

Sample sizes (i.e., the number of replicate stations within a stream reach) required for detecting pre-defined levels of change in the density metric were high for all scenarios, which is likely related to the high variability in the existing dataset (COVs up to 97%; Table 3-31). A total of 13 (-50%) and 22 (+50%) replicate stations would be required to detect a change in the mean of ±50% (power of 0.900).

Chironomidae Proportion

The power of the existing dataset for this metric to be able to detect a pre-defined level of change is very high (power of 1.000) for all scenarios (Table 3-30). Due to the low variability of this metric (COVs of only 2-4%), a sample size of 2 would be sufficient to detect a change in the mean of ±50%; sample size only increases to 3 to be able to detect a change of ±20% (Table 3-31).

Shannon's Equitability

The power of the existing dataset for the evenness metric is high to be able to detect a change in the mean of ±50% (power of 1.000), but declines for changes in the mean of ±25% (0.791) and ±20% (0.602) (Table 3-30). With respect to required sample sizes, Reach 4 requires 4, 12, and 18 replicate stations to be able to detect a change in the mean of ±50%, ±25%, and ±20%, respectively (Table 3-31).

Simpson's Diversity Index

The power of the existing dataset for the diversity index is high to be able to detect a change in the mean of ±50% (power of 1.000), but declines for changes in the mean of ±25% (0.750) and ±20% (0.578) (Table 3-30). Similar to the evenness metric, Reach 4 requires 5, 13, and 19 replicate stations to be able to detect a change in the mean of ±50%, ±25%, and ±20%, respectively (Table 3-31).

Total Taxa Richness

The power of the existing dataset for total taxa richness is high to be able to detect a change in the mean of ±50% (power of 1.000), but declines for changes in the mean of ±25% (0.844) and ±20% (0.651) (Table 3-30). Reach 4 requires 4, 10, and 16 replicate stations to be able to detect a change in the mean of ±50%, ±25%, and ±20%, respectively (power of 0.900; Table 3-31).

3.3.3 Sampling Sites and Areas

3.3.3.1 Lakes

In lakes, EC (2012) recommends the spatial extent of each of the exposure and reference areas should be at least 100 m x 100 m and large enough to accommodate the required number of replicate stations, with sufficient separation. Replicate stations should encompass a minimum of a 10 m x 10 m area and be separated by at least 20 m.

Baseline sampling in the Mine Area lakes has included between three and seven replicate stations per habitat type (Table 3-1). Replicate stations were separated by approximately 10 m in 2006 and 2007, and by at least 20 m in 2008 and 2011.

3.3.3.2 Streams

In rivers and streams, EC (2012) recommends the spatial extent of each of the exposure and reference areas should be at least 100 m x 100 m and large enough to accommodate the required number of replicate stations, with sufficient separation. Replicate stations should encompass a longitudinal stretch of the river that includes one pool/riffle sequence; a river distance of six times the bankfull width should be adequate. Replicate stations should be separated by a minimum of three times the bankfull width between stations of similar habitat.

Baseline sampling in rivers/streams in the Mine Area included a minimum separation of three wetted stream widths between each replicate station (where more than one replicate station was sampled; Table 3-2).

3.3.4 Sample Size

EC (2012) recommends BMI sampling should include at a minimum, five replicate stations, each consisting of a minimum of three sub-samples, for both the exposure and reference areas. Replicate stations should be located within the dominant habitat class to reduce variability (where possible). Actual number of samples may vary on a site-specific basis and existing data should be analysed to identify adequate sample size.

Baseline sampling has included between three and seven replicate stations within streams and lakes in the Mine Area, depending on the year and area sampled; the exception was in 2005 when only one replicate station was sampled (Table 3-2). In general, five sub-samples were collected for each replicate station (the exception was for Mary Lake in 2007 where only one sub-sample was collected for logistical reasons and at Sheardown Lake in 2011 where the three replicates were composed of one, three, and one grabs, respectively).

3.3.4.1 Lakes

The power of the existing dataset in Sheardown Lake NW to be able to detect a post-Project change in the mean of ±50% is high for the majority of metrics investigated, with the exception of total macroinvertebrate density (Table 3-28). Habitat Type 9 has a power of 0.807 for detecting a ±50% change in the mean of total macroinvertebrate density;

whereas habitat types 4 and 14 have power of 0.247 and 0.441, respectively. Depending on the aquatic habitat type, the power of numerous metrics remains high to be able to detect a change in the mean of ±25% and 20%, particularly in habitat types 4 and 9; existing power in Habitat Type 14 is notably lower in comparison for all metrics except Chironomidae proportion.

Sample sizes (i.e., the number of replicate stations within an aquatic habitat type) required for detecting pre-defined levels of change (i.e., mean ± 50%, mean ± 25%, mean ± 20%; power of 0.900) in total macroinvertebrate density in Sheardown Lake NW are high for all aquatic habitat types (minimum of 31 required to detect change in mean of ± 50%; Table 3-29). Minimum sample sizes for other metrics required to detect a change in the mean of ± 50% ranged from 1 (Chironomidae proportion, Habitat Type 14) to 12 (Simpson's Diversity Index, Habitat Type 14), with the majority being 7 or less. Depending on the aquatic habitat type, the sample size required for several metrics is 7 or less to be able to detect a change in the mean of ±25% and 20%. More sensitive metrics to change include:

- Shannon's Equitability, Simpson's Diversity Index, and total taxa richness in Habitat Type 4;
- Chironomidae proportion, Shannon's Equitability, and Simpson's Diversity Index in Habitat Type 9; and
- Chironomidae proportion in Habitat Type 14.

The number of field sub-samples (i.e., grabs) per replicate station was determined for Sheardown Lake NW by aquatic habitat type and year that would provide an estimate with 20% precision (i.e., an acceptable level of variance) for each metric (Tables 3-9, 3-11, 3-14, 3-15, 3-18, and 3-19). For total macroinvertebrate density, this number ranged between 1 and 22 sub-samples, depending on the habitat type and year; whereas for all other metrics the number of sub-samples ranged from 1 to 5. EC has recommended that sub-samples collected at replicate stations in the future be assessed separately, rather than composited as in previous years, to evaluate variability. Five sub-samples were collected at each replicate station and preserved separately in 2013 to allow for an assessment of the number of field sub-samples required.

3.3.4.2 Streams

The power of the existing dataset in Sheardown Lake Tributary 1, Reach 4 to be able to detect a post-Project change in the mean of ±50% is very high for the majority of metrics investigated, with the exception of total macroinvertebrate density (power of 0.564; Table 3-30). The power of numerous metrics remains high to be able to detect a change in the mean of ±25% and 20%, particularly the Chironomidae proportion metric.

Sample size (i.e., the number of replicate stations within an aquatic habitat type) required for detecting pre-defined levels of change (i.e., mean ± 50%, mean ± 25%, mean ± 20%; power of 0.900) in total macroinvertebrate density in Reach 4 is comparatively high for all change scenarios (minimum sample size of 22; Table 3-31). Minimum sample sizes for other metrics required to detect a change in the mean of ± 50% ranged from 2 (Chironomidae proportion) to 5 (Simpson's Diversity Index). The sample size required for the Chironomidae proportion metric is 3 to be able to detect a change in the mean of ±25% and 20%. More sensitive metrics to change include Chironomidae proportion, followed by total taxa richness, Shannon's Equitability, and Simpson's Diversity Index.

The number of field sub-samples (i.e., grabs) per replicate station was determined for Reach 4 by year that would provide an estimate with 20% precision (i.e., an acceptable level of variance) for each metric (Tables 3-20 to 3-25). For total macroinvertebrate density, this number ranged between 1 and 23 sub-samples, depending on year; whereas for all other metrics the number of sub-samples ranged from 1 to 6. An assessment of the variability of sub-samples at a replicate station has not been conducted to date, as grabs were composited at each replicate station in previous years prior to identification and enumeration of macroinvertebrates. As described for lakes, EC has recommended that sub-samples collected at replicate stations in the future be assessed separately. Sub-samples were collected at each replicate station and preserved separately in 2013 to allow for an assessment of the number of field sub-samples required.

3.3.5 Sampling Methods

EC (2012) recommends the use of quantitative sampling equipment and specifically, grab samplers such as a petit Ponar or Ekman dredge for depositional habitats and stream-net samplers for erosional habitats in freshwater systems. All baseline data collected in lakes used either an Ekman or a petit Ponar dredge which is consistent with EC (2012) recommendations. Although stream sampling has been conducted with a Surber sampler rather than the recommended Neill-Hess type sampler, a Surber sampler is similar to a Neill-Hess cylinder-type sampler. BMIs in streams should continue to be sampled using a Surber sampler in the future to maintain continuity with the methods used for the existing datasets to facilitate before-after comparisons. The importance of maintaining continuity in sampling methods is fundamental for monitoring programs and is acknowledged by EC (2012).

EC (2012) recommends the use of a 500 µm mesh size for the freshwater environment and preservation of samples in 10% buffered formalin. All sampling for the Mine Area lakes and streams, with the exception of samples collected in 2005 when a mesh size of 250 µm was used, used a 500 µm mesh size and 10% buffered formalin for sample preservation.

3.3.6 Timing of Sampling

Timing of sampling should be concentrated within a single sampling season and should consider timing of previous sampling and the most ecologically relevant season. EC (2012) indicates that timing should also occur during effluent discharge but after the receiving environment has been exposed to the effluent for sufficient period during which effects would reasonably be expected to occur (i.e., generally within 3-6 months) in relation to Metal Mining EEM. Similarly, timing of sampling should consider the temporal aspects of other impact pathways being addressed through monitoring (e.g., changes in hydrology, dust deposition).

BMI sampling has been consistently conducted in the Mine Area in late summer/fall. This is an ecologically relevant time for sampling and would be most appropriate considering the effluent discharge regime (i.e., discharge during the open-water season only), hydrology (i.e., streams/rivers freeze solid), and dust deposition (i.e., introduction during the open-water season).

3.3.7 Taxonomy

EC (2012) recommends taxonomic identification to the family level for first and subsequent monitoring of freshwater systems under the MMER EEM, but that finer taxonomic resolution may be required to detect more subtle effects.

All BMI sorting and taxonomic identifications were conducted by the same laboratory (ZEAS Inc., Nobleton, ON), using the same laboratory methods among study years. Macroinvertebrates were identified to the lowest practical level using the most recent publications. Most taxa were identified to the level of Genus or Species, with the exception of flatworms, mites, and harpacticoid crustaceans, which were identified to Order.

3.3.8 Summary

Existing BMI community data are appropriate to use for post-Project monitoring; the robustness of these data was assessed through conduct of a power analysis (Section 3.3.2) to determine appropriate sample sizes for the 2013 freshwater field program and subsequent development of the CREMP. See Section 3.4 for an overview of the 2013 sampling program.

3.4 OVERVIEW OF 2013 SAMPLING

As BMI community sampling had only been conducted once at the majority of waterbodies and/or aquatic habitat types, sampling in the fall of 2013 was conducted to augment the baseline database and improve its utility for post-Project comparisons. Results of this program were not yet available at the time of this review; a summary of sampling that was completed is provided below.

3.4.1 Lakes

The Mine Area lakes program focused upon sampling in key (i.e., predominant habitat utilized by Arctic Char) habitat types in Camp and Sheardown lakes (Figure 3-9). Five replicate stations were sampled in each of the targeted habitat types. Five sub-samples were collected at each replicate station and preserved separately to facilitate examination of variability between sub-samples (i.e., variability within a replicate station). Due to inclement weather, sampling was not conducted in Mary Lake in 2013. A total of 11 replicate stations (five in each of two habitats, one in the third targeted habitat type) were sampled in Camp Lake, and a total of 10 (five in each of two targeted habitat types) were sampled in each of Sheardown Lake NW and Sheardown Lake SE.

3.4.2 Streams

The Mine Area tributaries program focused upon tributaries to Sheardown Lake based on the following rationale:

- Three stream reaches in Tributary 1 (Sheardown Lake NW): Arctic char bearing and primary open-water rearing habitat for juveniles. Tributary 1 may be affected by stream diversion and dust deposition;

- One stream reach in Tributary 9 (Sheardown Lake SE): Arctic char bearing. Tributary 9 may be affected by stream diversion and dust deposition;

- Two stream reaches in Tributary 12 (Sheardown Lake NW): Arctic char bearing. Tributary 9 may be affected by stream diversion and dust deposition (Figure 3-9).

Within a stream reach, 2-3 replicate stations, each consisting of 2-5 randomly collected benthic invertebrate sub-samples, were collected. The sub-samples were kept separate to provide an estimate of variability in the benthic community at each station (with the exception of Tributary 1, Replicate Stations B1, B2, and B3 where sub-samples were composited).

4.0 ARCTIC CHAR

The following sections provide an inventory of available baseline Arctic Char (*Salvelinus alpinus*) data, a description of key pathways of effect and key questions respecting the Project, a preliminary examination of baseline Arctic Char data, a review of sample size, sampling sites, methods, and timing, and an overview of sampling completed in 2013.

Sampling of the fish community was initiated in 2005 in the Mine Area; Year 1 of the baseline studies was primarily a reconnaissance exercise aimed at identifying fish species present in the area and general distribution. Subsequent studies examined:

- Fish distribution across the Mine Area streams and identification of fish barriers;
- Fish movements (Arctic Char) between waterbodies;
- Fish population characteristics and condition (catch-per-unit-effort [CPUE], age structure, length/size at age, sex and sexual maturity, condition factors, deformities, erosion, lesions, and tumours [DELTs], and internal and external parasites);
- Seasonal movement of Arctic Char from lakes into and out of streams/rivers;
- Anadromy;
- Seasonal use of various habitat types by different life history stages;
- Metals in liver and muscle; and
- Spawning areas/timing.

This review focused upon metrics that were identified for the CREMP (i.e., individual and population level metrics of growth, survival, condition and reproduction) and did not therefore discuss data regarding fish movements/anadromy or metals in fish. Information on fish movements and habitat use were considered as supporting information for the review of baseline data and in the design of the CREMP.

While this review focused upon consideration of baseline data in Mine Area lakes, for the purposes of providing a general overview of available baseline data for Arctic Char in the Mine area, and because data collected in streams could be used to augment or support lake monitoring programs, Section 4.1 provides a brief description of baseline studies programs conducted in lakes and streams.

The detailed review of baseline data was completed in 2013 prior to the open-water season (NSC 2013) in part to provide recommendations for additional baseline data collection for the 2013 field season. A field program was subsequently completed in 2013, as summarized in Section 3.4. The detailed review of baseline data provided in Section 4.3 is based on data collected from 2005 through 2012 in the Mine Area.

4.1 INVENTORY OF FRESHWATER BASELINE DATA

The following sections provide an inventory of baseline studies for Arctic Char in the Mine Area. Specifically, the following provides:

- An overview of the sampling methods employed for collection and analysis of Arctic Char in the Mine Area waterbodies; and
- An inventory of existing baseline Arctic Char data for Mine Area waterbodies.

4.1.1 Sampling Methods

4.1.1.1 Lakes

A Smith-Root Model 11A or LR-24 backpack electrofisher was used during 2007, 2008 and 2013 to assess the use of wadeable nearshore lake habitat by small fish. During summer 2007, approximately 50-100 m long sections of shoreline with a variety of substrates (e.g., sand, cobble/boulder, gravel/cobble) were electrofished to assess habitat use by small fish in most Mine Area lakes. During spring 2008, electrofishing effort was focused on substrate types (cobble/boulder) thought to be preferred Arctic Char rearing habitat. The presence of recently hatched young-of-the-year (YOY) Arctic Char in nearshore habitat during early spring would provide some evidence of nearby fall spawning. Captured fish were sampled and released. During fall 2013, rocky habitats were fished in an attempt to collect sufficient numbers of juvenile Arctic Char for AEMP analyses.

During the open-water seasons of 2006-2008 and 2013, standard gang index gill nets were used to sample fish at sites in Camp, Sheardown, and Mary lakes. Small mesh gill nets were also used in 2013. During 2006, gillnet sites were selected opportunistically. In 2007, sites were selected to achieve good spatial coverage of Camp, Sheardown, and Mary lakes. In 2008, the focus of the gillnetting program was on the identification of Arctic Char spawning habitat. In 2013, the focus of the gillnetting was to capture a sufficient number of fish (n = 100) across all size ranges of Arctic Char as part of a baseline study to support the CREMP. Standard index gillnet gangs consisted of six 22.9

m long by 1.8 m deep twisted nylon or monofilament panels of 1.5, 2.0, 3.0, 3.75, 4.25, and 5.0 inch (38, 51, 76, 95, 108, and 127 mm, respectively) stretched mesh. Small mesh gangs consisted of three 10 m long by 1.8 m deep panels of 16, 20 and 25 mm stretched mesh. Nets were set on the bottom and left in place for short periods of time (typically less than 4 hours) to minimize fish mortality. Winter gillnetting conducted in May 2007 used different gang arrangements and different methods and are not comparable with open-water gillnetting. Therefore, winter gillnetting data were excluded from the analyses presented in this report. Locations (i.e., UTMs) of all captured fish were recorded using a hand-held global positioning system (GPS) unit.

Biological data were collected for most fish captured in both gear types; however, the amount of data collected varied by year, gear type, and size and condition (i.e., live or mortalities) of fish. In all surveys, fish were identified to species, enumerated by location, and measured for fork length (± 1 mm). For fish less than 250 mm in length, round weight was measured to an accuracy of ± 1 g in 2006-2008 and 0.01 g in 2013, while larger fish were consistently weighed to an accuracy of ± 25 g. When possible (i.e., during fall), live fish were examined for sex and maturity by gently massaging the abdomen and identifying any extruded gametes. Mortalities and fish in poor condition from all years were retained and examined internally to determine sex and state of sexual maturity (i.e., had never spawned, preparing to spawn in the current year, had just completed spawning in the current year, or had spawned in a previous year but would not be spawning in the current year), where possible. Ageing structures (otoliths) were collected from a length-stratified sub-sample of gillnet-caught fish from all Mine Area lakes and from a length-stratified sub-sample of electrofishing-caught fish from Mary River from 2006-2008. In 2013, pectoral fin rays were collected from live released fish and both otoliths and fin rays were collected from incidental mortalities.

4.1.1.2 Streams

Backpack electrofishing was conducted from 2006-2008 using a Smith-Root Model 11A or LR-24 backpack electrofisher to assess the use of streams and rivers within the Mine Area by fish. Electrofishing surveys were primarily confined to reaches of streams and rivers where the results of aquatic habitat surveys suggested some potential to support fish. Stream reaches that either were ephemeral, or were cut off from lakes by impassable barriers typically were not fished. Streams and rivers electrofished in 2006 were confined to summer surveys, whereas most streams and rivers electrofished in 2007 were surveyed during spring, summer, and fall to document seasonal use of the tributaries. During 2008, several tributaries that had not been electrofished previously (particularly tributaries to Mary Lake) were fished during spring and summer.

Streams were subdivided into reaches based primarily on changes in dominant habitat types. Sections of each reach (50 m long) were isolated with barrier nets, where possible, and electrofished to estimate total fish use and compare between habitat types. Three passes were made in a downstream direction along each reach and the number of fish captured during each pass was recorded. All captured fish were released back into the reach from which they were captured at the completion of sampling.

Additional information on the fish use of selected tributaries was collected using hoop nets. Hoop nets oriented to capture fish moving downstream were installed in Camp Lake Tributary 2 (CLT2) and Sheardown Lake Tributary 1 (SDLT1) during fall 2007 to assess downstream movements of fish out of these tributaries. During 2008, hoop nets were installed during spring and fall to identify timing and magnitude of movements of fish into and out of these two streams after spring melt and prior to freeze-up. Upstream and downstream movements were monitored in CLT2 during spring and fall and in SDLT1 during spring, 2008. Low water levels during fall 2008 prevented monitoring of upstream movements in SDLT1. During fall 2013, downstream facing hoop nets were installed in Camp Lake Tributaries 1 and 2 and Sheardown Lake NW Tributary 1.

Hoop nets were constructed of fine-mesh beach seine material, were 0.6 m in diameter, and had 5 m long wings. Each hoop net was positioned as close to the confluences as possible at sufficient depths to remain submerged. Each wing and the cod end of the net were anchored so that it remained taut and spanned the width of the stream. Wings were lengthened with rock barriers, where necessary, to achieve 100% blockage of the channel in either upstream or downstream configurations. All captured fish were released into the stream on the opposite side of the hoop net in which they were caught at the completion of sampling.

Biological data were collected for most fish captured in all gear types; however, the amount of data collected varied by gear type and size of fish. Fish were identified to species, enumerated by location, and measured for fork length (± 1 mm). For hoopnet-caught fish, only the first 50 fish captured each day were measured for fork length. For fish less than 250 mm in length, round weight was measured to an accuracy of ± 1 g, while larger fish were weighed to an accuracy of ± 25 g. Fish longer than 250 mm, and in good condition, were marked with individually numbered Floy® FD-94 tags inserted at the base of the dorsal fin. During 2013, pectoral fin rays were also collected from a subsample of fish and otoliths were collected from incidental mortalities.

4.1.2 Baseline Data Inventory

4.1.2.1 Lakes

Fish were sampled in lakes in the Mine Area using angling, minnow traps, backpack electrofishing, and standard gang and small mesh index gill nets during the open-water periods of 2005 to 2008, 2010 and 2013 and using gill nets deployed under the ice in May 2007 (Figure 4-1, Table 4-1). Sampled lakes included Camp, Sheardown (northwest and southeast basins), and Mary (north and south basins) lakes.

4.1.2.2 Streams

Fish were sampled in streams within the Mine Area using angling, minnow traps, backpack electrofishing, and hoop nets during the open-water periods of 2005 to 2008 and 2013 (Figure 4-2, Table 4-1). Sampled streams and rivers included inflows to Camp Lake, Sheardown Lake (northwest and southeast basins), and Mary Lake (north and south basins), as well as the Mary and Tom rivers. The largest data sets were obtained from the hoopnetting programs conducted at the confluences of tributary streams with Camp and Sheardown lakes. These data improve robustness of the baseline database respecting YOY and age 1+ juvenile datasets for lakes.

4.2 PATHWAYS OF EFFECT AND KEY QUESTIONS

Key questions were developed to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. The adequacy of baseline data to address these key questions is addressed in Section 4.3. These questions and metrics focus upon key potential residual effects identified in the FEIS (BIM 2012) and the Addendum to the FEIS for the ERP (BIM 2013), as well as metrics commonly applied for characterizing fish populations (growth, reproduction, condition and survival) and recommended by EC (2012).

The key pathways of potential residual effects of the Project on Arctic Char include:

- Water quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1);

- Water quality changes related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW);
- Water quality changes due to deposition of dust in lakes and streams (Mine Area in zone of dust deposition);
- Water quality changes due to non-point sources, such as site runoff and use of ANFO explosives (Mine Area);
- Changes in water levels and/or flows due to water withdrawals, diversions, and effluent discharges (i.e., alteration or loss of aquatic habitat);
- Dust deposition (i.e., sedimentation) in Arctic Char spawning areas (habitat) and on Arctic Char eggs; and
- Effects of the Project on primary and secondary producers.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources, sedimentation, habitat loss or alteration, and changes in primary or secondary producers on Arctic Char in Mine Area lakes (Sheardown Lake NW and SE, Camp Lake, and Mary Lake)?

Arctic Char will be monitored downstream of discharges of ore and waste rock stockpile runoff (i.e., Camp Lake Tributary 1 and the Mary River) under the MMER EEM program. Of the remaining waterbodies, potential effects of the Project on Arctic Char populations are predicted to be greatest in the Camp Lake and Sheardown Lake drainages.

4.3 EVALUATION OF DATA FOR POST-PROJECT MONITORING

The Mine Area streams and lakes support only two fish species: land-locked Arctic Char; and, Ninespine Stickleback (*Pungitius pungitius*). Of these, abundance of Ninespine Stickleback is relatively limited and highly localized while Arctic Char are overwhelmingly the most abundant fish species in the area. As Mine Area streams freeze solid during winter, overwintering habitat is provided exclusively by lakes.

EC (2012) recommends monitoring of sexually mature individuals of a minimum of two fish species for EEM programs and use of invasive sampling (i.e., lethal) if acceptable. Alternative study designs include non-lethal sampling methods for fish populations/communities, as well as studies of juvenile fish if appropriate and/or required.

Given that there are only two fish species present in the area, fish monitoring in the Mine Area would be limited to successful capture of sufficient numbers of both of these fish species in the exposure areas. In most lakes and streams in the exposure area, Arctic Char are sufficiently abundant that successful capture of enough fish for monitoring purposes is possible. In contrast, Ninespine Stickleback are absent or uncommon in a number of waterbodies. Similar results have been observed in most waterbodies surveyed for all components of the Mary River Project. It is unlikely, even with extensive effort, that sufficient numbers of Ninespine Stickleback could be captured for monitoring purposes from either the receiving environments or from prospective reference areas. For this reason, only a single species, Arctic Char, will be monitored used for the CREMP program.

4.3.1 Description of Existing Data

The following provides a description of existing data for Arctic Char based on backpack electrofishing and open-water gillnetting data collected in Mine Area lakes in 2006-2008 and hoopnetting data collected in streams in 2006-2008.

4.3.1.1 Data Analysis

To explore the robustness of various potential metrics for Arctic Char for the CREMP, several metrics were derived as indicated in Table 4-2, using the datasets indicated in Table 4-3. The CREMP and MMER EEM programs will employ non-lethal sampling methods to minimize impacts of monitoring on the Arctic Char populations. Therefore the metrics identified and assessed for the CREMP are those that can be measured using non-lethal sampling methods. Metric data for Arctic Char were analysed where sample sizes were $\geq$ 10, by waterbody, year, gear type (gill net and electrofishing only), and sex. When sex could not be determined for sufficient numbers of fish (e.g., electrofishing catches), data were pooled. Age data collected from a subsample of gillnetted fish in each lake were pooled to provide a sufficient sample size. Annual gillnetting data collected from 2006-2008 and shoreline electrofishing data (Sheardown Lake NW only) collected in 2007 and 2008 were analysed. Methods for the calculation of derived metrics are described below.

All fish catch and life history data were tabulated and reviewed for transcription errors as part of routine QA/QC measures and, if warranted, outliers were eliminated from datasets. Fish catches were examined by lake, species, gear type, and year.

For Arctic Char, mean length, weight, and condition factor were calculated by lake, year, gear type, and, where possible, sex. CPUE was calculated for fish captured by electrofishing (#fish/minute of electrofishing) and in gill nets (#fish/100 m of net/24 hrs). Summary statistics (mean, median, SE, SD, minimum, maximum, n, COV, and 95th percentile) for each of these metrics were derived for each year, waterbody, gear type and, where possible, sex using data from all sites sampled concurrently in that waterbody.

COV was calculated as SD/mean x 100; COV facilitated comparisons of the variability of various datasets to assist with identifying the most robust metrics as well as to assist with advising on sampling design. The variability of the metrics examined was then described to facilitate identification of those metrics with the lowest natural variation for further consideration and statistical analysis.

Additional summary statistics were conducted on YOY and fish aged 1+, including length-frequency analyses, length-at-age and weight-at-age to provide estimates of growth and survival of these early life stages.

Some hoop net data from streams (i.e., lengths and weights for YOY and 1+ fish) were pooled with shoreline electrofishing data in Sheardown Lake NW to improve robustness of the lake dataset for analysis.

4.3.1.2 Results

Fork Length (mm)

Mean lengths of Arctic Char show variation between lake, year, and sex (Tables 4-4 to 4-6). However, there were no significant differences observed between males and females sampled within the same year in any lakes and with one exception, there were no significant differences observed between years for this metric (Table 4-7). The sole exception occurred for females captured in Camp Lake where lengths were significantly different between years.

Comparing datasets between lakes revealed that Camp Lake had the smallest mean length and highest COV while the catches from the Mary Lake basins had the highest mean length and lowest variability (Tables 4-4 and 4-6). There were no significant differences for any between-lake comparisons of datasets (Table 4-8).

Weight (g)

Mean weights of Arctic Char show even greater variation between lake, year, and sex (Tables 4-9 to 4-11) than mean fork lengths. No significant differences between sexes or years were observed for Sheardown Lake NW or Mary Lake South. Weights of females were significantly lower than males captured in 2006, 2008, and with all years combined (2006-2008) and weights of both males and females were significantly different between years in Camp Lake (Table 4-12).

Comparing datasets between lakes revealed that north basin of Mary Lake had the smallest mean weight and COV while the south basin had the highest mean weight and Camp Lake had the highest variability (Tables 4-9 to 4-11). There were no significant differences for any between-lake comparisons of datasets (Table 4-13).

Condition Factor (K)

In contrast to length and weight metrics, mean condition factor of Arctic Char showed little variation between datasets and lower COVs than fork lengths (Tables 4-14 to 4-16). Mean condition factor was similar between males and females and between years in Camp Lake with consistently low COVs (Table 4-14). Mean condition factor of Arctic Char captured in Sheardown Lake was slightly lower than for Camp Lake, but also showed consistency between sexes and across years with low COVs for the gillnetting catch (Table 4-15). Condition factors of fish captured by electrofishing in Sheardown Lake NW was greater than for fish captured with gill nets, however the electrofishing dataset also exhibited higher COVs. In the south basin of Mary Lake, mean condition factor was higher in 2006 than in 2007, but relatively consistent between sexes and variability was low (Table 4-16).

Non-parametric analysis revealed significant interannual differences for males captured in Sheardown Lake NW and between males and females from Sheardown Lake NW in 2006 (Table 4-17). There were no significant differences for any between-lake comparisons of condition factor datasets (Table 4-18).

Catch-Per-Unit-Effort

As is commonly observed, CPUE for Arctic Char showed consistently high variation among datasets (Table 4-19). The highest COV was observed in the Sheardown Lake datasets. Data for males and females were not analysed separately because sex could not be identified for all captured fish, particularly during summer sampling.

Significant interannual differences (P value < 0.05) were observed for gillnetting datasets for Camp Lake and Mary Lake south and for the electrofishing dataset from Sheardown Lake NW (Table 4-20). In addition, there were significant differences for all between-lake comparisons (Table 4-21).

Age

Summary statistics for age data from Arctic Char are presented in Table 4-22. Fish sampled from Sheardown and Mary lakes had the highest average age while those sampled from Mary River had the lowest. Variation is relatively low between individual lakes and high between lakes and rivers. Length and weight-at-age statistics show a general increase in size with increasing age (Table 4-23). Growth rates appear to be higher between the ages of 2 and 10 than in older fish. Analysis of covariance (ANCOVA) tests show a significant effect of age on both length and weight (Table 4-24).

4.3.2 Power Analysis

4.3.2.1 Methods

Selected Arctic Char metrics (Table 4-25) were subject to a power analysis to:

- Provide a preliminary analysis of the power of the existing dataset to be used as the foundation for detecting post-Project change (i.e., Before-After comparisons);
- Explore samples sizes required for detecting pre-defined levels of change; and
- Advise on the need for collection of additional baseline data and/or modifications to future sampling programs (i.e., number of sites).

The variability of selected Arctic Char metrics measured during the baseline studies program was evaluated and described in Section 4.3.1 to assist with identifying the most robust metrics for further statistical exploration and consideration under the CREMP. Metrics that were subject to a power analysis included:

- Age 0+ and 1+ Length (mm);
- Age 1+ Weight (g); and
- Age 1+ Condition Factor.

Condition factor and weight of Age 0+ (i.e., YOY) fish could not be subject to a power analysis due to the precision of the weight measurements for the existing baseline datasets.

Power analysis was conducted following general guidance provided in the EC Metal Mining EEM Guidance Document (2012). Specifically, values for α (Type I error) and β (Type II error) were set at 0.1 as advised in EC (2012). Data were evaluated for assumptions of normality and equal variance and transformed where required. Baseline data on Arctic Char populations collected in Sheardown Lake NW and Camp Lake from 2006-2010 were evaluated statistically for consideration of monitoring under the CREMP.

For non-lethal sampling, EC (2012) recommends sampling of a minimum of 100 fish older than YOY for each study site but also recommends retaining and measuring all YOY collected during the sampling for older fish. Where possible, fish older than YOY should represent the whole range of fish sizes and be representative of the population (mature and immature).

A Priori Power Analyses

Power analysis by simulation was implemented using PopTools (Hood 2010).Two types of power analyses were used; one based on a *t*-test (parametric) and one based on the Mann-Whitney (nonparametric) *U*-test.

The power of existing baseline data to be used for demonstrating changes in the various metrics was explored for a range of effects sizes (i.e., ±10%, ±20%, and ±25%). Using the dNormalDev(mean, SD) function, random data were generated for the observed baseline and hypothetical monitoring scenarios. The Excel formula for a t-test was used keeping the first row fixed. This process was iterated 1000 times by Monte Carlo simulation to determine the frequency of a realised t-probability greater than α (Type I error). This provided an estimate of β (Type II error) with the power of the test being 1-β. Both α and β were set at 0.10 for a power of 90% following the EEM Guidelines (EC 2012).

4.3.2.2 Results

The power analyses indicated that a sample size of 100 fish is sufficient to detect changes in length of 10%, in weight of 20%, and in condition factor of 10% (Table 4-25). Weights were the most variable of these three metrics and the power associated with this metric is the lowest. The power analyses indicate that relatively small samples sizes are required to detect 10% changes in length (n = 25 YOY and n = 11 for Age 1+) and condition factor (n = 9 for Age 1+).

4.3.3 Study Design

Monitoring of Arctic Char in the Mine Area under the CREMP would utilize a non-lethal sampling design. The objective of the lake monitoring programs is to examine cumulative effects of the Project on Arctic Char populations. Lakes provide critical habitat for Arctic Char, as streams freeze solid in winter and spawning and overwintering habitat is restricted to lakes. The CREMP would examine the collective Project effects through monitoring Arctic Char in Mine Area lakes as a whole.

The lake-based CREMP sampling program is focused upon obtaining measures of metrics for Age 1+ fish using standardized sampling methods (i.e., standard gang index gillnetting). The monitoring program will consist of direct before-after comparisons within a lake and, depending on the suitability of the final reference lakes incorporated into the CREMP, may also include control-impact comparisons (or, ideally, before-after-control-impact comparisons).

Gear would be primarily standard gang index gill nets, supplemented with smaller mesh nets (i.e., Swedish nets) and/or electrofishing as required to obtain the required minimum target sample size and range of fish ages/sizes.

4.3.4 Timing of Sampling

EC (2012) indicates that timing of sampling should consider the time of year, hydrology/habitat variability, stage of reproductive development, and effluent discharge regime. Fish biology also affects timing of sampling (e.g., seasonal use of exposure areas) and reference and exposure areas should be sampled as close in time as feasible and should consider water temperature explicitly.

For Arctic Char, the recommended sampling period is 4-6 weeks prior to first spawn (EC 2012). For non-lethal surveys that include collection of YOY, EC (2012) recommends that sampling be conducted when YOY are a catchable size in the gear being used. They further recommend sampling YOY in late fall where appropriate, though timing should consider variability in YOY size distributions of the population being monitored, or ideally, at the beginning and end of the growing period.

From 2006-2008, baseline sampling programs conducted in Camp, Sheardown and Mary Lakes with standard gang index gill nets typically occurred during summer (late July/early August) and covered all habitat types throughout the lake. These data were supplemented with limited fall sampling intended to identify spawning locations. Fall gillnetting was primarily restricted to areas where preferred spawning substrates were located. Sampling in streams was conducted during spring, summer and fall in all available habitat types to document seasonal use of stream habitat by both species of fish.

In 2013, the Arctic Char sampling program was conducted in late summer/fall in Mine Area lakes to target the end of the growing season prior to spawning. During Project operation, this timing would allow for sampling of Arctic Char following a prolonged period of exposure to effluent (which will be discharged in the open-water season) and other non-point sources such as dust.

4.3.5 Sampling Areas

EC (2012) provides detailed direction on identifying exposure areas for the fish monitoring component under MMER EEM. As the objective of the MMER EEM programs is to monitor for effects of metal mining effluent on fish populations, these exposure areas are intentionally selected in areas affected by effluent discharges. Reference areas are then identified with, ideally, identical features and characteristics (e.g., habitat), for comparison.

Baseline sampling of Mine Area lakes with standard gang index gill nets was designed to provide quantitative estimates of Arctic Char populations for each lake and to identify spawning areas, while backpack electrofishing in all available nearshore habitat types of the lakes was conducted to identify habitat preferences of juveniles and assist with identification of spawning areas. During 2006, gillnet sites were selected opportunistically. In 2007, sites were selected to achieve good spatial and habitat coverage of Camp, Sheardown, and Mary lakes. In 2008, the focus of the gillnetting program was on the identification of Arctic Char spawning habitat.

In 2013, the program was designed to collect 100 fish from all size classes in each lake to provide baseline information for the CREMP. The CREMP is intended to monitor the cumulative effects of the Project on Arctic Char populations in Mine Area lakes and is not intended to focus upon mining effluent or any one particular effects pathway. As such the CREMP adopts a broader spatial scope and is intended to provide information on a lake-wide basis, rather than on a focused area of each lake.

4.3.6 Sample Size

For non-lethal sampling, EC (2012) recommends sampling of a minimum of 100 fish older than YOY for each study area but also recommends retaining and measuring all YOY collected during the sampling for older fish. Where possible, fish older than YOY should represent the whole range of fish sizes and be representative of the population (mature and immature).Where abundance of YOY is “extremely high” (i.e., >80-90% of the first 100 fish captured during the program), sampling should continue until 100 non-YOY fish are captured.

Results of the power analyses conducted on the Sheardown Lake NW datasets indicates that this recommended sample size will be adequate to detect CESs between 10 and 25% on selected metrics. However, the power analyses were based on baseline data collected from a representative lake (Sheardown Lake NW) using a different study design than recommended for the CREMP. Therefore the CREMP will target a minimum of 100 individuals per lake, as recommended by EC (2012).

4.3.7 Metrics

EC (2012) recommends that non-lethal sampling should include fork length for fish with a forked caudal fin (± 1 mm), total body weight (± 1.0%), assessment of external condition (i.e., DELTs), external sex determination (if possible), and age (where possible; ± 1 year). They further recommend the use of a 3-decimal scale for measuring weights of small-sized fish.

Baseline studies included measurement of all of these metrics but some metrics were not measured to the recommended precision for all fish sampled. Future programs will employ the level of precision identified by EC (2012) for all fish captured.

Arctic Char were aged using otoliths - the preferred ageing structure for this species – during most of the baseline studies. The CREMP will employ a non-lethal design and therefore will require use of another ageing structure (i.e., pectoral fin rays) for fish that are live released. Based on the results of a comparative analysis of pectoral fin rays and otoliths for ageing Arctic Char in the Mine Area (NSC 2014), it will be necessary to sacrifice fish from a length-stratified sub-sample during the conduct of future studies. Ageing measurements will also be independently confirmed on a minimum of 10% of samples, as recommended by EC (2012).

4.3.8 Sampling Equipment

EC (2012) indicates the same gear type should be used for sampling reference and exposure areas and ideally only one gear type is used for the fish study. In nearshore areas of lakes, backpack electrofishing has been the primary method of sampling and will be used for sampling these areas during the CREMP program as needed. Standard gang index gillnetting has been used for baseline lake surveys and will continue to be used during the CREMP program as the primary sampling method. Small mesh nets may also be used to capture sufficient numbers of fish, in particular smaller size ranges. However, small mesh nets have proven relatively ineffective for capture of fish smaller than 250 mm in length and it is anticipated that backpack electrofishing will be required in future programs to obtain Arctic Char in this length range.

4.4 OVERVIEW OF 2013 SAMPLING

The Arctic Char sampling program conducted in Mine Area lakes in 2013 was designed to be non-lethal and was based upon EC's EEM survey design (EC 2012). As such, the lake-based sampling program was focused upon obtaining measures of metrics for Age 1+ fish using standardized sampling methods (i.e., standard gang index gillnetting). The program was habitat-based, with sampling effort weighted in accordance with the proportions of major habitat types in each of the lakes. Major habitat types were defined in terms of water depth and substrate as follows:

- Deep (> 12 m)/hard;
- Deep/soft;
- Shallow (2-12 m)/hard; and
- Shallow/soft.

Sites were randomly selected within these habitats in each lake. Catch rates were lower than anticipated based on gillnetting surveys conducted from 2006-2008 and sampling was enhanced by addition of sites most likely to optimize catches (e.g., probable spawning areas). Gear included standard gang index gill nets, supplemented with smaller mesh nets (i.e., Swedish nets) and nearshore backpack electrofishing to obtain the required minimum target sample size (100 fish) and range of fish ages/sizes.

Twenty-four standard index and eleven small mesh gillnet gangs were set in Camp Lake from 27-29 August, 2013 (Figure 4-3). Twelve standard index and 6 small mesh gillnet gangs were set in Sheardown NW Lake on 30 August, 2013 (Figure 4-4). A total of 26 Arctic Char were captured in Camp Lake and 28 were captured Sheardown Lake NW with gill nets.

To supplement the small gillnetting catches, backpack electrofishing was conducted at one site in Camp Lake and two sites in Sheardown Lake NW. Fifty-seven juvenile Arctic Char were captured in Camp Lake and 183 Arctic Char and one Ninespine Stickleback were captured in Sheardown Lake NW during electrofishing surveys.

As noted in Section 4.3.7, pectoral fin rays and otoliths were collected from incidental mortalities of Arctic Char during the 2013 field program to facilitate comparison of the two ageing structures. The results of this comparison are provided in NSC (2014).

5.0 LITERATURE CITED

Azimuth Consulting Group. 2012. Core receiving environment monitoring program (CREMP): Design document 2012. Prepared for Agnico-Eagle Mines Ltd., Baker Lake, Nunavut. December 2012.

Baffinland Iron Mines Corporation (BIM). 2012. Mary River Project Final Environmental Impact Statement. February 2012.

BIM. 2013. Mary River Project – Addendum to the Final Environmental Impact Statement. June 2013.

Begon, M., J.L. Harper, and C.R. Townsend. 1996. Ecology: individuals, populations and communities; third edition. Blackwell Science. Mississauga.

Cole, G.E. 1983. Textbook of limnology. Third Edition, Waveland Press Inc., Prospect Heights, Illinois.

Environment Canada. 2012. Metal mining technical guidance for Environmental Effects Monitoring. ISBN 978-1-100-20496-3.

Hill. M.O.. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54: 427-432.

Hood, G. M. 2010. PopTools version 3.2.5. Available on the internet. URL http://www.poptools.org

Indian and Northern Affairs Canada (INAC). 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories. Yellowknife. June 2009. Volumes 1-6.

Magurran, A. E. 2004. Measuring biological diversity. Blackwell. Malden Massachusetts.

Magurran, A.E.1988. Ecological diversity and its measurement. Princeton University Press. New Jersey.

Mandaville, S.M. 2002. Benthic macroinvertebrates in freshwaters – taxa tolerance values, metrics, and protocols. Project H-1. Soil and Water Conservation Society of Metro Halifax. 48p. + Appendices.

Munkittrick, K., C. Arens, R. Lowell, G. Kaminski. 2009. A review of potential methods of determining critical effect size for designing environmental monitoring programs. Environmental Toxicology and Chemistry 28:1361-1371.

North/South Consultants Inc. (NSC). 2014. Arctic Char ageing structure comparison. Technical Memorandum prepared for Baffinland Iron Mines Inc., May 24, 2014.

NSC. 2013. Preliminary review of baseline data for freshwater biota: Mary River Mine Site. October 2013. Prepared for Baffinland Iron Mines Corporation.

Organization for Economic Cooperation and Development (OECD). 1982. Eutrophication of waters: monitoring, assessment and control. Final Report. OECD cooperative programme on monitoring of inland waters (eutrophication control). Environment Directorate, OECD, Paris, France. 154 pp.

TABLES AND FIGURES

Table 2-1. Summary of number of sites sampled for analysis of chlorophyll *a* in Mine Area lakes (near surface sampling).

Sampling Period	Sheardown Lake NW	Sheardown Lake SE	Camp Lake	Mary Lake
May 2007	3	2	3	4
August 2007	5	3	3	4
September 2007	5	3	3	4
June 2008	6	0	0	0
July/August 2008	22	6	3	3
September 2008	11	3	0	0
August/September 2009	4	1	0	0
July 2013	6	1	5	6
August 2013	6	1	5	3
Total	68	20	22	24
Total: Open-water Period	65	18	19	20

Table 2-2. Summary of number of sites sampled for analysis of phytoplankton taxonomy and biomass in Mine Area lakes.

Sampling Period	Sheardown Lake NW	Sheardown Lake SE	Camp Lake	Mary Lake
August 2007	5	3	3	5
September 2007	5	3	3	5
July/August 2008	5	3	3	4
September 2008	5	3	0	0
July 2013	11	8	10	10
August 2013	6	1	10	0
Total	37	21	29	24

Table 2-3. Summary of number of sites sampled for analysis of chlorophyll *a* in Mine Area streams.

Sampling Period	Mary River	Tom River	Sheardown Lake Tributaries						Camp Lake Tributaries		Tributary to CL Trib 1	Outlet of Camp Lake	Camp Lake Reference stream s		N. Trib of Mary River	Tributaries to Mary Lake	Mary River Reference Streams		Tributary to Katiktok Lake
			SDL NW Trib 1	SDL SE Trib 9	SDL NW Trib 12	SDL NW Trib 13	Unnamed Trib A SDL NW	Unnamed Trib B SDL NW	CL Trib 1	CL Trib 2			No. 3	No. 4		Mary Lake Trib 2	No. 2	No. 3	
Jun-07	7	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-07	8	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep-07	7	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun-08	3	2	3	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Jul-08	8	0	3	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sep-08	2	1	2	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Jun-13	9	1	0	0	0	0	0	0	4	1	1	1	0	0	1	0	0	0	1
Jul-13	10	1	2	0	0	0	0	0	4	1	1	1	1	1	1	0	1	1	0
Aug-13	9	1	2	0	0	0	0	0	4	1	1	1	1	0	1	0	0	0	0
Total	**63**	**12**	**15**	**4**	**6**	**2**	**2**	**1**	**12**	**3**	**3**	**3**	**2**	**1**	**3**	**3**	**1**	**1**	**1**

Table 2-4. Phytoplankton metrics considered for CREMP.

Effect Indicator	Metric	Unit
Algal Abundance/Density	Chlorophyll *a*	(µg/L)
	Total Biomass	(mg/m^3)
	Biomass of Major Groups	(mg/m^3)
	Biomass of Major Groups	(% of total biomass)
Evenness	Simpson's evenness	-
	Shannon's evenness	-
	Hill's evenness	-
Taxa Richness	Total number of species	-
	Hill's effective richness	-
	Simpson's diversity index	-

Table 2-5. Summary statistics for chlorophyll *a* (µg/L) measured in Mine Area lakes in summer and late summer/fall: 2007, 2008, and 2013. Analytical detection limit = 0.2 µg/L. Nearshore sampling sites excluded.

	Sheardown Lake NW	Sheardown Lake SE	Camp Lake	Mary Lake	All Lakes: 2007, 2008, and 2013
Mean	0.35	0.78	0.57	1.18	0.66
Median	0.20	0.20	0.20	1.05	0.20
Minimum	<0.20	<0.20	<0.20	<0.20	<0.20
Maximum	1.50	2.30	2.10	3.50	3.50
SD	0.29	0.78	0.60	1.00	0.72
SE	0.05	0.19	0.14	0.22	0.08
n	35	17	19	20	91
95th Percentile	0.90	2.14	1.74	1.80	2.10
% Detections	43	41	53	70	51
COV (%)	83	101	105	85	110
Mean + 2 x SD	0.92	2.34	1.78	3.17	2.10
2 x Mean	0.69	1.55	1.15	2.35	1.31
Mean + 50%	0.52	1.16	0.86	1.76	0.99
Mean + 25%	0.43	0.97	0.72	1.47	0.82
Mean + 20%	0.41	0.93	0.69	1.41	0.79

Table 2-6. Summary statistics and results of Kruskal-Wallis tests for chlorophyll *a* (µg/L) measured in Sheardown Lake NW in summer and late summer/fall: 2007, 2008, and 2013. Analytical detection limit = 0.2 µg/L. Nearshore sampling sites excluded. The mean of samples collected in July and August 2008 were averaged to represent the summer sampling period.

	Summer	Late Summer/Fall	2007	2008	2013	All Data (2007, 2008, and 2013)
Mean	0.42	0.29	0.38	0.28	0.40	0.35
Median	0.30	0.20	0.20	0.20	0.35	0.20
Minimum	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Maximum	0.90	0.90	0.90	0.90	0.80	0.90
SD	0.28	0.19	0.29	0.22	0.22	0.24
SE	0.07	0.05	0.09	0.07	0.07	0.04
n	15	15	10	10	10	30
95th Percentile	0.90	0.62	0.90	0.63	0.76	0.90
% Detections	67	33	60	20	70	50
COV (%)	66	67	76	79	55	69
Mean + 2 x SD	0.97	0.67	0.96	0.72	0.84	0.84
2 x Mean	0.84	0.57	0.76	0.56	0.80	0.71
Mean + 50%	0.63	0.43	0.57	0.42	0.60	0.53
Mean + 25%	0.53	0.36	0.48	0.35	0.50	0.44
Mean + 20%	0.50	0.34	0.46	0.34	0.48	0.42
P value[1]	0.134		0.235			-

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 2-7. Summary statistics for total phytoplankton biomass (mg/m^3) measured in Mine Area lakes in summer and late summer/fall: 2007 and 2008.

	Phytoplankton biomass (mg/m^3)			
	Sheardown Lake NW	**Sheardown Lake SE**	**Camp Lake**	**Mary Lake**
Mean	204	125	122	149
Median	160	62	109	173
Minimum	42	43	43	28
Maximum	456	336	250	415
SD	134	111	73	106
SE	30	32	24	28
n	20	12	9	14
95th Percentile	430	312	243	298
COV	66	89	60	71
Mean + 2 x SD	471	347	268	360
2 x Mean	408	250	243	298
Mean + 50%	306	188	183	223
Mean + 25%	255	157	152	186
Mean + 20%	245	150	146	179

Table 2-8. Summary statistics and results of Kruskal-Wallis tests for total phytoplankton biomass (mg/m^3) measured in Sheardown Lake NW in summer and late summer/fall: 2007 and 2008.

	Phytoplankton biomass (mg/m^3)				
	Summer	**Late Summer/Fall**	**2007**	**2008**	**All Data (2007 and 2008)**
Mean	182	226	87	321	204
Median	145	208	92	302	160
Minimum	42	88	42	183	42
Maximum	429	456	137	456	456
SD	137	134	30	79	134
SE	43	42	10	25	30
n	10	10	10	10	20
95th Percentile	378	410	129	444	430
COV	75	59	35	25	66
Mean + 2 x SD	456	493	148	479	471
2 x Mean	364	451	173	642	408
Mean + 50%	273	338	130	481	306
Mean + 25%	228	282	108	401	255
Mean + 20%	218	271	104	385	245
P value[1]	0.315		<0.0001		-

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 2-9. Mean, SD, COV, and 95th percentiles for phytoplankton species diversity, evenness, and richness metrics measured in Mine Area lakes in summer and late summer/fall: 2007 and 2008.

	MEANS					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
Sheardown Lake NW	0.71	0.22	18	0.61	6.19	0.34
Sheardown Lake SE	0.71	0.29	16	0.61	6.10	0.37
Camp Lake	0.72	0.22	17	0.60	5.55	0.33
Mary Lake	0.52	0.20	15	0.47	3.84	0.28
All lakes combined	0.66	0.23	17	0.58	5.47	0.33
	SD					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
Sheardown Lake NW	0.12	0.08	3	0.10	1.94	0.08
Sheardown Lake SE	0.88	0.43	20	0.77	9.31	0.54
Camp Lake	0.07	0.05	3	0.04	1.18	0.04
Mary Lake	0.19	0.15	4	0.17	2.00	0.15
All lakes combined	0.17	0.11	3	0.14	2.18	0.11
	COV					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
Sheardown Lake NW	17	34	16	16	31	25
Sheardown Lake SE	27	42	18	26	41	34
Camp Lake	9	25	20	7	21	13
Mary Lake	36	75	28	36	52	55
All lakes combined	26	47	21	24	40	34
	95TH PERCENTILE					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
Sheardown Lake NW	0.84	0.34	22	0.74	8.9	0.46
Sheardown Lake SE	0.87	0.42	19	0.76	9.2	0.51
Camp Lake	0.81	0.28	23	0.66	7.5	0.37
Mary Lake	0.84	0.52	21	0.78	7.5	0.56
All lakes combined	0.87	0.42	22	0.77	9.1	0.53

Table 2-10. Summary statistics and results of Kruskal-Wallis tests for phytoplankton taxonomy metrics measured in Sheardown Lake NW in summer and late summer/fall: 2007 and 2008.

	Simpson's Diversity Index				
	Summer	**Late Summer/Fall**	**2007**	**2008**	**All Data (2007 and 2008)**
Mean	0.76	0.66	0.80	0.62	0.71
Median	0.79	0.70	0.81	0.62	0.76
Minimum	0.59	0.41	0.71	0.41	0.41
Maximum	0.87	0.81	0.87	0.78	0.87
SD	0.10	0.13	0.05	0.11	0.12
SE	0.03	0.04	0.01	0.04	0.03
n	10	10	10	10	20
95th Percentile	0.86	0.80	0.86	0.77	0.84
COV	13	20	6	18	17
Mean + 2 x SD	0.95	0.93	0.89	0.85	0.96
2 x Mean	1.52	1.32	1.60	1.24	1.42
Mean + 50%	1.14	0.99	1.20	0.93	1.07
Mean + 25%	0.95	0.83	1.00	0.78	0.89
Mean + 20%	0.91	0.79	0.96	0.75	0.85
P value[1]	0.075		<0.0005		-

	Simpson's Evenness				
	Summer	**Late Summer/Fall**	**2007**	**2008**	**All Data (2007 and 2008)**
Mean	0.27	0.18	0.27	0.18	0.22
Median	0.27	0.17	0.26	0.17	0.20
Minimum	0.15	0.13	0.17	0.13	0.13
Maximum	0.40	0.26	0.40	0.32	0.40
SD	0.08	0.05	0.07	0.06	0.08
SE	0.02	0.01	0.02	0.02	0.02
n	10	10	10	10	20
95th Percentile	0.37	0.25	0.37	0.28	0.34
COV	29	25	27	32	34
Mean + 2 x SD	0.42	0.27	0.41	0.30	0.38
2 x Mean	0.53	0.36	0.53	0.36	0.45
Mean + 50%	0.40	0.27	0.40	0.27	0.34
Mean + 25%	0.33	0.23	0.33	0.23	0.28
Mean + 20%	0.32	0.22	0.32	0.22	0.27
P value[1]	0.007		0.009		-

Table 2-10. - continued -

	Species Richness				
	Summer	Late Summer/Fall	2007	2008	All Data (2007 and 2008)
Mean	18	18	19.9	16.0	18.0
Median	17	20	20.0	15.5	18.5
Minimum	13	13	16.0	13.0	13.0
Maximum	22	22	22.0	20.0	22.0
SD	3	3	1.9	2.4	2.9
SE	1	1	0.6	0.8	0.7
n	10	10	10	10	20
95th Percentile	21	22	22.0	20.0	22.0
COV	16	17	9	15	16
Mean + 2 x SD	23	24	23.6	20.9	23.8
2 x Mean	35	37	40	32	36
Mean + 50%	26	27	30	24	27
Mean + 25%	22	23	25	20	22
Mean + 20%	21	22	24	19	22
P value[1]	0.614		0.002		-

	Shannon's Evenness				
	Summer	Late Summer/Fall	2007	2008	All Data (2007 and 2008)
Mean	0.66	0.57	0.68	0.54	0.61
Median	0.69	0.59	0.69	0.56	0.62
Minimum	0.54	0.39	0.59	0.39	0.39
Maximum	0.77	0.72	0.77	0.69	0.77
SD	0.08	0.10	0.05	0.09	0.10
SE	0.03	0.03	0.02	0.03	0.02
n	10	10	10	10	20
95th Percentile	0.75	0.69	0.75	0.65	0.74
COV	12	18	8	16	16
Mean + 2 x SD	0.82	0.78	0.79	0.72	0.81
2 x Mean	1.31	1.14	1.37	1.09	1.23
Mean + 50%	0.98	0.86	1.02	0.81	0.92
Mean + 25%	0.82	0.71	0.85	0.68	0.77
Mean + 20%	0.79	0.68	0.82	0.65	0.74
P value[1]	0.105		0.001		-

Table 2-10. - continued -

	Hill's Effective Richness				
	Summer	Late Summer/Fall	2007	2008	All Data (2007 and 2008)
Mean	6.8	5.6	7.7	4.6	6.2
Median	6.8	5.9	7.6	4.5	6.1
Minimum	4.4	2.8	5.9	2.8	2.8
Maximum	9.7	8.9	9.7	6.2	9.7
SD	1.8	2.0	1.1	1.2	1.9
SE	0.6	0.6	0.4	0.4	0.4
n	10	10	10	10	20
95th Percentile	9.2	8.2	9.3	6.1	8.9
COV	27	35	15	25	31
Mean + 2 x SD	10.5	9.5	10.0	6.9	10.1
2 x Mean	13.5	11.2	15.5	9.3	12.4
Mean + 50%	10.1	8.4	11.6	6.9	9.3
Mean + 25%	8.5	7.0	9.7	5.8	7.7
Mean + 20%	8.1	6.7	9.3	5.6	7.4
P value[1]	0.280		<0.0001		-

	Hill's Evenness				
	Summer	Late Summer/Fall	2007	2008	All Data (2007 and 2008)
Mean	0.38	0.30	0.39	0.29	0.34
Median	0.40	0.30	0.40	0.30	0.32
Minimum	0.28	0.21	0.30	0.21	0.21
Maximum	0.52	0.42	0.52	0.45	0.52
SD	0.08	0.07	0.07	0.07	0.08
SE	0.03	0.02	0.02	0.02	0.02
n	10	10	10	10	20
95th Percentile	0.49	0.39	0.49	0.39	0.46
COV	21	22	17	24	25
Mean + 2 x SD	0.55	0.43	0.53	0.43	0.51
2 x Mean	0.77	0.60	0.78	0.58	0.68
Mean + 50%	0.58	0.45	0.59	0.44	0.51
Mean + 25%	0.48	0.37	0.49	0.36	0.43
Mean + 20%	0.46	0.36	0.47	0.35	0.41
P value[1]	0.052		0.004		-

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 2-11. Spearman rank correlation coefficients for phytoplankton metrics and total phosphorus (TP). Values in bold indicate significant correlations at α = 0.05. Correlation analysis includes data collected from all Mine Area lakes in 2007, 2008, and 2013. RA = relative abundance; > DL = detections only.

Variables	TN	TP	TN:TP	Chlorophyll *a* (>DL)	Chlorophyll *a*	Total Biomass	Diatom Biomass	Green-Algae Biomass	Chrysophyte Biomass	Cryptophyte Biomass	Blue-Green Algae Biomass	Euglenoid Biomass	Dinoflagellate Biomass	Diatom RA	Green-Algae RA	Green-Algae RA	Green-Algae RA	Green-Algae RA	Green-Algae RA	Green-Algae RA	Maximum Species Biomass	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness
TP	-0.099	**1**																								
TN:TP Molar Ratios	**0.679**	**-0.763**	**1**																							
Chlorophyll *a* (>DL)	0.242	**0.519**	-0.271	**1**																						
Chlorophyll *a*	0.049	**0.286**	-0.197	**1.000**	**1**																					
Total Biomass	-0.044	0.119	-0.018	0.272	-0.068	**1**																				
Diatom Biomass	0.009	0.046	0.060	0.148	-0.038	**0.957**	**1**																			
Green-Algae Biomass	0.066	-0.058	0.132	0.156	-0.224	**0.462**	**0.377**	**1**																		
Chrysophyte Biomass	-0.148	0.230	-0.186	0.130	-0.018	**0.533**	**0.457**	**0.323**	**1**																	
Cryptophyte Biomass	-0.146	0.129	-0.171	0.252	0.121	**0.318**	**0.288**	0.107	0.236	**1**																
Blue-Green Algae Biomass	-0.095	0.113	-0.102	0.204	0.007	0.224	0.091	0.045	0.159	0.059	**1**															
Euglenoid Biomass	-0.046	-0.164	0.106	-0.231	0.123	-0.244	-0.188	-0.253	**-0.310**	0.036	-0.061	**1**														
Dinoflagellate Biomass	0.063	-0.055	0.179	0.007	-0.070	**0.303**	0.223	0.218	0.120	0.157	0.195	0.017	**1**													
Diatom RA	0.070	-0.103	0.088	-0.194	0.165	0.035	**0.267**	**-0.431**	-0.085	-0.102	**-0.426**	0.079	**-0.398**	**1**												
Green-Algae RA	0.061	-0.226	0.192	-0.191	-0.256	-0.095	-0.167	**0.803**	-0.018	-0.036	-0.030	-0.074	0.053	**-0.528**	**1**											
Chrysophyte RA	-0.153	0.152	-0.192	0.022	0.032	0.001	-0.051	-0.003	**0.805**	0.032	0.075	-0.197	-0.098	-0.059	-0.067	**1**										
Cryptophyte RA	-0.145	0.134	-0.196	0.233	0.164	-0.067	-0.083	-0.110	0.009	**0.885**	-0.024	0.176	0.018	-0.131	-0.043	0.004	**1**									
Blue-Green Algae RA	-0.115	0.111	-0.125	0.183	0.028	0.140	0.000	0.028	0.096	0.032	**0.988**	-0.060	0.145	**-0.447**	0.008	0.048	-0.021	**1**								
Euglenoid RA	-0.024	-0.183	0.125	-0.258	0.112	**-0.289**	-0.237	-0.250	**-0.319**	-0.002	-0.051	**0.992**	0.026	0.048	-0.047	-0.184	0.156	-0.047	**1**							
Dinoflagellate RA	0.109	-0.093	0.230	0.003	-0.091	0.168	0.088	0.147	0.035	0.126	0.167	0.061	**0.970**	**-0.429**	0.078	-0.122	0.041	0.126	0.079	**1**						
Maximum Species Biomass	-0.012	0.142	-0.015	0.193	0.012	**0.951**	**0.957**	**0.360**	**0.513**	**0.284**	0.136	-0.227	0.181	0.184	-0.189	0.018	-0.083	0.047	**-0.274**	0.047	**1**					
Simpson's Diversity Index	-0.003	-0.244	0.126	-0.098	-0.183	**-0.595**	**-0.651**	-0.055	**-0.353**	-0.122	0.127	0.217	0.154	**-0.421**	**0.337**	-0.069	0.126	0.185	0.258	0.246	**-0.786**	**1**				
Simpson's Evenness	0.045	-0.084	0.015	0.073	-0.144	**-0.706**	**-0.781**	-0.094	**-0.282**	-0.156	0.010	0.062	-0.023	**-0.394**	**0.317**	0.077	0.115	0.083	0.109	0.089	**-0.858**	**0.901**	**1**			
Species Richness	-0.107	**-0.434**	0.269	**-0.582**	-0.170	0.008	0.061	0.023	-0.260	-0.006	0.190	**0.429**	**0.370**	-0.058	0.111	**-0.282**	-0.003	0.176	**0.417**	**0.353**	-0.108	**0.446**	0.052	**1**		
Shannon's Evenness	0.045	-0.164	0.091	-0.008	-0.099	**-0.645**	**-0.701**	-0.049	**-0.299**	-0.105	0.079	0.198	0.101	**-0.416**	**0.348**	0.019	0.156	0.137	0.241	0.192	**-0.811**	**0.969**	**0.936**	**0.307**	**1**	
Hill's Effective Richness	0.004	**-0.282**	0.169	-0.185	-0.159	**-0.551**	**-0.588**	-0.029	**-0.314**	-0.110	0.146	**0.289**	0.214	**-0.395**	**0.346**	-0.051	0.113	0.194	**0.326**	**0.294**	**-0.733**	**0.974**	**0.826**	**0.566**	**0.946**	**1**
Hill's Evenness	0.070	-0.084	0.035	0.062	-0.087	**-0.711**	**-0.770**	-0.089	**-0.276**	-0.137	0.021	0.123	0.017	**-0.386**	**0.318**	0.092	0.127	0.085	0.168	0.122	**-0.850**	**0.905**	**0.979**	0.103	**0.965**	**0.862**

Table 2-12. Summary of power analysis results for selected phytoplankton community metrics. Values represent the minimum number of samples required for achieving 90% power.

Metric	Minimum Sample Size					
	All data 2007-2008			Fall data 2007-2008		
	CES			CES		
	50%	25%	20%	50%	25%	20%
Simpson's Diversity Index	3	8	12	4	11	16
Species Richness	3	7	11	3	8	12
Shannon's Evenness	3	8	11	3	9	13
Total Biomass	8	27	99	6	22	86

Table 2-13. Overview of phytoplankton sampling conducted in Mine Area lakes: 2013.

Site ID	Sample Date	Season	Chlorophyll *a*		Biomass and Taxonomy
			No. of Replicates		No. of Replicates
			Surface	Bottom	
Camp Lake					
JL0-01	27-Jul-13	Summer	2	-	1
	26-Aug-13	Fall	2	-	1
JL0-02	27-Jul-13	Summer	1	1	3
	24-Aug-13	Fall	1	1	3
JL0-09	27-Jul-13	Summer	1	1	1
	26-Aug-13	Fall	1	1	1
JL0-10	27-Jul-13	Summer	1	-	1
	25-Aug-13	Fall	1	-	1
JL0-11	27-Jul-13	Summer	1	-	1
	26-Aug-13	Fall	1	-	1
JL0-PHYTO1	27-Jul-13	Summer	-	-	1
	25-Aug-13	Fall	-	-	1
JL0-PHYTO2	27-Jul-13	Summer	-	-	1
	25-Aug-13	Fall	-	-	1
JL0-PHYTO3	27-Jul-13	Summer	-	-	1
	26-Aug-13	Fall	-	-	1
JL0-PHYTO4	27-Jul-13	Summer	-	-	1
	26-Aug-13	Fall	-	-	1
JL0-PHYTO5	27-Jul-13	Summer	-	-	1
	27-Aug-13	Fall	-	-	1
Sheardown Lake NW					
DD-HAB9-STN1	25-Jul-13	Summer	1	1	1
DD-HAB9-STN1	28-Aug-13	Fall	1	1	1
DL0-01-1	26-Jul-13	Summer	1	1	1
	28-Aug-13	Fall	1	1	1
DL0-01-2	26-Jul-13	Summer	1	1	1
	28-Aug-13	Fall	1	1	3
DL0-01-4	26-Jul-13	Summer	1	1	1
	28-Aug-13	Fall	2	2	1
DL0-01-5	26-Jul-13	Summer	2	1	1
	27-Aug-13	Fall	1	1	1
DL0-01-7	26-Jul-13	Summer	1	1	1
	28-Aug-13	Fall	1	1	1
DL0-01-PHYTO 1	26-Jul-13	Summer	-	-	1
		Fall	-	-	NS
DL0-01-PHYTO 2	26-Jul-13	Summer	-	-	1
		Fall	-	-	NS
DL0-01-PHYTO 3	26-Jul-13	Summer	-	-	1
		Fall	-	-	NS
DL0-01-PHYTO 4	26-Jul-13	Summer	-	-	1
		Fall	-	-	NS
DL0-01-PHYTO 5	26-Jul-13	Summer	-	-	1
		Fall	-	-	NS

Table 2-13. - continued –

Site ID	Sample Date	Season	Chlorophyll *a*		Biomass and Taxonomy
			No. of Replicates		No. of Replicates
			Surface	Bottom	
Sheardown Lake SE					
DL0-02-1	26-Jul-13	Summer	NS	NS	1
		Fall	NS	NS	NS
DL0-02-3	26-Jul-13	Summer	1	1	1
	29-Aug-13	Fall	1	1	1
DL0-02-4	26-Jul-13	Summer	NS	NS	3
		Fall	NS	NS	NS
DL0-02-6	26-Jul-13	Summer	-	-	1
		Fall	-	-	NS
DL0-02-7	26-Jul-13	Summer	NS	NS	1
		Fall	NS	NS	NS
DL0-02-8	26-Jul-13	Summer	NS	NS	1
		Fall	NS	NS	NS
DL0-02-PHYTO 1		Summer	-	-	NS
		Fall	-	-	NS
DL0-02-PHYTO 2		Summer	-	-	NS
		Fall	-	-	NS
DL0-02-PHYTO 3	26-Jul-13	Summer	-	-	1
		Fall	-	-	-
DL0-02-PHYTO 4	26-Jul-13	Summer	-	-	1
		Fall	-	-	-
Mary Lake South					
BL0-03	28-Jul-13	Summer	1	1	1
		Fall	NS	1	NS
BL0-04	28-Jul-13	Summer	1	1	1
		Fall	1	1	NS
BL0-05	28-Jul-13	Summer	1	1	1
		Fall	1	1	NS
BL0-06	28-Jul-13	Summer	1	1	3
		Fall	1	1	NS
BL0-07	28-Jul-13	Summer	1	-	3
		Fall	NS	-	NS
BL0-PHYTO1	28-Jul-13	Summer	-	-	1
		Fall	-	-	NS
BL0-PHYTO2	28-Jul-13	Summer	-	-	3
		Fall	-	-	NS
BL0-PHYTO3	28-Jul-13	Summer	-	-	1
		Fall	-	-	NS
BL0-PHYTO4	28-Jul-13	Summer	-	-	1
		Fall	-	-	NS
BL0-PHYTO5		Summer	-	-	NS
		Fall	-	-	NS
Mary Lake North					
BL0-01	27-Jul-13	Summer	1	1	3
		Fall	NS	NS	NS

NS = not sampled

Table 2-14. Number of samples collected for chlorophyll *a* in Mine Area streams: 2013.

Stream	June	July	August
Mary River	9	10	9
N. Tributary of Mary River, D/S of Falls	1	1	1
Sheardown Lake Tributary 1	0	2	2
Tom River	1	1	1
Camp Lake Tributary 1	4	4	4
Stream north of airstrip - confluence with Camp Lake Tributary 1	1	1	1
Camp Lake Tributary 2	1	1	1
Outlet channel of Camp Lake	0	1	1
Proposed CLT Reference stream No. 3	0	1	0
Proposed CLT Reference stream No. 4	0	1	0
Proposed Mary River Reference stream No. 2	0	1	0
Proposed Mary River Reference stream No. 3	0	1	0

Table 3-1. Summary of benthic macroinvertebrate sampling methods for Mine Area lakes (2006-2013).

Year	Equipment	Mesh Size (µm)	Replicate Stations per Site or Habitat Type	Sub-samples per Replicate Station	Taxonomy	Description/Comments
2006	Ekman Dredge (sampling area of 0.023 m^2)	500	3	5	Genus level by qualified taxonomist (ZEAS Inc.)	Sub-samples approx. 1 m apart; replicates approx. 10 m apart
2007	Petit Ponar Dredge (sampling area of 0.023 m^2)	500	3	5 [1]	Genus level by qualified taxonomist (ZEAS Inc.)	Sub-samples approx. 1 m apart; replicates approx. 10 m apart
2008	Petit Ponar Dredge (sampling area of 0.023 m^2)	500	3-7	5	Genus level by qualified taxonomist (ZEAS Inc.)	Sub-samples approx. 1 m apart; replicates min. of 20 m apart
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	Petit Ponar Dredge (sampling area of 0.023 m^2)	500	3	1, 3, 1 [2]	Genus level by qualified taxonomist (ZEAS Inc.)	Sub-samples approx. 1 m apart; replicates min. of 20 m apart
2013	Petit Ponar Dredge (sampling area of 0.023 m^2)	500	5	5	-	Sub-samples approx. 1 m apart; replicates min. of 20 m apart

[1] excepting Mary Lake where only 1 sub-sample/replicate was collected

[2] sampling occurred at one site in Sheardown Lake NW only

Table 3-2. Summary of benthic macroinvertebrate sampling methods for Mine Area streams (2005-2013).

Year	Equipment	Mesh Size (µm)	Replicate Stations per Site or Habitat Type	Sub-samples per Replicate Station	Taxonomy	Description/Comments
2005	Surber sampler (sampling area of 0.097 m^2)	250	1	5	Genus level by qualified taxonomist (ZEAS Inc.)	-
2006	Surber sampler (sampling area of 0.097 m^2)	500	3	5	Genus level by qualified taxonomist (ZEAS Inc.)	replicates separated by 3 wetted stream widths
2007	Surber sampler (sampling area of 0.097 m^2)	500	3	5	Genus level by qualified taxonomist (ZEAS Inc.)	replicates separated by 3 wetted stream widths
2008	Surber sampler (sampling area of 0.097 m^2)	500	3	5	Genus level by qualified taxonomist (ZEAS Inc.)	replicates separated by 3 wetted stream widths
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	Surber sampler (sampling area of 0.097 m^2)	500	3	5	Genus level by qualified taxonomist (ZEAS Inc.)	replicates separated by 3 wetted stream widths
2013	Surber sampler (sampling area of 0.097 m^2)	500	2-3 [1]	2-5 [2]	-	replicates separated by 3 wetted stream widths

[1] KP field personnel were unable to find 3 suitable replicate stations in Sheardown Lake Tributary 12, downstream reach

[2] KP field personnel were unable to find 5 suitable locations in Sheardown Lake Tributary 1, Reach 4, and Sheardown Lake Tributary 12, downstream reach for required number of sub-samples

Table 3-3. Summary of benthic macroinvertebrate sampling periods in Mine Area lakes and streams (2005-2013).

Waterbody	Sampling Period							
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**
Lakes								
Mary Lake	-	Aug. 31-Sept.5	Aug. 31-Sept. 20	-	-	-	-	-
Camp Lake	-	-	Aug. 31-Sept. 20	-	-	-	-	Sept. 5-8
Sheardown Lake NW	-	-	Aug. 31-Sept. 20	Sept. 8-12	-	-	Sept. 3	Sept. 5-8
Sheardown Lake SE	-	-	Aug. 31-Sept. 20	-	-	-	-	Sept. 5-8
Streams								
Mary River	Aug. 6-17	Aug. 23-Sept. 1	Aug. 31-Sept. 5	-	-	-	Aug. 28-29	-
Tom River	-	Aug. 23-Sept. 1	Aug. 31-Sept. 5	-	-	-	-	-
Camp Lake Tributaries	Aug. 6-17	-	Aug. 31-Sept. 5	-	-	-	-	-
Sheardown Lake Tributaries	Aug. 6-17	-	Aug. 31-Sept. 5	Sept. 10-11	-	-	Sept. 4	Aug. 29-31

Table 3-4. Locations of benthic macroinvertebrate lake sampling sites in the Mine Area (2006-2013).

Waterbody	Site ID	Habitat Type	UTM			Sample Date
			Zone	Easting	Northing	
Camp Lake	JLO-10-B1	4	17W	556085	7913755	2-Sep-07
	JLO-10-B2			556085	7913753	2-Sep-07
	JLO-10-B3			556087	7913757	2-Sep-07
	JLO-10-B1			556085	7913755	7-Sep-13
	Stn 1	9	17W	556320	7914417	7-Sep-13
	Stn 2			556325	7914603	7-Sep-13
	Stn 3			556510	7914791	7-Sep-13
	Stn 4			556781	7914872	6-Sep-13
	Stn 5			557031	7914989	6-Sep-13
	JLO-01-B1	14	17W	557099	7914360	1-Sep-07
	JLO-01-B2			557105	7914375	1-Sep-07
	JLO-01-B3			557104	7914374	1-Sep-07
	JLO-01-B1			557099	7914360	7-Sep-13
	JLO-02-B1	14	17W	557617	7914749	31-Aug-07
	JLO-02-B2			557621	7914750	31-Aug-07
	JLO-02-B3			557624	7914747	31-Aug-07
	JLO-02-B1			557617	7914749	7-Sep-13
	JLO-07-B1	14	17W	556705	7914182	2-Sep-07
	JLO-07-B2			556715	7914157	2-Sep-07
	JLO-07-B3			556719	7914170	2-Sep-07
	JLO-07-B1			556705	7914182	7-Sep-13
	JLO-07-B2			556715	7914157	7-Sep-13
	JLO-09-B1	14	17W	556332	7913948	2-Sep-07
	JLO-09-B2			556342	7913946	2-Sep-07
	JLO-09-B3			556324	7913946	2-Sep-07
	JLO-09-B1			556332	7913948	7-Sep-13
Sheardown Lake NW	SDL-Hab4-Stn1	4	17W	560401	7912573	8-Sep-08
	SDL-Hab4-Stn2			560503	7912526	8-Sep-08
	SDL-Hab4-Stn3			560605	7912654	8-Sep-08
	SDL-Hab4-Stn4			560582	7912730	8-Sep-08
	SDL-Hab4-Stn5			560561	7912801	8-Sep-08
	DD-Hab4-Stn-1	4	17W	560420	7913355	12-Sep-08
	DD-Hab4-Stn-2			560374	7913391	12-Sep-08
	DD-Hab4-Stn-3			560351	7913426	12-Sep-08

Table 3-4. - continued -

Waterbody	Site ID	Habitat Type	UTM			Sample Date
			Zone	Easting	Northing	
Sheardown Lake NW continued	DD-Hab9-Stn-1	9	17W	560259	7913455	12-Sep-08
	DD-Hab9-Stn-2			560323	7913402	12-Sep-08
	DD-Hab9-Stn-3			560354	7913358	12-Sep-08
	DLO-01-3-B1	9	17W	560466	7912837	15-Sep-07
	DLO-01-3-B2			560485	7912833	15-Sep-07
	DLO-01-3-B3			560496	7912815	15-Sep-07
	DLO-01-3-B1			560474	7912833	12-Sep-08
	DLO-01-3-B1			560474	7912833	5-Sep-13
	DLO-01-4-B1	9	17W	560690	7913045	7-Sep-07
	DLO-01-4-B2			560678	7913055	7-Sep-07
	DLO-01-4-B3			560683	7913060	7-Sep-07
	DLO-01-4-B1			560695	7913043	9-Sep-08
	DLO-01-4-B2			560775	7913069	9-Sep-08
	DLO-01-4-B1			560695	7913043	6-Sep-13
	DLO-01-4-B2			560775	7913069	6-Sep-13
	DLO-01-6-B1	9	17W	559705	7913525	14-Sep-07
	DLO-01-6-B2			559721	7913526	14-Sep-07
	DLO-01-6-B3			559705	7913506	14-Sep-07
	DLO-01-6-B1			559685	7913509	11-Sep-08
	DLO-01-6-B2			559680	7913564	11-Sep-08
	DLO-01-6-B1			559685	7913509	5-Sep-13
	DLO-01-6-B2			559680	7913564	5-Sep-13
	DLO-01-7-B1	9	17W	560520	7912616	7-Sep-07
	DLO-01-7-B2			560509	7912603	7-Sep-07
	DLO-01-7-B3			560481	7912619	7-Sep-07
	DLO-01-7-B1			560525	7912609	9-Sep-08
	DLO-01-7-B2			560572	7912619	9-Sep-08
	DLO-01-2-B1	14	17W	560337	7912913	15-Sep-07
	DLO-01-2-B2			560342	7912915	15-Sep-07
	DLO-01-2-B3			560357	7912917	15-Sep-07
	DLO-01-2-B1			560353	7912924	12-Sep-08
	DLO-01-2-B2			560326	7912854	12-Sep-08
	DLO-01-2-B1			560353	7912924	5-Sep-13
	DLO-01-2-B2			560326	7912854	5-Sep-13
	DLO-01-5-B1	14	17W	559775	7913350	15-Sep-07
	DLO-01-5-B2			559788	7913335	15-Sep-07
	DLO-01-5-B3			559800	7913340	15-Sep-07
	DLO-01-5-B1			559798	7913356	9-Sep-08
	DLO-01-5-B1			559800	7913325	3-Sep-11
	DLO-01-5-B2			559867	7913325	3-Sep-11
	DLO-01-5-B3			559847	7913310	3-Sep-11
	DLO-01-5-B1			559800	7913325	5-Sep-13
	DLO-01-5-B2			559867	7913325	5-Sep-13
	DLO-01-5-B3			559847	7913310	5-Sep-13

Table 3-4. - continued -

Waterbody	Site ID	Habitat Type	UTM			Sample Date
			Zone	Easting	Northing	
Sheardown Lake SE	DLO-02-3-B1	4	17W	560950	7911919	4-Sep-07
	DLO-02-3-B2			560947	7911926	4-Sep-07
	DLO-02-3-B3			560958	7911925	4-Sep-07
	Stn 1	9	17W	561520	7911857	8-Sep-13
	Stn 2			561620	7911832	8-Sep-13
	Stn 3			561546	7911816	8-Sep-13
	Stn 4			561546	7911816	8-Sep-13
	Stn 5			561510	7911779	8-Sep-13
	DLO-02-4-B1	10	17W	561127	7911708	4-Sep-07
	DLO-02-4-B2			561133	7911717	4-Sep-07
	DLO-02-4-B3			561145	7911699	4-Sep-07
	DLO-02-1-B1	14	17W	560816	7912124	6-Sep-07
	DLO-02-1-B2			560824	7912125	6-Sep-07
	DLO-02-1-B3			560818	7912111	6-Sep-07
	DLO-02-1-B1			560816	7912124	8-Sep-13
	DLO-02-2-B1	14	17W	561161	7911866	6-Sep-07
	DLO-02-2-B2			561170	7911872	6-Sep-07
	DLO-02-2-B3			561164	7911864	6-Sep-07
	DLO-02-2-B1			561161	7911866	8-Sep-13
	Stn 3	14	17W	561082	7911929	8-Sep-13
	Stn 4			561107	7911890	8-Sep-13
	Stn 5			561229	7911868	8-Sep-13
Mary Lake	BLO-01 -B1	9	17W	554695	7913212	19-Sep-07
	BLO-01 -B2			554695	7913212	19-Sep-07
	BLO-01 -B3			554695	7913212	19-Sep-07
	BLO-05-B1	9	17W	554780	7906047	20-Sep-07
	BLO-05-B2			554769	7906066	20-Sep-07
	BLO-05-B3			554785	7906078	20-Sep-07
	BLO-06-B1	9	17W	555912	7903757	20-Sep-07
	BLO-06-B2			555913	7903734	20-Sep-07
	BLO-06-B3			555890	7903721	20-Sep-07
	BLO-01 -B1	14	17W	554695	7913212	31-Aug-06
	BLO-01-B2			554695	7913212	31-Aug-06
	BLO-01- B3			554695	7913212	31-Aug-06
	BLO-05-B1	14	17W	554771	7906033	31-Aug-06
	BLO-05-B2			554771	7906033	31-Aug-06
	BLO-05-B3			554771	7906033	31-Aug-06
	BLO-03-B1	14	17W	552387	7906645	20-Sep-07
	BLO-03-B2			552360	7906630	20-Sep-07
	BLO-03-B3			552356	7906635	20-Sep-07
	BLO-04-B1	14	17W	553799	7904897	20-Sep-07
	BLO-04-B3			553824	7904871	20-Sep-07

Table 3-5. Locations of benthic macroinvertebrate stream sampling sites in the Mine Area (2005-2013).

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Mary River	AO-01	17W	559019	7900094	1-Aug-05
	CO-01	17W	556305	7906894	1-Aug-05
	DO-01	17W	560765	7911692	1-Aug-05
	DO-01	17W	560765	7911692	28-Aug-11
	EO-01a (E2-01)	17W	562348	7911310	1-Aug-05
	EO-01a (E0-03)	17W	562974	7912472	1-Aug-05
	HO-01	17W	571409	7917611	1-Aug-05
	AO-01 B1	17W	559034	7900064	5-Sep-07
	AO-01 B2	17W	558997	7900112	5-Sep-07
	AO-01 B3	17W	558994	7900151	5-Sep-07
	CO-01 B1	17W	556291	7906919	3-Sep-07
	CO-01 B2	17W	-	-	3-Sep-07
	CO-01 B3	17W	556323	7906925	3-Sep-07
	CO-05 B1	17W	558364	7909231	3-Sep-07
	CO-05 B2	17W	558389	7909248	3-Sep-07
	CO-05 B3	17W	558411	7909298	3-Sep-07
	CO-05 B1	17W	-	-	28-Aug-11
	CO-05 B2	17W	558352	7909170	28-Aug-11
	CO-05 B3	17W	-	-	28-Aug-11
	CO-10 B1	17W	560490	7911370	30-Aug-06
	CO-10 B2	17W	560490	7911370	30-Aug-06
	CO-10 B3	17W	560490	7911370	30-Aug-06
	CO-10 B1	17W	560616	7911666	4-Sep-07
	CO-10 B2	17W	560661	7911687	4-Sep-07
	CO-10 B3	17W	560708	7911701	4-Sep-07
	EO-20 B1	17W	561688	7911724	29-Aug-11
	EO-20 B2	17W	561680	7911258	29-Aug-11
	EO-20 B3	17W	561649	7911241	29-Aug-11
	EO-01 B1	17W	560926	7911488	4-Sep-07
	EO-01 B2	17W	560940	7911429	4-Sep-07

Table 3-5. - continued -

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Mary River continued	EO-01 B3	17W	560906	7911533	4-Sep-07
	GO-03 B1	17W	567194	7912596	5-Sep-07
	GO-03 B2	17W	567220	7912598	5-Sep-07
	GO-03 B3	17W	567247	7912602	5-Sep-07
	GO-09 B1	17W	571665	7916111	1-Sep-06
	GO-09 B2	17W	571665	7916111	1-Sep-06
	GO-09 B3	17W	571665	7916111	1-Sep-06
	GO-09 B1	17W	571572	7916367	5-Sep-07
	GO-09 B2	17W	571577	7916330	5-Sep-07
	GO-09 B3	17W	571566	7916302	5-Sep-07
Tom River	IO-01 B1	17W	555441	7914175	25-Aug-06
	IO-01 B2	17W	555441	7914175	25-Aug-06
	IO-01 B3	17W	555441	7914175	25-Aug-06
	IO-01 B1	17W	555407	7914291	5-Sep-07
	IO-01 B2	17W	555449	7914160	5-Sep-07
	IO-01 B3	17W	555496	7914154	5-Sep-07
	IO-04 B1	17W	557136	7918889	23-Aug-06
	IO-04 B2	17W	557136	7918889	23-Aug-06
	IO-04 B3	17W	557136	7918889	23-Aug-06
	IO-04 B1	17W	557132	7918928	5-Sep-07
	IO-04 B2	17W	557153	7918972	5-Sep-07
	IO-04 B3	17W	557155	7918994	5-Sep-07
Camp Lake Tributaries	FS-01 (Trib.1, Reach 1)	17W	558264	7914877	Aug-05
	KO-01 (Trib.2, Reach 2)	17W	557390	7915030	Aug-05
	JO-01 (lake outlet stream)	17W	555701	7913773	Aug-05
	CLT-1 DS B1	17W	557641	7914880	2-Sep-07
	CLT-1 DS B2	17W	557648	7914888	2-Sep-07
	CLT-1 DS B3	17W	557653	7914898	2-Sep-07
	CLT-1 US B1	17W	558515	7915032	4-Sep-07
	CLT-1 US B2	17W	558509	7915020	4-Sep-07
	CLT-1 US B3	17W	558497	7914999	4-Sep-07
	L1-09	17W	558407	7914890	1-Sep-11
	L1-09	17W	558393	7914889	1-Sep-11
	L1-09	17W	558407	7914882	1-Sep-11

Table 3-5. - continued -

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Camp Lake Tributaries continued	L1-08	17W	558513	7914893	1-Sep-11
	L1-08	17W	558507	7914907	1-Sep-11
	L1-08	17W	558494	7914919	1-Sep-11
	L2-03	17W	558593	7914797	1-Sep-11
	L2-03	17W	558605	7914784	1-Sep-11
	L2-03	17W	554641	7914753	1-Sep-11
	CLT-2 DS B1	17W	557466	7914969	2-Sep-07
	CLT-2 DS B2	17W	557465	7914977	2-Sep-07
	CLT-2 DS B3	17W	557449	7914956	2-Sep-07
	CLT-2 US B1	17W	557448	7915324	2-Sep-07
	CLT-2 US B2	17W	557450	7915287	2-Sep-07
	CLT-2 US B3	17W	557464	7915251	2-Sep-07
Sheardown Lake Tributaries	SDLT-1 Reach 1 B1	17W	560320	7913504	10-Sep-08
	SDLT-1 Reach 1 B2	17W	560337	7913512	10-Sep-08
	SDLT-1 Reach 1 B3	17W	560346	7913525	10-Sep-08
	SDLT-1 Reach 1 B1	17W	560320	7913504	29-Aug-13
	SDLT-1 Reach 1 B2	17W	560337	7913512	29-Aug-13
	SDLT-1 Reach 1 B3	17W	560346	7913525	30-Aug-13
	SDLT-1 Reach 2a	17W	560753	7913507	Aug-05
	SDLT-1 DS Reach 2 B1	17W	560710	7913504	31-Aug-07
	SDLT-1 DS Reach 2 B2	17W	560716	7913506	31-Aug-07
	SDLT-1 DS Reach 2 B3	17W	560722	7913504	31-Aug-07
	SDLT-1 Reach 2 B1	17W	560739	7913502	10-Sep-08
	SDLT-1 Reach 2 B2	17W	560756	7913502	10-Sep-08
	SDLT-1 Reach 2 B3	17W	560774	7913598	10-Sep-08
	SDLT-1 Reach 2 B1	17W	560739	7913502	30-Aug-13
	SDLT-1 Reach 2 B2	17W	560756	7913502	30-Aug-13
	SDLT-1 Reach 2 B3	17W	560774	7913508	30-Aug-13
	SDLT-1 US Reach 4 B1	17W	561503	7913541	31-Aug-07
	SDLT-1 US Reach 4 B2	17W	-	-	31-Aug-07
	SDLT-1 US Reach 4 B3	17W	561521	7913524	31-Aug-07
	SDLT-1 Reach 4 B1	17W	561490	7913533	11-Sep-08
	SDLT-1 Reach 4 B2	17W	561506	7913538	11-Sep-08
	SDLT-1 Reach 4 B3	17W	561511	7913536	11-Sep-08
	SDLT-1 Reach 4 B1	17W	561476	7913550	4-Sep-11

Table 3-5. - continued -

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Sheardown Lake Tributaries continued	SDLT-1 Reach 4 B2	17W	561483	7913546	4-Sep-11
	SDLT-1 Reach 4 B3	17W	561490	7913533	4-Sep-11
	SDLT-1 Reach 4 B1	17W	561490	7913533	30-Aug-13
	SDLT-1 Reach 4 B2	17W	561506	7913538	30-Aug-13
	SDLT-1 Reach 4 B3	17W	561526	7913531	31-Aug-13
	SDLT-9 US B1	17W	561771	7911813	1-Sep-07
	SDLT-9 US B2	17W	561774	7911814	1-Sep-07
	SDLT-9 US B3	17W	561784	7911819	1-Sep-07
	SDLT-9 US B1	17W	561771	7911813	31-Aug-13
	SDLT-9 US B2	17W	561774	7911820	31-Aug-13
	SDLT-9 US B3	17W	561784	7911819	31-Aug-13
	SDLT-12 DS B1	17W	561000	7942973	1-Sep-07
	SDLT-12 DS B2	17W	561011	7912970	1-Sep-07
	SDLT-12 DS B3	17W	561027	7912966	1-Sep-07
	SDLT-12 DS B1	17W	561000	7942973	31-Aug-13
	SDLT-12 DS B2	17W	561011	7912970	31-Aug-13
	SDLT-12 US B1	17W	561091	7912833	1-Sep-07
	SDLT-12 US B2	17W	561092	7912848	1-Sep-07
	SDLT-12 US B3	17W	561097	7912837	1-Sep-07

Table 3-6. Benthic macroinvertebrate metrics considered for the CREMP.

Effect Indicator	Metric	Unit
Abundance/Density	Total Macroinvertebrate Density	(individuals/m^2)
Composition	Chironomidae Proportion	(% of total density)
	Shannon's Equitability (evenness)	-
	Simpson's Diversity Index	-
Richness	Total Taxa Richness	genus-level
	Hill's Effective Richness	genus-level

Table 3-7. Classification of lacustrine habitats in the Mine Area.

Zone	Substrata Type/ Aquatic Macrophytes		Habitat Type
Shoreline Zone (≤ 2 m water depth)	Cobble/Boulder		**1**
	Gravel/Pebble		**2**
	Sand		**3**
	Fine Sand, Silt/Clay	Macrophytes Absent	**4**
		Macrophytes Present	**5**
Littoral/Euphotic Zone (> 2-12 m water depth)	Cobble/Boulder		**6**
	Gravel/Pebble		**7**
	Sand		**8**
	Fine Sand, Silt/Clay	Macrophytes Absent	**9**
		Macrophytes Present	**10**
Profundal Zone (> 12 m water depth)	Cobble/Boulder		**11**
	Gravel/Pebble		**12**
	Sand		**13**
	Fine Sand, Silt/Clay	Macrophytes Absent	**14**

Table 3-8. Summary statistics for total macroinvertebrate density: all Mine Area lakes by aquatic habitat type.

Metric	Total Macroinvertebrate Density (individuals/m^2)									
Habitat Type	**4**			**9**		**10**	**14**			
Lake	**Camp**	**SDL NW**	**SDL SE**	**Mary**	**SDL NW**	**SDL SE**	**Camp**	**Mary**	**SDL NW**	**SDL SE**
Year	2007	2008	2007	2007	2007, 2008	2007	2007	2006, 2007	2007, 2008, 2011	2007
n (rep. stn.)	3	8	3	9	22	3	12	11	12	6
Mean	14	829	4270	4005	3658	18562	2649	2668	1588	5042
Median	0	507	1026	3957	2165	15235	1978	2670	1665	4674
SD	25.10	782.76	6137.08	2879.22	3428.83	11312.34	1496.51	2057.11	1233.42	1350.49
SE	14.49	276.75	3543.24	959.74	731.03	6531.18	432.01	620.24	356.06	551.34
Min	0	162	435	783	250	9287	730	609	102	3548
Max	43	2129	11348	8870	10470	31165	6226	7017	4652	6730
Sub-samples (20% precision)	75	22	52	13	22	9	8	15	15	2
95th Percentile	39.1	2022.8	10315.7	8243.5	10027.8	29572.2	5250.4	5917.0	3384.8	6700.0
COV (%)	173	94	144	72	94	61	57	77	78	27
Mean + 2 x SD	64.70	2394.87	16543.73	9763.27	10515.84	41187.00	5641.58	6782.20	4054.50	7743.01
2 x Mean	28.99	1658.70	8539.14	8009.66	7316.36	37124.64	5297.10	5335.96	3175.32	10084.06
Mean +50%	21.74	1244.03	6404.36	6007.25	5487.27	27843.48	3972.83	4001.97	2381.49	7563.05
Mean -50%	7.25	414.68	2134.79	2002.42	1829.09	9281.16	1324.28	1333.99	793.83	2521.02
Mean +25%	18.12	1036.69	5336.96	5006.04	4572.73	23202.90	3310.69	3334.98	1984.58	6302.54
Mean -25%	10.87	622.01	3202.18	3003.62	2743.64	13921.74	1986.41	2000.99	1190.75	3781.52
Mean +20%	17.39	995.22	5123.48	4805.80	4389.82	22274.78	3178.26	3201.58	1905.19	6050.44
Mean -20%	11.59	663.48	3415.66	3203.86	2926.54	14849.86	2118.84	2134.38	1270.13	4033.62
Data Normally Distributed	- [1]	Yes	- [1]	Yes	No	- [1]	Yes	Yes	Yes	Yes

[1] insufficient data points to determine

Table 3-9. Summary statistics for total macroinvertebrate density: Sheardown Lake NW by aquatic habitat type and year.

Metric	Total Macroinvertebrate Density (individuals/m^2)					
Habitat Type	**4**	**9**		**14**		
Year	**2008**	**2007**	**2008**	**2007**	**2008**	**2011**
n (rep. stn.)	8	12	10	6	3	3
Mean	829	6026	817	1577	149	3048
Median	507	5887	798	1665	158	2348
SD	782.76	2970.50	448.25	218.79	42.98	1392.69
SE	276.75	857.51	141.75	89.32	24.81	804.07
Min	162	2026	250	1226	102	2145
Max	2129	10470	1677	1783	186	4652
Sub-samples (20% precision)	22	6	8	0.5	2	5
95th Percentile	2022.8	10259.1	1516.9	1769.6	183.3	4421.7
COV (%)	94	49	55	14	29	46
Mean + 2 x SD	2394.87	11967.09	1713.20	2014.39	234.66	5833.68
2 x Mean	1658.70	12052.18	1633.40	3153.62	297.40	6096.62
Mean +50%	1244.03	9039.14	1225.05	2365.22	223.05	4572.46
Mean -50%	414.68	3013.05	408.35	788.41	74.35	1524.15
Mean +25%	1036.69	7532.61	1020.88	1971.01	185.88	3810.39
Mean -25%	622.01	4519.57	612.53	1182.61	111.53	2286.23
Mean +20%	995.22	7231.31	980.04	1892.17	178.44	3657.97
Mean -20%	663.48	4820.87	653.36	1261.45	118.96	2438.65
Data Normally Distributed	Yes	No		Yes		
Significant Inter-annual Difference	-	Yes [1]		Yes - all years [2]		

[1] p-value <0.0001 (Mann-Whitney U-test)

[2] p-value 2007 vs 2008 0.015; 2007 vs 2011 0.013; 2008 vs 2011 0.001 (ANOVA with Bonferroni pairwise comparison)

Table 3-10. Summary statistics for Chironomidae proportion: all Mine Area lakes by aquatic habitat type.

Metric	**Chironomidae Proportion (% of total density)**									
Habitat Type	**4**			**9**		**10**	**14**			
Lake	**Camp**	**SDL NW**	**SDL SE**	**Mary**	**SDL NW**	**SDL SE**	**Camp**	**Mary**	**SDL NW**	**SDL SE**
Year	2007	2008	2007	2007	2007, 2008	2007	2007	2006, 2007	2007, 2008, 2011	2007
n (rep. stn.)	3	8	3	9	22	3	12	11	12	6
Mean	7	66	55	90	83	73	95	96	94	97
Median	0	64	56	96	86	68	96	99	95	98
SD	11.55	18.28	41.93	10.47	9.05	13.05	4.32	4.54	2.55	2.85
SE	6.67	6.46	24.21	3.49	1.93	7.54	1.25	1.37	0.74	1.16
Min	0	40	13	70	67	62	88	89	88	92
Max	20	88	97	99	98	87	100	100	97	100
Sub-samples (20% precision)	75	2	14	0.3	0.3	1	0.1	0.1	0.02	0.02
95th Percentile	18.0	87.7	92.5	98.8	95.3	85.3	100.0	100.0	96.6	99.7
COV (%)	173	28	76	12	11	18	5	5	3	3
Mean + 2 x SD	29.76	102.33	138.95	111.05	101.48	98.66	103.57	105.52	99.28	102.71
2 x Mean	13.33	131.54	110.18	180.22	166.76	145.12	189.87	192.88	188.36	194.02
Mean +50%	10.00	98.66	82.64	135.17	125.07	108.84	142.40	144.66	141.27	145.52
Mean -50%	3.33	32.89	27.55	45.06	41.69	36.28	47.47	48.22	47.09	48.51
Mean +25%	8.33	82.21	68.86	112.64	104.23	90.70	118.67	120.55	117.73	121.26
Mean -25%	5.00	49.33	41.32	67.58	62.54	54.42	71.20	72.33	70.64	72.76
Mean +20%	8.00	78.92	66.11	108.13	100.06	87.07	113.92	115.73	113.02	116.41
Mean -20%	5.33	52.62	44.07	72.09	66.70	58.05	75.95	77.15	75.34	77.61
Data Normally Distributed	- [1]	Yes	- [1]	No	Yes	- [1]	Yes	No	Yes	Yes

[1] insufficient data points to determine

Table 3-11. Summary statistics for Chironomidae proportion: Sheardown Lake NW by aquatic habitat type and year.

Metric	**Chironomidae Proportion (% of total density)**					
Habitat Type	**4**	**9**		**14**		
Year	**2008**	**2007**	**2008**	**2007**	**2008**	**2011**
n (rep. stn.)	8	12	10	6	3	3
Mean	66	83	84	95	93	93
Median	64	87	85	96	95	93
SD	18.28	10.67	7.17	1.58	4.08	1.91
SE	6.46	3.08	2.27	0.64	2.36	1.10
Min	40	67	75	92	88	91
Max	88	98	95	97	96	94
Sub-samples (20% precision)	2	0.4	0.2	0.01	0.05	0.01
95th Percentile	87.7	96.5	94.4	96.7	95.7	94.3
COV (%)	28	13	9	2	4	2
Mean + 2 x SD	102.33	104.34	98.19	98.58	101.33	96.55
2 x Mean	131.54	166.00	167.70	190.84	186.34	185.46
Mean +50%	98.66	124.50	125.78	143.13	139.76	139.10
Mean -50%	32.89	41.50	41.93	47.71	46.59	46.37
Mean +25%	82.21	103.75	104.81	119.28	116.46	115.91
Mean -25%	49.33	62.25	62.89	71.57	69.88	69.55
Mean +20%	78.92	99.60	100.62	114.50	111.80	111.28
Mean -20%	52.62	66.40	67.08	76.34	74.54	74.18
Data Normally Distributed	Yes	Yes		Yes		
Significant Inter-annual Difference	-	No [1]		No - all years [2]		

[1] p-value 0.833 (t-test)

[2] p-value 2007 vs 2008 0.224; 2007 vs 2011 0.152; 2008 vs 2011 0.828 (ANOVA with Bonferroni pairwise comparison)

Table 3-12. Summary statistics for Shannon's Equitability: all Mine Area lakes by aquatic habitat type.

Metric	**Shannon's Equitability (evenness)**									
Habitat Type	**4**			**9**		**10**	**14**			
Lake	**Camp**	**SDL NW**	**SDL SE**	**Mary**	**SDL NW**	**SDL SE**	**Camp**	**Mary**	**SDL NW**	**SDL SE**
Year	2007	2008	2007	2007	2007, 2008	2007	2007	2006, 2007	2007, 2008, 2011	2007
n (rep. stn.)	1	8	3	9	22	3	12	11	12	6
Mean	0.72	0.65	0.67	0.70	0.72	0.65	0.56	0.52	0.40	0.59
Median	-	0.64	0.61	0.76	0.74	0.69	0.57	0.56	0.41	0.59
SD	-	0.10	0.16	0.16	0.08	0.09	0.13	0.21	0.11	0.09
SE	-	0.03	0.09	0.05	0.02	0.05	0.04	0.06	0.03	0.04
Min	-	0.49	0.56	0.37	0.56	0.54	0.33	0.00	0.23	0.46
Max	-	0.79	0.86	0.86	0.84	0.71	0.82	0.81	0.57	0.68
Sub-samples (20% precision)	-	1	1	1	0.3	0	1	4	2	1
95th Percentile	0.72	0.77	0.83	0.84	0.83	0.71	0.75	0.73	0.56	0.68
COV (%)	0	15	24	22	11	14	24	40	28	15
Mean + 2 x SD	0.72	0.84	1.00	1.01	0.87	0.82	0.83	0.94	0.63	0.76
2 x Mean	1.44	1.29	1.35	1.39	1.43	1.29	1.12	1.04	0.81	1.17
Mean +50%	1.08	0.97	1.01	1.04	1.07	0.97	0.84	0.78	0.61	0.88
Mean -50%	0.36	0.32	0.34	0.35	0.36	0.32	0.28	0.26	0.20	0.29
Mean +25%	0.90	0.81	0.84	0.87	0.89	0.81	0.70	0.65	0.50	0.73
Mean -25%	0.54	0.48	0.51	0.52	0.54	0.48	0.42	0.39	0.30	0.44
Mean +20%	0.86	0.77	0.81	0.84	0.86	0.78	0.67	0.62	0.48	0.70
Mean -20%	0.58	0.52	0.54	0.56	0.57	0.52	0.45	0.42	0.32	0.47
Data Normally Distributed	- [1]	Yes	- [1]	Yes	Yes	- [1]	Yes	Yes	Yes	Yes

[1] insufficient data points to determine

Table 3-13. Summary statistics for Simpson's Diversity Index: all Mine Area lakes by aquatic habitat type.

