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HAMMOND REEF GOLD PROJECT

Lake Water Quality Technical Support Document

VERSION 2

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Osisko Hammond Reef Gold Ltd.
155 University Avenue, Suite 1440
Toronto, Ontario M5H 3B7

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Distribution:

Alexandra Drapack, Director Sustainable Development

Cathryn Moffett, Project Manager Sustainable Development

Golder Associates

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PART A

Introduction

In support of the Osisko Hammond Reef Gold's (OHRG) Draft Environmental Impact Statement/Environmental Assessment (EIS/EA) Report, technical information related to water quality was provided in the following Technical Support Documents (TSD):

- **Water and Sediment Quality TSD** – provides a description of baseline water and sediment quality conditions within the Project site and surrounding waterbodies. This information is summarized in Section 3.0 of the EIS/EA Report.

- **Site Water Quality TSD** – provides predictions of potential changes to water quality within the mine study area as a result of the Project and information on site discharge volumes and water quality. The information and findings of this TSD are considered in other TSDs including the Lake Water Quality TSD and are summarized in Section 6.0 of the EIS/EA Report.

- **Lake Water Quality TSD** – provides a description of the predicted water quality conditions in the receiving water bodies, including Upper Marmion Reservoir, Lizard Lake and the discharge from Raft Lake Dam. The water quality analysis presented in this TSD considers site discharge water quality predictions presented in the Site Water Quality TSD, environmental processes such as hydrologic variability and hydrodynamic mixing within the receiving waters, and water level management activities at the Raft Lake Dam. The information presented in this TSD is summarized in Section 6.0 of the EIS/EA Report.

Version 1 of the Lake Water Quality TSD was published on February 15, 2013 as part of the Draft EIS/EA Report.

The Draft EIS/EA Report underwent a seven-week public review comment period after which, on April 5, 2013, OHRG received comments from the public, Aboriginal groups and the Government Review Team (GRT) seeking clarification and requesting new information.

Approximately 55 comments regarding the water quality component of the EIS/EA Report and water quality TSDs (Site Water Quality and Lake Water Quality) were received from the GRT. Written responses have been prepared for each comment and are provided in Appendix 1.IV of the EIS/EA Report.

Version 1 of the Lake Water Quality TSD has not been revised. The methods used to define the baseline water quality and predict potential changes to water quality are technically defensible and based on standard industry practices. The conclusions presented in the Lake Water Quality TSD are sound.

The EIS/EA Report has been revised and updated based on comments received. Version 2 of the Lake Water Quality TSD is comprised of the following:

- Part A: Introduction

- Part B: Supplemental Information Package (attached) that provides additional detail on new work undertaken related to the Lake Water Quality component and clarification of the information presented in the Lake Water Quality TSD.

- Part C: Version 1 of the Lake Water Quality TSD. Part C was issued in February 2013, and is available online on OHRG's website; it has not been re-printed as part of this Version 2 of the Lake Water Quality TSD. The Version 1 document should be reviewed within the context of this Version 2 document, and associated updated information as presented in Part A or Part B should be considered as correct should it differ from the information presented in Version 1.

A summary of the information found in Part B is provided below. Minor changes to the results presented in the Version 1 Lake Water Quality TSD have been made subsequent to the submittal of the Draft EIS/EA Report based on this new work. Throughout the EIS/EA Report, unless otherwise noted, all references made to the Lake Water Quality TSD are to Part C.

Revised Pit Flooding Duration

The pit flooding model was updated to better reflect planned water management activities at closure. The previous estimated flooding duration of 78 years was based on the assumption that runoff from the Waste Rock Management Facility (WRMF), Tailings Management Facility (TMF) and other project infrastructure would be diverted to the pits in perpetuity. However, as explained in the Conceptual Closure and Rehabilitation Plan TSD, runoff from these areas will be released to the environment when water quality is deemed to be suitable for discharge. The pit flooding model was updated based on this plan. The model update resulted in an increase in the predicted flooding duration to approximately 218 years. This change is not reflected in the Lake Water Quality TSD. A technical memorandum summarizing the revised pit flooding model results is provided in the Supplemental Information Package attached to the Conceptual Closure and Rehabilitation Plan TSD.

Revised Cyanide Treatment Efficiency and Baseline Lake Cyanide Concentration

Water in the cyanide leach circuit will undergo treatment through cyanide destruction processes prior to combination with the flotation tailings and release into the TMF and TMF reclaim pond. The effluent from the cyanide concentration circuit was assumed to have a concentration of 20 ppm weak acid dissociable cyanide in the previous water quality assessment. Based on ongoing engineering activities, an improved cyanide destruction efficiency been assumed, resulting in a revised concentration of effluent from the cyanide concentration circuit of 5 ppm weak acid dissociable cyanide. This change applies to the lake water quality assessment because it reduces the mine discharge cyanide concentration and reduces the resulted predicted Marmion Basin and Lizard Lake cyanide concentrations. Additionally, the baseline cyanide concentration in Marmion Reservoir had been incorrectly assumed to be equal the detection limit for free cyanide (5 µg/L), a component of total cyanide. Total cyanide concentrations have been sampled to be less than the total cyanide detection limit (2 µg/L). The assessment has been updated to consider a baseline concentration of 1 µg/L for total and free cyanide in Marmion Reservoir. This concentration is equal to half the detection limit for total cyanide. Tables 4-5, 4-6, 7-3, 7-4 and 9-1 and Appendices 2.II and 2.III of the Lake Water Quality TSD have been revised based on these new assumptions and are provided in the attached Supplemental Information Package.

Conceptual Diffuser Design and Preliminary Mixing-Zone Assessment

Several comments were received from the Ontario Ministry of Environment regarding effluent mixing in Marmion Reservoir. In response, a conceptual effluent diffuser design and preliminary mixing zone assessment was completed for the full range of anticipated discharge rates (as predicted in the Site Water Quality TSD) to estimate the potential extent and anticipated effluent concentration gradients within the near-field mixing zone at the mine effluent discharge location. The results of this assessment, including a figure showing the concentration gradients and extent of the mixing zone are provided in a technical memorandum in the attached Supplemental Information Package.

New Camp Effluent Discharge Location

In response to comments and information from the Ministry of Natural Resources that the proposed effluent discharge location from the accommodation camp is in an area containing potential walleye spawning and nursery habitat, the effluent discharge and freshwater intake locations have been relocated to an area where there is no perceived influence on the spawning habitat or other environmental impacts. The new proposed locations for the camp effluent discharge and freshwater intake are provided in a revised Figure 1-2 in the attached Supplemental Information Package.

Revised Baseline Monitoring Station Locations

The water quality monitoring program has been revised based on detailed bathymetry surveys and ongoing project developments. Some monitoring locations has been discontinued and some have been relocated to ensure that the deeper basins of the waterbodies being monitored and key locations such as the effluent discharge locations are included in the sampling plan. A revised figure presenting the 2013 water quality monitoring stations is provided in the attached Supplemental Information Package.

Additional Supplemental Information

In response to other Information Requests, additional information has been provided in the attached Supplemental Information Package. The table below provides a summary of other additional information requested and the corresponding documents in the Supplemental Information Package in which the information is provided.

Additional Information Requested	Location of Information in the Supplemental Information Package
A new figure showing a graphical representation of the effluent mixing proportions in Marmion Reservoir	New Figure EC-19
Revised box model schematic figure (Figure 3-1) showing correct references to alternative discharge locations	Revised Figure 3-1

Supplemental Information Provided in Part B

- Revised Tables 4-5,4-6, 5-4, 5-5, 7-3,7-4, and 9-1 of Version 1 Lake Water Quality TSD
- Revised Appendices 2.II and 2.III of Version 1 Lake Water Quality TSD
- Technical Memorandum: Conceptual Diffuser Design and Mixing Zone Assessment for Effluent Discharge from the Osisko Hammond Reef Gold Project (Rev 0, November 21, 2013)
- Revised Figure 1-2 of the Version 1 Lake Water Quality TSD showing new proposed locations for the camp effluent discharge and freshwater intake

- New Figure 1: Water Quality, Sediment and Profile Sample Locations in response to Information Request EC-34
- New Figure EC-19 showing graphical representation of the effluent mixing proportions in Marmion Reservoir
- Revised Figure 3-1 of the Version 1 Lake Water Quality TSD (from Response to Information Request EC-18) showing revised box model schematic figure

PART B

Supplemental Information Package

Table 4-5: Run 2ai Results for Average Water Quality Predictions in Basin 6 of Upper Marmion Reservoir for Operational Scenario.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Reservoir Baseline	Basin 6 (near discharge)	Basin 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Proportion (%)	
						0.00118	**0.00087**
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 7.8	6.5 – 7.8
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg(CaCO$_3$)	—	-25%	—	19	19	19
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.71	0.7
Sodium	mg/L	—	—	—	1.3	1.4	1.3
Sulphate	mg/L	—	—	—	1.6	1.8	1.8
Hardness	mg(CaCO$_3$)	—	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0012	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.0012	0.0012
Nutrients							
Nitrate-N	mg/L	13	—	—	0.063	0.065	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.041	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.00027	0.00022
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.00	—	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00043	0.00041
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.001	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00074	0.00073
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Receiving water quality guidelines do not exist for this parameter.

(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.

(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

Table 4-6: Run 2cii Results for Upper Bound Case Water Quality Predictions in Basin 6 and 11of Upper Marmion Reservoir for Operational Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Reservoir Baseline	Basin 6 (near discharge)	Basin 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Proportion (%)	
						0.01518	**0.00974**
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 8.3	6.5 – 8.3
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg(CaCO$_3$)	—	-25%	—	19	19	19
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.7	6.6
Chloride	mg/L	120	—	—	1.1	1.8	1.5
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.4	1.4
Potassium	mg/L	—	—	—	0.68	1.2	1
Sodium	mg/L	—	—	—	1.3	2.7	2.2
Sulphate	mg/L	—	—	—	1.6	4.9	3.7
Hardness	mg(CaCO$_3$)	—	—	—	21	22	22
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0012	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.0012	0.0012
Nutrients							
Nitrate-N	mg/L	13	—	—	0.063	0.085	0.077
Ammonia-N	mg/L	—	—	—	0.023	0.251	0.17
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.0096	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0072	0.0071
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.00	—	0.000036	0.000039	0.000038
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00019
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	**0.0028**	**0.0022**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.0014	0.001
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.0011	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.018	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000085	0.000085
Tin	mg/L	—	—	—	0.00071	0.0011	0.00099
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0023	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0053	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Receiving water quality guidelines do not exist for this parameter.

(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.