Metric	**Simpson's Diversity Index**									
Habitat Type	**4**			**9**		**10**	**14**			
Lake	**Camp**	**SDL NW**	**SDL SE**	**Mary**	**SDL NW**	**SDL SE**	**Camp**	**Mary**	**SDL NW**	**SDL SE**
Year	2007	2008	2007	2007	2007, 2008	2007	2007	2006, 2007	2007, 2008, 2011	2007
n (rep. stn.)	1	8	3	9	22	3	12	11	12	6
Mean	0.33	0.73	0.73	0.67	0.76	0.71	0.60	0.50	0.37	0.61
Median	-	0.72	0.67	0.73	0.79	0.77	0.61	0.58	0.37	0.65
SD	-	0.09	0.12	0.12	0.08	0.12	0.12	0.23	0.14	0.15
SE	-	0.03	0.07	0.04	0.02	0.07	0.03	0.07	0.04	0.06
Min	-	0.57	0.66	0.43	0.56	0.57	0.39	0.00	0.15	0.35
Max	-	0.83	0.87	0.77	0.86	0.78	0.76	0.69	0.58	0.75
Sub-samples (20% precision)	-	0.4	1	1	0.3	1	1	5	4	1
95th Percentile	0.33	0.83	0.85	0.77	0.86	0.78	0.76	0.68	0.56	0.74
COV (%)	0	13	16	17	10	17	19	46	39	24
Mean + 2 x SD	0.33	0.91	0.97	0.90	0.92	0.95	0.83	0.96	0.65	0.90
2 x Mean	0.66	1.46	1.47	1.34	1.53	1.42	1.20	1.00	0.73	1.22
Mean +50%	0.50	1.09	1.10	1.01	1.15	1.06	0.90	0.75	0.55	0.91
Mean -50%	0.17	0.36	0.37	0.34	0.38	0.35	0.30	0.25	0.18	0.30
Mean +25%	0.41	0.91	0.92	0.84	0.96	0.89	0.75	0.63	0.46	0.76
Mean -25%	0.25	0.55	0.55	0.50	0.57	0.53	0.45	0.38	0.27	0.46
Mean +20%	0.40	0.88	0.88	0.80	0.92	0.85	0.72	0.60	0.44	0.73
Mean -20%	0.26	0.58	0.59	0.54	0.61	0.57	0.48	0.40	0.29	0.49
Data Normally Distributed	- [1]	Yes	- [1]	Yes	No	- [1]	Yes	No	Yes	Yes

[1] insufficient data points to determine

Table 3-14. Summary statistics for Shannon's Equitability: Sheardown Lake NW by aquatic habitat type and year.

Metric	**Shannon's Equitability (evenness)**					
Habitat Type	**4**	**9**		**14**		
Year	**2008**	**2007**	**2008**	**2007**	**2008**	**2011**
n (rep. stn.)	8	12	10	6	3	3
Mean	0.65	0.73	0.70	0.36	0.52	0.39
Median	0.64	0.75	0.72	0.39	0.56	0.33
SD	0.10	0.08	0.08	0.10	0.08	0.13
SE	0.03	0.02	0.03	0.04	0.05	0.07
Min	0.49	0.57	0.56	0.23	0.42	0.30
Max	0.79	0.84	0.83	0.45	0.57	0.54
Sub-samples (20% precision)	1	0.3	0.3	2	1	3
95th Percentile	0.77	0.81	0.81	0.45	0.57	0.51
COV (%)	15	10	12	27	16	33
Mean + 2 x SD	0.84	0.88	0.86	0.55	0.68	0.64
2 x Mean	1.29	1.46	1.40	0.71	1.03	0.78
Mean +50%	0.97	1.09	1.05	0.53	0.77	0.58
Mean -50%	0.32	0.36	0.35	0.18	0.26	0.19
Mean +25%	0.81	0.91	0.88	0.44	0.65	0.49
Mean -25%	0.48	0.55	0.53	0.27	0.39	0.29
Mean +20%	0.77	0.87	0.84	0.43	0.62	0.47
Mean -20%	0.52	0.58	0.56	0.28	0.41	0.31
Data Normally Distributed	Yes	Yes		Yes		
Significant Inter-annual Difference	-	No [1]		No - all years [2]		

[1] p-value 0.416 (t-test)

[2] p-value 2007 vs 2008 0.051; 2007 vs 2011 0.659; 2008 vs 2011 0.155 (ANOVA with Bonferroni pairwise comparison)

Table 3-15. Summary statistics for Simpson's Diversity Index: Sheardown Lake NW by aquatic habitat type and year.

Metric	Simpson's Diversity Index					
Habitat Type	**4**	**9**		**14**		
Year	**2008**	**2007**	**2008**	**2007**	**2008**	**2011**
n (rep. stn.)	8	12	10	6	3	3
Mean	0.73	0.77	0.76	0.32	0.49	0.32
Median	0.72	0.79	0.78	0.35	0.55	0.24
SD	0.09	0.07	0.09	0.13	0.12	0.15
SE	0.03	0.02	0.03	0.05	0.07	0.09
Min	0.57	0.59	0.56	0.15	0.36	0.22
Max	0.83	0.86	0.86	0.47	0.58	0.49
Sub-samples (20% precision)	0.4	0.2	0.3	4	1	5
95th Percentile	0.83	0.85	0.85	0.46	0.57	0.47
COV (%)	13	10	12	41	24	47
Mean + 2 x SD	0.91	0.92	0.94	0.59	0.73	0.62
2 x Mean	1.46	1.54	1.52	0.65	0.99	0.64
Mean +50%	1.09	1.15	1.14	0.49	0.74	0.48
Mean -50%	0.36	0.38	0.38	0.16	0.25	0.16
Mean +25%	0.91	0.96	0.95	0.40	0.62	0.40
Mean -25%	0.55	0.58	0.57	0.24	0.37	0.24
Mean +20%	0.88	0.92	0.91	0.39	0.59	0.38
Mean -20%	0.58	0.61	0.61	0.26	0.40	0.25
Data Normally Distributed	Yes	No		Yes		
Significant Inter-annual Difference	-	No [1]		No - all years [2]		

[1] p-value 0.974 (Mann-Whitney U-test)

[2] p-value 2007 vs 2008 0.103; 2007 vs 2011 0.961; 2008 vs 2011 0.140 (ANOVA with Bonferroni pairwise comparison)

Table 3-16. Summary statistics for total taxa richness: all Mine Area lakes by aquatic habitat type.

Metric	Total Taxa Richness (genus-level)									
Habitat Type	**4**			**9**		**10**	**14**			
Lake	**Camp**	**SDL NW**	**SDL SE**	**Mary**	**SDL NW**	**SDL SE**	**Camp**	**Mary**	**SDL NW**	**SDL SE**
Year	2007	2008	2007	2007	2007, 2008	2007	2007	2006, 2007	2007, 2008, 2011	2007
n (rep. stn.)	3	8	3	9	22	3	12	11	12	6
Mean	1	15	15	8	13	13	9	9	7	9
Median	0	16	15	8	14	13	9	8	8	10
SD	1.15	1.04	1.53	1.42	2.72	1.53	2.76	5.66	1.62	2.83
SE	0.67	0.37	0.88	0.47	0.58	0.88	0.80	1.71	0.47	1.15
Min	0	13	14	5	8	12	6	1	4	4
Max	2	16	17	10	20	15	14	18	9	12
Sub-samples (20% precision)	75	0.1	0.2	1	1	0.3	2	10	1	2
95th Percentile	1.8	16.0	16.8	9.2	16.0	14.8	13.5	16.5	9.0	11.8
COV (%)	173	7	10	19	20	11	31	64	22	31
Mean + 2 x SD	2.98	17.32	18.39	10.40	18.85	16.39	14.53	20.24	10.66	14.66
2 x Mean	1.33	30.50	30.67	15.11	26.82	26.67	18.00	17.82	14.83	18.00
Mean +50%	1.00	22.88	23.00	28.50	20.11	20.00	13.50	13.36	11.13	13.50
Mean -50%	0.33	7.63	7.67	9.50	6.70	6.67	4.50	4.45	3.71	4.50
Mean +25%	0.83	19.06	19.17	23.75	16.76	16.67	11.25	11.14	9.27	11.25
Mean -25%	0.50	11.44	11.50	14.25	10.06	10.00	6.75	6.68	5.56	6.75
Mean +20%	0.80	18.30	18.40	22.80	16.09	16.00	10.80	10.69	8.90	10.80
Mean -20%	0.53	12.20	12.27	15.20	10.73	10.67	7.20	7.13	5.93	7.20
Data Normally Distributed	- [1]	No	- [1]	Yes	Yes	- [1]	Yes	Yes	Yes	Yes

[1] insufficient data points to determine

Table 3-17. Summary statistics for Hill's effective richness: all Mine Area lakes by aquatic habitat type.

Metric	**Hill's Effective Richness (genus-level)**									
Habitat Type	**4**			**9**		**10**	**14**			
Lake	**Camp**	**SDL NW**	**SDL SE**	**Mary**	**SDL NW**	**SDL SE**	**Camp**	**Mary**	**SDL NW**	**SDL SE**
Year	2007	2008	2007	2007	2007, 2008	2007	2007	2006, 2007	2007, 2008, 2011	2007
n (rep. stn.)	1	8	3	9	22	3	12	11	12	6
Mean	2	6	7	4	6	5	4	3	2	4
Median	-	6	5	5	6	6	3	4	2	4
SD	-	1.63	3.06	1.05	1.47	1.23	1.24	1.31	0.66	1.15
SE	-	0.58	1.77	0.35	0.31	0.71	0.36	0.40	0.19	0.47
Min	-	4	5	2	4	4	2	1	1	2
Max	-	8	10	5	9	6	6	5	3	5
Sub-samples (20% precision)	-	2	5	2	1	1	3	4	2	2
95th Percentile	1.6	8.1	9.7	5.3	8.7	6.4	5.5	4.9	3.3	5.0
COV (%)	0	27	46	26	23	23	35	39	28	31
Mean + 2 x SD	1.65	9.25	12.78	6.21	9.40	7.89	6.03	5.96	3.65	6.01
2 x Mean	3.30	11.98	13.33	8.22	12.94	10.85	7.11	6.68	4.68	7.43
Mean +50%	2.47	8.98	10.00	6.17	9.70	8.14	5.33	5.01	3.51	5.57
Mean -50%	0.82	2.99	3.33	2.06	3.23	2.71	1.78	1.67	1.17	1.86
Mean +25%	2.06	7.49	8.33	5.14	8.09	6.78	4.44	4.18	2.92	4.65
Mean -25%	1.24	4.49	5.00	3.08	4.85	4.07	2.67	2.51	1.75	2.79
Mean +20%	1.98	7.19	8.00	4.93	7.76	6.51	4.27	4.01	2.81	4.46
Mean -20%	1.32	4.79	5.33	3.29	5.18	4.34	2.84	2.67	1.87	2.97
Data Normally Distributed	- [1]	Yes	- [1]	Yes	Yes	- [1]	Yes	Yes	Yes	Yes

[1] insufficient data points to determine

Table 3-18. Summary statistics for total taxa richness: Sheardown Lake NW by aquatic habitat type and year.

Metric	**Total Taxa Richness (genus-level)**					
Habitat Type	**4**	**9**		**14**		
Year	**2008**	**2007**	**2008**	**2007**	**2008**	**2011**
n (rep. stn.)	8	12	10	6	3	3
Mean	15	12	15	8	8	7
Median	16	13	15	9	8	6
SD	1.04	2.35	2.67	2.07	0.58	1.73
SE	0.37	0.68	0.84	0.85	0.33	1.00
Min	13	8	11	4	7	6
Max	16	15	20	9	8	9
Sub-samples (20% precision)	0.1	1	1	2	0.1	2
95th Percentile	16.0	15.0	18.2	9.0	8.0	8.7
COV (%)	7	19	18	28	8	25
Mean + 2 x SD	17.32	17.03	20.04	11.65	8.82	10.46
2 x Mean	30.50	24.67	29.40	15.00	15.33	14.00
Mean +50%	22.88	18.50	22.05	11.25	11.50	10.50
Mean -50%	7.63	6.17	7.35	3.75	3.83	3.50
Mean +25%	19.06	15.42	18.38	9.38	9.58	8.75
Mean -25%	11.44	9.25	11.03	5.63	5.75	5.25
Mean +20%	18.30	14.80	17.64	9.00	9.20	8.40
Mean -20%	12.20	9.87	11.76	6.00	6.13	5.60
Data Normally Distributed	No	Yes		Yes		
Significant Inter-annual Difference	-	Yes [1]		No - all years [2]		

[1] p-value 0.039 (t-test)

[2] p-value 2007 vs 2008 0.897; 2007 vs 2011 0.699; 2008 vs 2011 0.655 (ANOVA with Bonferroni pairwise comparison)

Table 3-19. Summary statistics for Hill's effective richness: Sheardown Lake NW by aquatic habitat type and year.

Metric	Hill's Effective Richness (genus-level)					
Habitat Type	**4**	**9**		**14**		
Year	**2008**	**2007**	**2008**	**2007**	**2008**	**2011**
n (rep. stn.)	8	12	10	6	3	3
Mean	6	6	7	2	3	2
Median	6	6	7	2	3	2
SD	1.63	1.38	1.60	0.51	0.56	0.86
SE	0.58	0.40	0.51	0.21	0.32	0.49
Min	4	4	4	1	2	2
Max	8	9	9	3	3	3
Sub-samples (20% precision)	2	1	1	1	1	4
95th Percentile	8.1	8.5	9.1	2.6	3.3	3.1
COV (%)	27	22	24	24	19	38
Mean + 2 x SD	9.25	9.05	9.90	3.11	4.03	3.97
2 x Mean	11.98	12.56	13.39	4.19	5.82	4.50
Mean +50%	8.98	9.42	10.04	3.15	4.37	3.38
Mean -50%	2.99	3.14	3.35	1.05	1.46	1.13
Mean +25%	7.49	7.85	8.37	2.62	3.64	2.81
Mean -25%	4.49	4.71	5.02	1.57	2.18	1.69
Mean +20%	7.19	7.54	8.04	2.52	3.49	2.70
Mean -20%	4.79	5.02	5.36	1.68	2.33	1.80
Data Normally Distributed	No	Yes		Yes		
Significant Inter-annual Difference	-	No [1]		No - all years [2]		

[1] p-value 0.520 (t-test)

[2] p-value 2007 vs 2008 0.094; 2007 vs 2011 0.729; 2008 vs 2011 0.222 (ANOVA with Bonferroni pairwise comparison)

Table 3-20. Summary statistics for total macroinvertebrate density: Sheardown Lake Tributary 1 by reach and year.

Metric	Total Macroinvertebrate Density (individuals/m^2)							
Stream Reach	**1**	**2**			**4**			
Year	**2008**	**2007**	**2008**	**All**	**2007**	**2008**	**2011**	**All**
n (rep. stn.)	3	3	3	6	3	3	3	9
Mean	299	441	647	544	4520	3042	2432	3332
Median	315	421	429	425	2043	3225	1454	2266
SD	53.49	110.73	465.01	322.72	4372.64	702.61	1711.24	2549.53
SE	30.88	63.93	268.47	131.75	2524.55	405.65	987.99	849.84
Min	239	342	332	332	1948	2266	1435	1435
Max	342	561	1181	1181	9569	3635	4408	9569
Sub-samples (20% precision)	1	2	13	9	23	1	12	15
95th Percentile	339.6	546.8	1106.2	1026.3	8816.5	3594.0	4112.8	7504.7
COV (%)	18	25	72	59	97	23	70	77
Mean + 2 x SD	405.95	662.69	1577.44	1189.78	13265.56	4447.14	5854.79	8430.56
2 x Mean	597.94	882.47	1294.85	1088.66	9040.55	6083.85	4864.60	6663.00
Mean +50%	448.45	661.86	971.13	816.49	6780.41	4562.89	3648.45	4997.25
Mean -50%	149.48	220.62	323.71	272.16	2260.14	1520.96	1216.15	1665.75
Mean +25%	373.71	551.55	809.28	680.41	5650.34	3802.41	3040.38	4164.38
Mean -25%	224.23	330.93	485.57	408.25	3390.21	2281.44	1824.23	2498.63
Mean +20%	358.76	529.48	776.91	653.20	5424.33	3650.31	2918.76	3997.80
Mean -20%	239.18	352.99	517.94	435.46	3616.22	2433.54	1945.84	2665.20
Data Normally Distributed	- [1]	No			No			
Significant Inter-annual Difference	-	No [2]			No [3]			

[1] insufficient data points to determine

[2] p-value 1.000 (Mann-Whitney U-test)

[3] p-value 0.561

Table 3-21. Summary statistics for Chironomidae proportion: Sheardown Lake Tributary 1 by reach and year.

Metric	Chironomidae Proportion (% of total density)							
Stream Reach	**1**	**2**			**4**			
Year	**2008**	**2007**	**2008**	**All**	**2007**	**2008**	**2011**	**All**
n (rep. stn.)	3	3	3	6	3	3	3	9
Mean	69	64	78	71	92	94	87	91
Median	70	74	76	75	93	93	86	92
SD	1.97	22.96	4.20	16.56	3.84	2.19	2.68	4.06
SE	1.13	13.26	2.42	6.76	2.21	1.27	1.55	1.35
Min	67	38	75	38	88	92	85	85
Max	71	81	83	83	95	96	90	96
Sub-samples (20% precision)	0.02	3	0.1	1	0.04	0.01	0.02	0.05
95th Percentile	70.5	80.1	81.9	82.1	95.3	95.7	89.4	95.7
COV (%)	3	36	5	23	4	2	3	4
Mean + 2 x SD	73.03	110.04	86.22	104.09	99.87	97.97	92.12	98.96
2 x Mean	138.19	128.24	155.64	141.94	184.41	187.16	173.50	181.69
Mean +50%	103.64	96.18	116.73	106.46	138.31	140.37	130.12	136.27
Mean -50%	34.55	32.06	38.91	35.49	46.10	46.79	43.37	45.42
Mean +25%	86.37	80.15	97.28	88.71	115.25	116.98	108.44	113.56
Mean -25%	51.82	48.09	58.37	53.23	69.15	70.19	65.06	68.13
Mean +20%	82.91	76.95	93.39	85.17	110.64	112.30	104.10	109.01
Mean -20%	55.28	51.30	62.26	56.78	73.76	74.86	69.40	72.68
Data Normally Distributed	- [1]	No			Yes			
Significant Inter-annual Difference	-	No [2]			No [3]			

[1] insufficient data points to determine

[2] p-value 0.400 (Mann-Whitney U-test)

[3] p-value 2007 vs 2008 0.592; 2007 vs 2011 0.067; 2008 vs 2011 0.031

Table 3-22. Summary statistics for Shannon's Equitability: Sheardown Lake Tributary 1 by reach and year.

Metric	Shannon's Equitability (evenness)							
Stream Reach	**1**	**2**			**4**			
Year	**2008**	**2007**	**2008**	**All**	**2007**	**2008**	**2011**	**All**
n (rep. stn.)	3	3	3	6	3	3	3	9
Mean	0.77	0.70	0.71	0.71	0.62	0.66	0.62	0.63
Median	0.77	0.70	0.72	0.71	0.67	0.68	0.65	0.67
SD	0.06	0.03	0.03	0.03	0.18	0.08	0.11	0.11
SE	0.03	0.02	0.01	0.01	0.10	0.05	0.06	0.04
Min	0.72	0.67	0.69	0.67	0.42	0.57	0.50	0.42
Max	0.83	0.73	0.74	0.74	0.76	0.72	0.71	0.76
Sub-samples (20% precision)	0.1	0.1	0.03	0.04	2	0.4	1	1
95th Percentile	0.82	0.73	0.73	0.74	0.75	0.72	0.70	0.75
COV (%)	7	5	4	4	29	12	17	18
Mean + 2 x SD	0.89	0.77	0.76	0.76	0.97	0.82	0.83	0.86
2 x Mean	1.55	1.40	1.43	1.41	1.23	1.31	1.24	1.26
Mean +50%	1.16	1.05	1.07	1.06	0.93	0.98	0.93	0.95
Mean -50%	0.39	0.35	0.36	0.35	0.31	0.33	0.31	0.32
Mean +25%	0.97	0.87	0.89	0.88	0.77	0.82	0.77	0.79
Mean -25%	0.58	0.52	0.53	0.53	0.46	0.49	0.46	0.47
Mean +20%	0.93	0.84	0.86	0.85	0.74	0.79	0.74	0.76
Mean -20%	0.62	0.56	0.57	0.56	0.49	0.52	0.50	0.50
Data Normally Distributed	- [1]	Yes			Yes			
Significant Inter-annual Difference	-	No [2]			No [3]			

[1] insufficient data points to determine

[2] p-value 0.595 (t-test)

[3] p-value 2007 vs 2008 0.732; 2007 vs 2011 0.983; 2008 vs 2011 0.747

Table 3-23. Summary statistics for Simpson's Diversity Index: Sheardown Lake Tributary 1 by reach and year.

Metric	Simpson's Diversity Index							
Stream Reach	**1**	**2**			**4**			
Year	**2008**	**2007**	**2008**	**All**	**2007**	**2008**	**2011**	**All**
n (rep. stn.)	3	3	3	6	3	3	3	9
Mean	0.82	0.77	0.76	0.76	0.69	0.74	0.73	0.72
Median	0.83	0.76	0.75	0.76	0.77	0.81	0.76	0.77
SD	0.04	0.03	0.03	0.03	0.21	0.12	0.11	0.14
SE	0.02	0.02	0.02	0.01	0.12	0.07	0.06	0.05
Min	0.78	0.73	0.73	0.73	0.45	0.61	0.62	0.45
Max	0.85	0.80	0.80	0.80	0.85	0.81	0.82	0.85
Sub-samples (20% precision)	0.05	0.04	0.1	0.04	2	1	1	1
95th Percentile	0.85	0.80	0.79	0.80	0.84	0.81	0.82	0.84
COV (%)	4	4	5	4	31	16	15	19
Mean + 2 x SD	0.90	0.83	0.83	0.82	1.12	0.98	0.95	0.99
2 x Mean	1.65	1.53	1.52	1.53	1.38	1.48	1.47	1.44
Mean +50%	1.23	1.15	1.14	1.14	1.03	1.11	1.10	1.08
Mean -50%	0.41	0.38	0.38	0.38	0.34	0.37	0.37	0.36
Mean +25%	1.03	0.96	0.95	0.95	0.86	0.93	0.92	0.90
Mean -25%	0.62	0.57	0.57	0.57	0.52	0.56	0.55	0.54
Mean +20%	0.99	0.92	0.91	0.92	0.83	0.89	0.88	0.87
Mean -20%	0.66	0.61	0.61	0.61	0.55	0.59	0.59	0.58
Data Normally Distributed	- [1]	Yes			Yes			
Significant Inter-annual Difference	-	No [2]			No [3]			

[1] insufficient data points to determine

[2] p-value 0.856 (t-test)

[3] p-value 2007 vs 2008 0.684; 2007 vs 2011 0.726; 2008 vs 2011 0.954

Table 3-24. Summary statistics for total taxa richness: Sheardown Lake Tributary 1 by reach and year.

Metric	**Total Taxa Richness (genus-level)**							
Stream Reach	**1**	**2**			**4**			
Year	**2008**	**2007**	**2008**	**All**	**2007**	**2008**	**2011**	**All**
n (rep. stn.)	3	3	3	6	3	3	3	9
Mean	12	15	13	14	16	16	17	16
Median	12	15	13	14	16	17	17	17
SD	1.00	1.00	1.00	1.41	2.52	4.58	1.53	2.74
SE	0.58	0.58	0.58	0.58	1.45	2.65	0.88	0.91
Min	11	14	12	12	14	11	15	11
Max	13	16	14	16	19	20	18	20
Sub-samples (20% precision)	0.2	0.1	0.1	0.3	1	2	0.2	1
95th Percentile	12.9	15.9	13.9	15.8	18.7	19.7	17.9	19.6
COV (%)	8	7	8	10	15	29	9	17
Mean + 2 x SD	14.00	17.00	15.00	16.83	21.37	25.17	19.72	21.81
2 x Mean	24.00	30.00	26.00	28.00	32.67	32.00	33.33	32.67
Mean +50%	18.00	22.50	19.50	21.00	24.50	24.00	25.00	24.50
Mean -50%	6.00	7.50	6.50	7.00	8.17	8.00	8.33	8.17
Mean +25%	15.00	18.75	16.25	17.50	20.42	20.00	20.83	20.42
Mean -25%	9.00	11.25	9.75	10.50	12.25	12.00	12.50	12.25
Mean +20%	14.40	18.00	15.60	16.80	19.60	19.20	20.00	19.60
Mean -20%	9.60	12.00	10.40	11.20	13.07	12.80	13.33	13.07
Data Normally Distributed	- [1]	Yes			Yes			
Significant Inter-annual Difference	-	No [2]			No [3]			

[1] insufficient data points to determine

[2] p-value 0.070 (t-test)

[3] p-value 2007 vs 2008 0.901; 2007 vs 2011 0.901; 2008 vs 2011 0.804

Table 3-25. Summary statistics for Hill's effective richness: Sheardown Lake Tributary 1 by reach and year.

Metric	Hill's Effective Richness (genus-level)							
Stream Reach	**1**	**2**			**4**			
Year	**2008**	**2007**	**2008**	**All**	**2007**	**2008**	**2011**	**All**
n (rep. stn.)	3	3	3	6	3	3	3	9
Mean	7	7	6	6	6	6	6	6
Median	7	7	6	6	6	8	6	6
SD	1.17	0.48	0.43	0.47	3.20	2.20	1.94	2.18
SE	0.68	0.28	0.25	0.19	1.85	1.27	1.12	0.73
Min	6	6	6	6	3	4	4	3
Max	8	7	7	7	9	8	8	9
Sub-samples (20% precision)	1	0.1	0.1	0.1	6	3	3	3
95th Percentile	7.8	6.9	6.6	6.9	9.1	7.8	7.6	8.8
COV (%)	17	7	7	7	51	34	32	35
Mean + 2 x SD	9.24	7.60	7.09	7.37	12.70	10.82	9.86	10.59
2 x Mean	13.80	13.28	12.45	12.87	12.59	12.83	11.95	12.46
Mean +50%	10.35	9.96	9.34	9.65	9.44	9.62	8.96	9.34
Mean -50%	3.45	3.32	3.11	3.22	3.15	3.21	2.99	3.11
Mean +25%	8.62	8.30	7.78	8.04	7.87	8.02	7.47	7.79
Mean -25%	5.17	4.98	4.67	4.82	4.72	4.81	4.48	4.67
Mean +20%	8.28	7.97	7.47	7.72	7.55	7.70	7.17	7.48
Mean -20%	5.52	5.31	4.98	5.15	5.04	5.13	4.78	4.98
Data Normally Distributed	- [1]	Yes			Yes			
Significant Inter-annual Difference	-	No [2]			No [3]			

[1] insufficient data points to determine

[2] p-value 0.331 (t-test)

[3] p-value 2007 vs 2008 0.955; 2007 vs 2011 0.881; 2008 vs 2011 0.837

Table 3-26. Critical effects sizes for select benthic macroinvertebrate community metrics from Sheardown Lake NW.

Metric	Habitat Type 4 (2008; n = 8)					
	Mean +50%	Mean -50%	Mean +25%	Mean -25%	Mean +20%	Mean -20%
Total macroinvertebrate density	1244.03	414.68	1036.69	622.01	995.22	663.48
Chironomidae proportion	98.66	32.89	82.21	49.33	78.92	52.62
Shannon's Equitability	0.97	0.32	0.81	0.48	0.77	0.52
Simpson's Diversity Index	1.09	0.36	0.91	0.55	0.88	0.58
Total taxa richness	22.88	7.63	19.06	11.44	18.30	12.20

Metric	Habitat 9 (2007 and 2008; n = 22)					
	Mean +50%	Mean -50%	Mean +25%	Mean -25%	Mean +20%	Mean -20%
Total macroinvertebrate density	5487.27	1829.09	4572.73	2743.64	4389.82	2926.54
Chironomidae proportion	125.07	41.69	104.23	62.54	100.06	66.70
Shannon's Equitability	1.07	0.36	0.89	0.54	0.86	0.57
Simpson's Diversity Index	1.15	0.38	0.96	0.57	0.92	0.61
Total taxa richness	20.11	6.70	16.76	10.06	16.09	10.73

Metric	Habitat Type 14 (2007, 2008, 2011; n = 12)					
	Mean +50%	Mean -50%	Mean +25%	Mean -25%	Mean +20%	Mean -20%
Total macroinvertebrate density	2381.49	793.83	1984.58	1190.75	1905.19	1270.13
Chironomidae proportion	141.27	47.09	117.73	70.64	113.02	75.34
Shannon's Equitability	0.61	0.20	0.50	0.30	0.48	0.32
Simpson's Diversity Index	0.55	0.18	0.46	0.27	0.44	0.29
Total taxa richness	11.13	3.71	9.27	5.56	8.90	5.93

Table 3-27. Critical effects sizes for select benthic macroinvertebrate community metrics from Sheardown Lake Tributary 1, Reach 4.

Metric	2007, 2008, 2011; n = 9					
	Mean +50%	Mean -50%	Mean +25%	Mean -25%	Mean +20%	Mean -20%
Total macroinvertebrate density	4997.25	1665.75	4164.38	2498.63	3997.80	2665.20
Chironomidae proportion	136.27	45.42	113.56	68.13	109.01	72.68
Shannon’s Equitability	0.95	0.32	0.79	0.47	0.76	0.50
Simpson’s Diversity Index	1.08	0.36	0.90	0.54	0.87	0.58
Total taxa richness	24.50	8.17	20.42	12.25	19.60	13.07

Table 3-28. Power of existing benthic macroinvertebrate data to detect pre-defined levels of change in Sheardown Lake NW.

Metric	Habitat Type 4 (2008; n = 8)		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	0.247	0.148	0.123
Chironomidae proportion	0.957	0.536	0.402
Shannon's Equitability	1.000	0.935	0.813
Simpson's Diversity Index	1.000	0.982	0.938
Total taxa richness	1.000	1.000	1.000

Metric	Habitat 9 (2007 and 2008; n = 22)		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	0.807	0.387	0.282
Chironomidae proportion	1.000	1.000	1.000
Shannon's Equitability	1.000	1.000	0.999
Simpson's Diversity Index	1.000	1.000	1.000
Total taxa richness	1.000	0.992	0.943

Metric	Habitat Type 14 (2007, 2008, 2011; n = 12)		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	0.441	0.170	0.154
Chironomidae proportion	1.000	1.000	1.000
Shannon's Equitability	0.990	0.681	0.495
Simpson's Diversity Index	0.892	0.446	0.317
Total taxa richness	1.000	0.866	0.712

Table 3-29. Sample sizes (i.e., number of replicate stations) required for detecting pre-defined levels of change in Sheardown Lake NW.

Metric	Habitat Type 4		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	64	>180	>>180
Chironomidae proportion	6	22	37
Shannon's Equitability	3	7	10
Simpson's Diversity Index	3	5	7
Total taxa richness	<<3	<3	3

Metric	Habitat 9		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	31	>60	>>60
Chironomidae proportion	2	4	6
Shannon's Equitability	2	4	6
Simpson's Diversity Index	<5	5	6
Total taxa richness	4	12	18

Metric	Habitat Type 14		
	Mean +/-50%	Mean +/-25%	Mean +/-20%
Total macroinvertebrate density	43	167	>180
Chironomidae proportion	1	1	1
Shannon's Equitability	7	22	37
Simpson's Diversity Index	12	45	70
Total taxa richness	4	13	21

Table 3-30. Power of existing benthic macroinvertebrate data to detect pre-defined levels of change in Sheardown Lake Tributary 1, Reach 4.

Metric	2007, 2008, 2011; n = 9		
	Mean +/- 50%	Mean +/- 25%	Mean +/- 20%
Total macroinvertebrate density	0.564 [1]	0.248 [2]	0.209 [3]
Chironomidae proportion	1.000	1.000	1.000
Shannon's Equitability	1.000	0.791	0.602
Simpson's Diversity Index	1.000	0.750	0.578
Total taxa richness	1.000	0.844	0.651

[1] metric not normally distributed: -50%, 0.785

[2] metric not normally distributed: -25%, 0.276

[3] metric not normally distributes: -20%, 0.109

Table 3-31. Sample sizes (i.e., number of replicate stations) required for detecting pre-defined levels of change in Sheardown Lake Tributary 1, Reach 4.

Metric	2007, 2008, 2011; n = 9		
	Mean +/- 50%	Mean +/- 25%	Mean +/- 20%
Total macroinvertebrate density	22 [1]	>61 [2]	>>61 [3]
Chironomidae proportion	2	3	3
Shannon's Equitability	4	12	18
Simpson's Diversity Index	5	13	19
Total taxa richness	4	10	16

[1] metric not normally distributed: -50%, 13

[2] metric not normally distributed: -25%, 59

[3] metric not normally distributed: -20%, 60

Table 4-1. Summary of baseline electrofishing and gillnetting Arctic Char data collections in selected Mine Area waterbodies, 2006-2008 and 2013.

Waterbody	Year	Season	Gear Type[1]	Sampling Effort[2]	Catch
Camp Lake	2006	Summer	Gill Net	2	21
	2007	Winter	Gill Net	2	3
		Summer	Gill Net	20	94
			Electrofishing	1	8
	2008	Fall	Gill Net	14	22
	2013	Fall	Gill Net	35	26
			Electrofishing	1	57
Camp Lake Tributary 1	2006	Summer	Electrofishing	3	8
	2007	Summer	Electrofishing	3	196
		Fall	Electrofishing	3	211
Sheardown Lake NW	2006	Summer	Gill Net	1	17
	2007	Winter	Gill Net	2	5
		Summer	Gill Net	12	92
			Electrofishing	5	220
	2008	Spring	Electrofishing	10	36
		Fall	Gill Net	4	5
	2013	Fall	Gill Net	18	28
			Electrofishing	2	184
Sheardown Lake SE	2007	Winter	Gill Net	2	7
		Summer	Gill Net	2	30
			Electrofishing	2	32
	2008	Spring	Electrofishing	4	4
		Fall	Gill Net	4	63

Table 4-1. - continued -

Waterbody	Year	Season	Gear Type[1]	Sampling Effort[2]	Catch
Sheardown Lake Tributary 1	2006	Summer	Electrofishing	1	5
	2007	Spring	Electrofishing	4	4
		Summer	Electrofishing	4	145
		Fall	Electrofishing	4	52
			Hoop Net	23	1240
	2008	Spring	Electrofishing	2	33
			Hoop Net[3]	18	849
		Summer	Electrofishing	2	55
		Fall	Electrofishing	2	13
			Hoop Net	17	469
Mary Lake – South	2006	Summer	Gill Net	2	62
			Electrofishing	1	
	2007	Summer	Gill Net	24	168
	2008	Spring	Electrofishing	7	2
Mary Lake – North	2007	Summer	Gill Net	8	98
	2008	Spring	Electrofishing	3	4

[1] Does not include minnow trap or angling data.

[2] Effort for gill nets described as the number of standard index gillnet gangs set in each lake; electrofishing effort is the number of 50-100 m sections of shoreline or stream sampled, and hoopnetting effort is the number of days traps were installed.

[3] Data include two hoop nets (one facing upstream and one downstream) that each fished for 18 days.

Table 4-2. Summary of fish metrics and statistical analysis methods recommended under EEM (EC 2012). Metrics indicated with an asterisk are endpoints used for determining effects under EEM, as designated by statistically significant differences between exposure and reference areas. Other endpoints may be used to support analyses.

Effect Indicators	Fish Effect Endpoint			
	Non-Lethal Survey	**Statistical Test**	**Lethal Adult Survey**	**Statistical Test**
Growth	*Length of YOY (age 0) at end of growth period	ANOVA	-	
	*Weight of YOY (age 0) at end of growth period	ANOVA	-	
	*Size of 1+ fish if possible	ANOVA		
	*Size-at-age (body weight at age) - if possible	ANCOVA	*Size-at-age (body weight at age)	ANCOVA
	Length-at-age	ANCOVA	Length-at-age	ANCOVA
	Body Weight	ANOVA		
	Length	ANOVA		
Reproduction	*Relative abundance of YOY (% composition of YOY)	Kolmorgorov-Smirnov test performed on length-frequency distributions with and without YOY included; OR proportions of YOY can be tested using a Chi-squared test.	-	
	OR relative age-class strength		*Gonad weight at body weight	ANCOVA
	-		Gonad weight at length	
	-		Fecundity	
Condition	*Condition Factor	ANCOVA	*Condition Factor	ANCOVA
	-		*Liver size at body weight	ANCOVA
	-		Liver weight at length	
	-		Egg weight at body weight and/or age (mature females only)	
Survival	*Length-frequency-distribution	2-sample Kolmorgorov-Smirnov test[1]	Length-frequency-distribution	2-sample Kolmorgorov-Smirnov test
	*Age-frequency distribution (if possible)	2-sample Kolmorgorov-Smirnov test	*Age-frequency distribution (if possible)	2-sample Kolmorgorov-Smirnov test
	YOY Survival		*Age	ANOVA

[1] Examine YOY alone and for both sizes combined

Table 4-3. Datasets analysed for Arctic Char metrics.

Waterbody	Year	Gear Type	Sex
Camp Lake	2006	Gill Net	M, F, Total
	2007	Gill Net	M, F, Total
	2008	Gill Net	M, F, Total
	All Years	Gill Net	M, F, Total
Sheardown Lake	2006	Gill Net	M, F, Total
	2007	Electrofishing	Total
		Gill Net	M, F, Total
	2008	Electrofishing	Total
		Gill Net	M, F, Total
	All Years	Electrofishing	Total
		Gill Net	M, F, Total
Mary Lake – South	2006	Gill Net	M, F, Total
	2007	Gill Net	M, F, Total
	All Years	Gill Net	M, F, Total
Mary Lake – North	2007	Gill Net	Total

Table 4-4. Summary statistics for fork lengths (mm) of Arctic Char captured during backpack electrofishing (EF) and gillnetting surveys in Camp Lake, 2006-2008.

Statistic	2006			2007			2008			All Years		
	Males	Females	All	Males	Females	All	Males	Females	All	Males	Females	All
n	11	10	21	3	3	99	9	2	22	23	15	134
Mean	335	224	282	291	329	305	465	394	401	380	267	332
Median	265	221	230	312	338	321	430	394	368	350	236	323
SD	195	39	151	38	45	117	137	100	117	171	80	114
SE	59	12	33	22	26	12	46	71	25	36	21	10
Minimum	170	175	170	247	280	40	342	323	236	170	175	170
Maximum	751	311	751	315	368	682	745	464	745	751	464	751
95th Percentile	699	286	647	315	365	542	680	457	582	735	397	578
COV (%)	58	18	54	13	14	38	29	25	29	45	30	34

Table 4-5. Summary statistics for fork lengths (mm) of Arctic Char captured during backpack electrofishing (EF) and index gillnetting surveys in Sheardown Lake, 2006-2008.

Statistic	2006			2007				2008				All Years			
	Gillnetting			EF	Gillnetting			EF	Gillnetting			EF	Gillnetting		
	Males	Females	All		Males	Females	All		Males	Females	All		Males	Females	All
n	6	2	14	252	12	15	116	39	27	8	68	291	45	25	198
Mean	313	385	346	76	367	353	372	83	402	383	387	77	381	365	375
Median	281	385	293	65	371	335	369	87	403	380	385	66	388	364	377
SD	142	142	137	29	59	69	82	28	37	18	38	29	70	63	76
SE	58	101	37	2	17	18	8	4	7	6	5	2	10	13	5
Minimum	180	284	180	33	278	240	178	26	360	364	276	26	180	240	178
Maximum	572	485	599	180	507	508	587	140	552	420	552	180	572	508	599
95th Percentile	519	475	581	139	449	497	541	127	441	410	431	138	495	491	531
COV (%)	45	37	39	38	16	20	22	34	9	5	10	37	18	17	20

Table 4-6. Summary statistics for fork lengths (mm) of Arctic Char captured in standard index gill nets deployed in the north and south basins of Mary Lake, 2006-2007.

Statistic	South Basin									North Basin
	2006			2007			All Years			2007
	Males	Females	All	Males	Females	All	Males	Females	All	
n	26	33	62	14	12	161	40	45	223	98
Mean	386	370	384	383	375	383	385	372	384	379
Median	390	370	384	394	373	392	395	372	391	389
SD	132	116	133	74	43	71	114	102	92	41
SE	26	20	17	20	13	6	18	15	6	4
Minimum	165	181	165	266	266	197	165	181	165	198
Maximum	685	658	705	548	432	671	685	658	705	458
95^{th} Percentile	594	586	648	485	424	457	573	552	559	432
COV (%)	34	31	35	19	12	18	30	27	24	11

Table 4-7. Comparison of Arctic Char length between sexes and years. Data represent fish captured during backpack electrofishing (EF) and index gillnetting (GN) surveys in study area lakes, 2006-2008. Values in red indicate significant difference at $p < 0.05$.

Lake	Comparison			P value[1]
	Dataset 1	Dataset 2	Dataset 3	
Camp Lake	2006 GN Males	2006 GN Females	-	0.58
	2007 GN Males	2007 GN Females	-	0.38
	2008 GN Males	2008 GN Females	-	0.37
	All Years Males	All Years Females	-	0.17
	2006 GN Males	2007 GN Males	2008 GN Males	0.11
	2006 GN Females	2007 GN Females	2008 GN Females	0.04
	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	0.70
Sheardown Lake	2006 GN Males	2006 GN Females	-	0.11
	2007 GN Males	2007 GN Females	-	0.98
	2008 GN Males	2008 GN Females	-	0.47
	All Years GN Males	All Years GN Females	-	0.66
	2006 GN Males	2007 GN Males	2008 GN Males	0.91
	2006 GN Females	2007 GN Females	2008 GN Females	0.77
	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	0.98
	2007 EF All Fish	2008 EF All Fish	-	0.76
Mary Lake - S	2006 GN Males	2006 GN Females	-	0.79
	2007 GN Males	2007 GN Females	-	0.43
	All Years Males	All Years Females	-	0.72
	2006 GN Males	2007 GN Males	-	0.55
	2006 GN Females	2007 GN Females	-	0.60
	2006 GN All Fish	2007 GN All Fish	-	0.72

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-8. Inter-lake comparisons of fork lengths (mm) of Arctic Char captured during index gillnetting surveys, 2006-2008.

Comparison				P value[1]
Dataset 1	Dataset 2	Dataset 3	Dataset 4	
Camp L. 2006 GN	Sheardown L. 2006 GN	Mary L – S 2006 GN	-	0.74
Camp L. 2007 GN	Sheardown L. 2007 GN	Mary L – S 2007 GN	Mary L – N 2007 GN	0.94
Camp L. 2008 GN	Sheardown L. 2008 GN	-	-	0.52
Camp L. All GN	Sheardown L. All GN	Mary L – S All GN	Mary L – N All GN	0.94

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-9. Summary statistics for weights (g) of Arctic Char captured in Camp Lake, 2006-2008.

Statistic	2006			2007			2008			All Years		
	Males	Females	All	Males	Females	All	Males	Females	All	Males	Females	All
n	11	9	20	3	3	91	9	2	22	23	14	133
Mean	823	139	515	275	342	435	1450	625	876	997	252	520
Median	200	150	150	325	400	350	750	625	463	375	150	350
SD	1512	69	1152	109	146	509	1705	460	1181	1506	234	785
SE	456	23	258	63	85	53	568	325	252	314	62	68
Minimum	50	75	50	150	175	25	375	300	200	50	75	25
Maximum	4900	300	4900	350	450	3050	5600	950	5600	5600	950	5600
95^{th} Percentile	3650	240	2525	348	445	1475	4320	918	2368	4650	625	1965
COV (%)	184	49	224	40	43	117	118	74	135	151	93	151

Table 4-10. Summary statistics for weights (g) of Arctic Char captured during backpack electrofishing (EF) and gillnetting surveys in Sheardown Lake, 2006-2008.

Statistic	2006			2007				2008				All Years			
	Gillnetting			EF	Gillnetting			EF	Gillnetting			EF	Gillnetting		
	Males	Females	All		Males	Females	All		Males	Females	All		Males	Females	All
n	6	2	8	230	12	15	116	36	27	8	68	266	45	25	192
Mean	479	600	509	7	435	396	494	9	698	591	604	7	599	475	533
Median	200	600	225	4	400	350	425	8	675	575	538	4	525	425	500
SD	711	566	640	9	218	209	317	6	249	101	209	8	348	227	306
SE	290	400	226	1	63	54	29	1	48	36	25	1	52	45	22
Minimum	50	200	50	1	150	125	50	1	475	450	250	1	50	125	50
Maximum	1900	1000	1900	59	1000	950	1800	28	1750	725	1750	59	1900	1000	1900
95th Percentile	1538	1900	1585	27	780	828	1119	20	948	716	850	26	998	915	1086
COV (%)	148	94	126	123	50	53	64	70	36	17	35	115	58	48	57

Table 4-11. Summary statistics for weights (g) of Arctic Char captured in standard index gill nets set in the north and south basins of Mary Lake, 2006-2007.

Statistic	South Basin									North Basin
	2006			2007			All Years			2007
	Males	Females	All	Males	Females	All	Males	Females	All	
n	26	33	62	14	12	161	40	45	223	98
Mean	736	639	743	534	467	548	665	593	602	493
Median	600	525	600	513	475	525	575	450	525	500
SD	596	600	709	329	132	344	523	522	481	125
SE	117	104	90	88	38	27	83	78	32	13
Minimum	25	75	25	125	175	75	25	75	25	75
Maximum	2350	2450	3300	1425	700	3050	2350	2450	3300	850
95th Percentile	1825	2060	2348	1019	645	825	1630	1780	1590	679
COV (%)	81	94	95	62	28	63	79	88	80	25

Table 4-12. Comparison of Arctic Char weights between sexes and years. Data represent fish captured during backpack electrofishing (EF) and index gillnetting (GN) surveys in study area lakes, 2006-2008. Values in red indicate significant difference at $p < 0.05$.

Lake	Comparison			P value[1]
	Dataset 1	Dataset 2	Dataset 3	
Camp Lake	2006 GN Males	2006 GN Females	-	**< 0.01**
	2007 GN Males	2007 GN Females	-	0.32
	2008 GN Males	2008 GN Females	-	**0.02**
	All Years Males	All Years Females	-	**0.01**
	2006 GN Males	2007 GN Males	2008 GN Males	**< 0.01**
	2006 GN Females	2007 GN Females	2008 GN Females	**< 0.01**
	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	0.34
Sheardown Lake	2006 GN Males	2006 GN Females	-	0.55
	2007 GN Males	2007 GN Females	-	0.76
	2008 GN Males	2008 GN Females	-	0.29
	All Years GN Males	All Years GN Females	-	0.40
	2006 GN Males	2007 GN Males	2008 GN Males	0.42
	2006 GN Females	2007 GN Females	2008 GN Females	0.28
	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	0.92
	2007 EF All Fish	2008 EF All Fish	-	0.77
Mary Lake - S	2006 GN Males	2006 GN Females	-	0.95
	2007 GN Males	2007 GN Females	-	0.42
	All Years Males	All Years Females	-	0.85
	2006 GN Males	2007 GN Males	-	0.33
	2006 GN Females	2007 GN Females	-	0.12
	2006 GN All Fish	2007 GN All Fish	-	0.31

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-13. Inter-lake comparisons of weights (g) of Arctic Char captured during index gillnetting surveys, 2006-2008.

Comparison				P value[1]
Dataset 1	Dataset 2	Dataset 3	Dataset 4	
Camp L. 2006 GN	Sheardown L. 2006 GN	Mary L – S 2006 GN	-	0.71
Camp L. 2007 GN	Sheardown L. 2007 GN	Mary L – S 2007 GN	Mary L – N 2007 GN	0.91
Camp L. 2008 GN	Sheardown L. 2008 GN	-	-	0.14
Camp L. All GN	Sheardown L. All GN	Mary L – S All GN	Mary L – N All GN	0.67

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-14. Summary statistics for condition factors of Arctic Char captured in standard index gill nets set in Camp Lake, 2006-2008.

Statistic	2006			2007			2008			All Years		
	Males	Females	All	Males	Females	All	Males	Females	All	Males	Females	All
n	11	9	20	3	3	91	9	2	22	23	14	133
Mean	1.00	1.10	1.04	1.06	0.91	0.96	1.03	0.92	1.02	1.02	1.03	0.99
Median	1.01	1.06	1.02	1.04	0.90	0.98	1.01	0.92	0.95	1.01	1.01	0.99
SD	0.13	0.15	0.14	0.08	0.12	0.19	0.16	0.04	0.23	0.14	0.16	0.19
SE	0.04	0.05	0.03	0.05	0.07	0.02	0.05	0.03	0.05	0.03	0.04	0.02
Minimum	0.84	0.89	0.84	1.00	0.80	0.47	0.86	0.89	0.82	0.84	0.80	0.47
Maximum	1.23	1.35	1.35	1.15	1.04	1.43	1.35	0.95	1.67	1.35	1.35	1.67
95th Percentile	1.19	1.32	1.27	1.14	1.02	1.23	1.30	0.95	1.51	1.23	1.29	1.28
COV (%)	12.77	13.39	13.69	7.62	13.11	19.45	15.93	4.66	22.03	13.28	15.00	19.25

Table 4-15. Summary statistics for condition factors of Arctic Char captured during backpack electrofishing (EF) and gillnetting surveys in Sheardown Lake, 2006-2008.

Statistic	2006			2007				2008				All Years			
	Gillnetting			EF	Gillnetting			EF	Gillnetting			EF	Gillnetting		
	Males	Females	All		Males	Females	All		Males	Females	All		Males	Females	All
n	6	2	8	230	12	15	116	36	27	8	68	266	45	25	192
Mean	0.91	0.87	0.90	0.98	0.82	0.86	0.85	1.21	1.04	1.05	1.02	1.01	0.97	0.92	0.91
Median	0.89	0.87	0.87	1.02	0.80	0.90	0.87	1.13	1.03	1.02	1.01	1.02	0.98	0.93	0.93
SD	0.08	0.00	0.07	0.24	0.07	0.11	0.13	0.29	0.09	0.11	0.13	0.26	0.13	0.13	0.15
SE	0.03	0.00	0.02	0.02	0.02	0.03	0.01	0.05	0.02	0.04	0.02	0.02	0.02	0.03	0.01
Minimum	0.83	0.87	0.83	0.44	0.70	0.59	0.54	0.72	0.86	0.93	0.49	0.44	0.70	0.59	0.49
Maximum	1.02	0.88	1.02	2.04	0.93	0.98	1.16	2.02	1.24	1.22	1.51	2.04	1.24	1.22	1.51
95th Percentile	1.01	0.88	1.00	1.36	0.93	0.96	1.05	1.80	1.19	1.21	1.21	1.40	1.17	1.16	1.16
COV (%)	8.37	0.28	7.37	24.04	8.65	12.62	15.06	23.98	8.75	10.35	12.86	25.30	13.37	14.69	16.29

Table 4-16. Summary statistics for condition factors of Arctic Char captured in standard index gill nets set in the north and south basins of Mary Lake, 2006-2007.

Statistic	South Basin									North Basin
	2006			2007			All Years			2007
	Males	Females	All	Males	Females	All	Males	Females	All	
n	26	33	62	14	12	161	40	45	223	98
Mean	1.03	1.00	1.01	0.85	0.86	0.88	0.96	0.96	0.92	0.90
Median	1.02	0.99	0.99	0.86	0.87	0.88	0.88	0.96	0.90	0.91
SD	0.27	0.16	0.21	0.08	0.08	0.11	0.24	0.16	0.16	0.13
SE	0.05	0.03	0.03	0.02	0.02	0.01	0.04	0.02	0.01	0.01
Minimum	0.56	0.77	0.56	0.66	0.71	0.60	0.56	0.71	0.56	0.60
Maximum	1.93	1.64	1.93	1.01	0.98	1.41	1.93	1.64	1.93	1.20
95^{th} Percentile	1.46	1.23	1.39	0.97	0.97	1.04	1.41	1.21	1.15	1.11
COV (%)	26.24	16.42	20.97	9.87	9.08	12.37	24.64	16.45	16.96	14.94

Table 4-17. Comparison of Arctic Char condition factors between sexes and years. Data represent fish captured during backpack electrofishing (EF) and index gillnetting (GN) surveys in study area lakes, 2006-2008. Values in red indicate significant difference at $p < 0.05$.

Lake	Comparison			P value[1]
	Dataset 1	Dataset 2	Dataset 3	
Camp Lake	2006 GN Males	2006 GN Females	-	0.44
	2007 GN Males	2007 GN Females	-	0.38
	2008 GN Males	2008 GN Females	-	0.29
	All Years Males	All Years Females	-	0.79
	2006 GN Males	2007 GN Males	2008 GN Males	0.86
	2006 GN Females	2007 GN Females	2008 GN Females	0.42
	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	0.85
Sheardown Lake	2006 GN Males	2006 GN Females	-	**< 0.01**
	2007 GN Males	2007 GN Females	-	0.60
	2008 GN Males	2008 GN Females	-	0.85
	All Years GN Males	All Years GN Females	-	0.69
	2006 GN Males	2007 GN Males	2008 GN Males	**< 0.01**
	2006 GN Females	2007 GN Females	2008 GN Females	0.19
	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	0.67
	2007 EF All Fish	2008 EF All Fish	-	0.49
Mary Lake - S	2006 GN Males	2006 GN Females	-	0.95
	2007 GN Males	2007 GN Females	-	0.42
	All Years Males	All Years Females	-	0.85
	2006 GN Males	2007 GN Males	-	0.33
	2006 GN Females	2007 GN Females	-	0.12
	2006 GN All Fish	2007 GN All Fish	-	0.31

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-18. Inter-lake comparisons of condition factors of Arctic Char captured during index gillnetting surveys, 2006-2008.

Comparison				P value[1]
Dataset 1	**Dataset 2**	**Dataset 3**	**Dataset 4**	
Camp L. 2006 GN	Sheardown L. 2006 GN	Mary L – S 2006 GN	-	0.51
Camp L. 2007 GN	Sheardown L. 2007 GN	Mary L – S 2007 GN	Mary L – N 2007 GN	0.84
Camp L. 2008 GN	Sheardown L. 2008 GN	-	-	0.63
Camp L. All GN	Sheardown L. All GN	Mary L – S All GN	Mary L – N All GN	0.85

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-19. Summary statistics for catch-per-unit-effort (#fish/24 hours/100 m net) of Arctic Char captured in standard index gill nets deployed in Mine Area lakes, 2006-2008.

Statistic	Camp Lake				Sheardown Lake				Mary Lake – South Basin			Mary Lake – North Basin
	2006	2007	2008	All	2006	2007	2008	All	2006	2007	All	Males
n	2	21	14	36	1	14	8	23	2	24	26	8
Mean	13.4	41.8	10.1	29.0	13.8	92.8	57.8	77.2	27.1	73.4	69.9	175.2
Median	13.4	34.9	10.0	18.0	-	55.6	41.8	53.9	27.1	66.2	64.4	169.1
SD	5.0	37.5	8.4	32.6	-	86.3	64.0	78.6	12.4	55.5	54.7	59.8
SE	3.5	8.2	2.2	5.4	-	23.1	22.6	16.4	8.7	11.3	10.7	21.1
Minimum	9.9	0.0	0.0	0.0	13.8	0.0	0.0	0.0	18.4	0.0	0.0	78.8
Maximum	16.9	157.2	22.9	157.2	13.8	314.4	189.9	314.4	35.9	216.7	216.7	286.3
95th Percentile	16.5	99.8	21.4	86.1	-	219.0	158.3	187.6	35.0	159.9	159.2	259.7
COV (%)	37.1	89.7	83.2	112.4	-	93.0	110.8	101.9	45.6	75.6	78.3	34.1

Table 4-20. Comparison of catch-per-unit-effort (#fish/24 hours/100 m net) of Arctic Char between years. Data represent fish captured during backpack electrofishing (EF) and index gillnetting (GN) surveys in study area lakes, 2006-2008. Values in red indicate significant difference at p < 0.05.

Lake	Comparison			P value[1]
	Dataset 1	Dataset 2	Dataset 3	
Camp Lake	2006 GN All Fish	2007 GN All Fish	2008 GN All Fish	**< 0.01**
Sheardown Lake	2007 GN All Fish	2008 GN All Fish	-	0.23
	2007 EF All Fish	2008 EF All Fish	-	**< 0.01**
Mary Lake - S	2006 GN All Fish	2007 GN All Fish	-	**< 0.01**

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-21. Inter-lake comparisons of catch-per-unit-effort (#fish/24 hours/100 m net) of Arctic Char captured during index gillnetting surveys, 2006-2008. Values in red indicate significant difference at p < 0.05.

Comparison				P value[1]
Dataset 1	Dataset 2	Dataset 3	Dataset 4	
Camp L. 2006 GN	Mary L – S 2006 GN	-	-	**< 0.01**
Camp L. 2007 GN	Sheardown L. 2007 GN	Mary L – S 2007 GN	Mary L – N 2007 GN	**0.02**
Camp L. 2008 GN	Sheardown L. 2008 GN	-	-	**< 0.01**
Camp L. All GN	Sheardown L. All GN	Mary L – S All GN	Mary L – N All GN	**0.01**

[1]Differences between two groups tested with a Kruskal-Wallis test at alpha = 0.05.

Table 4-22. Summary statistics for age of Arctic Char captured during standard index gillnetting and backpack electrofishing surveys in selected mine area lakes and in the Mary River, 2006-2008.

Statistic	Camp Lake	Sheardown Lake	Mary Lake	Mary River	All Waterbodies
n	28	35	97	29	189
Mean	9.5	13.3	13.2	2.6	11.1
Median	9	13	13	2	11
SD	3.7	4.5	3.6	0.9	5.2
SE	0.7	0.8	0.4	0.2	0.4
Minimum	4	5	7	2	2
Maximum	19	22	24	5	24
95^{th} Percentile	16.7	21	19.4	4.6	19
COV (%)	39.2	33.8	27.5	33.5	47.3

Table 4-23. Length and weight-at-age for Arctic Char pooled from all Study Area waterbodies, 2006-2008.

Age	Fork Length (mm)				Weight (g)			
	n	Mean	SD	Range	n	Mean	SD	Range
2	17	88	12	63 - 108	17	10	4	4 - 18
3	9	106	13	86 - 128	9	17	7	7 - 28
4	2	179	69	130 - 228	2	92	82	33 - 150
5	5	189	44	149 - 240	4	92	53	44 - 150
6	4	186	13	170 - 197	4	69	24	50 - 100
7	7	228	46	171 - 301	7	125	76	50 - 275
8	9	246	59	172 - 331	9	178	90	75 - 300
9	15	273	48	192 - 351	15	210	111	75 - 450
10	14	294	78	167 - 496	14	300	306	50 - 1300
11	19	337	63	181 - 465	19	400	230	75 - 1100
12	12	364	39	312 - 451	12	473	154	275 - 800
13	13	398	107	241 - 658	13	685	625	100 - 2450
14	12	404	81	315 - 615	12	756	573	325 - 2300
15	11	390	17	370 - 418	11	525	51	450 - 600
16	16	404	43	357 - 490	16	608	232	350 - 1200
17	7	488	98	354 - 647	7	1114	691	350 - 2400
18	4	385	8	373 - 391	4	494	94	375 - 600
19	5	541	143	384 - 751	5	1985	1753	525 - 4900
20	0	-	-	-	-	-	-	-
21	3	440	62	387 - 508	3	608	163	450 - 775
22	1	507	-	-	1	1000	-	-
23	3	529	93	424 - 602	3	1408	610	725 - 1900
24	1	685	-	-	1	2350	-	-
Total	189	316	136	63 - 751	188	462	570	4 - 4900

Table 4-24. Results of Analysis of Covariance (ANCOVA) tests of length and weight-at-age for Arctic Char captured in Study Area waterbodies.

Statistic	Degrees of Freedom	R^2	Sum of Squares	Mean Squares	Pr > F[1]
Length	157	0.581	1544.568	772.284	< 0.0001
Weight	156	0.351	913.208	456.604	< 0.0001

[1] Fisher's F-test significance

Table 4-25. Results of power analyses for selected Arctic Char metrics for Sheardown Lake.

Effect Indicator	Metric	Effect Size	Sample Size @ β = 0.1
Growth	Age 0+ Length	10%	25
		20%	8
		25%	6
	Age 1+ Length	10%	11
		20%	4
		25%	3
	Age 1+ Weight	10%	250
		20%	62
		25%	42
Condition	Age 1+ Condition	10%	9
		20%	3
		25%	3

.

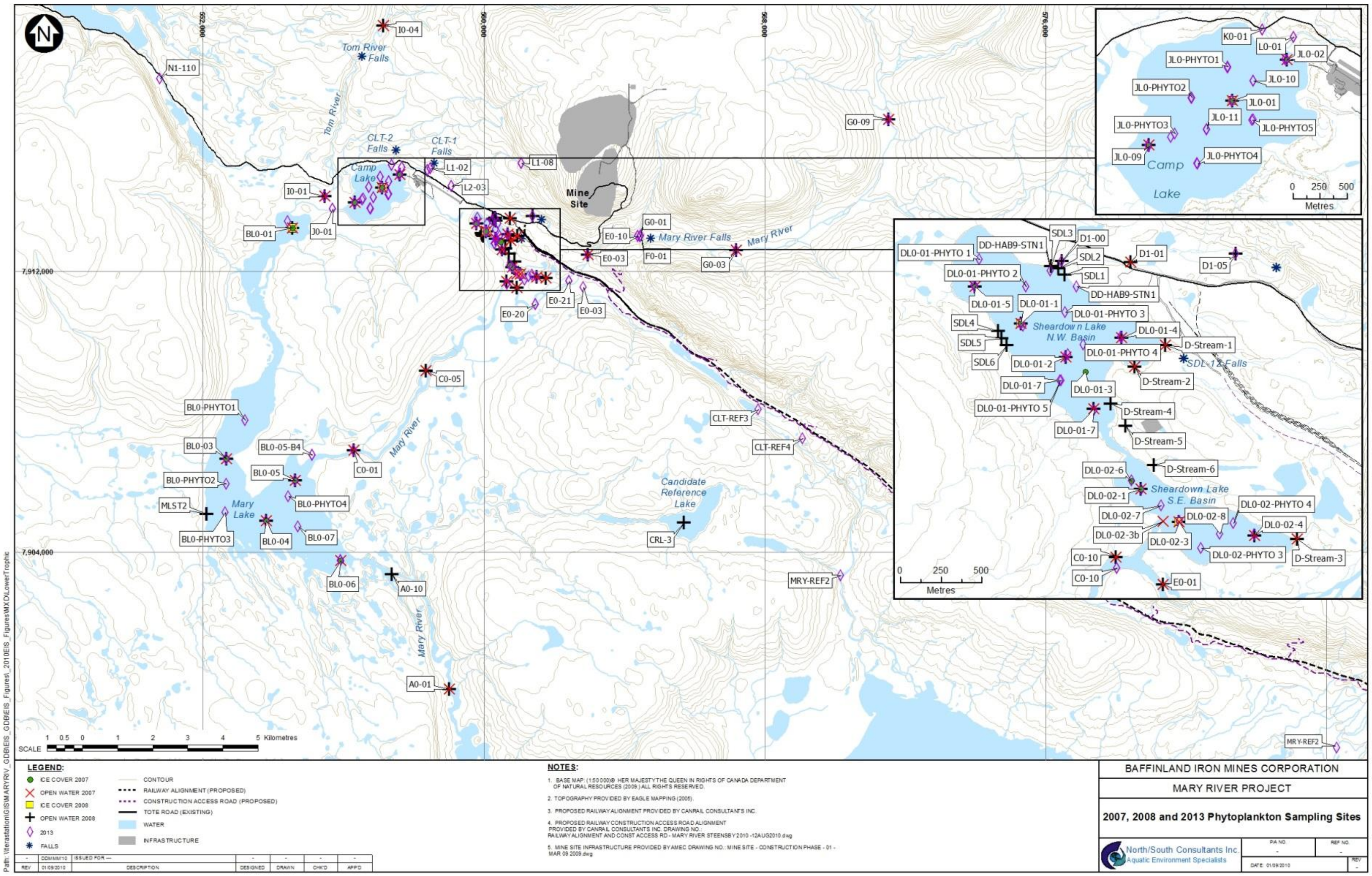
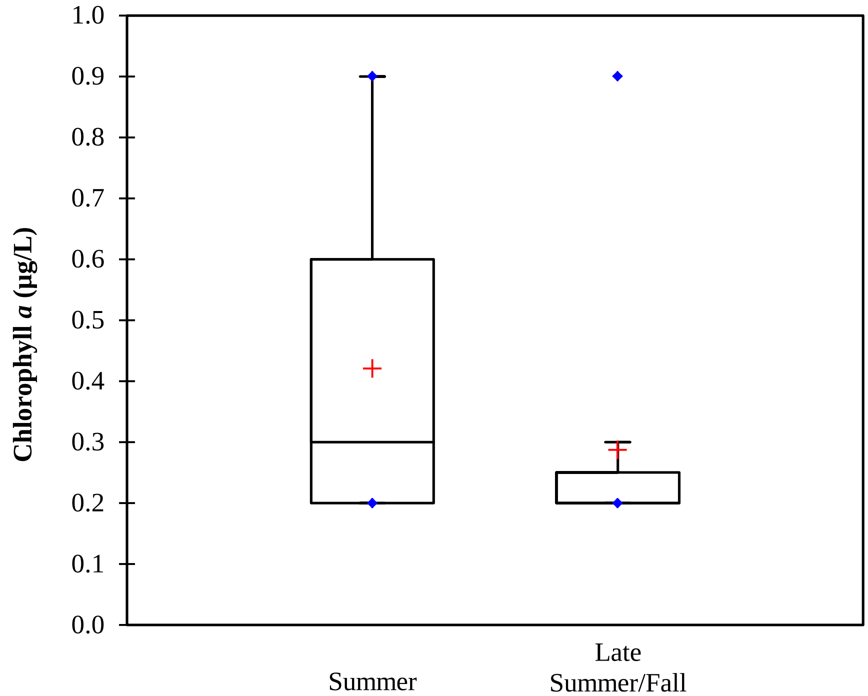


Figure 2-1. Locations of sites where phytoplankton taxonomy and biomass and/or chlorophyll *a* were measured in Mine Area lakes and streams: 2007-2013.

(A)



(B)

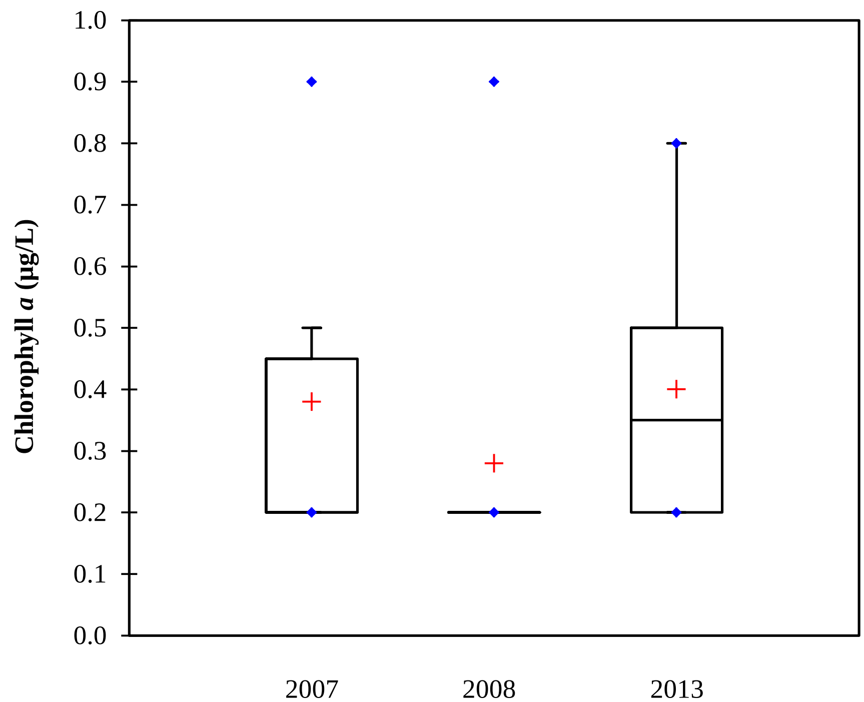
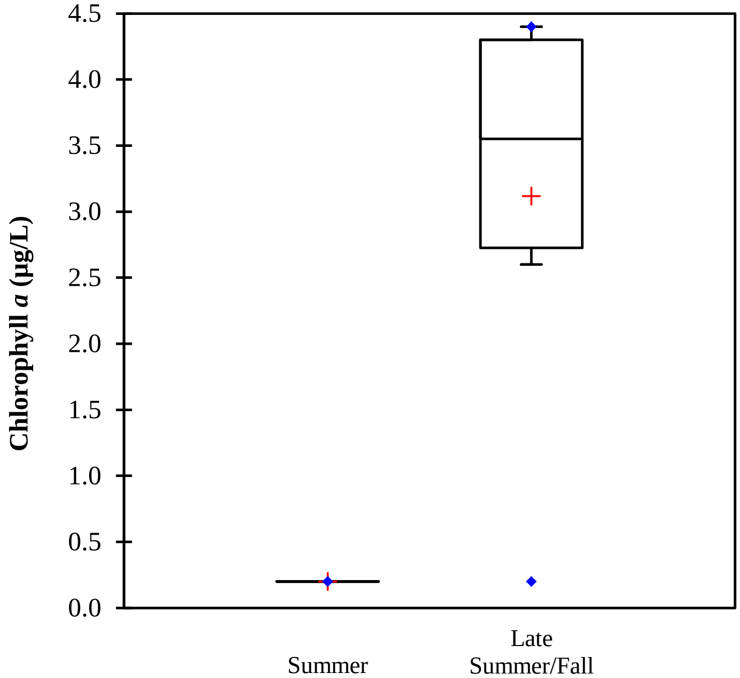


Figure 2-2. Box plots of chlorophyll *a* measured in Sheardown Lake NW by (A) sampling period and (B) sampling year. Data include offshore sampling measurements collected in summer and late summer/fall in 2007, 2008, and 2013.

(A)



(B)

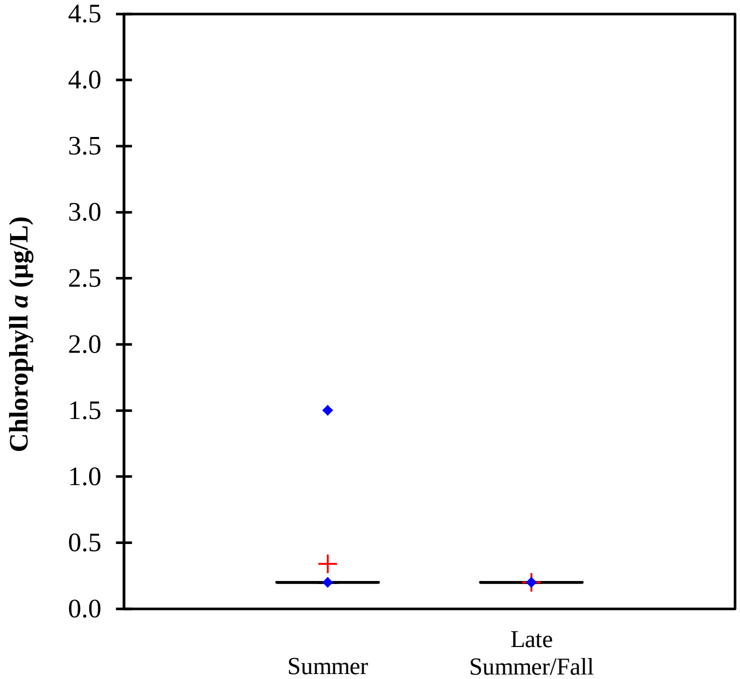


Figure 2-3. Comparisons of chlorophyll *a* measured in Sheardown Lake (A) nearshore sites and (B) offshore sites. Data include measurements collected in summer and late summer/fall in 2008.

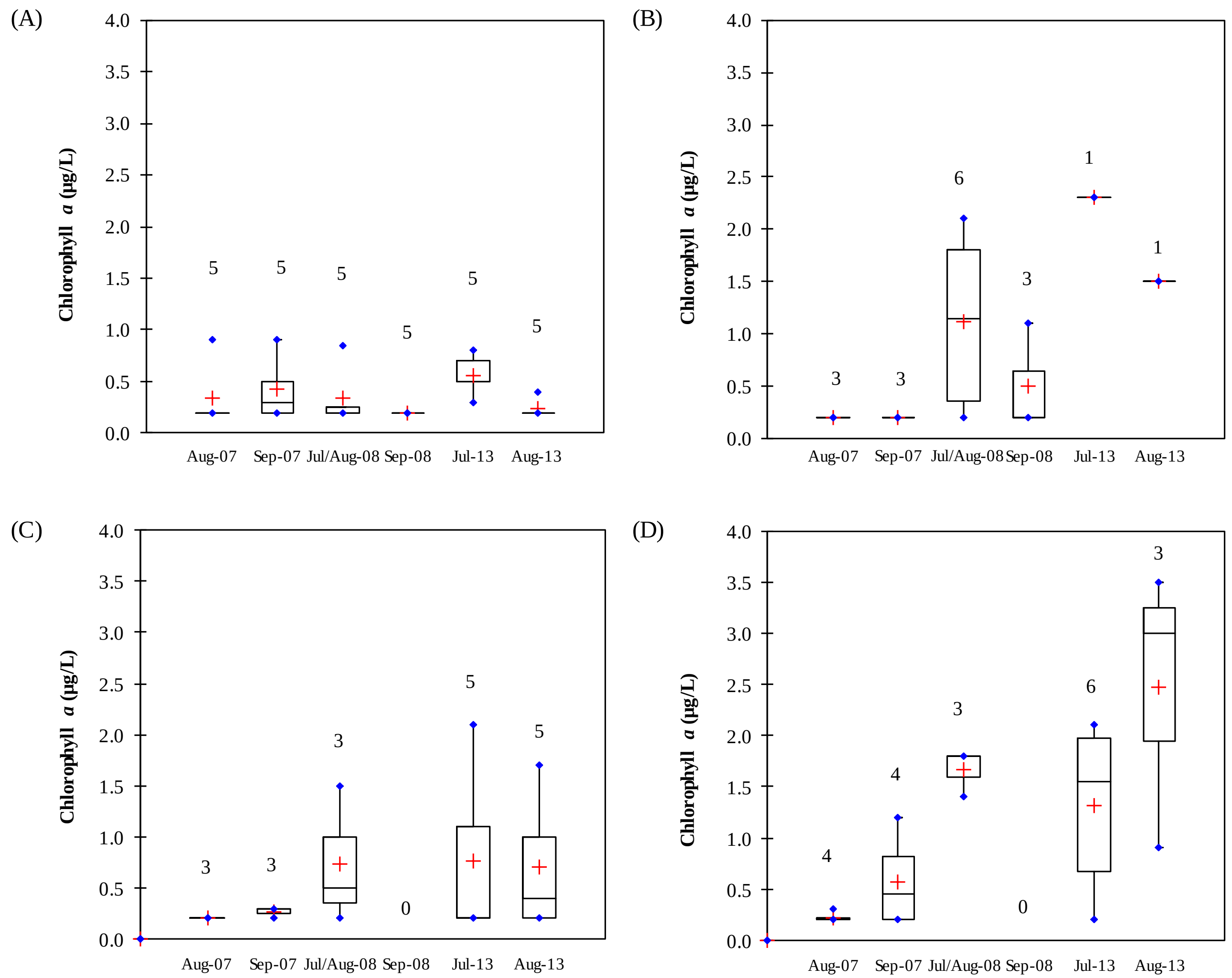


Figure 2-4. Comparisons of chlorophyll *a* measured in the open-water season of 2007, 2008, and 2013: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake. Where two samples were collected in summer 2008 (Sheardown Lake NW and SE), the data points were averaged to normalize sample sizes. Sample sizes are indicated above each box.

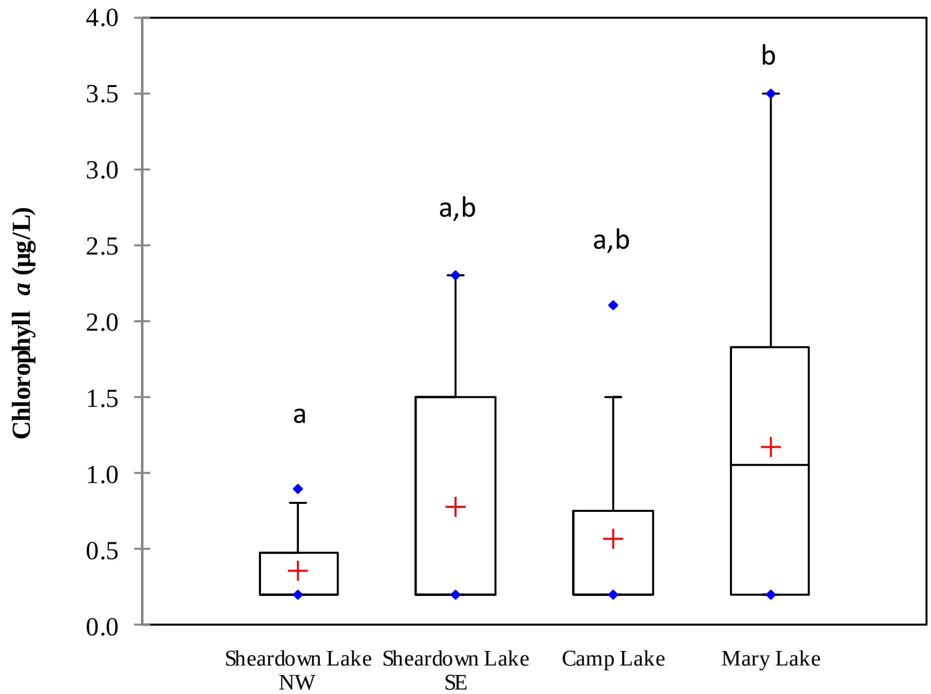


Figure 2-5. Chlorophyll *a* measured in Mine Area lakes: 2007-2013. Statistically significant spatial differences are denoted with different superscripts ($p < 0.05$).

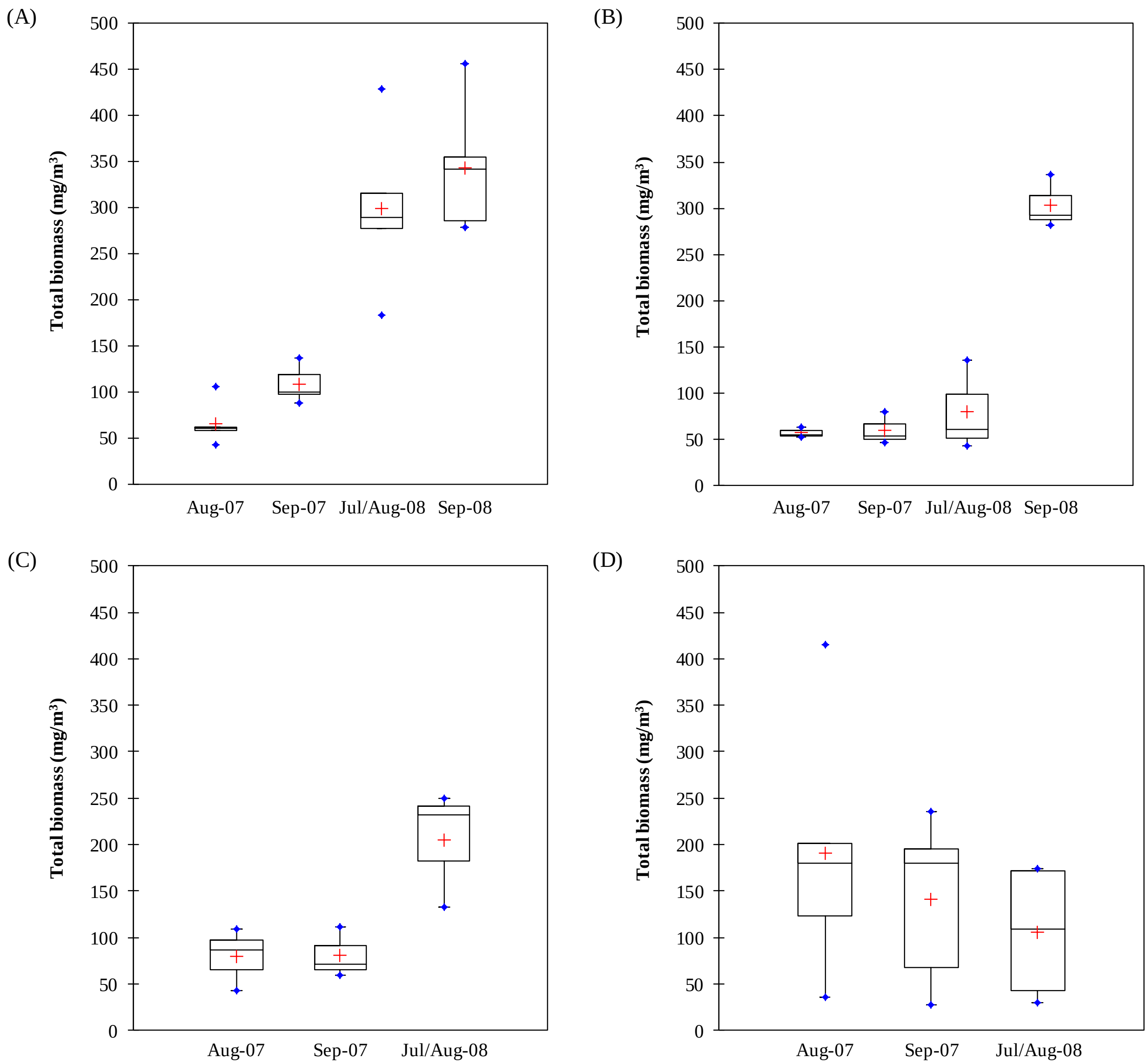


Figure 2-6. Total biomass of phytoplankton measured by sampling period in Mine Area lakes, 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

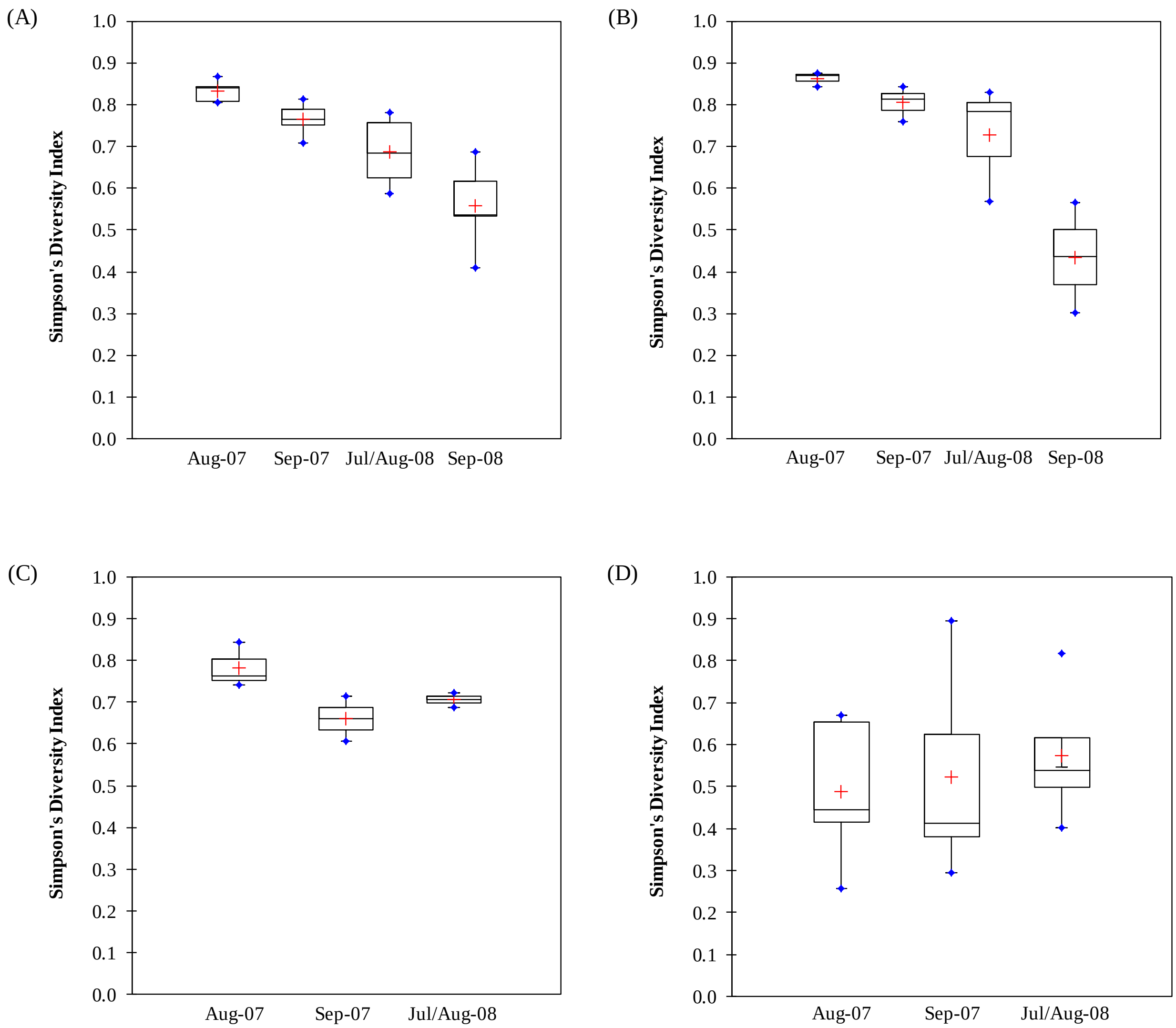


Figure 2-7. Phytoplankton Simpson's Diversity Index by sampling period in Mine Area lakes, 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

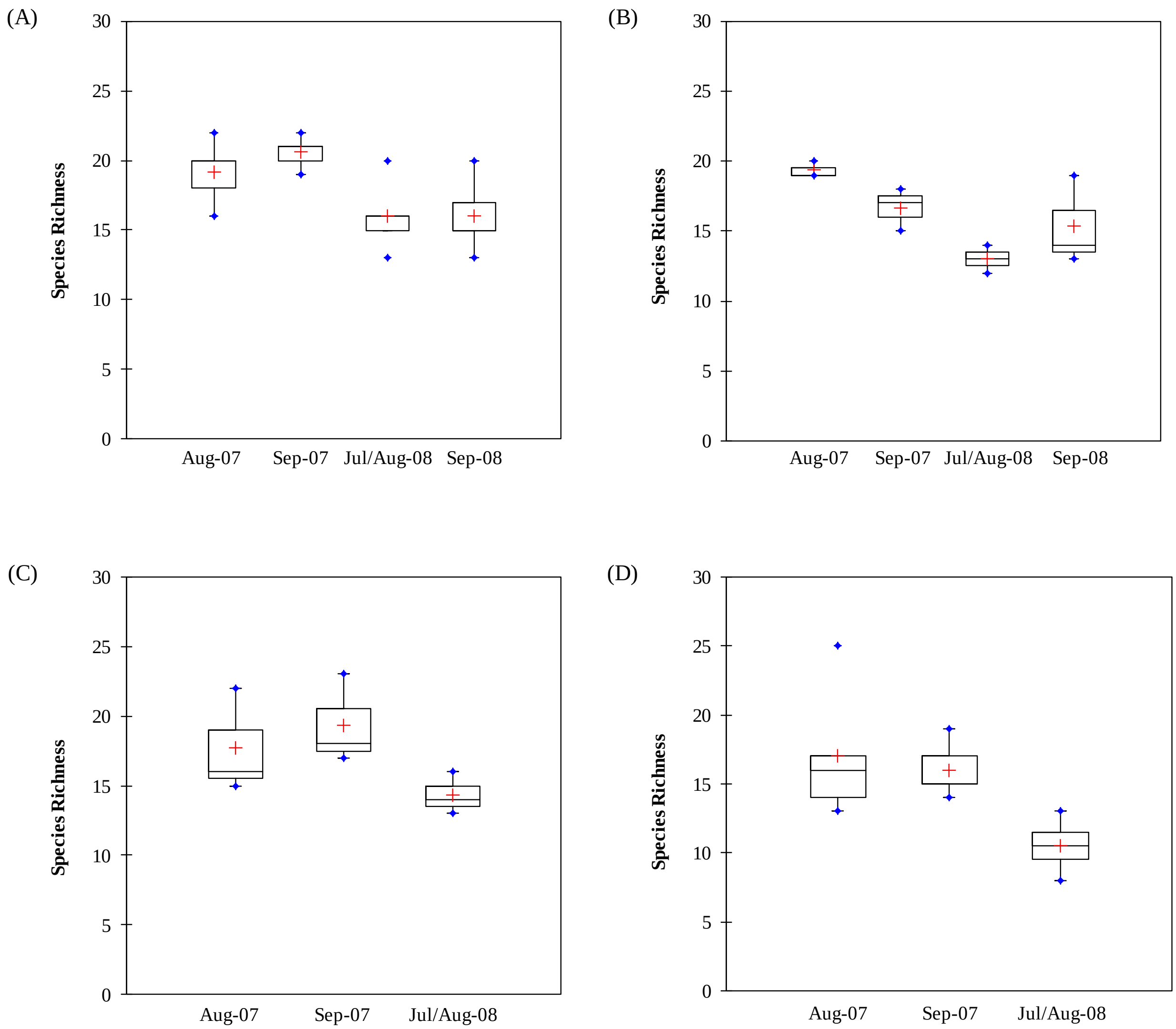


Figure 2-8. Phytoplankton species richness by sampling period in Mine Area lakes, 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

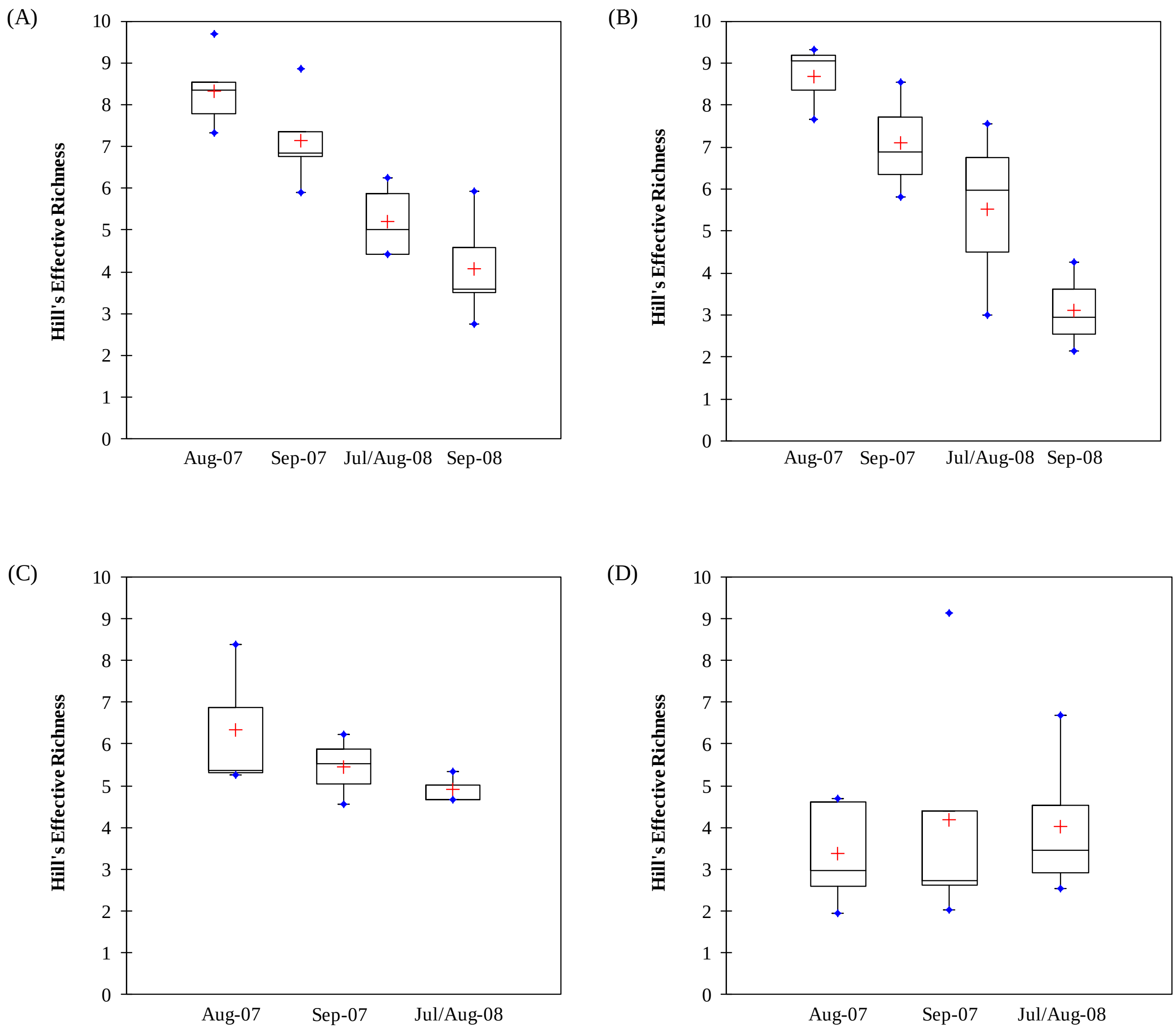


Figure 2-9. Phytoplankton Hill's effective richness by sampling period in Mine Area lakes, 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

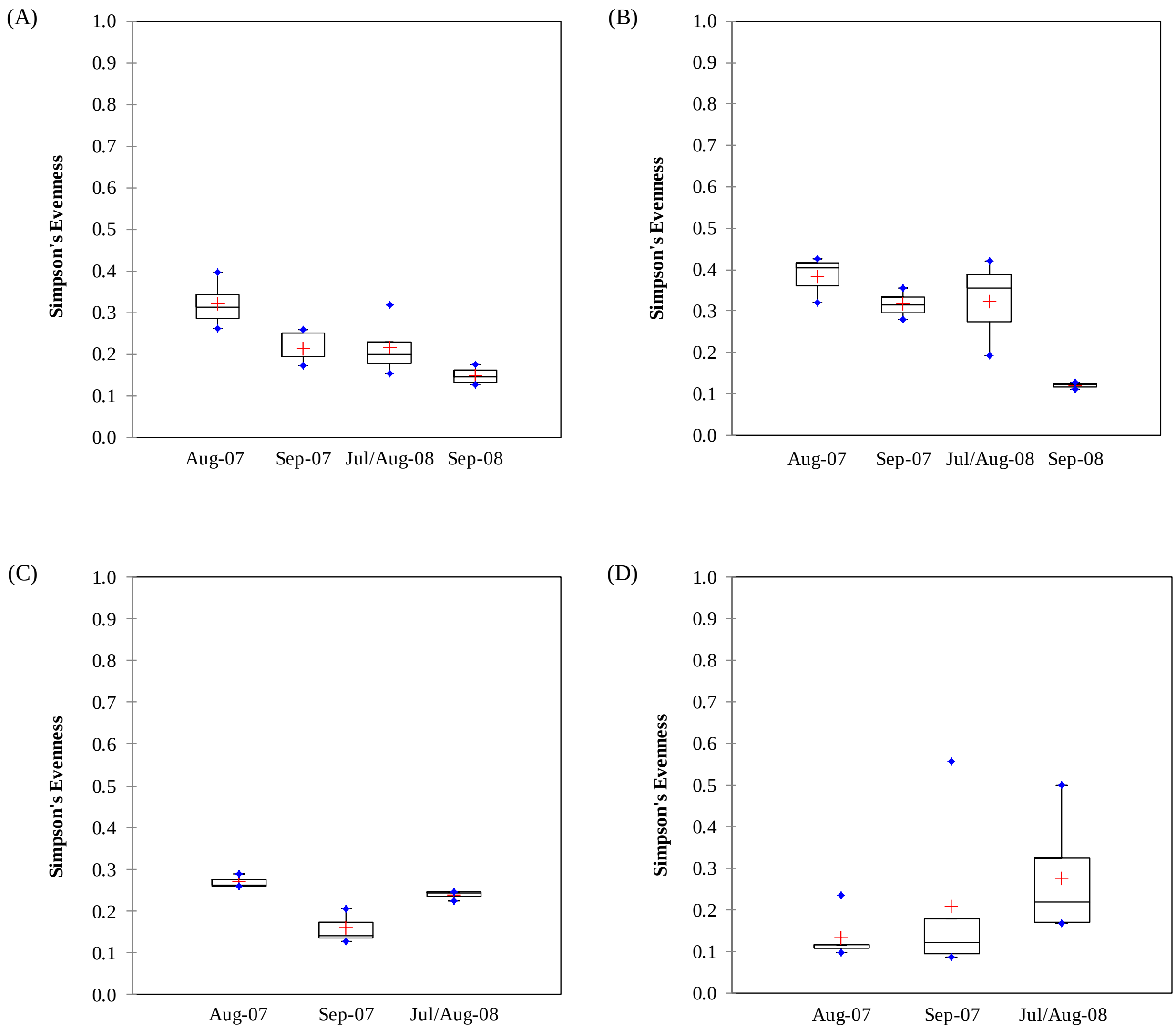


Figure 2-10. Phytoplankton Simpson’s evenness by sampling period in Mine Area lakes, 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

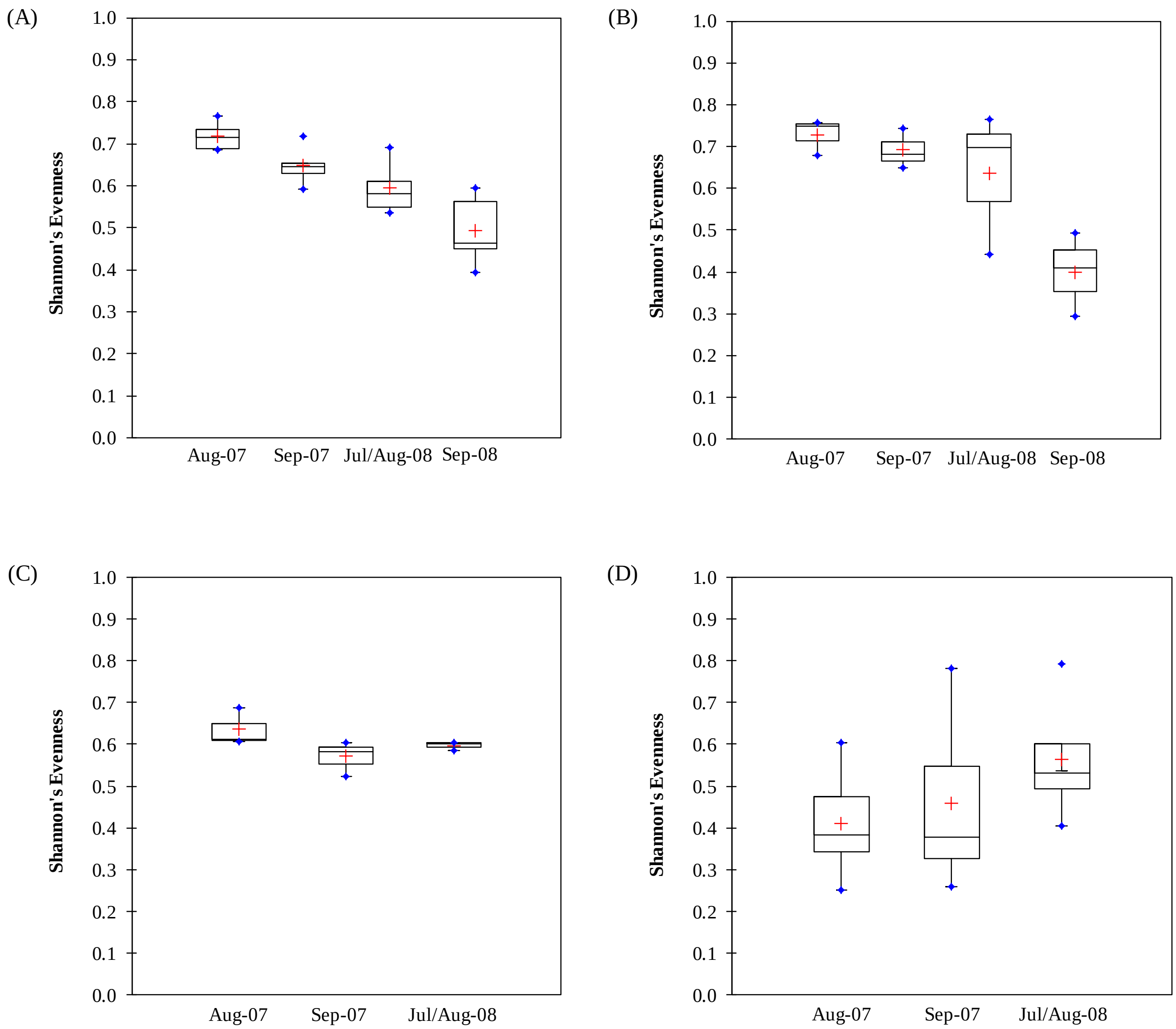


Figure 2-11. Shannon's evenness by sampling period in Mine Area lakes, 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

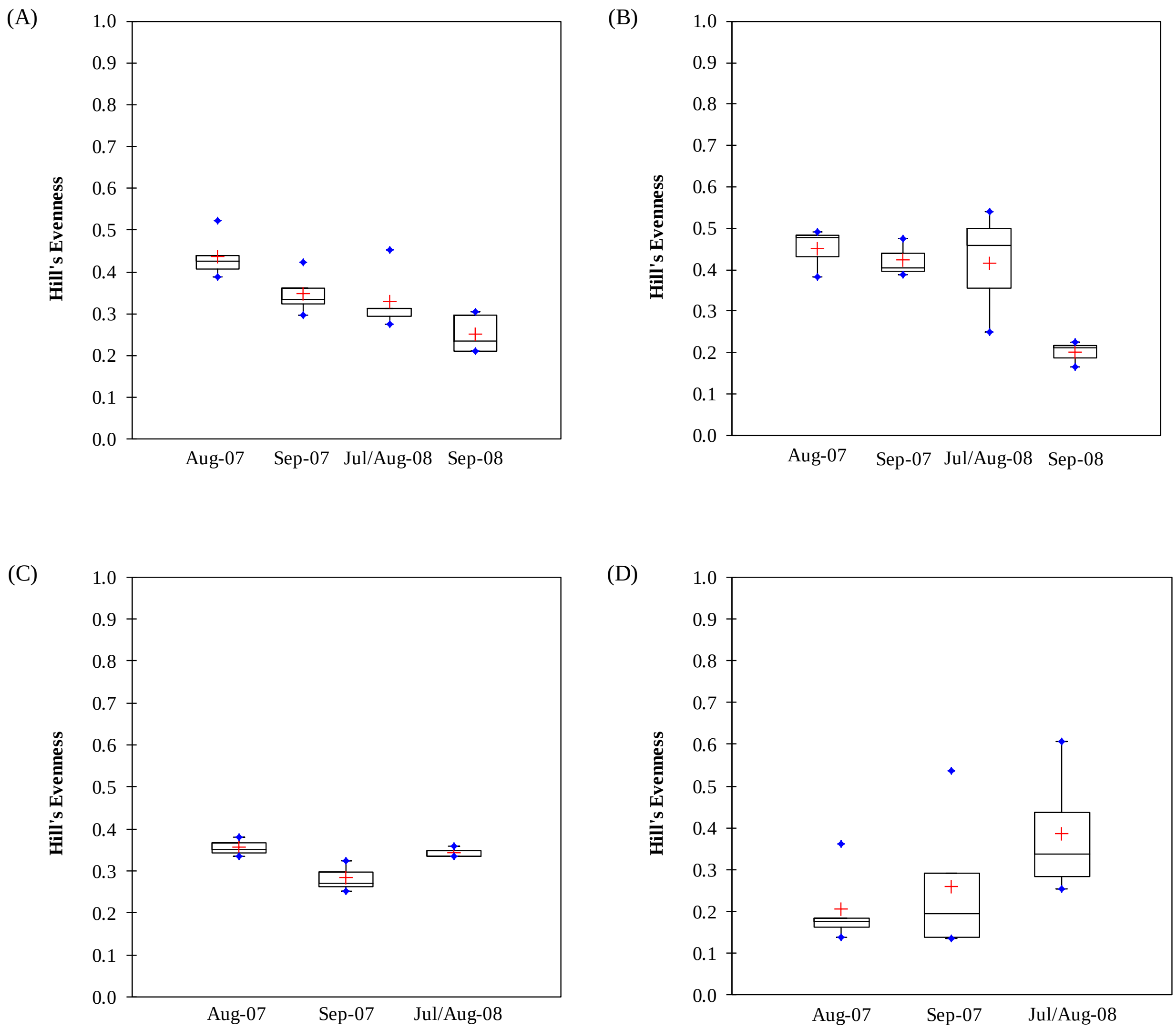


Figure 2-12. Phytoplankton Hill's evenness by sampling period in Mine Area lakes 2007-2008: (A) Sheardown Lake NW; (B) Sheardown Lake SE; (C) Camp Lake; and (D) Mary Lake.