(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

Table 7-3: Run 3gi Results for Average TMF Seepage Water Quality Predictions in Lizard Lake for Operational Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	<u>PWQO</u>	MISA		Proportion (%)		
						0.0028	**0.0039**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7	7.0 – 7.8	7.0 – 7.8	7.0 – 7.8
Acidity	mg/L	—	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$	—	-25%	—	27	-	-	-
Conductivity	µS/cm	—	—	—	63	-	-	-
Total Suspended Solids	mg/L	-20	—	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	—	55	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.34	0.37	0.38
Fluoride	mg/L	—	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	—	0.9	0.94	0.96	0.96
Potassium	mg/L	—	—	—	0.65	0.76	0.81	0.82
Sodium	mg/L	—	—	—	0.67	0.97	1.1	1.1
Sulphate	mg/L	—	—	—	1.9	2.6	2.8	2.9
Carbonate (CO_{32}-)	mg/L	—	—	—	5	-	-	-
Bicarbonate ($H(CO_3)$-)	mg/L	—	—	—	30	-	-	-
Hardness	mg($CaCO_3$	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0011	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.0011	0.0011	0.0011
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.078	0.1	0.1
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.00075	0.001	0.0011
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00097	0.00097	0.00097
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00023	-	-	-
Bismuth	mg/L	—	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.00	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00013	0.00013	0.00013
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0012	0.0013	0.0013
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.00054	0.00063	0.00065
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00083	0.00084	0.00084
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	—	0.005	-	-	-
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	—	0.002	-	-	-

Notes:

<u>Underlined</u> values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Receiving water quality guidelines do not exist for this parameter.

[a] See Appendix 2.IV for the list of all parameters, guidelines and notes.

[b] Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

Table 7-4: Run 3hii Results for Maximum TMF Seepage Water Quality Predictions in Lizard Lake for Operational Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Northern	Central	Southern
						Proportion (%)		
		CCME CWQG	PWQO	MISA		0.0081	0.0095	0.0071
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7	7.0 – 7.7	7.0 – 7.7	7.0 – 7.7
DOC	% wt	—	—	—	8.2	-	-	-
TOC	% wt	—	—	—	8.5	-	-	-
Acidity	mg/L	—	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$	—	-25%	—	27	-	-	-
Conductivity	µS/cm	—	—	—	63	-	-	-
Total Suspended Solids	mg/L	-20	—	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	—	55	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	11	11	10
Chloride	mg/L	120	—	—	0.25	0.81	0.91	0.74
Fluoride	mg/L	—	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	—	0.9	1.1	1.1	1
Potassium	mg/L	—	—	—	0.65	1	1.1	1
Sodium	mg/L	—	—	—	0.67	1.7	1.9	1.6
Sulphate	mg/L	—	—	—	1.9	4.1	4.5	3.9
Hardness	mg($CaCO_3$	—	—	—	30	32	32	31
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0011	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.0011	0.0011	0.0011
Nutrients								
Nitrate	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia	mg/L	—	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0017	0.0019	0.0015
Phosphorus	mg/L	—	0.02	—	0.0082	0.0084	0.0084	0.0083
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00098	0.00099	0.00098
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00023	-	-	-
Bismuth	mg/L	—	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.00	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00014	0.00015	0.00014
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	**0.0022**	**0.0024**	**0.002**
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.001	0.0012	0.00096
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00087	0.00089	0.00087
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	—	0.005	-	-	-
Uranium	mg/L	0.015	0.005	—	0.0025	0.0026	0.0026	0.0026
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	—	0.002	-	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Receiving water quality guidelines do not exist for this parameter.

[a] See Appendix 2.IV for the list of all parameters, guidelines and notes.

[b] Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

Table 9-1: Summary of Parameters that Exceed CCME CWQG and/or PWQO Guidelines in Predicted Water Quality for all Cases in Upper Marmion Reservoir and Lizard Lake for Operational and Post-closure Scenarios

Water Quality Prediction Scenario			Parameters	Guidelines		Total Number (Basins)	Predicted Concentrations Exceeding Guidelines				Basin Location (CCME CWQG)	Basin Location (PWQO)
				CCME CWQG[(a)]	PWQO[(b)]		CCME CWQG[(a)]		PWQO[(b)]			
							Number	Percent	Number	Percent		
Operations	Marmion Reservoir	2ai – Average Case/Site Discharge	No exceedances									
Operations	Marmion Reservoir	2cii – Upper Bound Case/Site Discharge	Dissolved Copper	0.002-0.004	0.001-0.005	11	5	45%	0	0%	Basin locations:	None
Operations	Lizard Lake	3gi – Average Case/TMF Seepage	No exceedances									
Operations	Lizard Lake	3hii – Upper Bound Case /TMF Seepage	Dissolved Copper	0.002-0.004	0.001-0.005	3	3	100%	0	0%	All basin locations	None
Post-Closure	Marmion Reservoir	2ki – Expected Pit Lake Discharge	No exceedances									
Post-Closure	Marmion Reservoir	2lii – Upper Bound Case Pit Lake Discharge	No exceedances									
Post-Closure	Marmion Reservoir	2mi – Average Site Runoff/Average Mixing	Dissolved Iron	0.3	0.3	11	2	18%	2	18%	Basin locations: 7B,7C	Basin locations: 7B,7C
Post-Closure	Marmion Reservoir	2mii – Average Site Runoff/Maximum Mixing	Dissolved Iron	0.3	0.3	11	3	27%	3	27%	Basin locations: 7A,7B,7C	Basin locations: 7A,7B,7C
Post-Closure	Lizard Lake	3ni – Average TMF Seepage/Average Mixing	No exceedances									
Post-Closure	Lizard Lake	3nii – Average TMF Seepage/Maximum Mixing	No exceedances									

Table 5‑4: Run 2ki Results for Average Case Pit Lake Discharge Water Quality Predictions in Basin 6 of Upper Marmion Reservoir for Post‑closure Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Basin – 6 (near discharge)	Basin – 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Proportion (%)	
						0.00062	**0.00042**
Physical‑Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 7.1	6.5 – 7.1
DOC	% wt	—	—	—	8.8	-	-
TOC	% wt	—	—	—	9.3	-	-
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	-	-
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.4	6.4
Chloride	mg/L	120	—	—	1.1	1.05	1.05
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-
Nutrients							
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.00014	0.00012
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.0008
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-
Tin	mg/L	—	—	—	0.00071	-	-
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Si Receiving water quality guidelines do not exist for this parameter.

(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.

(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness‑dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

Table 5‑5: Run 2iii Results for Upper Bound Case Pit Lake Discharge Water Quality Predictions in Basin 6 of Upper Marmion Reservoir for Post‑closure Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Basin – 6 (near discharge)	Basin – 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Proportion (%)	
						0.00062	**0.00042**
Physical‑Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 7.1	6.5 – 7.1
DOC	% wt	—	—	—	8.8	-	-
TOC	% wt	—	—	—	9.3	-	-
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	-	-
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.4	6.4
Chloride	mg/L	120	—	—	1.1	1.05	1.05
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-
Nutrients							
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.00014	0.00012
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.0008
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-
Tin	mg/L	—	—	—	0.00071	-	-
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Si Receiving water quality guidelines do not exist for this parameter.

(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.

(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness‑dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

TABLE 1
Water Quality Model Inputs

Parameter	Units	Predicted Site Inputs - Operations						Predicted Site Inputs - Post-Closure				Receiving Water Body	
		Reclaim Tank				TMF Seepage		Pit Lake Flooding - Discharge to Marmion		Site Runoff to Marmion	TMF Seepage	Average Baseline	
		Average / Steady State	10 year wet / Steady State	Average / Maximum	10 year wet / Maximum	Steady State	Maximum	Expected	Upper Bound			Marmion	Lizard
Physical-Chemical													
pH	—	7.8	7.7	8.3	8.3	7.8	7.7	7.1	7.0	6.8	7.3	6.5	7.0
DOC	% wt	—	—	—	—	—	—	—	—	—	—	8.8	8.2
TOC	% wt	—	—	—	—	—	—	—	—	—	—	9.3	8.5
Acidity	mg/L	—	—	—	—	—	—	—	—	—	—	2.9	2.9
Alkalinity	mg(CaCO3)/L	104	96	64	64	—	—	—	—	—	—	19	27
Conductivity	µS/cm	—	—	—	—	—	—	—	—	—	—	49	63
Total Suspended Solids	mg/L	—	—	—	—	—	—	—	—	—	—	4.5	2.1
Total Dissolved Solids	mg/L	—	—	—	—	—	—	—	—	—	—	53	55
Major Ions													
Calcium	mg/L	21	20	20	20	28	36	11	12	13	6	6.4	10
Chloride	mg/L	21	19	49	45	31	69	3	3	1	0	1.1	0.25
Fluoride	mg/L	—	—	—	—	—	—	—	—	—	—	0.031	0.03
Magnesium	mg/L	11	10	10	10	16	21	2	1	2	3	1.3	0.9
Potassium	mg/L	28	26	37	34	40	47	1	1	1	3	0.68	0.65
Sodium	mg/L	73	66	93	85	106	129	1	1	1	0	1.3	0.67
Sulphate	mg/L	168	152	217	202	242	280	1	1	2	0	1.6	1.9
Hardness[a]	mg(CaCO3)/L	100	93	94	93	136	176	34	36	40	27	21	30
Cyanide (free)[b]	mg/L	0.19	0.17	0.19	0.17	0.028	0.028	—	—	—	—	0.001	0.001
Cyanide (total)	mg/L	0.19	0.17	0.19	0.17	0.028	0.028	—	—	—	—	0.001	0.001
Nutrients													
Nitrate-N[a]	mg/L	1.5	1.3	1.5	1.3	0.00004	0.00004	0.00050	0.00050	—	—	0.063	0.034
Nitrite-N[a]	mg/L	—	—	—	—	—	—	—	—	—	—	0.02	0.02
Ammonia-N	mg/L	15.0	15.1	15.0	15.0	20	20	—	—	—	—	0.023	0.022
Un-ionized ammonia	mg/L	0.173	0.165	0.63	0.63	0.25	0.2	0.12	0.17	—	—	0.000067	0.000047
Phosphorus	mg/L	0.019	0.018	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.01	0.013	0.0082
Organics													
Oil and Greases	mg/L	—	—	—	—	—	—	—	—	—	—	2.5	2.4
Phenols	mg/L	—	—	—	—	—	—	—	—	—	—	0.0022	0.0016
Micro-organisms													
Escherichia coli	per 100mL	—	—	—	—	—	—	—	—	—	—	1.5	0.88
Total coliforms	per 100mL	—	—	—	—	—	—	—	—	—	—	239	40