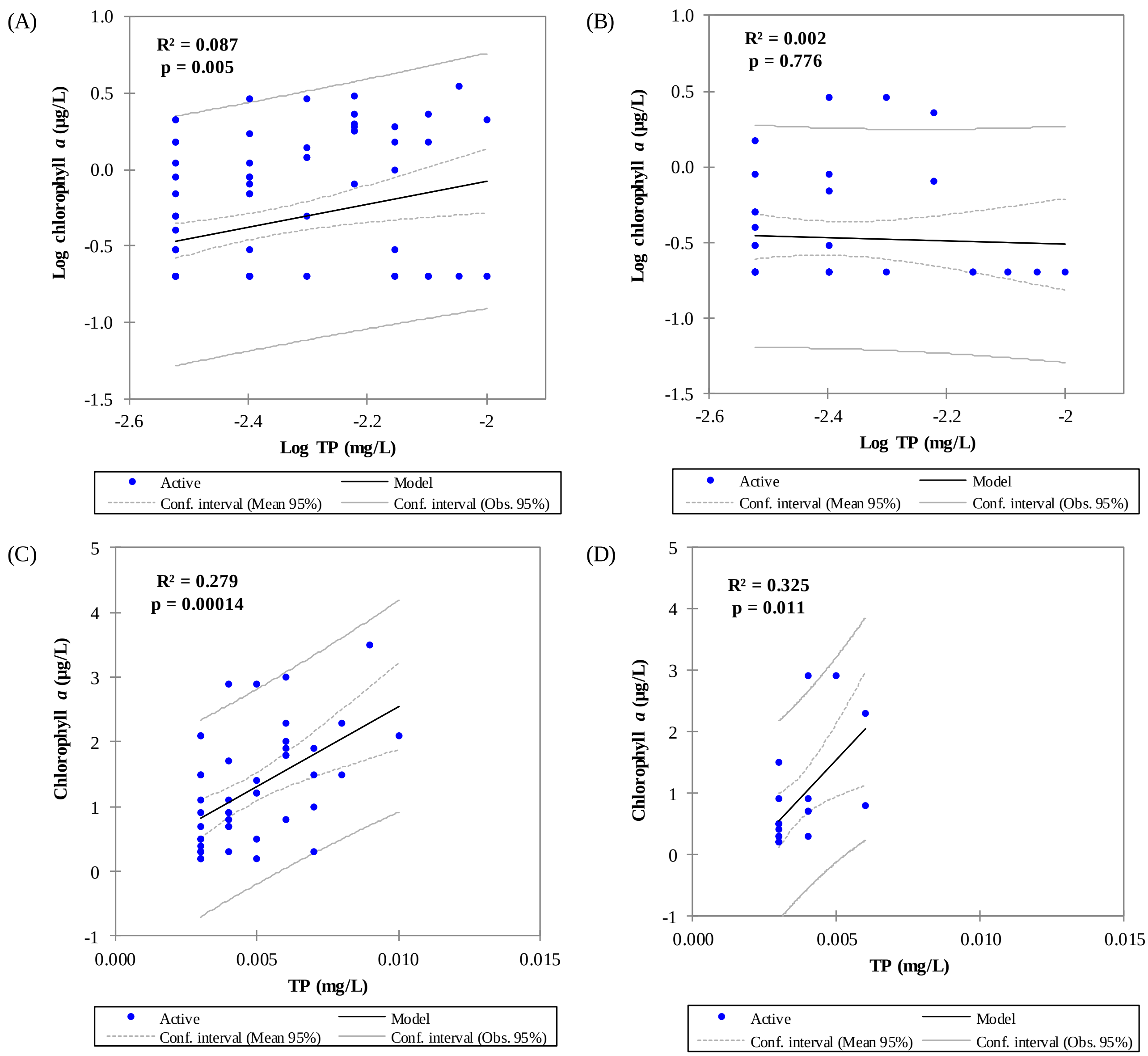


Figure 2-13. Linear regressions between total phosphorus (TP) and chlorophyll *a* (nearshore samples excluded) in Mine Area lakes. (A) and (B) present regressions for all lakes and Sheardown Lake NW, respectively, using all data points. (C) and (D) present regressions for all lakes and Sheardown Lake NW, respectively, using only chlorophyll *a* measurements that exceeded the analytical detection limits.

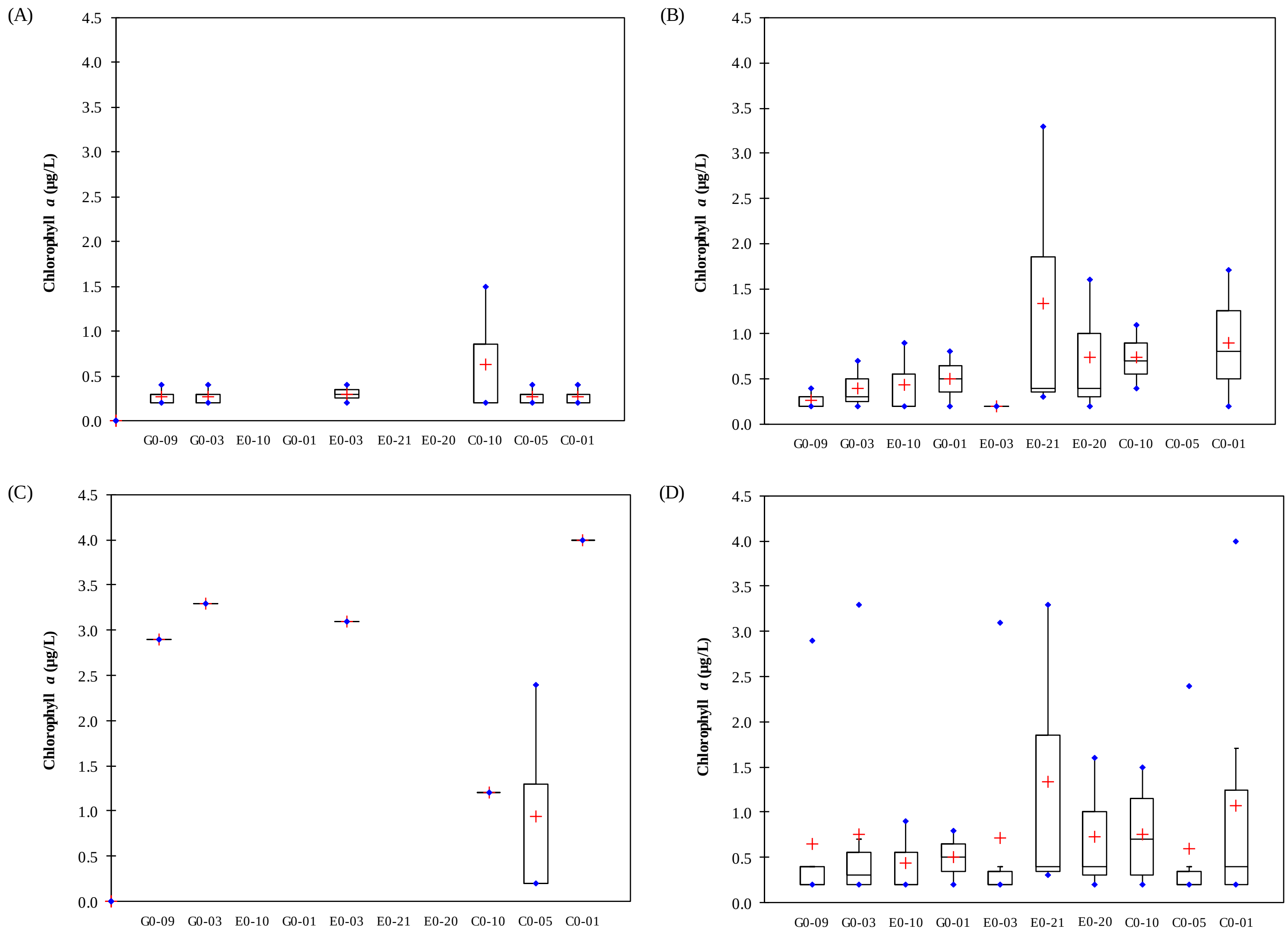


Figure 2-14. Chlorophyll *a* measured in the Mary River, 2007-2013: (A) 2007; (B) 2008; (C) 2013; and (D) all years combined.

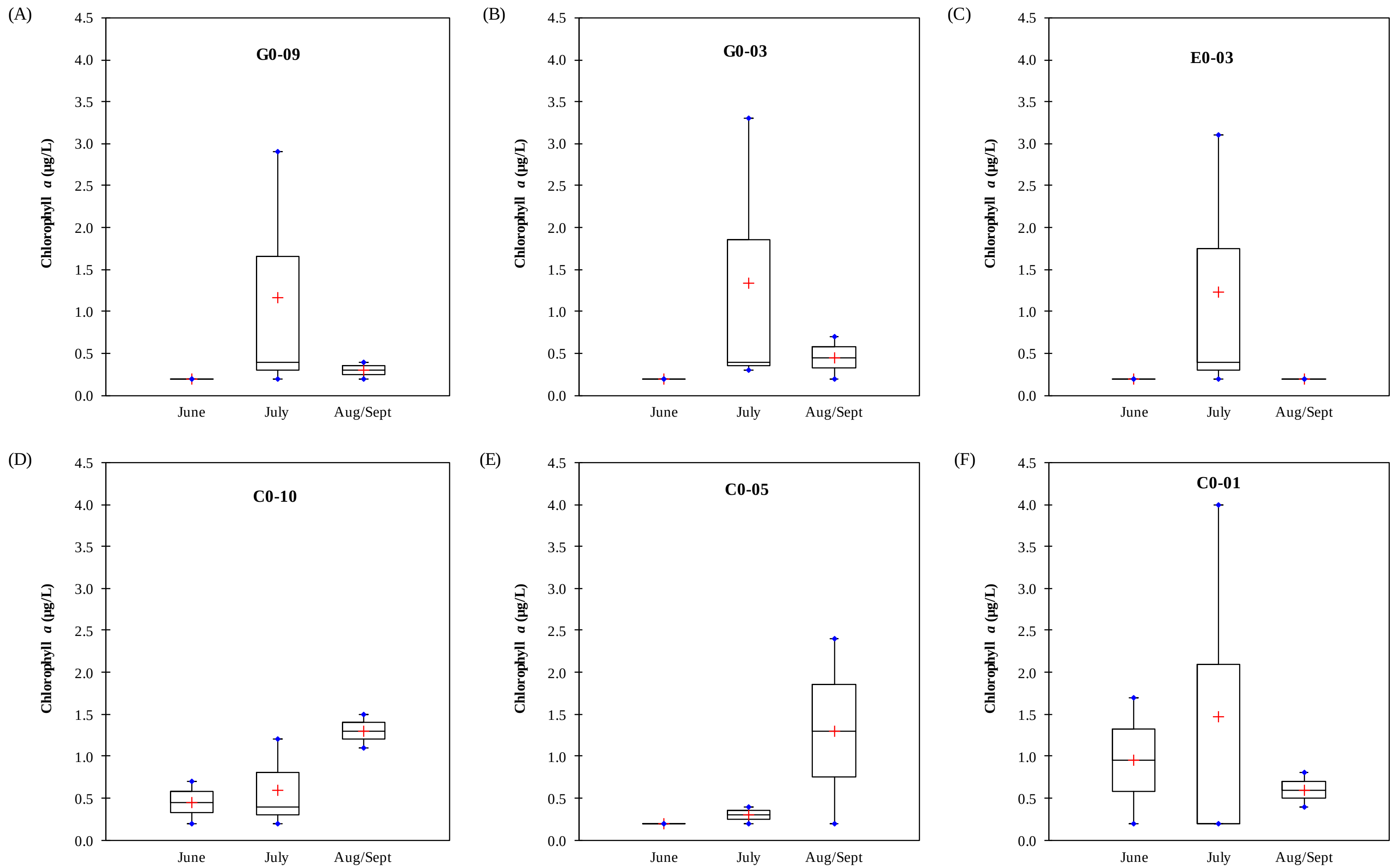
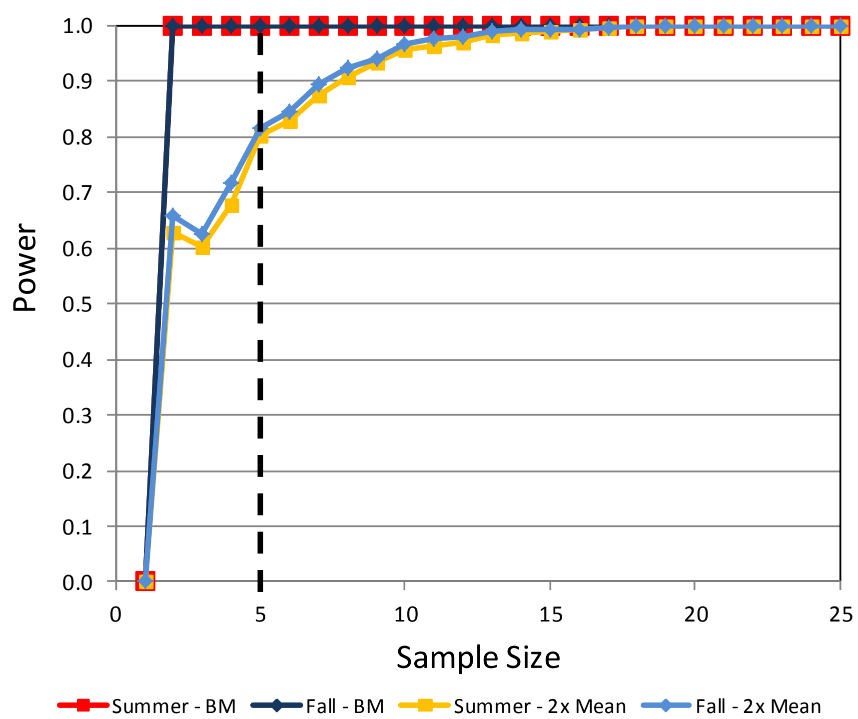


Figure 2-15. Seasonal boxplots of chlorophyll *a* measured at sites along the Mary River, 2007-2013: (A) G0-09; (B) G0-03; (C) E0-03; (D) C0-10; (E) C0-05; and (F) C0-01.

(A)



(B)

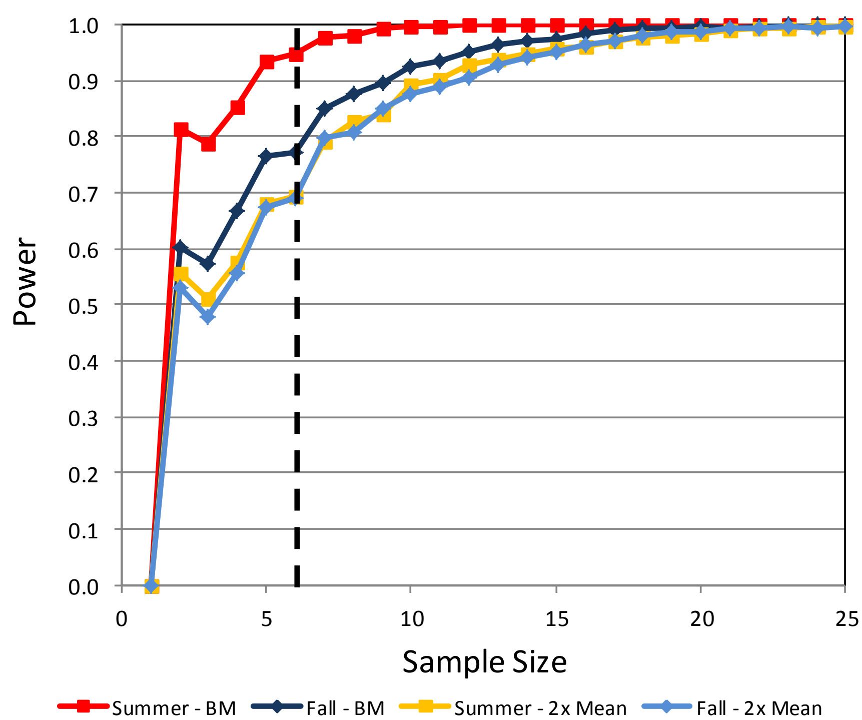


Figure 2-16. Results of *an priori* power analysis for chlorophyll *a* in (A) Sheardown Lake NW and (B) Mary Lake. BM = benchmark.

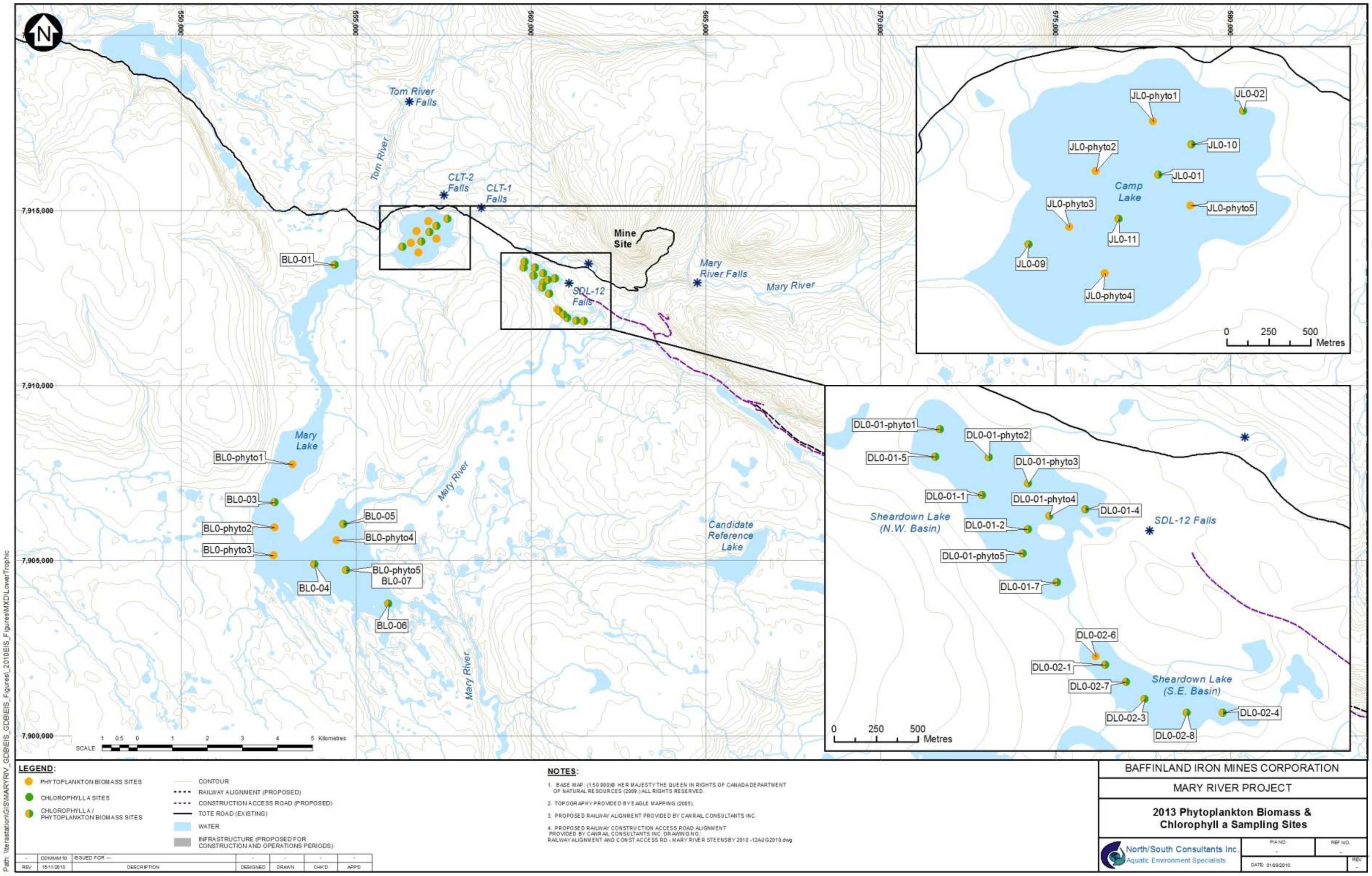


Figure 2-17. Locations of sites where phytoplankton taxonomy and biomass and/or chlorophyll *a* were measured in Mine Area lakes: 2013.

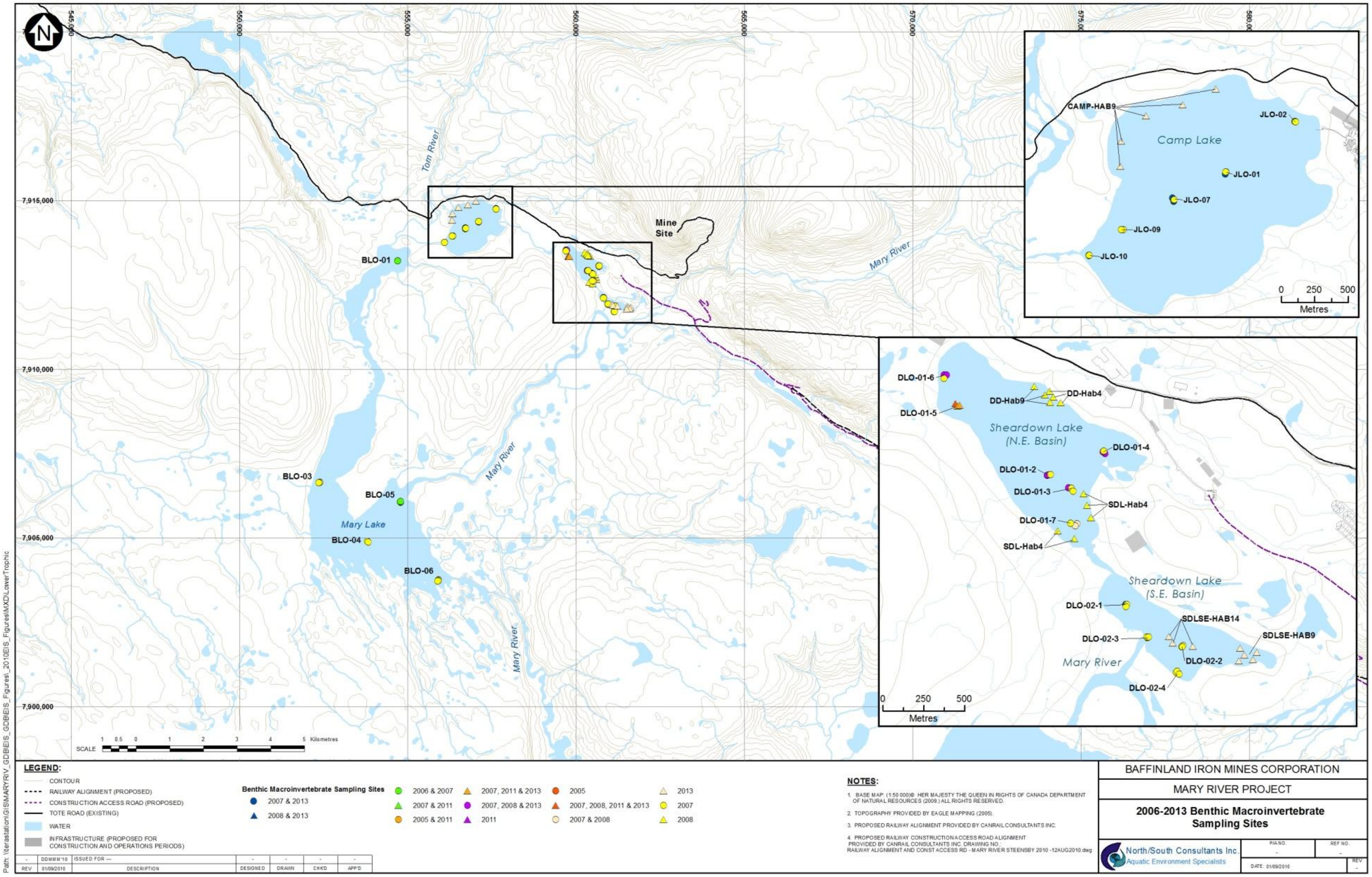


Figure 3-1. Benthic invertebrate sampling sites in Mine Area lakes.

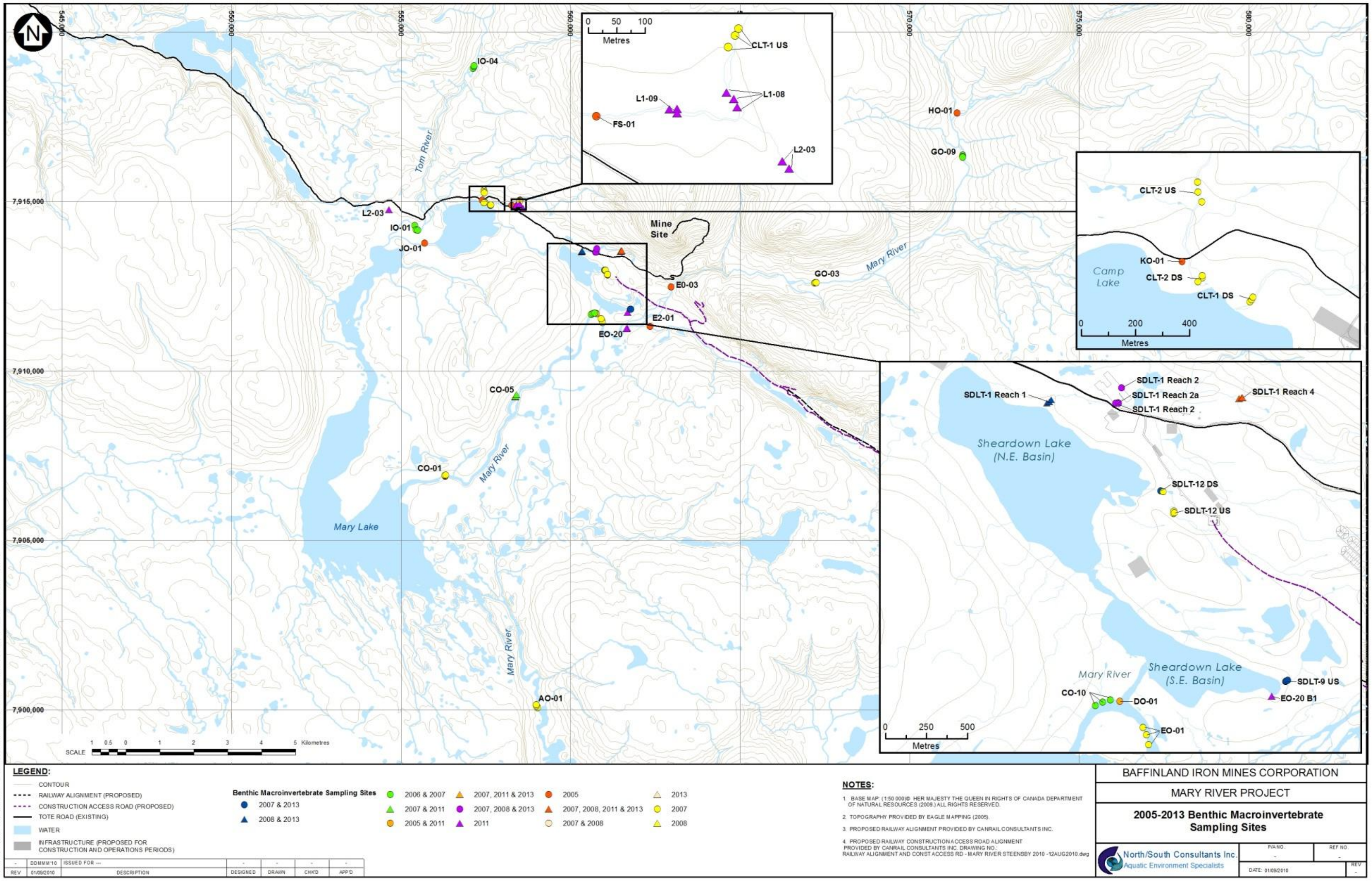


Figure 3-2. Benthic invertebrate sampling sites in Mine Area streams.

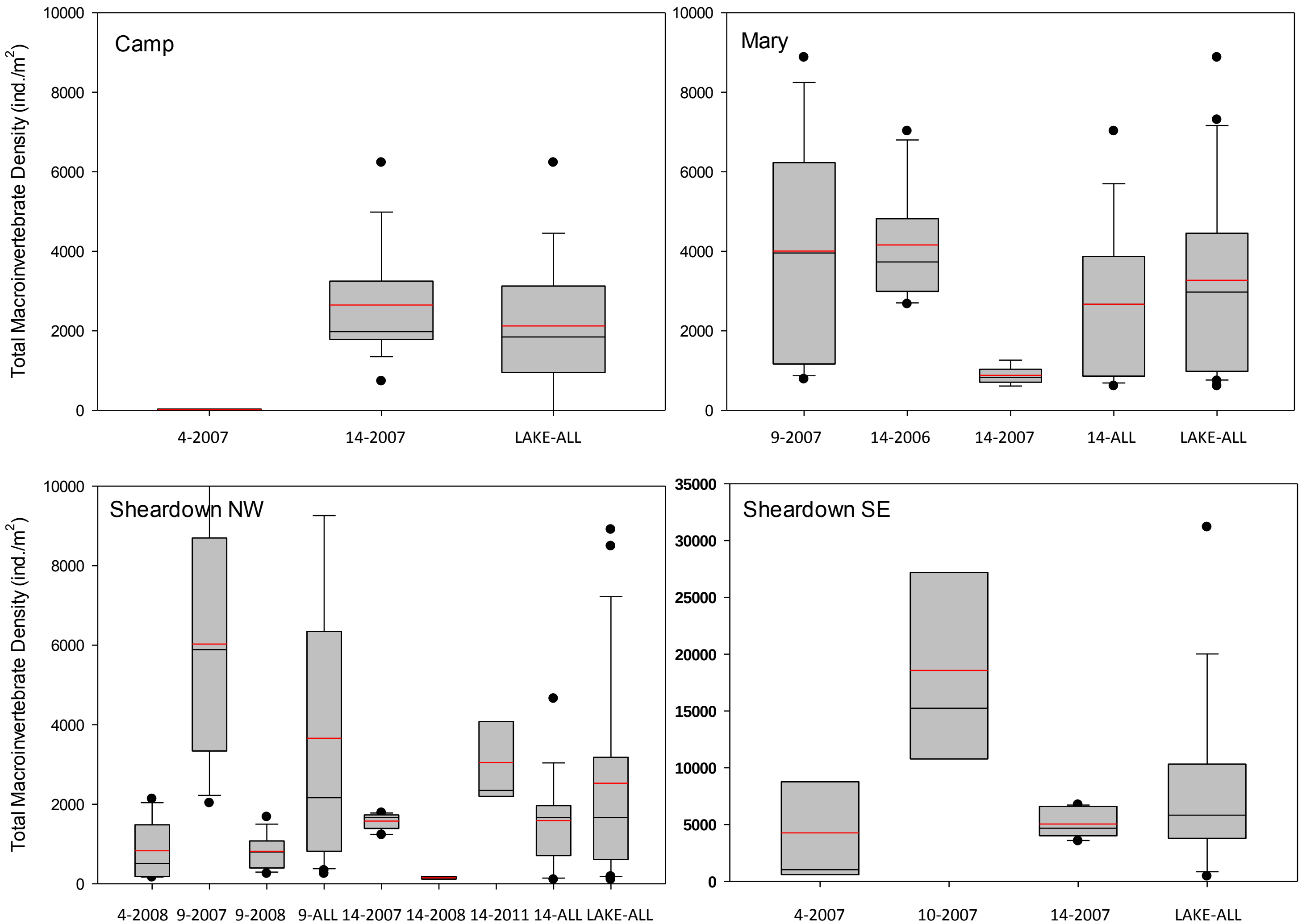


Figure 3-3. Boxplot of total macroinvertebrate density (ind./m^2) for all Mine Area lakes, by aquatic habitat type and year. Mean is represented by red line. Note different vertical scale for Sheardown SE.

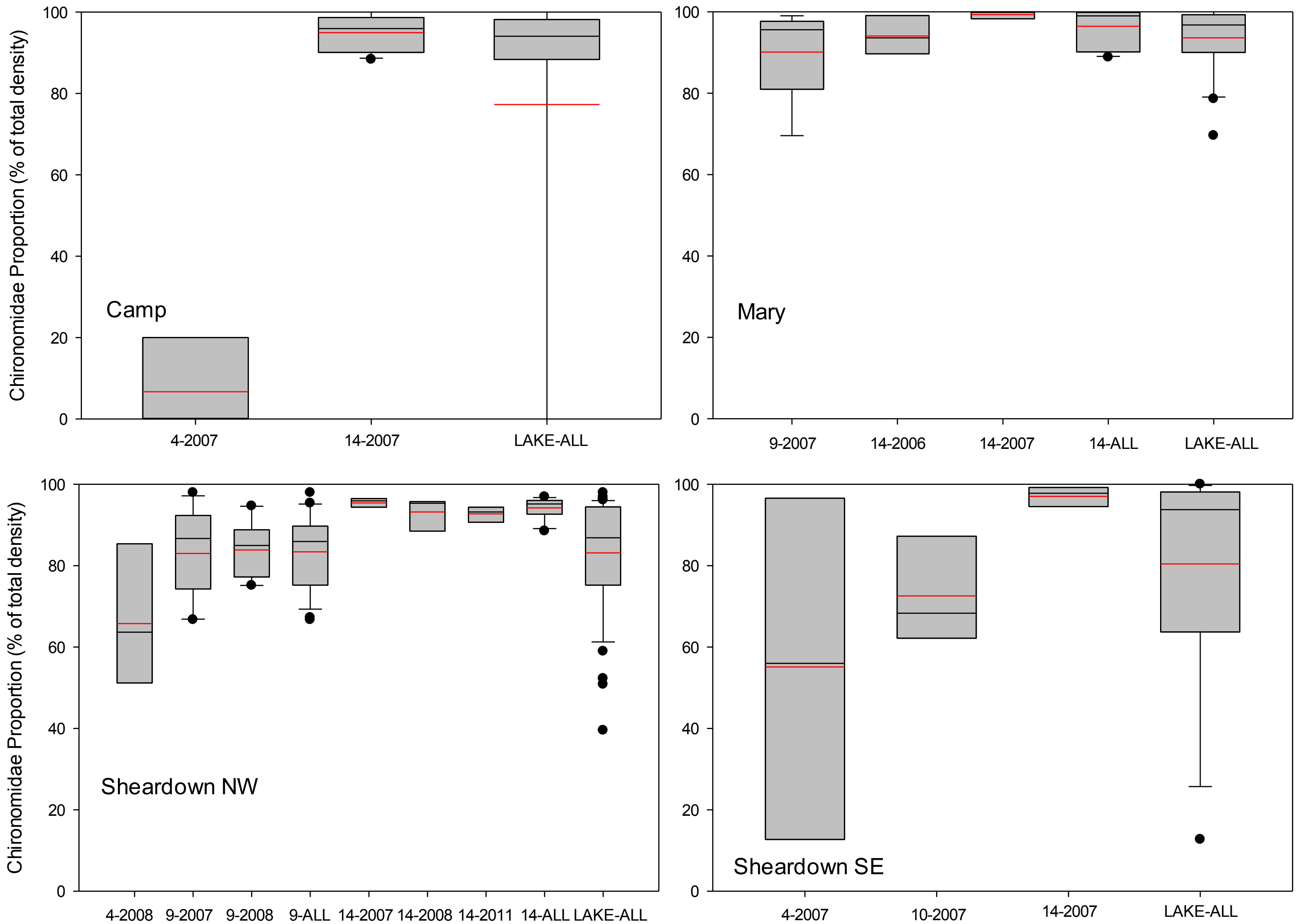


Figure 3-4. Boxplot of Chironomidae proportion (% of total density) for all Mine Area lakes, by aquatic habitat type and year.

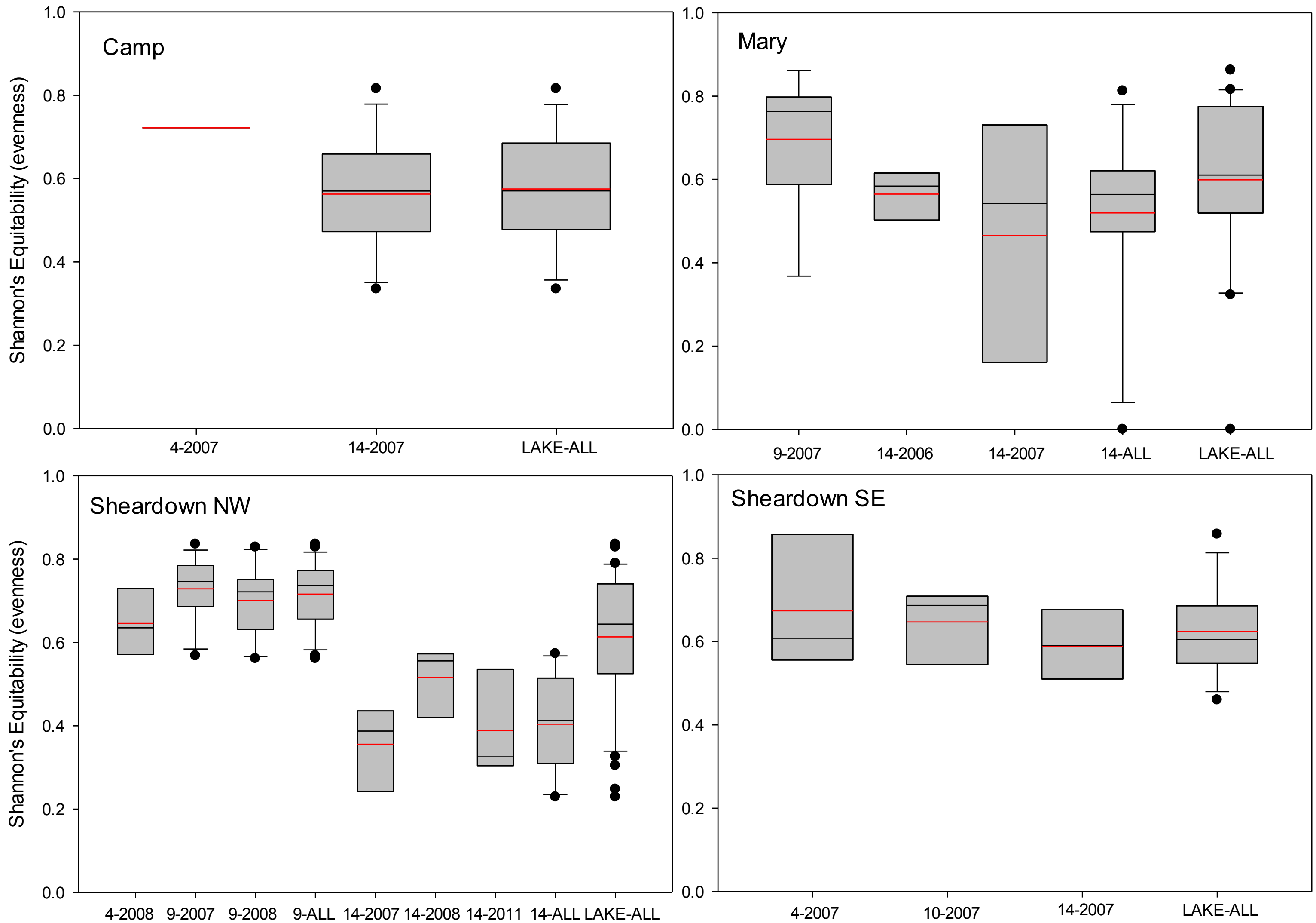


Figure 3-5. Boxplot of Shannon's Equitability (evenness) for all Mine Area lakes, by aquatic habitat type and year.

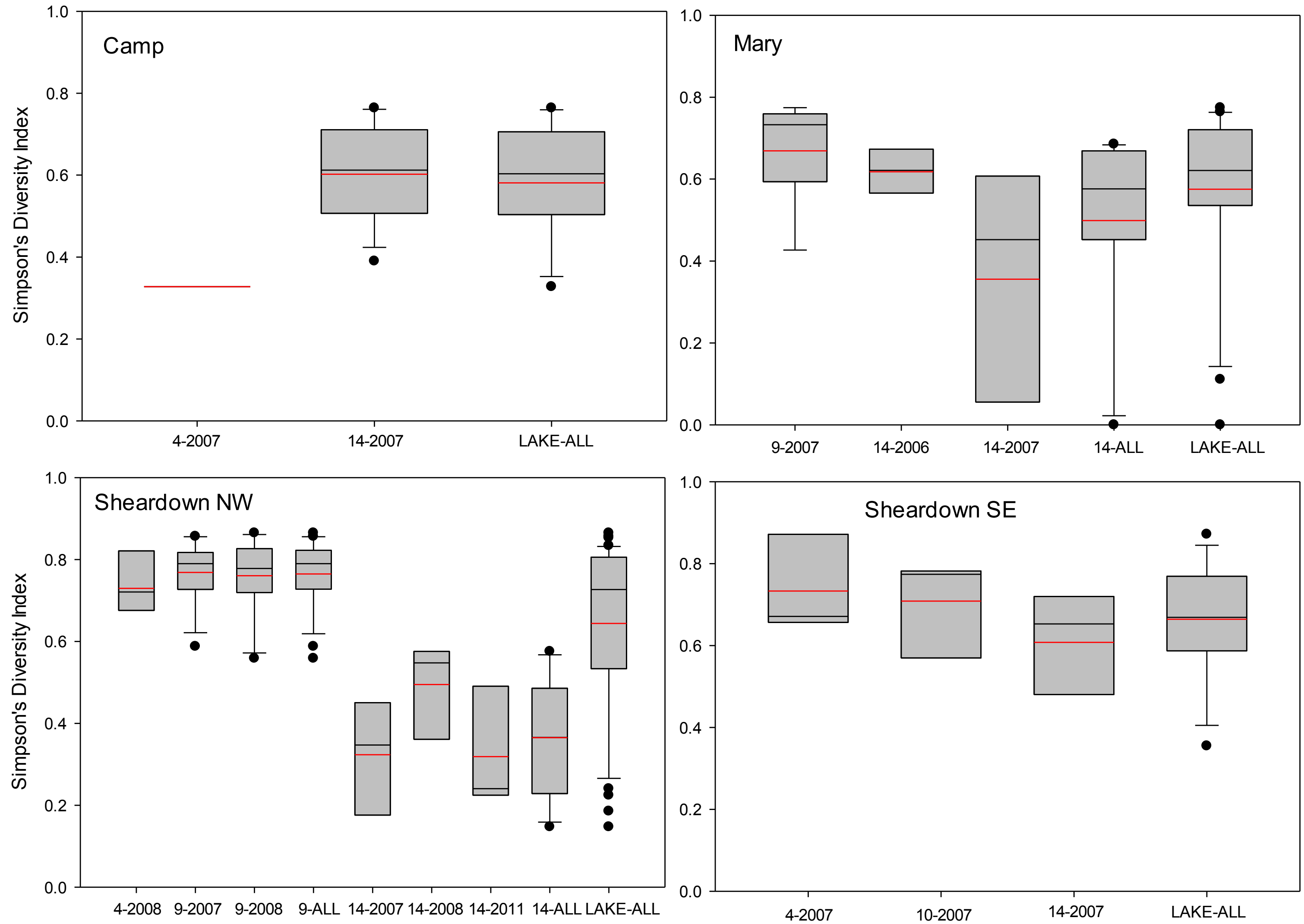


Figure 3-6. Boxplot of Simpson's Diversity Index for all Mine Area lakes, by aquatic habitat type and year.

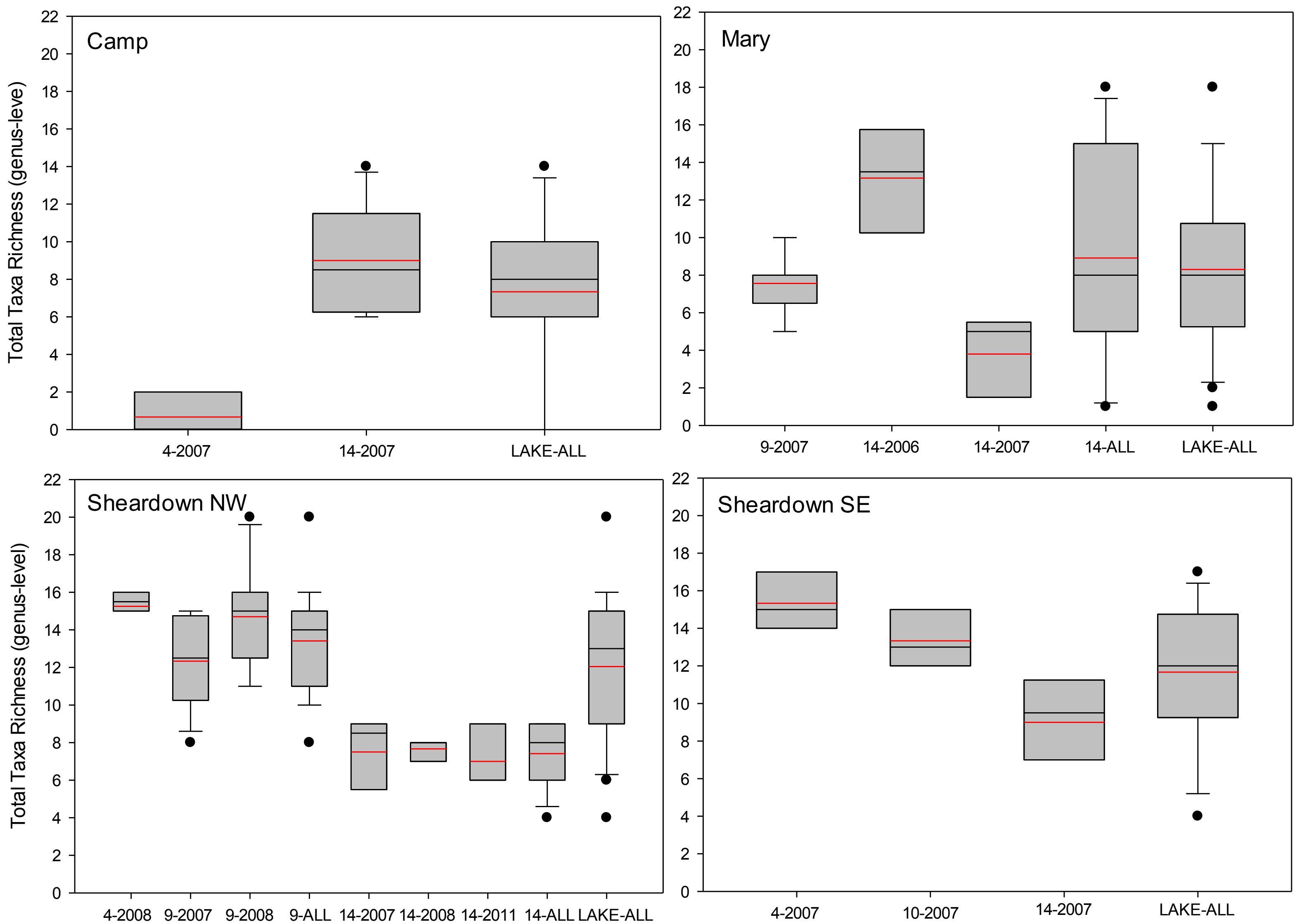


Figure 3-7. Boxplot of total taxa richness (genus-level) for all Mine Area lakes, by aquatic habitat type and year.

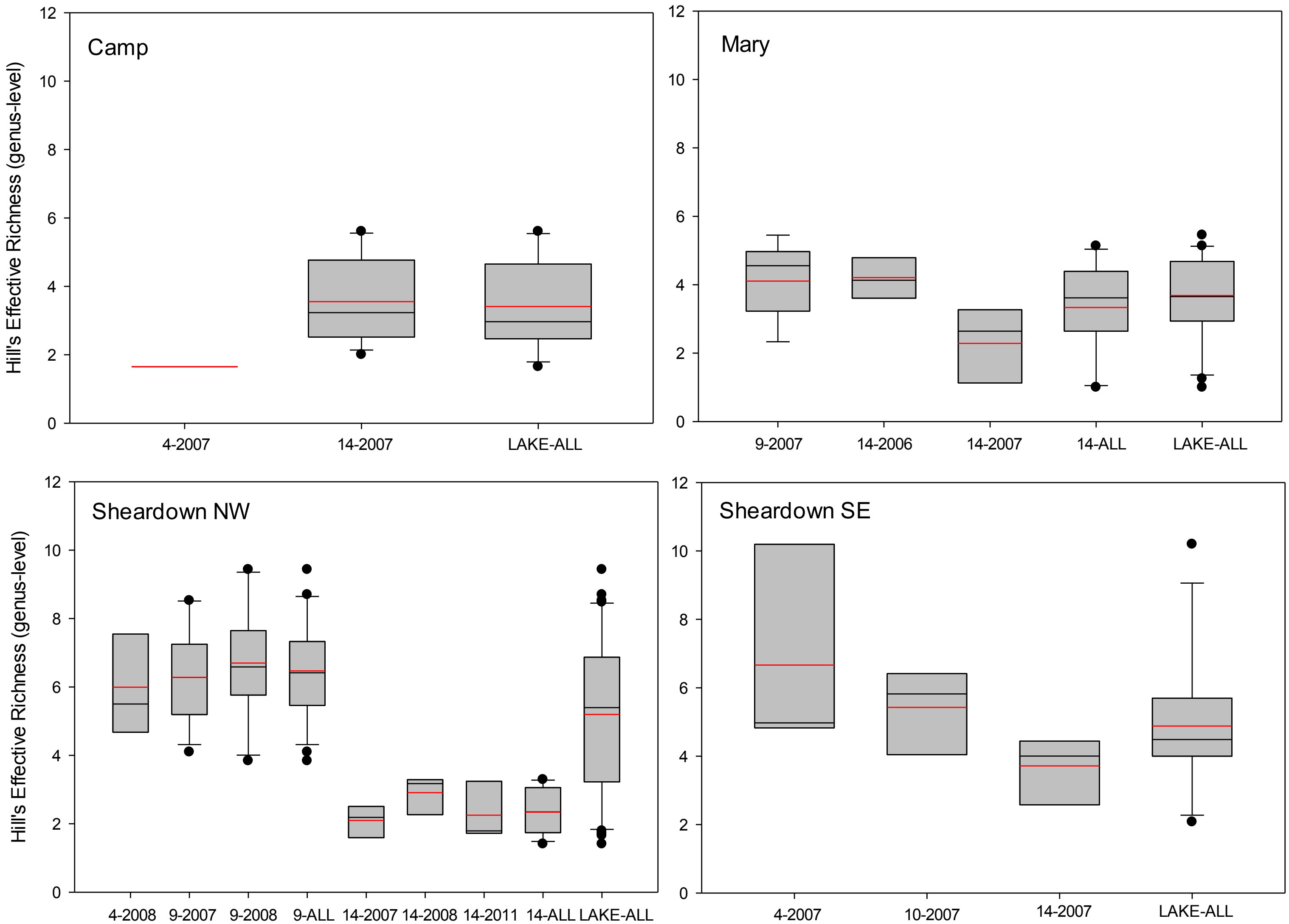


Figure 3-8. Boxplot of Hill's effective richness (genus-level) for all Mine Area lakes, by aquatic habitat type and year.

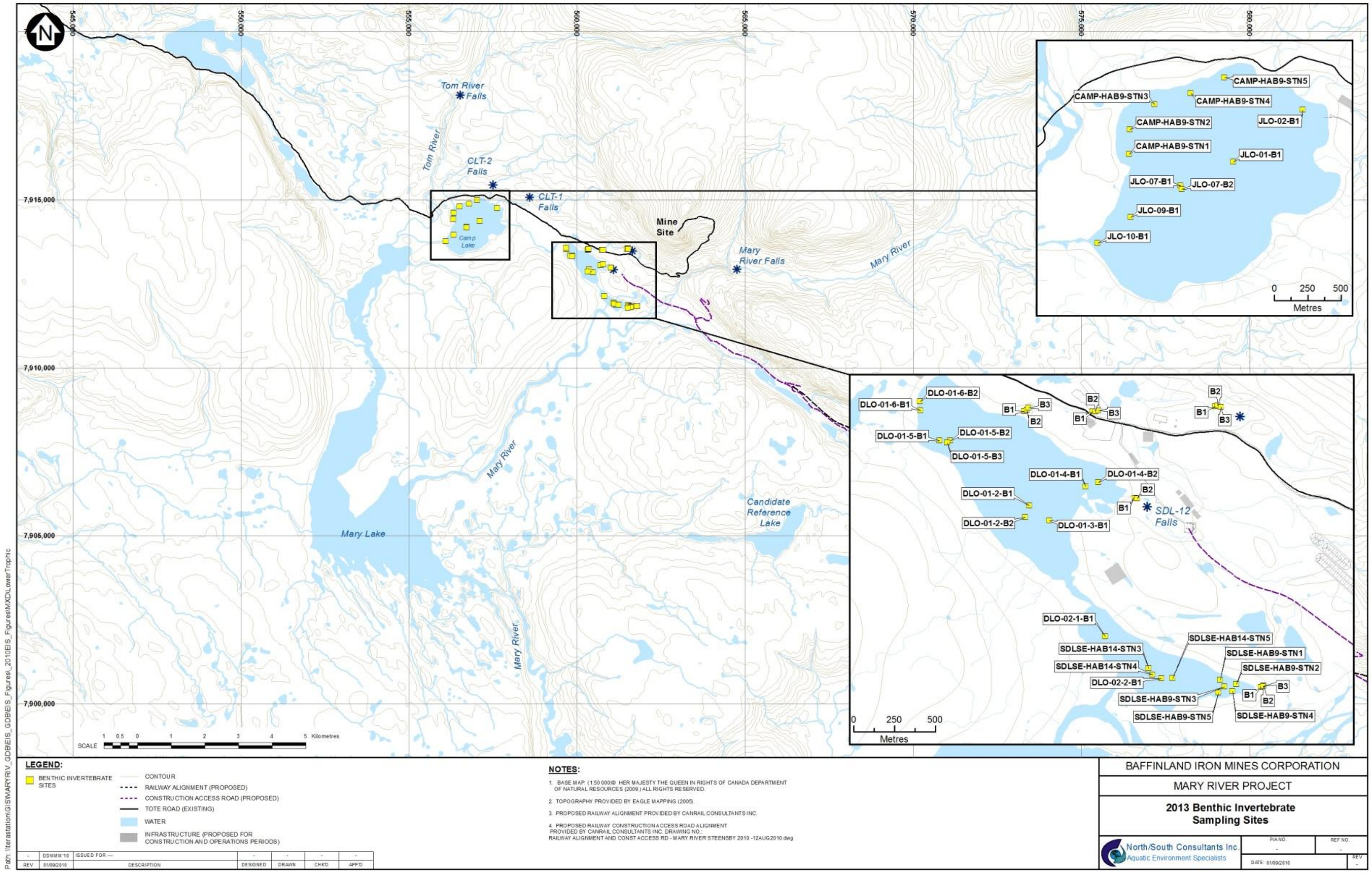


Figure 3-9. Benthic invertebrate sampling sites: 2013.

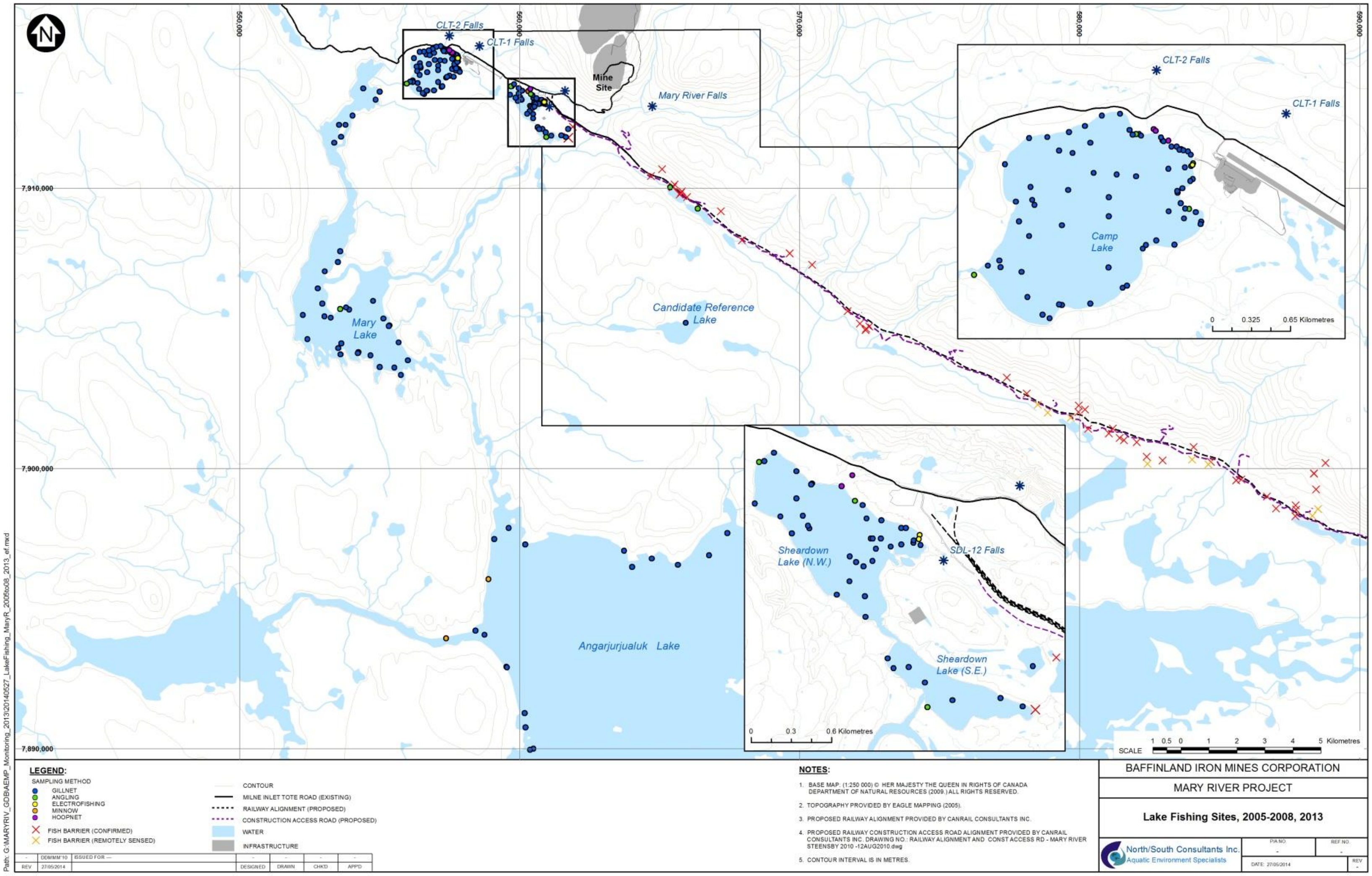


Figure 4-1. Fish sampling sites in Mine Area lakes.

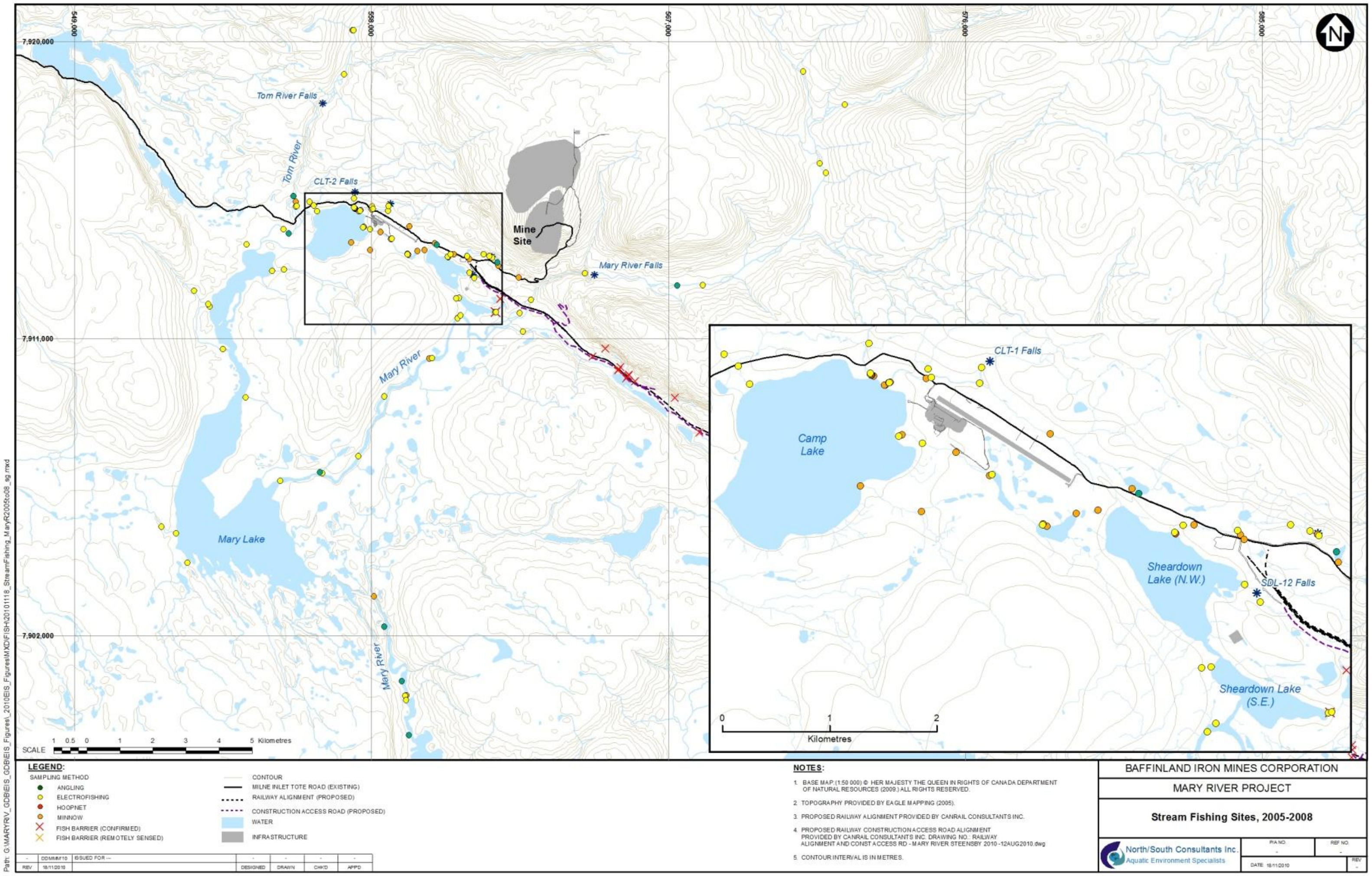


Figure 4-2. Fish sampling sites in Mine Area streams.

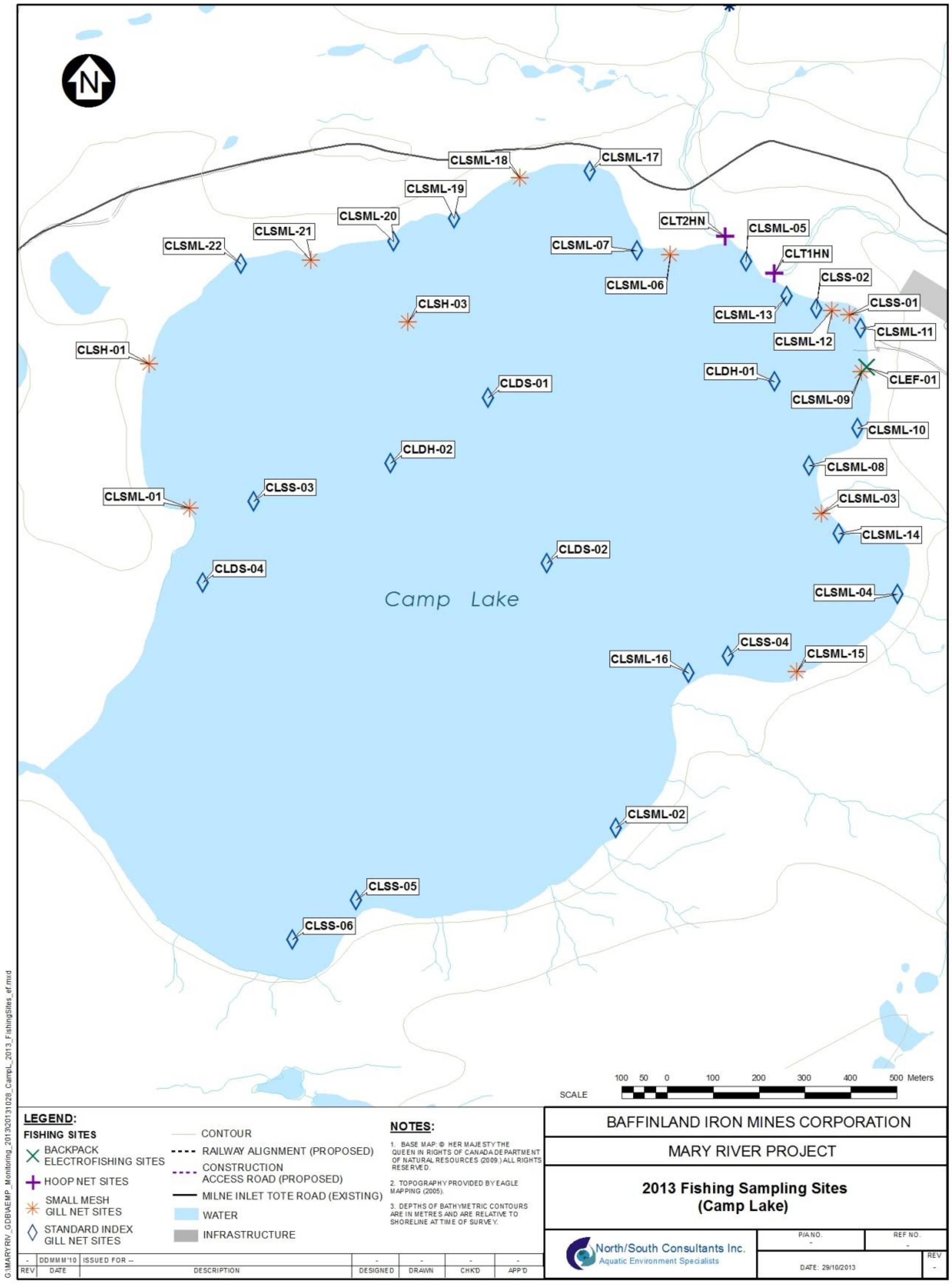


Figure 4-3. Fish sampling locations in Camp Lake: 2013.

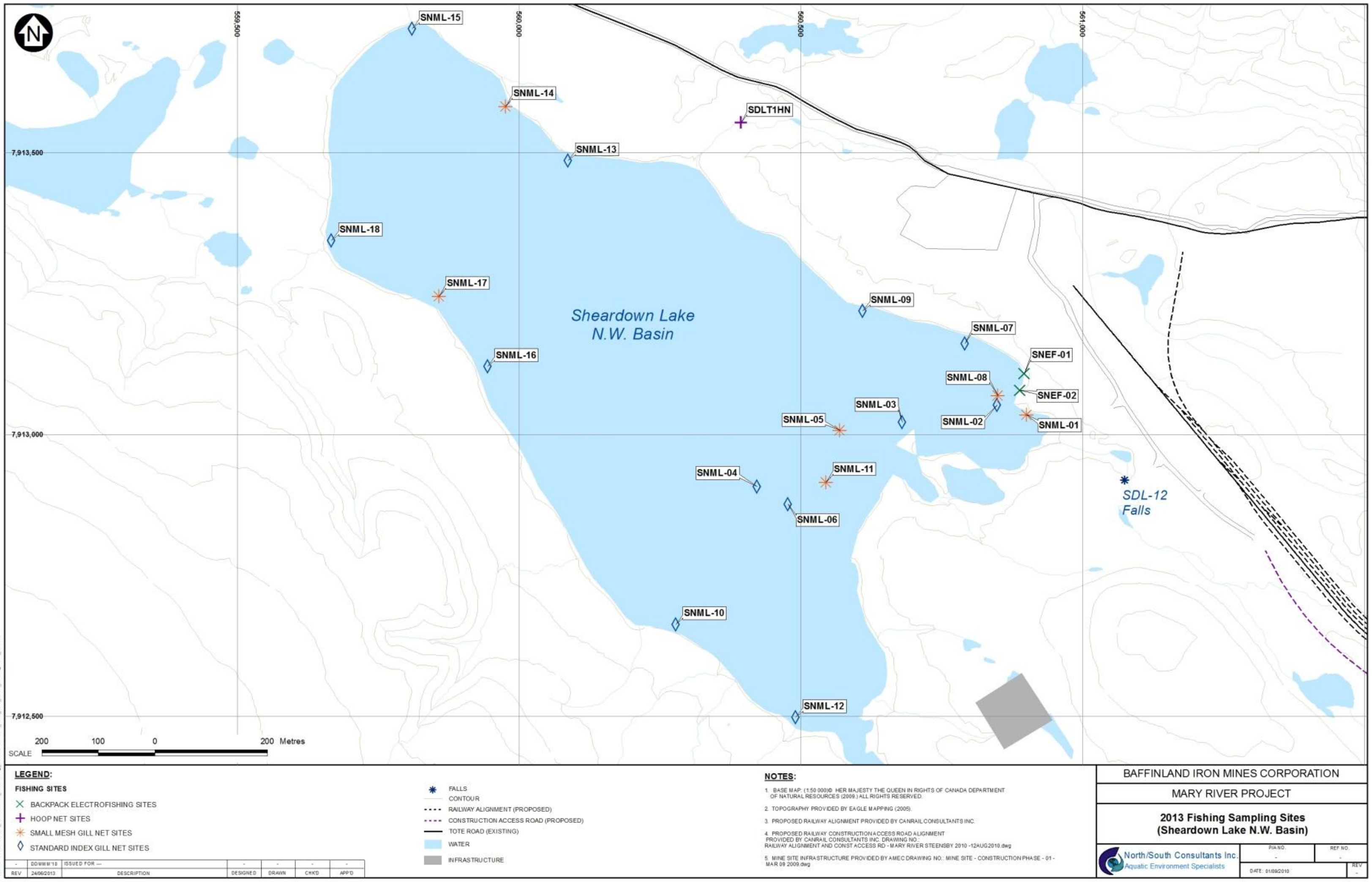


Figure 4-4. Fish sampling locations in Sheardown Lake: 2013.

Appendix E

Evaluation of Reference Lakes

Appendix E

Evaluation of Reference Lakes

Mary River Project

June 2014

Candidate Reference Lakes:

Preliminary Survey 2013

North/South Consultants Inc.
Aquatic Environment Specialists

Candidate Reference Lakes: Preliminary Survey 2013

June, 2014

Prepared by

North/South Consultants Inc.

For

Baffinland Iron Mines Corporation

North/South Consultants Inc.
Aquatic Environment Specialists

83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca

Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Program
BMI	Benthic macroinvertebrate(s)
CCME	Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
COV	Coefficient of variation
CREMP	Core Receiving Environment Monitoring Program
DO	Dissolved oxygen
NSC	North/South Consultants Inc.
PAL	Protection of aquatic life
PRSD	Percent relative standard deviation
PSA	Particle size analysis
RPMD	Relative percent mean difference
SD	Standard deviation
SE	Standard error of the mean
TDS	Total dissolved solids
TN	Total nitrogen
TP	Total phosphorus
TOC	Total organic carbon

1.0 INTRODUCTION AND OVERVIEW

The Core Receiving Environment Monitoring Program (CREMP) of the aquatic effects monitoring program (AEMP) for the Mary River Project incorporates monitoring in reference waterbodies. The AEMP identifies that a minimum of one reference lake would be monitored for chemical and biological parameters in parallel with the CREMP which will be conducted in the Mine Area.

Preliminary identification of candidate reference lakes for the CREMP and AEMP was completed through a series of desktop screening exercises completed in 2013. This exercise, which is described in North/South Consultants Inc. (NSC) and Knight Piésold (2013), identified 12 potential reference lakes for Camp and/or Sheardown lakes within an 80 km radius of the Mary River Mine Site (Figure 1).

This interim report provides a description of reconnaissance surveys conducted in the open-water season of 2013 to identify reference lakes for Camp and Sheardown lakes at the mine site. Reconnaissance surveys were planned for the open-water season of 2013, with the objective of collecting information on the biota, physical habitat, and chemical conditions (i.e., water quality) at the three most suitable lakes as identified through an initial survey. Ultimately, the objective was to determine presence/absence of land-locked resident Arctic Char (*Salvelinus alpinus*), conduct a coarse aquatic habitat survey, and collect water quality, phytoplankton, zooplankton, and benthic macroinvertebrate (BMI) samples (all from a single site) in each of three lakes to assist with selecting the final reference lake(s).

The first reconnaissance survey conducted in summer (i.e., early August 2013) identified two potentially suitable reference lakes and these lakes were surveyed as indicated above. As the overall objective was to identify three candidate lakes, a second reconnaissance survey was completed in fall 2013 with the intent to identify additional lakes for consideration.

The following provides a description of the aerial and ground reconnaissance surveys completed for candidate reference lakes in the open-water season of 2013, a description of results of the field programs, and qualitative comparisons to Mine Area lakes.

2.0 SUMMER RECONNAISSANCE SURVEY

The first reconnaissance survey was undertaken in early August and included an initial aerial survey to identify the most suitable lakes of the 12 candidates identified through the desktop screening exercise, followed by ground surveys of the these lakes.

2.1 AERIAL SURVEYS

Twelve potential reference lakes for Camp and/or Sheardown lakes were initially identified within an 80 km radius of the Mary River Mine Site through the desktop screening exercise (Figure 1, NSC and Knight Piésold 2013). On August 3, 2013, these 12 lakes were surveyed by helicopter to identify basic suitability characteristics such as general depth, shoreline substrate and connectivity to other waterbodies. Lakes that were identified as unsuitable during the aerial survey were eliminated as potential references. Depth was the primary limiting factor identified during aerial surveys. Based on several ground-truthed surveys of other lakes in the study area, depths < 3.0 m, which are insufficient for overwintering, can be identified reliably from aerial surveys.

Table 1 provides a summary of reconnaissance survey information for the 12 candidate reference lakes surveyed in early August. Five of the lakes were eliminated as potential references due to shallow depths observed during aerial surveys. An additional three lakes remained largely frozen in early August . These three lakes are located in a mountain range to the north of the Mine Area at significantly higher altitudes than Camp and Sheardown lakes and may remain at least partially ice-covered during most summers. For this reason, these lakes were disregarded from further consideration. Aerial surveys indicated four of the 12 lakes may be suitable candidates as reference lakes.

2.2 DETAILED GROUND SURVEYS

Of the four lakes identified as potentially suitable candidates through the aerial reconnaissance survey, detailed ground surveys were conducted at lakes CR-P3-11, CR-P3-09, and CL-P2-13. Lake CR-P3-12 appeared to have nearly identical physical characteristics to the adjacent Lake CR-P3-11, including a largely sandy shoreline, and only one (Lake CR-P3-11) of these two lakes was chosen for a detailed ground survey.

Ground surveys included collection of information on shoreline characteristics (qualitative observations), an aquatic habitat reconnaissance survey (collection of bathymetric and substrate information), determination of fish presence/absence (specifically identification of land-locked resident Arctic Char), collection of water quality information (*in situ* and laboratory measurements) and collection of phytoplankton and zooplankton samples (Table 2).

3.0 FALL RECONNAISSANCE SURVEY

The second round of the reconnaissance surveys was conducted in late August and included revisiting and sampling two of the candidate lakes visited in early August (CR-P3-11 and CL-P2-13), as well as conduct of a second aerial reconnaissance survey to identify additional potential candidate lakes for consideration. The third lake (Lake CR-P3-09) that was surveyed in early August was subsequently dropped from further consideration and was not sampled in late August due to the suspected presence of a population of dwarf Arctic Char (see Section 4.1.3 for a detailed description of results).

3.1 AERIAL SURVEY

Results from aerial and ground surveys conducted on potential reference lakes in early August confirmed only two lakes as likely suitable candidates. Both lakes are smaller than Sheardown and Camp lakes and one has primarily sandy substrate (less preferred by Arctic Char for spawning and rearing). As a result, 11 alternate lakes to the south of the mine site (ALT-1 to ALT-11) were surveyed aerially in late August for general depth, shoreline substrate and connectivity to other waterbodies to expand the list of potential suitable candidates (Figure 1).

Table 1 provides a summary of reconnaissance survey information for these 11 lakes. Several lakes appeared potentially suitable as references, but four have a combination of abundant, ideal nearshore habitat (cobble), sufficient depths (estimated to be > 10 m), and sufficient size when compared with Camp and/or Sheardown NW lakes.

3.2 DETAILED GROUND SURVEYS

Detailed sampling was completed in fall at lakes CR-P3-11 and CL-P2-13 and included collection of information on water quality, phytoplankton, zooplankton and BMIs (Table 2). Detailed ground surveys of the four alternate lakes identified during the aerial reconnaissance in late August could not be completed due to inclement weather conditions and time constraints.

4.0 SUMMARY OF RESULTS

The following sections provide a brief summary of the results of the ground reconnaissance surveys completed in 2013 and qualitative comparisons to Mine Area lakes to provide an initial screening of the suitability of the lakes as reference waterbodies.

4.1 LAKE CR-P3-09

4.1.1 WATER QUALITY

In situ water quality measurements are presented in Appendix 1 and the sampling site is indicated in Figure 2. As this lake was subsequently eliminated as a candidate reference lake, detailed review of water quality for this lake was not undertaken.

4.1.2 LOWER TROPHIC LEVEL BIOTA

Samples for taxonomic analysis of phytoplankton and zooplankton were collected from Lake CR-P3-09 in summer and have been archived at the laboratory at NSC in Winnipeg, MB. BMIs were not sampled in Lake CR-P3-09 as the lake was eliminated as a candidate following the summer sampling period. Metadata associated with the summer sampling period are presented in Appendix 2 and sampling sites are presented in Figure 2.

4.1.3 FISH AND FISH HABITAT

Lake CR-P3-09 is isolated from all nearby waterbodies. Both the inflow and outflow provide insufficient depth or flows for adult or juvenile Arctic Char use. Any fish in the lake are, therefore, resident and non-migratory. The shoreline of this lake is typically cobble/boulder with a relatively steep gradient (Photo 1). Nearshore substrate (to about 5-6 m depth) is a continuation of the cobble/boulder shoreline (Photo 2). As depth increases, cobble is replaced with increasing amounts of sand and silt (Figure 3). Silt is the dominant substrate at depths greater than 10 m. Maximum observed depth in this lake was 29.81 m with a mean of 11.92 m (Figure 2).

Juvenile Arctic Char (30-70 mm fork length) were observed in nearshore rocky habitat. Five Arctic Char were captured in two standard gang index gill nets set for short duration in the lake. The captured fish ranged in size from 191-332 mm. One fish (193 mm) died in the net and was frozen and transported to the laboratory at NSC in Winnipeg for further examination of sex, maturity, diet, parasite load and age. Laboratory examination indicated this fish was a sexually mature male aged 11 years with a diet of chironomids and a parasite infracommunity that included cestode cysts (probably *Diphyllobothrium* sp.) along the exterior surface of the digestive tract. The presence of a sexually mature 11-year-old male at that size, and the lack of

Photo 1. Typical shoreline of reference lake CR-P3-09.

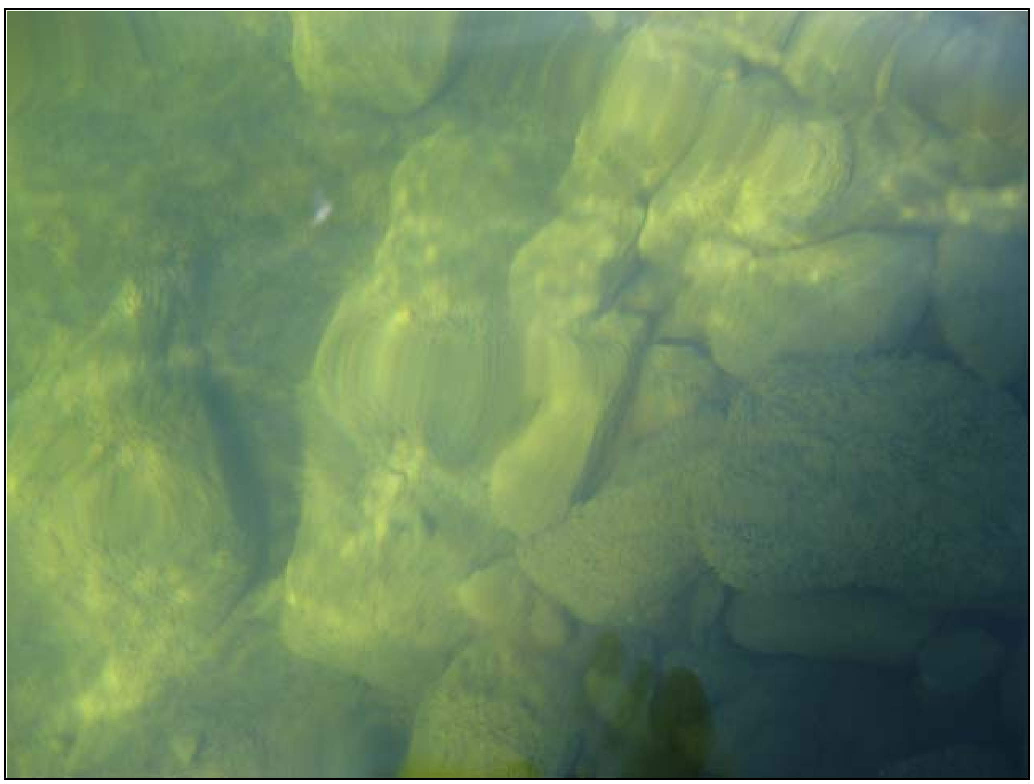


Photo 2. Typical nearshore substrate in reference lake CR-P3-09.

any fish larger than about 330 mm in the gill nets, suggest that this lake likely contains a stunted population of Arctic Char. On this basis Lake CR-P3-09 is likely not a suitable reference for Camp or Sheardown lakes. As previously noted, this lake was subsequently dropped from further consideration as a candidate reference lake based on this observation. Therefore, fall sampling was not undertaken in this lake.

4.2 LAKE CR-P3-11

4.2.1 WATER QUALITY

Laboratory and *in situ* water quality results collected in summer and fall at Lake CR-P3-11 are provided in Appendix 1 and the sampling site is indicated in Figure 4. Qualitative comparison of water quality conditions in Lake CR-P3-11 to Mine Area lakes (2013 data) indicates similarities for some parameters but differences for others (Table 3 and Figures 5-9).

Like Mine Area lakes, Lake CR-P3-11 was well-oxygenated and had a relatively high clarity. Nutrient concentrations were also relatively similar between this candidate reference lake and the Mine Area lakes (Figure 5) and the lake ranked as oligotrophic on the basis of total phosphorus (TP). Total nitrogen (TN) to TP ratios indicate this lake is strongly phosphorus limited, like Mine Area lakes (Table 3). Concentrations of many metals were also similar to Mine Area lakes, with a number of metals below detection (on average) in all of the lakes including antimony, beryllium, bismuth, boron, cadmium, cobalt, mercury, selenium, thallium, tin, titanium, and vanadium. Aluminum, iron, and copper were also similar to Mine Area lakes (Figure 6).

The primary difference between Lake CR-P3-11 and the Mine Area lakes relates to total dissolved solids (TDS)/conductivity, major cations, alkalinity, and hardness, all of which were lower in Lake CR-P3-11 (Table 3, Figure 7). Conductivity was less than half the levels measured in Sheardown Lake NW and SE and Camp Lake, but more similar to the more dilute Mary Lake (Figure 7). Lake CR-P3-11 ranked as very soft, whereas Mine Area lakes ranked as soft to moderately soft based on the Canadian Council of Resource and Environment Ministers (CCREM 1987) water hardness categories. These differences likely reflect differences in local geology.

Lake CR-P3-11 contains lower concentrations of calcium, magnesium, and potassium, but similar concentrations of sodium, than Mine Area lakes (Figure 8). Although concentrations of a number of metals were lower in Lake CR-P3-11, chromium, nickel, zinc (Figure 9) and manganese (Figure 6) were higher. Lake CR-P3-11 was not thermally stratified during the two sampling periods in 2013, whereas Mine Area lakes stratify during some sampling periods.

All water quality parameters measured in Lake CR-P3-11 in 2013 were within the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (PAL; CCME 1999; updated to 2014).

4.2.1 LOWER TROPHIC LEVEL BIOTA

Samples of phytoplankton, zooplankton, and BMIs were collected during summer and/or fall from Lake CR-P3-11. Metadata associated with this sampling are presented in Appendix 2 and sampling sites are presented in Figure 4.

Phytoplankton

Chlorophyll *a* concentrations measured in Lake CR-P3-11 were similar to those measured in Mine Area lakes in the open-water season of 2013 (Table 3, Figure 10), indicating similar levels of primary productivity.

Detailed phytoplankton results for samples collected in summer and fall at Lake CR-P3-11 are provided in Appendix 3. Qualitative comparisons of the phytoplankton community in Lake CR-P3-11 measured in the open-water season of 2013 to data collected in the open-water seasons of 2007 and 2008 from Mine Area lakes indicated that the community composition differs (Table 4; Figure 11). Unlike Mine Area lakes where diatoms dominated the phytoplankton community, dinoflagellates dominated the phytoplankton community and diatoms formed a small portion of the phytoplankton biomass in Lake CR-P3-11 (Figure 11). However, the dominant taxa (*Gymnodinium* and *Peridinium* sp.) were also present in Mine Area lakes in 2007 and 2008. Species diversity and richness were also higher in Lake CR-P3-11 in 2013 than in the Mine Area lakes in 2007 and 2008 (Table 4). Three phytoplankton not identified in the Mine Area lakes were observed in CR-P3-11, including: *Rhoicosphenia* sp. (Diatom), *Staurodesmus* sp. (Charophyta), and *Bitrichia* sp. (Charophyta).

During the summer, three phytoplankton replicates were collected and two of these were analysed for phytoplankton composition and biomass to assess variability (Appendix 3). The relative percent mean difference (RPMD) for biomass was high (63%) indicating that there is a high degree in variation in the phytoplankton. Variability of replicates of this order of magnitude is not uncommon for environmental monitoring programs (e.g., Coordinated Aquatic Monitoring Program 2014).

Zooplankton

Detailed zooplankton results for samples collected in summer and fall at Lake CR-P3-11 are provided in Appendix 4. Qualitative comparisons of the zooplankton community in CR-P3-11 to

Mine Area lakes (2007 and 2008 data) indicated that the communities were generally comparable (Table 5, Figure 12). A total of five crustacean zooplankton taxa were identified from vertical tows in Lake CR-P3-11, within the range of the number of taxa observed in the Mine Area lakes. As observed in Mine Area lakes, copepods, particularly cyclopoids, dominated the community and consisted of two species, *Cyclops scutifer* and *Diaptomus minutus*. The cladoceran community was primarily composed of two small-bodied taxa, *Bosmina longirostris* and *Daphnia longiremis*. The other cladoceran observed, *Holopedium gibberum*, was rare in comparison. As is typical, cladoceran density increased through the growing season and these organisms contributed to a greater proportion of the community sampled in the fall in comparison to the summer. Cyclopoid copepods and smaller-bodied cladocerans are more likely to be present in lakes with fish predators (i.e., Arctic char).

During the summer sampling period, three replicate samples of zooplankton were collected in Lake CR-P3-11 (Appendix 4). Percent relative standard deviation (PRSD) of zooplankton density for the three replicates was low (9%). Higher levels of variability were observed for individual taxa.

Benthic Macroinvertebrates

The objective of the BMI program was to sample aquatic habitat type 14 for comparison to Mine Area lakes. Habitat type 14 is characterized by water depths greater than 12 m, fine sand, silt, clay substrate, and an absence of macrophytes. While mean water depth in CR-P3-11 was only 8.8 m, it was decided that the samples represented the offshore profundal habitat based on its maximum depth of 11.65 m. Supporting variables for the BMI program (i.e., sediment total organic carbon [TOC] and particle size analysis [PSA]) were measured at each replicate station.

Detailed taxonomic results for BMI samples collected in the fall at Lake CR-P3-11 are provided in Appendix 5. Qualitative comparisons of BMI metrics in CR-P3-11 (2013; n=1) were made to the same habitat type within the Mine Area lakes using available data as follows: Sheardown Lake NW (2007, 2008, 2011, 2013; n=17); Sheardown Lake SE (2007; n=6); Camp Lake (2007; n=12); and Mary Lake (2006, 2007; n=11). Statistics for six community metrics: total density, proportion of Chironomidae, Shannon's evenness index, Simpson's diversity index, taxa richness (total number of genera), and Hill's effective richness, were graphically compared using summary statistics. Reference lake values were visually comparable to the mine site lake values for most of the metrics (Figures 13 and 14).

A total of 3,861 individuals/m^2 were collected in Lake CR-P3-11 which was in the range of BMI densities measured in all Mine Area lakes (Table 6). Chironomidae comprised 98% of the total abundance, and was compositionally similar to the Mine Area lakes. Evenness and diversity indices were also similar amongst all lake sites. Mean taxa richness and Hill's effective richness values for Lake CR-P3-11 were both within the ranges for all Mine Area lakes.

Supporting sediment analysis results for Lake CR-P3-11 (n=1) are provided in Figure 15. The benthic sediment was predominantly silt (47.8%), loam in texture; and TOC was 3.17%.

4.2.1 FISH AND FISH HABITAT

The shoreline of Lake CR-P3-11 is predominantly sandy with occasional small patches of rocks and a gradient ranging from low to high (Photos 3 and 4). Nearshore substrate (to about 5-6 m depth) is largely sand with occasional gravel or cobble (Figure 16). Silt and sand are dominant at depths greater than 5 m with occasional patches of coarser material. The most predominant substrate type in this lake is fines (i.e., fine sand, silt, and clay) but hard substrates are present at depths greater than 2 m, indicating the lake provides suitable spawning habitat for Arctic Char (Table 8). Maximum observed depth in this lake was 11.65 m with a mean of 6.10 m (Figure 4). The greatest depths were located in the northern third of the lake. There are several shallow shoals in the southern two thirds of the lake.

Lake CR-P3-11 has tributaries suitable for use by juvenile Arctic Char, but of insufficient depth for adult use. Any fish in the lake are, therefore, likely resident and non-migratory. Juvenile Arctic Char (30-70 mm fork length) were observed in tributary streams and in pools along the lake margin that had become isolated as water levels decreased. Fifteen Arctic Char were captured in two standard gang index gill nets set for short duration in the lake. The captured fish ranged in size from 313-431 mm. There were five mortalities, which were frozen and returned to the laboratory at NSC in Winnipeg for further examination of sex, maturity, diet, parasite load and age. Of the five mortalities, four were immature males (FL = 318-334 mm) and one was a resting female (FL = 355 mm). These fish were aged 10-13 years. Stomachs from all five mortalities contained chironomids and cestode cysts (probably *Diphyllobothrium* sp.) were present along the exterior surface of the digestive tracts. One fish was also infected with adult nematodes (likely *Cystidicola* sp.) in the body cavity, which may have been in the swim bladder before it was punctured during the necropsy.

Although the largely sandy nearshore substrate differs from the nearshore substrate of Camp or Sheardown lakes, which contain greater amounts of coarser substrate, and the lake is smaller and shallower than Camp or Sheardown lakes (Table 8), preliminary analysis of the fish population shows that basic meristics, growth rates, diet and parasite load are similar to populations in the Mine Area lakes. As previously noted, the lake also contains habitat that could support Arctic Char spawning.

Photo 3. Low-relief shoreline in reference lake CR-P3-11.

Photo 4. High-relief shoreline in reference lake CR-P3-11.

4.3 LAKE CL-P2-13

4.3.1 WATER QUALITY

Laboratory and *in situ* water quality results collected in summer and fall at Lake CL-P2-13 are provided in Appendix 1 and the sampling site is indicated in Figure 17. Qualitative comparison of water quality conditions in Lake CL-P2-13 to Mine Area lakes (2013 data) indicates some similarities but also a number of differences (Table 3 and Figures 5-9).

Like Mine Area lakes, Lake CL-P2-13 was well-oxygenated and had a relatively high clarity. Secchi disk depth was within the range measured at the Mine Area lakes, though was most similar to the less clear Mary Lake (Table 3). TP concentrations were also relatively similar between this candidate reference lake and the Mine Area lakes (Figure 5) and the lake ranked as oligotrophic on the basis of TP. TN to TP ratios indicate this lake is strongly phosphorus limited, like Mine Area lakes (Table 3). Concentrations of many metals were similar to Mine Area lakes, with a number of metals below detection (on average) in all of the lakes including antimony, beryllium, bismuth, boron, cadmium, cobalt, mercury, selenium, thallium, tin, titanium, and vanadium. Aluminum, iron, and copper were similar to Mine Area lakes, though the mean iron concentration was slightly higher than Mine Area lakes or Lake CR-P3-11 (Figure 6).

Like Lake CR-P3-11, the primary difference between Lake CL-P2-13 and the Mine Area lakes relates to TDS/conductivity, major cations, alkalinity, and hardness, all of which are lower in Lake CL-P2-13 (Table 3). Conductivity was less than half the levels measured in Sheardown Lake NW and SE and Camp Lake, but more similar to the more dilute Mary Lake (Figure 7). Lake CL-P2-13 ranked as very soft, whereas Mine Area lakes ranked as soft to moderately soft based on the CCREM (1987) water hardness categories. These differences likely reflect differences in local geology. Lake CL-P2-13 contains lower concentrations of calcium, magnesium, potassium, and sodium than Mine Area lakes (Figure 8). Although concentrations of a number of metals were lower in Lake CL-P2-13 than Mine Area lakes, like Lake CR-P3-11, chromium and nickel were higher (Figure 9). Lake CL-P2-13 was not thermally stratified during the two sampling periods in 2013, whereas Mine Area lakes stratify during some sampling periods.

All water quality parameters measured in Lake CL-P2-13 in 2013 were within the CCME PAL guidelines (CCME 1999; updated to 2014).

4.3.2 LOWER TROPHIC LEVEL BIOTA

Samples of phytoplankton, zooplankton, and BMIs were collected during summer and/or fall from Lake CL-P2-13. Metadata associated with this sampling are presented in Appendix 2 and sampling sites are presented in Figure 17.

Phytoplankton

Chlorophyll *a* concentrations measured in Lake CL-P2-13 were similar to those measured in Mine Area lakes and Lake CR-P3-11 in the open-water season of 2013 (Table 3, Figure 10), indicating similar levels of primary productivity.

Detailed results of phytoplankton biomass and community composition analyses of samples collected in summer and fall at Lake CR-P3-13 are provided in Appendix 3. Qualitative comparisons of the phytoplankton community in Lake CR-P3-13 to Mine Area lakes (2007 and 2008 data) indicates that the communities are different, but compared to Lake CR-P3-11, the phytoplankton community of Lake CR-P3-13 is more similar to the Mine Area lakes (Table 4; Figure 11). Unlike Mine Area lakes where diatoms dominated, dinoflagellates dominated the phytoplankton community in Lake CR-P3-13 (Figure 11).

In general, species diversity was similar to Mine Area lakes, but a greater number of species (i.e., richness) was observed in Lake CR-P3-13 in 2013 than in the Mine Area lakes in 2007 and 2008 (Table 4). The phytoplankton *Bitrichia* sp. (Charophyta) was observed in CR-P3-13, but was not identified in the Mine Area lakes.

During the fall, three phytoplankton replicates were collected and two of these were analysed for phytoplankton composition and biomass to evaluate variability (Appendix 3). The RPMD for biomass was low (8%) indicating good precision in the estimate of phytoplankton biomass.

Zooplankton

Detailed zooplankton results for samples collected in summer and fall at Lake CL-P2-13 are provided in Appendix 3. Qualitative comparisons of the zooplankton community in CL-P2-13 to Mine Area lakes (2007 and 2008 data) indicate that the communities are generally comparable (Table 5, Figure 12). Total zooplankton density in CL-P2-13 was somewhat lower than in Mine Area lakes and Lake CR-P3-11, but within the range of densities observed in the Mine Area lakes throughout the open-water season. The distribution of zooplankton is inherently patchy (i.e., these organisms are often highly aggregated). Spatial (e.g., within a lake or among lakes in the same area) and temporal (e.g., seasonal) variation in lake zooplankton density is typical and may be related to a variety of factors such as water depth, prevailing wind direction, water temperature regimes, and fish predation pressure.

A total of five crustacean zooplankton taxa were identified from vertical tows in Lake CL-P2-13, which is within the range of the number of taxa observed in the Mine Area lakes. As observed in Mine Area lakes and Lake CR-P3-11, copepods, particularly cyclopoids, dominated the community and consisted of two species, *Cyclops scutifer* and *Diaptomus minutus*. The cladoceran community was primarily composed of two small-bodied taxa, *Bosmina longirostris* and *Daphnia longiremis*. The other cladoceran observed, *Holopedium gibberum*, was rare in comparison.

During the summer, three zooplankton replicate samples were collected in CL-P2-13 (Appendix 4). PRSD for total zooplankton density was relatively low (26%) but higher variability was observed among the replicates for the various taxa.

Benthic Macroinvertebrates

BMIs were sampled in the profundal zone of Lake CL-P2-13 (i.e., aquatic habitat type 14) in the fall of 2013. Detailed taxonomic results for BMI samples are provided in Appendix 5. Qualitative comparisons of BMI metrics measured in Lake CL-P2-13 (2013; n=1) were made to the data collected from the same habitat type within the Mine Area lakes as follows: Sheardown Lake NW (2007, 2008, 2011, 2013; n=17); Sheardown Lake SE (2007; n=6); Camp Lake (2007; n=12); and Mary Lake (2006, 2007; n=11). Statistics for six community metrics: total density, proportion of Chironomidae, Shannon’s evenness index, Simpson’s diversity index, taxa richness (total number of genera), and Hill’s effective richness, were graphically compared using summary statistics. Reference lake values were visually comparable to the mine site lake values for most of the metrics (Figures 13 and 14).

A total of 1,593 individuals/m^2 were collected in CL-P2-13 which was in the range of BMI densities for Mine Area lakes, except for Sheardown Lake SE (Table 6). Chironomidae comprised 100% of the total abundance, and was compositionally similar to the Mine Area lakes, except for Sheardown Lake NW. Evenness and diversity indices were also similar amongst all lake sites. Mean taxa richness and Hill’s effective richness values for Lake CL-P2-13 were both within the ranges for all Mine Area lake sites.

Supporting sediment analysis results for Lake CL-P2-13 (n=1) are provided in Figure 15. The sediment was predominantly silt (73.0%), silt loam in texture; and TOC was 2.02%.

4.3.3 FISH AND FISH HABITAT

Lake CL-P2-13 has the smallest surface area of the three lakes that were surveyed in detail in 2013 (Figure 17). There are tributaries suitable for use by juvenile Arctic Char, but of insufficient depth for adult use. Any fish in the lake are, therefore, likely resident and non-migratory. The shoreline of this lake is predominantly rocky with a gradient ranging from low to high (Photo 5). Nearshore substrate (to about 5-6 m depth) ranged from almost 100% sand in some areas to almost 100% cobble/boulder in others (Photo 6, Figure 18). Silt and sand were dominant at depths greater than 5 m, however, the northwest section of the lake consisted of large amounts of cobble to at least 12 m depth. The predominant substrate type in this lake is fines (i.e., fine sand, silt, and clay) but hard substrates are present at depths greater than 2 m, indicating the lake provides suitable spawning habitat for Arctic Char (Table 9).The lake is characterized by steep shorelines typically reaching depths of 8-10 m within 50 m of shore tapering to a broad basin ranging from 10-15 m deep (Figure 17). Maximum observed depth in this lake was 15.34 m with a mean of 9.40 m.

Juvenile Arctic Char (30-70 mm fork length) were observed in tributary streams and in rocky nearshore areas. Two Arctic Char were captured in two standard gang index gill nets set for short duration in the lake. The captured fish ranged in size from 395-558 mm. One mortality (FL = 395 mm) was frozen and returned to the NSC laboratory in Winnipeg for further examination of sex, maturity, diet, parasite load and age. The fish was an immature male aged 17 years with chironomids in the stomach and larval cestode (likely *Diphyllobothrium* sp.) cysts along the gut and adult cestodes (possibly *Proteocephalus* sp.) in the stomach. Although this fish is older than most similarly-sized fish from Mine Area lakes, it is immature and may not necessarily be indicative of an overall slower growth rate for fish in this lake. Additional data are required to more thoroughly assess the fish population compatibility with Mine Area lakes.

Despite a smaller surface area, a higher proportion of fines, and a shallower basin than the Mine Area lakes (Table 8), preliminary surveys indicate Lake CL-P2-13 may be suitable as a reference lake.

Photo 5. Typical shoreline of reference lake CL-P2-13.

Photo 6. Typical nearshore substrate in reference lake CL-P2-13.

5.0 SUMMARY AND RECOMMENDATIONS

5.1 WATER QUALITY

Some water quality variables, notably water clarity, dissolved oxygen (DO), nutrients, and numerous metals, were similar between candidate reference lakes and Mine Area lakes. The primary differences observed relate to hardness, TDS/conductivity, and major cations – all of which were lower in candidate reference lakes than Mine Area lakes, notably Camp Lake and Sheardown Lake NW. These parameters were more similar to Mary Lake, which is softer and more dilute than other Mine Area lakes.

5.2 LOWER TROPHIC LEVEL BIOTA

5.2.1 PHYTOPLANKTON

The key findings of the phytoplankton analyses are:

- Primary productivity was similar between the candidate reference lakes and Mine Area lakes based on chlorophyll *a* concentrations; and

- Phytoplankton community composition varied between the candidate reference lakes and Mine Area lakes. The former were dominated by dinoflagellates (Dinophyceae) whereas the latter were typically dominated by diatoms.

While the differences in community composition are not ideal, the community composition of all the lakes (candidate reference lakes and Mine Area lakes) is consistent with nutrient-poor Arctic lakes. Other studies have reported high abundance of dinoflagellates, and specifically the Genus *Gymnodinium*, in other Arctic lakes (e.g., Snap Lake and a reference lake; De Beers 2002; Golder Associates 2012).

5.2.2 ZOOPLANKTON

Densities and composition of the zooplankton communities were similar between Mine Area lakes (as measured in 2007 and 2008) and the candidate reference lakes CR-P3-11 and CL-P2-13 (as measured in 2013).

5.2.3 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrate abundance and composition metrics were similar between Mine Area lakes (as measured in 2006, 2007, 2008, 2011, and 2013) and the candidate reference lakes CR-P3-11 and CL-P2-13 (as measured in 2013).

5.3 FISH AND FISH HABITAT

Available information regarding Arctic Char populations and aquatic habitat in the two candidate reference lakes indicate both lakes support what are likely land-locked resident populations and both are supplied by tributary streams that appear to provide juvenile rearing habitat (similar to Mine Area lakes). Also like Mine Area lakes, Lakes CR-P3-11 and CL-P21-13 likely provide overwintering and spawning habitat. Of the two lakes, growth rates of Arctic Char in Lake CL-P2-13 may be slower than Mine Area lakes. However, due to limited sample size this suggestion requires further investigation.

5.4 RECOMMENDATIONS

Although some differences in aquatic habitat, water quality, and lower trophic level biota were noted between the candidate reference lakes and Mine Area lakes based on the results of the 2013 survey and comparison to existing data for Mine Area lakes, it is recommended to retain one or both of these lakes for further consideration as reference lakes. However, additional sampling is required to confirm the suitability of these lakes as reference systems, in particular in relation to the Arctic Char populations.

Should additional reference lakes be desired, lakes ALT-06, ALT-07, ALT-09 and ALT-10 (Figure 1) were deemed to be the most likely suitable candidates based on aerial surveys conducted in fall 2013. These lakes have suspected depths, nearshore substrates and, in particular, surface areas that appear to suitably match Camp and Sheardown NW lakes. Surface areas of these lakes area greater than lakes CR-P3-11 and CL-P2-13 and more comparable to the surface areas of Camp and Sheardown NW lakes. If additional reference lakes are to be identified, these lakes could be subject to a ground level screening comparable to that conducted in lakes CR-P3-11 and CL-P2-13 in 2013 to evaluate physical, chemical, and biological conditions.

6.0 LITERATURE CITED

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg, MB. Updated to 2014.

Canadian Council of Resource and Environment Ministers (CCREM). 1987. Canadian water quality guidelines. Canadian Council of Resource and Environment Ministers, Winnipeg, MB.

Coordinated Aquatic Monitoring Program (CAMP). 2014. Three year summary report (2008-2010). Report prepared for the Manitoba/Manitoba Hydro MOU Working Group by North/South Consultants Inc.,Winnipeg, MB.

De Beers Canada Mining Inc. 2002. Snap Lake Diamond Project Environmental Impact Assessment. Chapter 9.

Golder Associates. 2012. Snap Lake aquatic effects re-evaluation report. Submitted to De Beers Canada Inc.

North/South Consultants (NSC) and Knight Piésold Ltd. 2013. Desktop screening for candidate reference lakes: Mary River Mine Site. Report prepared for Baffinland Iron Mines Corporation, July 2013.

TABLES AND FIGURES

Table 1. Summary of information collected during preliminary surveys of potential reference lakes, August 2013. Lakes highlighted in bold, blue lettering have been identified as the best possible candidates.

Lake	Date	Survey Type	Maximum Depth (m)	Dominant Substrate (0-5 m depth)	Dominant Substrate (> 5 m depth)	Fish Community	Potential Reference Lake Status	Comments
CR-P3-07	03-Aug-13	Ground	3.0	Cobble	NA	Small juveniles observed along shore	Not Suitable	Too shallow for overwintering or large adult fish use
CL-P2-05	03-Aug-13	Aerial	< 3.0	NA	NA	Unknown	Not Suitable	Too shallow for overwintering or large adult fish use
CL-P2-01	03-Aug-13	Aerial	> 5.0	Appears to be cobble	NA	Unknown	Potentially Suitable	Lake was still ~80% covered in ice and could not be surveyed in detail
CR-P3-29	03-Aug-13	Aerial	> 5.0	Appears to be cobble	NA	Unknown	Potentially Suitable	Lake was still ~90% covered in ice and could not be surveyed in detail
CL-P2-04	03-Aug-13	Aerial	> 5.0	Appears to be cobble	NA	Unknown	Potentially Suitable	Lake was still ~80% covered in ice and could not be surveyed in detail
CL-P2-13	**07-Aug-13**	**Ground**	**13.0-15.0**	**Cobble/boulder**	**Sand/silt with rocky patches**	**Small juveniles along shore and in tributary streams; large adults captured in lake**	**Potentially Suitable**	**Lake is small, but substrate is ideal and there are large, resident Arctic Char**
CL-P2-07	03-Aug-13	Aerial	~ 5.0	Appears to be cobble	NA	Unknown	Not Suitable	80-90% of the lake is < 3.0 m deep

Table 1. - continued -

Lake	Date	Survey Type	Maximum Depth (m)	Dominant Substrate (0-5 m depth)	Dominant Substrate (> 5 m depth)	Fish Community	Potential Reference Lake Status	Comments
CR-P3-09	05-Aug-13	Ground	28.0-30.0	Cobble/ boulder	Sand/silt with rocky patches	Probable isolated stunted Arctic Char population	Not Suitable if resident char are stunted	May need more studies to confirm lack of large fish, but seems unlikely as a reference
CR-P3-01	03-Aug-13	Aerial	~ 5.0-10.0	Appeared to be cobble	NA	Unknown	Not Suitable	50% of the lake is < 3.0 m deep and lake is isolated from other waterbodies
CL-03	03-Aug-13	Aerial	< 2.0	NA	NA	Unknown	Not Suitable	Too shallow for overwintering or large adult fish use
CR-P3-11	**06-Aug-13**	**Ground**	**10.0-12.0**	**Sand**	**Sand/silt**	**Small juveniles along shore and in tributary streams; large adults captured in lake**	**Potentially Suitable**	**Substrate not ideal, but resident fish population present**
CR-P3-12	03-Aug-13	Aerial	~10.0-15.0	Sand	Sand/silt	Probable juvenile and adult use	Potentially Suitable	Very similar to CR-P3-11, so only one of the two was surveyed in detail
ALT-01	31-Aug-13	Aerial	> 10	Sand	NA	Probable juvenile and adult use	Potentially Suitable	Does not have ideal nearshore habitat (larger cobble), but may qualify for more detailed survey
ALT-02	31-Aug-13	Aerial	> 10	Cobble/sand	NA	Probable juvenile and adult use	Potentially Suitable	Nearshore habitat more suitable than ALT-1

Table 1. - continued -

Lake	Date	Survey Type	Maximum Depth (m)	Dominant Substrate (0-5 m depth)	Dominant Substrate (> 5 m depth)	Fish Community	Potential Reference Lake Status	Comments
ALT-03	31-Aug-13	Aerial	~ 5.0-10.0	Cobble/sand	NA	Unknown	Not Likely Suitable	Substrate decent, but depths a little shallow
ALT-04	31-Aug-13	Aerial	> 10	Cobble/sand	NA	Probable juvenile and adult use	Not Suitable	Essentially a bay in Nina Bang Lake
ALT-05	31-Aug-13	Aerial	> 10	Mainly Cobble	NA	Probable juvenile and adult use	Potentially Suitable	Excellent nearshore habitat and depths, but lake is a little small
ALT-06	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Excellent nearshore habitat and depths and lake is larger than other reference sites**
ALT-07	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Connected to ALT-06, but even better suited as reference**
ALT-08	31-Aug-13	Aerial	> 10	Sand/Cobble	NA	Unknown	Potentially Suitable	Low shoreline slope and lower quality habitat means this is likely less suitable than others in the area
ALT-09	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Among the best nearshore habitat and depth of any ALT lakes**
ALT-10	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Shallow connection to ALT-09 with similar habitat**
ALT-11	31-Aug-13	Aerial	> 10	Sand/Cobble	NA	Probable juvenile and adult use	Potentially Suitable	Good size and depth, but nearshore habitat not as ideal as ALT-06 or ALT-09/10)

Table 2. Sampling programs completed in candidate reference lakes, summer and fall 2013.

Lake	Season	Bathymetry & Substrate	Water Quality			Phytoplankton	Zooplankton	Benthic Macroinvertebrates	Fish
			in situ	Surface Sample	Bottom Sample				
CR-P3-09	Summer	+	+	+[1]		+	+		+
	Fall								
CR-P3-11	Summer	+	+	+	+	+	+		+
	Fall		+	+	+	+	+	+	
CL-P2-13	Summer	+	+	+	+	+	+		+
	Fall		+	+	+	+	+	+	

[1] Sample was collected by not analysed.

Table 3. Water quality measured in candidate reference lakes CR-P3-11 and CL-P2-13 and Mine Area lakes in the open-water season of 2013. Values represent means of surface samples. SDL NW = Sheardown Lake northwest and SDL SE = Sheardown Lake southeast.

Parameter	Unit	Reference Lakes		Mine Area Lakes			
		CR-P3-11	CR-P2-13	SDL NW	SDL SE	Camp L.	Mary L.
In situ							
Temperature	ºC	Summer: 9.6 Fall: 4.4	Summer: 6.9 Fall: 3.8	Summer: 8.6 Fall: 6.9	Summer: 10.0 Fall: 6.3	Summer: 4.6 Fall: 6.9	Summer: 6.2 Fall: 5.9
Dissolved oxygen	mg/L	11.54	11.55	12.20	12.09	12.20	12.37
pH	pH units	8.01	7.83	7.87	7.62	7.54	7.53
Specific conductance	µS/cm	40.1	42.0	120	100	122	64.3
Secchi Disk Depth	m	6.13	4.30	7.48	4.17	7.15	4.56
Laboratory Routine							
Lab pH	pH units	6.70	6.73	7.44	7.35	7.42	7.02
Lab Conductivity	µS/cm	41	42	121	106	124	67
Lab Turbidity	NTU	0.60	0.90	0.43	0.65	0.27	1.30
Total Alkalinity (as $CaCO_3$)	mg/L	17	22	57	50	59	33
Bromide	mg/L	<0.25	<0.25	<0.25	<0.25	0.25	<0.25
Chloride	mg/L	2.0	<1	3.0	2.5	3.2	2.0
Dissolved Hardness	mg/L	16.0	18.8	58.7	48.7	59.1	31.0
Total Hardness	mg/L	16.7	18.7	61.1	51.2	61.2	31.7
Ammonia	mg N/L	0.03	0.52	0.08	<0.02	0.28	0.14
Nitrite	mg N/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrite/nitrate	mg N/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate	mg N/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sulphate	mg/L	3	<3	4	4	<3	<3
Total Dissolved Solids	mg/L	26.7	27.5	79	68.5	80.7	43.6
Total Suspended Solids	mg/L	<2	<2	<2	<2	<2	<2
Total Phosphorus	mg/L	0.005	0.005	0.005	0.006	0.004	0.005
Total Kjeldahl Nitrogen	mg/L	0.75	0.80	0.20	<0.10	0.60	0.22
Total Nitrogen	mg/L	0.85	0.90	0.30	<0.2	0.70	0.32
TN:TP Molar Ratios	-	533	556	163	101	493	144
Phenols	mg/L	<0.001	0.009	<0.001	<0.001	<0.001	<0.001
Total Organic Carbon	mg/L	2.0	1.2	1.8	1.6	1.9	1.4
Dissolved Organic Carbon	mg/L	1.9	1.1	1.7	1.4	1.8	1.3
Chlorophyll *a*	µg/L	0.45	0.90	0.59	1.90	0.73	1.70
Pheophytin *a*	µg/L	0.72	0.80	0.75	0.20	2.22	0.42

Table 3. - continued -

Parameter	Unit	Reference Lakes		Mine Area Lakes			
		CR-P3-11	CR-P2-13	SDL NW	SDL SE	Camp L.	Mary L.
Total Metals							
Al	mg/L	0.0164	0.0346	0.0090	0.0356	0.0060	0.0425
Sb	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
As	mg/L	<0.00010	0.00012	<0.00010	<0.00010	<0.00010	<0.00010
Ba	mg/L	0.00276	0.00243	0.00502	0.00462	0.00548	0.00372
Be	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Bi	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
B	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Cd	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Ca	mg/L	3.6	3.8	12.2	10.4	12.3	6.5
Cr	mg/L	0.00077	0.00175	0.00038	0.00019	0.00014	0.00023
Cu	mg/L	0.00046	0.00179	0.00312	0.00076	0.00087	0.00066
Co	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Fe	mg/L	0.03	0.08	0.02	0.04	0.01	0.05
Pb	mg/L	0.00007	0.00009	<0.00005	<0.00005	<0.00005	0.00007
Li	mg/L	<0.00005	<0.00005	0.00034	<0.00005	0.00082	<0.00005
Mg	mg/L	1.89	2.24	7.42	6.15	7.39	3.77
Mn	mg/L	0.00402	0.00232	0.00203	0.00276	0.00230	0.00168
Hg	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Mo	mg/L	0.00006	0.00042	0.00077	0.00047	0.00022	0.00011
Ni	mg/L	0.0008	0.0010	0.0007	0.0006	0.0006	<0.00050
K	mg/L	0.355	0.310	0.873	0.706	0.881	0.471
Se	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Si	mg/L	0.27	0.37	0.61	0.57	0.40	0.47
Ag	mg/L	<0.000001	0.0000085	<0.000001	<0.000001	<0.000001	<0.000001
Na	mg/L	1.09	0.70	1.06	1.06	1.04	0.94
Sr	mg/L	0.00492	0.00368	0.00795	0.00706	0.00919	0.00513
Tl	mg/L	<0.000001	<0.000001	<0.000001	<0.000001	<0.000001	<0.000001
Sn	mg/L	<0.00010	0.00050	<0.00010	<0.00010	<0.00010	<0.00010
Ti	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
U	mg/L	0.000074	0.000136	0.000931	0.000695	0.000584	0.000498
V	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zn	mg/L	0.013	0.004	<0.0030	<0.0030	<0.0030	<0.0030

Table 3. - continued -

Paramaeter	Unit	Reference Lakes		Mine Area Lakes			
		CR-P3-11	CR-P2-13	SDL NW	SDL SE	Camp L.	Mary L.
Dissolved Metals							
Al	mg/L	0.0043	0.0039	<0.00100	0.0022	<0.00100	0.0073
Sb	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
As	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Ba	mg/L	0.00274	0.00220	0.00494	0.00439	0.00546	0.00349
Be	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bi	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
B	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Cd	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Ca	mg/L	3.44	3.83	11.73	9.81	11.97	6.38
Cr	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cr(VI)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr(III)	mg/L	-	-	<0.005	<0.005	<0.005	<0.005
Co	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cu	mg/L	0.00036	0.00041	0.00074	0.00059	0.00279	0.00049
Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Li	mg/L	<0.00005	<0.00005	0.00090	0.00095	0.00113	0.00117
Mg	mg/L	1.81	2.24	7.16	5.85	7.08	3.66
Mn	mg/L	0.00116	0.00084	0.00041	0.00032	0.00063	0.00072
Hg	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Mo	mg/L	<0.00005	0.00012	0.00072	0.00045	0.00021	0.00015
Ni	mg/L	0.00050	0.00109	0.00060	<0.00050	0.00054	<0.00050
K	mg/L	0.349	0.288	0.852	0.694	0.876	0.458
Se	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Si	mg/L	0.23	0.32	0.59	0.49	0.36	0.36
Ag	mg/L	<0.0000010	<0.0000010	<0.0000010	<0.0000010	<0.0000010	<0.0000010
Na	mg/L	1.11	0.670	1.05	0.92	1.05	0.959
Sr	mg/L	0.00475	0.00352	0.00756	0.00667	0.00857	0.00480
Tl	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sn	mg/L	<0.00010	0.00082	<0.00010	<0.00010	<0.00010	<0.00010
Ti	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02
U	mg/L	0.000063	0.000118	0.000897	0.000666	0.000552	0.000455
V	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zn	mg/L	0.00139	0.00255	0.00133	0.00092	0.00217	0.00199

Table 4. Mean, standard deviation (SD), coefficient of variation (COV), and 95th percentiles for phytoplankton species diversity, evenness, and richness metrics measured in reference lakes (summer and fall 2013) and Mine Area lakes (summer and late summer/fall, 2007 and 2008).

	MEANS					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	0.82	0.24	24	0.70	9.20	0.39
CL-P2-13	0.69	0.18	22	0.59	6.41	0.30
Camp Lake	0.72	0.22	17	0.60	5.55	0.33
Sheardown Lake NW	0.71	0.22	18	0.61	6.19	0.34
Sheardown Lake SE	0.71	0.29	16	0.61	6.1	0.37
Mary Lake	0.52	0.2	15	0.47	3.84	0.28
	SD					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	0.00	0.00	1	0.02	0.44	0.03
CL-P2-13	0.17	0.09	1	0.14	2.81	0.12
Camp Lake	0.07	0.05	3	0.04	1.18	0.04
Sheardown Lake NW	0.12	0.08	3	0.10	1.94	0.08
Sheardown Lake SE	0.88	0.43	20	0.77	9.31	0.54
Mary Lake	0.19	0.15	4	0.17	2.00	0.15
	COV					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	1	1	3	3	5	8
CL-P2-13	25	53	3	24	44	41
Camp Lake	9	25	20	7	21	13
Sheardown Lake NW	17	34	16	16	31	25
Sheardown Lake SE	27	42	18	26	41	34
Mary Lake	36	75	28	36	52	55
	95TH PERCENTILE					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	0.83	0.24	24	0.72	9.5	0.41
CL-P2-13	0.80	0.24	22	0.68	8.2	0.37
Camp Lake	0.81	0.28	23	0.66	7.5	0.37
Sheardown Lake NW	0.84	0.34	22	0.74	8.9	0.46
Sheardown Lake SE	0.87	0.42	19	0.76	9.2	0.51
Mary Lake	0.84	0.52	21	0.78	7.5	0.56

Table 5. Summary statistics for total crustacean zooplankton density (individuals/m^3) by waterbody (seasonally) for the candidate reference (2013) and Mine Area (2007 and 2008) lakes.

Waterbody	Season	n [1]	Mean	SD	Min	Max	Taxonomic Richness [2]
Lake CR-P3-11							
	Summer	3	7,942	741	7,153	8,623	5
	Fall	1	7,920	-	-	-	4
Lake CL-P2-13							
	Summer	1	1,163	-	-	-	5
	Fall	3	1,619	414	1,354	2,096	5
Camp Lake							
	Summer	6	11,772	8,442	3,244	22,619	4
	Fall	3	9,829	6,269	5,561	17,027	5
Sheardown Lake NW							
	Summer	10	11,878	8,335	2,637	26,211	7
	Fall	10	19,966	17,352	3,753	53,307	6
Sheardown Lake SE							
	Summer	6	13,127	10,132	3,303	31,074	6
	Fall	6	10,578	5,707	4,776	16,854	6
Mary Lake							
	Summer	9	2,713	2,246	750	7,811	9
	Fall	5	6,147	5,159	1,528	13,832	5

[1] number of samples collected

[2] total number of taxa observed to species-level, not the average number of taxa

Table 6. Mean, median, standard deviation (SD), standard error (SE), minimum (Min), maximum (Max), precision (20%), 95th percentile, and coefficient of variation (%COV) for BMI composition and richness metrics measured from the offshore profundal habitat of candidate reference lakes and Mine Area lakes.

Metric	**Total Macroinvertebrate Density (individuals/m²)**					
Habitat Type	**Offshore Profundal (14)**					
Lake	**CL-P2-13**	**CR-P3-11**	**SDL NW**	**SDL SE**	**Camp**	**Mary**
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	1593	3861	1871	5042	2649	2668
Median	--	--	1783	4674	1978	2670
SD	--	--	1143.36	1350.49	1496.51	2057.11
SE	--	--	277.31	551.34	432.01	620.24
Min	--	--	102	3548	730	609
Max	--	--	4652	6730	6226	7017
Sub-samples (20% precision)	--	--	9.33	1.79	7.98	14.86
95th Percentile	--	--	3603.56	6700.00	5250.43	5917.00
COV (%)	--	--	61.10	26.78	56.50	77.10

Metric	**Chironomidae Proportion (% of total density)**					
Habitat Type	**Offshore Profundal (14)**					
Lake	**CL-P2-13**	**CR-P3-11**	**SDL NW**	**SDL SE**	**Camp**	**Mary**
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	100	98	91	97	95	96
Median	--	--	94	98	96	99
SD	--	--	7.68	2.85	4.32	4.54
SE	--	--	1.86	1.16	1.25	1.37
Min	--	--	70	92	88	89
Max	--	--	98	100	100	100
Sub-samples (20% precision)	--	--	0.18	0.02	0.05	0.06
95th Percentile	--	--	97.08	99.74	100.00	100.00
COV (%)	--	--	8.46	2.94	4.55	4.71

Metric	**Shannon's Evenness Index**					
Habitat Type	**Offshore Profundal (14)**					
Lake	**CL-P2-13**	**CR-P3-11**	**SDL NW**	**SDL SE**	**Camp**	**Mary**
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	0.63	0.67	0.45	0.59	0.56	0.52
Median	--	--	0.43	0.59	0.57	0.56
SD	--	--	0.14	0.09	0.13	0.21
SE	--	--	0.03	0.04	0.04	0.06
Min	--	--	0.23	0.46	0.33	0.00
Max	--	--	0.68	0.68	0.82	0.81
Sub-samples (20% precision)	--	--	2.53	0.54	1.41	4.09
95th Percentile	--	--	0.66	0.68	0.75	0.73
COV (%)	--	--	31.80	14.65	23.75	40.42

Table 6. - continued -

Metric	Simpson's Diversity Index					
Habitat Type	Offshore Profundal (14)					
Lake	CL-P2-13	CR-P3-11	SDL NW	SDL SE	Camp	Mary
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	0.51	0.67	0.41	0.61	0.60	0.50
Median	--	--	0.44	0.65	0.61	0.58
SD	--	--	0.16	0.15	0.12	0.23
SE	--	--	0.04	0.06	0.03	0.07
Min	--	--	0.15	0.35	0.39	0.00
Max	--	--	0.63	0.75	0.76	0.69
Sub-samples (20% precision)	--	--	4.06	1.46	0.94	5.38
95th Percentile	--	--	0.61	0.74	0.76	0.68
COV (%)	--	--	40.30	24.13	19.41	46.38

Metric	Total Taxa Richness (genus-level)					
Habitat Type	Offshore Profundal (14)					
Lake	CL-P2-13	CR-P3-11	SDL NW	SDL SE	Camp	Mary
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	9 [1]	17 [1]	9	9	9	9
Median	--	--	9	10	9	8
SD	--	--	2.27	2.83	2.76	5.66
SE	--	--	0.55	1.15	0.80	1.71
Min	--	--	4	4	6	1
Max	--	--	12	12	14	18
Sub-samples (20% precision)	--	--	1.77	2.47	2.36	10.11
95th Percentile	--	--	12.00	11.75	13.45	16.50
COV (%)	--	--	26.58	31.43	30.70	63.59

[1] Total number of taxa observed to genus-level, not the average number of taxa

Metric	Hill's Effective Richness					
Habitat Type	Offshore Profundal (14)					
Lake	CL-P2-13	CR-P3-11	SDL NW	SDL SE	Camp	Mary
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	3	5	3	4	4	3
Median	--	--	2	4	3	4
SD	--	--	0.88	1.15	1.24	1.31
SE	--	--	0.21	0.47	0.36	0.40
Min	--	--	1	2	2	1
Max	--	--	4	5	6	5
Sub-samples (20% precision)	--	--	2.82	2.39	3.04	3.85
95th Percentile	--	--	3.94	5.03	5.52	4.90
COV (%)	--	--	33.60	30.89	34.85	39.27

Table 7. Substrate types in Lake CR-P3-11.

Substrate Type	Shoreline Zone (0-2 m)		Euphotic Zone (2-12 m)		Total	
	(m^2)	%	(m^2)	%	(m^2)	%
Boulder / Cobble	6,687	17	36,976	8	43,663	9
Gravel/Pebble	5,843	15	2,241	0.5	8,084	2
Sand	9,623	25	167,909	37	177,532	36
Fine Sand, Silt/Clay	16,504	43	250,251	55	266,754	54
Grand Total	38,657	100	457,376	100	496,033	100

Table 8. Comparison of aquatic habitat and lake characteristics.

Lake	Drainage Basin Area (km^2)	Lake Area (km^2)	Lake Area (km^2)	Drainage Basin: Lake Area Ratio	Mean Depth (m)	Maximum Depth (m)	Volume (1,000,000 m^3)	Substrate			
								Cobble/ Boulder (%)	Gravel/ Pebble (%)	Sand (%)	Fine Sand and Silt/Clay (%)
Camp Lake	26.47	2.21	2.21	11.98	13.03	35.08	27.5	5.1	28.2	61.1	5.6
Sheardown Lake NW	6.55	0.678	0.678	9.66	12.11	30.1	8.18	10.1	41.8	46.0	2.0
CR-P3-11	2.35	0.496	0.484	4.86	6.1	11.65	3.01	8.8	1.6	35.8	53.8
CL-P2-13	3.39	0.241	0.228	14.9	9.4	15.34	2.27	18.1	12.6	8.4	60.9

Table 9. Substrate types in Lake CL-P2-13.

Substrate Type	Shoreline Zone (0-2 m)		Euphotic Zone (2-12 m)		Profundal Zone (>12 m)		Total	
	(m^2)	%	(m^2)	%	(m^2)	%	(m^2)	%
Boulder / Cobble	3,128	30.4	35,752	19.5	4,547	9.8	43,427	18.1
Gravel/Pebble	1,031	10.0	23,035	12.6	6,102	13.2	30,169	12.6
Sand	5,164	50.1	14,918	8.1	157	0.3	20,238	8.4
Fine Sand, Silt/Clay	982	9.5	109,761	59.8	35,443	76.6	146,186	60.9
Grand Total	10,305	100.0	183,466	100.0	46,250	100.0	240,021	100.0

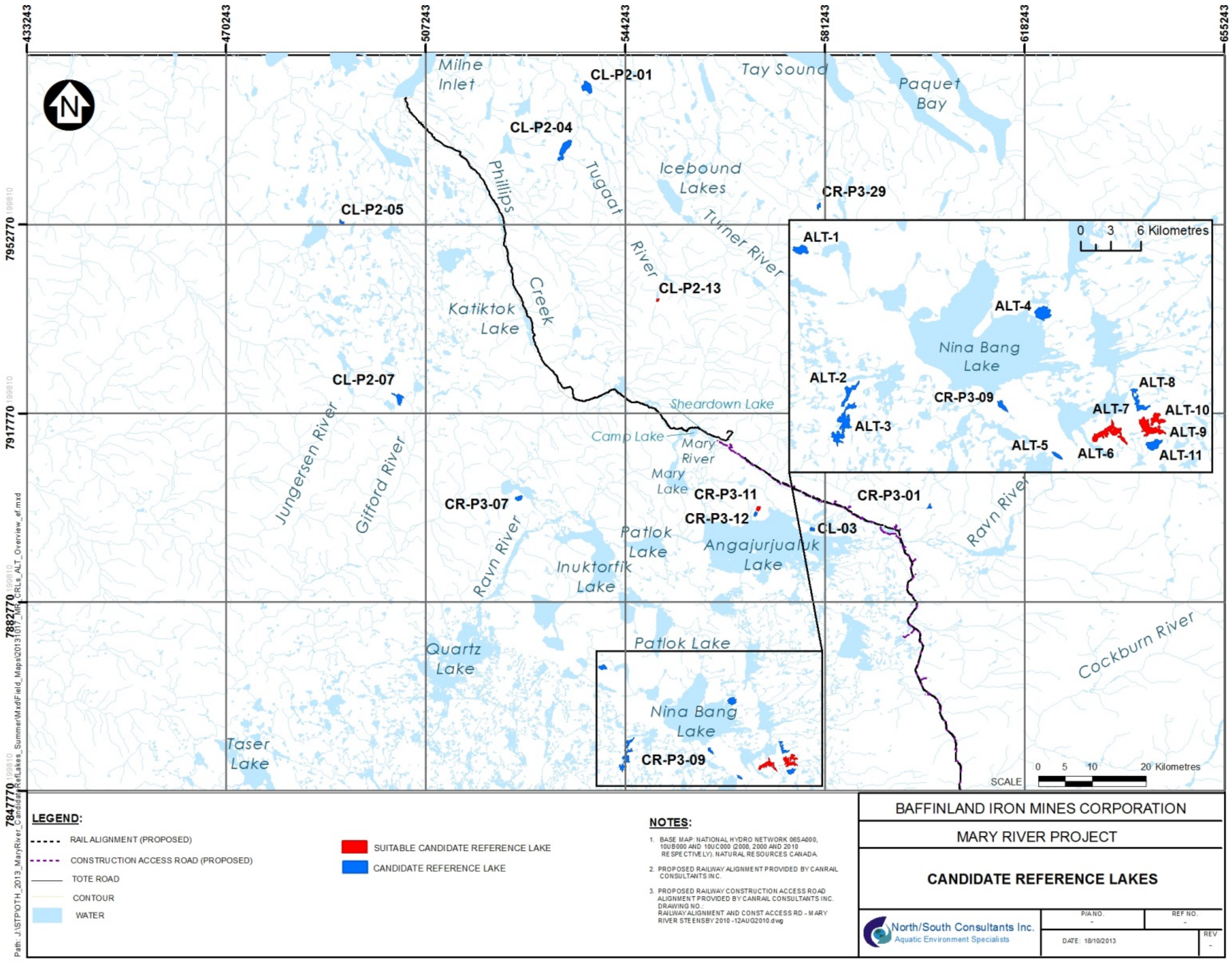


Figure 1. **Proposed candidate reference lakes surveyed during summer and fall 2013. Lakes highlighted in red were identified as those most likely to be suitable as references for Camp and/or Sheardown NW lakes.**

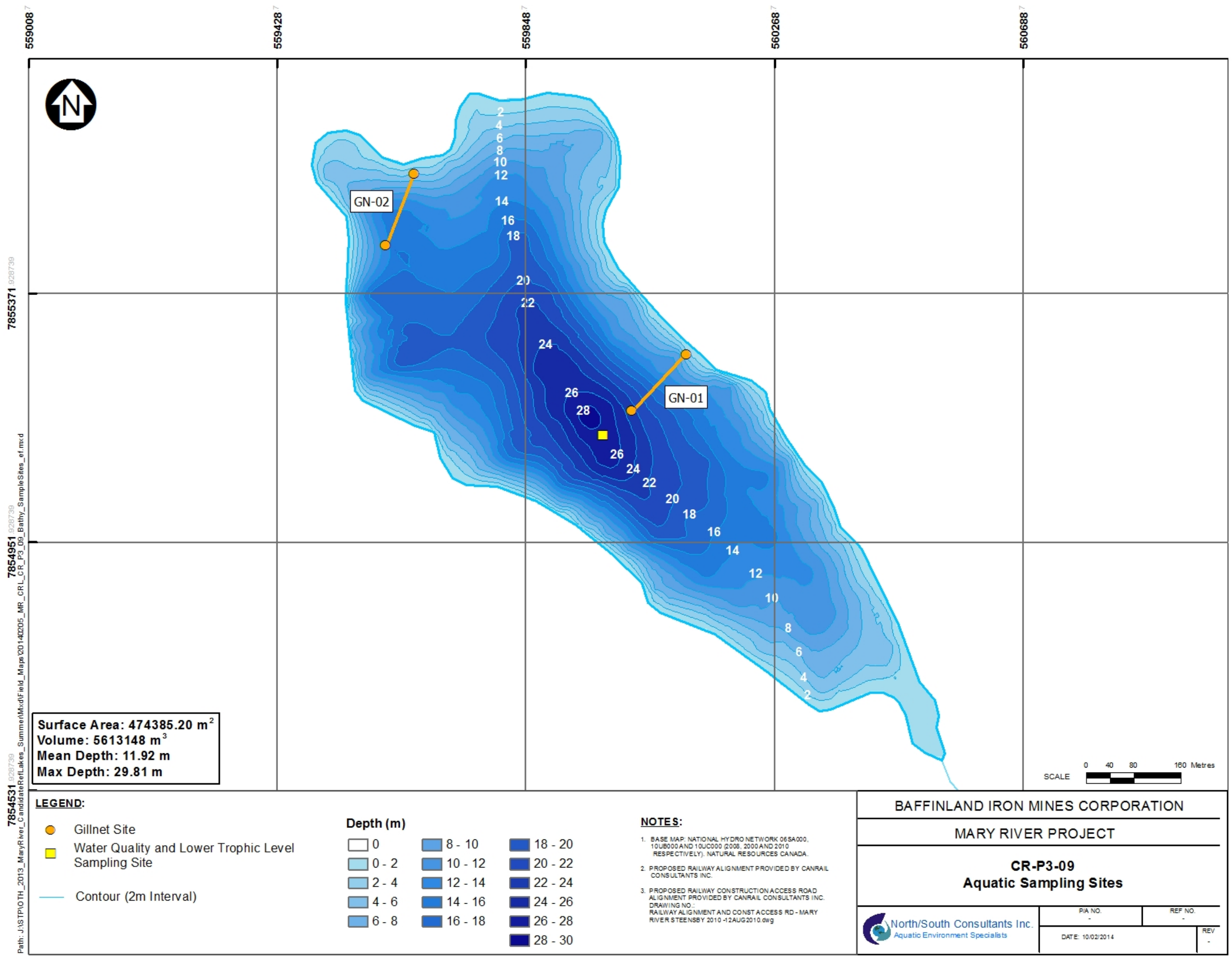


Figure 2. Bathymetry and locations of water quality, lower trophic level (phytoplankton & zooplankton), and fish sampling sites in Lake CR-P3-09.

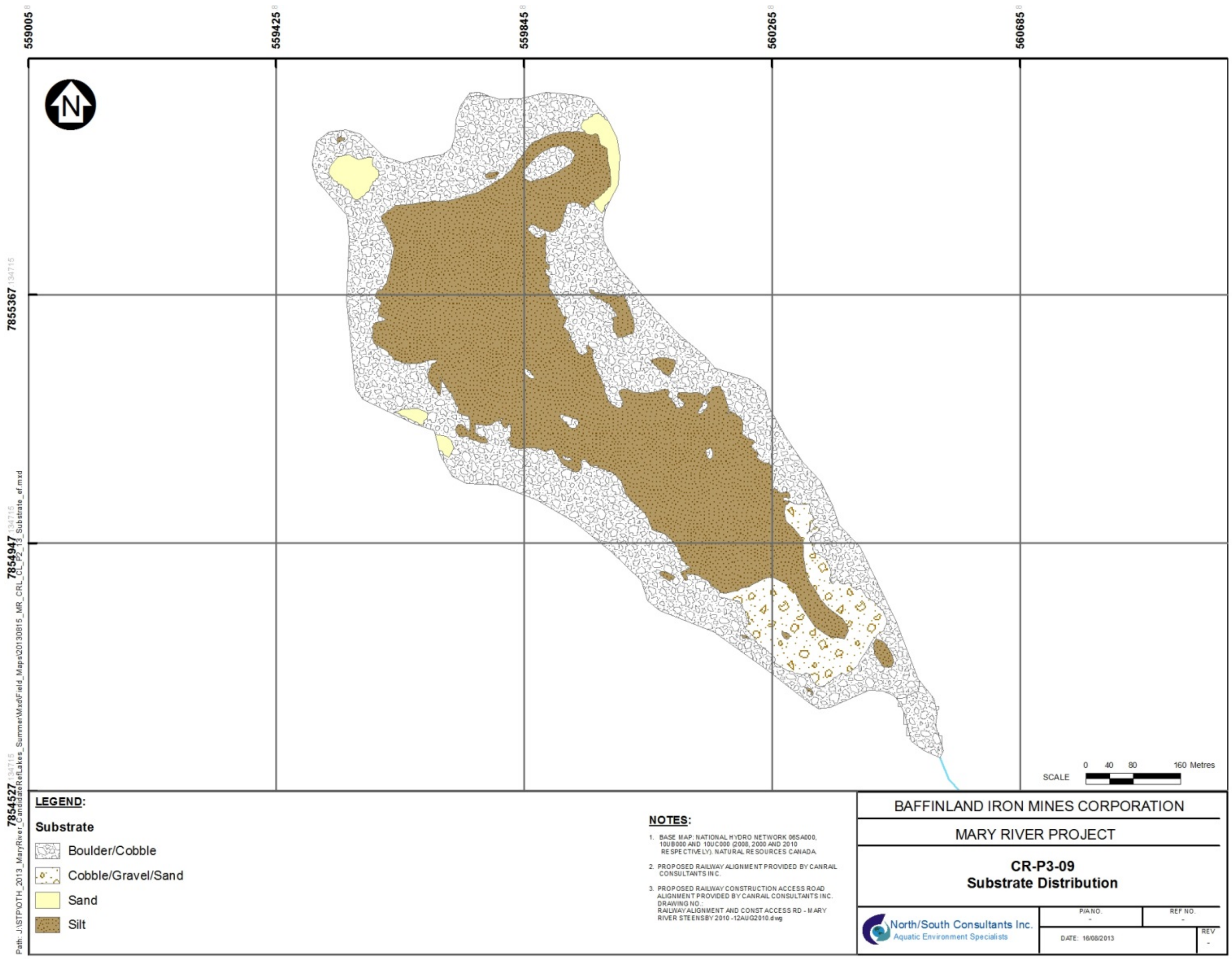


Figure 3. Substrate distribution map for Lake CR-P3-09, summer 2013.

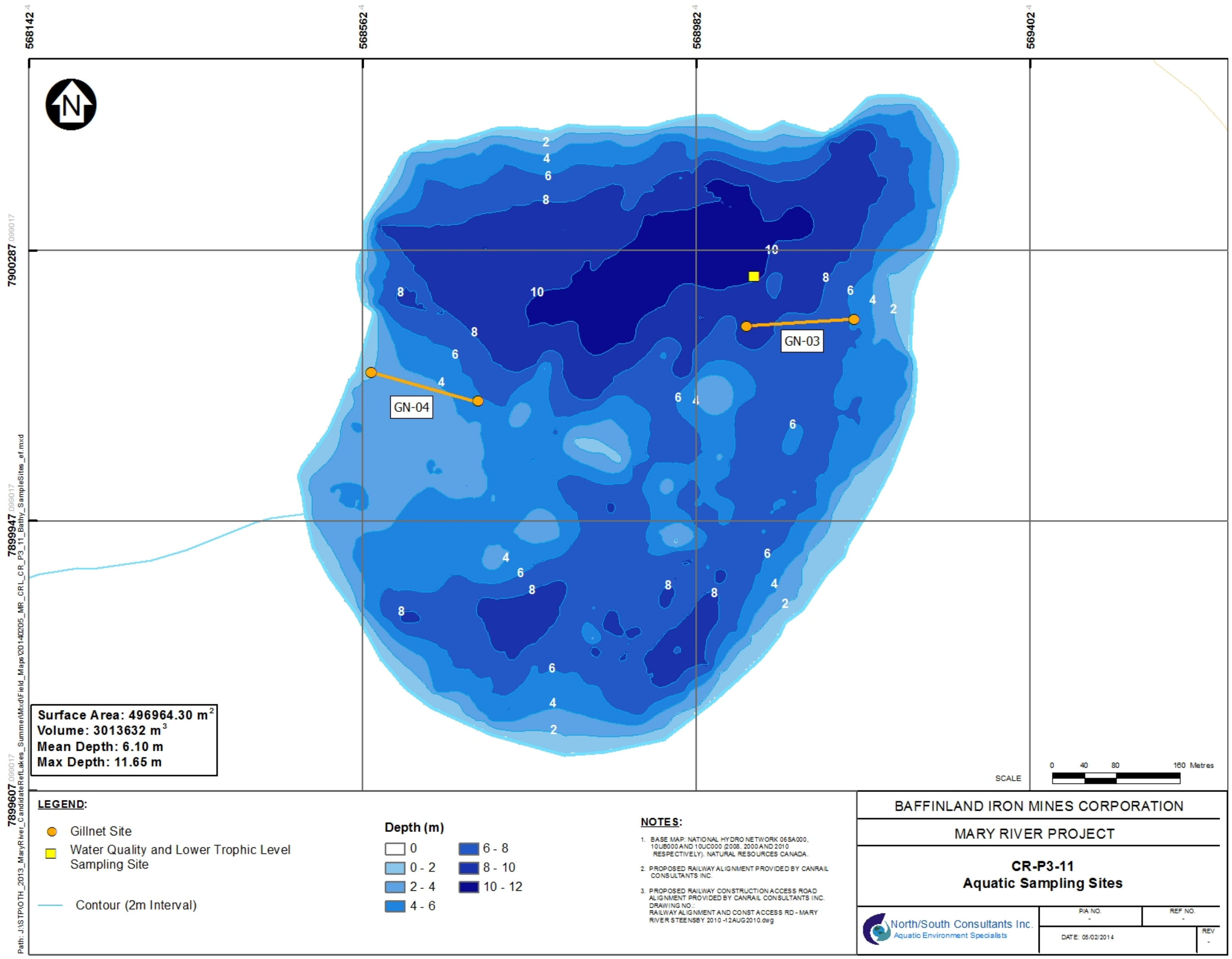


Figure 4. **Bathymetry and locations of water quality, lower trophic level (phytoplankton, zooplankton & BMI), and fish sampling sites in Lake CR-P3-11.**

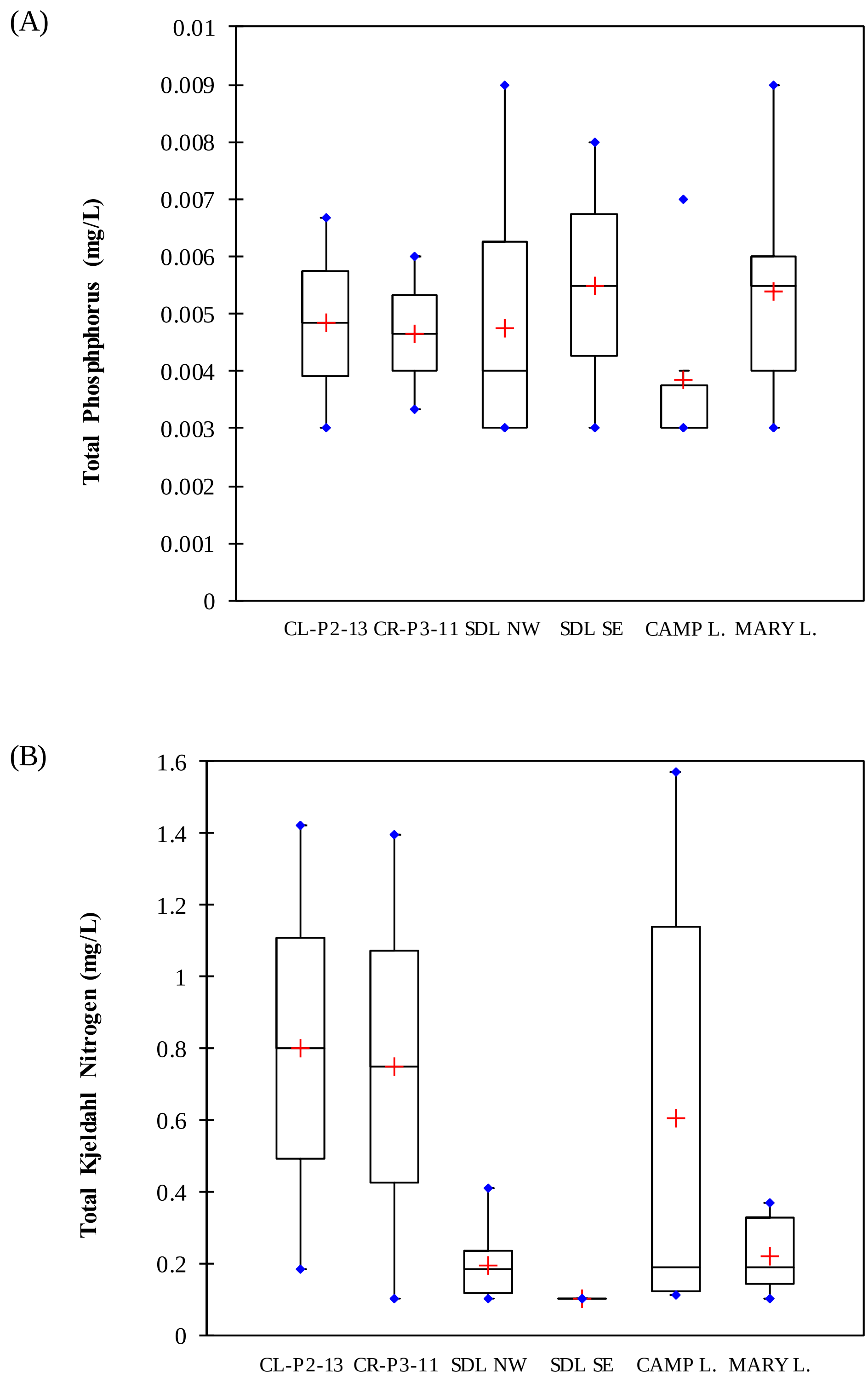


Figure 5. Total phosphorus (A) and total Kjeldahl nitrogen (B) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

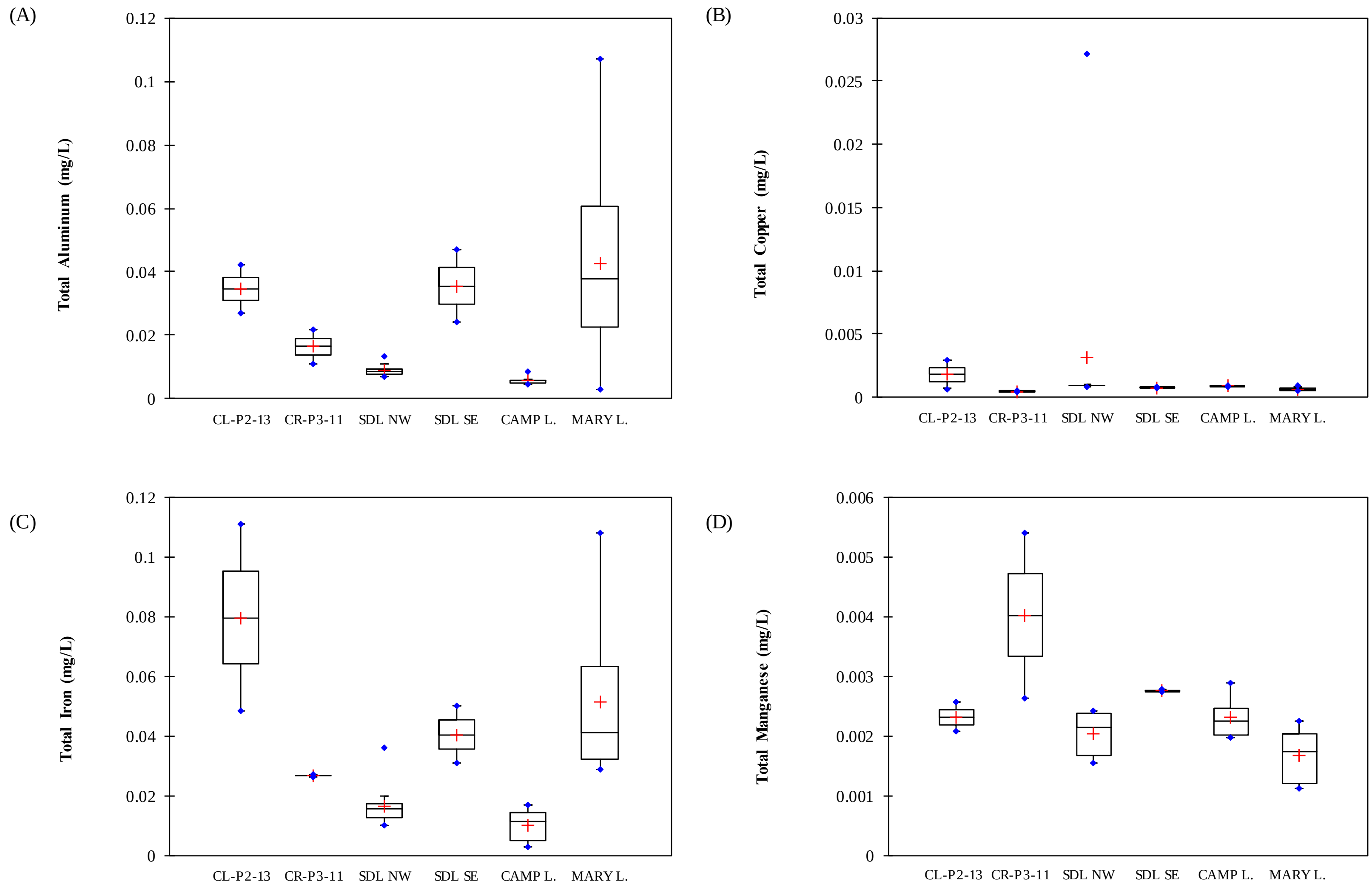


Figure 6. **Total aluminum (A), total copper (B), total iron (C), and total manganese (D) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.**

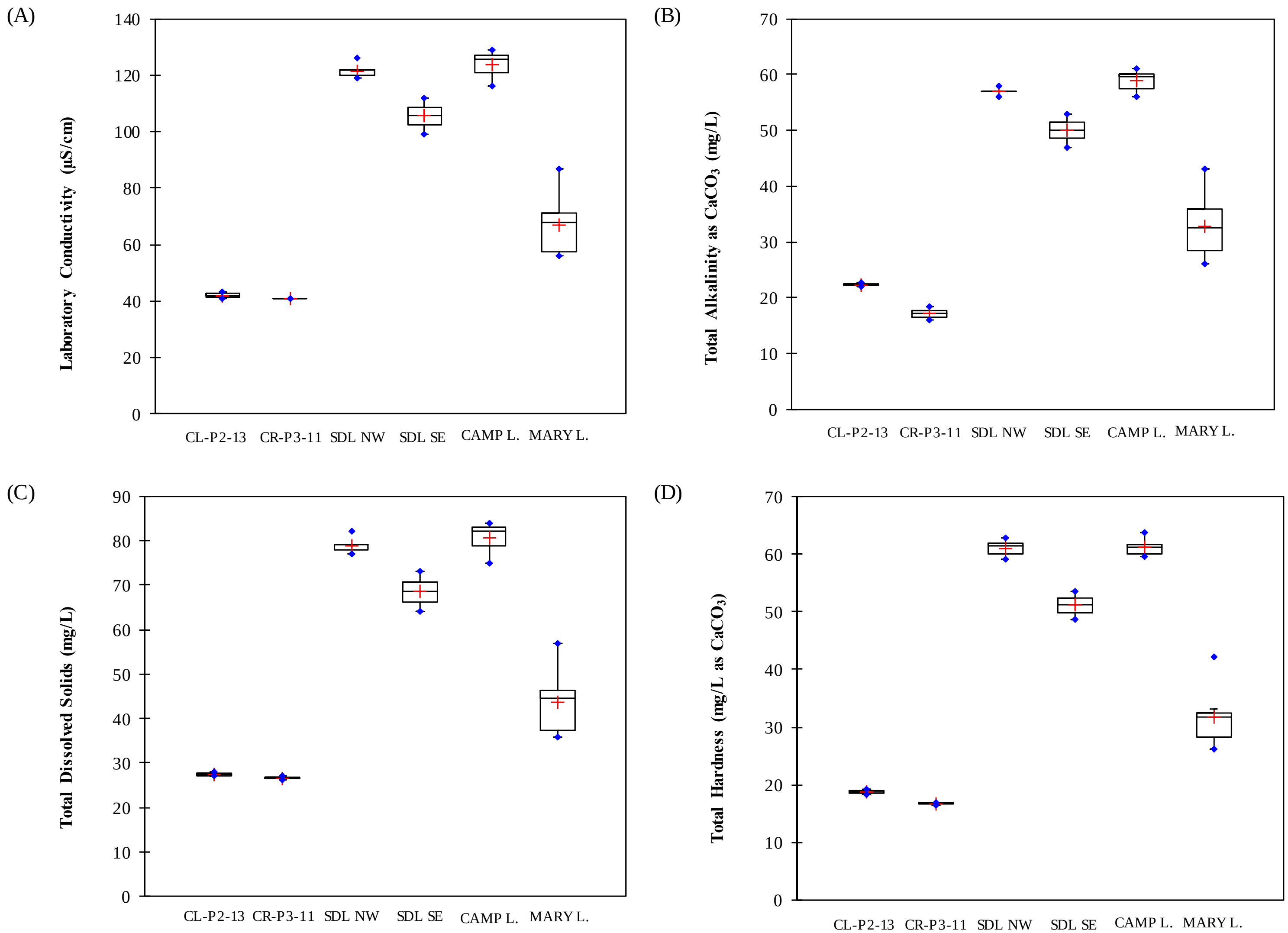


Figure 7. **Laboratory conductivity (A), total alkalinity (B), total dissolved solids (C), and hardness (D) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.**

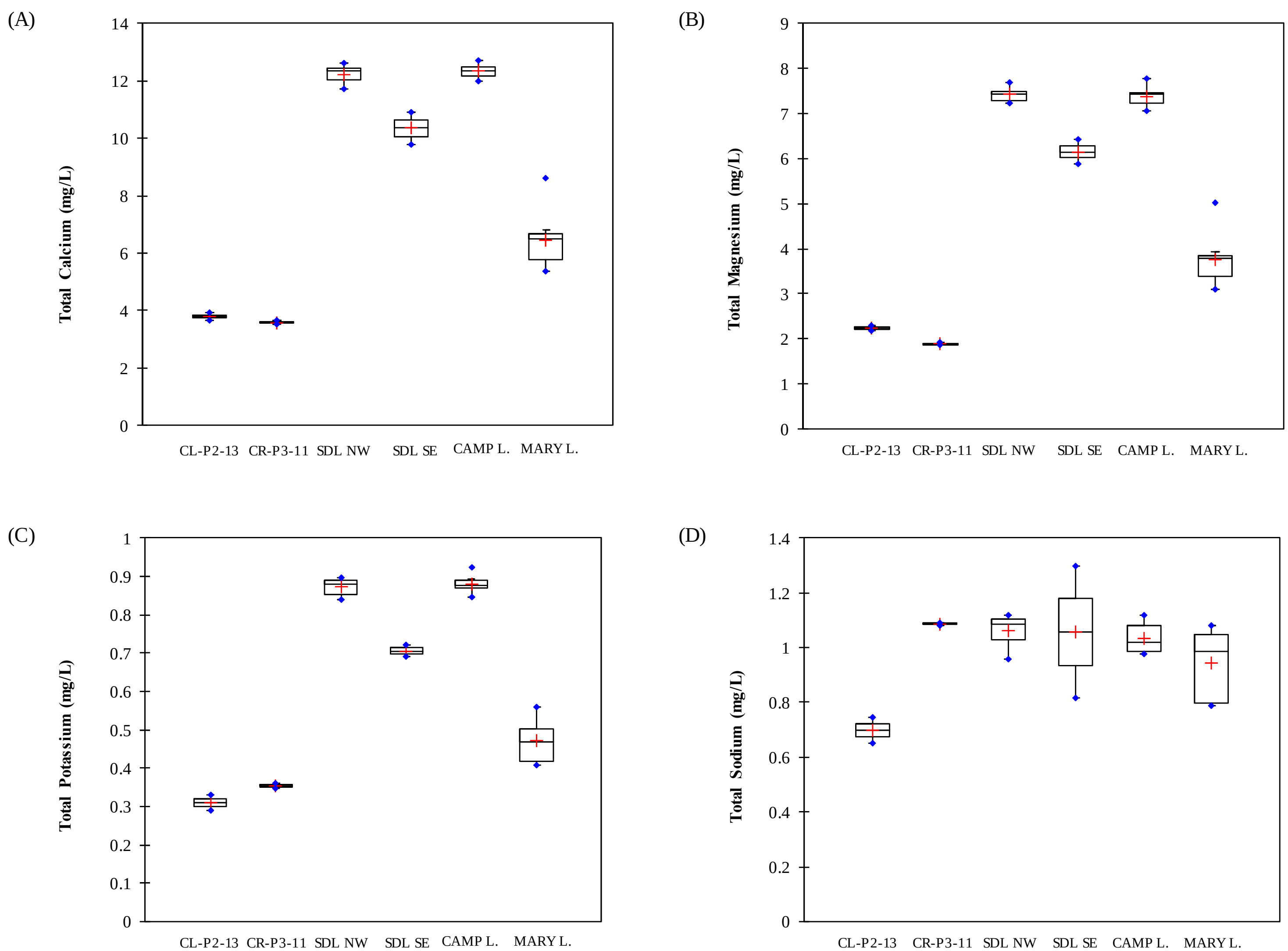


Figure 8. Total calcium (A), total magnesium (B), total potassium (C), and total sodium (D) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

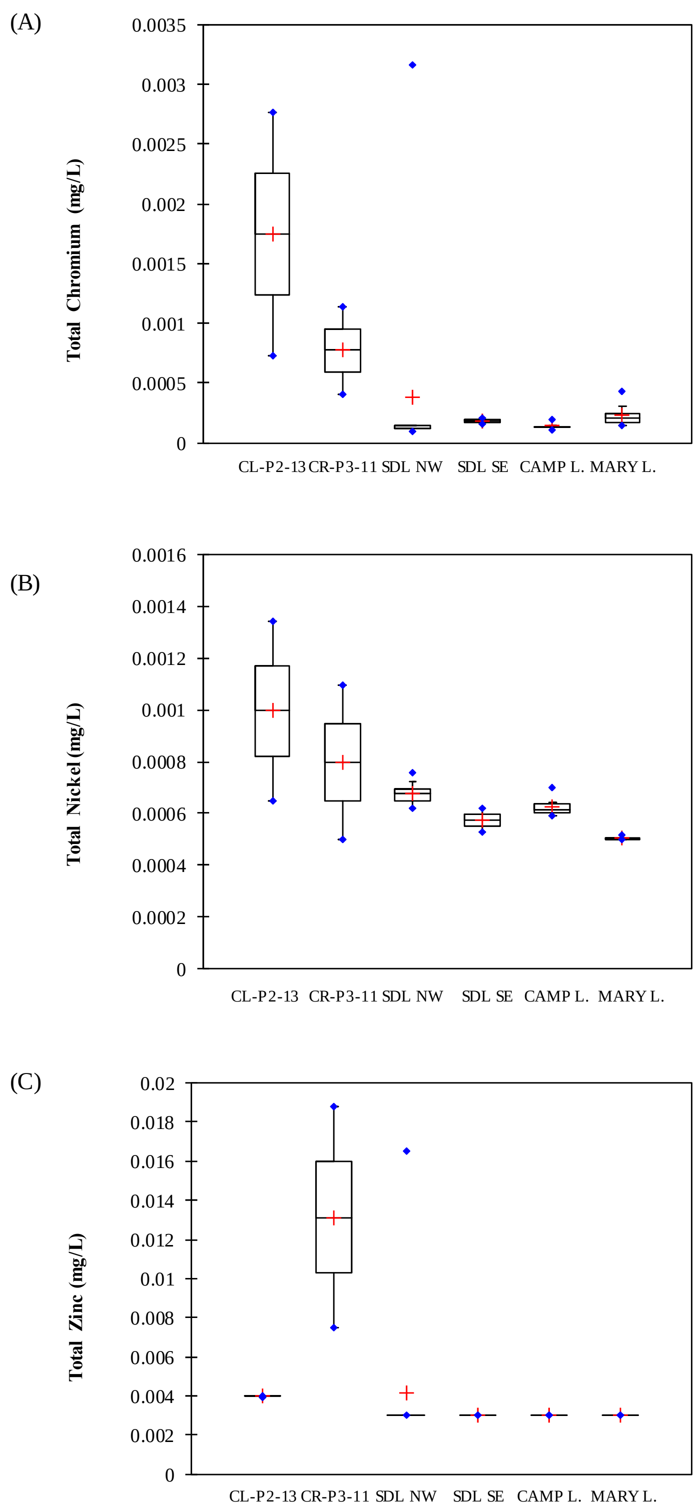


Figure 9. Total chromium (A), total nickel (B), and total zinc (C) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

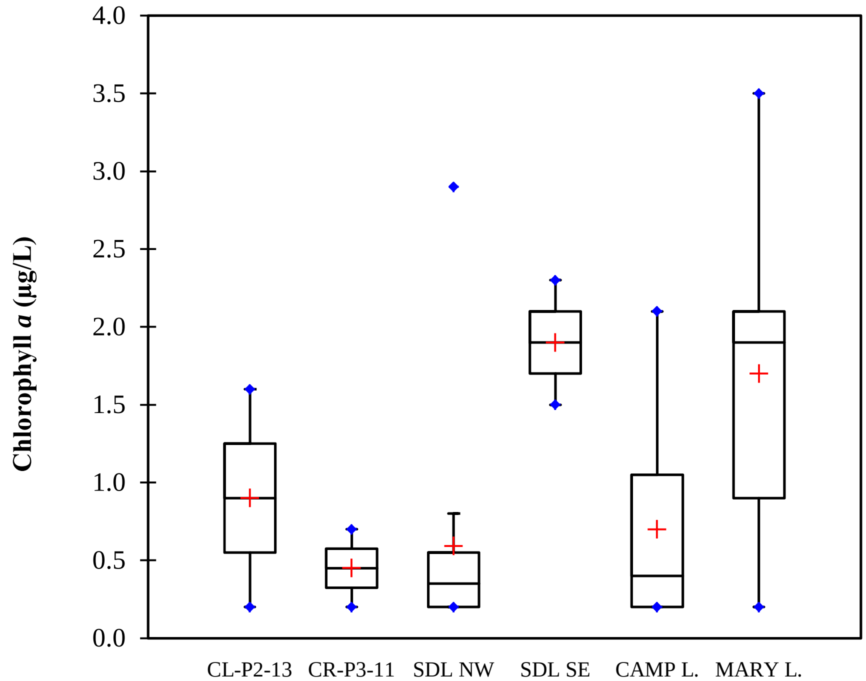


Figure 10. Chlorophyll *a* measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

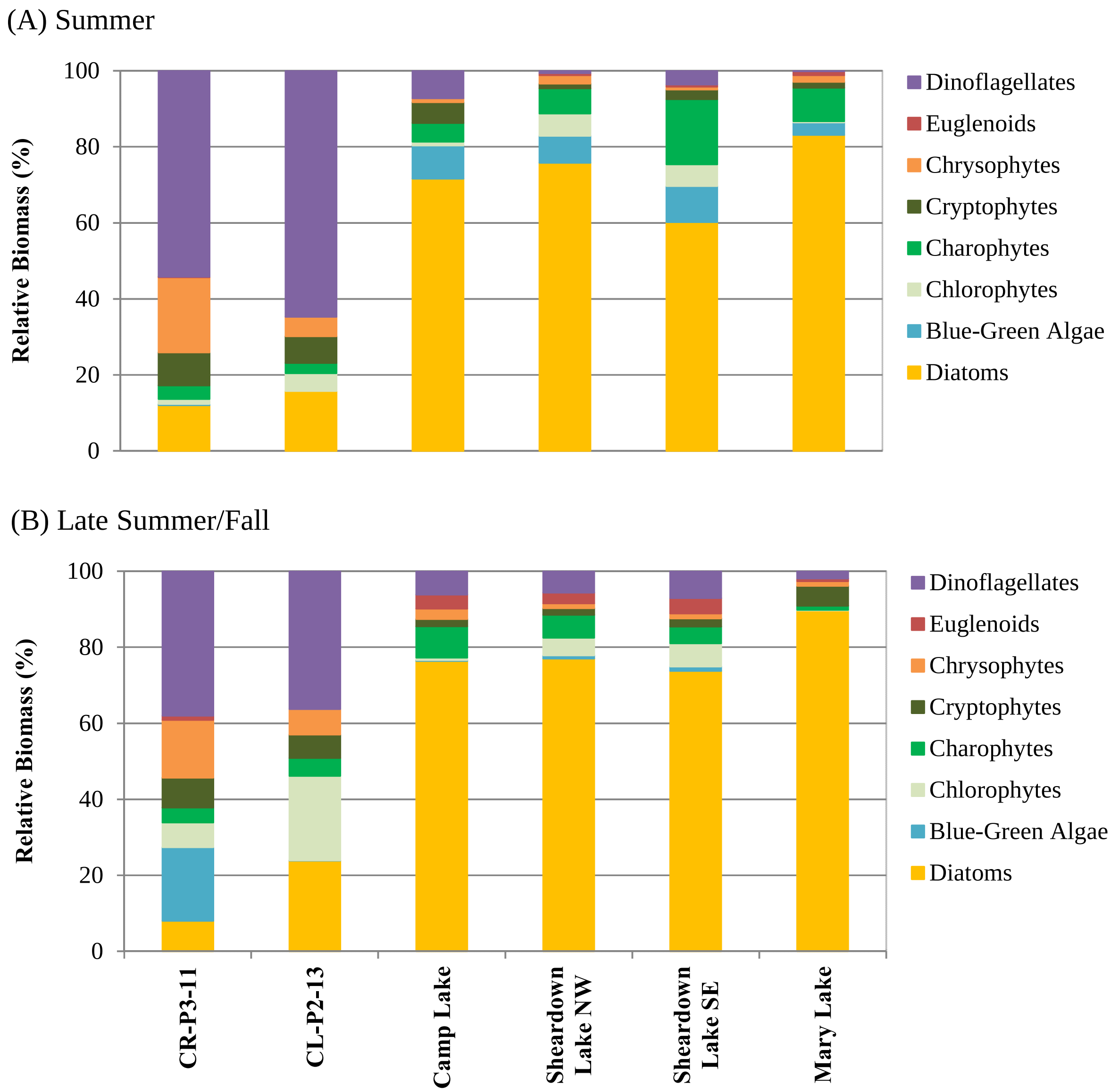


Figure 11. Percent relative biomass of major groups of phytoplankton measured in reference lakes (summer and fall 2013) and Mine Area lakes (summer and late summer/fall, 2007 and 2008).

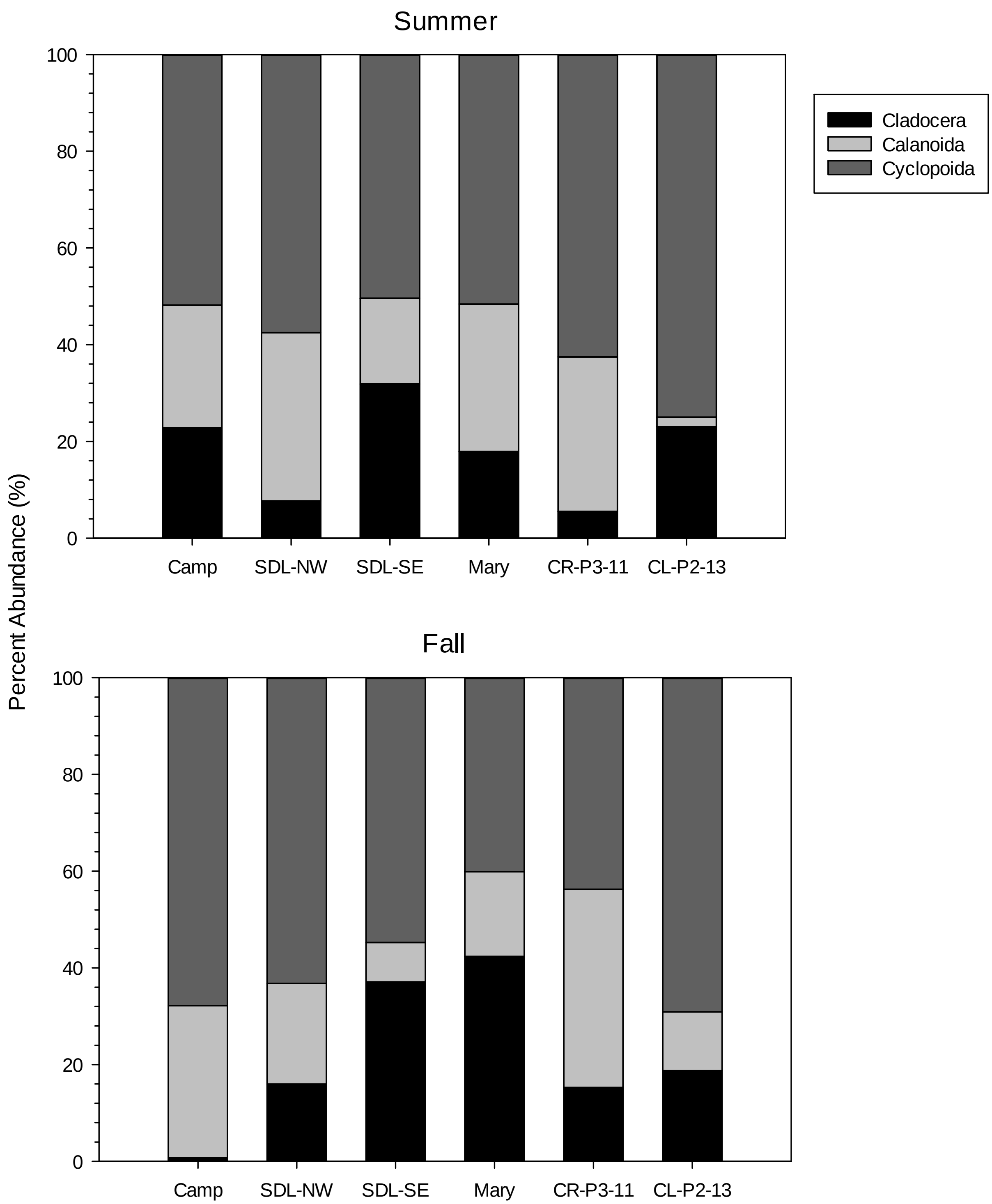


Figure 12. Seasonal relative abundance of crustacean zooplankton in Mine Area (2007 and 2008) and candidate reference (2013) lakes.

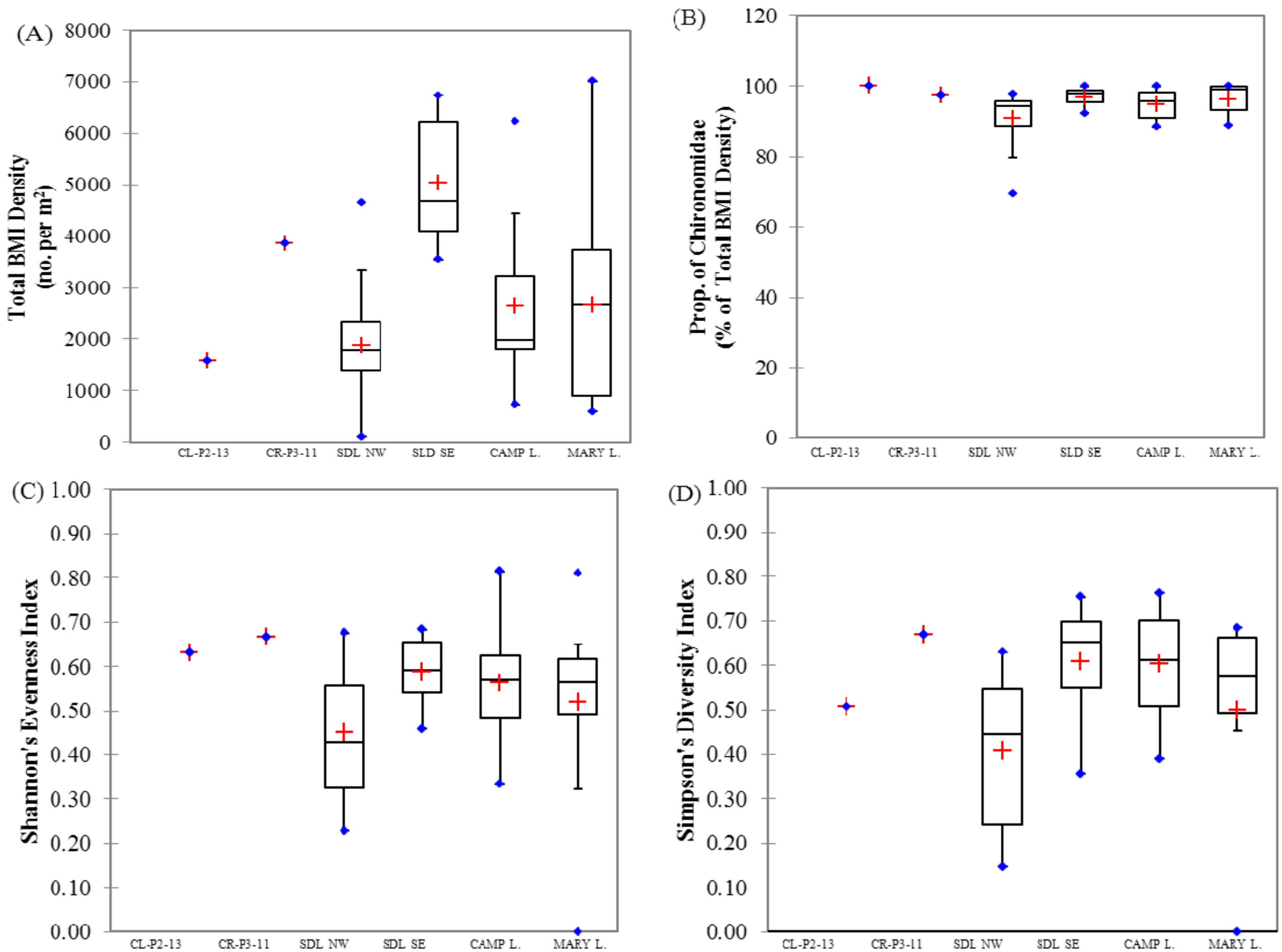


Figure 13. **Total benthic macroinvertebrate (BMI) density (A), proportion of Chironomidae (B), Shannon's evenness index (C), and Simpson's diversity index (D) measures calculated from samples collected in the offshore profundal zone of candidate reference lakes (2013) and Mine Area lakes (2006, 2007, 2008, 2011, 2013).**

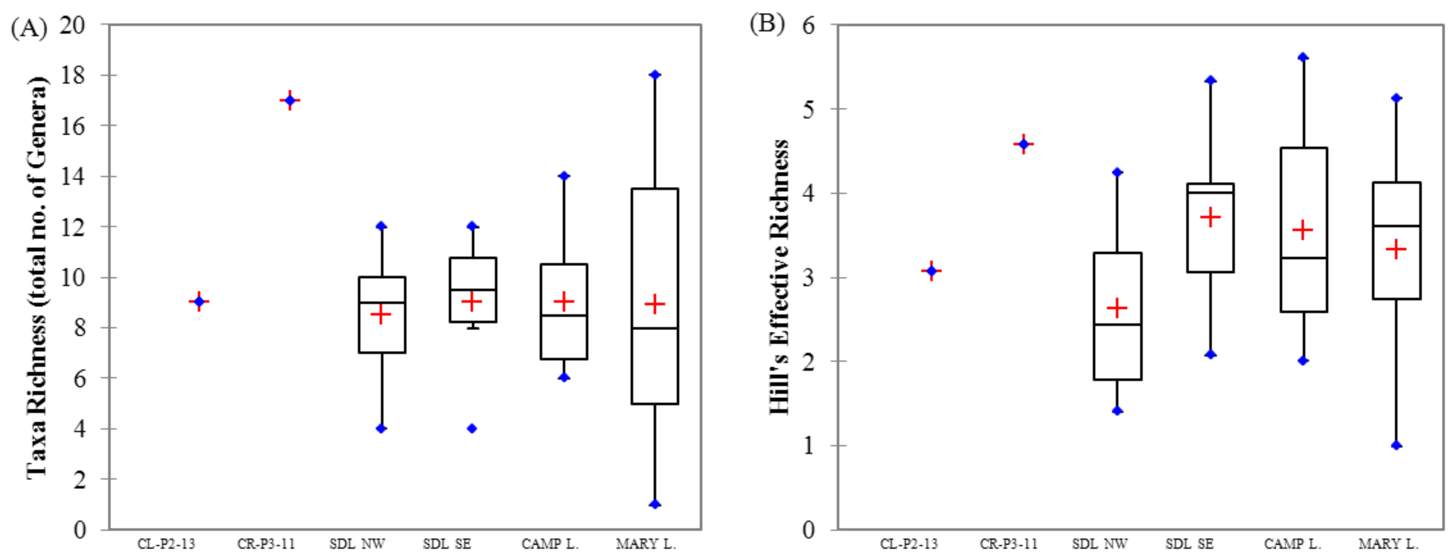


Figure 14. **Total number of benthic macroinvertebrate taxa (genus-level) (A), and Hill's effective richness (B) measures calculated from samples collected in the offshore profundal zone of candidate reference lakes (CL-P2-13 and CR-P3-11; 2013) and Mine Area lakes (2006, 2007, 2008, 2011, 2013). Note: taxa richness for candidate reference lakes is the total number of taxa observed, not the average number of taxa.**

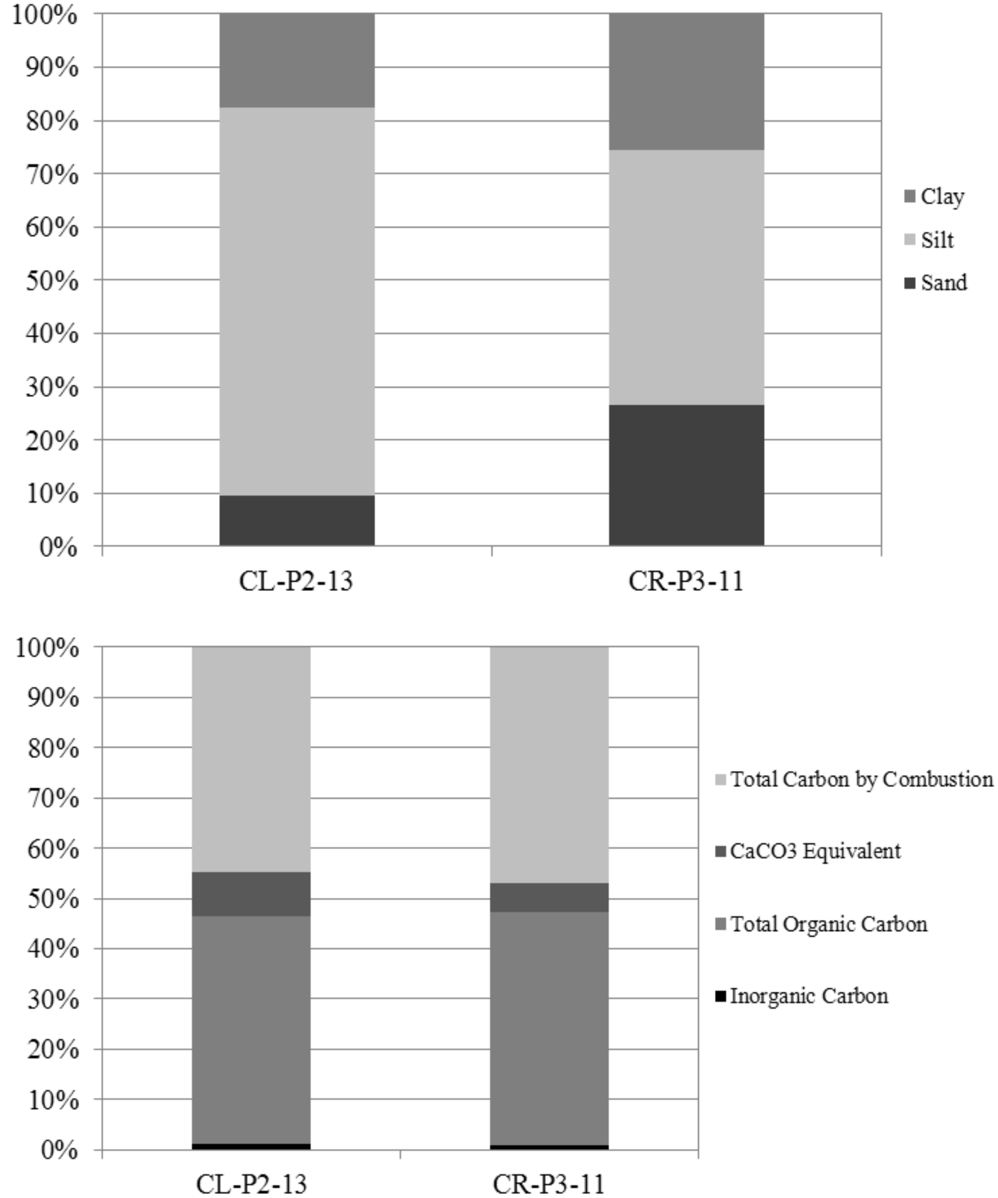


Figure 15. **Particle size (% sand, % silt, % clay) (A) and organic carbon analyses (%) (B) from benthic sediment samples collected in the offshore profundal zone of candidate reference lakes (CL-P2-13 and CR-P3-11; 2013).**

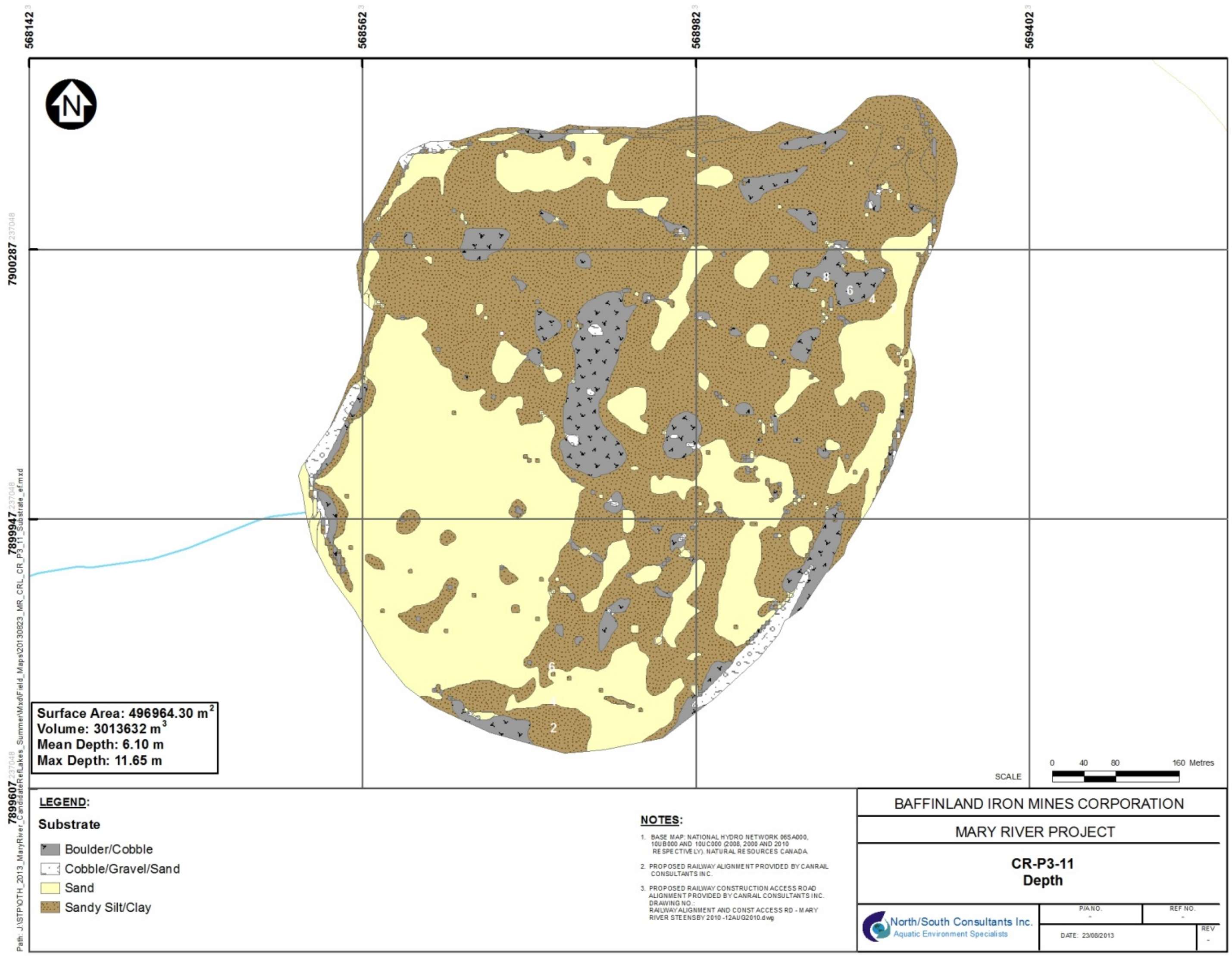


Figure 16. Substrate distribution map for Lake CR-P3-11, summer 2013.

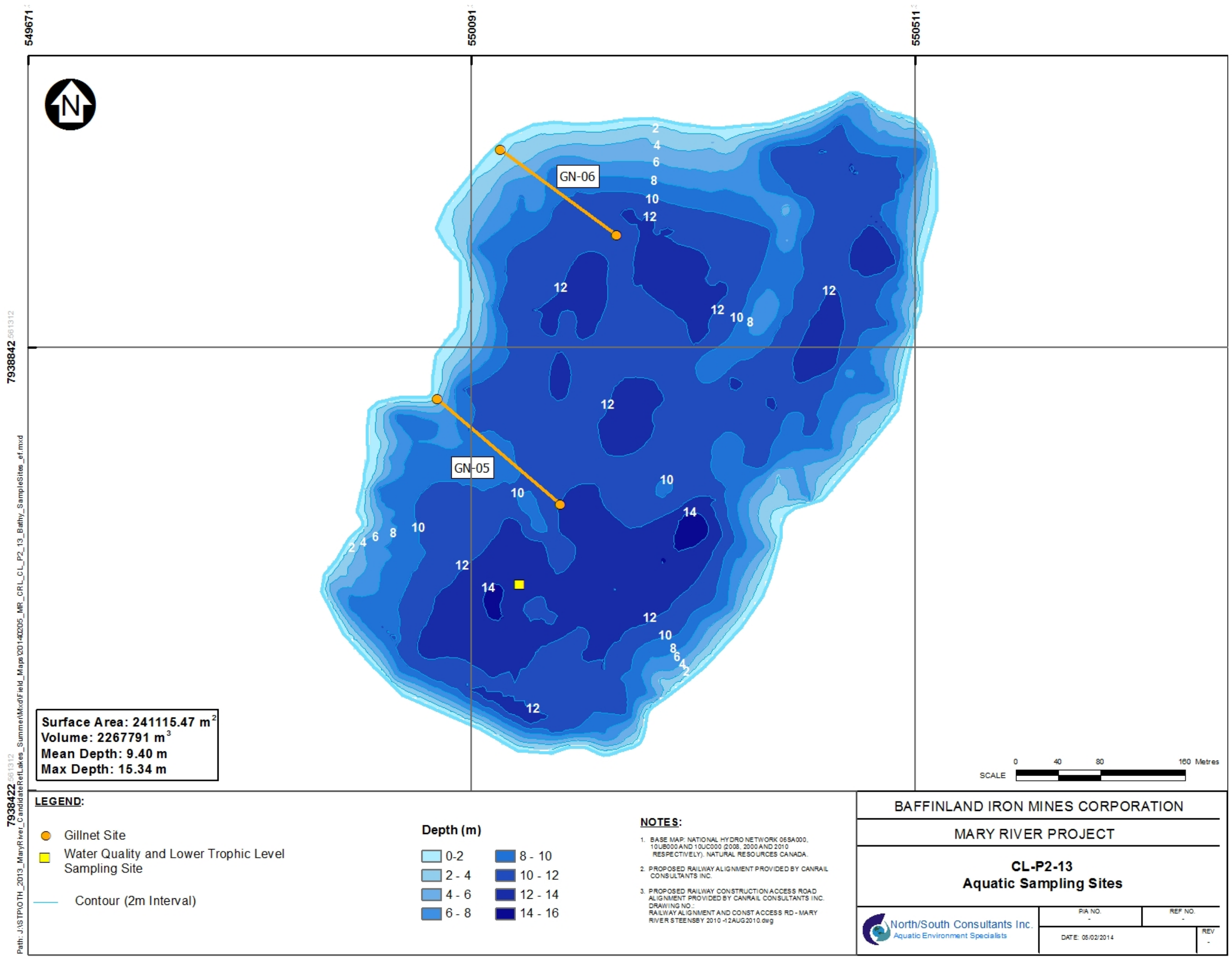


Figure 17. Bathymetry and locations of water quality, lower trophic level (phytoplankton, zooplankton & BMI), and fish sampling sites in Lake CL-P2-13.

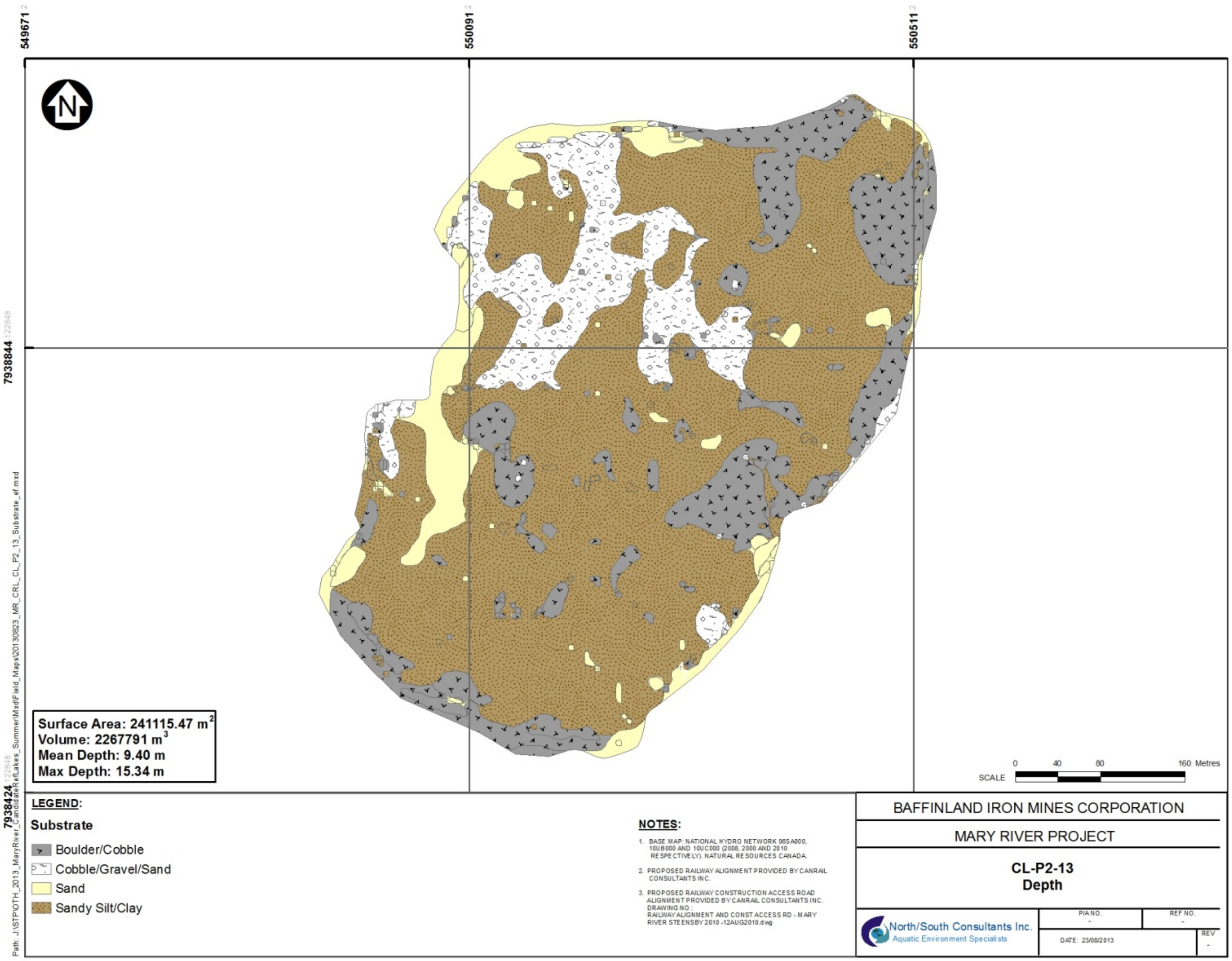


Figure 18. Substrate distribution map for Lake CL-P2-13, summer 2013.

APPENDIX 1. CANDIDATE REFERENCE LAKE WATER QUALITY DATA, 2013

Table A1-1. Summary of water quality sampling conducted in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Site Depth (m)	Secchi Depth (m)	*in situ* Sample	Surface Sample	Bottom Sample
		Easting	Northing							
CR-P3-09	WQ-01	559980	7855131	05-Aug-13	15:10	28.4	9.25	Y	Y	N
CR-P3-11	WQ-02	569055	7900254	06-Aug-13	17:00	10.5	6.50	Y	Y	Y
CL-P2-13	WQ-03	550137	7938617	07-Aug-13	14:00	12.9	4.35	Y	Y	Y

Table A1-2. *In situ* water quality parameters measured in Lake CR-P3-09, summer 2013.

Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO (% saturation)	DO (mg/L)	pH	Turbidity (FNU)	Secchi Disk Depth (m)
1	8.5	44.9	95.8	11.30	8.11	0.04	9.25
2	8.2	44.9	96.6	11.43	8.03	0.08	
3	7.6	45.2	96.4	11.53	7.94	0.04	
4	7.6	45.2	96.8	11.58	7.88	0.05	
5	7.4	45.3	96.2	11.58	7.85	0.04	
6	7.3	45.5	96.5	11.63	7.71	0.06	
7	7.2	45.5	96.4	11.63	7.69	0.03	
8	7.2	45.5	96.2	11.64	7.68	0.05	
9	7.1	45.5	96.1	11.65	7.68	0.05	
10	7.0	45.6	96.1	11.66	7.67	0.06	
11	7.0	45.5	96.0	11.67	7.65	0.06	
12	6.9	45.6	95.9	11.67	7.66	0.04	
13	6.8	45.6	95.7	11.69	7.65	0.04	
14	6.7	45.6	95.5	11.71	7.64	0.05	
15	6.6	45.6	95.5	11.72	7.64	0.05	
16	6.5	45.6	95.3	11.73	7.63	0.05	
17	6.2	45.6	94.9	11.77	7.62	0.05	
18	6.1	45.6	95.0	11.79	7.61	0.04	
19	6.1	45.6	95.0	11.79	7.60	0.04	
20	6.0	45.6	94.8	11.80	7.59	0.05	
21	6.0	45.6	94.7	11.80	7.58	0.03	
22	5.8	45.6	94.6	11.81	7.58	0.06	
23	5.9	45.6	94.6	11.80	7.58	0.04	
24	5.9	45.6	94.6	11.81	7.57	0.05	
25	5.8	45.6	94.5	11.81	7.57	0.04	

Table A1-3. *In situ* water quality parameters measured in potential reference Lake CR-P3-11, summer and fall 2013.

Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO (%)	DO (mg/L)	pH	Turbidity (FNU)	Secchi Disk Depth (m)
August 6, 2013							
1	9.6	38.7	99.4	11.33	7.91	0.06	6.5
2	9.6	38.7	99.8	11.37	7.83	0.06	
3	9.6	38.7	99.9	11.39	7.77	0.06	
4	9.4	38.7	99.8	11.42	7.73	0.07	
5	9.4	38.7	99.8	11.43	7.67	0.08	
6	9.3	38.7	99.8	11.46	7.64	0.07	
7	9.3	38.7	99.7	11.45	7.61	0.08	
8	9.0	38.7	99.4	11.50	7.60	0.08	
9	8.2	38.6	98.3	11.60	7.57	0.05	
September 4, 2013							
1	4.4	41.5	90.6	11.75	8.10	0.32	5.75
2	4.4	44.1	91.8	11.90	7.82	0.29	
3	4.4	44.1	91.2	11.82	7.74	0.33	
4	4.4	44.0	91.5	11.87	7.63	0.32	
5	4.4	44.0	91.4	11.85	7.59	0.32	
6	4.4	44.0	91.2	11.84	7.52	0.30	
7	4.4	44.0	91.2	11.83	7.50	0.29	
8	4.4	43.9	90.4	11.73	7.56	0.37	
9	4.4	43.8	90.5	11.74	7.55	0.32	

Table A1-4. *In situ* water quality parameters measured in potential reference Lake CL-P2-13, summer and fall 2013.

Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO (%)	DO (mg/L)	pH	Turbidity (FNU)	Secchi Disk Depth (m)
August 7, 2013							
1	6.9	40.8	93.7	11..46	8.23	0.58	4.35
2	6.8	40.7	96.3	11.75	8.02	0.60	
3	6.8	40.7	97.3	11.88	7.96	0.58	
4	6.8	40.7	97.7	11.92	7.82	0.63	
5	6.7	40.7	97.6	11.93	7.73	0.57	
6	6.6	40.7	97.4	11.96	7.59	0.61	
7	6.4	40.7	97.6	12.01	7.42	0.59	
8	6.4	40.8	97.5	12.01	7.37	0.62	
9	5.8	40.6	96.8	12.08	7.29	0.59	
10	5.6	40.7	96.7	12.14	7.23	0.58	
11	5.4	40.6	96.4	12.18	7.20	0.61	
September 4, 2013							
1	3.8	43.2	87.8	11.55	7.42	0.73	4.25
2	3.8	43.2	87.5	11.52	7.66	0.74	
3	3.8	43.3	87.2	11.49	7.58	0.71	
4	3.8	43.3	87.1	11.47	7.66	0.67	
5	3.8	43.2	87.0	11.46	7.61	0.66	
6	3.8	43.3	86.9	11.45	7.48	0.70	
7	3.8	43.2	86.8	11.43	7.43	0.64	
8	3.8	43.2	86.7	11.43	7.62	0.70	
9	3.8	43.3	86.7	11.42	7.60	0.66	
10	3.8	43.2	86.6	11.41	7.51	0.70	
11	3.8	43.2	86.5	11.40	7.46	0.70	
12	3.8	43.3	86.5	11.39	7.38	0.67	

Table A1-5. Laboratory water quality results for lakes CR-P3-11 and CL-P2-13, 2013.