TABLE 1
Water Quality Model Inputs

Parameter	Units	Predicted Site Inputs - Operations						Predicted Site Inputs - Post-Closure				Receiving Water Body	
		Reclaim Tank				TMF Seepage		Pit Lake Flooding - Discharge to Marmion		Site Runoff to Marmion	TMF Seepage	Average Baseline	
		Average / Steady State	10 year wet / Steady State	Average / Maximum	10 year wet / Maximum	Steady State	Maximum	Expected	Upper Bound			Marmion	Lizard
Dissolved Metals													
Aluminum	mg/L	0.013	0.013	0.010	0.0093	0.02	0.01	0.001	0.001	0.25	0.01	0.03	0.018
Antimony	mg/L	0.0017	0.0016	0.0021	0.002	0.002	0.003	0.0008	0.0006	0.002	0.0002	0.00078	0.00097
Arsenic	mg/L	0.000041	0.000047	0.000001	0.0000015	0.0001	0.00003	0.0010	0.0010	0.0006	0.0002	0.00049	0.00043
Barium	mg/L	0.012	0.011	0.011	0.0085	—	—	—	—	—	—	0.0071	0.0069
Beryllium	mg/L	—	—	—	—	—	—	—	—	—	—	0.00028	0.00023
Bismuth	mg/L	—	—	—	—	—	—	—	—	—	—	0.00054	0.00058
Boron	mg/L	0.0012	0.0015	0.0036	0.0049	0.00002	0.00002	0.00900	0.00500	0.01900	0.00080	0.014	0.011
Cadmium	mg/L	0.000017	0.000017	0.0002	0.00021	0.000017	0.000028	0.00002	0.00002	0.00005	0.00001	0.000036	0.00003
Chromium	mg/L	0.0002	0.00021	0.00009	0.00009	0.0002	0.0002	0.0005	0.0006	0.0009	0.0005	0.00048	0.00049
Cobalt	mg/L	0.002	0.0018	0.0023	0.0021	0.003	0.003	0.0002	0.0001	0.0005	0.0001	0.00017	0.00012
Copper	mg/L	0.075	0.068	0.11	0.1	0.11	0.16	0.0	0.0	0.0	0.0	0.0011	0.00087
Iron	mg/L	0.000067	0.000069	0.000075	0.000058	0.0001	0.00008	0.0008	0.0006	1.3000	0.0030	0.24	0.053
Lead	mg/L	0.00012	0.00011	0.00032	0.0003	0.0002	0.0004	0.00005	0.00005	0.0004	0.00003	0.00029	0.00024
Manganese	mg/L	0.037	0.036	0.065	0.066	—	—	0.0004	0.0005	0.0006	0.00003	0.024	0.0094
Mercury	mg/L	0.000009	0.000009	0.000009	0.000009	0.00001	0.00001	0.00002	0.00002	0.000005	0.00001	0.000005	0.000005
Molybdenum	mg/L	0.056	0.051	0.066	0.06	0.08	0.09	0.001	0.001	0.001	0.002	0.00036	0.00032
Nickel	mg/L	0.0077	0.007	0.009	0.0083	0.01	0.01	0.001	0.001	0.001	0.00	0.00099	0.0008
Selenium	mg/L	0.0007	0.0006	0.001	0.001	0.0008	0.001	0.001	0.001	0.0005	0.0005	0.0005	0.0005
Silicon	mg/L	—	—	—	—	—	—	—	—	—	—	2.6	2.1
Silver	mg/L	0.000016	0.000017	0.000013	0.000014	0.00001	0.00001	0.00005	0.00004	0.00010	0.00001	0.000087	0.0001
Strontium	mg/L	0.22	0.21	0.33	0.32	—	—	—	—	—	—	0.013	0.015
Thallium	mg/L	0.00015	0.00014	0.00014	0.00013	—	—	—	—	—	—	0.000084	0.000068
Tin	mg/L	0.023	0.021	0.029	0.027	—	—	—	—	—	—	0.00071	0.00055
Titanium	mg/L	—	—	—	—	—	—	—	—	—	—	0.0012	0.0013
Tungsten	mg/L	—	—	—	—	—	—	—	—	—	—	0.0045	0.005
Uranium	mg/L	0.0051	0.0047	0.0069	0.0066	0.007	0.009	0.001	0.001	0.002	0.0008	0.0022	0.0025
Vanadium	mg/L	0.000037	0.000044	0.00026	0.00039	0.00004	0.000002	—	—	—	—	0.0005	0.00037
Zinc	mg/L	0.0019	0.0019	0.0093	0.01	0.002	0.002	0.002	0.003	0.003	0.002	0.0052	0.0055
Zirconium	mg/L	—	—	—	—	—	—	—	—	—	—	0.0015	0.002

Notes:

— = Site water quality data was not modeled for this parameter.

(a) Hardness for site water quality and TMF seepage was calculated using the formula: Hardness, mg equivalent/L CaCO3 = ([Ca,mg/l]*2.497) + ([Mg,mg.l]*4.116). (REF: USEPA)

(b) Free cyanide was modeled using PHREEQC based on solution chemistry and the concentration of total cyanide.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[2]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	23	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Chloride	mg/L	—	—	—	1.1	0.78	0.8	0.81	0.79	0.79	0.79	0.8	0.8	0.8	0.8
Magnesium	mg/L	—	—	—	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.3	1.3	1.2	1.2
Potassium	mg/L	—	—	—	0.68	0.63	0.65	0.66	0.64	0.63	0.63	0.66	0.66	0.65	0.66
Sodium	mg/L	—	—	—	1.3	1.1	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Sulphate	mg/L	—	—	—	1.6	1.7	1.8	1.8	1.7	1.7	1.7	1.8	1.8	1.8	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	26	26	26	26	26	26	26	26	26	26
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0012	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0012	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0012
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.059	0.06	0.059	0.058	0.058	0.059	0.059	0.059	0.059
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.052	0.057	0.046	0.041	0.041	0.053	0.053	0.051	0.052
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.00024	0.0003	0.00017	0.000112	0.00011	0.00025	0.00024	0.00022	0.00024
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00021	0.00021	0.0002	0.0002	0.0002	0.00021	0.00021	0.00021	0.00021
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.00047	0.00048	0.00044	0.00042	0.00042	0.00047	0.00047	0.00046	0.00047
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093
Tin	mg/L	—	—	—	0.00071	0.00082	0.00084	0.00085	0.00083	0.00083	0.00083	0.00084	0.00084	0.00084	0.00084
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 1-6.