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Chlorophyll *a*	Pheophytin *a*	pH	Conductivity	Turbidity	Alkalinity as $CaCO_3$	Bromide	Chloride	Hardness as $CaCO_3$ (Dissolved)	Hardness as $CaCO_3$ (Total)	Ammonia	Nitrite	Nitrate/nitrite	Nitrate	Sulphate	Total Dissolved Solids	Total Suspended Solids
					µg/L	µg/L		µS/cm	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg N/L	mg N/L	mg N/L	mg N/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.2	0.2	6.72	39	0.3	17	<0.25	2	15.8	16.2	0.03	<0.005	<0.10	<0.10	<3	25	<2
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.2	2.8	6.71	39	0.4	17	<0.25	2	15.9	16.5	0.04	<0.005	<0.10	<0.10	<3	25	<2
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.2	0.7	6.86	45	0.5	21	<0.25	2	15.9	16.7	0.03	<0.005	<0.10	<0.10	<3	29	<2
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		1.1	<0.2	6.71	39	0.5	16	<0.25	2	15.8	16.2	0.04	<0.005	<0.10	<0.10	<3	25	<2
CP-P3-11	CR-P3-11S	2013-09-04	Surface		0.7	<0.2	6.64	41	0.8	16	<0.25	2	16.2	17.0	0.03	<0.005	<0.10	<0.10	<3	27	<2
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		1.8	<0.2	6.63	41	0.7	17	<0.25	2	16.0	16.8	0.05	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.2	1.4	6.77	41	0.8	22	<0.25	<1	18.5	18.2	1.01	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.2	2.7	6.76	41	0.9	22	<0.25	<1	18.8	18.0	0.04	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	1.5	<0.2	6.69	42	0.9	23	<0.25	<1	18.7	19.1	<0.02	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	2.3	<0.2	6.68	43	1.1	22	<0.25	<1	19.1	19.3	<0.02	<0.005	<0.10	<0.10	<3	28	<2
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	1.0	<0.2	6.71	44	1.0	23	<0.25	<1	19.2	19.2	<0.02	<0.005	<0.10	<0.10	<3	29	<2
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		3.8	<0.2	6.69	43	0.8	23	<0.25	<1	18.9	19.1	0.93	<0.005	<0.10	<0.10	<3	28	<2
	CL-P2-13F	2013-08-07		Field Blank	<0.2	<0.2	5.75	<5	0.1	<5	<0.25	<1	<0.5	<0.5	0.17	<0.005	<0.10	<0.10	<3	<1	<2
	Trip Blank	2013-09-04		Trip Blank	1.5	<0.2	6.19	<5	<0.1	<5	<0.25	<1	<0.5	<0.5	<0.02	<0.005	<0.10	<0.10	<3	<1	<2
	Field Blank	2013-09-04		Field Blank	2.0	<0.2	5.72	<5	<0.1	<5	<0.25	<1	<0.5	<0.5	<0.02	<0.005	<0.10	<0.10	<3	<1	<2

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Total Phosphorus	Total Kjeldahl Nitrogen	Phenols	Total Organic Carbon	Dissolved Organic Carbon	Aluminum (Dissolved)	Aluminum (Total)	Antimony (Dissolved)	Antimony (Total)	Arsenic (Dissolved)	Arsenic (Total)	Barium (Dissolved)	Barium (Total)	Beryllium (Dissolved)	Beryllium (Total)	Bismuth (Dissolved)	Bismuth (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	0.004	0.68	<0.001	1.7	1.7	0.0042	0.0106	<0.00010	<0.00010	<0.00010	<0.00010	0.0026	0.00260	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	0.003	0.14	<0.001	1.8	1.6	0.0039	0.0114	<0.00010	<0.00010	<0.00010	<0.00010	0.00261	0.00269	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	0.003	3.37	<0.001	2	1.7	0.0039	0.0112	<0.00010	<0.00010	<0.00010	<0.00010	0.00259	0.00274	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		0.003	0.11	<0.001	1.8	1.7	0.0047	0.0136	<0.00010	<0.00010	<0.00010	<0.00010	0.00268	0.00263	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CR-P3-11S	2013-09-04	Surface		0.006	<0.10	<0.001	2.2	2.2	0.0046	0.0218	<0.00010	<0.00010	<0.00010	<0.00010	0.00287	0.00284	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		0.005	0.11	<0.001	2	2	0.0044	0.0237	<0.00010	<0.00010	<0.00010	<0.00010	0.00287	0.00287	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.003	1.42	<0.001	1.1	0.8	0.0040	0.0271	<0.00010	<0.00010	<0.00010	<0.00010	0.00215	0.00233	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		0.003	1.33	<0.001	0.9	0.8	0.0046	0.0287	<0.00010	<0.00010	<0.00010	<0.00010	0.00211	0.00218	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	0.004	0.35	<0.001	1.4	1.2	0.0033	0.0323	<0.00010	<0.00010	<0.00010	0.00013	0.00231	0.00248	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	0.009	<0.10	0.021	1.1	1.3	0.0037	0.0504	<0.00010	<0.00010	<0.00010	0.00014	0.00223	0.00248	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	0.007	<0.10	0.029	1.2	1.4	0.0044	0.0434	<0.00010	<0.00010	<0.00010	0.00015	0.00222	0.00263	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		0.06	1.12	<0.001	1.1	1.2	0.0042	0.3870	<0.00010	<0.00010	<0.00010	<0.00010	0.00226	0.00381	<0.00010	<0.00002	<0.00050	<0.00050
	CL-P2-13F	2013-08-07		Field Blank	<0.003	0.37	<0.001	<0.5	<0.5	<0.001	<0.001	<0.00010	<0.00010	<0.00010	<0.00010	0.000788	0.000596	<0.00010	<0.00002	<0.00050	<0.00050
	Trip Blank	2013-09-04		Trip Blank	<0.003	<0.10	<0.001	<0.5	<0.5	<0.001	<0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.000050	<0.00010	<0.00002	<0.00050	<0.00050
	Field Blank	2013-09-04		Field Blank	<0.003	<0.10	<0.001	<0.5	<0.5	<0.001	<0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.000050	<0.00010	<0.00002	<0.00050	<0.00050

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Boron (Dissolved)	Boron (Total)	Cadmium (Dissolved)	Cadmium (Total)	Calcium (Dissolved)	Calcium (Total)	Chromium (Dissolved)	Chromium (Total)	Hexavalent Chromium (dissolved(	Cobalt (Dissolved)	Cobalt (Total)	Copper (Dissolved)	Copper (Total)	Iron (Dissolved)	Iron (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.01	<0.01	<0.000010	<0.000010	3.37	3.47	<0.00010	0.00029	<0.001	<0.00010	<0.00010	0.0003	<0.00020	<0.01	0.02
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.01	<0.01	<0.000010	<0.000010	3.4	3.53	<0.00010	0.0022	<0.001	<0.00010	<0.00010	0.00031	0.0005	<0.01	0.032
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.01	<0.01	<0.000010	<0.000010	3.38	3.57	<0.00010	0.00092	<0.001	<0.00010	<0.00010	0.00034	0.00054	<0.01	0.027
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		<0.01	<0.01	<0.000010	<0.000010	3.37	3.45	<0.00010	0.00951	<0.001	<0.00010	<0.00010	0.00039	0.00052	<0.01	0.059
CP-P3-11	CR-P3-11S	2013-09-04	Surface		<0.01	<0.01	<0.000010	<0.000010	3.5	3.65	<0.00010	0.00041	<0.001	<0.00010	<0.00010	0.0004	0.0005	<0.01	0.027
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		<0.01	<0.01	<0.000010	0.000021	3.43	3.58	0.00015	0.00037	<0.001	<0.00010	<0.00010	0.00037	<0.00020	<0.01	0.03
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.01	<0.01	<0.000010	<0.000010	3.73	3.68	<0.00010	0.00277	<0.001	<0.00010	<0.00010	0.00045	0.00292	<0.01	0.111
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.01	<0.01	<0.000010	<0.000010	3.79	3.65	<0.00010	0.00019	<0.001	<0.00010	<0.00010	0.00053	0.00053	<0.01	0.028
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	<0.01	<0.01	<0.000010	<0.000010	3.81	3.88	0.0001	0.00037	<0.001	<0.00010	<0.00010	0.00054	0.00063	<0.01	0.038
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	<0.01	<0.01	<0.000010	<0.000010	3.96	3.94	<0.00010	0.0009	<0.001	<0.00010	<0.00010	0.00026	0.00071	<0.01	0.055
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	<0.01	<0.01	<0.000010	<0.000010	3.99	3.95	<0.00010	0.00093	<0.001	<0.00010	<0.00010	0.00031	0.00066	<0.01	0.052
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		<0.01	<0.01	<0.000010	<0.000010	3.87	3.77	<0.00010	0.00137	<0.001	<0.00010	0.00021	0.00046	0.00133	<0.01	0.522
	CL-P2-13F	2013-08-07		Field Blank	<0.01	<0.01	<0.000010	<0.000010	0.115	0.126	<0.00010	<0.00002	<0.001	<0.00010	<0.00010	<0.00020	<0.00020	<0.01	<0.003
	Trip Blank	2013-09-04		Trip Blank	<0.01	<0.01	<0.000010	<0.000010	<0.050	<0.050	<0.00010	<0.00002	<0.001	<0.00010	<0.00010	<0.00020	<0.00020	<0.01	<0.003
	Field Blank	2013-09-04		Field Blank	<0.01	<0.01	<0.000010	<0.000010	<0.050	<0.050	<0.00010	<0.00002	<0.001	<0.00010	<0.00010	<0.00020	<0.00020	<0.01	<0.003

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Lead (Dissolved)	Lead (Total)	Lithium (Dissolved)	Lithium (Total)	Magnesium (Dissolved)	Magnesium (Total)	Manganese (Dissolved)	Manganese (Total)	Mercury (Dissolved)	Mercury (Total)	Molybdenum (Dissolved)	Molybdenum (Total)	Nickel (Dissolved)	Nickel (Total)	Potassium (Dissolved)	Potassium (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.00005	<0.00005	<0.00005	<0.00005	1.80	1.83	0.00168	0.00534	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	0.342	0.351
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.00005	<0.00005	<0.00005	<0.00005	1.80	1.86	0.00154	0.00556	<0.000010	<0.000010	<0.000050	0.000072	<0.00050	0.00173	0.341	0.348
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.00005	0.00019	<0.00005	<0.00005	1.81	1.90	0.00171	0.00532	<0.000010	<0.000010	<0.000050	0.000063	<0.00050	0.00106	0.341	0.342
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		<0.00005	0.00006	<0.00005	<0.00005	1.80	1.83	0.00170	0.00647	<0.000010	<0.000010	0.000075	0.000216	0.00167	0.00524	0.347	0.336
CP-P3-11	CR-P3-11S	2013-09-04	Surface		<0.00005	<0.00005	<0.00005	<0.00005	1.82	1.91	0.000671	0.00263	<0.000010	<0.000010	<0.000050	0.000056	<0.00050	<0.00050	0.357	0.362
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		<0.00005	<0.00005	<0.00005	<0.00005	1.80	1.90	0.00144	0.00257	<0.000010	<0.000010	0.052	<0.000050	<0.00050	<0.00050	0.346	0.357
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.00005	0.00013	<0.00005	<0.00005	2.24	2.19	0.00121	0.00256	<0.000010	<0.000010	0.000181	0.00076	0.00166	0.00134	0.286	0.290
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.00005	<0.00005	<0.00005	<0.00005	2.26	2.17	0.000627	0.00192	<0.000010	<0.000010	0.000087	0.000052	0.00061	<0.00050	0.286	0.285
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	<0.00005	0.00005	<0.00005	<0.00005	2.24	2.28	0.000505	0.00187	<0.000010	<0.000010	0.000075	0.000077	0.00051	<0.00050	0.289	0.322
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	<0.00005	0.00006	<0.00005	<0.00005	2.23	2.29	0.000447	0.00217	<0.000010	<0.000010	<0.000050	0.000073	<0.00050	0.00078	0.287	0.334
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	<0.00005	0.00006	<0.00005	<0.00005	2.24	2.28	0.000439	0.00217	<0.000010	<0.000010	<0.000050	0.000064	0.00053	0.00067	0.296	0.333
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		<0.00005	0.00033	<0.00005	0.00061	2.25	2.35	0.000444	0.0109	<0.000010	<0.000010	0.000053	0.000056	<0.00050	0.00105	0.299	0.449
	CL-P2-13F	2013-08-07		Field Blank	<0.00005	<0.00005	<0.00005	<0.00005	<0.10	<0.10	<0.000050	0.000092	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	<0.050	<0.050
	Trip Blank	2013-09-04		Trip Blank	<0.00005	<0.00005	<0.00005	<0.00005	<0.10	<0.10	<0.000050	<0.000050	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	<0.050	<0.050
	Field Blank	2013-09-04		Field Blank	<0.00005	<0.00005	<0.00005	<0.00005	<0.10	<0.10	<0.000050	<0.000050	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	<0.050	<0.050

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Selenium (Dissolved)	Selenium (Total)	Silicon (Dissolved)	Silicon (Total)	Silver (Dissolved)	Silver (Total)	Sodium (Dissolved)	Sodium (Total)	Strontium (Dissolved)	Strontium (Total)	Thallium (Dissolved)	Thallium (Total)	Tin (Dissolved)	Tin (Total)	Titanium (Dissolved)	Titanium (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.0001	<0.00001	0.25	0.26	<0.0000010	<0.0000010	1.06	1.08	0.00462	0.00481	<0.000010	<0.000001	0.00031	0.00019	<0.01	<0.01
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.0001	<0.00001	0.25	0.26	<0.0000010	<0.0000010	1.07	1.1	0.0046	0.00479	<0.000010	<0.000001	0.00023	0.00018	<0.01	<0.01
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.0001	<0.00001	0.25	0.26	<0.0000010	<0.0000010	1.07	1.07	0.00461	0.00483	<0.000010	<0.000001	0.00039	0.0004	<0.01	<0.01
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		<0.0001	<0.00001	0.26	0.26	<0.0000010	<0.0000010	1.12	1.12	0.00467	0.00479	<0.000010	<0.000001	0.00098	0.00098	<0.01	<0.01
CP-P3-11	CR-P3-11S	2013-09-04	Surface		<0.0001	<0.00001	0.21	0.27	<0.0000010	<0.0000010	1.15	1.09	0.00489	0.00502	<0.000010	<0.000001	0.00047	0.0003	<0.01	<0.01
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		<0.0001	<0.00001	0.19	0.27	<0.0000010	<0.0000010	1.09	1.12	0.00475	0.00498	<0.000010	<0.000001	0.00038	0.0002	<0.01	<0.01
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.0001	<0.00001	0.32	0.35	<0.0000010	0.000016	0.667	0.652	0.00353	0.00352	<0.000010	<0.000001	0.0014	0.00077	<0.01	<0.01
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.0001	<0.00001	0.32	0.35	<0.0000010	<0.0000010	0.656	0.636	0.00344	0.0035	<0.000010	<0.000001	0.00036	0.00021	<0.01	<0.01
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	<0.0001	<0.00001	0.33	0.37	<0.0000010	<0.0000010	0.67	0.709	0.00357	0.00379	<0.000010	<0.000001	0.0005	0.00021	<0.01	<0.01
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	<0.0001	<0.00001	0.32	0.42	<0.0000010	<0.0000010	0.668	0.732	0.00351	0.00382	<0.000010	<0.000001	<0.00010	0.00019	<0.01	<0.01
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	<0.0001	<0.00001	0.32	0.37	<0.0000010	<0.0000010	0.679	0.791	0.00345	0.00391	<0.000010	<0.000001	<0.00010	0.00027	<0.01	<0.01
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		<0.0001	<0.00001	0.34	1.02	<0.0000010	0.000019	0.728	0.68	0.00358	0.00381	<0.000010	<0.000001	0.00034	0.00015	<0.01	0.02
	CL-P2-13F	2013-08-07		Field Blank	<0.0001	<0.00001	<0.050	<0.050	<0.0000010	<0.0000010	<0.0012	<0.0012	<0.00040	<0.00040	<0.000010	<0.000001	<0.00010	<0.00010	<0.01	<0.01
	Trip Blank	2013-09-04		Trip Blank	<0.0001	<0.00001	<0.050	<0.050	<0.0000010	<0.0000010	<0.0012	<0.0012	<0.00040	<0.00040	<0.000010	<0.000001	<0.00010	<0.00010	<0.01	<0.01
	Field Blank	2013-09-04		Field Blank	<0.0001	<0.00001	<0.050	<0.050	<0.0000010	<0.0000010	<0.0012	<0.0012	<0.00040	<0.00040	<0.000010	<0.000001	<0.00010	<0.00010	<0.01	<0.01

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Uranium (Dissolved)	Uranium (Total)	Vanadium (Dissolved)	Vanadium (Total)	Zinc (Dissolved)	Zinc (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	0.00006	0.00007	<0.001	<0.001	<0.00033	<0.003
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	0.000063	0.00007	<0.001	<0.001	<0.00033	<0.003
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	0.000062	0.00007	<0.001	<0.001	0.0014	0.0164
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		0.000061	0.000071	<0.001	<0.001	0.0016	<0.003
CP-P3-11	CR-P3-11S	2013-09-04	Surface		0.000065	0.000077	<0.001	<0.001	0.0021	0.0188
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		0.000066	0.000078	<0.001	<0.001	0.0013	<0.003
CL-P2-13	CL-P2-13S	2013-08-07	Surface		0.000113	0.000127	<0.001	<0.001	0.0018	0.004
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		0.000121	0.000136	<0.001	<0.001	0.0014	<0.003
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	0.000126	0.000141	<0.001	<0.001	0.0011	<0.003
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	0.000121	0.000142	<0.001	<0.001	0.0051	0.004
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	0.000124	0.000149	<0.001	<0.001	0.0037	0.0049
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		0.000133	0.000242	<0.001	<0.001	<0.00033	<0.003
	CL-P2-13F	2013-08-07		Field Blank	<0.000010	<0.000010	<0.001	<0.001	0.0012	<0.003
	Trip Blank	2013-09-04		Trip Blank	<0.000010	<0.000010	<0.001	<0.001	<0.00033	<0.003
	Field Blank	2013-09-04		Field Blank	<0.000010	<0.000010	<0.001	<0.001	<0.00033	<0.003

APPENDIX 2. SUMMARY OF LOWER TROPHIC LEVEL SAMPLING CONDUCTED IN CANDIDATE REFERENCE LAKES, 2013

Table A2-1. Summary of phytoplankton sampling completed in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Site Depth (m)	Secchi Depth (m)	Euphotic Zone Depth (m)	Sampled Depth Range (m)
		Easting	Northing						
CR-P3-09	PHYTO-01U	559980	7855131	05-Aug-13	15:10	28.4	9.25	27.75	0-10
CR-P3-09	PHYTO-01L	559980	7855131	05-Aug-13	15:10	28.4	9.25	27.75	10-27
CR-P3-11	PHYTO-02	569055	7900254	06-Aug-13	17:00	10.5	6.50	19.50	0-9
CL-P2-13	PHYTO-03	550137	7938617	07-Aug-13	14:00	12.9	4.35	13.05	0-11

Table A2-2. Summary of zooplankton sampling completed in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Site Depth (m)	Secchi Depth (m)	Sampled Depth Range (m)	No. of Tows
		Easting	Northing						
CR-P3-09	ZOO-01	559980	7855131	05-Aug-13	15:10	28.4	9.25	0-27	1
CR-P3-11	ZOO-02	569055	7900254	06-Aug-13	17:00	10.5	6.50	0-9	1
CL-P2-13	ZOO-03	550137	7938617	07-Aug-13	14:00	12.9	4.35	0-11	1
CR-P3-11	ZOO-02	569055	7900254	04-Sep-13	12:05	10.6	5.75	0-9	1
CL-P2-13	ZOO-03	550137	7938617	04-Sep-13	15:40	12.5	4.25	0-11	1

Table A2-3. Summary of benthic macroinvertebrate sampling completed in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Secchi Depth (m)	No. of Replicate Grabs	Depth Range of Grabs (m)	Macrophyte Abundance	Dominant Substrate(s)
		Easting	Northing							
CR-P3-11	BMI-01	569055	7900254	04-Sep-13	12:57	18:00	5	8.2 - 9.7	Absent	Sand/Silt
CL-P2-13	BMI-02	550137	7938617	04-Sep-13	18:10	6:00	5	12.1 - 13.8	Absent	Silt/Sand

APPENDIX 3. PHYTOPLANKTON COMMUNITY COMPOSITION IN CANDIDATE REFERENCE LAKES, 2013.

Table A3-1. Phytoplankton biomass and composition measured in reference lakes in 2013. Means and relative percent mean difference (RPMD) have been calculated for duplicate samples.

Waterbody	Sample ID	Sample Date	Sample Type	Major Group	Diatoms						
				Class	Bacillariophyceae					Coscinodiscophyceae	
				Genus	*Eunotia*	*Navicula*	*Nitzschia*	*Rhoicosphenia*	*Surirella*	*Cyclotella*	*Rhizosolenia*
				Species	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate		1.35	10.00	0.77	-	-	4.50	-
	CR-P3-11 B	6-Aug-13	Duplicate		13.50	4.80	0.77	-	-	6.66	-
	CR-P3-11	6-Aug-13	Mean		7.43	7.40	0.77	-	-	5.58	-
			RPMD		164	70	0	-	-	39	-
	CR-P3-11	4-Sep-13	Normal		-	-	7.17	0.45	-	4.50	-
CL-P2-13	CL-P2-13	7-Aug-13	Normal		3.60	-	1.60	-	-	49.60	1.55
	CL-P2-13 REP 1	4-Sep-13	Duplicate		-	-	0.77	-	6.40	54.40	0.71
	CL-P2-13 REP 2	4-Sep-13	Duplicate		5.00	4.80	0.77	-	-	24.80	1.67
	CL-P2-13	4-Sep-13	Mean		2.50	2.40	0.77	-	3.20	39.60	1.19
			RPMD		200	200	0	-	200	75	81

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Diatoms				Chlorophyta			
				Fragilariophyceae				Chlorophyceae			
				Asterionella	*Diatoma*	*Synedra*	*Tabellaria*	*Botryococcus*	*Dictyosphaerium*	*Elakatothrix*	*Tetraedron*
				formosa	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*minimum*
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	4.70	0.96	15.07	8.80	-	-	6.25	0.20
	CR-P3-11 B	6-Aug-13	Duplicate	3.46	2.00	17.09	-	-	-	3.35	0.20
	CR-P3-11	6-Aug-13	Mean	4.08	1.48	16.08	4.40	-	-	4.80	0.20
			RPMD	30	70	13	200	-	-	60	0
	CR-P3-11	4-Sep-13	Normal	2.70	2.00	3.00	0.80	-	-	11.61	-
CL-P2-13	CL-P2-13	7-Aug-13	Normal	22.79	0.96	26.08	-	10.80	-	6.70	1.71
	CL-P2-13 REP 1	4-Sep-13	Duplicate	18.74	0.96	30.13	-	-	135.94	8.71	3.01
	CL-P2-13 REP 2	4-Sep-13	Duplicate	14.74	-	11.99	-	-	-	3.13	2.26
	CL-P2-13	4-Sep-13	Mean	16.74	0.48	21.06	-	-	67.97	5.92	2.64
			RPMD	24	200	86	-	-	200	94	29

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Chlorophyta			Charophyta			Chrysophytes		
				Trebouxiophyceae			Conjugophyceae			Chrysophyceae		
				Lagerheimia sp.	***Monoraphidium sp.***	***Oocystis sp.***	***Cosmarium sp.***	***Staurastrum sp.***	***Staurodesmus sp.***	***Bitrichia sp.***	***Dinobryon bavaricum***	***Dinobryon sp.***
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	-	-	-	-	1.35	10.00	0.15	9.40	26.78
	CR-P3-11 B	6-Aug-13	Duplicate	-	-	-	14.40	-	2.40	0.47	20.09	22.79
	CR-P3-11	6-Aug-13	Mean	-	-	-	7.20	0.68	6.20	0.31	14.74	24.79
			RPMD	-	-	-	200	200	123	102	73	16
	CR-P3-11	4-Sep-13	Normal	-	-	5.00	-	-	10.00	0.15	4.00	12.74
CL-P2-13	CL-P2-13	7-Aug-13	Normal	0.32	9.53	2.40	18.00	-	-	0.32	0.65	16.74
	CL-P2-13 REP 1	4-Sep-13	Duplicate	0.64	1.63	-	26.65	-	-	0.15	-	1.35
	CL-P2-13 REP 2	4-Sep-13	Duplicate	0.15	8.18	-	8.05	-	-	0.15	-	14.74
	CL-P2-13	4-Sep-13	Mean	0.40	4.91	-	17.35	-	-	0.15	-	8.05
			RPMD	123	133	-	107	-	-	0	-	166

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Chrysophytes	Cryptophytes		Blue-Green Algae				
				Chrysophyceae	Cryptophyceae		Cyanophyceae				
				small chrysophytes	*Cryptomonas sp.*	*Unidentified*	*Anabaena sp.*	*Aphanocapsa sp.*	*Aphanothece sp.*	*Oscillatoria sp.*	*Planktolyngbya sp.*
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	32.22	44.40	5.68	-	-	-	-	1.20
	CR-P3-11 B	6-Aug-13	Duplicate	42.85	14.40	3.84	-	-	-	-	1.20
	CR-P3-11	6-Aug-13	Mean	37.54	29.40	4.76	-	-	-	-	1.20
			RPMD	28	102	39	-	-	-	-	0
	CR-P3-11	4-Sep-13	Normal	21.90	14.40	5.68	0.86	18.23	29.60	0.58	0.19
CL-P2-13	CL-P2-13	7-Aug-13	Normal	16.83	44.40	2.84	-	-	-	-	-
	CL-P2-13 REP 1	4-Sep-13	Duplicate	16.03	7.20	7.60	-	-	-	-	-
	CL-P2-13 REP 2	4-Sep-13	Duplicate	17.22	14.40	16.20	-	-	-	-	0.58
	CL-P2-13	4-Sep-13	Mean	16.63	10.80	11.90	-	-	-	-	0.29
			RPMD	7	67	72	-	-	-	-	200

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Blue-Green Algae	Euglenoids	Dinoflagellates		Total Biomass
				Cyanophyceae	Euglenophyceae	Dinophyceae		
				Pseudanabaena	*Euglena*	*Gymnodinium*	*Peridinium*	
				sp.	*sp.*	*sp.*	*sp.*	(mg/m^3)
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	0.10	1.20	72.90	-	258.0
	CR-P3-11 B	6-Aug-13	Duplicate	-	-	178.20	172.80	525.3
	CR-P3-11	6-Aug-13	Mean	0.05	0.60	125.55	86.40	391.6
			RPMD	200	200	84	200	68
	CR-P3-11	4-Sep-13	Normal	-	2.70	97.20	-	255.5
CL-P2-13	CL-P2-13	7-Aug-13	Normal	-	-	434.70	-	672.1
	CL-P2-13 REP 1	4-Sep-13	Duplicate	-	-	32.40	-	353.4
	CL-P2-13 REP 2	4-Sep-13	Duplicate	-	-	234.90	-	383.7
	CL-P2-13	4-Sep-13	Mean	-	-	133.65	-	365.4
			RPMD	-	-	152	-	8

APPENDIX 4. ZOOPLANKTON ABUNDANCE AND COMMUNITY COMPOSITION IN CANDIDATE REFERENCE LAKES, 2013.

Table A4-1. Crustacean zooplankton (individuals/m^3) collected in vertical net tows from reference lakes during 2013. Individual abundances may not add up to totals due to rounding.

Waterbody	Lake CR-P3-11										
Site ID	**Stn CR P3-11**										
Sampling Date	**6-Aug-13**							**4-Sep-13**		**Overall**	
Replicate	**A**	**B**	**C**	**Mean**	**SD [1]**	**% [2]**	**PRSD [3]**		**%**	**Mean**	**%**
water volume filtered (m^3)	0.09	0.09	0.09	-	-	-	-	0.09	-		
Cladocera (water fleas)											
Alona guttata	0	0	0	0	0	0	-	0	0	0	0
Bosmina longirostris	197	219	219	212	13	3	6	395	5	258	3
Chydorus sphaericus	0	0	0	0	0	0	-	0	0	0	0
Daphnia longiremis	132	307	176	205	91	3	45	812	10	357	4
Holopedium gibberum	44	22	0	22	22	0	*100*	0	0	16	0
Total Cladocera	**373**	**549**	**395**	**439**	**96**	**6**	**22**	**1207**	**15**	**631**	**8**
Copepoda (copepods)											
Calanoida											
Diaptomus minutus	1404	1163	1646	1404	241	18	17	2743	35	1739	22
Limnocalanus macrurus	0	0	0	0	0	0	-	0	0	0	0
Calanoida copepodite	658	1426	1316	1134	415	14	37	505	6	976	12
Total Calanoida	**2062**	**2589**	**2962**	**2538**	**452**	**32**	**18**	**3247**	**41**	**2715**	**34**
Cyclopoida											
Cyclops scutifer	2567	2194	2084	2282	253	29	11	1997	25	2210	28
Cyclopoida nauplii	2150	2721	3181	2684	517	34	19	1470	19	2381	30
Total Cyclopoida	**4717**	**4915**	**5266**	**4966**	**278**	**63**	**6**	**3467**	**44**	**4591**	**58**
Harpacticoida	0	0	0	0	0	0	-	0	0	0	0
Total Copepoda	**6780**	**7504**	**8228**	**7504**	**724**	**94**	**10**	**6714**	**85**	**7306**	**92**
OVERALL TOTAL	**7153**	**8052**	**8623**	**7942**	**741**	**100**	**9**	**7920**	**100**	**7937**	**100**
Taxonomic Richness [4]	**5**	**5**	**4**	**5**	**-**	**-**	**-**	**4**	**-**	**5**	**-**

Table A4-1. - continued -

Waterbody	Lake CL-P2-13										
Site ID	Stn CL P2-13										
Sampling Date	7-Aug-13		4-Sep-13							Overall	
Replicate		%	A	B	C	Mean	SD	%	PRSD	Mean	%
water volume filtered (m^3)	0.13		0.13	0.13	0.13	-	-		-		
Cladocera (water fleas)											
Alona guttata	0	0	0	0	0	0	0	0	-	0	0
Bosmina longirostris	214	18	260	130	84	158	91	10	***58***	172	11
Chydorus sphaericus	0	0	0	0	0	0	0	0	-	0	0
Daphnia longiremis	46	4	199	76	138	138	61	9	44	115	8
Holopedium gibberum	8	1	0	0	23	8	13	0	***173***	8	1
Total Cladocera	**268**	**23**	**459**	**207**	**245**	**303**	**136**	**19**	**45**	**294**	**20**
Copepoda (copepods)											
Calanoida											
Diaptomus minutus	23	2	444	38	8	163	243	10	***149***	128	9
Limnocalanus macrurus	0	0	0	0	0	0	0	0	-	0	0
Calanoida copepodite	0	0	31	54	15	33	19	2	***58***	25	2
Total Calanoida	**23**	**2**	**474**	**92**	**23**	**196**	**243**	**12**	***124***	**153**	**10**
Cyclopoida											
Cyclops scutifer	849	73	765	765	773	767	4	47	1	788	52
Cyclopoida nauplii	23	2	398	344	314	352	43	22	12	270	18
Total Cyclopoida	**872**	**75**	**1163**	**1109**	**1086**	**1119**	**39**	**69**	**4**	**1057**	**70**
Harpacticoida	0	0	0	0	0	0	0	0	-	0	0
Total Copepoda	**895**	**77**	**1637**	**1201**	**1109**	**1316**	**282**	**81**	**21**	**1210**	**80**
OVERALL TOTAL	**1163**	**100**	**2096**	**1407**	**1354**	**1619**	**414**	**100**	**26**	**1505**	**100**
Taxonomic Richness [4]	**5**	**-**	**4**	**4**	**5**	**5**	**-**	**-**	**-**	**5**	**-**

[1] Standard deviation
[2] Percent abundance of the overall total
[3] Percent relative standard deviation; evaluation of precision for triplicate samples
[4]Total number of taxa observed to species-level, not the average number of taxa

APPENDIX 5. BENTHIC MACROINVERTEBRATE ABUNDANCE AND COMMUNITY COMPOSITION IN CANDIDATE REFERENCE LAKES, 2013.

Table A5-1. Benthic macroinvertebrates (no. of individuals/m^2) collected in petite Ponar grab (area 0.023 m^2) samples from reference lake candidate CR-P3-11 during 2013. Individual abundances may not add up to totals due to rounding.

Waterbody				**CR-P3-11**				
Habitat Type				**Offshore Profundal (14)**				
Subsample no.				**1**	**2**	**3**	**4**	**5**
Sample ID				**CR-P3-11-1**	**CR-P3-11-2**	**CR-P3-11-3**	**CR-P3-11-4**	**CR-P3-11-5**
Number of invertebrates per m^2								
ROUNDWORMS				0	0	0	0	0
P. Nemata				0	0	0	0	43
ANNELIDS				0	0	0	0	0
P. Annelida				0	0	0	0	0
	WORMS			0	0	0	0	0
	Cl. Oligochaeta			0	0	0	0	0
		F. Naididae		0	0	0	0	0
	S.F. Tubificinae			0	0	0	0	0
			Aulodrilus limnobius	0	0	0	0	0
		F. Lumbriculidae		0	0	0	0	0
			Lumbriculus	0	0	0	0	0
ARTHROPODS				0	0	0	0	0
P. Arthropoda				0	0	0	0	0
	MITES			0	0	0	0	0
	Cl. Arachnida			0	0	0	0	0
	Subcl. Acari			43	87	43	87	43
	HARPACTICOIDS			0	0	0	0	0
	O. Harpacticoida			0	0	0	0	0
	SEED SHRIMPS			0	0	0	0	0
	Cl. Ostracoda			0	43	0	43	0
INSECTS				0	0	0	0	0
	Cl. Insecta			0	0	0	0	0
	CADDISFLIES			0	0	0	0	0
	O. Trichoptera			0	0	0	0	0
		F. Apataniidae		0	0	0	0	0
			Apatania	0	0	0	0	0
TRUE FLIES				0	0	0	0	0
	O. Diptera			0	0	0	0	0
	MIDGES			0	0	0	0	0
		F. Chironomidae		0	0	0	0	0
			chironomid pupae	0	0	0	0	0
	S.F. Chironominae			0	0	0	0	0
			Chironomus	0	0	2640	1169	1169
			Corynocera	0	0	173	0	0
			Micropsectra	87	303	0	0	0
			Paratanytarsus	0	0	0	0	0
			Sergentia	0	0	0	0	0
			Stictochironomus	173	649	0	43	0
			Tanytarsus	390	519	1342	3246	2554
	S.F. Diamesinae			0	0	0	0	0
			Protanypus	0	0	43	0	0
			Pseudodiamesa	0	0	0	0	0

Table A5-1. - continued -

Waterbody				CR-P3-11				
Habitat Type				**Offshore Profundal (14)**				
Subsample no.				**1**	**2**	**3**	**4**	**5**
Sample ID				**CR-P3-11-1**	**CR-P3-11-2**	**CR-P3-11-3**	**CR-P3-11-4**	**CR-P3-11-5**
Number of invertebrates per m^2								
	S.F. Orthocladiinae			0	0	0	0	0
			Abiskomyia	87	87	346	260	216
			Corynoneura	0	0	0	0	0
			Cricotopus/Orthocladius	0	0	0	0	0
			Genus "Greenland"	0	0	0	0	0
			Heterotrissocladius	693	173	173	216	260
			Mesocricotopus	0	0	0	0	0
			Paracladius	0	0	0	0	43
			Parakiefferiella	43	43	0	0	0
			Psectrocladius	87	260	0	0	0
			Pseudosmittia	0	0	43	0	0
			Zalutschia	0	43	43	43	0
			indeterminate	0	0	0	0	0
	S.F. Tanypodinae			0	0	0	0	0
			Procladius	390	822	0	0	0
			Thienemannimyia complex	0	0	0	0	0
Total Density (no. per m^2)				1991	3030	4848	5107	4328
Proportion of Chironomidae (% of total density)				98	96	99	97	98
Shannon's Evenness Index				0.82	0.82	0.58	0.53	0.58
Simpson's Diversity Index				0.79	0.83	0.62	0.54	0.57
Taxonomic Richness (genus-level) [1]				9	11	9	8	7
Hill's Effective Richness				6.01	7.21	3.60	3.01	3.07

[1] Total number of taxa observed to genus-level

Table A5-2. Benthic macroinvertebrates (no. of individuals/m^2) collected in petite Ponar grab (area 0.023 m^2) samples from reference lake candidate CL-P2-13 during 2013. Individual abundances may not add up to totals due to rounding.

Waterbody	**CL-P2-13**				
Habitat Type	**Offshore Profundal (14)**				
Subsample no.	**1**	**2**	**3**	**4**	**5**
Sample ID	**CL-P2-13-1**	**CL-P2-13-2**	**CL-P2-13-3**	**CL-P2-13-4**	**CL-P2-13-5**
Number of invertebrates per m^2					
ROUNDWORMS	0	0	0	0	0
P. Nemata	0	0	0	0	0
ANNELIDS	0	0	0	0	0
P. Annelida	0	0	0	0	0
WORMS	0	0	0	0	0
Cl. Oligochaeta	0	0	0	0	0
F. Naididae	0	0	0	0	0
S.F. Tubificinae	0	0	0	0	0
Aulodrilus limnobius	0	0	0	0	0
F. Lumbriculidae	0	0	0	0	0
Lumbriculus	0	0	0	0	0
ARTHROPODS	0	0	0	0	0
P. Arthropoda	0	0	0	0	0
MITES	0	0	0	0	0
Cl. Arachnida	0	0	0	0	0
Subcl. Acari	0	0	0	0	0
HARPACTICOIDS	0	0	0	0	0
O. Harpacticoida	0	0	0	0	0
SEED SHRIMPS	0	0	0	0	0
Cl. Ostracoda	0	0	0	0	0
INSECTS	0	0	0	0	0
Cl. Insecta	0	0	0	0	0
CADDISFLIES	0	0	0	0	0
O. Trichoptera	0	0	0	0	0
F. Apataniidae	0	0	0	0	0
Apatania	0	0	0	0	0
TRUE FLIES	0	0	0	0	0
O. Diptera	0	0	0	0	0
MIDGES	0	0	0	0	0
F. Chironomidae	0	0	0	0	0
chironomid pupae	0	0	0	0	0
S.F. Chironominae	0	0	0	0	0
Chironomus	43	43	3333	1212	0
Corynocera	0	0	0	0	0
Micropsectra	0	43	43	0	0
Paratanytarsus	0	0	0	0	0
Sergentia	0	0	0	0	0
Stictochironomus	0	43	0	87	0
Tanytarsus	0	0	0	0	0
S.F. Diamesinae	0	0	0	0	0
Protanypus	216	0	43	43	87
Pseudodiamesa	0	0	0	0	0

Table A5-2. - continued -

Waterbody				CL-P2-13				
Habitat Type				Offshore Profundal (14)				
Subsample no.				1	2	3	4	5
Sample ID				CL-P2-13-1	CL-P2-13-2	CL-P2-13-3	CL-P2-13-4	CL-P2-13-5
Number of invertebrates per m^2								
	S.F. Orthocladiinae			0	0	0	0	0
			Abiskomyia	87	130	0	130	0
			Corynoneura	0	0	0	0	0
			Cricotopus/Orthocladius	0	0	0	0	0
			Genus "Greenland"	0	0	0	0	0
			Heterotrissocladius	87	0	0	43	519
			Mesocricotopus	0	0	0	0	0
			Paracladius	476	260	0	87	606
			Parakiefferiella	0	43	0	216	0
			Psectrocladius	0	0	0	0	0
			Pseudosmittia	0	0	0	0	0
			Zalutschia	43	0	0	0	0
			indeterminate	0	0	0	0	0
	S.F. Tanypodinae			0	0	0	0	0
			Procladius	0	0	0	0	0
			Thienemannimyia complex	0	0	0	0	0
Total Density (no. per m^2)				952	563	3419	1818	1212
Proportion of Chironomidae (% of total density)				100	100	100	100	100
Shannon's Evenness Index				0.78	0.83	0.12	0.61	0.82
Simpson's Diversity Index				0.68	0.71	0.05	0.53	0.56
Taxonomic Richness (genus-level) [1]				6	6	3	7	3
Hill's Effective Richness				4.06	4.41	1.15	3.25	2.46

[1] Total number of taxa observed to genus-level

Appendix F

Lake Sedimentation Monitoring Program

Appendix F

Lake Sedimentation Monitoring Program

Mary River Project

June 2014

Aquatic Effects Monitoring Program:

Lake Sedimentation Monitoring Program

North/South Consultants Inc.
Aquatic Environment Specialists

Mary River Project

Aquatic Effects Monitoring Program:
Lake Sedimentation Monitoring Program

June, 2014

Prepared by

North/South Consultants Inc.

For

Baffinland Iron Mines Corporation

North/South Consultants Inc.
Aquatic Environment Specialists

83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca

Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Program
BIM	Baffinland Iron Mines Corporation
BMI	Benthic macroinvertebrate(s)
DFO	Department of Fisheries and Oceans
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statements
NSC	North/South Consultants Inc.
QA/QC	Quality assurance/quality control
TSS	Total suspended solids
UTM	Universal Transverse Mercator

1.0 INTRODUCTION AND BACKGROUND

The Mary River Project is expected to result in increased sediment deposition in Mine Area waterbodies, including lakes, due to dust deposition and potentially due to introduction of suspended solids from various activities (e.g., wastewater discharges). Dust will be directly deposited on watercourses during the open-water season and on snow and ice during the winter. Dust will be indirectly introduced from runoff within the watersheds which will likely be greatest during the snowmelt/freshet period.

Potential effects of dust on aquatic ecosystems include effects on water quality (i.e., total suspended solids [TSS], metals, nutrients, water clarity) when suspended in the water column and effects once deposited on the lake bottom or streambed. Sedimentation of dust in lakes and streams may affect aquatic biota through changes in sediment quality (e., metals, nutrients, particle size, organic matter), through changes in habitat quality (i.e., changes in substrate composition), direct effects on benthic macroinvertebrates (BMI; i.e., smothering), and direct effects on fish eggs (i.e., smothering of eggs).

Baffinland Iron Mines Corporation (BIM) proposed a targeted study, which was subsequently recommended by the Department of Fisheries and Oceans (DFO), to measure rates of sediment deposition in Mine Area lakes. The following describes the general background, approach, and methods for this targeted study to monitor sediment deposition in Mine Area lakes during Project operation as part of the Aquatic Effects Monitoring Program (AEMP).

2.0 PATHWAYS OF EFFECT AND KEY QUESTIONS

The Project may affect sediment deposition in Mine Area lakes through airborne dust deposition and through introduction of suspended materials (i.e., TSS) to lakes via tributary streams and/or aqueous point or non-point sources. Potential pathways of effect on freshwater biota in lakes include:

- Increased sediment deposition in lakes may adversely affect BMI communities which may in turn affect Arctic Char populations;
- Increased sediment deposition in lakes may alter Arctic Char (*Salvelinus alpinus*) habitat, notably Arctic Char spawning habitat, through changes in substrate composition; and
- Increased sediment deposition in lakes during the Arctic Char egg incubation period (i.e., over winter) may adversely affect egg survival and hatching success.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources of suspended materials on sedimentation rates in Mine Area lakes?

The primary issue of concern in relation to Mine Area lakes is the potential effect of the Project on sediment deposition on Arctic Char eggs.

3.0 PARAMETERS

The key parameter that will be monitored under this special study is total sediment deposition, measured as total dry weight of sediment deposited in a known area over a known duration (i.e., $mg/cm^2/day$). Measurements will also allow for determination of the total mass of sediment deposited over the sampling period. Results of a baseline sampling program conducted over the open-water season of 2013 in Sheardown Lake NW indicate that sufficient volumes of sediment for laboratory analysis of total dry weight of sediment can be obtained during this period (North/South Consultants Inc. [NSC] 2014). Sediment deposition monitoring over the ice-cover season is ongoing and it is unknown whether sufficient volumes of sediments can be obtained from the lake over this period for reliable laboratory analysis. Results of the winter sedimentation program will be reviewed when available and details of this study may be modified in accordance.

If sufficient sample was collected in future lake sedimentation monitoring, bulk density would also be measured to facilitate estimates of total depth of sediment deposition in lakes (i.e., mm of sediment). However required volumes for these measurements were not realized in the open-water season of 2013 due to low rates of sedimentation (even with deployment of multiple traps and sample compositing) in the Mine Area. Therefore, it is anticipated that due to logistical restrictions, samples will only be analysed for total dry weight of sediment in the lake sedimentation monitoring program.

4.0 MONITORING AREA AND SAMPLING SITES

In the Mine Area, Arctic Char spawning habitat is restricted to lakes, as rivers and streams freeze solid in winter, and lakes provide the sole overwintering habitat for Arctic Char. The results of air quality modeling presented in the Final Environmental Impact Statement (FEIS) and the Addendum to the FEIS for the Early Revenue Phase (ERP), indicate that Sheardown Lake will experience the largest increases in sediment deposition of the Mine Area lakes. The lake sediment deposition special study is therefore focused on monitoring in Sheardown Lake NW. However, monitoring at additional Mine Area lakes may be undertaken in the future upon review of initial monitoring results collected during the ERP and/or during full production if increased effects (e.g., greater rates of dust deposition) are measured.

Increases in sedimentation rates may affect BMIs (through smothering and changes in substrate characteristics), Arctic Char habitat (notably spawning areas which are typically hard substrates), and/or Arctic Char eggs (through deposition on incubating eggs). Therefore the sampling sites will include a suspected Arctic Char spawning area, a shallow, soft substrate area, and a deep-water location. Collectively this information will provide information on sedimentation rates in different habitat types in the lake. Sites sampled during baseline studies will be retained for operation monitoring. A brief description of these sites is provided below.

Specific spawning sites have not been identified within Sheardown Lake NW and the FEIS conservatively assumed that areas of hard substrate at water depths ranging from 2-12 m in the lakes could potentially provide spawning habitat. One area in Sheardown Lake NW best matched these criteria and was selected for sediment trap deployment in 2013 to represent potential Arctic Char spawning habitat (Figure 1). A second sampling site was selected at a similar depth range (2-12 m), but with a soft substrate for comparison. A third sampling site was selected near the deepest point in the lake as these areas are typically the ultimate depositional areas in lakes and because sampling the profundal zone (i.e., depth > 12 m) would provide a measure of a dominant aquatic habitat type.

5.0 SAMPLING FREQUENCY AND SCHEDULE

Sediment traps will be deployed year-round in Sheardown Lake NW but will be retrieved and emptied in late summer/fall prior to freeze up and again in spring following ice breakup on the lake. This will provide a means for quantifying annual deposition rates in the lake as well as rates associated with the open-water and ice-cover seasons.

Baseline studies are on-going and will continue into fall 2014. Monitoring during Project operation will commence this fall and will continue for three years, following which a review of the program and results will be undertaken to advise on monitoring during full production.

6.0 FIELD AND LABORATORY METHODS

Sedimentation rates will be measured through deployment of sediment traps with an aspect ratio of > 5:1 as recommended for cylindrical sediment traps (Mudroch and MacKnight 1994). Traps will be anchored such that the trap is suspended off the bottom and secured with a buoy.

Five replicate traps (i.e., subsamples) will be deployed within close proximity at each of the three sites. The number of replicates may be modified pending the results of the ongoing baseline studies and initial results of monitoring during operation. Total water depth, substrate, date, time, and universal transverse mercator units (UTMs) will be recorded at each site.

Traps will be retrieved and emptied in late summer/fall and in spring following breakup. Trap contents will be transferred to sample bottles, kept cool and in the dark and transported to an analytical laboratory for analysis.

Samples will be analysed by filtering samples, which includes sediments and water, through a pre-weighed 0.70 µm glass fibre filter, rinsing the filter apparatus and container three times, and drying the filter at 105 ^{o}C for two hours. Samples are then allowed to cool for one hour and weighed.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance/quality control (QA/QC) measures will include verifications that sediments are not disturbed (i.e., resupended) during sediment deployment and retrieval and inclusion of sample replicates to measure variability.

8.0 STUDY DESIGN AND DATA ANALYSIS

As the objective of this study is to monitor rates of sediment deposition in Mine Area lakes as it may affect BMIs, habitat, and Arctic Char eggs, the study is designed to provide measures of sediment deposition on a seasonal (i.e., open-water vs. ice-cover season) basis. Rates will be measured through deployment of sediment traps in Sheardown Lake NW year-round, but with retrieval of samples at the end of the open-water and ice-cover seasons to provide measures for both periods. This will facilitate examination of sedimentation rates during the Arctic Char incubation period as well as during the growing season in Sheardown Lake NW.

Measured sedimentation rates will be compared to effects predictions presented in the FEIS and the Addendum to the FEIS for the ERP, as well as to the effects threshold applied in the impact assessment (i.e., 1 mm of deposition on fish eggs). Sedimentation rates exceeding 1 mm during the egg incubation period have been identified as exerting adverse effects on fish eggs (e.g., Fudge and Bodaly 1984). The FEIS and Addendum to the FEIS indicated that sedimentation is not expected to exceed this threshold in Mine Area lakes.

The study is designed to compare results directly to the threshold rather than to demonstrate statistically significant differences. Therefore, true replicates for each habitat type are not included in the design of the monitoring program. Rather, replicates will be included to provide a measure of variability at each site (i.e., subsamples) and to provide additional contingency in the event that traps cannot be located and/or quantities of sediments collected in the traps are so low that sample compositing is required. As previously indicated, results of open-water season sampling completed in 2013 indicate that sufficient sediment volumes will likely be obtainable in the open-water season, however, it is unknown whether this can be attained for winter.

Results of the targeted study may also be compared to baseline data collected in 2013 and 2014 from Sheardown Lake NW to provide a means of identifying Project-related effects on this parameter.

This document was prepared, and the special study was designed, with baseline information available at the time of preparation of this report. It is noted that not all results of additional baseline sampling initiated in 2013 were available at the time of preparation of this report; upon receipt and analysis of these additional data, recommendations for modification to the special study may be made. Results of the baseline program completed in the open-water season of 2013 are presented in NSC (2014).

9.0 REFERENCES

Fudge, R.J.P. and R.A. Bodaly. 1984. Post-impoundment winter sedimentation and survival of lake whitefish (*Coregonus clupeaformis*) eggs in Southern Indian Lake, Manitoba. Canadian Journal of Fisheries and Aquatic Sciences 41: 118-125.

Mudroch, A., and S.D. MacKnight (Eds). 1994. Handbook of techniques for aquatic sediment sampling. Second Edition, Lewis Publishers. 235 p.

North/South Consultants Inc. (NSC). 2014. Sediment trap sampling program: Open-water season 2013. A report prepared for Baffinland Iron Mines Corporation by NSC, Winnipeg, MB. February 2014.

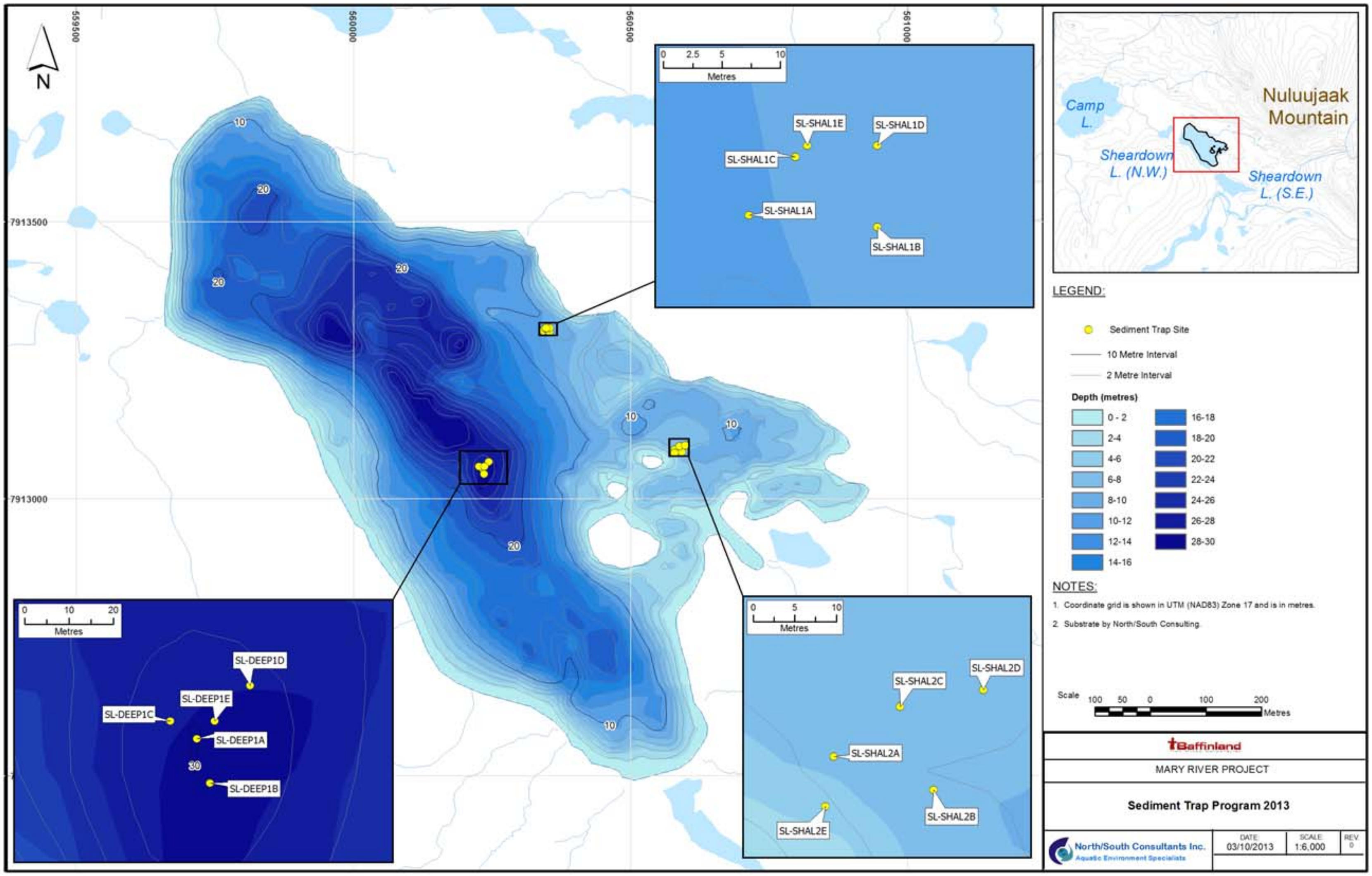


Figure 1. Sediment trap sampling sites in Sheardown Lake NW, 2013.

Appendix G

Dustfall Monitoring Program

Appendix G

Dustfall Monitoring Program

4-3 VEGETATION MONITORING: DUST FALL

The potential impacts of dust deposition on soil and vegetation has been identified as an issue of concern for the Project. In particular, other studies have shown dust deposition to have a detrimental effect on vegetation health, and dust deposition on caribou forage (i.e., lichen) has been suggested as a potential mechanism causing caribou to avoid habitat at a distance of up to 14 km (Boulager et al. 2012). The main sources of dust emissions are fugitive sources, specifically bulk handling operations, crushing, blasting, storage, and dust emissions from vehicle and equipment traffic, although natural sources of dust fall also exist (e.g. wind erosion). The largest amount of dust fall generated by the Project is expected to be associated with use of the existing Tote road linking the Mine site with the port at Milne Inlet; however, there will also be dust fall generation from the railway and from point source locations at both the Mine site and ports.

The Mary River dust fall monitoring program was initiated in the summer of 2013 with sampling stations set up at the Mine site, Milne Port, along the Tote road, and at reference sites within the RSA. At this time, the railway and Steensby port are not included in the dust fall monitoring program, due to access issues. Future construction of the railway linking Steensby port with the Mine site will initiate dust fall monitoring for the southern section of the RSA. The dust fall monitoring program was developed using knowledge gathered from other similar air monitoring programs (Ekati Mine, High Lake Project, Rescan 2006), as well as applicable caribou research. The monitoring program is in accordance with the American Society for Testing and Materials (ASTM) ASTM D1739-98 sampling method (ASTM 2004).

Objectives

There are three main objectives of the dust fall monitoring program:

2. To quantify the extent and magnitude of dust fall generated by Project activites;
3. To determine seasonal variations in dust fall at all sampling locations; and
4. To determine if annual changes in dust fall at sampling locations exceed identified thresholds associated with isopleth dispersion models.

Thresholds

There are no known dust deposition thresholds specific to effects on vegetation. Health Canada/Environment Canada's national ambient air quality objectives for particulate matter (CEPA/FPAC Working Group 1998) state that for the lack of quantitative dose-effect information, it is not possible to define a reference level for vegetation and dust deposition. In the absence of published thresholds for dust effects on vegetation, the High Lake Project (Wolfden Resources Inc. 2006), a proposed base metal mine in western Nunavut, developed thresholds in consideration of effects to vegetation health ranging from 4.6 $g/m^2/a$ for a low magnitude effect to ≥50 $g/m^2/a$ for a high magnitude effect (Table B-2). These values were based on a combination of the Alberta (AB) and Ontario (ON) ambient air quality criteria for human health purposes, and values reported by Spatt and Miller (1981) specific to effects of road dust on vegetation.

In addition to the consideration of thresholds developed by the High Lake Project, isopleth dispersion models (CALPUFF dispersion models) were used to predict deposition patterns from all sources during the operations phase of the Project. The CALPUFF dispersion model was recommended by a number of regulatory agencies and has been the *de facto* standard for environmental assessments in Canada's North. To refer to activities that are included in the assessment of the operations phase refer to the *ERP Addendum to FEIS Volume 5*.

To align with results of the isopleth dispersion models and the thresholds described above (Table B-2), the following annual TSP depositions thresholds will be used for the Mary River Project:

Low: 1–4.6 g/m²/a;

Moderate: 4.6–50 g/m²/a; and

High: ≥ 50 g/m²/a.

Table B-2 Dust (TSP) Deposition Rates and Criteria for Potential Effects on Vegetation Health.

Source of Information	Dust (TSP) deposition rate	Equivalent annual dust deposition rate (g/m²/a)	Comments
High Lake Impact Assessment (Wolfden 2006)	1.0–4.6 g/m²/a	1.0–4.6	Predicted low magnitude effect on vegetation health
	4.6–50 g/m²/a	4.6–50	Predicted moderate magnitude effect on vegetation health
	50–200 g/m²/a	50–200	Predicted high magnitude effect on vegetation health
Spatt and Miller (1981)	0.07 g/ m²/ d	26	Some effects to Sphagnum species
	1.0-2.5 g/ m²/ d	365-913	Decline in Sphagnum species abundance
Alberta	5.3 g/m²/30 d	64	Alberta Guidelines for Residential and Recreational Areas (human health)
Ontario	4.6 g/m²/a	4.6	Ontario Ambient Air Quality Criteria (human health)

Methods

The Mary River dust fall monitoring program is based on passive dust fall monitoring methods. A total of 26 sampling sites were installed July 2013 at the Mine site, Milne Inlet, Tote road and reference sites within the RSA (Figure B 4.3-1). Sample site locations were chosen with consideration of the direction of prevailing winds within the RSA, excluding areas of future infrastructure development, and to represent areas of various expected dust fall concentrations based on isopleth dispersion models. The 26 dust fall sample sites include:

- Four reference sites (two located southeast and upwind of the Baffinland Mine Site; two located 14 km south and west of the road centerline with no prevalent wind direction to direct location effort).
- Three sample sites located in dust generating areas of the Baffinland Mine Site (identified via isopleth models);
- Three sample sites in Milne Inlet (two within the port area itself, and one northeast and upwind of the port); and
- Two road stations, each composed of eight sample sites located at 30 m, 100 m, 1 km and 5 km to either side of the centreline along Tote Road (prevalent wind direction roughly parallel to the roadway as opposed to perpendicular, therefore no 'upwind' and 'downwind' directions from the road are identified).

Each site is comprised of one sampling apparatus, which is made up of a hollow post (~ 2m long) and terminal bowl shaped holder for the dust collection vessel (Photo B-1). The terminal bowl is topped with bird spikes to prevent contamination by bird fecal matter. The sampling apparatus was installed by pounding 5-foot rebar into the ground, placing the post over the rebar, and then stabilizing with guy wires. Dust collection vessels are placed in the holder, pre-charged with 250 mL of algaecide in summer and 250 mL of alcohol in winter. Collection vessels are changed out every month (28–31 days) and shipped to ALS Environmental Laboratory (ALS) in Vancouver for analysis of total, fixed and volatile insoluble particulate matter.

Caribou present in the area of the Baffinland Mine site are sedentary and are present year-round. Therefore, sampling of the dust fall monitoring stations will occur on a year-round basis; however, during the winter, the sampling program will be limited to a subset of the sampling sites (at present, 14 out of 26) as access to remote sites is limiting.

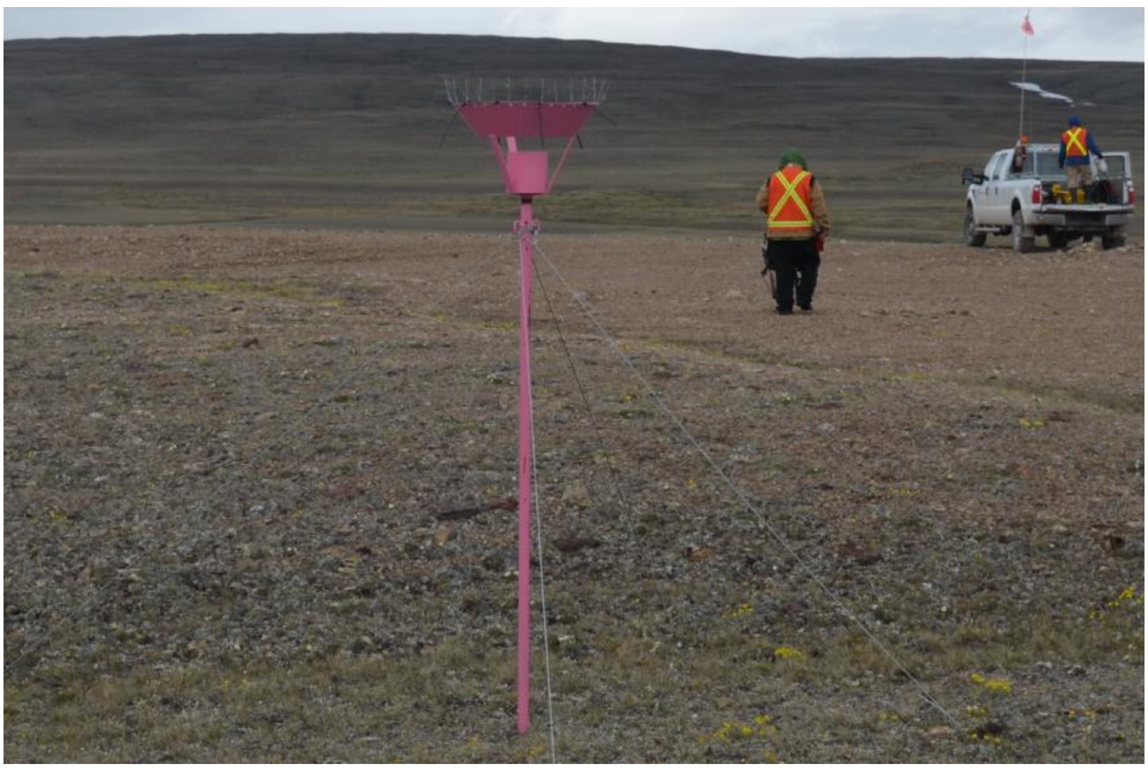


Photo B-1. Dust fall collector sampling apparatus, July 10, 2013.

Laboratory results are analyzed against the predicted dust deposition thresholds for the Project to determine if concentrations are exceeding the applicable indicator threshold. Results are also reviewed to investigate concentrations on a temporal and spatial scale relative to background concentrations with focus on seasonal differences in dust fall data. As of January 2014, three months of sampling results have been received back from the lab; in addition to the analyses described above, a power analysis is also being completed based on these results to determine the level of variability among the sampling stations and assess whether the current monitoring program is sufficient or if additional sampling stations are required to accurately capture Project effects.

References

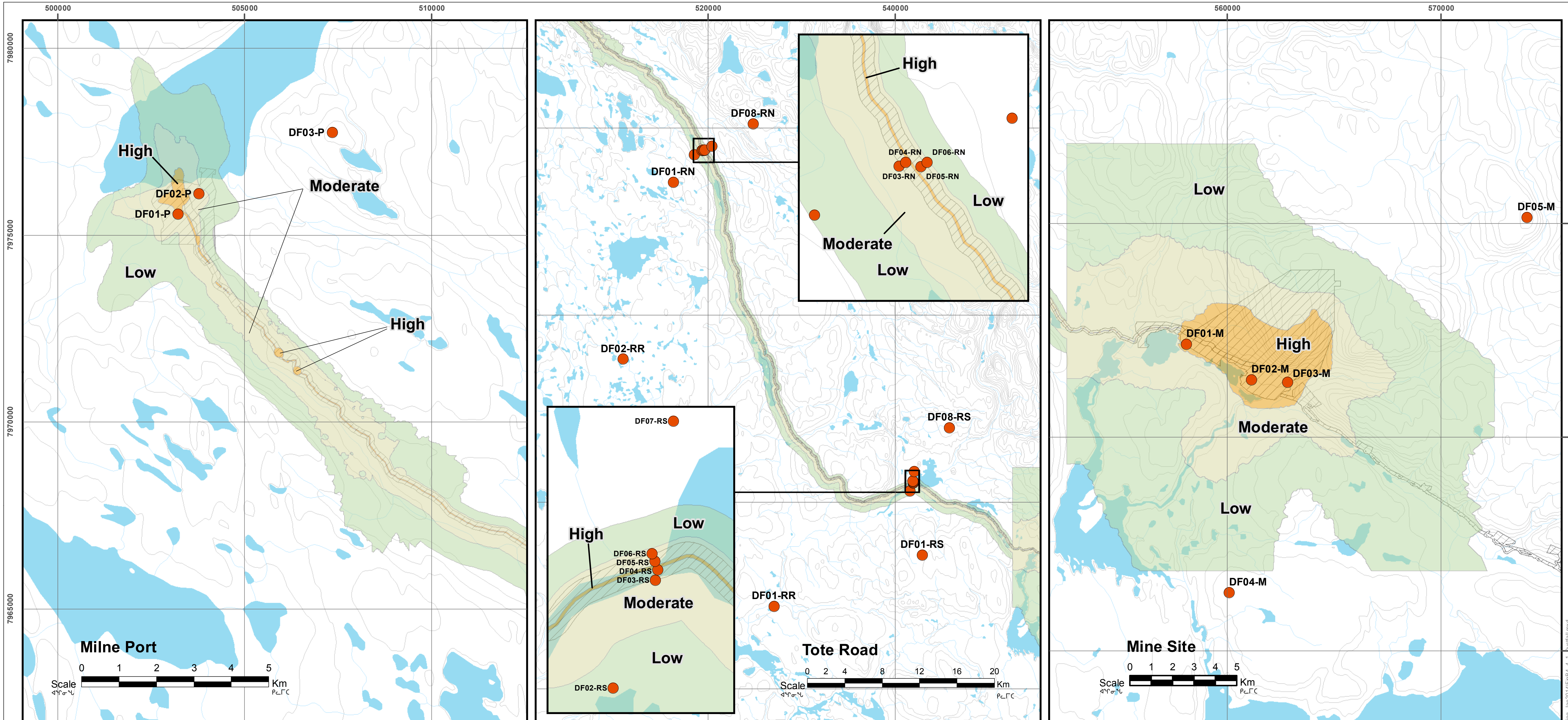
American Society for Testing and Materials (ASTM). 2004. Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter) Designation D 1739-98 Reapproved 2004, West Conshohocken, PA.

Boulanger J., Poole K.G., Gunn A., and J. Wierzchowski. 2012. Estimating the zone of influence of industrial developments on wildlife: a migratory caribou *Rangifer tarandus groenlandicus* and diamond mine case study. Wildlife Biology 18:2.

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. 1998. National ambient air quality objectives for particulate matter. Executive Summary. Part 1: Science assessment document. http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/air/naaqo-onqaa/particulate_matter_matieres_particulaires/summary-sommaire/98ehd220.pdf.

Rescan Environmental Services Ltd. 2012. Ekati Mine 2011 Air Quality Monitoring Program. Produced for: BHP Billiton Canada Inc.

Wolfden Resources Inc. 2006. High Lake Project Proposal. Volume 6: Terrestrial Environment, Section 2.0 - Vegetation. Project proposal submission the Nunavut Impact Review Board, November 2006.

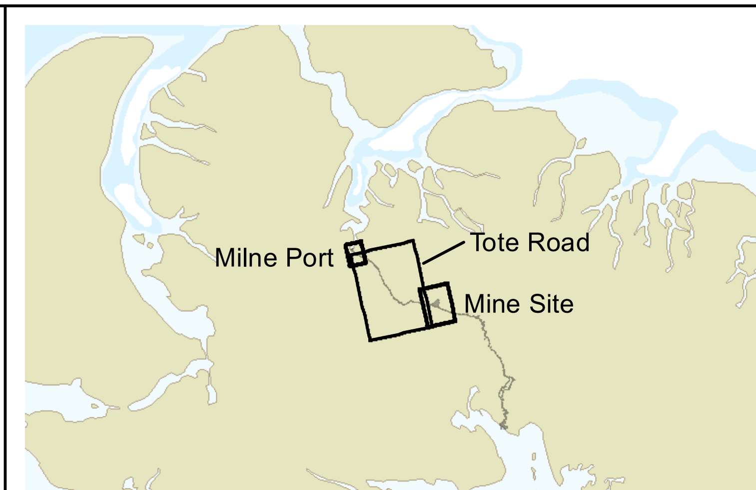


LEGEND

- Dustfall Sampling Sites
- Potential Development Area
- Topographic Contour (20m Interval)
- Watercourses
- Waterbodies

TSP Annual Deposition

- High (>50 g/m²/a.)
- Moderate (4.6–50 g/m²/a.)
- Low (1–4.6 g/m²/a.)



NOTES ᖃᐅᔨᒪᔭᕐᕆᐊᑦ

TSP deposition isopleths provided by RWDI Air Inc. (2013) and modified by EDI for display purposes.

Northern Land Cover of Canada (Circa-2000) courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Updated PDA provided by Hatch (25 April 2013).

Projection: North American Datum 1983 UTM Zone 17N.

Baffinland Iron Mines Corporation

2013 Dustfall Collector Locations within the Mary River Project Area

EDI

Date: 15/01/2014

FIGURE B4.4-1

Appendix H

Initial Stream Diversion Barrier Study

Appendix H

Initial Stream Diversion Barrier Study

MEMORANDUM

To:	Mr. Oliver Curran	Date:	June 25, 2014
Copy To:		File No.:	NB102-181/34-A.01
From:	Dale Klodnicki	Cont. No.:	NB14-00160
Re:	Initial Stream Diversion Barrier Study - Rev. 0 Mary River Project - Aquatic Effects Monitoring Program		

1 – INTRODUCTION

A stream diversion barrier study was identified as a follow-up program in the Final Environmental Impact Statement (FEIS) for the Mary River Project (Baffinland, 2012). The primary objectives of the study are to monitor the effects of both increases and reductions in streamflow at several mine site streams and to further understand how Project-related reductions in streamflow may result in the creation of fish barriers that have the potential to occur at low flows. The monitoring program may identify the need for mitigation measures to address Project-related fish stranding.

The stream diversion barrier study is a “targeted study”, which forms part of Baffinland’s Aquatic Effects Monitoring Program (AEMP). This memorandum describes the initial study that was focussed on obtaining a better understanding for existing flow conditions and, in particular, the frequency and duration of the occurrence of fish barriers and fish stranding that was identified in five (5) mine site streams (North/South Consultants Inc. - NSC, 2008; Knight Piésold Ltd. - KP, 2012).

Since the stream diversion barrier study was identified in the FEIS, Baffinland has developed plans that are now in the final stages of approval to initiate an Early Revenue Phase (ERP) of the Project (Baffinland, 2013). The ERP will involve mining 3.5 million tonnes per annum (Mt/a) of iron ore. The iron ore will be transported year-round by truck to Milne Port and then to market by ship during the open water season. Baffinland has contemplated a 5-year operating plan for the ERP, after which time the full-scale railway project would also be brought on-line. This development schedule is subject to a commercial decision by Baffinland to proceed and will be influenced by both market conditions and available financing.

The reduced production rate associated with the ERP will result in a considerably smaller mining footprint (open pit and waste rock stockpile) than was originally envisioned. As such, Project-related stream diversions will be negligible. The absence of diversions provides Baffinland with an opportunity to better understand existing flow conditions as it relates to fish passage. This initial study is exploratory in nature with the following objectives (which contribute to the primary objectives stated above):

- Develop an understanding of low-flow conditions that may result in barriers to fish passage within two tributaries of Camp Lake and three tributaries of Sheardown Lake (Figure 1).
- Document fish presence throughout the stream length under various flow conditions. It is important to document upstream access during spring freshet, since high water velocities in the spring can prevent fish passage. It is also important to document the downstream passage of fish in the fall, when they are returning to overwintering habitat in the lakes.

Stream gauging stations are seasonally operated on three of the five targeted streams (Figure 1). The conditions observed throughout each season and between years can be related to the calculated flows in the streams. An understanding of the relationship between flow conditions and the presence of fish barriers and fish presence, understanding that streams are dynamic systems that change over time.

2 – PROJECT EFFECTS AND PROPOSED MONITORING

2.1 GENERAL

The Project footprint (including water management features) will reduce flows in five mine site streams. The resulting flow reduction will result in a loss of fish habitat that was assessed to be minor (low magnitude) in the FEIS. The flow reductions also have the potential to affect the ability of Arctic Char (primarily juveniles) to access small tributaries in the mine site area, particularly in the spring as fish move into the streams and in fall when fish return to the lakes to overwinter. The creation of barriers (or increased frequency or changed timing of existing barriers) due to reduced flows could impede fish passage upstream or downstream in the tributaries. Although considered unlikely, mortalities are possible in the event fish became stranded in the streams in fall.

The development of the open pit, a waste rock stockpile, and associated water management facilities (ditches, berms and settling ponds) will divert and redirect runoff away from certain watercourses during the operational phase of the Mary River Project (Baffinland, 2012). Five tributary streams are anticipated to be affected by diversions in the Mine Area (Figure 1).

2.2 CAMP LAKE TRIBUTARY 1 (CLT-1)

CLT-1 provides approximately 5.7 km of probable or confirmed fish-bearing habitat within the main channel and its smaller tributaries. This habitat is generally shallow (typically < 0.5 m deep), with predominantly cobble substrates (NSC, 2012; see Figure 2). Habitat in the upper reaches of the tributaries typically consists of a shallow series of cascades and riffles, with intermittent flow that provides only small amounts of habitat for aquatic life. The L1 branch of CLT-1 extends from the north-eastern shore of Camp Lake for approximately 1,400 m before reaching an impassable barrier (waterfall). It consists predominantly of riffle/pool habitat with cobble substrata. Undercut banks, deep pools and boulders provide ample cover in this stream. The utilization of the L1 branch of CLT-1 by Arctic Char is high. During surveys by Knight Piésold and NSC, one area on the L1 branch of CLT-1 between the lake and the falls was identified as a potential fish barrier under low flow conditions (Figures 1 and 2). Baffinland has continued to operate a seasonal stream gauge on the L1 branch of CLT-1 since 2006 (Figure 1).

A secondary channel (L2, referred to in NSC (2012) as Tributary 1b), continues an additional 1.25 km from downstream of the impassable falls into a series of broad and shallow ponds. This channel runs parallel to the airstrip along the base of the mountain. This channel is a low gradient area where several large, shallow (0.5 m) pools with cobble bottoms where limited in-stream cover is present. Limited sampling in the L2 stream suggests a much lower level of fish utilization compared with the L1 branch.

The west pond will collect runoff from the west half of the waste rock stockpile area and discharge it to the L1 stream of the Camp Lake Tributary 1 (CLT-1). This will result in an overall increase in flows in the L1 stream of CLT-1 that will be not be typical of the natural hydrograph. The L2 branch (CLT-1 L2 stream) will not receive flows from the west pond and will experience a flow reduction.

Flow regimes in CLT-1 for the FEIS predicted (Page 225 in Volume 7; Baffinland, 2012):

- An 8% reduction in flows during July
- A 25 to 39% increase in flows during June, August and September during operation and closure
- A 7 to 22% increase in flows throughout the open water period during post-closure

These predictions considered the total flow of CLT-1, including the L1 and L2 streams. A section of CLT-1 L1 was identified as a potential barrier under low flow conditions. Increased flow in CLT-1 L1 has the potential to create a barrier to upstream movement during the spring.

A detailed survey of L2 stream was not conducted. Anticipated effects from flow diversion are different between these streams. The L2 stream of CLT-1 flows parallel to the airstrip, and experiences a net reduction in flow as a result of west pond discharges being directed solely into the L1 stream. The L2 stream is identified as Arctic Char habitat, though it is lower quality habitat compared with the main channel of CLT-1 (L1 stream).

Monitoring within CLT-1 will initially include the potential barrier location on the L1 branch under low flow conditions and support a better understanding of the flow conditions and fish utilization of the L2 branch under different flow conditions (i.e., in spring and fall).

2.3 CAMP LAKE TRIBUTARY 2 (CLT-2)

CLT-2 is characterized by moderate to steep gradient, coarse bed material and a channel that tends to be braided (multiple channels, split by unvegetated islands and bars). Falls are located approximately 600 m from the mouth of the tributary (Figures 1 and 2). This tributary is heavily utilized by Arctic Char. During surveys by Knight Piésold and NSC, one area between the mouth and the falls on CLT-2 was identified as a potential fish barrier under low flow conditions (KP, 2011 and 2012; NSC, 2012).

Diversion of runoff from the west waste rock stockpile area and open pit will also alter discharge to CLT-2. The reduction in mean monthly flows is predicted to be 15 to 32% throughout the open-water period during operation, closure and post-closure (Page 225 in Volume 7; Baffinland, 2012). This reduction is predicted for the fish barrier location. Due to the apparent absence of any substantial inflows between the fish barrier and Camp Lake, the 15 to 32% reduction in flows is expected to be a fairly accurate estimate at its confluence with Camp Lake. No significant depth reduction was predicted within the fish-bearing section between Camp Lake and the upstream barrier that would impede fish access to habitat in CLT-2.

Since no barriers are expected under baseline flow conditions, limited “baseline” monitoring of CLT-2 will be undertaken during this initial study to validate predictions made in the FEIS. The stream will be visited opportunistically in the spring and fall during low flow years. More detailed monitoring of the fish-bearing section of CLT-2 will be undertaken once the Project has advanced to full-scale mining and the potential flow reductions identified in the FEIS have been realized.

2.4 SHEARDOWN LAKE TRIBUTARY 1 (SLDT-1)

Only four tributaries of Sheardown Lake support fish, and, of these, only one is of substantial size (SLDT-1). Three of the four fish-bearing tributaries (SDLT 1, SLDT 9, and SLDT 12) will be affected by a combination of open pit mining, ore stockpile placement and the associated water management practices during the Project’s operations and closure phases (Page 226 in Volume 7; Baffinland, 2012).

SDLT-1 (Tributary 1) and its main branch (Tributary 1b) flow into the northwest basin of Sheardown Lake and provide approximately 3 km of fish-bearing stream channel before reaching parts of the tributary that would not be passable to fish (Figure 3). Much of the stream is riffle or riffle/pool habitat over a predominantly cobble substrate and it is shallow (<0.1 m deep). The stream depth increases in the mid-section (up to 0.5 m) and both riffles and pools are present. Further upstream, the tributary forms a series of broad shallow pools. Stream habitat upstream of these pools is limited, consisting of a shallow (<0.1 m) stream with a cobble/boulder substrate and little cover. Cover in Tributary 1 varies with position, but is provided by boulders, undercut banks, and deep pools. SDLT-1 is the largest tributary of Sheardown Lake, providing important open water habitat for juvenile Arctic Char. Two potential barriers were identified within SDLT-1 (Figure 3).

The SDLT-1 stream contains stream gauge station H11 (established in 2011). Discharge hydrographs and rating curves have been developed for this stream.

During the operating and closure phases of the Project, SDLT-1 will experience flow reductions in the range of 21 to 35%. Post-closure, SDLT-1 will continue to experience a reduction in flows of 6 to 20% throughout the open-water period due to diversion of water around the open pit.

Monitoring within SDLT-1 will include the identified potential barrier locations within the lower reach near the outlet to the northwest lake basin and the other reach near the mine access road upstream. The proposed monitoring program will improve the mine's understanding of the flow and fish utilization conditions under different flow regimes (i.e., in the spring and fall).

2.5 SHEARDOWN LAKE TRIBUTARY 9 (SDLT-9)

SDLT-9 is characterized by cascade/pool habitat over cobble with varying amounts of boulder, gravel and/or sand (NSC, 2012). SDLT-9 drains a small fish-bearing lake with sufficient depth for overwintering, but an impassable barrier prevents upstream access from Sheardown Lake. Use of Tributary 9 habitat downstream of the barrier can also be limited due to lack of connectivity to Sheardown Lake under low flow conditions.

During operation of the railway project, SDLT-9 will experience an estimated 29% reduction in open-water season flows during operation and closure. Ore stockpiles will be removed at closure, so SDLT-9 flows will only be impacted during operations and closure. No Project-related reduction in flows is anticipated in SDLT-9 during the ERP, since there are no ERP facilities within this catchment.

SDLT-9 will be monitored during this initial program to understand the frequency and duration of fish barriers between Sheardown Lake and the small lake during low flow conditions (Figure 3). The presence and/or absence of fish will also be noted during low flow conditions.

2.6 SHEARDOWN LAKE TRIBUTARY 12 (SDLT-12)

SDLT-12 is similar to SDLT-9 and characterized by cascade/pool habitat over cobble with varying amounts of boulder, gravel and/or sand. Fish use of SDLT-12 is limited by an impassable waterfall and low flows during much of the open-water season.

SDLT-12 will experience an estimated 15% reduction in open-water season flows during operation and closure. Ore stockpiles will be removed at closure, so SDLT-12 flows will only be impacted during operations and closure. No Project-related reduction in flows is anticipated in SDLT-12 during the ERP, since there are no ERP facilities within this catchment.

SDLT-12 will be monitored during this initial program to understand the frequency and duration of fish barriers between Sheardown Lake and the permanent fish barrier (waterfall) during low flow conditions. The presence and/or absence of fish will also be noted during low flow conditions.

3 – MONITORING PROGRAM METHODOLOGY

The five streams of interest will be monitored in spring and fall during the initial years of operation. Low and high flow periods will be targeted where possible. Results of this initial monitoring will be reviewed to determine whether mitigation and/or ongoing monitoring is required. In spring, all five streams will be visually assessed to monitor for potential barriers and obstructions to upstream fish passage.

Surveys will document conditions within the monitoring streams between the upstream fish barriers and their outlets into Camp Lake and Sheardown Lake. The survey will utilize a field sheet (Appendix A) to document in situ conditions, including:

- A visual inspection along the targeted stream reaches
- Measurements of total water depth and point velocities at locations that may pose barriers to fish passage
- Instantaneous flow measurements within the SDLT-9 and SDLT-12 tributaries (not currently gauged)
- Photographing the potential natural barriers (facing upstream, downstream and the left and right banks). A minimum of 4 photos will be taken at each location.
- Documenting the presence and location of fish during the stream inspections

A target of two (2) spring surveys and three (3) fall surveys has been set. The number of surveys completed will be subject to on-site resource availability.

Other monitoring programs will contribute data relevant to this study. For example, Baffinland`s hydrology monitoring program includes stream gauges on three streams monitored under this program, and the freshwater biota monitoring will be undertaken as part of the Core Receiving Environment Monitoring Program (CREMP). Monitoring data from both these programs will be used in the analysis of data from this initial stream diversion monitoring study.

4 – ANALYSIS OF MONITORING RESULTS

The proposed Initial Stream Diversion Study will be completed annually over the next three years (2014, 2015 and 2016) followed by a review at the end of 2016. At the end of the three-year initial program, a report will be produced that summarizes the monitoring data and presents an analysis of results, including:

- Hydrographs from the existing stream gauging stations - The hydrograph results for the three years will be compared to historical hydrology records to better understand how flows varied throughout the year and how the flow rates compared to historical norms.
- The flow and water depths will also be compared to the values presented in support of the FEIS (KP, 2011 and 2012).
- Presentation of fish barrier identification information - This information will be summarized in tabular format and will most likely be organized by fish barrier or transect location. Comments will be provided on how the presence of specific fish barriers relate to flow conditions. This may help identify when specific sections of the streams become barriers to fish passage.
- Fish stranding information - A discussion on the frequency, timing and duration of current fish stranding. Comments will be provided on whether these events are likely to result in fish mortalities.

The 3-year initial stream diversion study monitoring report will be presented with the AEMP Annual Monitoring Report in the first half of 2017. The report will also include recommendations on potential mitigation measures and future monitoring.

Continuation of the monitoring program will depend upon the schedule and size of the Project. The Approved Project (18 Mt/a) will result in meaningful reductions in streamflow and monitoring will be required to identify Project-related fish barriers and fish stranding. If the ERP were to continue beyond 2017 and the 3-year study has met the stated objectives, then this targeted study may be discontinued until such time as the Approved Project proceeds. If possible, monitoring for the Approved Project will start one year prior to the start of larger scale mining.

5 – POTENTIAL MITIGATION MEASURES

A number of mitigation measures have been identified in the FEIS (Baffinland, 2012) and the Updated AEMP Framework (Baffinland, 2013), including:

- Monitoring and salvage fisheries
- Channel improvements
- Exclusion of Arctic Char from streams

Since the ERP will result in minimal to no changes in flows, implementation of mitigation measures will not be required within the initial three year study period. These mitigation options will be carried forward for consideration when the Project has reached full scale and the Project-related changes in flow can be expected to occur.

6 – REFERENCES

Baffinland Iron Mines Corporation, 2012. *Mary River Project Final Environmental Impact Statement*. February 2012.

Baffinland Iron Mines Corporation, 2013. *Mary River Project - Addendum to the Final Environmental Impact Statement*. June 2013.

Knight Piésold Ltd., 2011. Memorandum to: Richard Remnant, North/South Consultants Inc. Re: *Mary River Project - Revised Habitat Assessment Support*. December 16. Ref. No. VA11-01684.

Knight Piésold Ltd., 2012. Memorandum to: Richard Remnant, North/South Consultants Inc. Re: *Mary River Project - Fish Passage Barrier Assessment Support*. January 9. Ref. No. VA12-00095.

North/South Consultants Inc., 2008. *Freshwater Aquatic Environment Baseline Report: Fish and Fish Habitat 2007 DRAFT*. April 2008.

North/South Consultants Inc., 2012. *Freshwater Aquatic Biota and Habitat Baseline Synthesis Report 2005-2011*. January 2012.

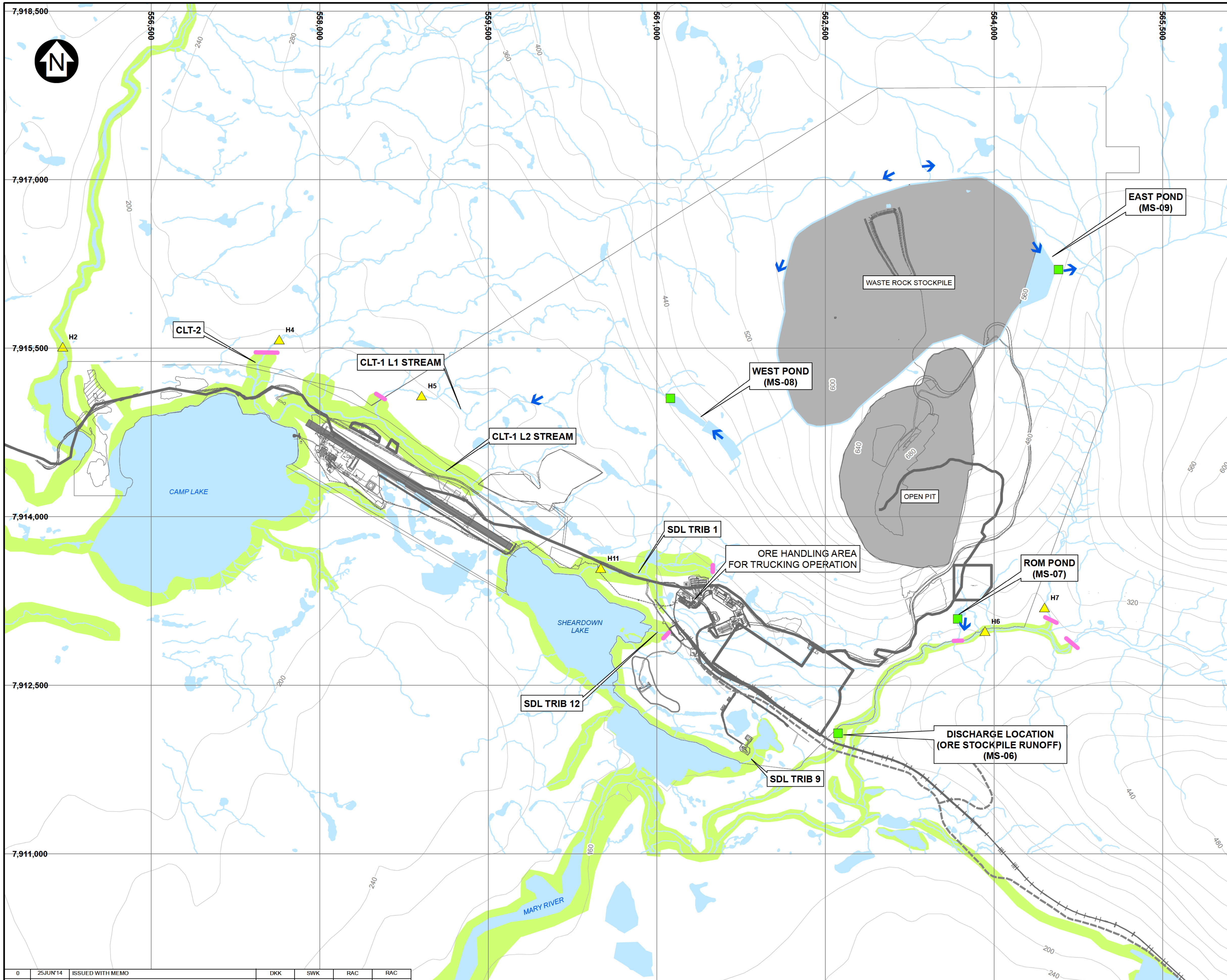
Signed: for Dale Klodnicki, C.E.T. - Environmental Technologist

Reviewed and Approved: Richard Cook, B.Sc. - Senior Scientist

Attachments:

Figure 1 Rev 0	Diversion Study Area Streams
Figure 2 Rev 0	Camp Lake Tributaries Subject to Monitoring
Figure 3 Rev 0	Sheardown Lake Tributaries Subject to Monitoring
Appendix A	Stream Diversion Field Data Sheet

/dkk



LEGEND:

- FINAL DISCHARGE POINT
- STREAM FLOW GAUGING STATION
- FISH BARRIER
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- CONFIRMED ARCTIC CHAR HABITAT

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.
5. ARCTIC CHAR HABITAT (PRESENCE) FROM NSC, 2012 MARY RIVER PROJECT FRESHWATER AQUATIC BASELINE SYNTHESIS. REPORT: 2005-2011.

SCALE 250 125 0 250 500 750 1,000 1,250 1,500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

DIVERSION STUDY AREA STREAMS

Knight Piésold CONSULTING

P/A NO.	REF NO.	
NB102-181/34	NB14-00160	
FIGURE 1		REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH MEMO	DKK	SWK	RAC	RAC

SAVED: I:\102\00181\34\A\GIS\Figs\B50_r0.mxd; Jun 25, 2014 2:50 PM; skozmick

LEGEND:

- STREAM FLOW GAUGING STATION
- FISH BARRIER
- PREVIOUS TRANSECT LINE (KNIGHT PIESOLD, 2011)
- MILNE INLET TOTE ROAD
- CONTOUR

NOTES:

1. TOPOGRAPHY AND ORTHOPHOTOS PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOUR INTERVAL IS 10 METRES.

SCALE 100 50 0 100 200 300 400 500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CAMP LAKE TRIBUTARIES SUBJECT TO MONITORING

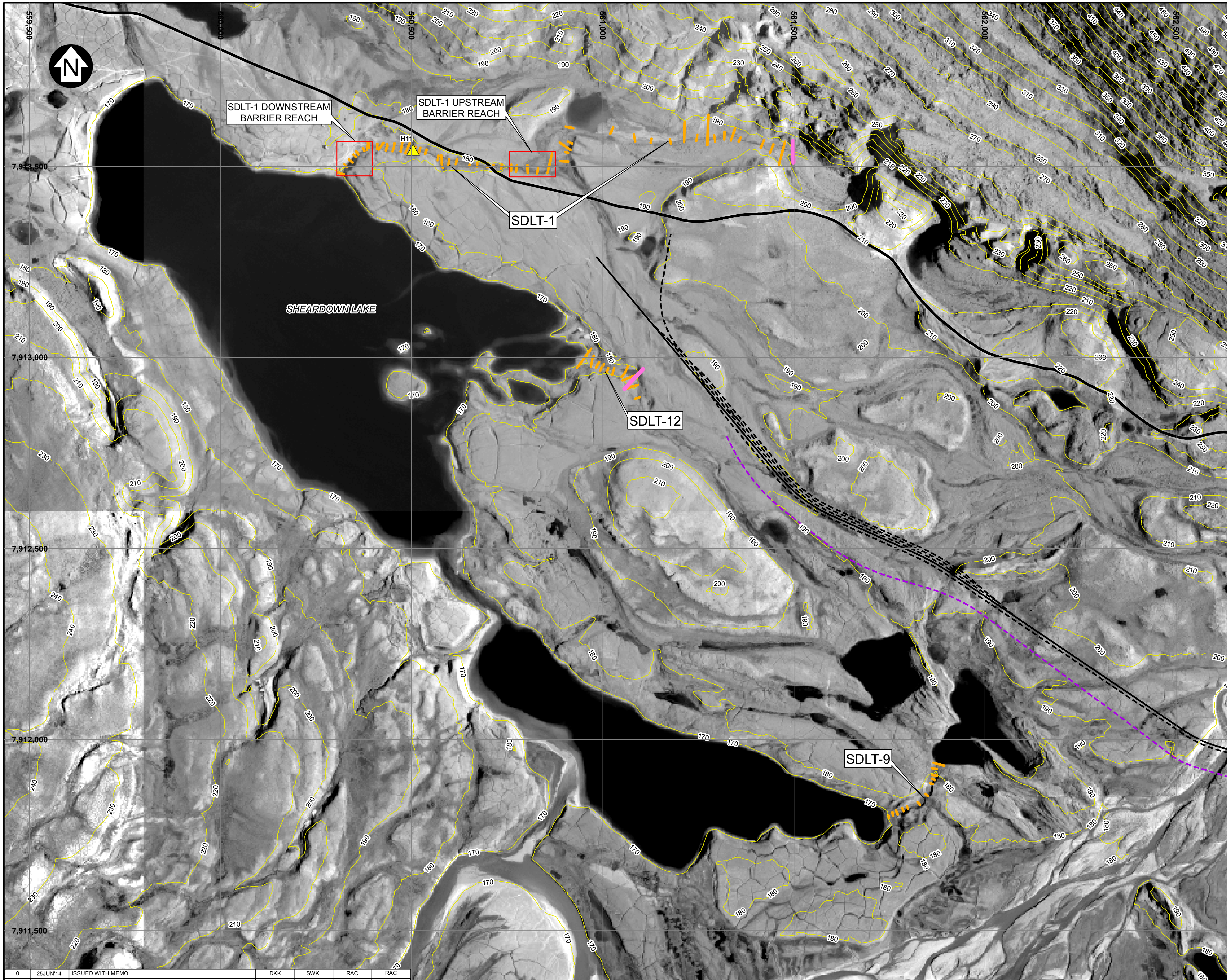
Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	NB14-00160

FIGURE 2 REV 0

0	25JUN'14	ISSUED WITH MEMO	DKK	SWK	RAC	RAC
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

SAVED: I:\1\02\00181\34\A\GIS\Figs\B51_r0.mxd; Jun 25, 2014 2:05 PM; skozmick



LEGEND:

- STREAM FLOW GAUGING STATION
- FISH BARRIER
- PREVIOUS TRANSECT LINE (KNIGHT PIESOLD, 2011)
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- CONTOUR

NOTES:

1. TOPOGRAPHY AND ORTHOPHOTOS PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOUR INTERVAL IS 10 METRES.
4. RAILWAY ALIGNMENT PROVIDED BY CANARAIL CONSULTANTS INC. (AUGUST, 2010).

SCALE 100 50 0 100 200 300 400 500 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SHEARDOWN LAKE TRIBUTARIES SUBJECT TO MONITORING

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/34	NB14-00160

FIGURE 3 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	25JUN'14	ISSUED WITH MEMO	DKK	SWK	RAC	RAC

SAVED: I:\102\00181\34\A\GIS\Figs\B52_r0.mxd; Jun 25, 2014 2:44 PM; skozmick

APPENDIX A

STREAM DIVERSION FIELD DATA SHEET

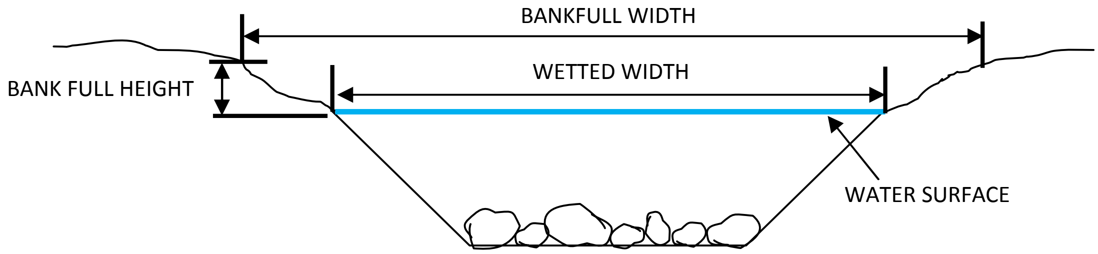
(Page A-1)

Knight Piésold CONSULTING

STREAM DIVERSION FIELD DATA SHEET

PROJECT NO: NB102-181/34	**WATER BODY:**	**DATE(ddmmmyyyy):**
FIELD CREW:	**START TIME:**	**END TIME:**
WEATHER:		

CHANNEL CHARACTERISTICS



Station ID:	**UTM Easting (m):**	**UTM Northing (m):**
Wetted Width (m):	**Bank Full Width (m):**	**Bank Full Height (m):**
Photos (check): ☐ Upstream ☐ Right Bank	☐ Downstream	☐ Left Bank

Depth/Point Velocity measurements across the stream

Total Depth (m):	m	m	m	m	m	m
Velocity (m/s):	m/s	m/s	m/s	m/s	m/s	m/s
Total Depth (m)	m	m	m	m	m	m
Velocity (m/s):	m/s	m/s	m/s	m/s	m/s	m/s

Fish Presence (circle US/DS) : US / DS >10 individuals US / DS <10 individuals US / DS No Fish Observed

Comments:

Station ID:	**UTM Easting (m):**	**UTM Northing (m):**
Wetted Width (m):	**Bank Full Width (m):**	**Bank Full Height (m):**
Photos (check): ☐ Upstream ☐ Right Bank	☐ Downstream	☐ Left Bank

Depth/Point Velocity measurements across the stream

Total Depth (m):	m	m	m	m	m	m
Velocity (m/s):	m/s	m/s	m/s	m/s	m/s	m/s
Total Depth (m)	m	m	m	m	m	m
Velocity (m/s):	m/s	m/s	m/s	m/s	m/s	m/s

Fish Presence (circle US/DS) : US / DS >10 individuals US / DS <10 individuals US / DS No Fish Observed

Comments:

Incidental Fish Observations

UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals
UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals
UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals
UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals
UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals
UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals
UTM Easting (m)	**UTM Northing (m)**	**Fish:**	☐ >10 individuals	☐ <10 individuals

APPENDIX G

2016 GEOTECHNICAL INSPECTION REPORT

Baffinland

BHM Project No. 15-97

BAFFINLAND IRON MINES CORPORATION

ANNUAL GEOTECHNICAL INSPECTIONS
MARY RIVER PROJECT
SECOND INSPECTION OF TWO
October 2016

Prepared for:
Mr. Jeff Bush
Site Services Superintendent
Baffinland Iron Mines Corporation
2275 Upper Middle Road East, Suite 300
Oakville, Ontario L6H 0C3

BARRY H. MARTIN

Barry H. Martin, P. Eng., MRAIC, Consulting Engineer and Architect
1499 Kraft Creek Road
Timmins, Ontario P4N 7C5
Tel: 705-268-5621
barrymartin1499@gmail.com

INDEX

November 15, 2016

Baffinland Iron Mines Corporation
2275 Upper Middle Road East, Suite 300
Oakville, Ontario
L6H 0C3

Attention: Jeff Bush
jeff.bush@baffinland.com

**RE: ANNUAL GEOTECHNICAL INSPECTIONS
BAFFINLAND IRON MINES CORPORATION
OUR REFERENCE NO. 15-097**

1.0 INTRODUCTION

Barry H. Martin, P. Eng., Consulting Engineer, completed the eighth annual water licence geotechnical inspection of the following on-site engineered facilities as required by Licence No. 2AM-MRY 1325 of the Nunavut Water Board:

Pit Walls
Quarries
Landfills
Land Farms
Bulk Fuel Storage Facilities
Sediment Ponds
Collection Ponds
Polishing and Waste Stabilization Ponds

The inspection that took place October 5 to October 11th, 2016 is the second phase of a biannual inspection to be carried out within the open water shipping season at the two Baffinland sites, in Mary River at the mine site, and at Milne Inlet at the port facility. Although the shipping season extended into October, snow came early in mid September and although inspections were completed , the photos did not show well

The inspections were carried out in accordance with the guidelines set out in "Dam Safety Guidelines 2007" as published by the Canadian Dam Association.

The inspections were completed by Mr. Barry H. Martin, P. Eng., the design Engineer for the initial containment facilities both at Mary River and Milne Inlet, the runway extension, initial bridges on the connecting road, the solid waste disposal site as well as continuing construction of select mine infrastructure.

The seven previous annual water licences geotechnical inspections were completed by Mr. Martin. You shall note that Hazardous Waste Containment Structures have been assigned new designations in the report as compared to previous years.

The facilities inspected are as per the following:

Mary River Site

Bulk Fuel Storage Containment
Generator Fuel Storage Facility Containment
Polishing/Waste Stabilization Pond No. 1
Polishing/Waste Stabilization Ponds Nos. 2 and 3 (constructed as a two-cell structure)
Helicopter Fuel Cell Containment
Barrel Fuel Containment (constructed as a two-cell structure)(MS-HWB-3 and MS-HWB-4)
Hazardous Waste Storage (MS-HWB-2)
Enviro-Tank Storage (constructed contiguous with hazardous waste storage and stove oil storage) (MS-HWB-1)
Stove Oil Storage (MS-HWB-5)
Jet Fuel Tank and Pump Containment
Solid Waste Disposal Site
Minesite Steel Fuel Tank Farm Containment
Quarry
Crusher Pad Drainage Containment
Waste Pile Drainage Containment
Jet "A" Aircraft Containment
Hazardous Waste Containment (MS-HWB-6)

A site plan for the Mary River site showing most structures reviewed is attached.

Milne Inlet Site

Hazardous Waste Storage (constructed as a two-cell structure) (MP-HWB-3, and MP-HWB-4,)
Fuel Tank Farm
New Sewage Effluent Pond (PWSP)
Land Farm
Contaminated Snow Containment
Sediment Ponds East and West
Quarry
Loading Area Contaminated Storage (MP-HWB-1)
Fuelling Facility Containment

A site plan for the Milne Inlet site showing most structures reviewed is attached.

2.0 METHODOLOGY FOR INSPECTION

The geotechnical inspector was Barry H. Martin, P. Eng., who also reviewed the two sites for the first of the biannual inspections on July 28th to August 3rd, 2016 just as the annual shipping season commenced with the arrival of the first ship into port. This particular inspection took place just prior to the end of the shipping season. Although it was possible to complete inspections, snow came early at

Mary River in mid September, and as a result the inspections took place with 2" to 4" of snow on the ground.

The inspections primarily focused on the following aspects:

1. The structures were inspected for conformance with the design basis as presented in "as constructed" and "as-built" drawings (provided in the first and subsequent reports).

2. The structures were specifically inspected for settlement, cracking, and seepage through the berms.

3. The areas around the structures were examined for evidence of seepage.

4. Quarry walls were reviewed for relative stability. I note that the quarries are active removal areas and long term stability was not yet established.

5. New structures under construction were reviewed for conformity with design drawings.

6. Photographs were taken to document observations made during the inspection and are attached. These photos however are somewhat compromised by the slight snow cover.

3.0 MARY RIVER CAMP

3.01 General

Due to the very cold weather encountered during the inspection it was difficult to confirm moisture within the containment structures although ice was found in some.

A monitoring program is in place to test storm water that does accumulate within the containment structures. As reviewed, the water that does not meet the water licence effluent requirements is treated on site prior to release. In some cases, water collected within the structures has been pumped out.

At the Bulk Fuel Storage Facility Containment, the water that collects within the dyke is treated at the end of the containment structure. At the time of this inspection, the treatment equipment had been moved to another location.

As with the report last year, there are some new code names assigned to the containment structures.

We report on the new Jet "A" Fuelling Containment Structure and Hazardous Waste Containment for the first time.

As with the August report of this year there are new code names assigned to hazardous waste structures.

The Bulk Fuel Storage Containment (Exploration Phase Bladder Farm) is coming due for decommissioning but is still used to store barrels of fuel, lubricant cubes, and a large fuel tank at this time.

3.02 Bulk Fuel Storage Facility (Exploration Phase Bladder Farm)

General Conditions

The Bulk Fuel Storage Facility still exists but it is no longer utilized as a bulk fuel storage facility. There are a number of full fuel barrels and lubricant cubes now stored within the berms, as well as a large fuel tank.

The granular cover over the geotextile and liner is still in place within the containment structure awaiting land farming. There is water that is contained within the dykes at one end awaiting treatment.

There is now a ramp over the north end of the containment to permit access over the dyke for placing barrels and cubes for storage.

Stability

At the time of this initial review, water had not been removed for a period from within the containment and water was ponding above the level of the gravel within the bottom of the containment at the north end of the facility. This water was frozen in place as ice.

At the load-out end of the facility there was water ponding within the dykes as ice was present..

The soil structure is considered stable in the present condition and is in conformance with the design basis for the facility.

The presence of water within the structure and at the load-out area is an indication of the integrity of the liner.

The dykes have been built up this year to reinforce the concept of no loader travel over the dykes.

Recommendations

We have no recommendations with respect to this containment structure as it awaits decommissioning.

3.03 Generator Fuel Storage Containment (Exploration Phase)

This particular containment structure is currently being decommissioned. The fuel bladder that was contained within the dyke has been removed.

The granular fill over the geotextile and liner shall require landfarming with the material from the bulk fuel storage facility.

There is no indication that the liner is compromised and decommissioning should proceed when the granular cover is either moved to a land farm or other containment. There is ice within the structure.

3.04 Polishing/Waste Stabilization Pond #1

General Conditions

PWSP No. 1 continues to be utilized as a holding facility for sewage plant effluent that does not meet water effluent quality criteria.

Currently the pond is being used primarily as a repository for off spec sewage and sewage sludge forming in lift stations.

The supernatant from PWSP No. 1 is periodically decanted to PWSPs Nos. 2 and 3 where it is tested and treated as required to meet Water Licence effluent requirements.

At the time of our visit there was approximately fifty percent of capacity to accommodate further sewage and the structure readily conforms to its design intent.

Stability

Our review of this area around the pond at the base of the slopes showed no sign of seepage and hence we conclude that the liner has been effective in containing sewage and there are no tears or ruptures in the membrane, excepting some minor tears from past activity at the top of the dyke well above the allowable effluent level in the structure in the horizontal portion of the membrane.

A review of the top of the dyke showed no indication of cracking or settlement which would indicate stresses within the structure.

Many of the tears that had occurred in the liner on the top of the dyke have been patched during the period between reviews in 2008 and 2009 and are holding well. As well, there are no signs of weather related deterioration of the liner where it is exposed.

There appears to be no sign of erosion of the dykes, even with the precipitation that has occurred over the lifetime of the facility.

The minor settlements have had little effect on the integrity of the structure.

Recommendations

We have no recommendations with respect to this containment facility.

3.05 Polishing Ponds/Waste Stabilization Ponds #2 and #3

General Conditions

The structure was designed and constructed as a two-cell structure.

The supernatant from PWSP #1 is currently discharged to PWSPs Nos. 2 and 3. The treated effluent is tested for Water Licence effluent requirements, treated if necessary, and discharged to the environment.

At the time of our visit there was considerable freeboard to accommodate further sewage and the structure readily conforms to its design intent. Both cells were almost empty and contained less than one foot of liquid as an ice covered liquid which was the capacity allowed for sludge in the original design.

Stability

Our review of the area around the pond at the base of the slopes showed no sign of seepage and hence we conclude that the liner has been effective in containing the sewage and there are no tears or ruptures in the membrane.

Longitudinal cracking which appeared in the dykes of PWSP #3 due to the melt of permafrost wedges in 2009 has not reoccurred and we consider this structure to be stable in its present condition.

Monitoring points have been set upon the top of the dyke and have been monitored since 2009. Settlements have occurred since that time. These settlements have not led to any stress cracks in the structure. Monitoring was discontinued last year.

There appears to be no sign of erosion of the dykes and plants are continuing to seed themselves on the dykes. This growth is minimal, however.

The small bubbles that were observed under the liner at the time of the last inspection were not evident with the colder weather that we have encountered

Recommendations

We have no recommendations with respect to this containment facility.

3.06 Helicopter Fuel Tank Containment

General Conditions

The structure was designed and constructed as a single cell structure that contains a 1000 gal fuel storage tank.

The structure currently conforms to its design intent.

In the past, a liner clad wood curb had been added to the top of the berm to prevent the erosion of gravel off the berm, caused by pulling the fuel hose from within the dyke out to the helicopters to provide them with fuel..

As it was the intent of the mine to use fuel that was available in barrels, a temporary cell had been constructed to contain the barrels with a one piece liner and wood timbers . This containment has been recently removed

Stability

Our review of the area around the pond at the base of the slopes showed no sign of seepage.

A review of the exterior and the top of the berms showed no sign of cracking or settlement which would indicate stress within the structure.

The structure is considered to be stable in its present condition.

Recommendations

We have no recommendations with respect to this structure.

3.07 Barrel Fuel Containment (Now MS-HWB-3 and MS-HWB-4)

General Conditions

This particular structure which we called "Barrel Fuel Containment" in our previous inspection reports is a two-cell structure which is currently used to accommodate cubes of lubricant and barrels in the east cell and cubes of lubricant and antifreeze in the west cell.

Stability

Our review of the area around this containment structure showed no sign of seepage. There is water ponding in this structure as evidenced by the ice in the cell.

A review of the exterior and top of the dyke showed no sign of cracking or settlement which would indicate stresses within the structure.

The structure is considered to be stable in its present condition. The ice confirms the integrity of the liner.

Recommendations

We have no recommendations at this time.

3.08 Hazardous Waste Storage (Now MS-HWB-2)

General Conditions

This particular cell was constructed contiguous with an existing cell, which is referred to on site as the "Enviro Tank Storage", from drawings by our office in 2010 and conforms to our drawings. It is also contiguous with the Stove Oil Storage cell.

This structure contains barrels and bags of hazardous waste.

Stability

Our review of the area around this cell at the base of the slopes, showed no sign of seepage. There is water ponding in this structure as evidenced by ice in the cell.
The structure appears to be stable in its present condition. The ice confirms the integrity of the liner.

Recommendations

There are no recommendations at this time.

3.09 Enviro Tank Storage (Now MS-HWB-1)

General Conditions

This particular structure is constructed contiguous with the Hazardous Waste Storage constructed in 2010 and the Stove Oil Storage cell. It was utilized as a wash down cell during the last season. It is currently not being usedand access is blocked

Stability

Last year there was concern for the integrity of this cell as the cell was dry and the geotextile was exposed from heavy traffic during our initial inspection. During our second inspection, the cell was holding a small amount of water confirming limited integrity of the liner.

The cell is dry this year at both of the 2015 inspections raising concerns anew on the integrity of the liner.

Recommendations

We recommend that the geotextile over the liner be checked and the granular cover be made good prior to continuing use of this cell

3.10 Stove Oil Storage (Now MS-HwB-5)

General Conditions

This particular structure had been used to store barrels of stove fuel in 2011.

The structure again contains barrels of stove oil and some Jet "A" fuel.

This structure was constructed in accordance with a standardized drawing provided by this office utilizing a one piece liner.

Stability

Our review of the exterior at the base of the dyke showed no sign of seepage. This shows that there is reasonably little chance of tearing or rupture of the membrane having taken place.

A review of the exterior and the top of the dyke showed no sign of cracking or settlement which would indicate stresses with the structure.

There is ice contained within the cell confirming the integrity of the liner.

The structure is considered to be stable in its present condition.

3.11 Jet Fuel Tank and Pump Containment

General Conditions

This particular structure was reconstructed based on our recommendation of the 2012 Geotechnical Inspection.

The construction was completed in accordance with our recommendations for such structures and the liner was constructed as a one piece liner with geotextile protection on both sides and gravel over the geotextile as protection.

The construction appears proper and the structure is in good condition.

Minor water ponding confirms the integrity of the liner.

At this time as in our earlier inspection report this year, the jet fuel tank and pump have been removed and the cell is empty.

Stability

Our review of the area around the cell at the base of the slopes showed no sign of seepage and water is ponding within the cell.

.

The structure is stable in its present condition.

Recommendations

There are no recommendations at this time.

3.12 Solid Waste Disposal Site

The solid waste disposal site is currently entering the second phase of its construction. The first lift of solid waste has been placed and covered fully and appears to be doing exactly what it was proposed to do at the design stage. Since our last inspection in July/August the first lift has been expanded.

Work is currently continuing on building a berm on three sides of the disposal site at a level above the existing lift in advance of placing another lift. The berm is being constructed as per the berm on the first level that served well over the past several years,

The blow fence has not been reinstalled yet. In the meantime, solid waste has been covered as it is installed and may be continued to be done to control "blow".

There has been a fence structure of sections of screen and pallets to control snow drift at the activity area of the waste disposal site.

3.13 Minesite Steel Fuel Tank Farm Containment

General Conditions

All work appears to be complete including the installation of the sump pits that shall be utilized to facilitate the removal of water that collects from precipitation. These sump pit are installed at both ends of the containment.

There is ice forming in the bottom of the containment confirming the integrity of the liner. This ponding of water and current forming of ice is above the cover on the bottom of the containment in some areas.

Stability

All work appears to have been completed in accordance with drawings and we have no concerns with the stability of this containment structure.

Recommendations

We currently have no recommendations with respect to this containment structure.

3.14 Quarry QMR2

General Conditions

The quarry has well defined benches. The quarry faces at the benches appear clean.

The quarry is inactive at this time but definitely not closed.

.

The area where the road was undermined in September 2015 has undergone further quarrying and the access road is gone. This area is a fractured zone and subject to subsidence as we noted while on site.

Much of the blasted rock that was in the quarry at our last visit has now been removed

Care must be taken while quarrying in the unstable fractured zone.

3.15 Crusher Pad Drainage Containment

General Conditions

Although there was no moisture flowing to the catchment pond, it is evident that the ditches in place and the containment pond are operating as intended.

Stability

The structure has been completed in accordance with drawings included in our last report in a most satisfactory manner.

Recommendations

We have no recommendations with respect to this containment structure.

3.16 Waste Stockpile Drainage Containment

Stability

The dyke appears stable at this time.

This particular structure has now been completed. The structure is in place with only minor trimming required on the inlet side. The outfall hose to pump the supernatant water over to the Mary River watershed is in place with the pump in place on the dyke.

3.17 Jet “A” Fuel Containment

General Conditions

This cell was constructed to replace the containment structure near the Weatherhaven Camp.

This cell now contains two double walled tanks and is located north of the air terminal buildings.

Stability

The cell was constructed using a one piece enviroliner with geotextile and was constructed in accordance with standardized drawings prepared in the past for such construction by our office.

There is water ponding in the form of ice in the bottom of the cell confirming the integrity of the liner.

There were no signs of cracking of the dykes. A granular ramp has been constructed over the dyke to facilitate access for snow removal.

Recommendations

We have no recommendations with respect to this structure.

3.18 Hazardous Waste Containment (MS-HW-6)

General Conditions

Although it was constructed in 2012, we first reported on it in 2015.

It is located near the incinerator and is utilized to store barrels of ash from the incinerator. It is, however, empty at this time.

Stability

The cell was constructed utilizing a one piece enviroliner with geotextile and was constructed in accordance with standardized drawings prepared in the past for such construction by our office.

There is water ponding in the bottom of the cell confirming the integrity of the liner. This water is currently in the form of ice.

There were no signs of cracking of the dykes or seepage around the exterior of the dykes.

Recommendations

We have no recommendations with respect to this structure at this time..

3.19 Overview

This report is the second phase of the eighth annual Geotechnical Inspection at Mary River and Milne Inlet completed by this author on behalf of Baffinland Iron Mines Corporation and the second year of reporting covering the second of two inspections in one shipping season.

As set out in our past reports, there has been little or no erosion taken place from wind or rain and the dykes constructed of the sand/gravel soil have remained stable at slopes of 3:1 and 4:1.

As noted last year, there are only just now signs of settlement appearing at PSWP's 1, 2 and 3. The settlements are not differential settlements of the dykes but are minor overall settlements of the total structures with respect to the surrounding area.

These settlements appear to be settlements within the one metre ± active layer above the permafrost and are of little concern as the PWSP's are temporary structures and the settlements have no effect on the dyke stability.

It is expected that many of the structures that form the basis for the inspections set out in the biannual Geotechnical inspections shall be decommissioned as the mine facilities are finalized.

A number of these structures at Mary River are awaiting the construction of a land farm facility to facilitate the disposal of contaminated granular fill from the bottom of containment cells.

Mary River Photos

Bulk Fuel Storage Facility

Bulk Fuel Storage – Sump Installed

Generator Fuel Storage Containment

PWSP #1

PWSP #2

PWSP #3

Helicopter Fuel Tank Containment

Stove Oil Storage MS-HWB-1

Enviro Tank Storage MS-HWB-5

Solid Waste Disposal Site

Barrel Fuel Containment MS-HWB-3

Barrel Fuel Containment MS-HWB-4

Mary River Quarry

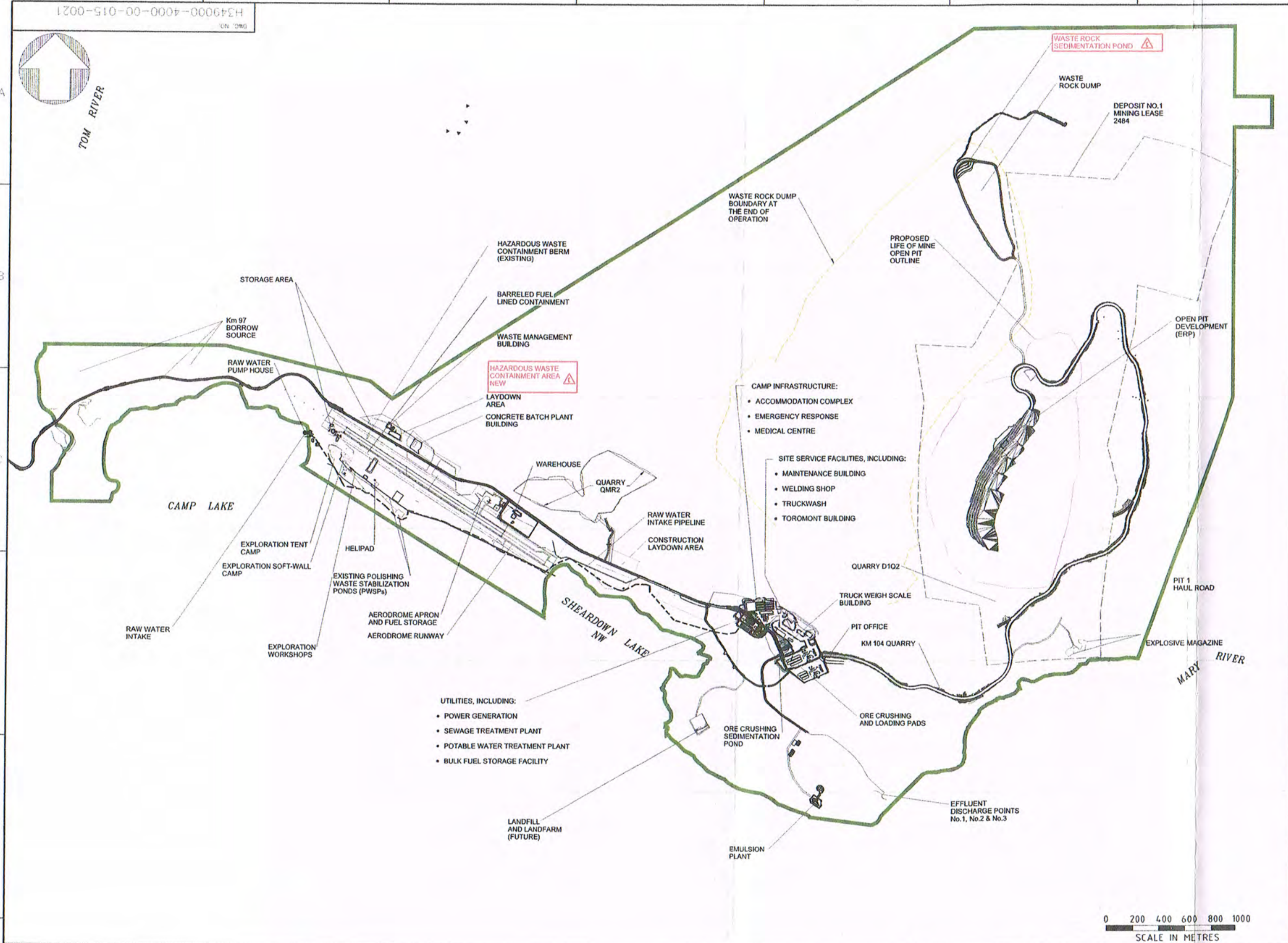
Crusher Pad Drainage Containment

Hazardous Waste Containment MS-HWB-6

Waste Pile Drainage Containment

Jet “A” Fuel Containment

Mary River Drawing



MILNE PORT

MINE SITE

KEYPLAN

FOR INFORMATION

NOTES:

1. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
2. 2016 WORK SHOWN IN RED TEXT.

LEGEND:

WATER	BORROW AREA	RIVER/STREAM/DRAINAGE	COMMERCIAL LEASE
QUARRY	ROAD	RAW WATER INTAKE PIPELINE	PROJECT DEVELOPMENT AREA

REV.	ISSUE FOR	AUTH. BY		DATE
C	ISSUED FOR USE	M.B.	J.B.	2015-10-15
B	ISSUE FOR USE	S.M.	T.M.	2014-12-10
A	ISSUE FOR USE	C.L.	A.G.	2014-10-31

ISSUE AUTHORIZATION

HATCH

DESIGNED BY C. LEISTNER DATE 2014-10-21	DRAWN BY J. BAJAGIC DATE 2014-10-21
CHECKED BY S. POTTER DATE 2014-10-21	DISCIP. ENGR. A. GHZEGORCZYK DATE 2014-10-21
PROJ. DES. COORD. T. THERTELL DATE 2014-10-21	PROJ. ENGR. J. CLELAND DATE 2014-10-21
PROJ. MGR. J. CLELAND DATE 2014-10-21	

Baffinland

MARY RIVER PROJECT

MINE SITE
INFRASTRUCTURE FOOTPRINT
WORK PLAN 2016

SCALE 1:15000 OR AS NOTED

DWG. NO. H349000-4000-00-015-0021 REV C

ORIGINAL SHEET SIZE: ISO A1 (841 x 594)

bajo45702
10/15/2015 9:49:01 AM
c:\prj\projectwise\bajo45702\pw_idc_datasource\dms88860\H349000-4000-00-015-0021.dgn

4.0 MILNE INLET

4.01 General

There are still changes taking place at Milne Inlet, since our last inspection in July/August of this year.

The sediment ponds at the shore that were under nearing completion are now fully operational with inlet ditching complete.

4.02 Hazardous Waste Storage (MP-HWB-3 and MP-HWB-4)

General Conditions

This particular structure has been constructed as a two-cell structure and is now only used to store a few items.

A new hazardous waste storage facility has now been constructed near the loadout area for storing hazardous waste to be shipped out and is in full operation at this time.

Stability

There is no water ponding in both cells of the original structure. We are advised that water has been pumped from these structures and sand in the structures contains ice.

Our review of the area around the dykes, at the base of the slopes, showed no sign of seepage. The structure is considered stable.

Recommendations

We have no recommendations with respect to the use of these two cells at this time. Prior to our inspection in September, we request that water not be pumped from the structures.

4.03 Fuel Tank Farm

General Conditions

Since both 2012 and 2013 the fuel tank farm has been expanded considerably with the addition of a number of new tanks. No tanks have been added since last season but there is room to place additional tanks.

During the last day of our earlier inspections, a major fuel oil spill took place. The berm around the containment effectively contained the pill. The sumps had not been installed at the time of the spill. These sumps have been installed.

Stability

We have minor water ponding at the low end of the containment confirming the integrity of the liner. This ponding is now in the form of ice in the bottom of the containment.

Recommendations

We have no recommendations with respect to the containment at this time.

4.04 New Effluent Pond (PWSP)

General Conditions

The pond was put into operation in 2014.

The containment pond was operating at approximately sixty-percent of capacity at the time of our inspection.

Stability

We noted no sign of weakness in any of the construction.

Recommendations

We have no recommendations with respect to the use of this structure having no negative comments on the construction of this structure.

4.05 Landfarm Containment

General Conditions

The landfarm containment is complete except for soil cover on the dykes in the area of the sump.

The landfarm was constructed to accommodate approximately 9000 m^3 of oil contaminated soil and seasonal water accumulations.

At the time of our inspection the landfarm was in operation and some sorting of contaminated materials had taken place. Since our last inspection, there is still minor sorting to take place including the removal of some waste and contaminated waste.

There is still some contaminated waste in the landfarm in addition to contaminated soil. No landfarming of treated contaminated soil has taken place.

It appears as though the structure has been constructed in accordance with good construction practice for structures of this type.

Stability

The structure appears stable as constructed.

Recommendations

We recommend that the remaining dyke structure, without protective cover over it, be covered as per the design drawings. This, however, is not an absolute requirement.

4.06 Contaminated Snow Containment

General Conditions

The construction of the contaminated snow containment structure is contiguous with the east end of the landfarm.

It appears as though the structure has been constructed in accordance with good construction practice for structures of this type.

The snow containment facility has a containment volume of 929 m^3 based on estimates of snow volume provided by the owner and only a small percentage of the capacity is utilized.

The structure has been constructed with good quality control.

Stability

The structure appears stable as constructed.

Recommendations

We have no recommendations with respect to this construction at this time. The structure appears as it did in our July/August review.

4.07 Sediment Pond East

General Conditions

The construction of this sedimentation pond for drainage from the east side of the site is complete.

The basin is shaped and the liner has been installed throughout the basin from inlet to the berms on the north side of the basin.

There has been no cover placed over the liner to this point and rip rap has not yet been placed in the outlet weir.

The tears and punctures that were present at the time of our July/August review have yet to be repaired.

Stability

We still have concerns over the stability of the liner and recommend possibly tire ballast over the liner which appears possibly subject to wind damage. This shall provide a function for used tires.

Recommendations

We recommend review of the use of a ballast (possibly tires) on the exposed liner at the dyke to prevent wind uplift.

We further recommend the re-installation of the liner at the westerly Inlet such that the liner is shaped to the profile of the inlet ditch

4.08 Sediment Pond West

General Conditions

The construction of this sedimentation pond for drainage from the west side of the site is nearing completion except for the west end on the south side where the liner must be "tucked" in as set out in our report last year.

The inlet where the water was being conducted under the liner with gravel has been made good.

Stability

We have some concern over the stability of the liner on this pond as we have with the east pond and recommend the further use of tire ballast on the liner.

Recommendations

Complete construction at the inlet structures to ensure contaminated water flows into the containment and not under it. With snow conditions it was difficult to confirm the construction.

4.09 Quarry

General Conditions

The quarry was inactive at the time of our review and most blasted rock had been removed from the quarry site.

It appears that little or no quarrying has taken place since our last visit.

Stability

Rock faces appear stable.

Recommendations

We have no recommendations to be made with respect to the quarry.

4.10 Loading Area Contaminated Storage (Now MP-HWB-1)

General Conditions

This area has been constructed near the loading dock to facilitate assembly of hazardous materials for shipment out. It appears that all material from the temporary hazardous storage containment have now been assembled here.

Most hazardous waste has now been removed from the containment and shipped out.

Construction appears to have taken place in accordance with standardized drawings prepared in the past.

Stability

Construction appears stable.

Recommendations

We have no recommendations with respect to this structure.

4.13 Fueling Facility Containment

General Conditions

A new fueling facility for the fueling of B trains is completed utilizing design drawings prepared by our office.

Work conforms to the design drawing.

A second cell is now to be constructed south of the existing.

4.12 Overview

Work on containment structures is now almost complete and only the hazardous waste cells MP-HWB-3 and 4 require decommissioning.

Respectfully submitted,

Barry H. Martin, P. Eng., MRAIC

REGISTERED PROFESSIONAL ENGINEERS
B.H. MARTIN
LICENSEE
NWT/NU

Milne Inlet Photos

Hazardous Waste Storage MP-HWB-4

Hazardous Waste Storage MP-HWB-5

Fuel Tank Farm

Milne Inlet Sewage Effluent Pond (PWSP)

Land Farm Containment

Contaminated Snow Containment

Milne Inlet Quarry

Loading Area Contaminated Storage MP-HWB-1

Fuelling Facility Containment

East Drainage Pond

East Drainage Pond. Westerly Inlet

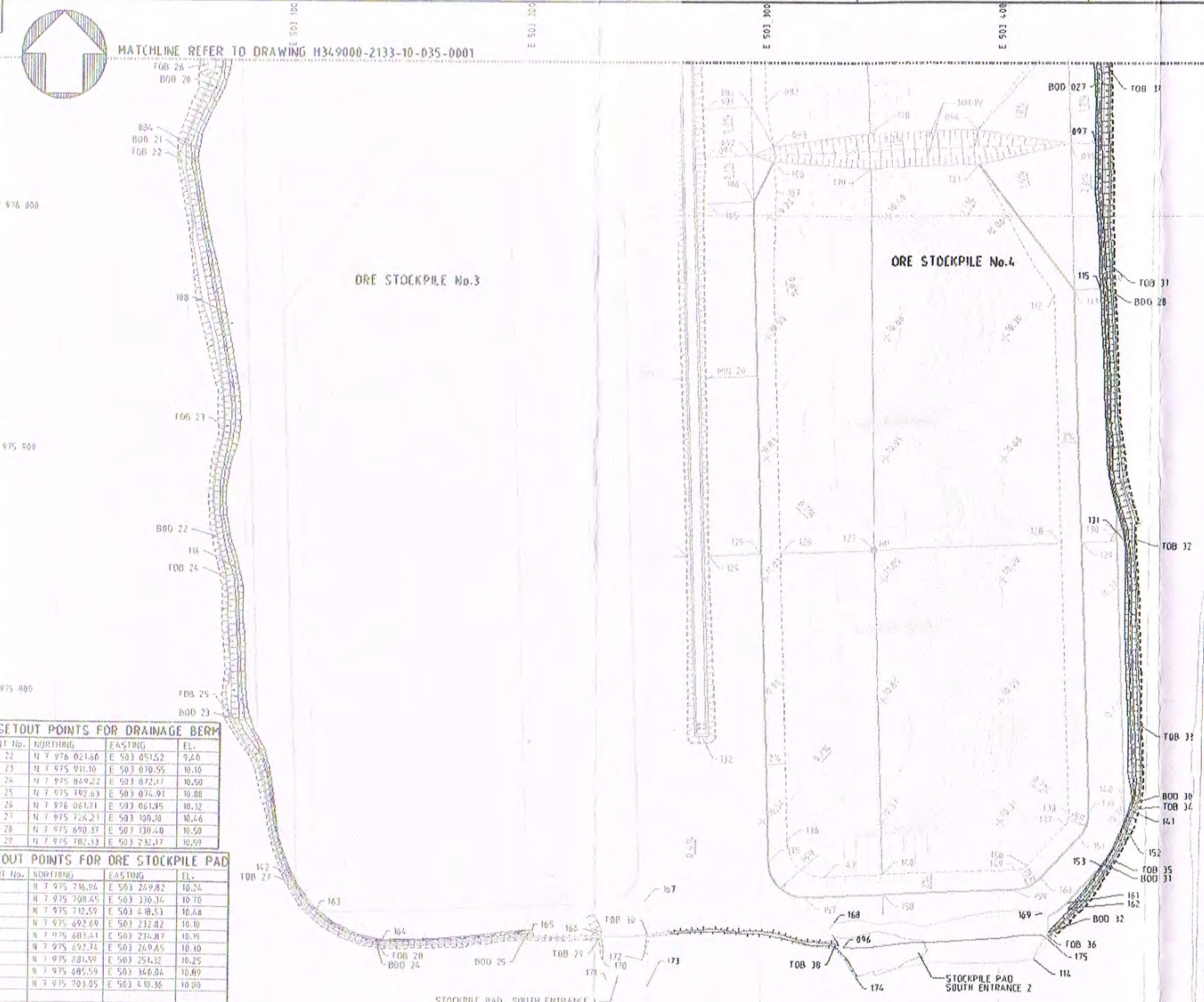
Milne Inlet Drawings

H349000-2133-10-035-0002

DWG. NO.

SETOUT POINTS FOR ORE STOCKPILE PAD

POINT No.	NORTHING	EASTING	EL.
084	N 7 976 025.76	E 503 058.52	9.01
096	N 7 975 698.20	E 503 334.31	11.20
097	N 7 976 030.52	E 503 436.52	9.82
108	N 7 975 959.00	E 503 070.81	9.51
114	N 7 975 693.33	E 503 414.38	10.42
115	N 7 975 970.50	E 503 439.10	10.39
116	N 7 975 852.46	E 503 077.95	9.64
151	N 7 975 865.80	E 503 450.35	10.10
161	N 7 975 755.08	E 503 453.18	10.50
142	N 7 975 723.64	E 503 103.65	9.86
152	N 7 975 748.97	E 503 450.89	10.60
153	N 7 975 731.52	E 503 441.73	10.60
156	N 7 975 713.57	E 503 224.28	9.99
162	N 7 975 745.17	E 503 428.27	10.40
163	N 7 975 712.88	E 503 112.23	9.93
164	N 7 975 700.42	E 503 139.89	10.00
165	N 7 975 706.64	E 503 205.12	10.20
166	N 7 975 703.79	E 503 230.79	10.19



SETOUT POINTS FOR DRAINAGE BERM

POINT No.	NORTHING	EASTING	EL.
TOB 22	N 7 976 021.60	E 503 051.52	9.40
TOB 23	N 7 975 911.10	E 503 070.55	10.10
TOB 24	N 7 975 849.22	E 503 072.17	10.50
TOB 25	N 7 975 792.63	E 503 074.91	10.88
TOB 26	N 7 976 061.71	E 503 061.95	10.32
TOB 27	N 7 975 724.21	E 503 100.10	10.46
TOB 28	N 7 975 690.37	E 503 130.40	10.50
TOB 29	N 7 975 702.33	E 503 232.17	10.59

SETOUT POINTS FOR ORE STOCKPILE PAD

POINT No.	NORTHING	EASTING	EL.
167	N 7 975 716.94	E 503 249.82	10.24
168	N 7 975 708.45	E 503 330.34	10.70
169	N 7 975 712.59	E 503 418.53	10.68
170	N 7 975 692.69	E 503 232.82	10.10
171	N 7 975 683.41	E 503 234.87	10.19
172	N 7 975 692.74	E 503 249.65	10.30
173	N 7 975 681.59	E 503 251.32	10.25
174	N 7 975 685.59	E 503 340.04	10.89
175	N 7 975 703.05	E 503 418.36	10.80

SETOUT POINTS FOR BOTTOM OF DITCH

POINT No.	NORTHING	EASTING	EL.
BOD 20	N 7 976 051.57	E 503 065.67	8.30
BOD 21	N 7 976 020.93	E 503 055.86	8.40
BOD 22	N 7 975 864.98	E 503 072.00	8.80
BOD 23	N 7 975 790.91	E 503 079.79	9.17
BOD 24	N 7 975 699.91	E 503 137.42	9.95
BOD 25	N 7 975 703.99	E 503 201.35	10.20

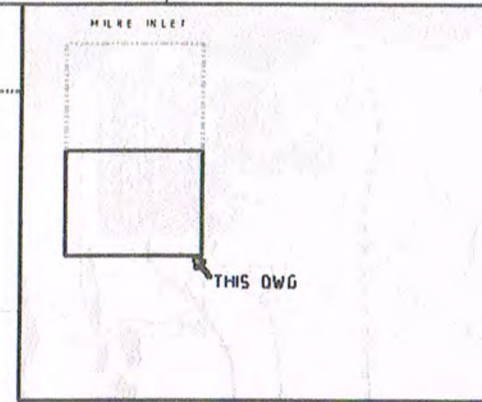
SETOUT POINTS FOR BOTTOM OF DITCH

POINT No.	NORTHING	EASTING	EL.
BOD 27	N 7 976 056.18	E 503 437.51	9.50
BOD 28	N 7 975 970.55	E 503 441.11	9.73
BOD 29	N 7 975 900.59	E 503 444.39	9.90
BOD 30	N 7 975 757.48	E 503 454.64	10.40
BOD 31	N 7 975 732.12	E 503 443.03	10.52
BOD 32	N 7 975 704.30	E 503 420.25	10.64

SETOUT POINTS FOR DRAINAGE BERM

POINT No.	NORTHING	EASTING	EL.
TOB 30	N 7 975 702.93	E 503 251.66	10.80
TOB 31	N 7 975 979.85	E 503 443.26	10.80
TOB 32	N 7 975 867.04	E 503 453.99	10.90
TOB 33	N 7 975 790.49	E 503 457.05	10.79
TOB 34	N 7 975 755.12	E 503 455.42	10.90
TOB 35	N 7 975 734.09	E 503 446.17	11.00
TOB 36	N 7 975 703.01	E 503 420.23	11.19
TOB 37	N 7 976 061.19	E 503 441.65	11.00
TOB 38	N 7 975 698.80	E 503 331.08	11.30

0 10 20 30 40 50
SCALE IN METRES



KEY PLAN

LEGEND

10.0	AS BUILT CONTOUR
	EXISTING WATERBODY
	BAFFINLAND'S COMMERCIAL LEASE ON INUIT OWNED LAND
	PROJECT DEVELOPMENT AREA (PDA)
	FILL SLOPE
	CUT SLOPE
	TOE OF SLOPE
	SLOPE BREAKLINE
%	GRADING SLOPE
	CENTERLINE OF SWALE/DITCH
	FG EL. AT 50m x 50m GRID
HP	HIGH POINT
01	AS BUILT POINT NUMBER
01	SETOUT POINT NUMBER (NONE AS BUILT)
UB	UTILITY BERM
TOB	AS BUILT TOP OF BERM
BOD	AS BUILT BOTTOM OF DITCH

NOTES:

1. AS BUILT SURVEY DATA PROVIDED BY BAFFINLAND.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS AND ELEVATIONS SHOWN ARE IN METRES UNLESS NOTED OTHERWISE.

3 AS BUILT

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
H349000-3000-10-012-0001	TOTE ROAD - PLAN AND PROFILE
H349000-2000-10-014-0001	MILNE PORT - SITE LAYOUT

REVISIONS

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
3	AS BUILT INFORMATION ADDED	AW	MK		2016-09-28
2	LOWERED NORTH SECTION OF PAD BY 0.3m	GJ	JG	JC	2014-08-07
1	EARTHWORKS BOUNDARY AND ELEVATIONS AT SOUTH CHANGED DUE TO CONVEYOR MODIFICATIONS	GJ	LF	SH	2013-11-15

ISSUE AUTHORIZATION

REV.	ISSUE FOR	AUTH.	BY	DATE
3	AS BUILT			2016-09-26
2	CONSTRUCTION	JG	GJ	2014-08-07
1	CONSTRUCTION	SH	GJ	2013-11-15
D	CONSTRUCTION	SH	MM	2013-08-30

HATCH

DESIGNED BY K. FALLAHI DATE 2013-08-23
DRAWN BY M. MCDOUGALD DATE 2013-08-23
CHECKED BY A. MOHEBKHANI DATE 2013-08-30
DISCIP. ENGR S. HASSAN DATE 2013-08-30
PROJ. DES. COORD. T. THERTELL DATE 2013-08-30
PROJ. ENGR. S. PERRY DATE 2013-08-30
PROJ. MGR. J. CLELAND DATE 2013-08-30

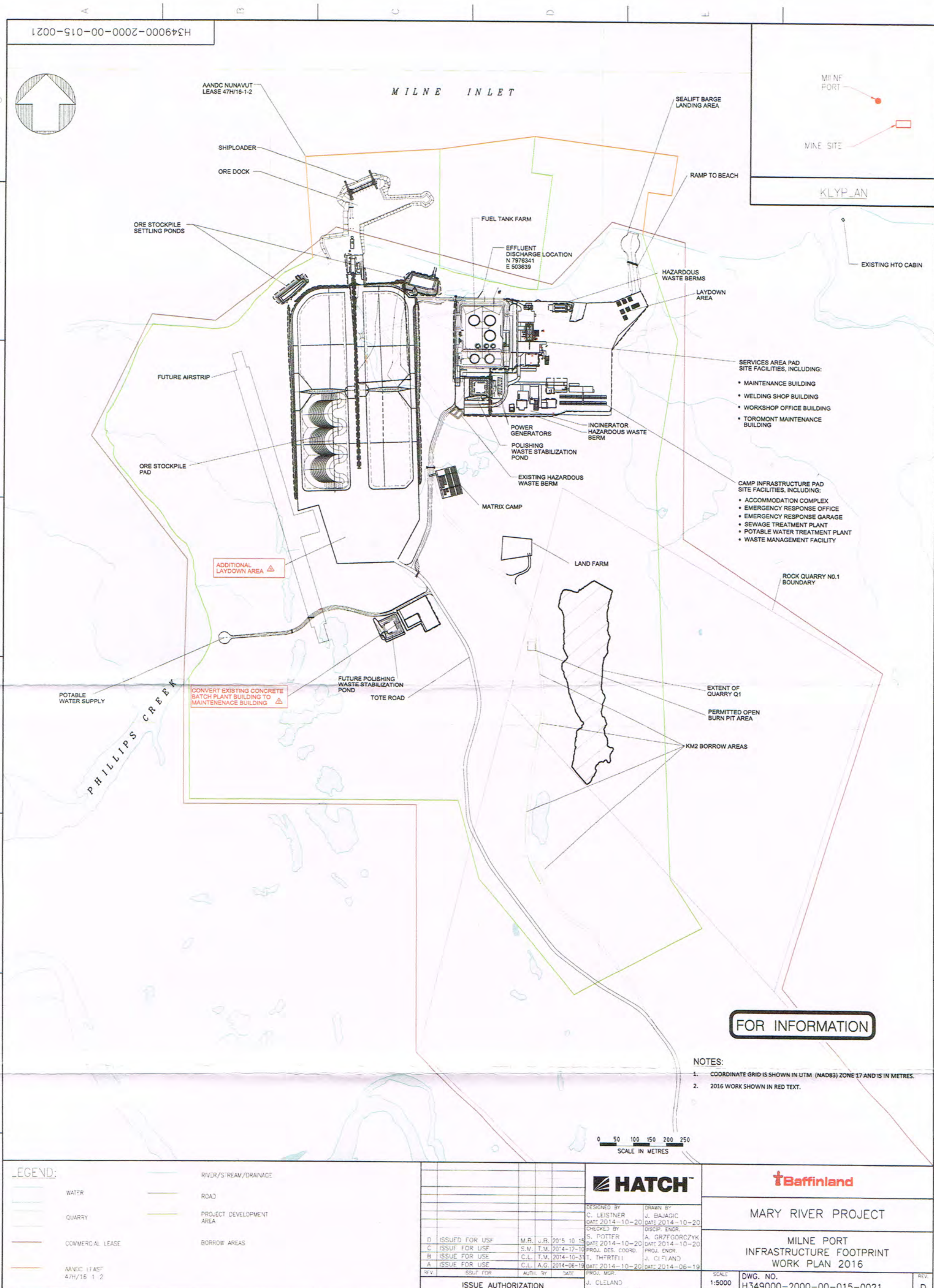
Baffinland

MARY RIVER PROJECT

MILNE PORT
ORE STOCKPILES NO. 3 & 4
EARTHWORKS & DRAINAGE - PLAN

SCALE 1:1000 OR AS NOTED | DWG. NO. H349000-2133-10-035-0002 | REV. 3

ORIGINAL SHEET SIZE: ISO A1 (841 x 594)


H349000-2000-00-015-0021
MILNE INLET
AANDC NUNAVUT LEASE 47H/16-1-2
SHIPLOADER
ORE DOCK
ORE STOCKPILE SETTLING PONDS
FUEL TANK FARM
EFFLUENT DISCHARGE LOCATION N 7976341 E 503639
SEALIFT BARGE LANDING AREA
RAMP TO BEACH
HAZARDOUS WASTE BERMS
LAYDOWN AREA
MILNE PORT
MINE SITE
KLYPLAN
EXISTING HTO CABIN
FUTURE AIRSTRIP
SERVICES AREA PAD SITE FACILITIES, INCLUDING:
• MAINTENANCE BUILDING
• WELDING SHOP BUILDING
• WORKSHOP OFFICE BUILDING
• TOROMONT MAINTENANCE BUILDING
POWER GENERATORS
INCINERATOR HAZARDOUS WASTE BERM
POLISHING WASTE STABILIZATION POND
ORE STOCKPILE PAD
EXISTING HAZARDOUS WASTE BERM
CAMP INFRASTRUCTURE PAD SITE FACILITIES, INCLUDING:
• ACCOMMODATION COMPLEX
• EMERGENCY RESPONSE OFFICE
• EMERGENCY RESPONSE GARAGE
• SEWAGE TREATMENT PLANT
• POTABLE WATER TREATMENT PLANT
• WASTE MANAGEMENT FACILITY
MATRIX CAMP
LAND FARM
ADDITIONAL LAYDOWN AREA
ROCK QUARRY NO.1 BOUNDARY
POTABLE WATER SUPPLY
CONVERT EXISTING CONCRETE BATCH PLANT BUILDING TO MAINTENENACE BUILDING
FUTURE POLISHING WASTE STABILIZATION POND
TOTE ROAD
EXTENT OF QUARRY Q1
PERMITTED OPEN BURN PIT AREA
KM2 BORROW AREAS
PHILLIPS CREEK
FOR INFORMATION
NOTES:
1. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
2. 2016 WORK SHOWN IN RED TEXT.
0 50 100 150 200 250
SCALE IN METRES
LEGEND:
WATER
QUARRY
COMMERCIAL LEASE
AANDC LEASE 47H/16 1 2
RIVER/STREAM/DRAINAGE
ROAD
PROJECT DEVELOPMENT AREA
BORROW AREAS
D ISSUED FOR USE M.B. J.B. 2015 10 15
C ISSUE FOR USE S.M. T.M. 2014-12-10
B ISSUE FOR USE C.L. T.M. 2014-10-31
A ISSUE FOR USE C.L. A.G. 2014-06-19
REV. ISSUE FOR AUTH. BY DATE
ISSUE AUTHORIZATION
HATCH
DESIGNED BY C. LEISTNER DATE 2014-10-20
DRAWN BY J. BAJAGIC DATE 2014-10-20
CHECKED BY S. POTTER DATE 2014-10-20
DISCIP. ENGR. A. GRZEGORCZYK DATE 2014-10-20
PROJ. DES. COORD. T. THERTELL DATE 2014-10-20
PROJ. ENGR. J. CLELAND DATE 2014-06-19
PROJ. MGR. J. CLELAND DATE 2014-06-19
Baffinland
MARY RIVER PROJECT
MILNE PORT INFRASTRUCTURE FOOTPRINT WORK PLAN 2016
SCALE 1:5000 OR AS NOTED
DWG. NO. H349000-2000-00-015-0021
REV. D

H349000-2133-10-035-0001

DWG NO.

POINTS FOR ORE STOCKPILE PAD

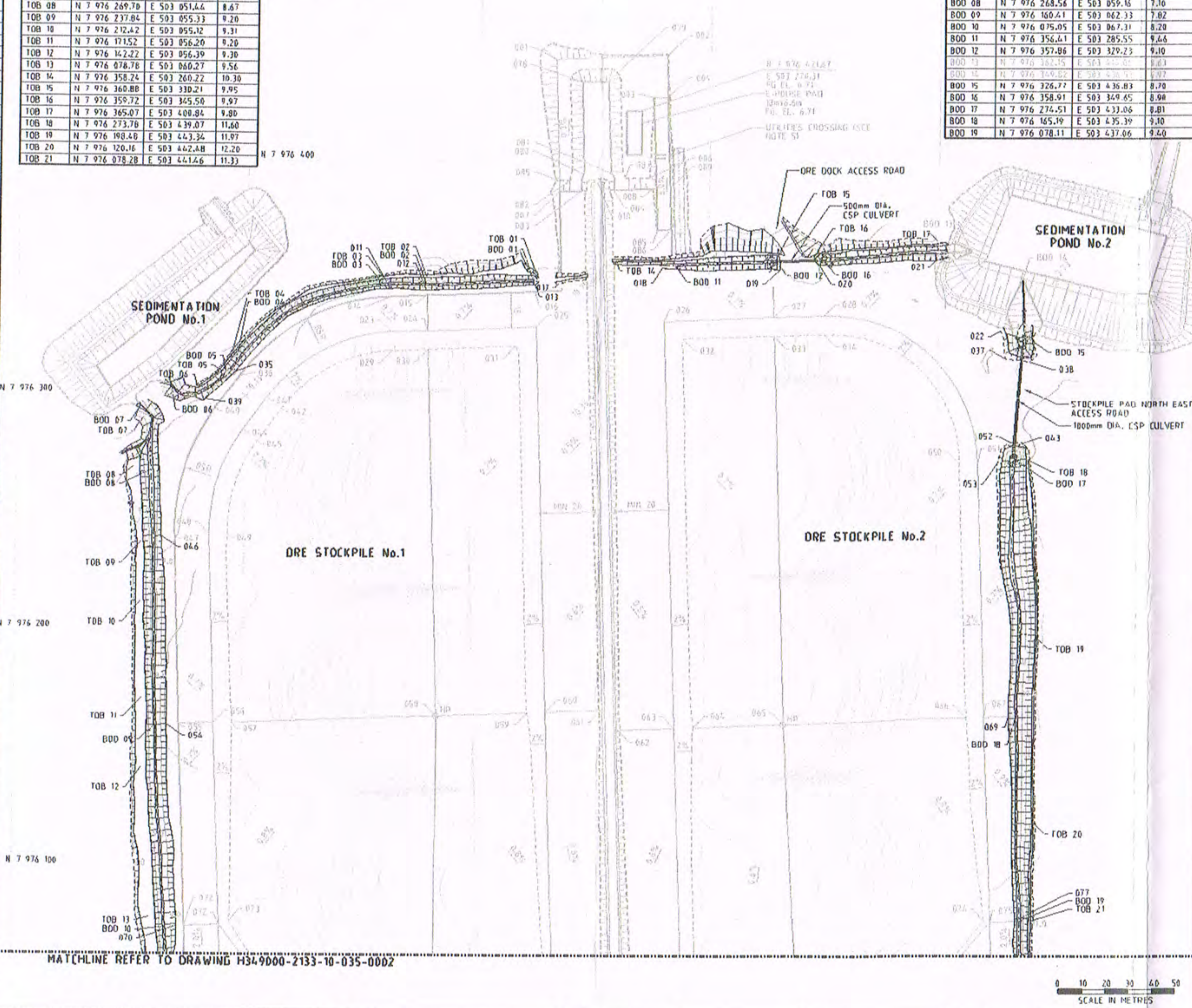
POINT No.	NORTHING	EASTING	EL.
001	[illegible]	[illegible]	[illegible]
002	[illegible]	[illegible]	[illegible]
003	[illegible]	[illegible]	[illegible]
004	[illegible]	[illegible]	[illegible]
005	[illegible]	[illegible]	[illegible]
006	[illegible]	[illegible]	[illegible]
007	[illegible]	[illegible]	[illegible]
008	[illegible]	[illegible]	[illegible]
009	[illegible]	[illegible]	[illegible]
010	[illegible]	[illegible]	[illegible]
011	N 7 976 345.75	E 503 161.96	9.08
012	N 7 976 345.20	E 503 177.87	9.60
013	N 7 976 347.79	E 503 224.80	9.33
014	[illegible]	[illegible]	[illegible]
015	[illegible]	[illegible]	[illegible]
016	[illegible]	[illegible]	[illegible]
017	N 7 976 347.96	E 503 233.92	9.50
018	N 7 976 355.09	E 503 280.05	9.90
019	N 7 976 354.53	E 503 331.05	9.79
020	N 7 976 356.61	E 503 347.90	9.95
021	N 7 976 358.22	E 503 398.59	10.00
022	N 7 976 328.24	E 503 427.18	10.10
023	[illegible]	[illegible]	[illegible]
024	[illegible]	[illegible]	[illegible]
025	[illegible]	[illegible]	[illegible]
026	[illegible]	[illegible]	[illegible]
027	[illegible]	[illegible]	[illegible]
028	[illegible]	[illegible]	[illegible]
029	[illegible]	[illegible]	[illegible]
030	[illegible]	[illegible]	[illegible]
031	[illegible]	[illegible]	[illegible]
032	[illegible]	[illegible]	[illegible]
033	[illegible]	[illegible]	[illegible]
034	[illegible]	[illegible]	[illegible]
035	N 7 976 310.11	E 503 095.15	8.80
036	[illegible]	[illegible]	[illegible]
037	N 7 976 316.45	E 503 429.53	10.4
038	N 7 976 315.33	E 503 439.37	10.6
039	N 7 976 298.46	E 503 082.21	8.02
040	[illegible]	[illegible]	[illegible]
041	[illegible]	[illegible]	[illegible]
042	[illegible]	[illegible]	[illegible]
043	N 7 976 288.98	E 503 437.26	10.9
044	[illegible]	[illegible]	[illegible]
045	[illegible]	[illegible]	[illegible]
046	N 7 976 240.27	E 503 064.18	8.71
047	[illegible]	[illegible]	[illegible]
048	[illegible]	[illegible]	[illegible]
049	[illegible]	[illegible]	[illegible]
050	[illegible]	[illegible]	[illegible]
051	[illegible]	[illegible]	[illegible]
052	N 7 976 281.34	E 503 431.50	10.68
053	N 7 976 272.60	E 503 426.34	10.49
054	N 7 976 160.59	E 503 067.48	10.20
055	[illegible]	[illegible]	[illegible]
056	[illegible]	[illegible]	[illegible]
057	[illegible]	[illegible]	[illegible]
058	[illegible]	[illegible]	[illegible]
059	[illegible]	[illegible]	[illegible]
060	[illegible]	[illegible]	[illegible]
061	[illegible]	[illegible]	[illegible]
062	[illegible]	[illegible]	[illegible]
063	[illegible]	[illegible]	[illegible]
064	[illegible]	[illegible]	[illegible]
065	[illegible]	[illegible]	[illegible]
066	[illegible]	[illegible]	[illegible]
067	[illegible]	[illegible]	[illegible]
069	N 7 976 165.87	E 503 432.04	10.21
070	N 7 976 075.22	E 503 072.60	9.70
071	[illegible]	[illegible]	[illegible]
072	[illegible]	[illegible]	[illegible]
073	[illegible]	[illegible]	[illegible]
074	[illegible]	[illegible]	[illegible]
075	[illegible]	[illegible]	[illegible]
077	N 7 976 078.03	E 503 435.17	9.90
078	[illegible]	[illegible]	[illegible]
079	[illegible]	[illegible]	[illegible]
080	[illegible]	[illegible]	[illegible]
081	[illegible]	[illegible]	[illegible]
082	[illegible]	[illegible]	[illegible]
083	[illegible]	[illegible]	[illegible]
084	[illegible]	[illegible]	[illegible]
085	[illegible]	[illegible]	[illegible]
086	[illegible]	[illegible]	[illegible]
087	[illegible]	[illegible]	[illegible]

POINTS FOR DRAINAGE BERM

POINT No.	NORTHING	EASTING	EL.
TOB 01	N 7 976 350.70	E 503 225.79	9.70
TOB 02	N 7 976 351.31	E 503 177.58	9.89
TOB 03	N 7 976 350.54	E 503 158.77	9.50
TOB 04	N 7 976 315.95	E 503 093.10	9.30
TOB 05	N 7 976 310.71	E 503 089.01	8.90
TOB 06	N 7 976 303.66	E 503 070.84	8.49
TOB 07	N 7 976 288.78	E 503 054.23	7.77
TOB 08	N 7 976 269.70	E 503 051.44	8.67
TOB 09	N 7 976 237.84	E 503 055.33	9.20
TOB 10	N 7 976 212.42	E 503 055.12	9.31
TOB 11	N 7 976 171.52	E 503 056.20	9.20
TOB 12	N 7 976 142.22	E 503 056.39	9.30
TOB 13	N 7 976 078.78	E 503 060.27	9.56
TOB 14	N 7 976 358.24	E 503 260.22	10.30
TOB 15	N 7 976 360.88	E 503 330.21	9.95
TOB 16	N 7 976 359.72	E 503 345.50	9.97
TOB 17	N 7 976 365.07	E 503 400.84	9.80
TOB 18	N 7 976 273.78	E 503 439.07	11.60
TOB 19	N 7 976 198.48	E 503 443.34	11.97
TOB 20	N 7 976 120.16	E 503 442.48	12.20
TOB 21	N 7 976 078.28	E 503 441.46	11.33

POINTS FOR DRAINAGE DITCH

POINT No.	NORTHING	EASTING	EL.
BOD 01	N 7 976 349.44	E 503 224.15	8.80
BOD 02	N 7 976 347.80	E 503 177.78	8.52
BOD 03	N 7 976 347.60	E 503 159.07	8.40
BOD 04	N 7 976 313.71	E 503 095.32	8.10
BOD 05	N 7 976 309.50	E 503 091.27	8.00
BOD 06	N 7 976 304.36	E 503 067.66	5.27
BOD 07	N 7 976 295.09	E 503 054.39	5.26
BOD 08	N 7 976 268.56	E 503 059.16	7.10
BOD 09	N 7 976 160.41	E 503 062.33	7.82
BOD 10	N 7 976 075.05	E 503 067.31	8.20
BOD 11	N 7 976 356.41	E 503 285.55	9.46
BOD 12	N 7 976 357.86	E 503 329.23	9.10
BOD 13	N 7 976 362.15	[illegible]	8.63
BOD 14	N 7 976 349.82	[illegible]	[illegible]
BOD 15	N 7 976 326.77	E 503 436.83	8.70
BOD 16	N 7 976 358.91	E 503 349.65	8.98
BOD 17	N 7 976 274.51	E 503 433.06	8.81
BOD 18	N 7 976 165.19	E 503 435.39	9.10
BOD 19	N 7 976 078.11	E 503 437.06	9.40



0 10 20 30 40 50
SCALE IN METRES

KEY PLAN

MILNE INLET

THIS DWG

LEGEND

- AS BUILT CONTOURS
- EXISTING WATERBODY
- BAFFINLAND'S COMMERCIAL LEASE ON INUIT OWNED LAND
- PROJECT DEVELOPMENT AREA (PDA)
- FILL SLOPE
- CUT SLOPE
- TOE OF SLOPE
- SLOPE BREAKLINE
- GRADING SLOPE
- CENTERLINE OF DITCH
- CULVERT
- FG EL. AT 50m x 50m GRID
- HIGH POINT
- AS BUILT POINT NUMBER
- SETOUT POINT NUMBER (NONE AS BUILT)
- CSP — CORRUGATED STEEL PIPE
- UTILITIES CROSSING (SEE NOTE 7)
- TOB — TOP OF BERM
- BOD — BOTTOM OF DITCH

NOTES:

1. AS BUILT SURVEY DATA PROVIDED BY BAFFINLAND.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS AND ELEVATIONS SHOWN ARE IN METRES UNLESS NOTED OTHERWISE.
5. FOR SEDIMENTATION PONDS PLAN AND DETAIL REFER TO DRAWING H349000-2345-10-035-0001.
6. UTILITIES ARE CROSSING ROAD SURFACES UNDERNEATH OF RAMP TO REACH ON TOP OF FINISHED SURFACE ELEVATION (6.7). FOR TYPICAL DETAILS FOR ROAD CROSSING SEE DETAIL 10, DRAWING H349000-1000-10-041-0009

3 AS BUILT

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
H349000-2345-10-035-0001	MILNE PORT-ORE STOCKPILE SEDIMENTATION PONDS-EARTHWORKS & DRAINAGE
H349000-2000-00-014-0001	MILNE PORT-SITE LAYOUT

REVISIONS

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
3	AS BUILT INFOMATION ADDED	AW	MK		2016-08-26
2	LOWERED NORTH SECTION OF PAD BY 0.3m	GJ	JG	JC	2014-08-07
1	EARTHWORKS BOUNDARY AND ELEVATIONS AT NORTH CHANGED DUE TO CONVEYOR MODIFICATIONS	GJ	KF	SH	2013-11-15

ISSUE AUTHORIZATION

REV.	ISSUE FOR	AUTH.	BY	DATE
3	AS BUILT	AW	AW	
2	CONSTRUCTION	JG	GJ	2014-08-07
1	CONSTRUCTION	SH	GJ	2013-11-15
0	CONSTRUCTION	SH	MM	2013-08-30

HATCH

DESIGNED BY K. FALLAHI DATE 2013-08-23	DRAWN BY M. MCDOUGALD DATE 2013-08-23
CHECKED BY A. MOHEBKHANI DATE 2013-08-29	DISCIP. ENGR. S. HASSAN DATE 2013-08-29
PROJ. DES. COORD. T. THERTELL DATE 2013-08-29	PROJ. ENGR. S. PERRY DATE 2013-08-29
PROJ. MGR. J. CLELAND DATE 2013-08-29	

Baffinland

MARY RIVER PROJECT

MILNE PORT
ORE STOCKPILES NO. 1 & 2
EARTHWORKS & DRAINAGE - PLAN

SCALE 1:1000 OR AS NOTED | DWG. NO. H349000-2133-10-035-0001 | REV. 3

ORIGINAL SHEET SIZE: ISO A1 (841 x 594)

wong67629 9/23/2016 2:01:35 PM c:\pw\projectwise\wong67629\pw_idc_datasource\d0260512\H349000-2133-10-035-0001.dgn

H349000-2133-10-035-0001.dgn Default 9/23/2016 2:01:39 PM

APPENDIX H

2016 SOCIO-ECONOMIC MONITORING REPORT

2016 Socio-Economic Monitoring Report for the Mary River Project

March 2017

Prepared For:
Baffinland Iron Mines Corporation
2275 Upper Middle Road East, Suite 300
Oakville, Ontario
L6H 0C3

Jason Prno
CONSULTING SERVICES LTD

420 George Street, Suite 210
Peterborough, Ontario • K9H 3R5
(519) 983-8483 • www.jpcsl.com

Report Contributors

This report has been prepared by Jason Prno (PhD) of Jason Prno Consulting Services Ltd. on behalf of Baffinland Iron Mines Corporation. This report has been reviewed and edited by Baffinland Iron Mines Corporation and contains various company statements.

Suggested Citation

Jason Prno Consulting Services Ltd. 2017. *2016 Socio-Economic Monitoring Report for the Mary River Project*. Report prepared for Baffinland Iron Mines Corporation. March 2017.

EXECUTIVE SUMMARY

This report has assessed the socio-economic performance of the Mary River Project in 2016, as well as Baffinland's compliance with various Project Certificate conditions. Performance was assessed using socio-economic indicators for a number of Valued Socio-Economic Components (VSECs) included in the Final Environmental Impact Statement (EIS):

- Population demographics
- Education and training
- Livelihood and employment
- Contracting and business opportunities
- Human health and well-being
- Community infrastructure and public services
- Resources and land use
- Economic development and self-reliance
- Benefits, royalty, and taxation

The information presented in this report supports many of the Final EIS predictions for these VSECs and identifies positive effects the Project has had. For example, approximately 1,881,506 hours of Project labour were performed by Baffinland employees and contractors in Nunavut in 2016, which was equal to approximately 905 full time equivalent positions. Of this total, 305,836 hours were worked by residents of the Local Study Area (LSA). In addition, approximately $7.6 million in payroll was provided to Baffinland LSA employees (not including contractors) and $64.4 million was spent on procurement with Inuit-owned businesses and joint ventures in 2016.

Employment in the LSA is one area where Project activities didn't fully match Final EIS predictions in 2016. For example, LSA employment hours in 2016 were slightly lower than originally predicted (although North Baffin LSA employment hours *did* correspond with Final EIS predictions). Likewise, there were several Inuit employee departures in 2016. Baffinland continues to take positive steps to address the issue of Inuit employment and is in the process of finalizing an Inuit Human Resources Strategy (IHRS) and Inuit Contracting and Procurement Strategy (ICPS). These documents will describe goals and initiatives that will be used to increase Inuit employment and contracting at the Project. The ongoing establishment of an annual Minimum Inuit Employment Goal (MIEG) with the QIA should also assist with increasing Inuit employment. However, additional monitoring will be necessary to track the success of these and other Baffinland Inuit employment programs. Baffinland will also continue to track employee turnover causes and outcomes, moving forward.

Where appropriate, trends have been described for the indicators assessed in this report. These trends (i.e. pre-development, post-development, and since the previous year) demonstrate whether an indicator has exhibited change and describes the direction of that change. Trend analyses can also be useful for assessing potential Project influences on an indicator. The table that follows summarizes the information and trends observed in 2016 relative to previous years. In some cases, additional data and monitoring will be necessary before the Final EIS predictions presented in this report can be fully verified. In others, direct correlations between the Project and data trends were either unable to be identified or were unclear. The process of socio-economic monitoring often requires many years of data to effectively discern trends and causality. Even then, various factors may be found to influence causality and some of these may not be easy to measure. Successful socio-economic monitoring for the

Project will require appropriate long-term data, the regular input of all Project stakeholders, and a focus on continuous improvement.

2016 Socio-Economic Monitoring Reporting Summary for Baffinland Iron Mines Corporation's Mary River Project

VSEC	Indicator(s)	Pre-Development Trend	Post-Development Trend	Trend Since Previous Year	Scale	Summary
Population Demographics	Known in-migrations of non-Inuit Project employees and contractors	n/a	No change	No change	North Baffin LSA	Since 2015, a net of zero known non-Inuit employees/contractors have in-migrated to the North Baffin LSA
	In-migration of non-Inuit to the North Baffin LSA	n/a	n/a	n/a	North Baffin LSA	Limited data currently available. However, the percentage of Inuit vs. non-Inuit residents in the North Baffin LSA has remained relatively constant.
	Known out-migrations of Inuit Project employees and contractors	n/a	↑	↑	North Baffin LSA	Since 2015, a net of three known Inuit employees/contractors have out-migrated from the North Baffin LSA
	Out-migration of Inuit from the North Baffin LSA	n/a	n/a	n/a	North Baffin LSA	Limited data currently available. However, the percentage of Inuit vs. non-Inuit residents in the North Baffin LSA has remained relatively constant.
	Population estimates	↑ ↑	↑ ↑	↑ ↑	North Baffin LSA Iqaluit	Population numbers continue to increase across the territory
	Nunavut annual net migration	↓	↓	↓	Territory	A downward trend in Nunavut annual net migration is occurring
	Employee changes of address, housing status, and migration intentions	n/a	n/a	n/a	Project	20.9% of Employee Information Survey respondents (43 surveys total) housing situation changed in the past 12 months. 16.3% moved (either to different housing or a different community) and 7.0% moved to a different community. 16.3% intend to move to a different community in the next 12 months. 7.0% intend to move away from the North Baffin LSA. No individuals intend to move into the North Baffin LSA. Over two-thirds of respondents currently live in public housing.
	Employee origin	n/a	n/a	n/a	Project	An average of 1180 individuals worked at the Project in 2016, of which 182 were Inuit. Most the Project's Inuit employees and contractors were based in the North Baffin LSA communities. Most of the Project's non-Inuit employees and contractors were based in Canadian locations outside of Nunavut.
Education and Training	Participation in pre-employment training	n/a	↑	n/a (not offered 2014-2016)	Project	Since 2012, there have been 277 graduates of Baffinland pre-employment training programs. A new Work Ready program will be delivered in local communities in 2017.
	Number of secondary school graduates	↑ ↓	↓ ↓	↑ ↑	North Baffin LSA Iqaluit	A long-term decrease in graduation numbers is apparent in Iqaluit and was evident prior to the Project. A decrease in the North Baffin LSA has occurred since the Project, after experiencing a prior increase. However, a similar decrease has occurred throughout the territory as a whole.
	Secondary school graduation rate	↓	↓	↑	Region	A long-term decrease in graduation rates is apparent in the region and was evident prior to the Project
	Hours of training completed by Inuit employees	n/a	↑	↓	Project	Inuit received 2,434 hours of training in 2016 and a total of 11,843 training hours since Project development
	Types of training provided to Inuit employees	n/a	↑	No change	Project	Inuit continue to receive various forms of Project-related training
	Apprenticeships and other opportunities	n/a	↑	↓	Project	One Inuit apprentice worked at the Project in 2016
	Education and employment status prior to Project employment	n/a	n/a	n/a	Project	37.2% of Employee Information Survey respondents (43 surveys total) had no certificate, diploma or degree, 23.3% of respondents had a high school diploma or equivalent, and 34.9% of respondents had higher than a high school diploma or equivalent. 20.9% resigned from a previous job placement to take up employment with the Project (no individuals resigned from an academic or vocational program).
Livelihood and Employment	Total hours of Project labour performed in Nunavut	n/a	↑	↑	Project	1,881,506 hours of labour were performed in Nunavut in 2016 and 6,456,646 hours of labour have been performed since Project development
	Project hours worked by LSA employees and contractors	n/a	↑ ↑	↑ ↓	North Baffin LSA Iqaluit	230,732 hours of labour were performed by North Baffin LSA residents (12.3% of total) and 75,104 hours of labour were performed by Iqaluit residents (4.0% of total) in 2016
	Inuit employee promotions	n/a	↑	No change	Project	14 Inuit employee promotions occurred in 2016
	Inuit employee turnover	n/a	↑	↑ (total number of departures)	Project	There were 44 Inuit employee departures in 2016, equating to an Inuit employee turnover rate of 45%
	Hours worked by female employees and contractors	n/a	↑	↓ (% hours worked compared to Q4 2015)	Project	151,128 hours were worked by female employees and contractors in 2016 (8.0% of total), 68,862 hours of which were worked by Inuit females (3.7% of total)
	Childcare availability and costs	n/a	n/a	n/a	Project	This topic continues to be tracked through the QSEMC process and Baffinland's community engagement program

Contracting and Business Opportunities	Value of procurement with Inuit-owned businesses and joint ventures	n/a	↑	↓	Project	Baffinland awarded $64.4 million to Inuit-owned businesses and joint ventures in 2016; a total of $431.9 million has been awarded to Inuit-owned businesses and joint ventures since Project development
	LSA employee payroll amounts	n/a	↑	↓	Project	Approximately $7.6 million in payroll was provided to LSA residents in 2016. Since 2014, Baffinland has provided approximately $25 million in payroll to its Inuit employees.
	Number of registered Inuit firms in the LSA	n/a	↑ ↑	↑ ↑	North Baffin LSA Iqaluit	There were 40 NTI registered Inuit firms in the North Baffin LSA in 2016 and 116 in Iqaluit
Human Health and Well-Being	Total number of youth charged	↓ ↓	↓ ↓	↑ ↓	North Baffin LSA Iqaluit	A long-term decrease in the number of youth charged is apparent in the LSA and was evident prior to the Project
	Proportion of taxfilers with employment income	↓ ↓	↓ ↓	↓ No change	North Baffin LSA Iqaluit	A long-term decrease in the proportion of taxfilers with employment income is apparent in the LSA and was evident prior to the Project
	Median employment income	↓ ↑	↑ ↑	↑ ↑	North Baffin LSA Iqaluit	A long-term increase in median employment income is apparent in Iqaluit and was evident prior to the Project. An increase in the North Baffin LSA has occurred since the Project, after experiencing a prior decrease.
	Percentage of population receiving social assistance	↓ ↓	↓ ↓	↑ ↓	North Baffin LSA Iqaluit	A long-term decrease in the percentage of the population receiving social assistance is apparent in the LSA and was evident prior to the Project
	Number of drug and alcohol related contraband infractions at Project sites	n/a	↑	↑	Project	There were 11 drug and alcohol related contraband infractions at Project sites in 2016
	Number of impaired driving violations	↑ ↓	↑ ↓	↑ ↑	North Baffin LSA Iqaluit	A long-term increase in the number of impaired driving violations is apparent in the North Baffin LSA, while a long-term decrease is apparent in Iqaluit. Both trends were evident prior to the Project.
	Number of drug violations	↑ ↑	↑ ↓	↑ ↑	North Baffin LSA Iqaluit	A long-term increase in the number of drug violations is apparent in the North Baffin LSA and was evident prior to the Project. A decrease in Iqaluit has occurred since the Project, after experiencing a prior increase.
	Absence from the community during work rotation	n/a	n/a	n/a	Project	These topics continue to be tracked through the QSEMC process and Baffinland's community engagement program
	Prevalence of gambling issues	n/a	n/a	n/a	Project	
	Prevalence of family violence	n/a	n/a	n/a	Project	
	Prevalence of marital problems	n/a	n/a	n/a	Project	
	Percent of health centre visits related to infectious diseases	↓ ↓	↓ ↓	No change ↓	North Baffin LSA Iqaluit	A long-term decrease in the percent of health centre visits related to infectious diseases is apparent in the LSA and was evident prior to the Project
	Rates of teenage pregnancy	n/a	n/a	n/a	Project	This topic continues to be tracked through the QSEMC process and Baffinland's community engagement program
	Crime rate	↑ ↓	↑ ↓	↑ ↑	North Baffin LSA Iqaluit	A long-term increase in crime rates in the North Baffin LSA and long-term decrease in Iqaluit are apparent and were evident prior to the Project.
Community Infrastructure and Public Services	Number of Project employees who left positions in their community	n/a	↑	n/a	Project	The 2017 Employee Information Survey (43 surveys total) indicated 9 Project employees (or 20.9%) left positions in their communities to pursue employment at the Project. Of these, 3 were casual/part-time positions and 6 were full-time positions.
	Number of health centre visits (total)	↑ ↑	↑ ↑	↑ ↑	North Baffin LSA Iqaluit	A long-term increase in the total number of health centre visits is apparent in the LSA and was evident prior to the Project
	Number of health centre visits (per capita)	↑ ↑	↑ ↑	↑ ↑	North Baffin LSA Iqaluit	A long-term increase in the per capita number of health centre visits is apparent in the LSA and was evident prior to the Project
	Number of visits to Project site medic	n/a	↑	↑	Project	There were 4,012 visits to the Project site medic in 2016 (801 visits by Inuit)
	Baffinland use of LSA community infrastructure	n/a	↑	No change	Project	Baffinland continued to use some LSA community infrastructure to support Project operations in 2016
	Number of Project aircraft movements at LSA community airports	n/a	↑	↓	Project	There were 1,254 Project fixed-wing aircraft movements at LSA airports in 2016
Resources and Land Use	Number of recorded land use visitor person-days at Project sites	n/a	↑	↑	Project	There were 293 recorded land use visitor person-days at Project sites in 2016
	Number of wildlife compensation fund claims	n/a	↑	n/a (fund began in 2016)	Project	Two claims were submitted to QIA for review in 2016. One claim was approved and resulted in compensation of $600.00 being paid, while the second claim was reviewed and denied.
Economic Development and Self-Reliance	Project harvesting interactions and food security	n/a	n/a	n/a	Project	This topic continues to be tracked through the QSEMC process and Baffinland's community engagement program
Benefits, Royalty, and Taxation	Annual payroll and corporate taxes paid by Baffinland to the territorial government	n/a	↑	n/a	Project	Approximately $1.135 million in employee payroll tax was paid to the GN in 2016. Baffinland expects increased tax amounts will be paid once the Company enters full commercial production and becomes profitable.

Guide to Using the Table:
VSEC: Refers to 'Valued Socio-Economic Component' and includes a selection of VSECs assessed in the Mary River Project Final EIS.
Indicator(s): Indicators are an important aspect of socio-economic monitoring. Indicators are metrics used to measure and report on the condition and trend of a VSEC.
Trend: Refers to whether the indicator(s) has exhibited change and describes the direction of that change. Black arrows (↑↓) indicate the direction of change that has occurred. Where there is no discernable or significant change 'No change' is used. Where there are insufficient data or other issues preventing a trend analysis, 'n/a' is used. 'Pre-development trend' refers to the five-year period preceding Project construction (i.e. 2008 to 2012) and is calculated using available indicator data for those five years. 'Post-development trend' refers to the period after Project construction commenced (i.e. 2013 onwards), is calculated using available indicator data from that period, and may be in reference to a baseline calculated from pre-development period data. 'Trend since previous year' refers to the two most recent years in which indicator data are available.
Scale: 'Territory' refers to data that are available for Nunavut. 'Region' refers to data that are available for the Qikiqtaaluk Region. 'North Baffin LSA' refers to data that are available for the North Baffin Local Study Area communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet. 'Project' refers to data that are available for the Mary River Project.
Summary: A brief description of the trend and/or related data.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 MARY RIVER PROJECT OVERVIEW

The Mary River Project (the Project) is an operating open pit iron ore mine with associated project components that is owned and operated by Baffinland Iron Mines Corporation (Baffinland or the Company). The Project is located in the Qikiqtaaluk Region of Nunavut on northern Baffin Island. The mine site is located approximately 160 km south of Pond Inlet (Mittimatalik) and 1,000 km north of the territorial capital of Iqaluit.

The Project consists of three currently active main project locations - the Mine Site, the 100-km long Milne Inlet Tote Road, and Milne Port. The Project also includes a proposed railway and Steensby Port, both located to the south of the mine site. At the end of 2012, the Nunavut Impact Review Board (NIRB) issued Project Certificate No. 005 authorizing the construction, operation, and closure of an 18 million tonne per annum (Mt/a) operation which included a 149-km railway and year-round shipping of iron ore from a port facility at Steensby Inlet (Steensby Port). Mine construction began in 2013.

In 2013, Baffinland applied to the NIRB to amend its Project Certificate to allow for an Early Revenue Phase (ERP) operation, which included the additional production of up to 4.2 Mt/a of iron ore, ore haulage over the Milne Inlet Tote Road, and open water shipping of ore from Milne Port. On May 28, 2014, the NIRB issued an amended Project Certificate No. 005 approving the ERP. Mining of ore began in the last quarter of 2014 and the first shipment of ore occurred in the summer of 2015. The amended Project Certificate allows for the future development of the 18 Mt/a railway operation, for a total combined production rate of 22.2 Mt/a. However, the mine is currently working toward the 4.2 Mt/a production rate via Milne Port associated with the ERP.

In the fall of 2014, Baffinland announced its intention to seek approval for a second phase of the ERP. 'Phase 2' consists of an expansion of the 4.2 Mt/a ERP operation by 7.8 Mt/a to 12 Mt/a of ore. This ore will be transported to Milne Port by rail and then delivered to market over an expanded shipping season. The Phase 2 proposal is part of Baffinland's approach to develop the Mary River Project in a phased and economically feasible manner. A Phase 2 Project Description was submitted to the NIRB on October 29, 2014, and on November 30, 2016 a Project Update on the Phase 2 proposal was provided. Baffinland expects to submit an Environmental Impact Statement (EIS) for Phase 2 in 2017. Additional information on Baffinland's regulatory submissions and approvals can be found on the NIRB public registry: http://www.nirb.ca/.

1.2 SOCIO-ECONOMIC MONITORING REQUIREMENTS

Project-related socio-economic monitoring requirements originate from the Nunavut Agreement and NIRB Project Certificate No. 005. The Nunavut Agreement is a comprehensive land claims agreement signed in 1993 between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada. As a result of signing the Nunavut Agreement, Inuit exchanged Aboriginal title to all their traditional land in the Nunavut Settlement Area for a series of rights and benefits. The Nunavut Agreement also created various 'institutions of public government' such as the NIRB and Nunavut Water Board and established conditions for the review and oversight of resource development projects. Article 12, Part 7 of the Nunavut Agreement provides details on monitoring programs which may be required under a NIRB project certificate and notes the purpose of these programs shall be:

(a) to measure the relevant effects of projects on the ecosystemic and socio-economic environments of the Nunavut Settlement Area;
(b) to determine whether and to what extent the land or resource use in question is carried out within the predetermined terms and conditions;
(c) to provide the information base necessary for agencies to enforce terms and conditions of land or resource use approvals; and
(d) to assess the accuracy of the predictions contained in the project impact statements.

As noted previously, NIRB issued an amended Project Certificate No. 005 (i.e. NIRB 2014) approving the ERP on May 28, 2014. NIRB (2014) and Section 12.4 of this report should be consulted for further information on the terms and conditions specific to socio-economic monitoring that were included in the Project Certificate.

Several conditions included in Project Certificate No. 005 relate to Baffinland's engagement with the Qikiqtaaluk Socio-Economic Monitoring Committee (QSEMC). The QSEMC is one of three regional socio-economic monitoring committees in Nunavut. These committees were established in 2007 to address project certificate requirements for project-specific monitoring programs and to create a discussion forum and information sharing hub that supports impacted communities and interested stakeholders to take part in monitoring efforts (SEMCs 2016). Baffinland is actively involved in the QSEMC and regularly participates in its meetings. Most recently, Baffinland participated in the QSEMC's July 2016 meeting in Iqaluit.

The Mary River Socio-Economic Monitoring Working Group (Mary River SEMWG, or Working Group) Terms of Reference also provides guidance on Baffinland's socio-economic monitoring program. Baffinland, in addition to the Government of Nunavut, the Government of Canada, and the Qikiqtani Inuit Association (QIA), is a member of the Mary River SEMWG. The Mary River SEMWG is intended to support the QSEMC's regional monitoring initiatives through project-specific socio-economic monitoring. The Mary River SEMWG also supports the fulfillment of terms and conditions set out in Project Certificate No. 005 that relate to socio-economic monitoring. Baffinland is actively involved in the Mary River SEMWG and regularly participates in its meetings. Most recently, Baffinland met with the Mary River SEMWG in July 2016 in Iqaluit. A Terms of Reference for the Mary River SEMWG can be found in Appendix A. It describes the Working Group's purpose; membership and member roles; objectives; and reporting, communication, and meeting requirements. Furthermore, Section 4.1 of the Terms of Reference notes that Baffinland:

> "*…will prepare an annual socio-economic report, presenting performance data, to the Nunavut Impact Review Board for review…containing data on the indicators selected by the Working Group for the previous calendar year (January to December). These reports will further describe the Company's participation in the [QSEMC], other collaborative monitoring processes and any activities related to better understanding of socio-economic processes.*"

As established in the Mary River SEMWG Terms of Reference, the Working Group members agreed that collaboration is required to effectively monitor the socio-economic performance of the Mary River Project. It was acknowledged that Baffinland is best able to collect and provide data concerning employment and training in relation to the Project, and the Government of Nunavut and the Government of Canada are best able to report public statistics on general health and well-being, food security, demographics, and other socio-economic indicators at the community and territorial level. The

QIA was noted to be best able to provide information and data relating to Inuit land use and culture at the community and regional level

This *2016 Socio-Economic Monitoring Report for the Mary River Project* helps fulfill Project-related socio-economic monitoring requirements associated with the Nunavut Agreement and NIRB Project Certificate No. 005, and follows the guidance provided by the Mary River SEMWG Terms of Reference, described above. Baffinland will continue to review and address its socio-economic monitoring requirements moving forward.

1.3 REPORT OBJECTIVES AND ORGANIZATION

This is the fourth annual socio-economic monitoring report prepared by Baffinland for the Mary River Project. Project-specific socio-economic monitoring programs in Nunavut are generally expected to focus on two areas: 'effects monitoring' and 'compliance monitoring'. Effects monitoring keeps track of the socio-economic effects of a project to see if management plans are working or if any unexpected effects are occurring. Compliance monitoring occurs to make sure proponents follow the terms and conditions of the licences, decisions, and certificates issued by authorizing agencies (NIRB 2013). This focus is commensurate with socio-economic monitoring best-practice (e.g. Noble 2015; Vanclay et al. 2015) and can assist companies with achieving their sustainable development goals.

Socio-economic monitoring also supports adaptive management, as findings can alert project proponents to the emergence of unanticipated effects and help initiate a management response. Furthermore, regular review of monitoring plans will help determine whether existing socio-economic indicators and monitoring methods remain appropriate (Vanclay et al. 2015).

In consideration of the above, this report aims to meet the following objectives:

1. Evaluate the accuracy of selected socio-economic effect predictions presented in the Mary River Project Final EIS[1] and identify any unanticipated effects.
2. Help identify areas where Baffinland's existing socio-economic mitigation and management programs may not be functioning as anticipated.
3. Assist regulatory and other agencies in evaluating Baffinland's compliance with socio-economic monitoring requirements for the Project.
4. Support adaptive management, by identifying potential areas for improvement in socio-economic monitoring and performance, where appropriate.

This 2016 report presents information related to VSECs assessed in the Final EIS. Throughout this report, predicted residual VSEC effects and associated mitigation measures from the Final EIS are described. In some other cases, socio-economic Project Certificate conditions are described instead of effect predictions. This is followed by a presentation of indicator data (where available) and an analysis of that data. This structure allows Baffinland's reporting to align with the Final EIS predictions and Project Certificate conditions, and increases comparability between them and currently available data. However, Baffinland also acknowledges the structure and content of its socio-economic monitoring report may benefit from refinement in the future (see Section 1.4 for further information).

[1] References to the Mary River Project Final EIS in this report include any revisions that were made to the Final EIS for the original ERP addendum.

This report is organized in the following manner:

- Section 1 (i.e. this section) introduces the report and the scope of its contents.
- Section 2 describes the methods used in this report and how they support the conclusions that are reached.
- Sections 3 to 11 assess the socio-economic performance of VSECs included in the Final EIS.
- Section 12 provides a report summary, comments on adaptive management and future monitoring plans, and summarizes how Baffinland has addressed Project Certificate terms and conditions specific to socio-economic monitoring.

1.4 SOCIO-ECONOMIC MONITORING PLAN

Baffinland will continue to conduct comprehensive socio-economic monitoring for the Project. A long-term socio-economic monitoring plan is presented in Table 1 and summarizes indicators and data sources for all VSECs assessed in the Final EIS (or notes where monitoring is not required or other forms of issue tracking and monitoring will take place). More specifically, indicators are proposed for VSEC-related residual effects and information that has been requested through the Project Certificate.

Prior to finalizing the Project's socio-economic monitoring plan, Baffinland solicited feedback from members of the Mary River SEMWG on a draft version of the plan presented in the 2015 monitoring report (i.e. Jason Prno Consulting Services Ltd. 2016). Baffinland also identified several internal refinements to this plan and its approach to socio-economic monitoring prior to finalization. Some of these refinements include the modification of previously proposed indicators and/or addition of new indicators, aggregation of some community-level data to a more appropriate scale of analysis (e.g. presenting aggregated data for the North Baffin LSA rather than for individual communities), and the introduction of data trends analyses.

However, Baffinland acknowledges the structure and content of its socio-economic monitoring report may benefit from additional refinement in the future; suggestions from reviewers on how indicators and data sources could potentially be improved are welcome. It is further acknowledged that any significant changes to the Project's socio-economic monitoring program require discussion with the Mary River SEMWG. Likewise, Table 1 includes several instances where indicators haven't been identified by Baffinland for various reasons (e.g. sufficient monitoring is already conducted elsewhere, no residual effects were identified in the Final EIS, insufficient data availability). In some additional cases, other forms of issue tracking will take place (e.g. through the QSEMC process or Baffinland's community engagement program). Should indicators be required for these topics in the future, they will be selected in consultation with the Mary River SEMWG.

VSEC	Residual Effect or Project Certificate Condition	Topic	Indicator(s)	Data Source
Population Demographics	Residual Effect	In-migration of non-Inuit Project employees into the North Baffin LSA	Known in-migrations of non-Inuit Project employees and contractors	Baffinland
			In-migration of non-Inuit to the North Baffin LSA	Limited data currently available
		Out-migration of Inuit residents from the North Baffin LSA	Known out-migrations of Inuit Project employees and contractors	Baffinland
			Out-migration of Inuit from the North Baffin LSA	Limited data currently available
	Project Certificate Condition	Demographic change	Population estimates	NBS (2016a)
			Nunavut annual net migration	NBS (2016b)
		Employee changes of address, housing status, and migration intentions	Employee changes of address, housing status, and migration intentions	Baffinland
		Employee origin	Employee origin	Baffinland
Education and Training	Residual Effect	Improved life skills amongst young adults	Participation in pre-employment training	Baffinland
			LSA employment and on-the-job training	Baffinland
		Incentives related to school attendance and success	Number of secondary school graduates	NBS (2016c)
			Secondary school graduation rate	NBS (2016d)
		Opportunities to gain skills	Hours of training completed by Inuit employees	Baffinland
			Types of training provided to Inuit employees	Baffinland
			Apprenticeships and other opportunities	Baffinland
	Project Certificate Condition	Education and employment status prior to Project employment	Education and employment status prior to Project employment	Baffinland
Livelihood and Employment	Residual Effect	Creation of jobs in the LSA	Total hours of Project labour performed in Nunavut	Baffinland
		Employment of LSA residents	Project hours worked by LSA employees and contractors	Baffinland
		New career paths	LSA employment	Baffinland
			Inuit employee promotions	Baffinland
			Inuit employee turnover	Baffinland
	Project Certificate Condition	Barriers to employment for women	Hours worked by female employees and contractors	Baffinland
			Re: childcare availability and costs – Topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG.	
Contracting and Business Opportunities	Residual Effect	Expanded market for business services to the Project	Value of procurement with Inuit-owned businesses and joint ventures	Baffinland
		Expanded market for consumer goods and services	LSA employee payroll amounts	Baffinland
			Number of registered Inuit firms in the LSA	NTI (2016)
Human Health and Well-Being	Residual Effect	Changes in parenting	Total number of youth charged	Statistics Canada (2016a)
		Household income and food security	Proportion of taxfilers with employment income and median employment income	NBS (2016e)
			Percentage of population receiving social assistance	NBS (2014)
		Overall effects on children	N/A – Monitoring already conducted through other 'human health and well-being' indicators	
		Transport of substances through Project site	Number of drug and alcohol related contraband infractions at Project sites	Baffinland
		Affordability of substances	Number of impaired driving violations	NBS (2016f)
		Attitudes toward substances and addictions	Number of drug violations	NBS (2016f)
		Absence from the community during work rotation	Topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG.	
	Project Certificate Condition	Prevalence of substance abuse	N/A – Monitoring already conducted through other 'human health and well-being' indicators	
		Prevalence of gambling issues	Topics will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG.	
		Prevalence of family violence		
		Prevalence of marital problems		
		Rates of sexually transmitted infections and other communicable diseases	Percent of health centre visits related to infectious diseases	NBS (2016g)
		Rates of teenage pregnancy	Topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG.	
		High school completion rates	N/A – Monitoring already conducted through other 'education and training' indicators	
		Other	Crime rate	NBS (2016h)
Community Infrastructure and Public Services	Residual Effect	Competition for skilled workers	Number of Project employees who left positions in their community	Baffinland
		Labour force capacity	Training and experience generated by the Project	Baffinland
			Inuit employee turnover	Baffinland

	Project Certificate Condition	Pressures on existing health and social services provided by the GN that may be impacted by Project-related in-migration of employees	Number of health centre visits (total and per capita)	NBS (2016g)
			Number of visits to Project site medic	Baffinland
		Project-related pressures on community infrastructure	Baffinland use of LSA community infrastructure	Baffinland
			Number of Project aircraft movements at LSA community airports	Baffinland
Cultural Resources	N/A	N/A	N/A – Monitoring already conducted through annual archaeology reports	
Resources and Land Use	Residual Effect	Quantity of caribou harvested per level of effort	N/A – Potential effects on caribou will continue to be tracked through Baffinland's terrestrial wildlife monitoring program	
		Safe travel around Eclipse Sound and Pond Inlet	Number of recorded land use visitor person-days at Project sites Number of wildlife compensation fund claims	Baffinland QIA
		Safe travel through Milne Port		
		Emissions and noise disruption at camps		
		Sensory disturbances and safety along Milne Inlet Tote Road		
		Detour around mine site for safety and travel		
		Difficulty and safety relating to railway crossing		
		Detour around Steensby Port		
		HTO cabin closures	N/A – No monitoring required. Effects are permanent for life of Project.	
		Restriction of camping locations around Steensby Port		
Cultural Well-Being	N/A	N/A	N/A – No monitoring required. No residual effects identified in the Final EIS.	
Economic Development and Self-Reliance	Residual Effect	Increased pressure on the land	N/A – As noted in the Final EIS, monitoring is already conducted through other VECs/VSECs	
		Changes to land-based economy		
		Increased opportunities for youth		
		Education and training opportunities		
		Increased wealth and well-being		
		Increased wealth in community		
		Rotational absence of residents		
		Increased local business opportunities		
		Expanded economic activity, flows, and opportunities		
	Project Certificate Condition	Project harvesting interactions and food security, which includes broad indicators of dietary habits	Topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG.	
Benefits, Royalty, and Taxation	Residual Effect	Payments of payroll and corporate taxes to the territorial government	Annual payroll and corporate taxes paid by Baffinland to the territorial government	Baffinland
Governance and Leadership	N/A	N/A	N/A – No monitoring required. No residual effects identified in the Final EIS.	

Table 1: Socio-economic monitoring plan for the Mary River Project

2. METHODS

2.1 ANALYSIS OF PROJECT EFFECTS

This report assesses the socio-economic performance of the Mary River Project in 2016. It does so primarily through an analysis of Project-related socio-economic effects that were originally predicted to occur in the Final EIS. To help focus this analysis, only residual effects that were identified in the Final EIS are assessed; 'subjects of note' and other potential effects are not reviewed. Furthermore, only the direction (e.g. positive, negative) and magnitude (where appropriate)[2] of these residual effects are evaluated.

One or more monitoring indicators are then identified for each of these residual effects and recent indicator data is presented for consideration against the original effect predictions that were made. Structuring the report in this manner allows the effect predictions to be more readily verified (or refuted) and provides insight into the effectiveness of existing mitigation measures. This report also presents information that was requested through the Project Certificate. This information is evaluated in a similar manner to the residual effects mentioned above, although comparisons against Final EIS predictions were not required.

'Indicators' are an important aspect of socio-economic monitoring. Indicators are metrics used to measure and report on the condition and trend of a Valued Component (VC)[3], and help facilitate the analysis of interactions between a project and a selected VC (BCEAO 2013). Indicators can also provide an early warning of potential adverse effects and are considered the most basic tools for analyzing change (Noble 2015). Noble (2015) suggests that good indicators are:

- *Measurable, either in a qualitative or quantitative fashion*
- *Indicative of the VC of concern*
- *Sensitive and detectable in terms of project-induced stress*
- *Appropriate to the spatial scale of the VC of concern*
- *Temporally reliable*
- *Diagnostic to change*
- *Applicable across different types of development projects*
- *Cost-effective to collect, measure, or analyze*
- *Predictable and accurate with an acceptable range of variability*
- *Understandable by non-scientists*
- *Useful for informing management actions or decisions*

The socio-economic monitoring indicators presented in this report were selected with this guidance in mind. The analyses presented in this report also generally focus on one of two spatial scales: a Local Study Area (LSA) or Regional Study Area (RSA). As identified in the Final EIS, the LSA includes the North Baffin point-of-hire communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet, in addition to the City of Iqaluit (which is also a point-of-hire). References to the 'North Baffin LSA' include all these communities but Iqaluit. In some cases, data for the North Baffin LSA

---

[2] Effect magnitude is only assessed where quantitative metrics were provided in the Final EIS.

[3] Valued Components are typically referred to as Valued Ecosystem Components (VECs) and Valued Socio-Economic Components (VSECs) in Nunavut.

communities have been aggregated to facilitate trend analyses in this report. The RSA includes the entire territory of Nunavut.

Indicator 'trends' are discussed throughout this report and describe whether an indicator has exhibited change (and the direction of that change). For example, a 'pre-development' trend in this report refers to the five-year period preceding Project construction (i.e. 2008 to 2012) and is calculated using available indicator data for those five years. In some cases, this data has also been averaged, so that a baseline is created to measure a 'post-development' trend against. Likewise, a 'post-development' trend refers to the period after Project construction commenced (i.e. 2013 onwards) and is calculated using available indicator data from that period. A trend 'since previous year' refers to the two most recent years in which indicator data are available. Many trends in this report have been assessed using a line of best fit (e.g. using the trendline function in Microsoft Excel).

Trend magnitude (e.g. using qualifiers such as 'large' or 'small') is generally not described in this report; trends are often simply referred to as increasing/decreasing. Available data and trends are then assessed to see if the Project is having an influence on the indicator(s) in question. However, it is important to note that Project construction only began in 2013 and there is a minimal amount of post-development data currently available. Socio-economic indicators can also be influenced by many different factors. Correlations (if any) between the Project and socio-economic indicators presented in this report may only come to light with the analysis of additional annual data.

2.2 DATA SOURCES

Data for this report have been obtained from Company, government, Inuit organization, and other sources. Data are presented in textual, graphical, or tabular formats, with a source identified for each. Company data sources include human resources records, site files, and information obtained from other Company documents and employees. Some 2013 and 2014 Project-specific data were also drawn from previous socio-economic monitoring reports prepared for the Project (e.g. Brubacher Development Strategies Inc. 2015). Results from Baffinland's community engagement program are also referenced throughout this report and include information received from public and stakeholder meetings on the Project, North Baffin community surveys, or other forums. This information has been accessed through Baffinland's stakeholder information management system (StakeTracker) and other relevant sources (e.g. topic-specific reports prepared by the Company).

Government data have been obtained primarily from the Nunavut Bureau of Statistics, the Government of Nunavut's central statistical agency. The Nunavut Bureau of Statistics posts current Nunavut population data, economic data, labour force and employment data, social data, census data, and Nunavut Housing Survey data on its website (http://www.stats.gov.nu.ca/en/home.aspx) for the public to use. Reports from the QSEMC annual meetings (e.g. Government of Nunavut 2016) were also reviewed, with the goal of integrating relevant data and insights where appropriate. Some data have also been obtained from Nunavut Tunngavik Inc. (e.g. on registered Inuit firms) and from other sources (e.g. QIA, federal government agencies, third party groups such as mining associations).

2.3 DATA LIMITATIONS

Some data limitations were identified during the preparation of this report. Notably, comprehensive government data on in-migration and out-migration of Inuit and non-Inuit residents in the North Baffin LSA were not available in 2016 (these data gaps are described in more detail in Sections 3.2 and 3.3).

Some 2013 and 2014 Company data have also been drawn from previous socio-economic monitoring reports prepared for the Project (e.g. Brubacher Development Strategies Inc. 2015). However, comparisons against some of this data should be made with a degree of caution. This is because the socio-economic data collection and analysis methods employed by Baffinland have changed in some instances.[4] Furthermore, some of the (primarily historic) Company data presented in this report is of a limited nature, or reflects information that was only available for certain periods of time (due to ongoing development of Baffinland's human resources data management system).

Baffinland continues to refine its socio-economic data management and reporting systems. Improvements to the methods used for tracking employee hours are currently being investigated by Baffinland, as some inconsistencies in existing systems have been identified. However, Baffinland has attempted to present conservative employment data and/or identify data limitations wherever possible in this report. Finally, data are presented in this report for the most recent years that are currently available. Lag times in data availability exist for some data sources and 2016 data were not available in all cases.

[4] Tables 13, 14, and 17 present 2013 and 2014 data from Brubacher Development Strategies Inc. (2015). However, comparisons against this data should be made with a degree of caution. This is because some calculation methods used by Baffinland have changed and some historic data makes assumptions with regards to hours worked at the Project. Hours worked by non-Inuit in 2013 in Table 17 also do not add up completely (i.e. 144 hours are unaccounted for), for unknown reasons. 2016 calculations for these tables include individuals who worked on the Project in Nunavut in 2016, but do not include individuals who worked on the Project outside of Nunavut, Baffinland corporate head office staff, or account for turnover.

3. VSEC – POPULATION DEMOGRAPHICS

Two residual effects associated with the VSEC 'Population Demographics' were assessed in the Final EIS. These include 'in-migration of non-Inuit Project employees into the North Baffin LSA' and 'out-migration of Inuit residents from the North Baffin LSA'. These are reviewed more fully below, in addition to information on three other topics requested through the Project Certificate (i.e. demographic change; employee changes of address, housing status, and migration intentions; and employee origin). However, community and territorial demographic change data are first reviewed for greater context.

3.1 DEMOGRAPHIC CHANGE

3.1.1 Project Certificate Condition

Project Certificate condition #131 requests that monitoring occur on:

> *…demographic changes including the movement of people into and out of the North Baffin communities and the territory as a whole.*

Population estimates and other demographic change measures are included in many socio-economic monitoring initiatives. This is because of their importance in helping understand broad socio-economic trends. As such, this section provides an overview of some of the major demographic changes that are occurring in Nunavut and the LSA communities. Sections 3.2 and 3.3, however, review the Final EIS predictions made regarding in-migration and out-migration in the North Baffin LSA in more detail.

3.1.2 Indicator Data

Population Estimates

Population estimates for Nunavut and the LSA communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, Pond Inlet, and Iqaluit are provided by the Nunavut Bureau of Statistics (2016a)[5] and presented in Table 2. 2016 is the most recent year for which Nunavut population estimates were available. In 2016, the North Baffin LSA communities had a total population of 6,608, of which approximately 94.5% were Inuit and 5.5% were non-Inuit. Iqaluit had a total population of 7,590, of which approximately 55.4% were Inuit and 44.6% were non-Inuit. Nunavut had a total population of 37,082, of which approximately 84.2% were Inuit and 15.8% were non-Inuit.

Between 2012 and 2016, the North Baffin LSA communities grew from a total population of 6,050 to 6,608 (or 9.2%). Iqaluit grew from a total population of 7,013 to 7,590 (or 8.2%), while Nunavut grew from a total population of 34,707 to 37,082 (or 6.8%). Average annual growth rates over this period for the North Baffin LSA communities (2.3%), Iqaluit (2.1%), and Nunavut (1.7%) were considerably higher than the Canadian average (1.1%) (Statistics Canada 2016b). Figure 1 displays the total population in these locations from 2008 to 2016.

---

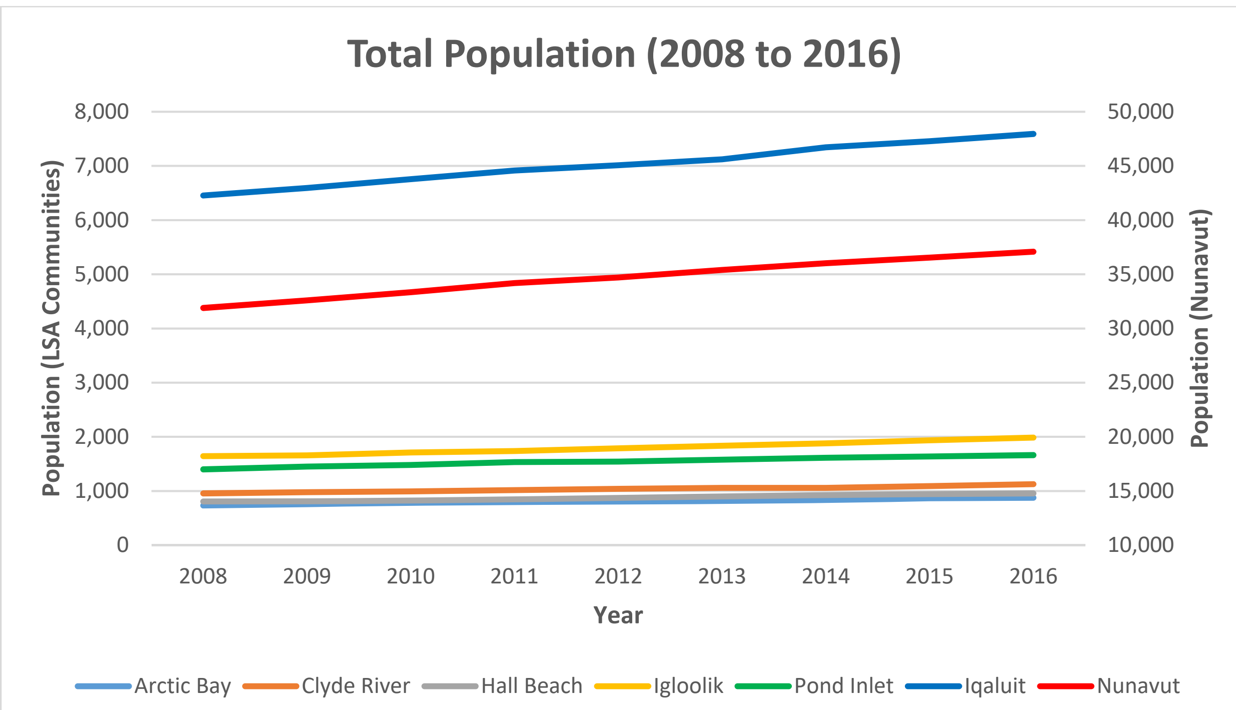
[5] The Nunavut Bureau of Statistics (2016a) notes that community population estimates are preliminary and subject to revision. 2016 estimates, in particular, are suggested to be viewed with some caution, as these are in early preliminary stages.

2016 Population Estimates			
Community	**Total Population**	**Inuit**	**Non-Inuit**
North Baffin LSA	6,608	6,247	361
· Arctic Bay	876	828	48
· Clyde River	1,127	1,085	42
· Hall Beach	956	915	41
· Igloolik	1,986	1,850	136
· Pond Inlet	1,663	1,569	94
Iqaluit	7,590	4,208	3,382
Nunavut	37,082	31,234	5,848

Source: Nunavut Bureau of Statistics (2016a)

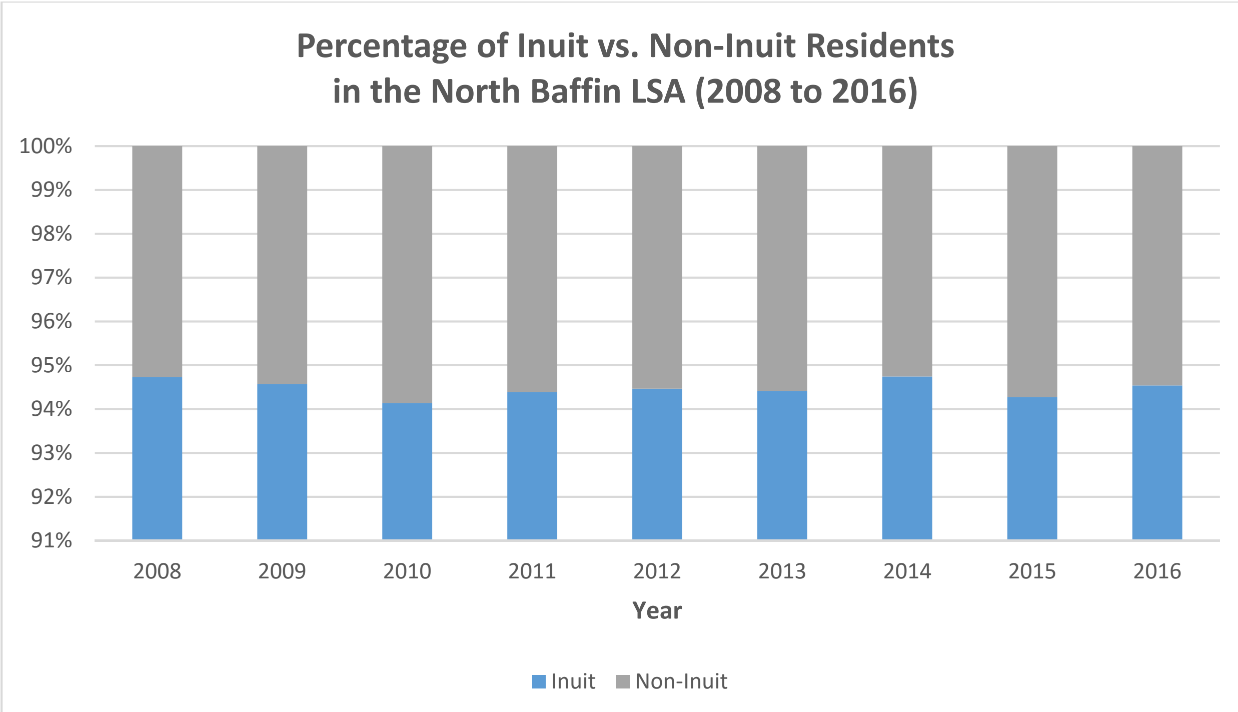
Table 2: 2016 population estimates

The percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities remains high. 94.5% of North Baffin LSA residents were Inuit in the pre-development period, while an equal 94.5% were Inuit in 2016. Since the pre-development period, a slight increasing trend in the percentage of Inuit versus non-Inuit residents has occurred. Figure 2 displays the percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities from 2008 to 2016.