[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	7.0	7.0	6.9	6.9	6.9	7.0	7.0	6.9	7.0
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	24	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.2	8.3	8.1	8.1	8.1	8.2	8.2	8.1	8.2
Chloride	mg/L	—	—	—	1.1	0.78	0.99	1.1	0.83	0.79	0.79	1.0	0.99	0.81	0.98
Magnesium	mg/L	—	—	—	1.3	1.2	1.3	1.4	1.3	1.2	1.2	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.63	0.91	1.1	0.7	0.64	0.64	0.91	0.91	0.67	0.9
Sodium	mg/L	—	—	—	1.3	1.1	1.8	2.2	1.2	1.1	1.1	1.8	1.8	1.2	1.8
Sulphate	mg/L	—	—	—	1.6	1.7	3.3	4.2	2.0	1.7	1.7	3.3	3.3	1.9	3.3
Hardness	mg(CaCO3)/L	—	—	—	21	26	27	27	26	26	26	27	27	26	27
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0029	0.0038	0.0014	0.0011	0.0010	0.0029	0.0029	0.0013	0.0028
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0029	0.0038	0.0014	0.0011	0.001	0.0029	0.0029	0.0013	0.0028
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.073	0.08	0.061	0.058	0.058	0.073	0.072	0.06	0.072
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.192	0.266	0.075	0.044	0.043	0.192	0.189	0.06	0.185
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.00186	0.00271	0.0005	0.00015	0.00014	0.00186	0.00181	0.00034	0.00177
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	**0.04**	0.04	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00022	0.00023	0.00021	0.0002	0.0002	0.00022	0.00022	0.00021	0.00022
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0019	**0.0022**	0.0013	0.0011	0.0011	0.0019	0.0019	0.0012	0.0018
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.00099	0.0013	0.00055	0.00044	0.00043	0.00099	0.00098	0.0005	0.00096
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.001	0.001	0.00095	0.00094	0.00094	0.001	0.001	0.00094	0.001
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.02	0.021	0.018	0.018	0.018	0.02	0.02	0.018	0.02
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000094	0.000094	0.000094	0.000093	0.000093	0.000094	0.000094	0.000094	0.000094
Tin	mg/L	—	—	—	0.00071	0.00082	0.001	0.0012	0.00087	0.00083	0.00083	0.001	0.001	0.00085	0.001
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.002	0.0021	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.
(d) Beryllium, Copper, Lead and Nickel CCME and/or PWQO criteria is hardness dependent.

Parameter	Unit	Receiving WQ Guidelines[(a)]			Marmion Baseline	Marmion Resevoir Mixing Basin[(e)]									
						1 to 4[(f)]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.00085**	**0.00118**	**0.00045**	**0.00012**	**0.00011**	**0.0009**	**0.00089**	**0.00076**	**0.00087**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	23	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Chloride	mg/L	—	—	—	1.1	0.78	0.8	0.81	0.79	0.79	0.79	0.8	0.8	0.8	0.8
Magnesium	mg/L	—	—	—	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Potassium	mg/L	—	—	—	0.68	0.63	0.65	0.66	0.64	0.63	0.63	0.65	0.65	0.65	0.65
Sodium	mg/L	—	—	—	1.3	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Sulphate	mg/L	—	—	—	1.6	1.7	1.8	1.8	1.7	1.7	1.7	1.8	1.8	1.8	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	26	26	26	26	26	26	26	26	26	26
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0011	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0011	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0011
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.059	0.059	0.059	0.058	0.058	0.059	0.059	0.059	0.059
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.052	0.057	0.046	0.041	0.041	0.053	0.053	0.051	0.052
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.00023	0.00029	0.00017	0.000111	0.000109	0.00024	0.00024	0.00022	0.00023
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00021	0.00021	0.0002	0.0002	0.0002	0.00021	0.00021	0.0002	0.00021
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.00046	0.00048	0.00044	0.00042	0.00042	0.00046	0.00046	0.00046	0.00046
Nickel [(d)]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093
Tin	mg/L	—	—	—	0.00071	0.00082	0.00084	0.00085	0.00083	0.00083	0.00082	0.00084	0.00084	0.00084	0.00084
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
(a) See Appendix 2.IV for the list of all parameters, guideline and notes.
(b) Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
(e) Locations of model basins are shown on Figure 1-6.
(f) Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[(a)]			Marmion Baseline	Marmion Resevoir Mixing Basin[(e)]									
						1 to 4[(f)]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	7.0	7.0	6.9	6.9	6.9	7.0	7.0	6.9	7.0
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	24	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.2	8.3	8.1	8.1	8.1	8.2	8.2	8.1	8.2
Chloride	mg/L	—	—	—	1.1	0.78	0.98	1.1	0.83	0.79	0.79	0.98	0.97	0.81	0.97
Magnesium	mg/L	—	—	—	1.3	1.2	1.3	1.4	1.3	1.2	1.2	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.63	0.89	1.0	0.69	0.64	0.64	0.89	0.88	0.67	0.88
Sodium	mg/L	—	—	—	1.3	1.1	1.7	2.1	1.2	1.1	1.1	1.7	1.7	1.2	1.7
Sulphate	mg/L	—	—	—	1.6	1.7	3.2	3.9	2.0	1.7	1.7	3.2	3.2	1.9	3.1
Hardness	mg(CaCO3)/L	—	—	—	21	26	27	27	26	26	26	27	27	26	27
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0027	0.0036	0.0014	0.0011	0.0010	0.0027	0.0027	0.0012	0.0027
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0027	0.0036	0.0014	0.0011	0.001	0.0027	0.0027	0.0012	0.0027
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.071	0.077	0.061	0.058	0.058	0.071	0.07	0.06	0.07
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.193	0.268	0.075	0.044	0.043	0.193	0.189	0.061	0.186
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.00178	0.0026	0.00048	0.00014	0.00013	0.00178	0.00174	0.00033	0.0017
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	**0.04**	0.04	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00022	0.00023	0.00021	0.0002	0.0002	0.00022	0.00022	0.00021	0.00022
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0018	**0.0021**	0.0013	0.0011	0.0011	0.0018	0.0018	0.0012	0.0018
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.00094	0.0012	0.00054	0.00043	0.00043	0.00094	0.00092	0.00049	0.00091
Nickel [(d)]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.0010	0.001	0.00095	0.00094	0.00094	0.0010	0.0010	0.00094	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.02	0.021	0.018	0.018	0.018	0.02	0.02	0.018	0.02
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000094	0.000094	0.000094	0.000093	0.000093	0.000094	0.000094	0.000093	0.000094
Tin	mg/L	—	—	—	0.00071	0.00082	0.001	0.0011	0.00087	0.00083	0.00083	0.001	0.001	0.00085	0.001
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.002	0.0021	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[(a)] See Appendix 2.IV for the list of all parameters, guideline and notes.
[(b)] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[(c)] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[(d)] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[(e)] Locations of model basins are shown on Figure 1-6.
[(f)] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 5
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	23	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Chloride	mg/L	—	—	—	1.1	0.78	0.83	0.84	0.81	0.79	0.79	0.83	0.83	0.82	0.83
Magnesium	mg/L	—	—	—	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Potassium	mg/L	—	—	—	0.68	0.63	0.66	0.67	0.65	0.64	0.64	0.66	0.66	0.66	0.66
Sodium	mg/L	—	—	—	1.3	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.2	1.1	1.2
Sulphate	mg/L	—	—	—	1.6	1.7	1.8	1.9	1.7	1.7	1.7	1.8	1.8	1.8	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	26	26	26	26	26	26	26	26	26	26
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0012	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0012	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0012
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.059	0.06	0.059	0.058	0.058	0.059	0.059	0.059	0.059
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.052	0.057	0.046	0.041	0.041	0.053	0.053	0.051	0.052
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.00063	0.00084	0.00038	0.00017	0.00016	0.00066	0.00065	0.00057	0.00064
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00021	0.00021	0.0002	0.0002	0.0002	0.00021	0.00021	0.00021	0.00021
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.00047	0.0005	0.00045	0.00043	0.00043	0.00048	0.00048	0.00047	0.00047
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093
Tin	mg/L	—	—	—	0.00071	0.00082	0.00085	0.00086	0.00084	0.00083	0.00083	0.00085	0.00085	0.00084	0.00085
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