Source: Nunavut Bureau of Statistics (2016a)

Figure 1: Total population (2008 to 2016)



Source: Nunavut Bureau of Statistics (2016a)

Figure 2: Percentage of Inuit versus non-Inuit residents in the North Baffin LSA (2008 to 2016)

Nunavut Annual Net Migration

Territorial annual net migration estimates provide insight into the broad migration patterns that are occurring in Nunavut. Table 3 displays annual net migration estimates for Nunavut from 2008/2009 to 2015/2016, which have been obtained from the Nunavut Bureau of Statistics (2016b). A net of -174 individuals were estimated to have migrated into Nunavut in 2015/2016. However, estimates for the preceding seven years have been variable, from a net of 71 individuals migrating into Nunavut in 2010/2011, to a net of -112 individuals migrating into the territory in 2014/2015. 2015/2016 had the highest number of interprovincial/interterritorial out-migrants, with 1,642. 2015/2016 also had the highest number of interprovincial/interterritorial in-migrants, with 1,443. Since the pre-development period, a negative decreasing trend in Nunavut annual net migration has occurred.

Nunavut Annual Net Migration Estimates							
2008/2009	**2009/2010**	**2010/2011**	**2011/2012**	**2012/2013**	**2013/2014**	**2014/2015**	**2015/2016**
12	-27	71	-108	23	-6	-112	-174

Source: Nunavut Bureau of Statistics (2016b)

Table 3: Nunavut annual net migration estimates (2008/2009 to 2015/2016)

3.1.3 Analysis

The populations of the North Baffin LSA communities, Iqaluit, and Nunavut have continued to grow since Project development. The percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities has also remained high since that time. However, a negative downward trend in Nunavut annual net migration has occurred. No linkage to Project activities is currently evident with any of these indicators. Population growth was occurring throughout Nunavut prior to Project development, and the percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities was similarly high during this period. Likewise, annual net migration estimates are currently conducted at too coarse a scale (i.e. territorial) to ascertain any Project-related influences.

3.2 IN-MIGRATION OF NON-INUIT PROJECT EMPLOYEES INTO THE NORTH BAFFIN LSA

3.2.1 Predicted Effect and Mitigation Measures

The Final EIS predicted that some in-migration of non-Inuit employees hired to work at the Project could occur in the North Baffin LSA, but would be of low magnitude (i.e. <5% change in the non-Inuit baseline population). Associated mitigation measures developed by Baffinland include the designation of Iqaluit and an additional southern location as ‘points of hire’, with free transportation provided to employees from these points of hire to the mine site.

3.2.2 Indicator Data

Known In-Migrations of Non-Inuit Project Employees and Contractors

Data on the movement of Project employees and contractors can provide insight into potential in-migration trends occurring in the North Baffin LSA. Table 4 presents data on known in-migrations of Project employees and contractors to the North Baffin LSA. These data were provided by Baffinland Community Liaison Officers (BCLOs) located in each North Baffin LSA community. More specifically, the BCLOs were asked to report on the number of Project employees and contractors they knew who had moved into and out of each of their communities. BCLOs were also asked to identify whether individuals were Inuit or non-Inuit and locations where these individuals had moved to and from, if known.[6]

Table 4 indicates one Inuit employee is known to have moved into the North Baffin LSA communities in 2016. This individual moved from a location outside of Nunavut. No non-Inuit employees or contractors and no Inuit contractors hired to work at the Project are known to have moved into the North Baffin LSA communities in 2016.

[6] Family members that may have migrated with employees were not accounted for.

Known In-Migration of Project Employees and Contractors to the North Baffin LSA		
Year	**Inuit**	**Non-Inuit**
2015	3	0
2016	1	0
Total	**4**	**0**

Source: Baffinland records

Table 4: Known in-migrations of Project employees and contractors to the North Baffin LSA (2015 to 2016)

In-Migration of Non-Inuit to the North Baffin LSA

Annual in-migration data for non-Inuit North Baffin LSA residents were not available from the Nunavut Bureau of Statistics in 2016. However, some insight into this topic may be obtained by assessing changes in the percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities since Project development. If substantial non-Inuit in-migration (as per this section) and Inuit out-migration (as per Section 3.3) were occurring because of the Project, the ratio of Inuit to non-Inuit residents in the North Baffin LSA communities would be expected to noticeably decrease. As seen in Figure 2, however, the percentage of Inuit residents in the North Baffin LSA communities has remained relatively constant between 2008 and 2016 (ranging between a low of 94.1% Inuit and a high of 94.7% Inuit). In fact, a slight increasing trend in the percentage of Inuit residents has been identified since the pre-development period.

3.2.3 Analysis

The Final EIS predicted a <5% change in the non-Inuit baseline population could occur in the North Baffin LSA because of Project activities. In 2012, the Project baseline year, 5% of the North Baffin non-Inuit population would have equaled approximately 28 individuals. Cumulative Baffinland data available since 2015[7] indicates a net of zero non-Inuit employees/contractors have in-migrated to the North Baffin LSA. Data on changes in the percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities have also failed to reveal a Project-induced trend at this time.

However, this data presents only a partial assessment of migration trends and more detailed in-migration data for the North Baffin LSA communities are currently unavailable from the Nunavut Bureau of Statistics. Furthermore, the factors involved in deciding to migrate can be complex and specific to an individual. While these limitations are acknowledged, available migration data appears to support the Final EIS predictions that were made.

[7] 2013-2014 Baffinland migration data was presented in Brubacher Development Strategies Inc. (2015). However, comparisons with this data should be made with some caution as this report did not identify whether its migration calculations included both Inuit and non-Inuit individuals and/or both employees and contractors. Furthermore, the number of migrating individuals were rounded and calculated using different methods than subsequent Baffinland socio-economic monitoring reports. From 2013 to 2014, Brubacher Development Strategies Inc. (2015) notes less than five individuals moved into the North Baffin LSA from other North Baffin LSA communities. This report also notes less than five individuals moved into the North Baffin LSA from Iqaluit during this period, while less than five individuals moved out of the North Baffin LSA to other North Baffin LSA communities. Five to ten individuals also moved from the North Baffin LSA to Iqaluit during this period, while less than five individuals moved from the North Baffin LSA to Ottawa.

3.3 OUT-MIGRATION OF INUIT RESIDENTS FROM THE NORTH BAFFIN LSA

3.3.1 Predicted Effect and Mitigation Measures

The Final EIS predicted that some out-migration of Inuit residents from the North Baffin LSA could occur, but would be of moderate magnitude (i.e. 1% to <5% of the total population). Mitigation developed by Baffinland regarding this effect includes the designation of all North Baffin LSA communities as 'points of hire', with free transportation provided to employees from these points of hire to the mine site.

3.3.2 Indicator Data

Known Out-Migrations of Inuit Project Employees and Contractors

Data on the movement of Project employees and contractors can provide insight into potential out-migration trends occurring in the North Baffin LSA. Table 5 presents data on known out-migrations of Project employees and contractors from the North Baffin LSA. As noted previously, these data were provided by BCLOs located in each North Baffin LSA community. More specifically, the BCLOs were asked to report on the number of Project employees and contractors they knew who had moved into and out of each of their communities. BCLOs were also asked to identify whether individuals were Inuit or non-Inuit and locations where these individuals had moved to and from, if known.[6]

Four Inuit employees and one Inuit contractor are known to have moved out of the North Baffin LSA communities in 2016. Of these individuals, two moved to another North Baffin LSA community (these individuals will not be counted as North Baffin LSA out-migrants), one moved to another community in Nunavut, and two moved to a location outside of Nunavut. No non-Inuit employees or contractors are known to have moved out of the North Baffin LSA communities in 2016. However, Table 4 also indicates the out-migration of these three Inuit individuals was offset by the in-migration of one Inuit individual to the North Baffin LSA in 2016. Thus, a net of two Inuit individuals out-migrated from the North Baffin LSA in 2016.

Known Out-Migration of Project Employees and Contractors from the North Baffin LSA		
Year	**Inuit**	**Non-Inuit**
2015	4	0
2016	3	0
Total	**7**	**0**

Source: Baffinland records

Table 5: Known out-migrations of Project employees and contractors from the North Baffin LSA (2015 to 2016)

Out-Migration of Inuit from the North Baffin LSA

Annual out-migration data for Inuit North Baffin LSA residents were not available from the Nunavut Bureau of Statistics in 2016. However, some insight into this topic may be obtained by assessing changes in the percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities since Project development. If substantial Inuit out-migration (as per this section) and non-Inuit in-migration (as per Section 3.2) were occurring because of the Project, the ratio of Inuit to non-Inuit residents in the North Baffin LSA communities would be expected to noticeably decrease. As seen in Figure 2, however, the percentage of Inuit residents in the North Baffin LSA communities has remained relatively constant between 2008 and 2016 (ranging between a low of 94.1% Inuit and a high of 94.7% Inuit). In fact, a slight increasing trend in the percentage of Inuit residents has been identified since the pre-development period.

3.3.3 Analysis

The Final EIS predicted 1% to <5% of the total, primarily Inuit, North Baffin LSA baseline population could migrate out of the North Baffin LSA because of the Project. In 2012, the selected population baseline year, 5% of the total North Baffin LSA population would have equaled approximately 306 individuals. As mentioned previously, a net of two Inuit employees/contractors out-migrated from the North Baffin LSA in 2016. Cumulative Baffinland data available since 2015[7] indicates there have been a net of three Inuit employees/contractors who have out-migrated from the North Baffin LSA. Data on changes in the percentage of Inuit versus non-Inuit residents in the North Baffin LSA communities have also failed to reveal a Project-induced trend at this time.

However, this data presents only a partial assessment of migration trends and more detailed out-migration data for the North Baffin LSA communities are currently unavailable from the Nunavut Bureau of Statistics. Furthermore, the factors involved in deciding to migrate can be complex and specific to an individual. While these limitations are acknowledged, available migration data appears to support the Final EIS predictions that were made.

3.4 EMPLOYEE CHANGES OF ADDRESS, HOUSING STATUS, AND MIGRATION INTENTIONS

3.4.1 Project Certificate Condition

No specific predictions related to employee changes of address, housing status, and migration intentions were presented in the Final EIS. However, Project Certificate condition #133 states:

> *"The Proponent is encouraged to work with the Qikiqtaaluk Socio-Economic Monitoring Committee and in collaboration with the Government of Nunavut's Department of Health and Social Services, the Nunavut Housing Corporation and other relevant stakeholders, design and implement a voluntary survey to be completed by its employees on an annual basis in order to identify changes of address, housing status (i.e. public/social, privately owned/rented, government, etc.), and migration intentions while respecting confidentiality of all persons involved. The survey should be designed in collaboration with the Government of Nunavut's Department of Health and Social Services, the Nunavut Housing Corporation and other relevant stakeholders. Non-confidential results of the survey are to be reported to the Government of Nunavut and the NIRB.*

3.4.2 Indicator Data

Employee Changes of Address, Housing Status, and Migration Intentions

Baffinland has developed a voluntary *Employee Information Survey* (see Appendix C) to address Project Certificate condition #133. The latest version of this survey[8] was administered by Baffinland representatives at Project sites in February/March 2017. A total of 43 surveys were ultimately completed by employees.[9]

Table 6 summarizes results pertaining to changes in employee housing situation and/or address. Of the 43 surveys received, 9 individuals (20.9%) indicated their housing situation had changed in the past 12 months. Of these 9 individuals, 7 (16.3% of the total) indicated they had recently moved (either to different housing or a different community). 3 individuals (7.0%) indicated they had moved to a different community in the past 12 months, 2 of whom (4.7%) moved from a North Baffin LSA community to outside of the North Baffin LSA. No individuals moved from outside the North Baffin LSA to a North Baffin LSA community. Of the 9 individuals who indicated their housing situation had changed in the past 12 months, 2 indicated 'rent increase' when explaining the nature of this change although it's unclear what exactly they were referring to. 1 individual did not provide an explanation for how their housing situation had changed.

Changes in Employee Housing Situation and/or Address (2017 Employee Information Survey Results)	
Type of Change	**Number of Individuals (43 Surveys Received)**
Housing situation has changed in the past 12 months	9
Moved to a different community in the past 12 months	3
Moved from North Baffin LSA to outside of North Baffin LSA	2
Moved from outside of North Baffin LSA to North Baffin LSA	0

Source: Baffinland records

Table 6: Changes in employee housing situation and/or address (2017 employee information survey results)

Table 7 summarizes results pertaining to current employee housing status. Of the 43 surveys received, 1 individual (2.3%) indicated they lived in a private dwelling owned by them, 4 individuals (9.3%) indicated they lived in a private dwelling owned by another individual, 6 individuals (14.0%) indicated they were renting from a private company, 29 individuals (67.4%) indicated they were living in public housing, and results were unclear/unknown for 3 individuals (7.0%).

---

[8] Results from earlier versions of this survey have been presented in previous Baffinland socio-economic monitoring reports. The content of the Employee Information Survey continues to evolve, based on feedback obtained from members of the Mary River SEMWG and through internal refinements.

[9] This survey was offered to a) Inuit employees residing in Nunavut, b) Inuit employees residing outside of Nunavut, and c) non-Inuit employees residing in Nunavut. It was not offered to contractors. Efforts were made to capture all rotations of current employees, but individuals on vacation or medical leave at the time of the survey would not have been captured in the survey results. A small number of questions were not filled out by those who completed the survey. Where survey answers were not provided or were unclear, results were recorded as 'unknown'. Survey results are for general informational purposes only and should not be considered representative of any particular population.

Current Employee Housing Status (2017 Employee Information Survey Results)	
Current Housing Status	**Number of Individuals (43 Surveys Received)**
Privately owned – Owned by you	1
Privately owned – Owned by another individual	4
Renting from a private company	6
Public housing	29
Government of Nunavut staff housing	0
Other staff housing	0
Other/unknown	3

Source: Baffinland records

Table 7: Current employee housing status (2017 employee information survey results)

Table 8 summarizes results pertaining to employee migration intentions. Of the 43 surveys received, 7 individuals (16.3%) indicated they intended to move to a different community in the next 12 months. 3 of these individuals (7.0% of the total) were intending to move from a North Baffin LSA community to outside of the North Baffin LSA. No individuals intended to move from outside the North Baffin LSA to a North Baffin LSA community, and 1 individual indicated they were still determining where they would move to.

Employee Migration Intentions (2017 Employee Information Survey Results)	
Migration Intentions	**Number of Individuals (43 Surveys Received)**
Intend to move to a different community in the next 12 months	7
Intend to move from North Baffin LSA to outside of North Baffin LSA	3
Intend to move from outside of North Baffin LSA to North Baffin LSA	0

Source: Baffinland records

Table 8: Employee migration intentions (2017 employee information survey results)

3.4.3 Analysis

Information obtained from Baffinland's *Employee Information Survey* in 2017 indicates that some employees have changed their housing situation and/or address in the past 12 months, or have migration intentions. The survey also provided an overview of respondents' current housing status and demonstrated over two-thirds of respondents reside in public housing. Surveys conducted in future years are expected to provide additional data to compare these results against.

3.5 EMPLOYEE ORIGIN

3.5.1 Project Certificate Condition

No specific prediction related to employee origin was presented in the Final EIS. However, Project Certificate condition #134 states:

The Proponent shall include with its annual reporting to the NIRB a summation of employee origin information as follows:

a. The number of Inuit and non-Inuit employees hired from each of the North Baffin communities, specifying the number from each;

b. The number of Inuit and non-Inuit employees hired from each of the Kitikmeot and Kivalliq regions, specifying the number from each;

c. The number of Inuit and non-Inuit employees hired from a southern location or other province/territory outside of Nunavut, specifying the locations and the number from each; and

d. The number of non-Canadian foreign employees hired, specifying the locations and number from each foreign point of hire.

3.5.2 Indicator Data

Employee Origin

Data on the origin, number, and ethnicity of Project employees and contractors who worked at the Project in 2016 are presented in Table 9. An average of 1180 individuals worked at the Project in 2016, of which 182 (15.4%) were Inuit. In 2016, most of the Project's Inuit employees and contractors were based in the North Baffin LSA communities. Most of the Project's non-Inuit employees and contractors were based in Canadian locations outside of Nunavut, with Ontario having the greatest number and Yukon having the fewest. However, some non-Inuit employees and contractors were based in the North Baffin LSA communities and Iqaluit, and a small number of Inuit employees and contractors resided outside of Nunavut. There were a small number of non-Inuit international contractors, and various employees and contractors whose origin was unknown. Within the North Baffin LSA, Hall Beach had the greatest average number of employees and contractors (37), while Igloolik had the fewest (26). Several employees and contractors also resided in Iqaluit (52).

3.5.3 Analysis

The Project employed several Inuit from the LSA communities in 2016, which is a likely reflection of the Inuit hiring commitments Baffinland has made for those locations. Most non-Inuit individuals in 2016 came from Canadian provinces and territories other than Nunavut. A mine like Mary River requires many employees with various skill sets. Individuals with advanced mining and/or more technical skill sets are in limited supply in Nunavut (e.g. Gregoire 2014, MacDonald 2014, MIHR 2014, Conference Board of Canada 2016). The large number of Baffinland employees from outside of Nunavut would at least partly reflect this skills gap.

Mary River Project Employees and Contractors by Origin and Ethnicity in 2016																		
Origin		Baffinland								Contractors								Yearly Average
		Inuit				Non-Inuit				Inuit				Non-Inuit				
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Nunavut	Arctic Bay	22	21	19	18	1	3	2	3	5	6	10	7	1	7	8	7	**35**
	Clyde River	18	18	17	15	0	1	3	3	3	10	8	8	3	13	6	3	**32**
	Hall Beach	11	9	9	9	0	1	2	2	27	25	15	14	1	6	6	9	**37**
	Igloolik	15	13	12	8	0	1	1	1	14	11	11	4	1	5	4	4	**26**
	Pond Inlet	16	17	15	20	0	0	2	0	14	18	15	10	2	3	3	2	**34**
	Iqaluit	12	13	12	12	0	2	2	3	24	24	16	21	9	15	23	18	**52**
	Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Other Canadian Provinces and Territories	Alberta	0	0	0	0	17	25	29	32	0	0	0	0	35	37	52	62	**72**
	British Columbia	0	0	0	0	31	33	35	28	0	1	1	1	36	30	38	24	**65**
	Manitoba	0	0	0	0	13	13	11	10	0	0	0	0	7	6	5	5	**18**
	New Brunswick	0	0	0	0	24	21	21	22	0	0	0	0	17	14	5	4	**32**
	Newfoundland	1	1	1	1	45	40	41	37	0	0	0	0	11	16	23	10	**57**
	Northwest Territories	0	0	0	0	1	1	1	2	0	0	0	0	3	2	8	5	**6**
	Nova Scotia	0	0	0	0	38	43	44	44	0	0	0	0	17	19	14	18	**59**
	Ontario	7	7	7	10	246	250	258	263	3	3	3	0	156	173	126	118	**408**
	Prince Edward Island	0	0	0	0	1	2	3	4	0	0	0	0	2	3	2	2	**5**
	Quebec	0	0	0	0	21	19	22	22	0	0	0	0	25	25	34	24	**48**
	Saskatchewan	0	0	0	0	4	4	5	5	0	0	0	0	4	5	1	5	**8**
	Yukon	0	0	0	0	1	1	1	0	0	0	0	0	1	0	2	1	**2**
International	Other	0	0	0	0	2	1	0	0	0	0	0	0	4	0	0	3	**3**
Unknown	Unknown	0	1	1	4	43	60	93	109	0	0	2	0	76	88	129	124	**183**
Quarterly Totals		**102**	**100**	**93**	**97**	**488**	**521**	**576**	**590**	**90**	**98**	**81**	**65**	**411**	**467**	**489**	**448**	
Average		98				544				84				454				
AVERAGE TOTAL		1180																

Source: Baffinland records. This table includes individuals who worked on the Project in Nunavut in 2016. This table does not include individuals who worked on the Project outside of Nunavut, Baffinland corporate head office staff, or account for turnover.

Table 9: Mary River Project employees and contractors by origin and ethnicity in 2016

4. VSEC – EDUCATION AND TRAINING

Three residual effects associated with the VSEC 'Education and Training' were assessed in the Final EIS. These include 'improved life skills amongst young adults', 'incentives related to school attendance and success', and 'opportunities to gain skills'. These are reviewed more fully below, in addition to information on one other topic requested through the Project Certificate (i.e. education and employment status prior to Project employment).

4.1 IMPROVED LIFE SKILLS AMONGST YOUNG ADULTS

4.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted that positive effects on life skills development amongst young adults in the LSA would arise from the Project. This would occur primarily through access to industrial work supported by pre-employment preparation and on-the-job training. Associated mitigation measures developed by Baffinland include the provision of job readiness training, creation of a supportive work environment, a 'second chance' hiring policy, and development of a no drugs/no alcohol policy on site.

4.1.2 Indicator Data

Participation in Pre-Employment Training

Participation in pre-employment training is a useful indicator of life skills development because some individuals may have lacked basic employment skills prior to participating. Baffinland successfully carried out a 'Work Ready' pre-employment training program with North Baffin LSA residents in 2012 and 2013. There were 277 graduates of the program and 150 of those graduates went on to be employed at the Project in 2013. From 2014 to 2016, Baffinland focused on revising and improving its Work Ready program. The revised program is intended to provide future Inuit employees with an advanced understanding of some of the demands of working at the Project. A new Work Ready program is targeted to be delivered in local communities beginning in 2017.

LSA Employment and On-the-Job Training

Employment and on-the-job training are also important components of life skills development amongst young adults, as they provide additional opportunities for gaining valuable experience. In 2016, approximately 305,836 hours were worked by LSA residents at the Project. Likewise, 2,434 hours of on-the-job training were delivered to Inuit in 2016. Sections 4.3 and 5.2 of this report should be reviewed for additional information on Project-related employment and on-the-job training provided in 2016.

4.1.3 Analysis

In 2016, Baffinland continued to provide and/or develop various programs to support the development of life skills amongst LSA residents (including employment). These opportunities are notable, especially when considering the lack of employment and mining-related training opportunities that have historically existed in the North Baffin LSA. Furthermore, Baffinland maintains a healthy and supportive work environment. The Company provides employees and their dependents with ongoing access to an

Employee and Family Assistance Program and established on-site elder positions to provide counsel and support to Inuit employees.

Definitions of 'youth' and 'elder' in Inuit culture can be subjective and often based more on personal knowledge and experience rather than an exact age. While not all individuals who received pre-employment training, employment, and on-the-job training from Baffinland can be considered 'youth', it can reasonably be assumed that many of these individuals stood to benefit from the life skills development opportunities that were provided. It is further acknowledged that the development of life skills for some individuals can take time to achieve. However, there are indications that positive effects on life skills development amongst young adults in the LSA continue to result from the Project, as predicted in the Final EIS.

4.2 INCENTIVES RELATED TO SCHOOL ATTENDANCE AND SUCCESS

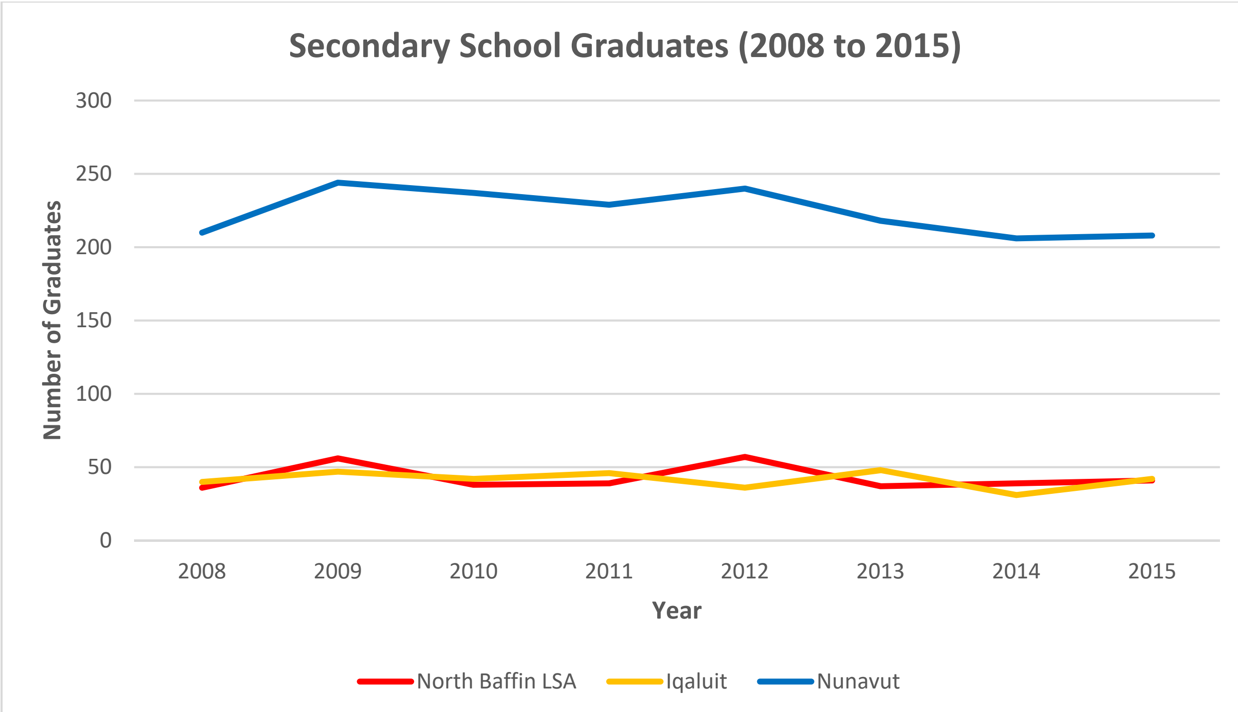
4.2.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on education and skills development across the LSA by providing incentives related to school attendance and success. While there is some potential that individuals may drop out of school or forego further education to work at the Project, the overall effect of the Project will be to increase the value of education and thereby the 'opportunity cost' of dropping out of school. Associated policies or mitigation measures developed by Baffinland include the establishment of a minimum age (i.e. 18) for Project employment, provision of career planning services, and priority hiring for Inuit. Furthermore, Baffinland continues to support a number educational and training initiatives through its donations program and the Inuit Impact and Benefit Agreement (IIBA) it negotiated with the QIA.

4.2.2 Indicator Data

Number of Secondary School Graduates

The number of secondary school graduates in the LSA is a useful indicator of school attendance and success. 2015 was the most recent year for which data on secondary school graduates was available from the Nunavut Bureau of Statistics (2016c). Figure 3 displays the number of secondary school graduates by community from 2008 to 2015. In the North Baffin LSA communities in 2015, there were 41 total graduates, up from 39 in 2014. There were a low of 4 graduates in Arctic Bay and Igloolik, and a high of 20 graduates in Pond Inlet in 2015. In Iqaluit, there were 42 graduates in 2015, up from 31 in 2014. Compared to pre-development period averages, there has been a decreasing trend in the number of graduates in the North Baffin LSA communities and Iqaluit.



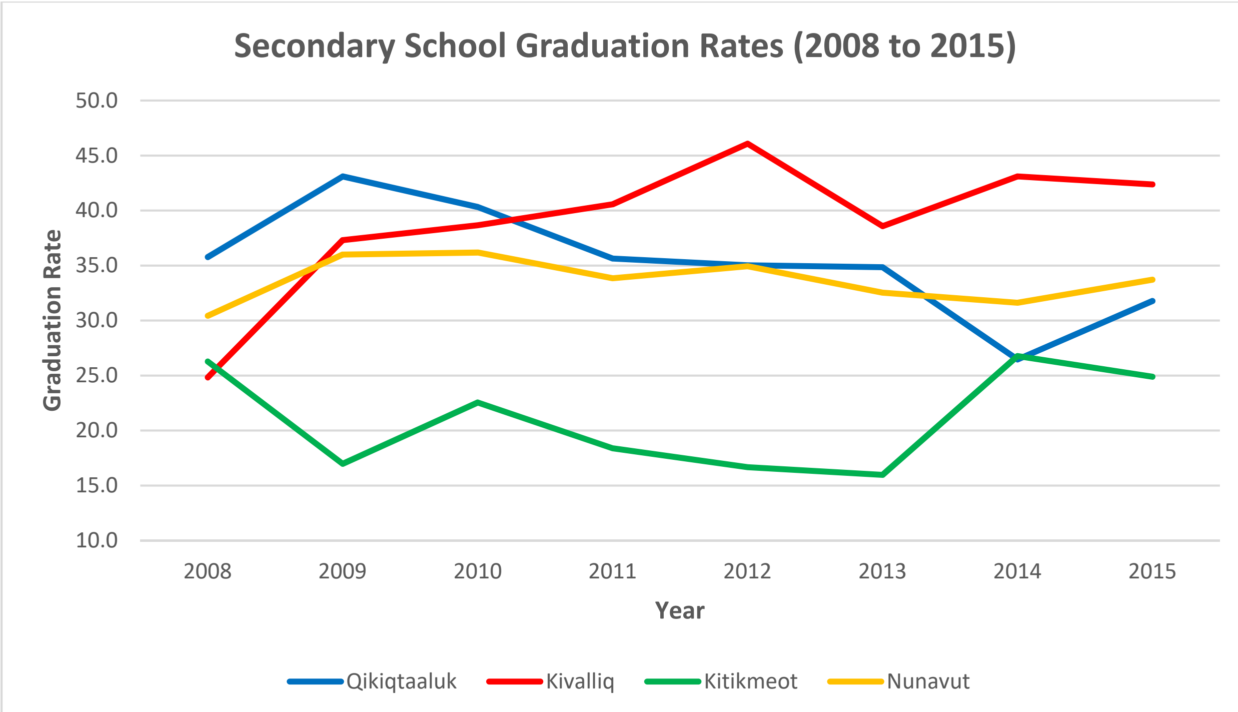
Source: Nunavut Bureau of Statistics (2016c)

Figure 3: Secondary school graduates (2008 to 2015)

Secondary School Graduation Rate

Secondary school graduation rates[10] are another useful indicator of school attendance and success. These have been obtained from the Nunavut Bureau of Statistics (2016d) and are presented in Figure 4. However, data are only available for Nunavut and the Qikiqtaaluk, Kivalliq, and Kitikmeot regions. In 2015, the Kivalliq Region had the highest graduation rate in the territory (42.4), followed by the Qikiqtaaluk Region (31.8), and Kitikmeot Region (24.9). Compared to 2014, graduation rates in the Qikiqtaaluk Region were up (by 5.3). Compared to pre-development period averages, there has been a decreasing trend in graduation rates in the Qikiqtaaluk Region, but increasing trends in the Kivalliq and Kitikmeot Regions.

[10] The Nunavut Bureau of Statistics (2016d) notes the 'graduation rate' is calculated by dividing the number of graduates by the average of estimated 17 and 18 year-old populations (the typical ages of graduation). 'Graduates' include students who completed secondary school but excludes those who completed equivalency or upgrading programs. Due to the small population of Nunavut, however, the Nunavut Bureau of Statistics (2016d) notes that graduation rate changes from year to year must be interpreted with caution.



Source: Nunavut Bureau of Statistics (2016d)

Figure 4: Secondary school graduation rates (2008 to 2015)

4.2.3 Analysis

While there have been decreasing trends in the number of graduates in Iqaluit and in graduation rates in the Qikiqtaaluk Region in the post-development period, decreasing trends were also evident in these indicators in the five years preceding Project development. This implies factors other than the Project are likely driving these trends. While the number of graduates in the North Baffin LSA has undergone a trend reversal in the post-development period (i.e. it was previously increasing), it should be noted that a similar trend reversal occurred for all of Nunavut during this period. This suggests factors other than the Project are again likely driving this trend. As Project construction only began in 2013, there is a minimal amount of post-development data currently available. School attendance and success can also be influenced by many socio-economic factors. Correlations between Project effects and school attendance and success, if any, will only come to light with the analysis of additional yearly data.

However, there are positive indications Baffinland's various initiatives continue to provide incentives for youth to stay in school, as predicted in the Final EIS. Baffinland continued to support several educational and training initiatives through its donations program and IIBA in 2016. For example, since 2007 Baffinland has donated laptops to secondary school graduates in the North Baffin LSA communities to motivate youth to complete their high school educations. Baffinland provided 46 laptops to newly graduated grade 12 students in 2016 and 42 laptops in 2015. In 2015, Baffinland also partnered with Mining Matters[11] to deliver a two-day *Mining Rocks Earth Science Program* to high school students and a

[11] Mining Matters is a charitable organization dedicated to bringing knowledge and awareness about Canada's geology and mineral resources to students, educators, and the public. See http://www.pdac.ca/mining-matters/about-us for more information.

Teacher Training Workshop in four communities (i.e. Iqaluit, Hall Beach, Igloolik, and Arctic Bay). A total of 411 students, educators, and community members participated. The intention of this program was to increase the awareness of earth science and the diverse careers available in the mining industry. As per the IIBA, Baffinland also continued contributing to an annual scholarship fund for Nunavut Inuit in 2016 (with priority given to applications from the North Baffin LSA communities). Seven scholarships valued at $5,000.00 each were provided in 2016.

4.3 OPPORTUNITIES TO GAIN SKILLS

4.3.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on education and skills development, by providing opportunities for training and skills acquisition amongst LSA residents. Associated mitigation measures developed by Baffinland include the provision of training programs, upgrading opportunities, and career counselling to employees, and summer experience to community members. Furthermore, Baffinland continues to support several educational and training initiatives through its donations program and through compliance with IIBA provisions respecting training and education.

4.3.2 Indicator Data

Hours of Training Completed by Inuit Employees

The number of training hours completed by Project employees is a useful indicator of the magnitude of Baffinland's annual training efforts. Hours of training completed on site from 2013 to 2016 for Inuit and non-Inuit employees (not including contractors) are presented in Table 10. In 2016, a total of 27,966 hours of training were completed at the Project site, of which 2,434 hours (or 8.7%) were provided to Inuit. There has been a total of 79,553 hours of training provided since Project development, of which 11,843 hours (or 14.9%) were provided to Inuit.

Hours of Training Completed				
Employee Ethnicity	**2013**	**2014**	**2015**	**2016**
Inuit	1,283	3,596	4,530	2,434
Non-Inuit	4,555	20,271	17,352	25,532
Total	**5,838**	**23,867**	**21,882**	**27,966**

Source: Baffinland records

Table 10: Hours of training completed (2013 to 2016)

Types of Training Provided to Inuit Employees

The types of training provided by Baffinland help reveal the full scope of learning opportunities available at the Project. Types and hours of training provided to Inuit and non-Inuit employees in 2016 are displayed in Figure 5. Training programs continued to evolve in 2016 based on operational needs and schedules. Training programs with the highest levels of Inuit participation in 2016 included heavy equipment operator (681 hours), 5 day basic MRT training (275 hours), mobile support equipment (254 hours), and ore haul truck (214 hours). Training programs are expected to continue to evolve at the Project as operations advance, employment increases, and feedback from Inuit employees is considered.

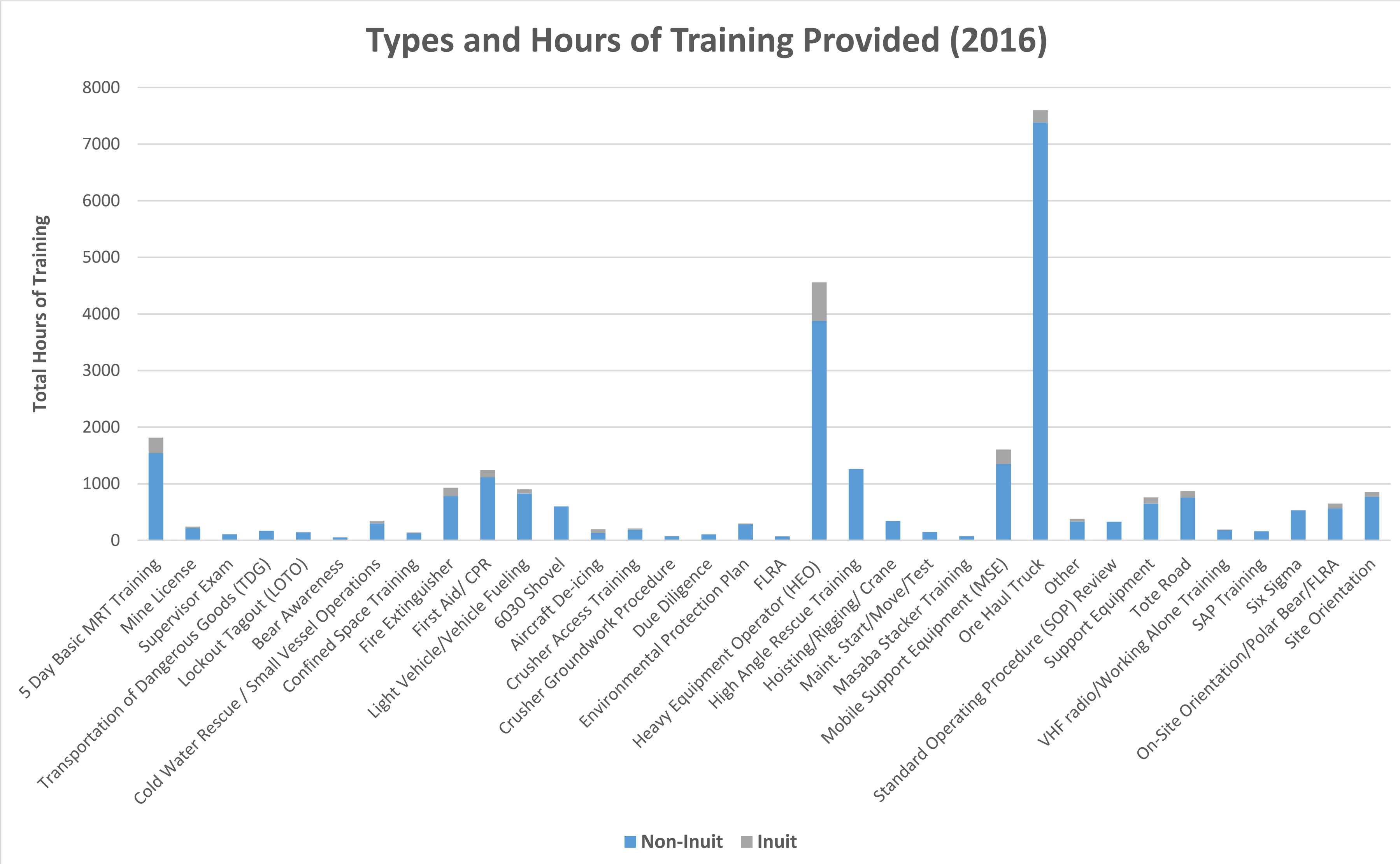
Apprenticeships and Other Opportunities

In 2015, Baffinland committed to support its first group of apprentices in the following trades: oil burner mechanic, welder, and heavy-duty equipment mechanic. In 2015, there were four Inuit apprentices enrolled in various stages of the program. In 2016, Baffinland employed one Inuit apprentice.

4.3.3 Analysis

The Final EIS predicted positive effects on training and skills acquisition amongst LSA residents would arise from the Project. In 2016, Baffinland continued to provide many training and skills development opportunities to its Inuit employees. Furthermore, Baffinland employees are regularly exposed to various 'informal' training and skills development opportunities through contact with more experienced coworkers and the process of everyday work. Several other Baffinland programs and IIBA initiatives have also contributed to the development of a more experienced Inuit workforce. As noted previously, Baffinland delivered a 'Work Ready' pre-employment training program to local residents in 2012 and 2013 and anticipates delivering a revised version of this training in 2017. Skills upgrading (GED and language) has also been identified as a priority for 2017.

It is evident the Project has had a positive effect on education and skills development amongst LSA residents, as was predicted in the Final EIS. The opportunities provided by the Project are notable, particularly when considering the current mining skills 'gap' that exists in Nunavut (e.g. Gregoire 2014, MacDonald 2014, MIHR 2014, Conference Board of Canada 2016).



Source: Baffinland records. Training programs totalling >50 hours have been included under 'Other'.

Figure 5: Types and hours of training provided (2016)

4.4 EDUCATION AND EMPLOYMENT STATUS PRIOR TO PROJECT EMPLOYMENT

4.4.1 Project Certificate Condition

No specific prediction related to employee education and employment status prior to Project employment was presented in the Final EIS. However, Project Certificate condition #140 states:

> *The Proponent is encouraged to survey Nunavummiut employees as they are hired and specifically note the level of education obtained and whether the incoming employee resigned from a previous job placement or educational institution in order to take up employment with the Project.*

4.4.2 Indicator Data

Education and Employment Status Prior to Project Employment

Baffinland has developed a voluntary *Employee Information Survey* (see Appendix C) to address Project Certificate condition #140. The latest version of this survey[8] was administered by Baffinland representatives at Project sites in February/March 2017. A total of 43 surveys were ultimately completed by employees.[9]

Table 11 summarizes results on the highest level of education obtained by survey respondents. Of the 43 surveys received, 16 individuals (or 37.2%) had no certificate, diploma, or degree. 10 individuals (or 23.3%) had a high school diploma or equivalent, 7 individuals (or 16.3%) had an apprenticeship or trades certificate or diploma, and 8 individuals (or 18.6%) had a college, CEGEP, or other non-university certificate or diploma. There were no individuals who indicated they had any type of university certificate, diploma, or degree, and 2 individuals (or 4.7%) had unknown educational levels.

Table 12 summarizes results on whether survey respondents resigned from a previous job placement or educational institution to take up employment with the Project. Of the 43 surveys received, 9 individuals (or 20.9%) indicated they resigned from a previous job placement to take up employment with the Project and no individuals indicated they resigned from an academic or vocational program to take up employment at the Project.

Highest Level of Education Obtained (2017 Employee Information Survey Results)	
Highest Level of Education	**Number of Individuals (43 Surveys Received)**
No certificate, diploma or degree	16
High school diploma or equivalent	10
Apprenticeship or trades certificate or diploma	7
College, CEGEP or other non-university certificate or diploma	8
University certificate or diploma below bachelor level	0
University certificate, diploma or degree - Bachelor's degree	0
University certificate, diploma or degree above bachelor level	0
Unknown	2

Source: Baffinland records

Table 11: Highest level of education obtained (2017 employee information survey results)

Resignation from a Previous Job Placement or Educational Institution (2017 Employee Information Survey Results)	
Pre-Employment Status	**Number of Individuals (43 Surveys Received)**
Resigned from a previous job placement to take up employment at the Project	9
Resigned from an academic or vocational program to take up employment at the Project	0

Source: Baffinland records

Table 12: Resignation from a previous job placement or educational institution (2017 employee information survey results)

4.4.3 Analysis

The employees who completed Baffinland's *Employee Information Survey* have varied educational and pre-employment backgrounds. As noted previously, 37.2% of respondents had no certificate, diploma or degree, 23.3% of respondents had a high school diploma or equivalent, and 34.9% of respondents had higher than a high school diploma or equivalent. By comparison, data from the 2011 National Household Survey indicate the proportion of Nunavut's population (aged 25 to 64 years) with no certificate, diploma or degree is 46%; with a high school certificate or equivalent is 12.4%; and with higher than a high school certificate or equivalent is 41.5% (Nunavut Bureau of Statistics 2013).

Furthermore, 20.9% of respondents were employed elsewhere at the time of being hired to work at Mary River. Nunavut's Inuit population employment rate[12] 3 month moving average ending in January 2017, by comparison, was 55.3% (Nunavut Bureau of Statistics 2017). Baffinland will continue to track the education and employment status of its Inuit employees prior to Project employment to see if any future trends emerge. Surveys conducted in future years are expected to provide additional data to compare these results against.

[12] The Nunavut Bureau of Statistics (2009) defines 'employment rate' as the "number of employed persons expressed as a percentage of the population 15 years of age and over". 'Employed persons' are defined as those who "(a) did any work at all at a job or business, that is paid work in the context of an employer-employee relationship, or self-employment; or (b) had a job but were not at work due to factors such as own illness or disability, personal or family responsibilities, vacation, labour dispute or other reasons (excluding persons on layoff, between casual jobs, and those with a job to start at a future date)."

5. VSEC – LIVELIHOOD AND EMPLOYMENT

Three residual effects associated with the VSEC 'Livelihood and Employment' were assessed in the Final EIS. These include 'creation of jobs in the LSA', 'employment of LSA residents', and 'new career paths'. These are reviewed more fully below, in addition to information on one other topic requested through the Project Certificate (i.e. barriers to employment for women).

5.1 CREATION OF JOBS IN THE LSA

5.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on wage employment in the LSA by introducing new job opportunities and assisting local residents to access these jobs. During ERP operations, the Project was predicted to generate a total labour demand of approximately 0.9 million hours per year. With the addition of the 18 Mt/a phase, annual labour demand will increase to 2.9 million hours. Labour demand during the Construction Phase will average roughly 4.1 million hours per year over a six-year period, but will reach a peak of approximately 7.3 million hours per year. Closure phase labour demand estimates do not currently exist but will be developed by Baffinland in the future. Mitigation measures developed by Baffinland associated with this prediction include the designation of all LSA communities as points-of-hire.

5.1.2 Indicator Data

Total Hours of Project Labour Performed in Nunavut

Total hours of labour performed each year is a useful indicator of the Project's labour demand. It also helps reveal the extent to which new job opportunities have become available to LSA residents. Table 13 presents the total hours of Project labour performed in Nunavut from 2013 and 2016, and is inclusive of both Baffinland employees and contractors. In 2016, 1,881,506 hours of labour were performed, which is equal to approximately 905 full time equivalent (FTE) positions.[13] There were 37,425 more hours of labour performed in 2016 than in 2015. A total of 6,456,646 hours of labour have been performed since Project development.

Total Hours of Project Labour Performed in Nunavut			
2013	2014	2015	2016
863,177	1,867,882	1,844,081	1,881,506

Source: Baffinland records[4]

Table 13: Total hours of Project labour performed in Nunavut (2013 to 2016)

5.1.3 Analysis

The Final EIS predicted a positive effect on the creation of jobs in the LSA would occur because of the Project. In 2016, the Project continued to generate a substantial number of employment opportunities and labour hours. The generation of 1,881,506 hours of labour in 2016 exceeds the Final EIS prediction

[13] FTE's were calculated assuming 2,080 hours of employment per person annually. Because these FTE calculations do not include paid time off-site (e.g. vacations) they may underestimate the Project's labour contributions.

of 0.9 million hours per year during ERP operations by 981,506 hours. As such, the positive effect on LSA job creation predicted to occur in the Final EIS is confirmed.

5.2 EMPLOYMENT OF LSA RESIDENTS

5.2.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on wage employment in the LSA by introducing new job opportunities and assisting local residents to access these jobs. The Project is predicted to result in the employment of an estimated 300 LSA residents each year. These residents would supply approximately 342,000 hours of labour to the Project, of which 230,000 hours will be provided by North Baffin LSA residents. Associated mitigation measures developed by Baffinland include management commitments and Company policies related to Inuit hiring, and the development of an Inuit employee recruitment and retention strategy.

5.2.2 Indicator Data

Project Hours Worked by LSA Employees and Contractors

Data on the number of hours worked on the Project provides insight into the varying labour contributions of LSA and non-LSA employees and contractors. Table 14 summarizes the number and percentage of hours worked by individuals on the Project from 2013 to 2016. Table 14 also includes information on the origin and ethnicity of these individuals, where applicable. This information is inclusive of Baffinland employees and contractors and is for work conducted in Nunavut only (including community-based Baffinland positions).

In 2016, a total of 305,836 hours were worked by LSA residents (both Inuit and non-Inuit), representing 16.3% of the total number of hours worked on the Project (i.e. 1,881,506). Of these, 230,732 hours were worked by North Baffin LSA residents (representing 12.3% of the total) and 75,104 hours were worked by Iqaluit residents (representing 4.0% of the total). Project hours worked by North Baffin LSA residents increased (by 17,340 hours) since 2015, while Project hours worked by Iqaluit residents decreased (by 19,074 hours) since 2015. Inuit individuals worked 277,454 Project hours in 2016 (representing 14.7% of the total).

5.2.3 Analysis

The Final EIS predicted a positive effect on the employment of LSA residents would occur because of the Project. In 2016, a total of 305,836 hours were worked by LSA residents, 230,732 of which were worked by North Baffin LSA residents. While these numbers don't fully reflect the Final EIS predictions (i.e. LSA residents would provide 342,000 hours of work, of which 230,000 would be provided by North Baffin LSA residents), Baffinland continues to refine its Inuit human resources programs and remains committed to meeting Inuit employment targets. Furthermore, it will likely take many years to fully realize the Project's Inuit employment potential (mine production only began in late 2014). The establishment of an annual Minimum Inuit Employment Goal (MIEG) with the QIA (which was 25% in 2016 and will remain at 25% in 2017) and finalization of Baffinland's Inuit Human Resources Strategy (IHRS) and Inuit Contracting and Procurement Strategy (ICPS) should assist in increasing LSA employment over time. The IHRS and ICPS will describe goals and initiatives designed to increase Inuit employment and contracting (and Inuit content in contracting) at the Project.

Comments shared during recent QSEMC meetings held in Iqaluit and Pond Inlet provide additional insight into this matter. For example, the 2016 QSEMC meeting report notes “the economic benefits of employment and contracts to local businesses have been interpreted as largely positive in the LSA” (Government of Nunavut 2016: 9). During the community roundtable portion of the April 2015 QSEMC meeting it was also noted that in Pond Inlet “the benefits of Mary River from increased employment and money in the community have been noticed and appreciated” (Government of Nunavut 2015: 16). In Igloolik it was noted that “residents and businesses have benefited from more money coming into town from Mary River employment” (Government of Nunavut 2015: 17).

The 2016 North Baffin community survey conducted by Baffinland provides some additional insight. For example, 57% of survey respondents indicated the Project has provided positive change for their community (only 8% indicated the Project has resulted in negative change, while 35% said they saw no change as a result of the Project). Positive changes noted by respondents included new jobs for local Inuit and youth, income and work-related benefits for families and communities, and new skills development opportunities for local residents.

Some comments related to the employment of LSA residents at the Project were also captured in a recent report commissioned by Baffinland on the experience of Inuit residents employed at the Project as perceived by employees, their spouses, managers and supervisors at Mary River. The report, *Mary River Experience – The First Three Years* (i.e. Brubacher Development Strategies Inc. 2016: 6), notes:

> *“Individuals spoke about various types of benefits arising from employment. These range from the material rewards that come with increased income, to the mental health benefits of participating on a team and having hope and plans to achieve goals, to the satisfaction associated with learning new things and having an avenue to put one’s skills to good use.”*

Insights such as these, combined with the data presented above, confirm the positive effects the Project has had on the employment of LSA residents. While the hours worked by LSA residents in 2016 don’t fully reflect the Final EIS predictions, this situation is expected to be temporary. Baffinland will continue to monitor LSA employment for future trends.

Hours of Project Labour Performed in Nunavut								
Employee Ethnicity & Origin (if applicable)	**2013**		**2014**		**2015**		**2016**	
	Hours Worked	% of total (863,177)	Hours Worked	% of total (1,867,882)	Hours Worked	% of total (1,844,081)	Hours Worked	% of total (1,881,506)
Inuit – North Baffin LSA	125,870	14.6%	281,679	15.1%	208,278	11.3%	198,618	10.6%
Inuit – Iqaluit	38,799	4.5%	80,796	4.3%	85,088	4.6%	51,216	2.7%
Inuit – Other	9,696	1.1%	17,131	0.9%	37,542	2.0%	27,620	1.5%
Inuit (Total)	174,365	20.2%	379,606	20.3%	330,908	17.9%	277,454	14.7%
Non-Inuit – North Baffin LSA	—	—	—	—	5,114	0.3%	32,114	1.7%
Non-Inuit – Iqaluit	—	—	—	—	9,090	0.5%	23,888	1.3%
Non-Inuit – Other	—	—	—	—	1,498,969	81.3%	1,548,050	82.3%
Non-Inuit (Total)	688,812	79.8%	1,488,276	79.7%	1,513,173	82.1%	1,604,052	85.3%
Number of Hours (Total)	863,177	—	1,867,882	—	1,844,081	—	1,881,506	—

Source: Baffinland records.[4] Data for non-Inuit LSA residents were not available for 2013 and 2014 and are included in the non-Inuit total instead.

Table 14: Hours of Project labour performed in Nunavut (2013 to 2016)

5.3 NEW CAREER PATHS

5.3.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on the ability of LSA residents to progress in their jobs and careers. This effect will occur because of new career paths that will be introduced to the region, from entry-level through step-by-step advancement to higher level jobs. Associated mitigation measures developed by Baffinland include management commitments and Company policies related to Inuit hiring and promotions, the provision of individual career support programs and the creation of a 'second chance' hiring policy.

5.3.2 Indicator Data

LSA Employment

Data on the employment of LSA residents at the Project provides insight into the new career paths made available to LSA residents. This is because some Project jobs may represent an opportunity for individuals to improve their existing employment status (e.g. from unemployed to employed, from part-time to full-time, from lower-skilled to higher-skilled positions) and/or form the basis of future promotion and advancement at the Project. As noted in Section 5.2, a total of 305,836 hours were worked by LSA residents in 2016.

Inuit Employee Promotions

The number of annual Inuit employee promotions is also an important indicator of career progression at the Project. Data on Baffinland Inuit employee promotions (not including contractors) from 2014 to 2016 are presented in Table 15. In 2016, 14 Inuit employee promotions occurred, which was the same number of promotions that occurred in 2015.

Baffinland Inuit Employee Promotions		
2014	2015	2016
9	14	14

Source: Baffinland records. Includes temporary promotions. Inuit promotion data were not available for 2013.

Table 15: Baffinland Inuit employee promotions (2014 to 2016)

Inuit Employee Turnover

Annual Inuit employee turnover provides additional insight into Inuit career progression. The term 'turnover' is inclusive of many different components including resignation, layoff, termination, end of contract, and retirement. High turnover would indicate that fewer individuals are maintaining stable employment and able to take advantage of potential advancement opportunities. Low turnover, conversely, would indicate a greater number of individuals are maintaining stable employment and able to take advantage of potential advancement opportunities. Table 16 displays information on Baffinland Inuit employee departures from 2013 to 2016 (not including contractors).

Number of Baffinland Inuit Employee Departures			
2013	2014	2015	2016
9	45	41	44

Source: Baffinland records. 2013 and 2014 numbers are for indeterminate employees only.

Table 16: Number of Baffinland Inuit employee departures (2013 to 2016)

In 2016, there were 44 Inuit employees whose employment with Baffinland ended for various reasons (e.g. resignation, layoff, termination, end of contract, retirement). This equates to a 45% Inuit employee turnover rate.[14]

Some of the most commonly cited reasons Inuit employees had for resigning in 2016 included family-related reasons, obtaining a job in their home community, not being happy with working at site, finding rotational work difficult, and dissatisfaction with position responsibilities. Some of these reasons were similar to those provided in 2015 (i.e. family/personal issues at home, obtaining a job in their home community - either a new job or going back to a job they had prior to working for Baffinland). For turnover due to dismissal by Baffinland or for involuntary terminations, typically cited reasons in 2016 included absenteeism and not passing probation (including not passing equipment training). Some of these reasons were similar to those provided in 2015 (i.e. absenteeism, poor job performance).

5.3.3 Analysis

The Final EIS predicted the Project would have a positive effect on the ability of LSA residents to progress in their jobs and careers. In 2016, many Inuit were employed by the Project and a number were promoted to new positions. The career opportunities introduced to the region represent a positive effect of the Project and are a likely result of the mitigation measures Baffinland has developed regarding local employment.

However, there were several Baffinland Inuit employee departures in 2016. High rates of employee turnover have been an issue for other Nunavut organizations in the past, including the Government of Nunavut and Agnico Eagle Mines Limited (e.g. Bell 2012, Government of Nunavut 2014). Baffinland will continue to monitor employee turnover causes and outcomes, and is committed to reducing turnover and increasing Inuit employment where feasible. The Inuit Human Resources Strategy (IHRS) currently being finalized by Baffinland will include several goals and initiatives directed to this end. Future monitoring will be necessary to track the success of this and other Baffinland career advancement programs.

5.4 BARRIERS TO EMPLOYMENT FOR WOMEN

5.4.1 Project Certificate Condition

No specific prediction related to barriers to employment for women was presented in the Final EIS. However, Project Certificate condition #145 states:

[14] The Inuit employee turnover rate has been calculated using guidance provided by Taylor (2002). More specifically, the total number of Inuit employee departures in the calendar year (44) were divided by the average number of Inuit employees employed in the same calendar year (98 – see Table 9), multiplied by 100.

The Proponent is encouraged to work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring Committee to monitor the barriers to employment for women, specifically with respect to childcare availability and costs.

5.4.2 Indicator Data

Hours Worked by Female Employees and Contractors

The number of hours worked by female employees and contractors at the Project can provide insight into the potential employment barriers females may face compared to their male counterparts. Table 17 displays the hours (and percentage of hours) worked by women and men in Nunavut on the Project from 2013 to 2016. In 2016, approximately 8.0% of hours worked on the Project were worked by women, which is 1.1% less than percentages documented for Q4 2015. The percentage of hours worked by Inuit and non-Inuit women in 2016 were similar (i.e. 3.7% and 4.4%, respectively). However, the percentage of hours worked by Inuit women compared to Inuit males on the Project (approximately 24.8% of this total) was much higher than non-Inuit women compared to non-Inuit males (approximately 5.1% of this total) in 2016. A similar trend was noted from 2013 to 2015.

Childcare Availability and Costs

Appropriate community-level indicator data are currently unavailable for this topic. As such, this topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. However, Baffinland acknowledges securing access to adequate child care remains an issue in some parts of Nunavut and can act as a barrier to employment for women (e.g. Pauktuutit et al. 2014; Sponagle 2016). The national non-profit organization representing Inuit women in Canada, Pauktuutit (undated), further notes "an additional barrier for [Inuit] women attaining lasting, full-time employment is inadequate childcare facilities for rotational work schedules".

Some information related to childcare availability and costs has been captured in the report *Mary River Experience – The First Three Years* (Brubacher Development Strategies Inc. 2016: 49), which notes:

"The limited access to daycare services was noted... In some instances this may add to the challenge of arranging adequate child care when a parent is working away from home for two weeks. One manager / supervisor identified childcare as a key issue leading to people not making it for their rotation. This is seen as a challenge for many employees, but seems to get amplified for Inuit from LSA communities. Another manager / supervisor also identified childcare as a key issue associated with unplanned absenteeism."

One comment on childcare availability and costs was also captured during Baffinland's 2016 community engagement meetings:

"Couldn't go back to work at Mary River because didn't have babysitter and because couldn't pay house bills. Prices went up. Would like to go back but can't afford it. People need to make enough to cover cost." [Hall Beach Public Meeting Participant]

5.4.3 Analysis

While Baffinland has continued to encourage the employment of women at the Project, women worked considerably fewer hours on the Project (approximately 8.0% of the total) than their male counterparts in 2016. However, women remain under-represented in the Canadian mining industry as a whole. The Mining Industry Human Resources Council (2016) notes that women comprise only 17% of the total Canadian mining workforce, which is significantly lower than the total participation of women in the general Canadian workforce, at 48%. Aboriginal women are also less likely than non-Aboriginal women to be employed in Canada (Statistics Canada 2016c).

Employment levels can be influenced by many different factors, including the existence of barriers faced by certain demographic groups. While Baffinland will continue to track this issue in future socio-economic monitoring reports, it is apparent that women continue to face barriers to employment in the Canadian mining industry as a whole. Inadequate access to childcare in the LSA may also be creating some barriers to increased employment of women at the Project. However, the new employment opportunities being created for women in the LSA because of the Project should also be acknowledged. The *Mary River Experience – The First Three Years* report (Brubacher Development Strategies Inc. 2016: 45 and 46) notes:

> *"The Mary River Project has opened up new opportunities for women in North Baffin communities. Several people spoke about how they perceived that opportunities for women in the hamlets are sometimes limited by gender role expectations… Even if some paths to employment may have the indirect effect of excluding women, the Project as a whole is opening new avenues of work for women from LSA communities."*

Hours Worked by Project Employees and Contractors in Nunavut, by Ethnicity and Gender									
Employee Ethnicity & Gender		**2013**		**2014**		**Q4 2015[15]**		**2016**	
		Hours Worked	% of total (863,177)	Hours Worked	% of total (1,867,882)	Hours Worked	% of total (430,244)	Hours Worked	% of total (1,881,506)
Inuit	Male	124,754	14.5%	267,169	14.3%	54,794	12.7%	208,592	11.1%
	Female	49,611	5.8%	112,437	6.0%	20,732	4.8%	68,862	3.7%
Non-Inuit	Male	639,468	74.1%	1,394,204	74.6%	336,124	78.1%	1,521,786	80.9%
	Female	49,200	5.7%	94,072	5.0%	18,594	4.3%	82,266	4.4%
TOTAL		**863,177**	—	**1,867,882**	—	**430,244**	—	**1,881,506**	—

Source: Baffinland records[4]

Table 17: Hours worked by Project employees and contractors in Nunavut, by ethnicity and gender (2013 to 2016)

[15] As Baffinland's human resources data management system was in the process of being developed, some information gaps were unable to be reconciled in 2015. In 2015, gender data related to hours worked was only available for Q4.

6. VSEC – CONTRACTING AND BUSINESS OPPORTUNITIES

Two residual effects associated with the VSEC 'Contracting and Business Opportunities' were assessed in the Final EIS. These include 'expanded market for business services to the Project' and 'expanded market for consumer goods and services'. These are reviewed in more detail below.

6.1 EXPANDED MARKET FOR BUSINESS SERVICES TO THE PROJECT

6.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on creating market opportunities for businesses in the LSA and RSA to supply goods and services to the Project. Mitigation measures designed by Baffinland to support this prediction include the implementation of several Inuit contracting policies. These policies have been designed to assist Inuit firms in developing capacity in the bidding process and to provide opportunities for large contracts to be broken down into smaller components which can then be bid on by Inuit firms. Baffinland's IIBA with the QIA also includes provisions related to local business development. For example, a Business Capacity and Start-Up Fund has been created (which is administered by Kakivak, a subsidiary of the QIA) to assist Designated Baffin Inuit Firms. This fund provides up to $500,000.00 annually to help with start-up capital and financing, management development, ongoing business management, financial management, contracts and procurement or human resources management.

6.1.2 Indicator Data

Value of Procurement with Inuit-Owned Businesses and Joint Ventures

The value of Project-related procurement with Inuit-owned businesses and joint ventures is a useful indicator of the business opportunities created by the Project. Table 18 summarizes the procurement that has occurred with Inuit-owned businesses and joint ventures from 2013 to 2016. Nine contracts worth approximately $64.4 million were awarded to Inuit-owned businesses and joint ventures in 2016. Of these nine contracts, all were awarded to Inuit-owned businesses and joint ventures in the LSA. Procurement values in 2016 were lower than in 2015 (i.e. by $39.1 million). Total procurement (with Inuit *and* non-Inuit firms) in 2016 totaled $190.7 million. Since Project development, a total of $431.9 million worth of contracts have been awarded to Inuit-owned businesses and joint ventures. The differing values in Table 18 are at least partly reflective of the construction activities that have occurred during varying periods on site (e.g. 2013 was a major construction year) and the transition to increased operational activities that occurred in 2015.

6.1.3 Analysis

The Project continued to procure a substantial amount of goods and services from Inuit-owned businesses and joint ventures in 2016. Likewise, Baffinland procurement data suggests the Project has had a positive effect on creating market opportunities for businesses in the LSA and RSA to supply goods and services to the Project, as was predicted in the Final EIS. Baffinland is also in the process of finalizing an Inuit Contracting and Procurement Strategy (ICPS) which is expected to further enable (if not enhance) the continued provision of these business opportunities.

Procurement with Inuit-Owned Businesses and Joint Ventures				
Procurement Details	Year			
	2013	2014	2015	2016
Value of Procurement with Inuit-Owned Businesses and JVs	$200 million	$64 million	$103.5 million	$64.4 million
Total Number of Contracts with Inuit-Owned Businesses and JVs	13	19	12	9
Number of Contracts with Inuit-Owned Businesses and JVs in the LSA	6	3	5	9

Source: Baffinland records

Table 18: Procurement with Inuit-owned businesses and joint ventures (2013 to 2016)

6.2 EXPANDED MARKET FOR CONSUMER GOODS AND SERVICES

6.2.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would expand the market for consumer (i.e. non-Project related) goods and services across the LSA. While no specific mitigation measures related to this prediction were proposed in the Final EIS, Company commitments related to Inuit employment and contracting support the development of an expanded market for consumer goods and services in the LSA. This is because of the increased purchasing power local residents are expected to have due to Project-induced direct and indirect employment income.

6.2.2 Indicator Data

LSA Employee Payroll Amounts

Yearly payroll expenditures to LSA employees are a useful indicator of the degree to which an expanded market for consumer goods and services may have been created by the Project. Through the creation of new jobs in the LSA, the Project has also created a new source of economic wealth for local residents. Thus, it is reasonable to expect that some of this new wealth will become available for residents to spend on consumer goods and services.

Baffinland's LSA employee payroll expenditures (in Canadian dollars, not including contractors, but including both Inuit and non-Inuit employees) totaled $7,586,379.00 in 2016. Compared to 2015, this was a decrease of $1,739,782.00. While contractor wages are not included in these amounts, the value of procurement with Inuit-owned businesses and joint ventures in 2016 was nevertheless substantial ($64.4 million, as described in Section 6.1) and represents another important benefit provided by the Project. Figure 6 displays the proportion of Baffinland's employee payroll earned by each LSA community in 2016. The top three LSA payroll recipient communities in 2016 were Arctic Bay, Pond Inlet, and Clyde River (in 2015 they were Arctic Bay, Pond Inlet, and Iqaluit, respectively). The highest earning community (Arctic Bay) received $1,800,199.00, while the lowest earning community (Hall Beach) received $901,337.00 in 2016. Baffinland's Inuit employee payroll (including LSA *and* non-LSA communities) is also notable, and totaled $7,841,203.00 in 2016. Since 2014, Baffinland has provided $24,947,468.00 in payroll to Inuit.

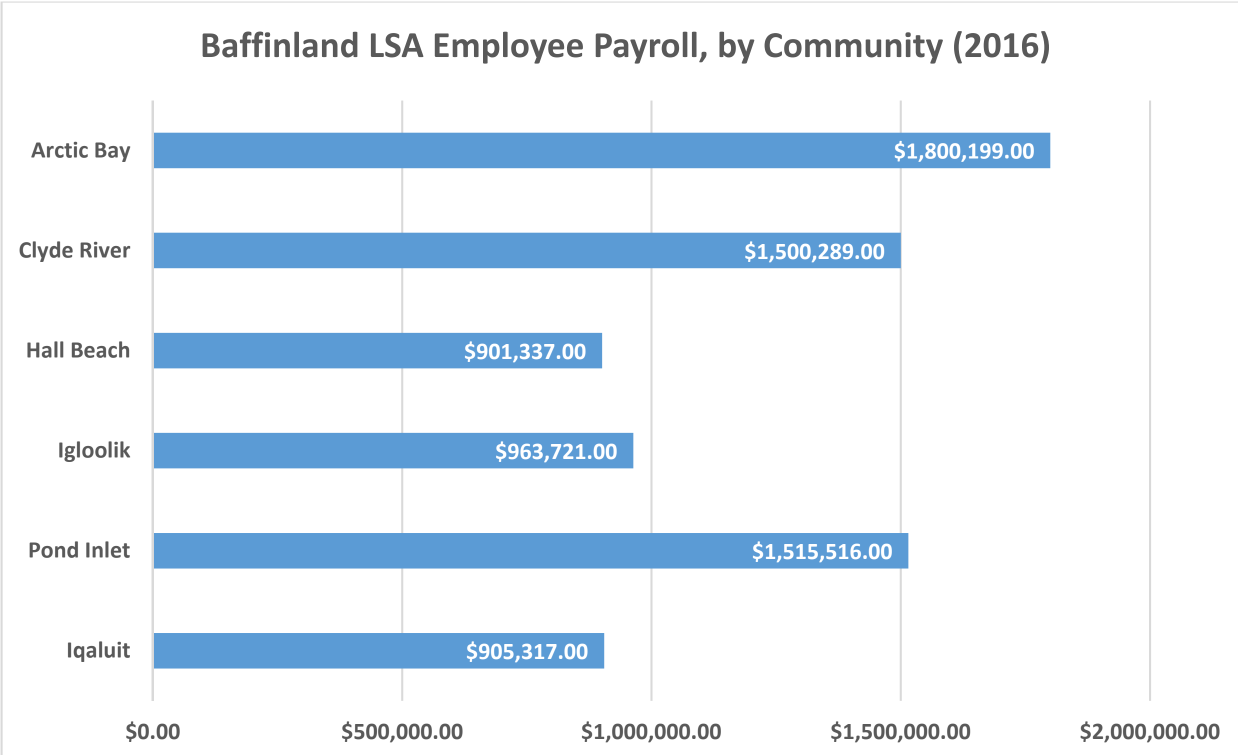


Figure 6: Baffinland LSA employee payroll, by community (2016)

Number of Registered Inuit Firms in the LSA

The number of registered Inuit firms in the LSA is another useful indicator of the degree to which an expanded market for consumer goods and services may have been created by the Project. This is because new Project-generated consumer discretionary income would be expected to result in increased demand for (and spending on) local goods and services. Subsequently, the number and offerings of local businesses would be expected to increase to meet this demand.

Nunavut Tunngavik Incorporated (NTI) maintains an Inuit firm[16] registry database for Nunavut. This database (i.e. NTI 2016) provides the name of each registered Inuit firm, describes each firm's area of business operations, and location where the firm is based. The number of registered Inuit firms in the LSA from 2013 to 2016 are summarized in Table 19. Information for 2013 to 2015 was obtained directly from NTI (E. Eegeesiak 2016, personal communication), while information for 2016 was obtained from the NTI database (i.e. NTI 2016).

In 2016, a total of 156 active Inuit firms were registered with NTI in the LSA. Forty of these firms were based in the North Baffin LSA communities and 116 were based in Iqaluit. The number of active Inuit firms registered in the North Baffin LSA communities has increased by 11 since 2013, while the number of active Inuit firms registered in Iqaluit has increased by 32 since 2013.

[16] As noted by NTI (2016), 'Inuit firm' means an entity which complies with the legal requirements to carry on business in the Nunavut Settlement Area, and which is a limited company with at least 51% of the company's voting shares beneficially owned by Inuit, or a cooperative controlled by Inuit, or an Inuk sole proprietorship or partnership.

NTI Registered Inuit Firms in the LSA				
Location	**Number of Firms**			
	2013	2014	2015	2016
North Baffin LSA Communities	29	29	31	40
Iqaluit	84	108	95	116
Total	**113**	**137**	**126**	**156**

Source: E. Eegeesiak (2016, personal communication), NTI (2016)

Table 19: NTI registered Inuit firms in the LSA (2013 to 2016)

6.2.3 Analysis

The Project continued to expand the market for consumer goods and services across the LSA in 2016. Considerable amounts were spent both on Baffinland's LSA employee payroll (approximately $7.6 million) and contracting with Inuit-owned businesses and joint ventures (approximately $64.4 million) in 2016. These new contributions to the Nunavut economy are a direct result of Project development and represent a positive effect. This is because increased income from direct and indirect Project employment provides LSA residents with a greater capacity to purchase local goods and services. Increased income can also can act to stimulate further business growth (e.g. existing businesses may expand to meet increased consumer demand or new businesses may emerge, wealth generated through employment may increase an individual's ability to start new businesses).

The number of active Inuit firms registered in the LSA communities also increased between 2013 and 2016, which suggests a potential positive Project effect. Anecdotal evidence shared with Baffinland by its suppliers indicates that at least some new Inuit firms were registered because of Project-related contracting opportunities. However, it is acknowledged that various factors can contribute to the decision to start (or not start) a new business.

As predicted in the Final EIS, the positive effect of the Project on creating an expanded market for consumer goods and services across the LSA is confirmed for this reporting period. It is possible that continued monitoring may uncover additional positive Project effects (e.g. it may take an extended period for some businesses to respond to emerging commercial opportunities); this matter will be assessed further in future reports.

7. VSEC – HUMAN HEALTH AND WELL-BEING

7.1 CHANGES IN PARENTING

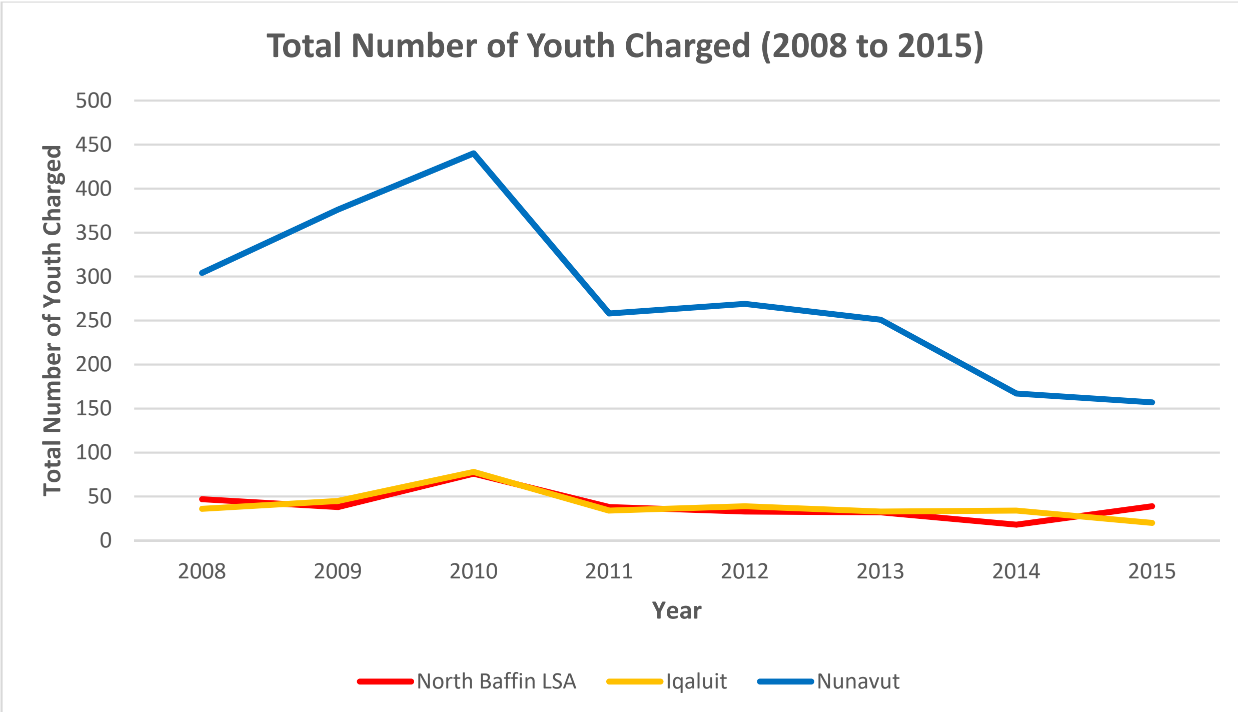
7.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a positive effect on parenting (particularly as it applies to well-being of children) in the LSA communities (e.g. from increased confidence and financial independence gained through employment, improved mental well-being from having a job and income). The Final EIS also predicted the Project could have some negative effects on parenting, but these would be of a non-significant nature. To help mitigate potential adverse effects from fly-in/fly-out employment, Baffinland has provided a predictable rotational schedule, meaningful local employment and incomes, job readiness training for LSA residents considering employment at the Project (e.g. to familiarize workers and their families with the fly-in/fly-out lifestyle), has implemented an Employee and Family Assistance Program for workers and their dependents, and contributes to the *Ilagiiktunut Nunalinnullu Pivalliajutisait Kiinaujat* (INPK) fund through the IIBA negotiated with QIA (which provides up to $750,000.00/year for projects in the Qikiqtaaluk Region which enhance community wellness).

7.1.2 Indicator Data

Total Number of Youth Charged

The number of youth charged is a useful indicator of parenting performance in the LSA communities. This is because children with stable homes and effective parents can be expected to have fewer encounters with the law. 2015 was the most recent year for which data on the number of youth charged by community was available from Statistics Canada (2016a). In the North Baffin LSA in 2015, Pond Inlet and Igloolik had the highest number of youth charged (15 each), while Clyde River had the fewest (0). The average number of youth charged in the North Baffin LSA communities in 2015 was 7.8. Iqaluit had 20 youth charged in 2015 and Nunavut as a whole had 157. Compared to the previous year (2014), there has been an increase in the number youth charged in the North Baffin LSA communities (by 21) but a decrease in Iqaluit (by 14) and Nunavut (by 10). Compared to pre-development period averages, there has been a decreasing trend in the number of youth charged in the North Baffin LSA, Iqaluit, and Nunavut. Figure 7 displays the total number of youth charged from 2008 to 2015.



Source: Statistics Canada (2016a)

Figure 7: Total number of youth charged, by community (2008 to 2015)

7.1.3 Analysis

While there has been a decreasing trend in the number of youth charged in the North Baffin LSA and Iqaluit in the post-development period, this decreasing trend was also evident in the five years preceding Project development (and throughout Nunavut). This implies factors other than the Project are likely driving these trends. However, crime rates can be influenced by many different socio-economic factors. As Project construction only began in 2013, there is a minimal amount of post-development data currently available. Correlations between the Project and youth crime rates, if any, will only come to light with the analysis of additional annual data. Regardless, there are positive indications the Project is contributing to the enhanced well-being of children, by providing LSA residents (and parents) with opportunities to obtain meaningful employment and incomes. These opportunities can help reduce the various family stresses and uncertainties associated with un- and under-employment. Baffinland has also implemented an Employee and Family Assistance Program for workers and their family members who may require family-related or other forms of personal assistance.

7.2 <u>HOUSEHOLD INCOME AND FOOD SECURITY</u>

7.2.1 Predicted Effect and Mitigation Measures

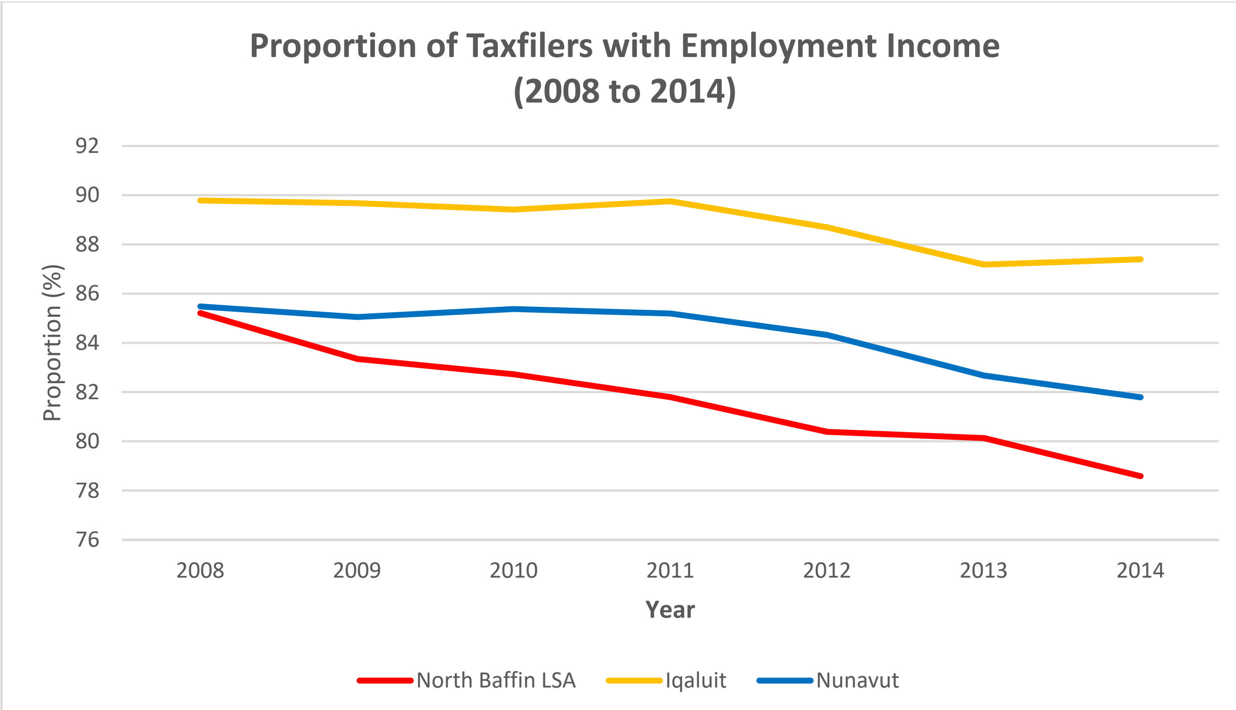
The Final EIS predicted the Project would have a positive effect on increased household income and food security (particularly as they apply to well-being of children) in the LSA. To help mitigate potential adverse effects, Baffinland has provided meaningful local employment and incomes, job readiness training for LSA residents considering employment at the Project (e.g. which has included a financial management module), and contributes to the INPK fund through the IIBA negotiated with the QIA.

7.2.2 Indicator Data

Proportion of Taxfilers with Employment Income and Median Employment Income

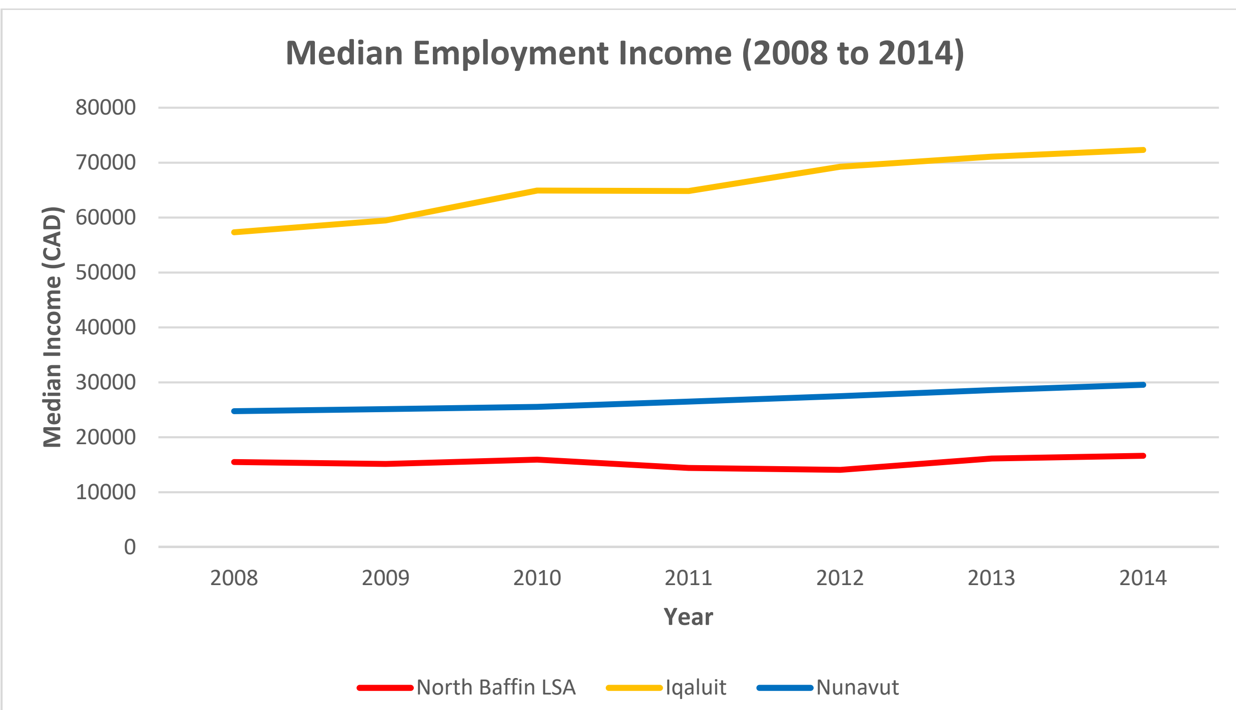
Employment income indicators are useful for tracking household financial performance in the LSA communities. 2014 was the most recent year for which data on the proportion of taxfilers with employment income was available from the Nunavut Bureau of Statistics (2016e). In the North Baffin LSA in 2014, Arctic Bay, Clyde River, Igloolik, and Pond Inlet were tied for the highest proportion of taxfilers with employment income (80%), while Hall Beach had the lowest (73%). The proportion of taxfilers with employment income in Iqaluit in 2014 was 87%, which was higher than the North Baffin LSA community average (79%) and Nunavut average (82%). Compared to the previous year (2013), there has been a decrease in the average proportion of taxfilers with employment income in the North Baffin LSA (by 1%) and Nunavut (by 1%), while Iqaluit has remained the same (at 82%). Compared to pre-development period averages, there has been a decreasing trend in the average proportion of taxfilers with employment income in the North Baffin LSA, Iqaluit, and Nunavut. Figure 8 displays the proportion of taxfilers with employment income from 2008 to 2014.

Likewise, 2014 was the most recent year for which data on median employment income was available from the Nunavut Bureau of Statistics (2016e). In the North Baffin LSA in 2014, Pond Inlet had the highest median employment income ($18,970), while Arctic Bay had the lowest ($15,160). Iqaluit's median employment income in 2014 was $72,310 and was significantly higher than the North Baffin LSA community average ($16,620) and Nunavut average ($29,550). Compared to the previous year (2013), there has been an increase in median employment income in the North Baffin LSA (by $486), Iqaluit (by $1,230) and Nunavut (by $970). Compared to pre-development period averages, there has been an increasing trend in median employment income in the North Baffin LSA, Iqaluit, and Nunavut. Figure 9 displays median employment income by community and territory from 2008 to 2014.



Source: Nunavut Bureau of Statistics (2016e)

Figure 8: Proportion of taxfilers with employment income (2008 to 2014)

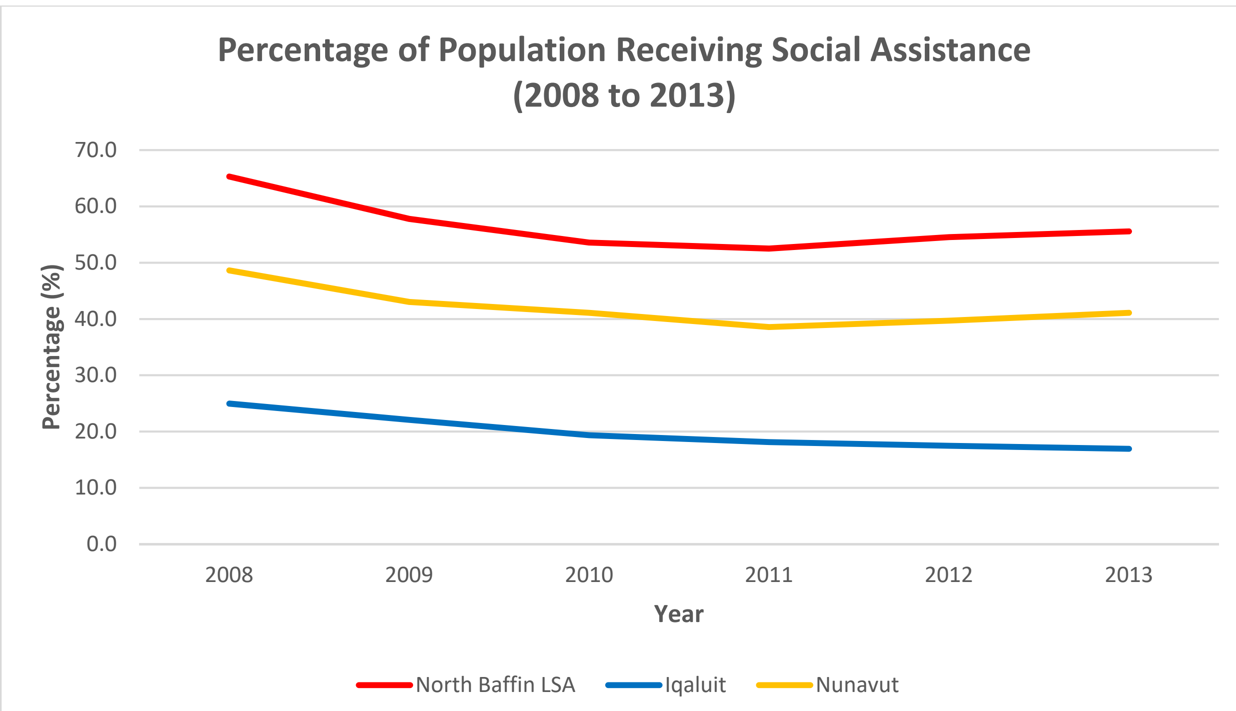


Source: Nunavut Bureau of Statistics (2016e)

Figure 9: Median employment income (2008 to 2014)

Percentage of Population Receiving Social Assistance

The percentage of the population receiving social assistance is also a useful indicator of household financial performance. 2013 was the most recent year for which data on the percentage of social assistance recipients in Nunavut was available from the Nunavut Bureau of Statistics (2014). In the North Baffin LSA in 2013, Clyde River had the highest percentage of population receiving social assistance (65.3%), while Hall Beach had the lowest (44.6%). The percentage of individuals receiving social assistance in Iqaluit in 2013 was 16.9%, which was significantly lower than the North Baffin LSA community average (55.6%) and Nunavut average (41.1%). Compared to the previous year (2012), there has been an increase in the percentage of the population receiving social assistance in the North Baffin LSA (by 1.1%) and Nunavut (by 1.4%), but a decrease in Iqaluit (by 0.6%). Compared to pre-development period averages, there has been a decreasing trend in the percentage of the population receiving social assistance in the North Baffin LSA, Iqaluit, and Nunavut. Figure 10 displays the percentage of the population receiving social assistance from 2008 to 2013.



Source: Nunavut Bureau of Statistics (2014)

Figure 10: Percentage of population receiving social assistance (2008 to 2013)

7.2.3 Analysis

While there has been a decreasing trend in the average proportion of taxfilers with employment income in the North Baffin LSA and Iqaluit in the post-development period, these trends were also evident in the five years preceding Project development (including throughout Nunavut). This implies factors other than the Project are likely driving these trends. Likewise, while there has been an increasing trend in median employment income in the North Baffin LSA and Iqaluit in the post-development period, this trend was also evident in Iqaluit in the five years preceding Project development. However, this trend was not evident in the North Baffin LSA (i.e. it was decreasing). These factors imply the Project may be having a positive effect in the North Baffin LSA, where employment opportunities have historically been limited.

Similarly, while there has been a decreasing trend in the percentage of the population receiving social assistance in the post-development period in the North Baffin LSA and Iqaluit these trends were also evident in the five years preceding Project development (including throughout Nunavut). This implies factors other than the Project are likely driving these trends, although potential positive Project employment effects will continue to be tracked through future monitoring.

As Project construction only began in 2013, there is a minimal amount of post-development data currently available. Employment income and social assistance rates can also be influenced by many different socio-economic factors. Direct correlations between the Project and employment income and social assistance rates, if any, will only come to light with the analysis of additional annual data. There is currently no indication the Final EIS prediction is not being met. In fact, there are positive indications the Project continues to improve household income and food security in the LSA. This has occurred by providing LSA residents with meaningful employment opportunities and through contributions to community wellness initiatives. Increased employment income facilitates the purchase of store bought food and other family goods, while also providing an improved means to participate in harvesting if desired.

7.3 TRANSPORT OF SUBSTANCES THROUGH PROJECT SITES

7.3.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project could increase availability of substances such as alcohol and illegal drugs in the North Baffin LSA due to their possible transportation through Project sites. Related mitigation measures developed by Baffinland include a no drugs/no alcohol policy on site and baggage searches for all employees and contractors arriving at site.

7.3.2 Indicator Data

Number of Drug and Alcohol Related Contraband Infractions at Project Sites

The number of drug and alcohol related contraband infractions at Project sites is a useful indicator of the degree to which the transport of substances may be occurring at the Project. Table 20 displays the total number of drug and alcohol related contraband infractions at Project sites from 2013 to 2016. In 2016, 11 drug and alcohol related contraband infractions occurred at Project sites amongst employees and contractors. This was 9 infractions higher than in 2015.

Number of Drug and Alcohol Related Contraband Infractions at Project Sites	
Year	**Total**
2013	5
2014	12
2015	2
2016	11

Source: Baffinland records. 2013 records are for a partial year.

Table 20: Number of drug and alcohol related contraband infractions at Project sites (2013 to 2016)

7.3.3 Analysis

While all contraband infractions are of concern and taken seriously by Baffinland, the 11 infractions that occurred in 2016 represent only a small number of individuals from the Project workforce. All individuals who do not comply with Baffinland's no drugs/no alcohol policy are immediately removed from site and disciplinary action (up to and including termination) is commenced. This management response supports Baffinland's goal of 'Safety First, Always' while also preventing further transport of contraband substances through Project sites.

7.4 AFFORDABILITY OF SUBSTANCES / ATTITUDES TOWARD SUBSTANCES AND ADDICTIONS

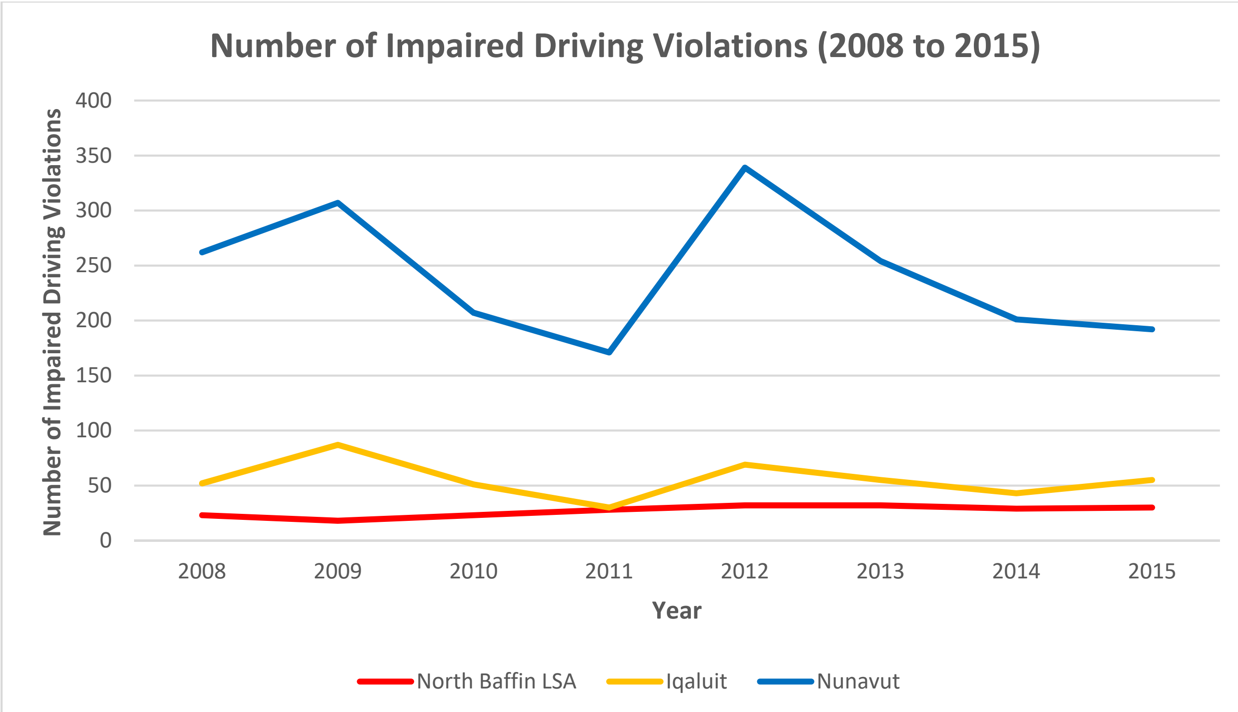
7.4.1 Predicted Effect and Mitigation Measures

The Final EIS predicted increased income from employment at the Project could increase the ability of LSA residents to afford substances such as alcohol and illegal drugs. However, the Final EIS also predicted the Project could improve attitudes toward substances and addictions in the LSA (i.e. by providing positive incentives for individuals to reduce substance abuse). Related mitigation measures developed by Baffinland include a no drugs/no alcohol policy and baggage searches for all employees and contractors arriving at site. Baffinland has also implemented an Employee and Family Assistance Program for workers and their family members, and contributes to the INPK community wellness fund through the IIBA negotiated with QIA.

7.4.2 Indicator Data

Number of Impaired Driving Violations

The number of impaired driving violations in the LSA provides some insight into whether rates of alcohol abuse are changing. 2015 was the most recent year for which data on the number of impaired driving violations by community was available from the Nunavut Bureau of Statistics (2016f). In the North Baffin LSA in 2015, Arctic Bay had the highest number of impaired driving violations (17), while Hall Beach had the fewest (0). The average number of impaired driving violations in the North Baffin LSA communities in 2015 was 6. Iqaluit had 55 impaired driving violations in 2015 and Nunavut as a whole had 192. Compared to the previous year (2014), there has been an increase in the total number of impaired driving violations in the North Baffin LSA communities (by 1) and Iqaluit (by 12) and a decrease in Nunavut (by 9). Compared to pre-development period averages, there has been an increasing trend in the number of impaired driving violations in the North Baffin LSA, and decreasing trends in Iqaluit and Nunavut. Figure 11 displays the number of number of impaired driving violations from 2008 to 2015.

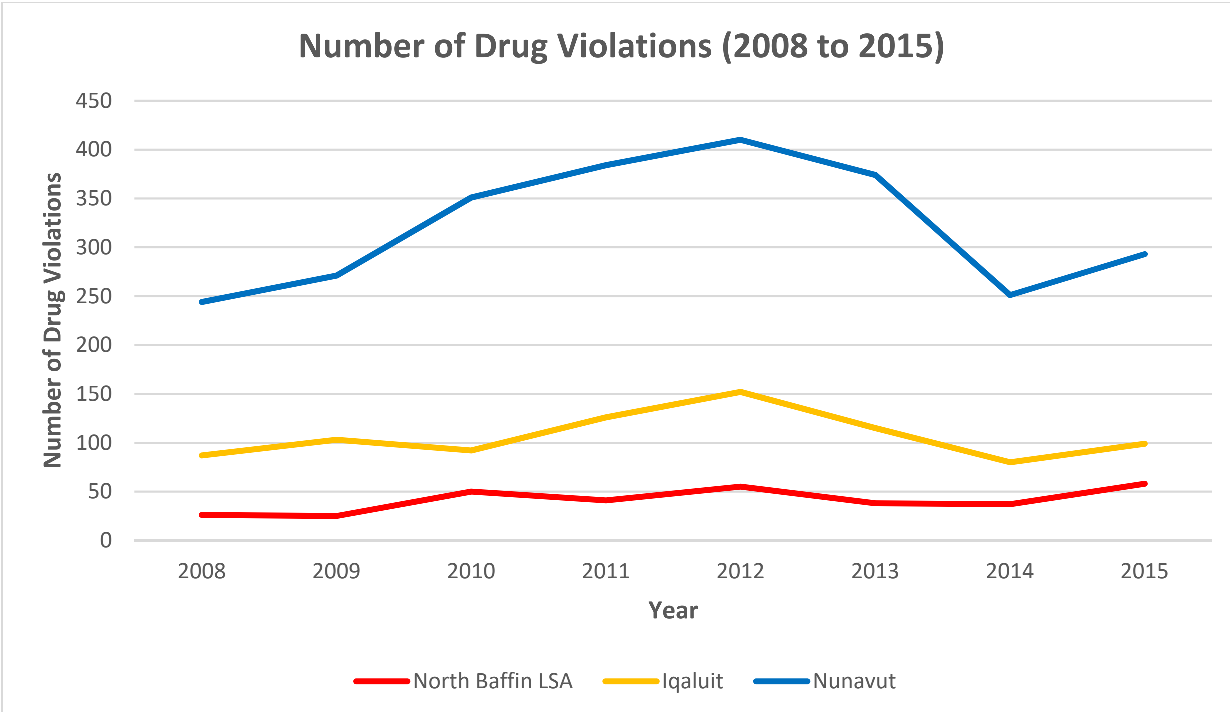


Source: Nunavut Bureau of Statistics (2016f)

Figure 11: Number of impaired driving violations (2008 to 2015)

Number of Drug Violations

The number of drug violations in the LSA provides some insight into whether rates of drug abuse are changing. 2015 was the most recent year for which data on the number of drug violations by community was available from the Nunavut Bureau of Statistics (2016f). In the North Baffin LSA in 2015, Pond Inlet had the highest number of drug violations (18), while Hall Beach had the fewest (4). The average number of drug violations in the North Baffin LSA communities in 2015 was 11.6. Iqaluit had 99 drug violations in 2015 and Nunavut as a whole had 293. Compared to the previous year (2014), there has been an increase in the total number of drug violations in the North Baffin LSA communities (by 21), Iqaluit (by 19) and Nunavut (by 42). Compared to pre-development period averages, there has been an increasing trend in the number of drug violations in the North Baffin LSA, and decreasing trends in Iqaluit and Nunavut. Figure 12 displays the number of number of drug violations from 2008 to 2015.



Source: Nunavut Bureau of Statistics (2016f)

Figure 12: Number of drug violations (2008 to 2015)

7.4.3 Analysis

While there has been an increasing trend in the number of impaired driving violations in the North Baffin LSA and a decreasing trend in Iqaluit in the post-development period, these trends were also evident in the five years preceding Project development. Likewise, while there has been an increasing trend in the number of drug violations in the North Baffin LSA in the post-development period, this trend was also evident in the five years preceding Project development. This implies factors other than the Project are likely driving these trends.[17] However, the number of drug violations in Iqaluit have experienced a decreasing trend in the post-development period, after experiencing an increasing trend in the five years preceding Project development. This implies the Project may be having a positive effect on this trend.