(a) See Appendix 2.IV for the list of all parameters, guideline and notes.

(b) Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

(d) Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

(e) Locations of model basins are shown on Figure 1-6.

(f) Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 6
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	7.0	7.0	6.9	6.9	6.9	7.0	7.0	6.9	7.0
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	23	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.2	8.3	8.1	8.1	8.1	8.2	8.2	8.1	8.2
Chloride	mg/L	—	—	—	1.1	0.78	1.3	1.5	0.9	0.8	0.8	1.3	1.3	0.85	1.3
Magnesium	mg/L	—	—	—	1.3	1.2	1.3	1.4	1.3	1.2	1.2	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.63	1.0	1.2	0.72	0.64	0.64	1.0	0.99	0.68	0.98
Sodium	mg/L	—	—	—	1.3	1.1	2.0	2.5	1.3	1.1	1.1	2.0	2.0	1.2	2.0
Sulphate	mg/L	—	—	—	1.6	1.7	3.9	4.9	2.2	1.7	1.7	3.9	3.8	2.0	3.8
Hardness	mg(CaCO3)/L	—	—	—	21	26	27	27	26	26	26	27	27	26	27
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0029	0.0038	0.0014	0.0011	0.0010	0.0029	0.0029	0.0013	0.0028
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0029	0.0038	0.0014	0.0011	0.001	0.0029	0.0029	0.0013	0.0028
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.073	0.08	0.061	0.058	0.058	0.073	0.072	0.06	0.072
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.192	0.27	0.075	0.044	0.043	0.192	0.189	0.06	0.185
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.0065	0.0097	0.00158	0.00029	0.00026	0.0066	0.0064	0.00099	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	0.04	0.04	**0.04**	**0.04**	**0.04**	0.04	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.000042	0.000042	0.00004	0.00004	0.00004	0.000042	0.000041	0.00004	0.000041
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00022	0.00023	0.00021	0.0002	0.0002	0.00022	0.00022	0.00021	0.00022
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	**0.0022**	**0.0028**	0.0014	0.0012	0.0011	**0.0022**	**0.0022**	0.0013	**0.0022**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.0011	0.0014	0.00057	0.00044	0.00044	0.0011	0.0011	0.00051	0.0011
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.001	0.0011	0.00095	0.00094	0.00094	0.001	0.001	0.00095	0.001
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.021	0.022	0.018	0.018	0.018	0.021	0.021	0.018	0.021
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000094	0.000094	0.000094	0.000093	0.000093	0.000094	0.000094	0.000094	0.000094
Tin	mg/L	—	—	—	0.00071	0.00082	0.0011	0.0013	0.00089	0.00083	0.00083	0.0011	0.0011	0.00086	0.0011
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.0021	0.0021	0.002	0.002	0.002	0.0021	0.0021	0.002	0.0021
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0057	0.0057	0.0056	0.0056	0.0056	0.0057	0.0057	0.0056	0.0057