As Project construction only began in 2013, there is a minimal amount of post-development data currently available. Drug and alcohol-related violations can also be influenced by many different socio-economic factors. Direct correlations between the Project and drug and alcohol violations, if any, will only come to light with the analysis of additional annual data. However, there are positive indications

[17] At the 2016 QSEMC, several communities including Arctic Bay, Hall Beach, and Pond Inlet cited substance abuse as a concern for their communities. However, no direct link to increases in substance abuse issues since the beginning of the Project were noted (Government of Nunavut 2016). For further context, the 2016 North Baffin community survey conducted by Baffinland found that 65% of survey respondents said they did not have any concerns about how the Project was affecting their community and environment. A much smaller number (17%) had concerns about how the Project was affecting their community, which included concerns on substance abuse and other issues.

the Project continues to improve attitudes toward substances and addictions in the LSA, by providing LSA residents with meaningful employment opportunities within a drug and alcohol free environment. Baffinland also provides access to an Employee and Family Assistance Program for workers and their family members who may require assistance with drug and alcohol-related issues.

7.5 ABSENCE FROM THE COMMUNITY DURING WORK ROTATION

7.5.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the absence of workers from communities during their work rotations may lead to some moderate negative effects on community processes (e.g. local coaching, politics, and social organizations) in the LSA. However, it was also predicted that organizations and activities would be able to adapt and carry on their functions in light of these effects. Related mitigation measures developed by Baffinland include a short (two week in / two week out) rotation that allows employees to spend considerable time in their home communities. Baffinland also contributes to the INPK community wellness fund through the IIBA negotiated with QIA.

7.5.2 Indicator Data

Absence from the Community During Work Rotation

Appropriate community-level indicator data are currently unavailable for this topic. As such, this topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. No comments related to the absence of workers from communities during their work rotations were made at the 2016 QSEMC meeting or during Baffinland's 2016 community engagement activities (although some comments were made on family-related and other effects, as noted in other sections of this report). In fact, two comments were received during public meetings held by Baffinland in 2016 about potentially increasing the length of employment rotations. Absence from the community does not appear to be an issue for at least some individuals:

> *"Two weeks in, two weeks out seems to be too short. It would be better to work for six months and then go back to the community. If they were to work more than two weeks than it would save a lot of money." [Hall Beach Public Meeting Participant]*

> *"When they are going in two weeks in two weeks out. Can we increase the number of weeks? It is too short of a break." [Igloolik Public Meeting Participant]*

7.5.3 Analysis

Baffinland acknowledges the absence of workers from communities during their work rotations may lead to some negative effects on community processes. However, there is no available evidence to suggest there have been any related long term or significant impacts because of the Project. The INPK fund also continues to provide support to various community wellness initiatives across the Qikiqtaaluk Region that may assist in this regard. This issue will continue to be tracked in future socio-economic monitoring reports.

7.6 PREVALENCE OF GAMBLING ISSUES

7.6.1 Project Certificate Condition

No specific prediction related to the prevalence of gambling issues was presented in the Final EIS. However, Project Certificate condition #154 states:

> *The Proponent shall work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring Committee to monitor potential indirect effects of the Project, including indicators such as the prevalence of substance abuse, gambling issues, family violence, marital problems, rates of sexually transmitted infections and other communicable diseases, rates of teenage pregnancy, high school completion rates, and others as deemed appropriate.*

7.6.2 Indicator Data

Prevalence of Gambling Issues

Appropriate community-level indicator data are currently unavailable for this topic. As such, this issue will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. Some comments related to the Project and the prevalence of gambling issues were made at the 2016 QSEMC (Government of Nunavut 2016: 25):

> *"Discussions then took place regarding observed increases in substance abuse, gambling and marital issues in Qikiqtaaluk communities. Communities are concerned with the relation between working at Mary River and an increase in substance and gambling abuse issues. Community representatives explained that this is an ongoing issue not directly related to Mary River and that hamlets are working with the RCMP in an attempt to reduce and eliminate substance abuse."*

Some comments related to the Project and the prevalence of gambling issues were also made in the recent *Mary River Experience – The First Three Years* report (i.e. Brubacher Development Strategies Inc. 2016: 32):

> *"You get into the problems of gambling, drugs, alcohol of the family here. The guy who goes off to work sees his family having a helluva good time drinking and gambling and drugs that he's working and paying for. So the resentment and jealousy? You bet." [Community Resident]*

> *"But sometimes I hear the spouses of the ones working at Mary River… They're going on the radio saying they want to borrow money until their spouse gets back from the mine site… Probably like this because the spouse [at home] might spend all the money on drugs or gambling." [Community Resident]*

7.6.3 Analysis

Baffinland acknowledges gambling issues remain a concern for some Project stakeholders. However, there is no available evidence to suggest there has been a long term or significant increase in gambling issues because of the Project. Gambling abuse is also a complex issue that can be influenced by many different factors. While this issue will continue to be monitored, it should be noted Baffinland continues to provide its employees and their immediate family members with access to an Employee and Family Assistance Program and has established on-site elder positions to provide counsel and support to its employees. Gambling-related or other forms of personal assistance can be obtained through these programs, as needed.

7.7 PREVALENCE OF FAMILY VIOLENCE

7.7.1 Project Certificate Condition

No specific prediction related to the prevalence of family violence was presented in the Final EIS. However, Project Certificate condition #154 requests this topic be monitored.

7.7.2 Indicator Data

Prevalence of Family Violence

Appropriate community-level indicator data are currently unavailable for this topic. As such, this issue will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. No comments related to the Project and the prevalence of family violence were made at the 2016 QSEMC meeting or during Baffinland's 2016 community engagement activities. However, some data on this topic is available at the territorial level. Statistics Canada (2016d) notes there were 911 incidents of police-reported family violence in Nunavut in 2014, which equates to a rate of 2,491 incidents per 100,000 population. This rate is substantially higher than the overall Canadian rate of 243 incidents per 100,000 population.

7.7.3 Analysis

Baffinland acknowledges family violence remains a concern for some Project stakeholders. However, there is no available evidence to suggest there has been a long term or significant increase in family violence rates because of the Project. Family violence is also a complex issue that can be influenced by many different factors. While this issue will continue to be monitored, it should be noted Baffinland continues to provide its employees and their immediate family members with access to an Employee and Family Assistance Program and has established on-site elder positions to provide counsel and support to its employees. Family-related and other forms of personal assistance can be obtained through these programs, as needed.

7.8 PREVALENCE OF MARITAL PROBLEMS

7.8.1 Project Certificate Condition

No specific prediction related to the prevalence of marital problems was presented in the Final EIS. However, Project Certificate condition #154 requests this topic be monitored.

7.8.2 Indicator Data

Prevalence of Marital Problems

Appropriate community-level indicator data are currently unavailable for this topic. As such, this issue will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. Some comments on this topic were made at the 2016 QSEMC meeting. For example, one individual from Hall Beach noted that one or more Project employees have left their spouse for a new relationship and moved to a new community:

> *"But a few years into the Mary River Project and we are now dealing [with] some of the impacts that were not expected. Employees moving to new communities and breaking up families has been something that is happening"* (Government of Nunavut 2016: 14).

Some comments related to the Project and the prevalence of marital problems were also made during Baffinland's 2016 community engagement program. For example:

> *"Something has to be done if someone goes to work for Baffinland and then they decide that they want to separate from their spouse. There are lots of impacts, people don't pay their spouses for child support. We are talking about community wellness here. Families should not be broken because they work for Baffinland. The families are now separated and there is no more help for the family left behind. This is not fair. When I went to Arctic Bay to a workshop, we were told that everything would be run to the best of their abilities and the communities would not be harmed… Something has to be done, because their children get hurt for life. If their father goes to work for Baffinland and then just never comes back." [Hall Beach Public Meeting Participant]*

> *"As a wife, my husband worked for Milne Inlet for 2.5 years, those years there was a lot of cheating though connector (Facebook) and it almost ruined my marriage. There is a lot of cheating happening in Baffinland and it had ruin so many relationships. You need to take a good look on their site to make sure cheating is not happening in BL." [Igloolik Survey Respondent]*

The recent *Mary River Experience – The First Three Years* report (i.e. Brubacher Development Strategies Inc. 2016) also contained some comments related to the Project and the prevalence of marital problems. For example, the report notes (page 24):

> *"Being separated every two weeks can put pressure on relationships. Anxiety around a partner being faithful can be heightened by the unknown nature of life at the mine site… Life at site may not be any more conducive to forming relationships than any other environment.*

> *But it may also not be any less so. Couples who are apart half the time may not survive. Breakups may arise from either or both partners."*

One community resident was also quoted as saying (page 24):

> *"It depends on how strong the relationship is between the man and the woman. One I know, when the man started working at Mary River, she found another man [in the community] and ended up breaking up. But others maybe want to stay with them more because they're making a lot of money." [Community Resident]*

The report also notes that relationships have sometimes become stronger because of the Project. Effective communication was noted to be particularly important to successful relationship outcomes (pages 25 and 21):

> *"Some couples express that positive effects on their relationship have emerged out of the Mary River Project employment experience. This was suggested during two conversations."*

> *"Maintaining good communication during the work rotation was also raised as a central part of making the fly-in/fly-out lifestyle work. This communication encompassed both the spouse as well as with the children."*

Some data on this topic are also available at the territorial level. For example, the Nunavut Bureau of Statistics (2016i) notes approximately 38% of the Nunavut population aged 15 or over were married or living common law in 2016, while 2.7% were separated or divorced. In 2012, approximately 36.8% of the Nunavut population aged 15 or over were married or living common law, while 2.5% were separated or divorced.

7.8.3 Analysis

Baffinland acknowledges the potential for increased martial problems remains a concern for some Project stakeholders. However, there is no available evidence to suggest there has been a long term or significant increase in the prevalence of marital problems because of the Project. Marital issues can also be complex and influenced by many different factors. While this issue will continue to be tracked, it should be noted Baffinland continues to provide its employees and their immediate family members with access to an Employee and Family Assistance Program and has established on-site elder positions to provide counsel and support to its employees. Family-related or other forms of personal assistance can be obtained through these programs, as needed.

7.9 RATES OF SEXUALLY TRANSMITTED INFECTIONS AND OTHER COMMUNICABLE DISEASES

7.9.1 Project Certificate Condition

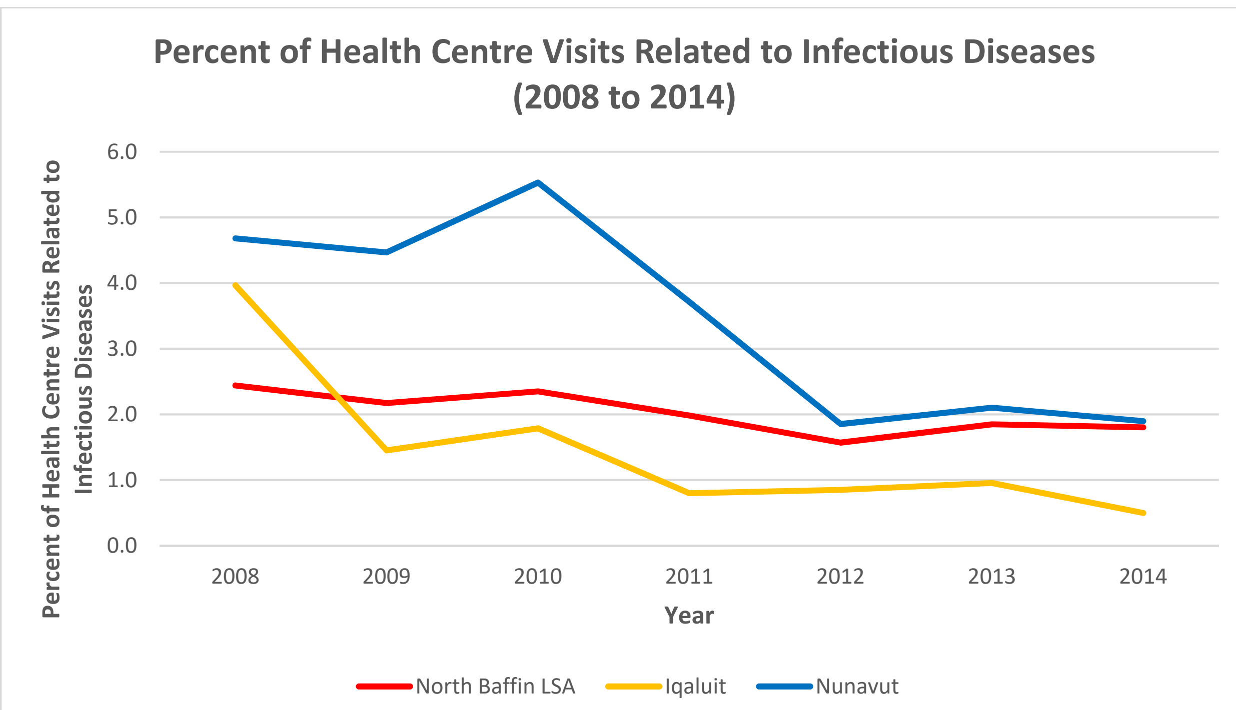
No specific prediction related to rates of sexually transmitted infections and other communicable diseases was presented in the Final EIS. However, Project Certificate condition #154 requests this topic be monitored.

7.9.2 Indicator Data

Percent of Health Centre Visits Related to Infectious Diseases

Data on community health centre visits can be used to identify whether health issues are increasing or decreasing in a community. Information on how the Project may affect rates of sexually transmitted infections and other communicable diseases in the LSA has been specifically requested in the Project Certificate. As such, data on the percentage of health centre visits by the diagnostic group 'infectious diseases' is a useful indicator to track.

2014 was the most recent year for which data on the percentage of health centre visits related to infectious diseases was available from the Nunavut Bureau of Statistics (2016g). In the North Baffin LSA in 2014, Arctic Bay had the highest percentage of health centre visits related to infectious diseases (2.3%), while Clyde River had the lowest (1.1%). The average percentage of health centre visits related to infectious diseases in the North Baffin LSA communities in 2014 was 1.8%. Iqaluit[18] had 0.5% of health centre visits related to infectious diseases in 2014, while Nunavut as a whole had 1.9%. Compared to the previous year (2013), there was no change in the percentage of health centre visits related to infectious diseases in the North Baffin LSA communities (1.8%), but decreases occurred in Iqaluit (by 0.5%) and Nunavut (by 0.2%). Compared to pre-development period averages, there has been a decreasing trend in the percentage of health centre visits related to infectious diseases in the North Baffin LSA, Iqaluit, and Nunavut. Figure 13 displays the percentage of health centre visits related to infectious diseases from 2008 to 2014.



Source: Nunavut Bureau of Statistics (2016g)

Figure 13: Percent of health centre visits related to infectious diseases (2008 to 2014)

[18] The Nunavut Bureau of Statistics (2016g) notes that only visits to Iqaluit's community health centre are reported on, while visits to Iqaluit's hospital are not.

7.9.3 Analysis

While there has been a decreasing trend in the percentage of health centre visits related to infectious diseases in the North Baffin LSA and Iqaluit in the post-development period, this decreasing trend was also evident in the five years preceding Project development (and throughout Nunavut). This implies factors other than the Project are likely driving these trends. However, infectious disease rates can be influenced by many different socio-economic factors. As Project construction only began in 2013, there is a minimal amount of post-development data currently available. Correlations between the Project and infectious disease rates, if any, will only come to light with the analysis of additional annual data. However, it is worth noting the Project continues to provide workers with regular access to a site medic, to whom they can confidentially visit with health-related (including sexual health) issues.

7.10 RATES OF TEENAGE PREGNANCY

7.10.1 Project Certificate Condition

No specific prediction related to teenage pregnancy rates was presented in the Final EIS. However, Project Certificate condition #154 requests this topic be monitored.

7.10.2 Indicator Data

Rates of Teenage Pregnancy

Appropriate community-level indicator data are currently unavailable for this topic. As such, this issue will continue to be tracked through the QSEMC process and Baffinland’s community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. No comments related to the Project and teenage pregnancy rates were made during Baffinland’s 2016 community engagement program or during the 2016 QSEMC. However, some data on this topic are available at the territorial level. Statistics Canada (2016e) notes 22.0% of all Nunavut live births in 2013 (the most recent year data were available) were to mothers under the age of 20. By comparison, only 3.1% of all Canadian live births in 2013 were to mothers under the age of 20.

7.10.3 Analysis

Baffinland acknowledges teenage pregnancy remains a concern for some Project stakeholders. However, there is no available evidence to suggest there has been a long term or significant increase in teenage pregnancy rates because of the Project. Teenage pregnancy rates can also be influenced by many different socio-economic factors. This topic will continue to be tracked in future monitoring reports.

7.11 OTHER - CRIME

7.11.1 Project Certificate Condition

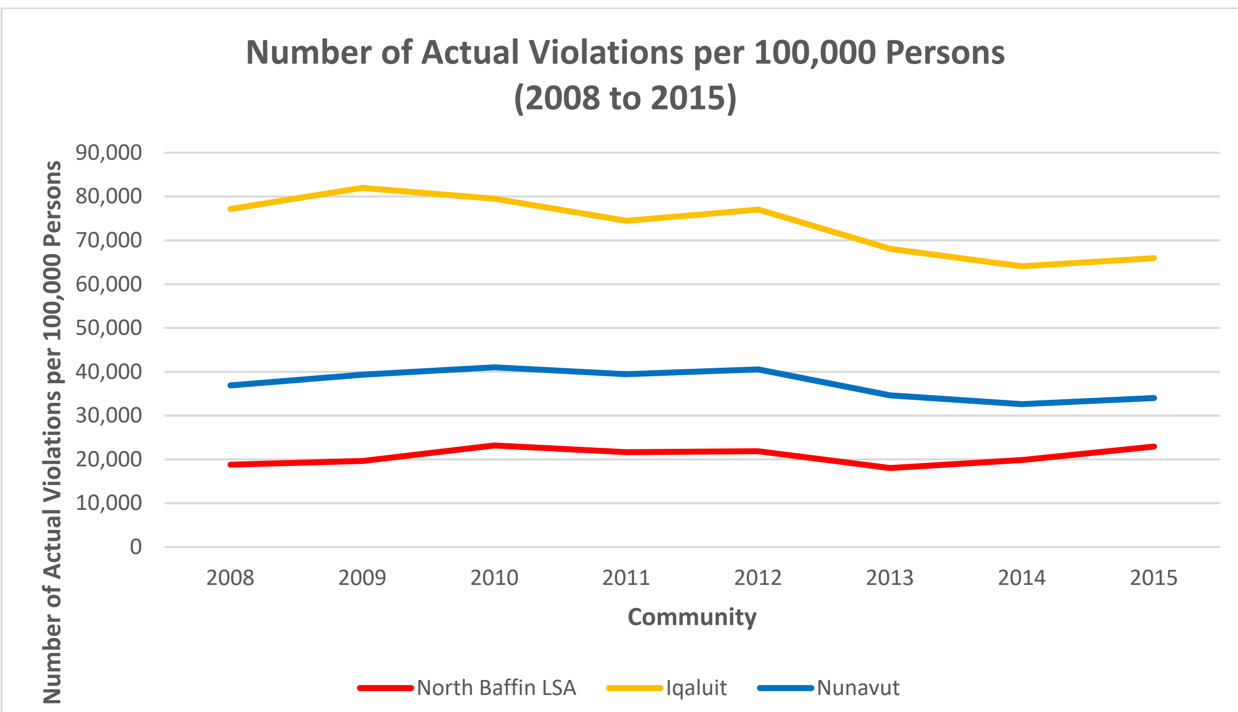
No specific prediction related to crime was presented in the Final EIS. However, Project Certificate condition #154 states other indicators (such as crime) should be monitored “as deemed appropriate”.

The Mary River SEMWG has requested community crime rate data be included in Baffinland's socio-economic monitoring program.

7.11.2 Indicator Data

Crime Rate

Data on community crime rates are useful for providing an indication of whether crime is increasing or decreasing. 2015 was the most recent year for which data on the number of actual violations per 100,000 persons was available from the Nunavut Bureau of Statistics (2016h). In the North Baffin LSA in 2015, Arctic Bay had the highest number of actual violations per 100,000 persons (28,764), while Hall Beach had the fewest (12,591). Iqaluit had 65,929 actual violations per 100,000 persons in 2015, which was significantly higher than the North Baffin LSA community average (22,917) and for Nunavut (34,007). Compared to the previous year (2014), there was an increase in the number of actual violations per 100,000 persons in the North Baffin LSA communities (by 3,065), Iqaluit (by 1,859), and Nunavut (by 1,393). Compared to pre-development period averages, there has been a trend of increasing crime rates in the North Baffin LSA, but decreasing crime rates in Iqaluit and Nunavut. Figure 14 displays the number of actual violations per 100,000 persons from 2008 to 2015.



Source: Nunavut Bureau of Statistics (2016h)

Figure 14: Number of actual violations per 100,000 persons (2008 to 2015)

7.11.3 Analysis

While there has been a trend of increasing crime rates in the North Baffin LSA and decreasing crime rates in Iqaluit in the post-development period, these trends were also evident in the five years preceding Project development. This implies factors other than the Project are likely driving these trends. However, crime rates can be influenced by many different socio-economic factors. As Project construction only began in 2013, there is a minimal amount of post-development data currently available. Correlations between the Project and crime rates, if any, will only come to light with the analysis of additional annual data.

8. VSEC – COMMUNITY INFRASTRUCTURE AND PUBLIC SERVICES

8.1 COMPETITION FOR SKILLED WORKERS

8.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project could negatively affect the ability of hamlets to maintain their staff in the short term, due to increased competition for skilled workers created because of the Project. Associated mitigation measures developed by Baffinland include the provision of ongoing skills training to local residents, combined with work experience generated by the Project. These measures are expected to increase the pool of skilled workers in the local labour force in the medium to long-term and negate any short-term, negative Project effects.

8.1.2 Indicator Data

Number of Project Employees Who Left Positions in their Community

Based on the 2017 Employee Information Survey conducted by Baffinland (43 surveys received), 9 Project employees (or 20.9%) indicated they had left positions in their communities to pursue employment at the Project. Of these, 3 were casual/part-time positions, while 6 were full-time positions.

The recent *Mary River Experience – The First Three Years* report (i.e. Brubacher Development Strategies Inc. 2016) also provides some insight into this topic. For example, the report notes:

> *"…the potential that the Mary River Project may draw employees away from other local employers seems evident." [Page 37]*

However, the report also describes the lack of full time hamlet work (and other job opportunities) in many communities and important role the Project plays in filling this gap:

> *"One current Mary River employee spoke about how permanent employment in the community seemed to be out of reach. As more and more people gained drivers' licenses the practice of sharing hamlet work around a pool of people was leading to slimmer and slimmer employment duration." [Page 35]*
>
> *"There are no jobs in the hamlets… and if you do get a job it's part-time, its casual, you can't get social assistance… and you may get very little work… you might get 40 hours this week and next week you'll only get 5 hours." [Key Person Interviewed, Page 35]*
>
> *"For some, the advantage of Mary River is that it offers jobs that simply are not available in the small, local economies of North Baffin LSA communities." [Page 37]*

8.1.3 Analysis

While some Project employees have left positions in their communities to pursue employment at the Project, there is no available evidence to suggest there has been a long term or significant impact on community staffing because of the Project. Furthermore, some of the community positions departed were of a casual/part-time nature, rather than full-time, permanent employment. Community engagement conducted by Baffinland further indicates there remains a high demand for employment opportunities in the LSA. It is also expected that ongoing training and experience generated by the Project, in addition to regular employee turnover (see Section 8.2), will continue to increase the pool of skilled workers in the local labour force and negate any short-term, negative Project effects.

8.2 LABOUR FORCE CAPACITY

8.2.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project could positively affect the ability of hamlets to maintain their staff in the medium to long term, due to the increased labour force capacity created because of the Project. Associated mitigation measures developed by Baffinland include the provision of ongoing skills training to local residents, combined with work experience generated by the Project. Together, these are expected to increase the overall pool of skilled workers in the local labour force from which hamlets (and other local and regional organizations) can draw upon.

8.2.2 Indicator Data

Training and Experience Generated by the Project

As noted in Sections 4 and 5, the Project continues to generate substantial training and experience opportunities for its employees. Since 2013, the Project has cumulatively generated 79,553 hours of training for Project employees, 11,843 hours (or 14.9%) of which were completed by Inuit employees (this does not include the additional training and experience gained by Project contractors). Likewise, 6,456,646 hours of labour have been cumulatively performed in Nunavut because of the Project since 2013, 1,162,333 hours (or 18.0%) of which were performed by Inuit employees and contractors.

Inuit Employee Turnover

As noted in Section 5.3, employee turnover continues to occur at the Project. While high rates of employee turnover are undesirable in most workplaces, some degree of turnover is expected and considered normal. In 2016, there were 44 Inuit employee departures (not including contractors) at the Project.

8.2.3 Analysis

The Project continues to generate substantial training and experience opportunities for its employees. Employee turnover also continues to occur at the Project, which ensures at least some previous Project employees become available for employment elsewhere. Together, these help increase the overall pool of skilled workers in the local labour force from which hamlets (and other local and regional organizations) can draw upon.

8.3 PRESSURES ON EXISTING HEALTH AND SOCIAL SERVICES PROVIDED BY THE GN THAT MAY BE IMPACTED BY PROJECT-RELATED IN-MIGRATION OF EMPLOYEES

8.3.1 Project Certificate Condition

No specific prediction related to pressures on existing health and social services provided by the GN that may be impacted by Project-related in-migration of employees was presented in the Final EIS. However, Project Certificate condition #158 states:

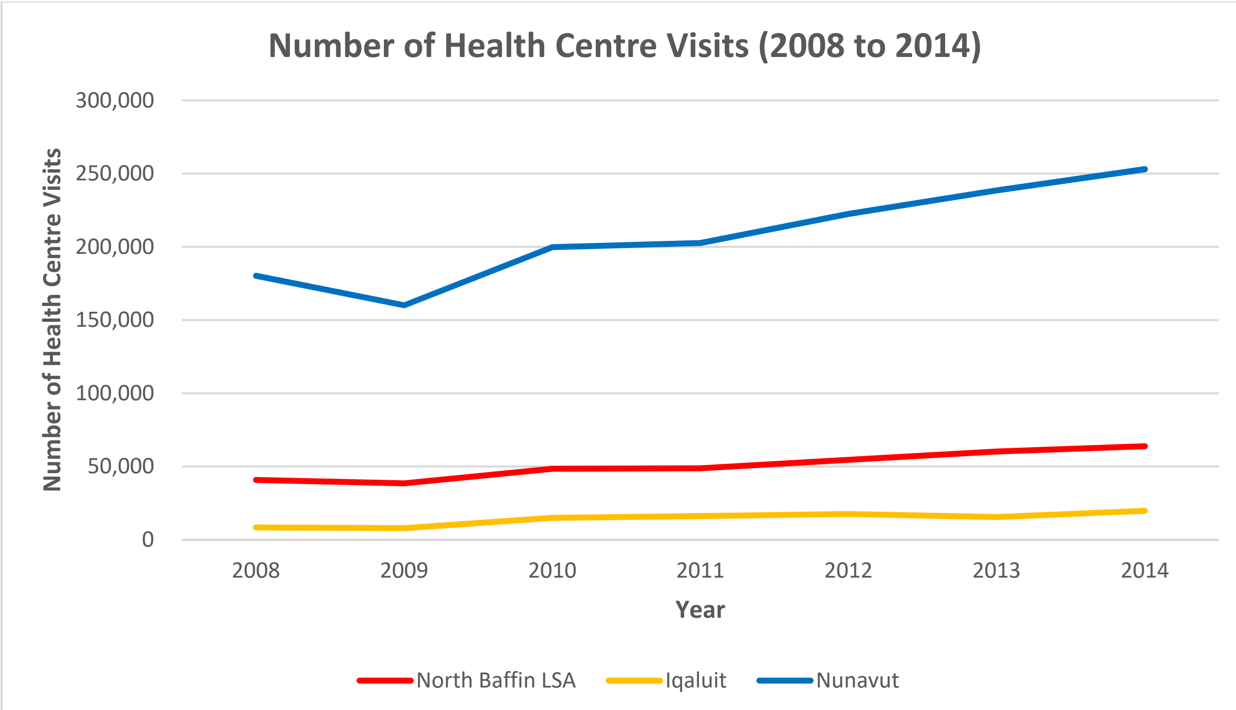
> *The Proponent is encouraged to work with the Government of Nunavut and other parties as deemed relevant in order to develop a Human Health Working Group which addresses and establishes monitoring functions relating to pressures upon existing services and costs to the health and social services provided by the Government of Nunavut as such may be impacted by Project-related in-migration of employees, to both the North Baffin region in general, and to the City of Iqaluit in particular.*

8.3.2 Indicator Data

Number of Health Centre Visits (Total and Per Capita)

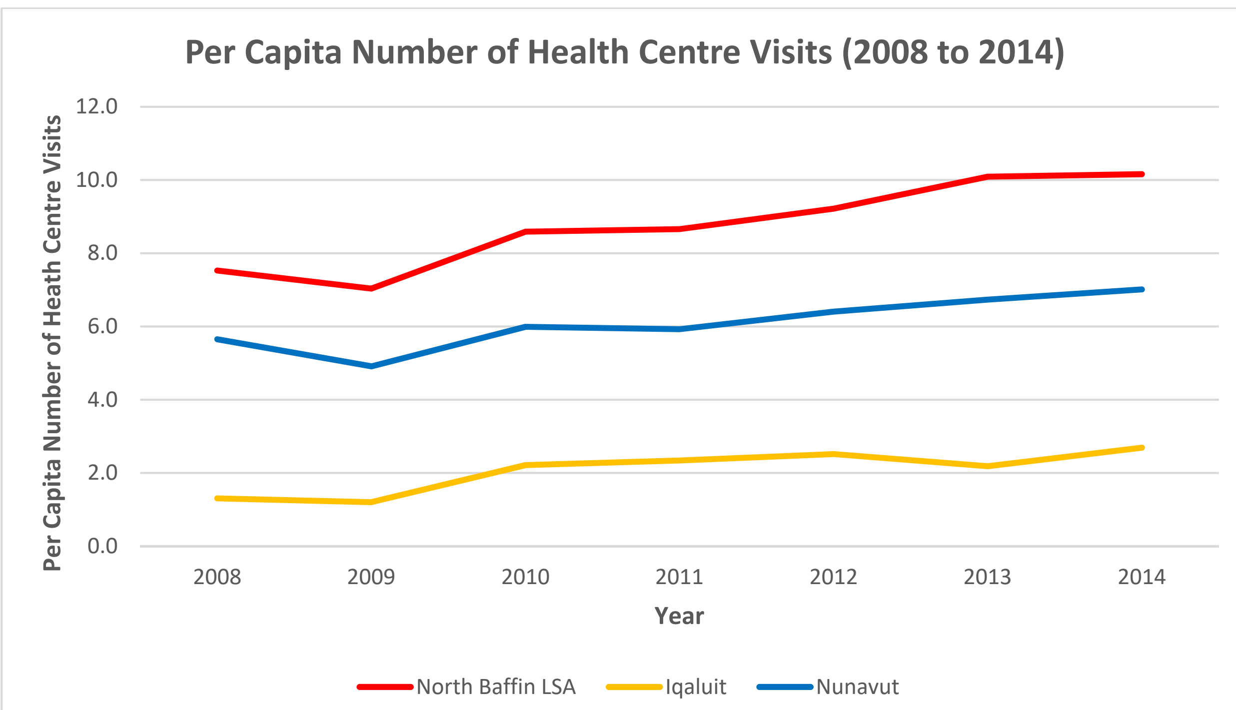
Health centre utilization data can be used to track changes to demands placed on community health services. 2014 was the most recent year for which data on the number of health centre visits was available from the Nunavut Bureau of Statistics (2016g). In the North Baffin LSA in 2014, Pond Inlet had the highest number of health centre visits (20,725), while Hall Beach had the fewest (6,203). The total number of health centre visits in the North Baffin LSA in 2014 was 63,891. Iqaluit had 19,794 health centre visits[18] in 2014 and Nunavut had 253,014. Compared to the previous year (2013), the number of health centre visits have increased in the North Baffin LSA (by 3,561), Iqaluit (by 4,270), and Nunavut (by 14,466). Compared to pre-development period averages, there has been an increasing trend in the number of health centre visits in the North Baffin LSA, Iqaluit, and Nunavut. Figure 15 displays the number of health centre visits from 2008 to 2014.

2014 was also the most recent year for which data on per capita number of health centre visits were available from the Nunavut Bureau of Statistics (2016g). In the North Baffin LSA in 2014, Pond Inlet and Clyde River had the highest number of per capita health centre visits (12.6 each), while Hall Beach had the fewest (6.7). The average number of per capita health centre visits in the North Baffin LSA in 2014 was 10.2. Iqaluit had 2.7 per capita health centre visits[18] in 2014 and Nunavut had 7.0. Compared to the previous year (2013), the per capita number of health centre visits have increased in the North Baffin LSA (by 0.1), Iqaluit (by 0.5), and Nunavut (by 0.3). Compared to pre-development period averages, there has been an increasing trend in the per capita number of health centre visits in the North Baffin LSA, Iqaluit, and Nunavut. Figure 16 displays the per capita number of health centre visits from 2008 to 2014.



Source: Nunavut Bureau of Statistics (2016g)

Figure 15: Number of health centre visits (2008 to 2014)



Source: Nunavut Bureau of Statistics (2016g)

Figure 16: Per capita number of health centre visits (2008 to 2014)

Number of Visits to Project Site Medic

The number of annual Project site medic visits can be used to track demands placed on Project-related health care services. This data also provides insight into the role played by the Project in reducing demands placed on local health care services. In 2016, there were 4,012 recorded visits to the Project site medic, an increase of 587 visits since 2015. Table 21 displays the number of recorded visits to the Project site medic from 2013 to 2016.

Number of Visits to Project Site Medic				
Ethnicity	**2013**	**2014**	**2015**	**2016**
Inuit	342	1,158	845	801
Non-Inuit	870	2,125	2,580	3,211
Total	**1,212**	**3,283**	**3,425**	**4,012**

Source: Baffinland records

Table 21: Number of visits to Project site medic (2013 to 2016)

8.3.3 Analysis

While there have been increasing trends in the number of total and per capita health centre visits in the North Baffin LSA and Iqaluit in the post-development period, these trends were also evident in the five years preceding Project development (and throughout Nunavut). This implies a longer-term, territory-wide trend is likely occurring rather than a Project-induced one. However, health centre utilization rates can also be influenced by many different socio-economic factors. As Project construction only began in 2013, there is a minimal amount of post-development data currently available. Correlations between the Project and health centre utilization, if any, will only come to light with the analysis of additional annual data.

In any case, the primary means through which the Project could negatively influence health service provision – in-migration of workers – has been shown (in Section 3.2) not be occurring in any significant manner. In fact, the Project may be having a positive effect on LSA health service provision, by providing employees with regular access to an on-site Project medic. This access allows LSA residents to have at least some of their health needs addressed on-site, thereby reducing demands placed on local health care providers.

8.4 PROJECT-RELATED PRESSURES ON COMMUNITY INFRASTRUCTURE

8.4.1 Project Certificate Condition

No specific prediction related to Project-related pressures on community infrastructure was presented in the Final EIS. However, Project Certificate condition #159 states:

> *The Proponent is encouraged to work with the Government of Nunavut to develop an effects monitoring program that captures increased Project-related pressures to community infrastructure in the Local Study Area communities, and to airport infrastructure in all point-of-hire communities and in Iqaluit.*

8.4.2 Indicator Data

Baffinland Use of LSA Community Infrastructure

Baffinland continues to utilize some community infrastructure in the LSA to support ongoing Project operations. In 2016, this included:

- Full-time rental of five offices for Baffinland Community Liaison Officers (BCLOs) in the North Baffin communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet, and one office for Baffinland's Northern Affairs team in Iqaluit
- Short-term rental of meeting rooms for Baffinland community meetings and/or workshops held in various North Baffin communities in May, July, and November 2016. Baffinland also utilized other local services during these events (for meals, accommodations, transport, etc.)
- Use of meeting rooms and local facilities for other events held in the LSA (e.g. Baffinland's participation in annual QSEMC meetings and IIBA forums)

A more detailed breakdown of stakeholder meetings and activities undertaken by Baffinland can be found in the company's *Annual Report to the Nunavut Impact Review Board.*

Number of Project Aircraft Movements at LSA Community Airports

To support the movement of workers, freight, and other materials to/from the Project, Baffinland is required to utilize community airport infrastructure in the LSA. This is due to the remote location of the Project and lack of viable alternative transportation methods (aside from seasonal marine re-supply). In 2016, there were 1,254 Project aircraft movements[19] at LSA community airports. This includes only fixed-wing aircraft (e.g. passenger, cargo, and 'combi' type); records for rotary-wing aircraft (e.g. helicopters used for site activities) were not available. Table 22 provides information on the number of Project aircraft movements at LSA community airports from 2014 to 2016.

---

[19] An aircraft movement is defined as a takeoff or landing at an airport. For example, one aircraft arrival and one departure is counted as two movements.

Number of Project Aircraft Movements at LSA Community Airports			
Community	**2014**	**2015**	**2016**
Arctic Bay	122	126	120
Clyde River	114	112	112
Hall Beach	130	122	122
Igloolik	118	106	114
Pond Inlet	212	136	134
Iqaluit	876	708	652
Total	**1,572**	**1,310**	**1,254**

Source: Baffinland records. Complete records are only available for fixed-wing aircraft movements and from 2014 onwards.

Table 22: Number of Project aircraft movements at LSA community airports (2014 to 2016)

8.4.3 Analysis

Like previous years, Baffinland continued to use some LSA community infrastructure to support ongoing Project operations in 2016. This use is small in comparison to other ongoing community uses and adds only minimal incremental pressure on LSA facilities. For example, Baffinland's rental of office spaces in the LSA is generally limited to small facilities (i.e. to support individual BCLOs and Northern Affairs staff), and the use of local meeting rooms and accommodations is often intermittent (e.g. community meetings may only occur a few times or less per year) and short-term in nature. Furthermore, the use of these spaces can be considered a positive economic contribution of the Project to local economies (e.g. through payments of rental fees, purchase of related goods and services).

LSA community airports also regularly accommodate various non-Project passenger, cargo, and other aircraft (both scheduled and charter). Project-related aircraft movements add only minimal incremental pressure on these facilities. For example, in 2015 (the most recent year in which data is available) there were a total of 24,458 aircraft movements in the LSA. This includes 6,056 aircraft movements at North Baffin LSA airports (Statistics Canada 2016f) and 18,402 aircraft movements at the Iqaluit airport (Statistics Canada 2016g). Project-related aircraft movements at community airports in the LSA in 2015 represent only a small portion (5.4%) of this total.

9. VSEC – RESOURCES AND LAND USE

9.1 VARIOUS RESIDUAL EFFECTS

9.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project could have some negative effects on Inuit travel and camping. These include effects on safe travel around Eclipse Sound and Pond Inlet, safe travel through Milne Port, emission and noise disruption at camps, sensory disturbances and safety along the Milne Inlet tote road, detouring around the mine site for safety and travel, difficulty and safety relating to railway crossing, and detouring around Steensby Port.

Shipping-related mitigation measures developed and/or proposed by Baffinland include the provision of community public safety awareness campaigns (e.g. informing the community of vessel movements, tracking the route and timing of passage, periodic public meetings and information sessions), commitments to placing reflective markers around the ship track, establishing a detour around Steensby Port and providing food, shelter, and fuel to detouring travellers. Road and rail-related mitigation measures developed and/or proposed by Baffinland include the development of a roads management plan (e.g. establishing speed control and signage, ensuring truck operator vigilance, reporting of non-Project individuals), public education, and the addition of six railway crossing locations. Mine site-related mitigation measures developed by Baffinland include various public safety mechanisms (e.g. establishing signage and access barriers, restrictions on entering industrial sites), and the development of a mine closure plan.

9.1.2 Indicator Data

Number of Recorded Land Use Visitor Person-Days at Project Sites

The number of recorded land use visitor 'person-days' at Project sites provides an indication of how often the Project area continues to be accessed for land use activities. Because groups of individuals may travel together and/or utilize Project sites over multiple days, person-days are useful for calculating the extent of site visitations in a year (i.e. one person-day is equal to one person visiting a site during one day, while ten person-days could equal one person visiting a site during ten days or five people visiting a site during two days). Baffinland maintains a 'Human Use Log' to track all land use parties that pass through or use Project areas. Table 23 presents the number of recorded land use visitor person-days at Project sites from 2013 to 2016. In 2016, a total of 293 land use visitor person-days were recorded at Project sites, which is 77 person-days more than in 2015.

Number of Wildlife Compensation Fund Claims

The number of annual Wildlife Compensation Fund claims[20] provides insight into harvesting issues which may be arising because of the Project. In 2016, two claims were submitted to QIA for review. One claim was approved and resulted in compensation of $600.00, while the second claim was reviewed and denied.

---

[20] The Wildlife Compensation Fund, established under the IIBA, is administered by the QIA and functions to compensate Inuit for incidents where Project activities interfere with or inhibit harvesting activities.

Number of Recorded Land Use Visitor Person-Days at Project Sites			
Year	**Mary River**	**Milne Port**	**Total**
2013	41	0	41
2014	14	57	71
2015	4	212	216
2016	15	278	293

Source: Baffinland records. This table only includes recorded land use visitors at selected Project sites; as such, it may underestimate the total number of land users accessing all Project sites.

Table 23: Number of recorded land use visitor person-days at Project sites (2013 to 2016)

9.1.3 Analysis

Monitoring data suggests Inuit land use and harvesting coexists with the Project. Local land users continued to access Project sites in 2016 and the number of land use visitor person-days have increased every year since record-keeping was commenced. However, Baffinland acknowledges the potential for future wildlife-related impacts from the Project and has contributed $750,000.00 to a Wildlife Compensation Fund (administered by the QIA under the terms of the IIBA) to address this issue. While two Wildlife Compensation Fund claims were made in 2016, only one of these was eventually approved (for a relatively small amount of compensation - $600.00). Furthermore, annual terrestrial and marine monitoring programs conducted by Baffinland have failed to reveal any significant Project-related impacts on terrestrial or marine resources utilized by residents of the LSA.

10. VSEC – ECONOMIC DEVELOPMENT AND SELF-RELIANCE

10.1 PROJECT HARVESTING INTERACTIONS AND FOOD SECURITY

10.1.1 Project Certificate Condition

No specific prediction related to Project harvesting interactions and food security was presented in the Final EIS. However, Project Certificate condition #148 states:

> *The Proponent is encouraged to undertake collaborative monitoring in conjunction with the Qikiqtaaluk Socio-Economic Monitoring Committee's monitoring program which addresses Project harvesting interactions and food security and which includes broad indicators of dietary habits.*

10.1.2 Indicator Data

Project Harvesting Interactions and Food Security

Appropriate community-level indicator data are currently unavailable for this topic. As such, this topic will continue to be tracked through the QSEMC process and Baffinland's community engagement program. Should indicators be required in the future, they will be selected in consultation with the Mary River SEMWG. However, some indicator data related to Project harvesting interactions and food security have already been presented in this report. For example, Section 7.2 discussed household income and food security and provided indicator data on *proportion of taxfilers with employment income*, *median employment income*, and *percentage of population receiving social assistance*. Section 9.1 discussed the topic of resources and land use and provided indicator data on *number of recorded land use visitor person-days at Project sites* and *number of Wildlife Compensation Fund claims*. Please refer directly to these sections for additional information.

Comments on harvesting and food security continue to be received through Baffinland's community engagement program. For example, the following comments on the importance of harvesting were made during recent community workshops held by Baffinland (see Jason Prno Consulting Services Ltd. 2017):

> *"…we care about the ocean in front of us because that's where our wildlife and food comes from. The ocean is like our farm. We live off what grows from there. For that reason, it's our life too. It's part of our culture. That's how we are different from southerners." [Pond Inlet Meeting Participant]*

> *"We historically relied on the game, we still do. We still hunt to survive. We're still like that. It's part of our Inuit system. We still eat country food. If that were to be affected in some way we would be very concerned." [Pond Inlet Meeting Participant]*

> *"We can't stop hunting as we need the food." [Pond Inlet Meeting Participant]*

> *"When you're used to eating caribou, it is much more delectable than eating store-bought food. Some of the caribou hunters are very hard-pressed. They are tired of relying on social income and want to eat healthy food." [Pond Inlet Meeting Participant]*

"We Inuit know we have full access to wildlife in the area, but when you're short of money, it's hard to keep up with the food. And you can only survive if you help each other with money. The youth are more centred on money nowadays. Before, we survived more on wildlife." [Pond Inlet Meeting Participant]

Some data also exists on this topic at the territorial level. For example, data from the 2012 Aboriginal Peoples Survey (Statistics Canada 2015a) indicates approximately 66% of Nunavummiut hunted, fished, or trapped in the past year, while approximately 37% of Nunavummiut hunted, fished, or trapped at least once a week during the season. Likewise, approximately 43% of Nunavummiut gathered wild plants in the past year, while approximately 29% of Nunavummiut gathered wild plants at least once a week during the season.

Achieving food security remains a pressing issue in Nunavut (e.g. Nunavut Food Security Coalition 2016). The Nunavut Food Security Coalition (2016) notes that food security exists when all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food insecurity exists when these conditions fail to be met. Data from the 2012 Aboriginal Peoples Survey (Statistics Canada 2015b) indicates approximately 25% of Nunavummiut have very low food security, 26% have low food security, while 41% have high or marginal food security.

The 2016 North Baffin community survey conducted by Baffinland provides some additional insight into this topic. For example, 65% of survey respondents indicated they were not concerned about how the Project was affecting their community or environment. 18% indicated they had concerns about Project effects on the environment. These concerns included effects on terrestrial and marine wildlife due to dust, changes in water quality, shipping, and blasting noise. 17% of survey respondents indicated they had concerns about Project effects on the community, which included effects on harvesting and other issues.

Some comments on potential Project-harvesting interactions have also been documented through Baffinland's community engagement program. For example, some participants in recent community workshops held by Baffinland (see Jason Prno Consulting Services Ltd. 2017) described negative effects that have been experienced because of the Project. In one instance, hunters said they were unable to execute a successful hunt because the wake of a passing Baffinland ship caused excessive movement of their boat and prevented them from shooting their targeted species. Another incident of concern involved narwhal hunters in a boat near the Milne Inlet port site being approached by Baffinland employees and being told they could not hunt in that location.

More generally, it was noted that Pond Inlet residents no longer use the Milne Inlet area as much as they did in the past because of the Project activities that now occur there. Some residents have also questioned whether Baffinland has been responsible (because of shipping and other Project activities) for recently observed changes to marine wildlife. These have included fewer narwhal being observed, a noted increase in harp seals in Eclipse Sound, and several dead sculpin and fish that were found in the Eclipse Sound area in the summer of 2015.

10.1.3 Analysis

It's evident that harvesting and consumption of country food remains a valued and important part of the Inuit culture and diet. As noted in Section 7.2, there are indications the Project continues to improve household income and food security in the LSA, by providing LSA residents with meaningful incomes (through employment) that enable the purchase of food and support the participation in harvesting activities. Baffinland also contributes to various community wellness initiatives (e.g. through the INPK Fund in the IIBA), which may assist individuals not directly benefiting from Project employment. Some concern has been expressed about potential negative effects of the Project on local harvesting. Concerns have also been expressed about declining rates of country food consumption and the lack of food security in Nunavut, generally.

Monitoring data presented in Section 9.1 also suggests Inuit land use and harvesting coexists with the Project. Local land users continued to access Project sites in 2016 and the number of land use visitor person-days have increased every year since record-keeping was commenced. However, Baffinland acknowledges the potential for future wildlife-related impacts from the Project and has contributed $750,000.00 to a Wildlife Compensation Fund to address this issue. Furthermore, annual terrestrial and marine monitoring programs conducted by Baffinland have failed to reveal any significant Project-related impacts on terrestrial or marine resources utilized by residents of the LSA.

11. VSEC – BENEFITS, ROYALTY, AND TAXATION

11.1 PAYMENTS OF PAYROLL AND CORPORATE TAXES TO THE TERRITORIAL GOVERNMENT

11.1.1 Predicted Effect and Mitigation Measures

The Final EIS predicted the Project would have a beneficial effect on revenues (e.g. through taxes) flowing to the territorial government. No specific mitigation measures have been developed to support this prediction.

11.1.2 Indicator Data

Annual Payroll and Corporate Taxes Paid by Baffinland to the Territorial Government

The value of annual payroll and corporate tax payments by Baffinland to the territorial government helps demonstrate the effect the Project has on revenues flowing to the territorial government. In 2016, Baffinland paid $1,134,975.08 in employee payroll tax to the Government of Nunavut (i.e. a 2% payroll tax levy; other payroll taxes are paid to the federal government). Baffinland did not pay any corporate income tax in 2016 (as the Company is not yet profitable) or property tax (as lease payments are made to the QIA and not the Government of Nunavut).

11.1.3 Analysis

The Project continued to pay taxes to the Government of Nunavut in 2016. As predicted in the Final EIS, the positive effect of the Project on revenues flowing to the territorial government is confirmed for this reporting period. Baffinland expects increased tax amounts will be paid once the Company enters full commercial production and becomes profitable.

12. CONCLUDING REMARKS

12.1 SUMMARY

12.1.1 Report Summary

This report has assessed the socio-economic performance of the Mary River Project in 2016, as well as Baffinland's compliance with various Project Certificate conditions. Performance was assessed using socio-economic indicators for a number of VSECs included in the Final EIS:

- Population demographics
- Education and training
- Livelihood and employment
- Contracting and business opportunities
- Human health and well-being
- Community infrastructure and public services
- Resources and land use
- Economic development and self-reliance
- Benefits, royalty, and taxation

The information presented in this report supports many of the Final EIS predictions for these VSECs and identifies positive effects the Project has had. For example, approximately 1,881,506 hours of Project labour were performed by Baffinland employees and contractors in Nunavut in 2016, which was equal to approximately 905 full time equivalent positions. Of this total, 305,836 hours were worked by residents of the LSA. In addition, approximately $7.6 million in payroll was provided to Baffinland LSA employees (not including contractors) and $64.4 million was spent on procurement with Inuit-owned businesses and joint ventures in 2016.

Employment in the LSA is one area where Project activities didn't fully match Final EIS predictions in 2016. For example, LSA employment hours in 2016 were slightly lower than originally predicted (although North Baffin LSA employment hours *did* correspond with Final EIS predictions). Likewise, there were several Inuit employee departures in 2016. Baffinland continues to take positive steps to address the issue of Inuit employment and is in the process of finalizing an Inuit Human Resources Strategy (IHRS) and Inuit Contracting and Procurement Strategy (ICPS). These documents will describe goals and initiatives that will be used to increase Inuit employment and contracting at the Project. The ongoing establishment of an annual Minimum Inuit Employment Goal (MIEG) with the QIA should also assist with increasing Inuit employment in the future. However, additional monitoring will be necessary to track the success of these and other Baffinland Inuit employment programs. Baffinland will also continue to track employee turnover causes and outcomes, moving forward.

Where appropriate, trends have been described for the indicators assessed in this report. These trends (i.e. pre-development, post-development, and since the previous year) demonstrate whether an indicator has exhibited change and describes the direction of that change. Trend analyses can also be useful for assessing potential Project influences on an indicator. In some cases, additional data and monitoring will be necessary before the Final EIS predictions presented in this report can be fully verified. In others, direct correlations between the Project and data trends were either unable to be identified or were unclear. The process of socio-economic monitoring often requires many years of data to effectively discern trends and causality. Even then, various factors may be found to influence causality and some of these may not be easy to measure. Successful socio-economic monitoring for the Project will require appropriate long-term data, the regular input of all Project stakeholders, and a focus on continuous improvement.

The objectives of this 2016 report (presented in Section 1.3) have been accomplished in several ways. First, this report provided an analysis (in Sections 3 to 11) of selected socio-economic effects that were predicted to occur in the Project's Final EIS. Second, this analysis provided insight into the functioning of Baffinland's existing socio-economic mitigation and management programs (again, in Sections 3 to 11). Third, this report provided information that will assist regulatory and other agencies in evaluating Baffinland's compliance with socio-economic monitoring requirements for the Project (found throughout the report, but Appendix B summarizes how Baffinland has addressed Project Certificate conditions related to socio-economic monitoring). Finally, this report supports Baffinland's adaptive management objectives for the Project, as all issues identified in this report will continue to be monitored and opportunities for potential performance improvements will be assessed.

12.1.2 Summary of Regional and Cumulative Economic Effects

This section provides a summary of regional and cumulative economic effects related to the Project. This is in relation to Project Certificate condition #169, which states:

> *The Proponent provide an annual monitoring summary to the NIRB on the monitoring data related to the regional and cumulative economic effects (positive and negative) associated with the Project and any proposed mitigation measures being considered necessary to mitigate the negative effects identified.*

The Project continued to make positive contributions to the Nunavut economy in 2016. As noted earlier, 1,881,506 hours of Project labour were performed by Baffinland employees and contractors in Nunavut in 2016, which was equal to approximately 905 full time equivalent positions. In addition, approximately $7.6 million in payroll was provided to Baffinland LSA employees and $64.4 million was spent on procurement with Inuit-owned businesses and joint ventures in 2016. When compared to annual economic outputs for Nunavut as a whole, these values are notable. In 2015 (the most recent year for which estimates are available), for example, there were a total of 15,815 jobs held in Nunavut and 28,338,000 total hours worked (Nunavut Bureau of Statistics 2016j), with average weekly earnings of $1,256.70 per employee (Nunavut Bureau of Statistics 2016k). By comparison, hours worked by Baffinland's employees and contractors in Nunavut in 2015 (i.e. 1,844,081) represent 6.5% of the Nunavut total. Average weekly earnings of Baffinland's Inuit employees in 2015 were also higher than the Nunavut average, at $1,851.57.[21]

---

[21] Baffinland Inuit employee numbers (92) and payroll amounts ($8,857,916.00) for 2015 were presented in Baffinland's 2015 Socio-Economic Monitoring Report. Employee numbers in 2015 were calculated based on regular full-time employees on staff at the end of December 2015. Weekly employee earnings are thus an estimate and may not fully reflect average amounts for the year.

Mining remains an important contributor to the Nunavut economy. Nunavut's real gross domestic product[22] (GDP) for all industries in 2015 was $2,027.2 million. Of this amount, '*mining, quarrying, and oil and gas extraction*' was responsible for contributing $337.4 million, while '*construction'* was responsible for $261.0 million (Nunavut Bureau of Statistics 2016l). The Mary River Project has been an important contributor to these amounts, as has Agnico Eagle Mines Limited's Meadowbank Mine (Nunavut's only other operating mine), and several other Nunavut-based mining projects that are in various stages of development. Mining in Canada, generally, contributed $57 billion to the country's GDP, or 3.5% of total Canadian GDP (in 2014). The industry also employs some 375,000 individuals and remains the largest proportional private sector employer of Aboriginal peoples in the country (Mining Association of Canada 2016).

No negative regional or cumulative economic effects associated with the Project were identified in 2016. As such, no mitigation measures are being proposed to mitigate negative effects.

12.2 ADAPTIVE MANAGEMENT

This report identifies several positive effects the Project has had on VSECs described in the Final EIS and supports many of the Final EIS predictions that were made. The information contained in this report also suggests the mitigation and management measures established by Baffinland for these VSECs are functioning largely as anticipated (or require additional time to have their potential fully realized). However, LSA employment and Inuit employee turnover are areas Baffinland will continue to address in 2017. Implementation of Baffinland's Inuit Human Resources Strategy (IHRS) and Inuit Contracting and Procurement Strategy (ICPS), and ongoing establishment of a Minimum Inuit Employment Goal (MIEG) with the QIA should assist with increasing LSA employment over time. Continued monitoring of LSA employment hours, causes of employee turnover, and the initiatives described in the IHRS and ICPS will be necessary to ensure successful socio-economic outcomes. Opportunities for potential performance improvements in these areas will also be assessed throughout 2017.

While additional monitoring will be required to confirm the findings presented in this report over the long-term, no need has been identified to update any of the Final EIS predictions or to significantly modify Baffinland's existing management approach. However, Baffinland will continue to use adaptive management as a tool for improving the Project's overall socio-economic performance in the future.

12.3 FUTURE MONITORING AND REPORTING

As noted previously, Baffinland has developed a socio-economic monitoring plan for the Project (see Section 1.4) which addresses the VSECs assessed in the Final EIS. Using this plan, Baffinland will continue to monitor and report on Project-related socio-economic performance on an annual basis. Regular engagement with the Mary River SEMWG and QSEMC on socio-economic matters will also occur.

---

[22] The Bank of Canada (2016) notes real GDP is "the most common way to measure the economy…GDP is the total value of everything - goods and services - produced in our economy. The word "real" means that the total has been adjusted to remove the effects of inflation." ISEDC (2011) adds that GDP *by industry* "measures the value of output of an industry less the value of intermediate inputs required in the production process." The real GDP amounts by industry presented by the Nunavut Bureau of Statistics (2016l) are in chained 2007 dollars.

Effectiveness of the Project's socio-economic monitoring program will be evaluated in an on-going manner. Should the need arise to modify this program, both the Mary River SEMWG and QSEMC will be consulted. Feedback obtained through this evaluation process may lead to future modifications of the Project's socio-economic monitoring plan, indicators used, and/or methods of analysis employed. Baffinland also anticipates that monitoring may cease for some indicators in the future, especially in cases where monitoring has sufficiently verified Final EIS predictions over time.

12.4 CONCORDANCE WITH PROJECT CERTIFICATE CONDITIONS ON SOCIO-ECONOMIC MONITORING

Submission of this report helps achieve concordance with several Project Certificate conditions related to socio-economic monitoring. A summary of each Project Certificate condition related to socio-economic monitoring, a description of how Baffinland has addressed each of these conditions, and 2016 socio-economic monitoring report references for these conditions (where applicable) can be found in Appendix B.

13. REFERENCES

Bank of Canada. 2016. Measuring Economic Growth. Accessed February 1, 2016. http://www.bankofcanada.ca/core-functions/monetary-policy/measuring-economic-growth/

Bell, J. 2012. Meadowbank a reality check for Nunavut mining: AEM executive. *Nunatsiaq News*. April 20, 2012. Accessed February 4, 2016. http://www.nunatsiaqonline.ca/stories/article/65674meadowbank_a_reality_check_for_nunavut_mining_aem_executive/

British Columbia Environmental Assessment Office (BCEAO). 2013. *Guideline for the Selection of Valued Components and Assessment of Potential Effects*. Accessed January 14, 2016. http://www.eao.gov.bc.ca/VC_Guidelines.html

Brubacher Development Strategies Inc. 2015. *Baffinland Iron Mines Corporation Mary River Project 2014 Socio-Economic Monitoring Report.* Prepared for Baffinland Iron Mines Corporation. March 2015.

Brubacher Development Strategies Inc. 2016. *Baffinland Iron Mines Corporation Mary River Project: Mary River Experience – The First Three Years.* January 18, 2016.

Conference Board of Canada. 2016. Education and Skills in the Territories. Accessed February 16, 2016. http://www.conferenceboard.ca/hcp/provincial/education/edu-territories.aspx

Eegeesiak, E. 2016. Inuit Firm Registry Coordinator, Nunavut Tunngavik Incorporated. Personal communication: February 2016.

Government of Nunavut. 2014. *Public Service Annual Report 2013-2014*. Prepared by the Department of Finance. Accessed February 4, 2016. http://www.gov.nu.ca/sites/default/files/public_service_annual_report_2013-14_english.pdf

Government of Nunavut. 2015. *Qikiqtaaluk Socio-Economic Monitoring Committee Spring 2015 Report*. Produced by the Government of Nunavut Department of Economic Development & Transportation. July 2015.

Government of Nunavut. 2016. *Qikiqtaaluk Socio-Economic Monitoring Committee 2016 Annual Meeting Report*. Produced by the Government of Nunavut Department of Economic Development & Transportation. April 4, 2016.

Gregoire, L. 2014. Nunavut premier says targeted training needed to build the future. *Nunatsiaq News*. January 30, 2014. Accessed February 16, 2016. http://www.nunatsiaqonline.ca/stories/article/65674nunavut_premier_says_targetted_training_needed_to_build_future/

Innovation, Science and Economic Development Canada (ISEDC). 2011. Canadian Industry Statistics – Glossary of Terms. Accessed February 1, 2016. https://www.ic.gc.ca/eic/site/cissic.nsf/eng/h_00005.html#rindex

Jason Prno Consulting Services Ltd. 2016. *Draft 2015 Socio-Economic Monitoring Report for the Mary River Project*. Report prepared for Baffinland Iron Mines Corporation. March 2016.

Jason Prno Consulting Services Ltd. 2017. *Results of Community Workshops Conducted for Baffinland Iron Mines Corporation's Phase 2 Proposal*. Report prepared for Baffinland Iron Mines Corporation. January 2017.

MacDonald, J. 2014. Occupational demand in the Nunavut mining sector: Developing the labour force. Presentation to the Nunavut Mining Symposium. Iqaluit, Nunavut. April 8, 2014.

Mining Association of Canada. 2016. *Facts and Figures of the Canadian Mining Industry 2015*. Accessed February 5, 2016. http://mining.ca/sites/default/files/documents/Facts-and-Figures-2015.pdf

Mining Industry Human Resources Council (MIHR). 2014. *Nunavut Mining Hiring Requirements and Available Talent Forecasts 2014*. Prepared for and in partnership with the Government of Nunavut. Accessed February 16, 2016.

http://www.gov.nu.ca/sites/default/files/nunavut_mining_hiring_requirements_and_available_talent_forecasts_web.pdf

Mining Industry Human Resources Council. 2016. *Exploring Gender Inclusion.* Accessed January 4, 2017. https://www.mihr.ca/pdf/MiHR_Gender_Report_EN_WEB.pdf

Noble, B.F. 2015. *Introduction to Environmental Impact Assessment: A Guide to Principles and Practice*. Third ed. Toronto, Ontario: Oxford University Press.

Nunavut Bureau of Statistics (NBS). 2009. *Guide to the Labour Force Survey in Nunavut*. Accessed February 17, 2016. http://www.stats.gov.nu.ca/en/Labour%20survey.aspx

Nunavut Bureau of Statistics (NBS). 2013. *Community Tables_Education_2011 NHS (2 tables).xlsx*. Accessed February 17, 2016. http://www.stats.gov.nu.ca/en/Census%202011NHS.aspx

Nunavut Bureau of Statistics (NBS). 2014. *Nunavut Social Assistance Recipients, 2005 to 2013.xlsx.* Prepared by Nunavut Bureau of Statistics December 11, 2014. Accessed February 14, 2017. http://www.stats.gov.nu.ca/en/Social%20assistance.aspx

Nunavut Bureau of Statistics (NBS). 2016a. *Nunavut Population Estimates by Inuit and Non-Inuit, Region and Community, 2001 to 2016 (3 tables).xlsx*. Prepared by Nunavut Bureau of Statistics December 1, 2016. Accessed December 8, 2016. http://www.stats.gov.nu.ca/en/Population%20estimate.aspx

Nunavut Bureau of Statistics (NBS). 2016b. *Nunavut Annual Migration Estimates, 1999 to 2016.xlsx.* Prepared by Nunavut Bureau of Statistics October 3, 2016. Accessed November 9, 2016. http://www.stats.gov.nu.ca/en/Population%20migration.aspx

Nunavut Bureau of Statistics (NBS). 2016c. *Nunavut Secondary School Graduates by Community, 1999 to 2015_Revised.xlsx*. Prepared by Nunavut Bureau of Statistics October 18, 2016. Accessed November 9, 2016. http://www.stats.gov.nu.ca/en/Social%20education.aspx

Nunavut Bureau of Statistics (NBS). 2016d. *Nunavut Secondary School Graduates, 1999 to 2015 (2 tables)_Revised.xlsx*. Prepared by Nunavut Bureau of Statistics October 18, 2016. Accessed November 9, 2016. http://www.stats.gov.nu.ca/en/Social%20education.aspx

Nunavut Bureau of Statistics (NBS). 2016e. *Nunavut Taxfilers with Employment Income by Region and Community, 2006 to 2014.xls*. Prepared by Nunavut Bureau of Statistics November 3, 2016. Accessed November 15, 2016. http://www.stats.gov.nu.ca/en/Economic%20income.aspx

Nunavut Bureau of Statistics (NBS). 2016f. *Nunavut Criminal Violations by Type and Community, 1999 to 2015 (26 tables).xlsx.* Prepared by Nunavut Bureau of Statistics August 4, 2016. Accessed November 15, 2016. http://www.stats.gov.nu.ca/en/Social%20crime.aspx

Nunavut Bureau of Statistics (NBS). 2016g. *Nunavut Community Health Centre Visits, 2003 to 2014 (28 tables).xlsx*. Prepared by Nunavut Bureau of Statistics May 30, 2016. Accessed November 15, 2016. http://www.stats.gov.nu.ca/en/Social%20health.aspx

Nunavut Bureau of Statistics (NBS). 2016h. *Nunavut Criminal Violations by Region and Community, 1999 to 2015 (16 tables).xls.* Prepared by Nunavut Bureau of Statistics July 22, 2016. Accessed November 15, 2016. http://www.stats.gov.nu.ca/en/Social%20crime.aspx

Nunavut Bureau of Statistics (NBS). 2016i. *Nunavut Population Estimates by Sex and Marital Status, 2001 to 2015 (3 tables).xls.* Prepared by Nunavut Bureau of Statistics November 2, 2016. Accessed January 10, 2017. http://www.stats.gov.nu.ca/en/Population%20estimate.aspx

Nunavut Bureau of Statistics (NBS). 2016j. *Nunavut Number of Jobs and Hours Worked, 1999 to 2015.xls.* Prepared by Nunavut Bureau of Statistics June 28, 2016. Accessed November 8, 2016. http://www.stats.gov.nu.ca/en/Labour%20and%20employment.aspx

Nunavut Bureau of Statistics (NBS). 2016k. *Nunavut Employment and Earnings, 2001 to 2015.xls.* Prepared by Nunavut Bureau of Statistics February 25, 2016. Accessed November 8, 2016. http://www.stats.gov.nu.ca/en/Labour%20and%20employment.aspx

Nunavut Bureau of Statistics (NBS). 2016l. *Nunavut Real GDP by Industry, 2011 to 2015.xls.* Prepared by Nunavut Bureau of Statistics May 12, 2016. Accessed November 8, 2016. http://www.stats.gov.nu.ca/en/Economic%20GDP.aspx

Nunavut Bureau of Statistics (NBS). 2017. *Labour Force Tables for Nunavut, 3MMA Ending in January 2016 and 2017 (4).xls.* Prepared by Nunavut Bureau of Statistics February 10, 2017. Accessed February 24, 2017. http://www.stats.gov.nu.ca/en/Labour%20survey.aspx

Nunavut Food Security Coalition. 2016. *Homepage.* Accessed January 9, 2016. https://www.nunavutfoodsecurity.ca/

Nunavut Impact Review Board (NIRB). 2013. *Monitoring: NIRB Public Guide Series.* Accessed January 7, 2015. http://www.nirb.ca/guides

Nunavut Impact Review Board (NIRB). 2014. *Project Certificate No. 005 for the Mary River Project, Amendment Number 01*. Issued by the Nunavut Impact Review Board to Baffinland Iron Mines Corporation on May 28, 2014.

Nunavut Tunngavik Incorporated (NTI). 2016. Inuit Firm Registry Database – Search the Registry. Accessed December 31, 2016. http://inuitfirm.tunngavik.com/search-the-registry/

Pauktuutit, K. Czyzewski, F. Tester, N. Aaruaq, and S. Blangy. 2014. *The Impact f Resource Extraction on Inuit Women and Families in Qamani'tuaq, Nunavut Territory: A Qualitative Assessment.* Accessed January 26, 2017. http://pauktuutit.ca/wp-content/blogs.dir/1/assets/Report-Final-Jan-2015.pdf

Pauktuutit. Undated. *Impacts of Resource Extraction on Inuit Women*. Accessed January 26, 2017. http://pauktuutit.ca/wp-content/blogs.dir/1/assets/08-Mining-Fact-Sheet_EN.pdf

Socio-Economic Monitoring Committees (SEMCs). 2016. About. Accessed January 5, 2016. http://nunavutsemc.com/?page_id=4

Sponagle, J. 2016. No childcare forces Iqaluit mom to leave town. *CBC News North*, July 11, 2016. Accessed January 26, 2017.

Statistics Canada. 2015a. *Table 576-0006 - Aboriginal peoples survey, harvesting activities by age group and sex, Inuit population aged 15 years and over, Canada and Inuit Nunangat, occasional,* CANSIM (database). Date modified November 9, 2015. Accessed January 9, 2017. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=5760006&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=

Statistics Canada. 2015b. *Table 577-0010 - Aboriginal peoples survey, food security, by age group, sex, and number of persons in household, Inuit population aged 6 years and over, Canada and Inuit Nunangat, occasional,* CANSIM (database). Date modified November 6, 2015. Accessed January 9, 2017. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=5770010&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=

Statistics Canada. 2016a. *Table 252-0082 – Incident-based crime statistics, by detailed violations and police services, Territories, annual (number unless otherwise noted),* CANSIM (database). Date modified July 19, 2016. Accessed November 14, 2016. http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=2520082

Statistics Canada. 2016b. *Table 051-0001 - Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (persons unless otherwise noted),* CANSIM (database). Date modified September 28, 2016. Accessed November 9, 2016. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0510001&pattern=&csid=

Statistics Canada. 2016c. *Women in Canada: A Gender-Based Statistical Report. First Nation, Métis and Inuit Women.* Produced by Paula Arriagada. Catalogue no. 89-503-X. Release date February 23, 2016. Accessed January 26, 2017. http://www.statcan.gc.ca/pub/89-503- x/2015001/article/14313-eng.pdf

Statistics Canada. 2016d. *Family Violence in Canada: A Statistical Profile, 2014.* Produced by the Canadian Centre for Justice Statistics. Catalogue no. 85-002-X. Release date January 21, 2016. Accessed January 10, 2017.

Statistics Canada. 2016e. *Table 102-4503 – Live births, by age of mother, Canada, provinces and territories, annual,* CANSIM (database). Date modified October 26, 2016. Accessed January 10, 2017.
http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1024503&pattern=&csid=

Statistics Canada. 2016f. *Table 401-0037 – Annual aircraft movements, by class of operation and type of operation, airports without air traffic control towers, occasional (number),* CANSIM (database). Date modified June 16, 2016. Accessed December 13, 2016.
http://www5.statcan.gc.ca/cansim/a26?id=4010037&retrLang=eng&lang=eng

Statistics Canada. 2016g. *Table 401-0030 Aircraft movements, by class of operation, airports with NAV CANADA flight service stations, annual (number),* CANSIM (database). Date modified. June 1, 2016. Accessed December 13, 2016.
http://www5.statcan.gc.ca/cansim/a26?id=4010030&retrLang=eng&lang=eng
http://www.statcan.gc.ca/pub/85-002-x/2016001/article/14303-eng.pdf

Taylor, S. 2002. *The Employee Retention Handbook.* London, England: Chartered Institute of Personnel and Development.

Vanclay, F., Esteves, A.M., Aucamp, I. & Franks, D. 2015 *Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Projects*. Fargo ND: International Association for Impact Assessment.

APPENDIX A: TERMS OF REFERENCE FOR THE MARY RIVER SOCIO-ECONOMIC MONITORING WORKING GROUP

December 3, 2012

MARY RIVER SOCIO-ECONOMIC MONITORING WORKING GROUP
TERMS OF REFERENCE

1. PURPOSE

1.1 This document sets the Terms of Reference for the Mary River Socio-Economic Monitoring Working Group (the "Working Group"). The Working Group will support the Qikiqtaaluk Socio-Economic Monitoring Committee's (QiSEMC) regional monitoring initiatives through project-specific socio-economic monitoring. It is intended to provide a forum for Working Group members to engage in the work of the QiSEMC through identification of areas of mutual interest and socio-economic monitoring priorities related to the Mary River project, communities, and the Baffin region as a whole.

1.2 The Working Group will support the fulfillment of Terms and Conditions set out in the Mary River Project Certificate that relate to socio-economic monitoring.

2. WORKING GROUP MEMBERSHIP AND MEMBER ROLES AND RESPONSIBILITIES

2.1 The Working Group will include as members:

a. Baffinland Iron Mines Corporation (BIMC) or the successor owner/operator of the Mary River project;
b. Government of Nunavut;
c. Government of Canada; and
d. Qikiqtani Inuit Association.

2.2 Each organization is responsible for their own costs of participating in activities of the Working Group.

2.3 Role of BIMC or the successor owner/operator of the Mary River project:

a. Identify indicators and share project-specific data that can contribute to priorities identified by QiSEMC, where appropriate;
b. Participate in the analysis of data arising from collaborative monitoring;
c. Review the effectiveness of socio-economic mitigation measures;
d. Participate and prepare presentations of project-related data/issues for the QiSEMC.

2.4 Role of the Government of Nunavut:

a. Identify indicators and share data that can contribute to priorities identified by the QiSEMC, where appropriate;
b. Participate in the analysis of data arising from collaborative monitoring;
c. Participate in the analysis of effectiveness of socio-economic mitigation measures.

2.5 Role of the Government of Canada:

a. Work with the Working Group to identify and align indicators and share relevant data from the Nunavut General Monitoring Plan (NGMP);
b. Participate in the analysis of data arising from collaborative monitoring;
c. Participate in the analysis of effectiveness of socio-economic mitigation measures.

1

2.6 Role of the Qikiqtani Inuit Association:

a. Identify indicators and share data that can contribute to priorities identified by QiSEMC, where appropriate;
b. Participate in the analysis of data arising from collaborative monitoring;
c. Participate in the analysis of effectiveness of socio-economic mitigation measures.

2.7 Protection of Personal Information

It is recognized that, in collecting and sharing of any information and data under these Terms of Reference, each of the members of the Working Group is required to comply with any rules governing the collection, use, and disclosure of personal information, applicable to each member respectively, in accordance with the provisions of privacy legislation.

2.8 Information

The members acknowledge that:

a. BIMC is best able to collect and provide data concerning employment and training in relation to the Project;
b. the Government of Nunavut and the Government of Canada are best able to report public statistics on general health and well-being, food security, demographics and other socio-economic indicators at the community and territorial level; and
c. the Qikiqtani Inuit Association is best able to provide information and data relating to Inuit land use and culture at the community and regional level.

3. OBJECTIVES

3.1 The Working Group has the overall goal of contributing to the ongoing expansion of knowledge related to interactions between communities in Nunavut and the Mary River Project. The priority is on knowledge that will ultimately assist in directing socio-economic benefit from the Project, enhance the accuracy of subsequent predictions related to socio-economic impact assessment, and improve the focus and efficiency of socio-economic monitoring.

3.2 The Working Group aims to undertake collaborative monitoring in order to identify and access priority data that will be useful in improving the socio-economic performance of the Mary River Project. This will involve combining Project-specific performance data with data generated by other member agencies. The resulting insight will be useful in supporting adaptive management measures implemented by member agencies to minimize adverse effects and maximize benefits from the project. The goal will be to analyze the monitoring data in order to assess the effectiveness of current practices; obtain early warning should mitigation measures not be achieving their intended outcome; and provide timely detection of unanticipated outcomes.

3.3 The Working Group aims to improve understanding of priority socio-economic issues in order to increase confidence in socio-economic assessment predictions. The Working Group will identify priority predictions contained in the Mary River Final Environmental Impact Statement (FEIS) and will then work to address how these predictions can be validated or how unanticipated trends/observations can be described.

3.4 The Working Group will provide monitoring data and objective analysis in a manner that is focused, efficient and cost-effective.

3.5 The Working Group will ensure that project-specific monitoring aligns, where appropriate, with QiSEMC priorities, such as, but not limited to:

a. Health and well-being;
b. Education, life skills, and training;
c. Employment and career progression;
d. Demographics;
e. Land use, culture, food security; and
f. Other priorities that may be identified by the QiSEMC.

4. Reporting and Communication

4.1 BIMC or the successor owner/operator of the Mary River project will prepare an annual socio-economic report, presenting performance data, to the Nunavut Impact Review Board for review. These annual reports will be due on 30 June of each year, containing data on the indicators selected by the Working Group for the previous calendar year (January to December). These reports will further describe the Company's participation in the QiSEMC, other collaborative monitoring processes and any activities related to better understanding of socio-economic processes.

4.2 Following Project Certificate issuance and BIMC's decision to proceed with the construction of the Mary River project, annual reporting will commence following the start of site activities.

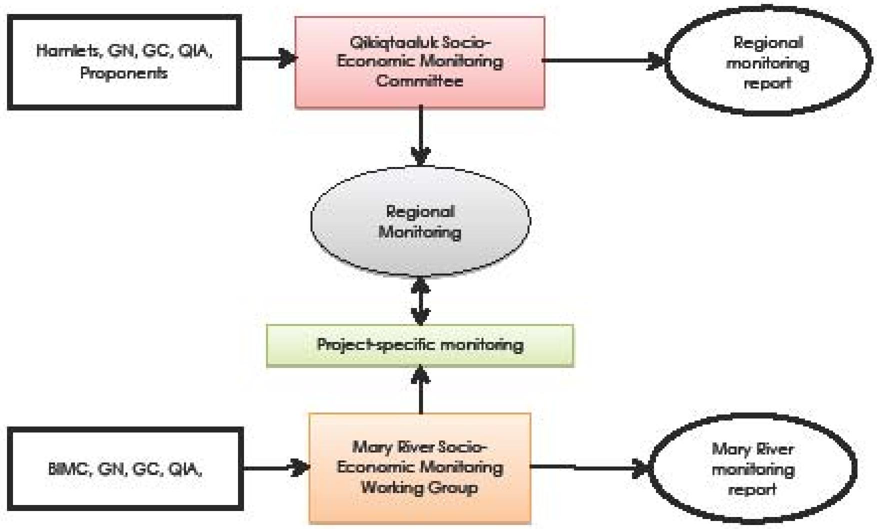
4.3 As appropriate, the Working Group may communicate with, and request data from, other issue-specific working groups that may arise throughout the life of the project.

5. Meetings

5.1 The first official meeting will be held within six (6) months of Certificate issuance or at the next QiSEMC following issuance, whichever is first.

5.2 The Working Group is to initially meet twice a year, preferably immediately prior to or immediately after the QiSEMC meetings. This meeting schedule may be changed at a later date if agreed to by all members.

5.3 BIMC will designate a Chair and optionally a Secretary for these meetings. BIMC's appointment of the Chair (which could include itself) recognises the significance of the weight of responsibility for reporting by the Company.



6. Relation to IIBA Obligations

6.1 The parties recognize that this ToR is separate from any obligations under the Inuit Impact and Benefit Agreement (IIBA) between the proponent and the Qikiqtani Inuit Association and that the mandate of the Working Group shall not include monitoring of the IIBA.

6.2 Any sharing of information with the Working Group related to the IIBA will be solely at the discretion of the Qikiqtani Inuit Association and Baffinland Iron Mines Corporation or successor.

7. Review of TORs

7.1 These Terms of Reference may be reviewed by Working Group members periodically for any required changes that may be applicable as the Project evolves from construction, through operations and closure.

APPENDIX B: CONCORDANCE WITH PROJECT CERTIFICATE CONDITIONS RELATED TO SOCIO-ECONOMIC MONITORING

Condition No.	Category	Condition	2016 Socio-Economic Monitoring Report Reference	Baffinland Comments
129	Population Demographics – Qikiqtaaluk Socio-Economic Monitoring Committee	The Proponent is strongly encouraged to engage in the work of the Qikiqtaaluk Socio-Economic Monitoring Committee along with other agencies and affected communities, and it should endeavour to identify areas of mutual interest and priorities for inclusion into a collaborative monitoring framework that includes socio-economic monitoring priorities related to the Project, communities, and the North Baffin region as a whole.	Section 1.2 Section 1.4 Appendix A	Baffinland continues to engage with the QSEMC and participates in the Mary River SEMWG, a sub-set of the QSEMC whose members include Baffinland, the Government of Nunavut, the Government of Canada, and the QIA. A Terms of Reference for the Mary River SEMWG (which identifies socio-economic monitoring priorities and objectives for the Project) has been finalized. Baffinland incorporated feedback from Mary River SEMWG members in 2016 to finalize the Project's socio-economic monitoring plan.
130	Population Demographics – Project-specific monitoring	The Proponent should consider establishing and coordinating with smaller socio-economic working groups to meet Project specific monitoring requirements throughout the life of the Project.	Section 1.2	Baffinland continues to work with the QSEMC and the Mary River SEMWG on socio-economic monitoring initiatives. In addition, Baffinland regularly engages the Pond Inlet-based Mary River Community Group and other committees which operate under provisions of the IIBA, on various socio-economic topics.
131	Population Demographics – Monitoring demographic changes	The Qikiqtaaluk Socio-Economic Monitoring Committee is encouraged to engage in the monitoring of demographic changes including the movement of people into and out of the North Baffin communities and the territory as a whole. This information may be used in conjunction with monitoring data obtained by the Proponent from recent hires and/or out-going employees in order to assess the potential effect the Project has on migration.	Section 3.1 Section 3.2 Section 3.3 Section 3.4 Appendix C	Baffinland has provided demographic change information in the 2016 socio-economic monitoring report. Baffinland also implemented a revised voluntary Employee Information Survey, which collected information related to employee changes of address, housing status, and migration intentions.
133	Population Demographics – Monitoring demographic changes	The Proponent is encouraged to work with the Qikiqtaaluk Socio-Economic Monitoring Committee and in collaboration with the Government of Nunavut's Department of Health and Social Services, the Nunavut Housing Corporation and other relevant stakeholders, design and implement a voluntary survey to be completed by its employees on an annual basis in order to identify changes of address, housing status (i.e. public/social, privately owned/rented, government, etc.), and migration intentions while respecting confidentiality of all persons involved. The survey should be designed in collaboration with the Government of Nunavut's Department of Health and Social Services, the Nunavut Housing Corporation and other relevant stakeholders. Non-confidential results of the survey are to be reported to the Government of Nunavut and the NIRB.	Section 3.4 Appendix C	Baffinland implemented a revised voluntary Employee Information Survey, which collected information related to employee changes of address, housing status, and migration intentions.
134	Population Demographics – Employee origin	The Proponent shall include with its annual reporting to the NIRB a summation of employee origin information as follows: a. The number of Inuit and non-Inuit employees hired from each of the North Baffin communities, specifying the number from each; b. The number of Inuit and non-Inuit employees hired from each of the Kitikmeot and Kivalliq regions, specifying the number from each; c. The number of Inuit and non-Inuit employees hired from a southern location or other province/territory outside of Nunavut, specifying the locations and the number from each; and d. The number of non-Canadian foreign employees hired, specifying the locations and number from each foreign point of hire.	Section 3.5	Baffinland has presented employee origin information in the 2016 socio-economic monitoring report.
140	Education and Training – Survey of Nunavummiut employees	The Proponent is encouraged to survey Nunavummiut employees as they are hired and specifically note the level of education obtained and whether the incoming employee resigned from a previous job placement or educational institution in order to take up employment with the Project.	Section 4.4 Appendix C	Baffinland implemented a revised voluntary Employee Information Survey, which collected information related to employee education and employment status prior to taking up employment with the Project.
145	Livelihood and Employment – Barriers to employment for women	The Proponent is encouraged to work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring Committee to monitor the barriers to employment for women, specifically with respect to childcare availability and costs.	Section 5.4	Baffinland has presented information on women employed at the Project and potential barriers they may face in the 2016 socio-economic monitoring report. Furthermore, specific reference is made in the Mary River Project IIBA to women in the workplace and the associated barriers they may face. This topic is addressed by Baffinland and QIA through section 7.15 of the IIBA.
148	Economic Development and Self-Reliance, and Contracting and	The Proponent is encouraged to undertake collaborative monitoring in conjunction with the Qikiqtaaluk Socio-Economic Monitoring Committee's monitoring program which addresses Project harvesting interactions and food security and which includes broad indicators of dietary habits.	Section 7.2 Section 9.1 Section 10.1	Baffinland has presented information on Project harvesting interactions and food security in the 2016 socio-economic monitoring report. Baffinland has also presented related information on household income and food security, and land user-Project interactions in this report.

	Business Opportunities – Food security			
154	Human Health and Well-being – Indirect impacts to health and well-being	The Proponent shall work with the Government of Nunavut and the Qikiqtaaluk Socio-Economic Monitoring Committee to monitor potential indirect effects of the Project, including indicators such as the prevalence of substance abuse, gambling issues, family violence, marital problems, rates of sexually transmitted infections and other communicable diseases, rates of teenage pregnancy, high school completion rates, and others as deemed appropriate.	Section 4.2 Section 7.3 Section 7.4 Section 7.6 Section 7.7 Section 7.8 Section 7.9 Section 7.10 Section 7.11	Baffinland has presented information on the prevalence of substance abuse, gambling issues, family violence, marital problems, rates of sexually transmitted infections and other communicable diseases, rates of teenage pregnancy, high school completion rates, and other topics (e.g. crime rates) in the 2016 socio-economic monitoring report.
158	Community Infrastructure and Public Services – Impacts to health services	The Proponent is encouraged to work with the Government of Nunavut and other parties as deemed relevant in order to develop a Human Health Working Group which addresses and establishes monitoring functions relating to pressures upon existing services and costs to the health and social services provided by the Government of Nunavut as such may be impacted by Project-related in-migration of employees, to both the North Baffin region in general, and to the City of Iqaluit in particular.	Section 8.3	Baffinland has presented information on pressures related to existing health and social services provided by the Government of Nunavut in the 2016 socio-economic monitoring report. A Memorandum of Understanding was also signed with the Government of Nunavut Department of Health in November 2013 regarding site health services.
159	Community Infrastructure and Public Services – Impacts to infrastructure	The Proponent is encouraged to work with the Government of Nunavut to develop an effects monitoring program that captures increased Project-related pressures to community infrastructure in the Local Study Area communities, and to airport infrastructure in all point-of-hire communities and in Iqaluit.	Section 8.4	Baffinland has presented information on Project-related pressures on community infrastructure in the 2016 socio-economic monitoring report.
168	Governance and Leadership – Monitoring program	The specific socioeconomic variables as set out in Section 8 of the Board's Report, including data regarding population movement into and out of the North Baffin Communities and Nunavut as a whole, barriers to employment for women, project harvesting interactions and food security, and indirect Project effects such as substance abuse, gambling, rates of domestic violence, and education rates that are relevant to the Project, be included in the monitoring program adopted by the Qikiqtani Socio-Economic Monitoring Committee.	Section 3.1 Section 3.2 Section 3.3 Section 3.4 Section 4.2 Section 5.4 Section 7.2 Section 7.3 Section 7.4 Section 7.6 Section 7.7 Section 10.1	Baffinland has presented information on demographic change, barriers to employment for women, Project harvesting interactions and food security, and potential indirect Project effects such as substance abuse, gambling, rates of domestic violence, and education rates in the 2016 socio-economic monitoring report.
169	Governance and Leadership – Monitoring economic effects	The Proponent provide an annual monitoring summary to the NIRB on the monitoring data related to the regional and cumulative economic effects (positive and negative) associated with the Project and any proposed mitigation measures being considered necessary to mitigate the negative effects identified.	Section 12.1.2	Baffinland has provided a summary of regional and cumulative economic effects in the 2016 socio-economic monitoring report.

APPENDIX C: BAFFINLAND EMPLOYEE INFORMATION SURVEY

Baffinland

Baffinland Employee Information Survey

This survey is voluntary. It is being conducted because Baffinland is required to collect survey information from its employees under the terms of its Project Certificate issued by the Nunavut Impact Review Board (NIRB). This survey is being offered to all Baffinland employees (not contractors) who fall into one of the following categories:

- Inuit employees residing in Nunavut
- Inuit employees residing outside of Nunavut
- Non-Inuit employees residing in Nunavut

You can choose to complete this survey on your own or with the assistance of Baffinland staff. Please let the Mary River Human Resources Office know if you require assistance. If you choose to complete this survey, you will remain confidential and your name will not be used. However, the information you provide may be used by Baffinland publically and for regulatory reporting purposes (e.g. NIRB annual reports). If you have any questions you can contact the Mary River Human Resources Office.

1. Gender:

□ Male □ Female

2. Are you:

□ Inuit □ Non-Inuit

a. If you are Inuit, are you enrolled under the Nunavut Agreement?

□ Yes □ No

3. How long have you been employed at the Project?

____

4. Highest education level obtained (check only one):

No certificate, diploma, or degree
□ No certificate, diploma or degree

High school diploma or equivalent
□ High school diploma or equivalent

Postsecondary certificate, diploma, or degree
□ Apprenticeship or trades certificate or diploma
□ College, CEGEP or other non-university certificate or diploma
□ University certificate or diploma below bachelor level
□ University certificate, diploma or degree - Bachelor's degree
□ University certificate, diploma or degree above bachelor level

5. Current community of residence:

- ◻ Arctic Bay
- ◻ Clyde River
- ◻ Hall Beach
- ◻ Igloolik
- ◻ Pond Inlet
- ◻ Iqaluit
- ◻ Other: ______________________

6. Employee work location

a. Location

- ◻ Mary River – Mine Site
- ◻ Mary River – Port Site
- ◻ Community Location
- ◻ Corporate Office (Oakville)

b. Department

____

7. What type of housing do you currently live in?

- ◻ Privately owned – Owned by you
- ◻ Privately owned – Owned by another individual
- ◻ Renting from a private company
- ◻ Public housing
- ◻ Government of Nunavut staff housing
- ◻ Other staff housing
- ◻ Other: ______________________

8. Has your housing situation changed in the past 12 months?

◻ Yes ◻ No

a. If you answered 'Yes' to Question 8, please explain (e.g. Have you moved? Has the type of housing you live in changed?)

____

9. Have you moved to a different community in the past 12 months?

◻ Yes ◻ No

a. If you answered 'Yes' to Question 9, which community did you move *from*?

____

10. Do you intend to move to a different community in the next 12 months?

◻ Yes ◻ No

Baffinland

a. If you answered 'Yes' to Question 10, which community do you intend to move *to*?

____

11. Did you resign from an academic or vocational program in order to take up employment with the Project?

☐ Yes ☐ No

a. If you answered 'Yes' to Question 11, what program were your enrolled in and where were you enrolled?

____

12. Did you resign from a previous job placement in order to take up employment with the Project?

☐ Yes ☐ No

a. If you answered 'Yes' to Question 12 what was your previous employment status (check one):

☐ Casual ☐ Part-Time ☐ Full-Time

b. If you answered 'Yes' to Question 12, what was your previous job title?

____

c. If you answered 'Yes' to Question 12, who was your previous employer?

____

Thank you for taking the time to complete this survey.
Please return this survey to the Mary River Human Resources Office.

APPENDIX I

STATUS OF PROPONENT COMMITMENTS IN 2016

Condition No.	Subject	Condition	Response
Project Setting and Description			
1	Environmental Design (Incorporation of Knowledge)	Baffinland is committed to incorporating the relevant changes in the site layout for infrastructure and design that will take into account the results of continuing environmental advances so as to address engineering concerns related to the Mary River Project.	This commitment is addressed with the submission of Issued for Construction Drawings and As Build Drawings.
3	Operations (Ore Processing and Tailings)	Baffinland will undertake only the physical crushing and screening processing of the ore generated from the Mary River Project within the project area.	The Mary River Project involves the crushing and screening of ore. It does not involve milling, processing and generation of tailings.
7	Design (Fuel Storage)	Baffinland is committed to constructing their on-land fuel storage with the capability to last at least 16 months, in lined, engineered structures as part of its normal operating practice.	At Milne Port and at the Mine Site, permanent fuel storage has been constructed. Please refer to the site layouts for the location of the permanent fuel containment areas. Steensby Port did not receive fuel and no containment was required.
12	Disaster Management Plan	Baffinland is committed to developing and implementing a Security Plan in accordance with regulatory requirements.	Addressed in Appendix A of the Emergency Response Plan (BAF-PH1-840-P16-0002).
16	Design (Railway Traffic Crossings)	Baffinland is committed to designing the rail track to allow for snow machine and ATV crossings at points intersecting with identified travel routes.	No update. Rail track has yet to be developed.
18	Railway (Locomotives)	Baffinland is committed to purchasing the highest tier (per the USA's EPA standards) of locomotive available for use at the Mary River project.	No update. Locomotives have not been purchased to date by Baffinland.
19	Railway	Baffinland is committed to having a Railway Emergency Response Plan and trained personnel for responding to Railway specific emergencies.	No update. Rail component of the Project has yet to be developed.
20	Railway (Track Clearing)	Baffinland is committed to installing ploughs on the sides of locomotives in order to ensure that the rail line is kept clear of snow during Railway operations.	No update. Rail component of the Project has yet to be developed.

Condition No.	Subject	Condition	Response
21	Railway (Maintenance/ Accident Prevention)	Baffinland is committed to carrying out regular maintenance and inspection of the Railway infrastructure in accordance with established guidelines and regulations.	No update. Rail component of the Project has yet to be developed.
22	Railway (Regulatory)	Baffinland is committed to comply with the Railway Locomotive Inspection and Safety Rules, Railway Freight Car Inspection and Safety Rules referenced in Transport Canada's final written submission to the NIRB.	No update. Rail component of the Project has yet to be developed.
23	Railway (Fuel Transfer)	Baffinland is committed to developing and finalizing an operating strategy that will provide the highest level of safety in transportation of fuel using rail cars.	No update. Rail component of the Project has yet to be developed.
24	Railway (Fuel and Hazardous Substance Transfer)	Baffinland is committed to ensuring that bulk fuel transported by rail is contained in tanker cars and all hazardous substances will be shipped in sea containers to minimize spill potential along the rail line.	No update. Rail component of the Project has yet to be developed.
25	Railway (Regulatory)	Baffinland is committed to providing detailed maps of the Railway corridor to the Nunavut Planning Commission if a NIRB project certificate is issued for the Mary River Project.	No update. Rail component of the Project has yet to be developed.
26	Marine (Safety Officer)	Baffinland is committed to appointing one of its personnel to act as a Marine Safety Officer during the construction, operation, and closure phases of the Mary River Project.	Addressed in Table 1-1 and Sections 5 and 6 (Roles and Responsibilities) in the Milne Port OPEP (BAF-PH1-830-P16-0013).
29	Marine (Shipping Route)	Baffinland is committed to ensuring that normal shipping activities will be confined to the Nunavut Settlement Area on the north side of the Hudson Straight where conditions are favorable to shipping and to incorporating the necessary mitigation measures to ensure that shipping does not impact marine wildlife and that community concerns are addressed from an operational standpoint.	No update. Southern Shipping Corridor has yet to be utilized. See Shipping and Marine Wildlife Management Plan (BAF-PH1-830-P16-0024) for description of mitigation measures adopted to ensure that shipping does not impact marine wildlife and that community concerns are addressed.

Condition No.	Subject	Condition	Response
33	Marine (Shipping)	Baffinland is committed to implementing appropriate mitigation measures including but not limited to, periodic suspension of shipping if Baffinland determines that shipping-related activities are negatively impacting the project area.	Addressed in the Shipping and Marine Wildlife Management Plan (BAF-PH1-830-P16-0024). The Marine Environment Working Group (MEWG) will inform future mitigations if required.
38	Design (Abandonment & Restoration)	Baffinland is committed to undertaking a phased approached to any abandonment and restoration, as well as final abandonment and restoration, of the Mary River Project site(s) and relevant monitoring activities in a manner that is consistent with applicable guidelines and regulations.	Addressed in the Interim Closure and Reclamation Plan (BAF-PH1-830-P16-0012).
44	General	GN is committed to working with Baffinland to ensure that an understanding of their respective roles are confirmed.	Applicable to GN.
52	IIBA	QIA is committed to explaining the contents of an IIBA for the Mary River Project to the GN once the IIBA has been finalized.	Applicable to QIA.
53	IIBA (Inuit Input into Monitoring)	Baffinland is committed to contributing to overseeing the implementation of the IIBA including monitoring of the Project on a continuous basis to allow for ongoing Inuit input related to environmental and social impacts.	The IIBA was signed between QIA and BIM in September 2013. Please refer to IIBA Annual Forum Report(s) for monitoring results related to IIBA implementation.
54	Fish Habitat Monitoring	DFO is committed to ongoing involvement in assisting Baffinland to develop a robustly designed and long-term monitoring program for verifying impact prediction, demonstrating the efficacy of mitigation measures, and adjusting those measures as needed.	Applicable to DFO.
55	CCG Services	CCG is committed to exploring the possibility of increases to its level of service in order to support shipping associated with the Mary River Project, if approved.	Applicable to CCG.
56	Consultation Opportunities (Regulatory)	AANDC is committed to exploring the possibility of having its assigned representatives inform communities in the Qikiqtani Region about the Project as it pertains to their mandate and/or responsibilities.	Applicable to INAC.

Condition No.	Subject	Condition	Response
Ecosystemic Effects			
72	Railway (Caribou) (Mortality)	Baffinland is committed to implementing appropriate measures to ensure that all caribou carcasses linked to the project activities are discarded in accordance with applicable regulations and guidelines.	This will be incorporated into the Terrestrial Environment Monitoring and Management Plan (BAF-PH1-830-P16-0027) in advance of railway operations. Wildlife compensation is also addressed in the IIBA.
76	Monitoring (Birds)	Baffinland is committed to carrying out monitoring over the next few years to look at other types of birds not considered during other research for the Mary River Project.	Addressed in Terrestrial Environment Monitoring and Management Plan (BAF-PH1-830-P16-0027) and via participation in Terrestrial Environmental Working Group (TEWG).
78	Monitoring (Marine Birds)	Baffinland is committed to continued contribution to marine bird baseline data collection along southern shipping routes.	Addressed in Marine Environment Monitoring Reports and ongoing support of seabird studies conducted by the Canadian Wildlife Service (CWS) of Environment Canada.
82	Monitoring (Biological Surveys Baseline)	Baffinland is committed to carrying out surveys in the Hudson Straight in 2012 to collect additional baseline data on species that might be potentially impacted by the project.	This is complete.
88	Regulatory (Reporting of Shoreline Study)	Baffinland is committed to making available to the NIRB and to interested persons, by December 31, 2012, the report for the shoreline studies completed for the Mary River Project in June 2012.	This was completed in 2013 through the TEWG. Minutes of the meetings are located in Appendix F.2 of the 2013 Annual Report to the NIRB.
Socio-Economic Effects			
89	Employment (Hiring Practices MOU)	Baffinland is committed to hiring practices that are consistent with the terms and conditions in the memorandum of understanding for the IIBA.	Addressed in IIBA Annual Forum Report.

Condition No.	Subject	Condition	Response
90	Employment (Hiring Practices)	Baffinland is committed to hiring Inuit at all levels in the company for the Mary River Project and intends to put a targeted recruitment program in place to ensure that Inuit, especially Inuit of the North Baffin Region, are hired.	Addressed in IIBA Annual Forum Report.
91	Employment (Preferential Hiring)	Baffinland is committed to the preferential hiring of employees from the defined points of hire, which include the communities of Pond Inlet, Igloolik, Hall Beach, Arctic Bay and Iqaluit. Baffinland may consider other points of hire if it deems that there are sufficient numbers individuals available in those communities who want to work at the project.	Addressed in IIBA Annual Forum Report.
95	Employment (Community Based Job Searching)	Baffinland is committed to distributing information related to available employment at the Mary River Project through its website, community newspapers and other methods of advertising.	This is ongoing on Baffinland's website as well as ads in community newspapers and in BCLO offices in North Baffin communities.
98	Archaeological Resources	Baffinland is committed to providing training to its employees regarding the protection of archeological resources within the project area.	This is ongoing and within current onsite training and orientation program.
99	Medical Facilities (Design)	Baffinland is committed to working with the Government of Nunavut to provide details on the design of medical facilities for the Mary River Project during the regulatory phase of the project.	This commitment was satisfied with the MOU signed with the GN in 2013.
100	Medical Facilities (Staffing)	Baffinland is committed having an on-site medical facility staffed by a registered nurse or certified paramedic in order to attend to any injury that workers might experience on-site, and is further committed to providing medi-vac services as may be required from the mine site to Iqaluit.	Baffinland currently has an on-site medical facility staffed by a registered nurse. This was also satisfied with the MOU signed with the GN in 2013.
102	Employment (Access to Harvesting)	Baffinland is committed to ensuring that, during key harvesting periods, Inuit employees are given priority to utilize vacation time over southern workers.	Addressed in IIBA signed in September of 2013.

Condition No.	Subject	Condition	Response
103	Land Use (Hunter Trapper Support)	Baffinland is committed to establishing policies related to Inuit visitation and wildlife harvesting for Inuit employees that is consistent with Baffinland's policies and which also allows for the secure storage of firearms.	Addressed in Hunter and Visitor Site Access Procedure (BAF-PH1-830-PRO-0002). It is noted Baffinland has a no hunting policy on site. Baffinland supports NIRB condition 62 prohibiting employees and contractors from bring firearms to site.
Other Matters Taken into Account			
107	Spill Training/Spill Exercises	Baffinland is committed to conducting routine training exercises and strategically placing resources and equipment on site for spill response.	Addressed in Emergency Response Plan (BAF-PH1-840-P16-0002), Spill Contingency Plan (BAF-PH1-830-P16-003), Milne Port Oil Pollution Emergency Plan (BAF-PH1-830-P16-0013) and Spill at Sea Response Plan (BAF-PH1-830-P16-0042).
109	Emergency Response	Baffinland is committed to meeting on a regular basis with the emergency response and preparedness working group to review emergency preparedness.	Since 2012, Baffinland has had annual spill response exercises whose participants include Petronav (fuel vessel), Baffinland and representatives of the community of Pond Inlet are active participants. Additional training and spill response capabilities for the community have been discussed with the Coast Guard in the past and the Coast Guard was reviewing efforts for the community to have additional spill response equipment to deal with non-Baffinland related spill response activity.

Condition No.	Subject	Condition	Response
111	Marine Regulatory (Spill Prevention Plans)	Baffinland is committed to requiring that all project vessels have Shipboard Oil Pollution Emergency Plans (SOPEPs) in place which meets or exceeds the international standards set out in the Port State Control Memorandum of Understanding, as well as trained personnel on board to respond to spills. Baffinland will be self-sufficient for spill response and will contract the services of an established Response Organization to enable the Company to escalate response capabilities to deal with spills of up to 10,000 tonnes. This Response Organization will have expertise in recovery and cleanup of spills along coast line and involving wildlife.	This commitment is satisfied by Transport Canada regulations. Baffinland has an agreement with Oil Spill Response Limited (OSRL) for spills up to 10,000 tonnes along the shipping route. A Spill at Sea Response Plan (BAF-PH1-830-P16-0042) was developed in 2015 that follows the international and Canadian best practice, ISO 15544, the IMO Manual on Assessment of Oil Spill Risk and Preparedness (2010) and the Spill Contingency Planning Guidelines and Reporting Regulations for Nunavut.
112	Spills (Fuel)	Baffinland is committed to ensuring that all spills are reported in accordance with the relevant spill contingency planning and reporting regulations and guidelines.	Addressed in Spill Contingency Plan (BAF-PH1-830-P16-003).
113	Spills (Fuel)	Baffinland is committed to exploring and implementing measures designed to recover residual fuel from spills under the surface of sea ice.	No update at this time. Bulk fuel associated with the Project is not transported in the marine environment during ice cover conditions.