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 7
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
		CCME	PWQO	MISA		1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	23	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Chloride	mg/L	—	—	—	1.1	0.78	0.82	0.84	0.8	0.79	0.79	0.82	0.82	0.82	0.82
Magnesium	mg/L	—	—	—	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Potassium	mg/L	—	—	—	0.68	0.63	0.66	0.67	0.65	0.64	0.64	0.66	0.66	0.66	0.66
Sodium	mg/L	—	—	—	1.3	1.1	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Sulphate	mg/L	—	—	—	1.6	1.7	1.8	1.9	1.7	1.7	1.7	1.8	1.8	1.8	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	26	26	26	26	26	26	26	26	26	26
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0011	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0011	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0011
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.059	0.06	0.059	0.058	0.058	0.059	0.059	0.059	0.059
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.052	0.057	0.046	0.041	0.041	0.053	0.053	0.051	0.052
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.00063	0.00083	0.00037	0.00017	0.00016	0.00066	0.00065	0.00057	0.00064
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00021	0.00021	0.0002	0.0002	0.0002	0.00021	0.00021	0.00021	0.00021
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.00047	0.00049	0.00045	0.00043	0.00042	0.00047	0.00047	0.00046	0.00047
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094	0.00094
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093	0.000093
Tin	mg/L	—	—	—	0.00071	0.00082	0.00084	0.00085	0.00083	0.00083	0.00083	0.00085	0.00085	0.00084	0.00085
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 8
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.01022**	**0.01518**	**0.00236**	**0.00032**	**0.00026**	**0.01024**	**0.00998**	**0.00142**	**0.00974**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	7.0	7.0	6.9	6.9	6.9	7.0	7.0	6.9	7.0
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	23	23	23	23	23	23	23	23	23	23
Major Ions															
Calcium	mg/L	—	—	—	6.4	8.1	8.2	8.3	8.1	8.1	8.1	8.2	8.2	8.1	8.2
Chloride	mg/L	—	—	—	1.1	0.78	1.2	1.5	0.89	0.8	0.8	1.2	1.2	0.85	1.2
Magnesium	mg/L	—	—	—	1.3	1.2	1.3	1.4	1.3	1.2	1.2	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.63	0.98	1.1	0.71	0.64	0.64	0.98	0.97	0.68	0.96
Sodium	mg/L	—	—	—	1.3	1.1	1.9	2.3	1.3	1.1	1.1	1.9	1.9	1.2	1.9
Sulphate	mg/L	—	—	—	1.6	1.7	3.7	4.7	2.1	1.7	1.7	3.7	3.7	1.9	3.6
Hardness	mg(CaCO3)/L	—	—	—	21	26	27	27	26	26	26	27	27	26	27
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0027	0.0036	0.0014	0.0011	0.0010	0.0027	0.0027	0.0012	0.0027
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0027	0.0036	0.0014	0.0011	0.001	0.0027	0.0027	0.0012	0.0027
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.058	0.071	0.077	0.061	0.058	0.058	0.071	0.07	0.06	0.07
Ammonia-N	mg/L	—	—	—	0.023	0.039	0.192	0.27	0.075	0.044	0.043	0.192	0.189	0.06	0.185
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000091	0.0065	0.0096	0.00158	0.00029	0.00025	0.0065	0.0064	0.00098	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	**0.04**	0.04	0.04	**0.04**	**0.04**	**0.04**	0.04	**0.04**	**0.04**	**0.04**
Antimony	mg/L	—	0.02	—	0.00078	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Boron	mg/L	1.5	0.2	—	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.00004	0.000042	0.000043	0.00004	0.00004	0.00004	0.000042	0.000042	0.00004	0.000042
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00022	0.00023	0.00021	0.0002	0.0002	0.00022	0.00022	0.00021	0.00022
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	**0.0021**	**0.0026**	0.0014	0.0012	0.0011	**0.0021**	**0.0021**	0.0013	**0.0021**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
Manganese	mg/L	—	—	—	0.024	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00042	0.001	0.0013	0.00056	0.00044	0.00043	0.001	0.001	0.0005	0.001
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00093	0.001	0.001	0.00095	0.00094	0.00094	0.001	0.001	0.00095	0.001
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089	0.000089
Strontium	mg/L	—	—	—	0.013	0.018	0.021	0.022	0.018	0.018	0.018	0.021	0.021	0.018	0.021
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000093	0.000094	0.000094	0.000094	0.000093	0.000093	0.000094	0.000094	0.000093	0.000094
Tin	mg/L	—	—	—	0.00071	0.00082	0.0011	0.0012	0.00088	0.00083	0.00083	0.0011	0.0011	0.00086	0.0011
Uranium	mg/L	—	0.005	—	0.0022	0.002	0.0021	0.0021	0.002	0.002	0.002	0.0021	0.0021	0.002	0.0021
Vanadium	mg/L	—	0.006	—	0.0005	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Zinc	mg/L	0.03	0.02	1	0.0052	0.0056	0.0057	0.0057	0.0056	0.0056	0.0056	0.0057	0.0057	0.0056	0.0057

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 9
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.00085**	**0.00118**	**0.00045**	**0.00012**	**0.00011**	**0.0009**	**0.00089**	**0.00076**	**0.00087**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.7	0.71	0.69	0.68	0.68	0.7	0.7	0.7	0.7
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.7	1.8	1.7	1.6	1.6	1.8	1.8	1.7	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0012	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0012	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0012
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00021	0.00027	0.000144	0.000087	0.000086	0.00022	0.00022	0.000198	0.00022
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00041	0.00043	0.00039	0.00037	0.00037	0.00041	0.00041	0.0004	0.00041
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.0010	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00073	0.00074	0.00072	0.00071	0.00071	0.00073	0.00073	0.00073	0.00073
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 10
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.01022**	**0.01518**	**0.00236**	**0.00032**	**0.00026**	**0.01024**	**0.00998**	**0.00142**	**0.00974**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	20	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.7	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	—	—	—	1.1	1.1	1.3	1.4	1.1	1.1	1.1	1.3	1.3	1.1	1.2
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	0.96	1.1	0.74	0.68	0.68	0.96	0.95	0.71	0.94
Sodium	mg/L	—	—	—	1.3	1.3	2.0	2.4	1.5	1.3	1.3	2.0	2.0	1.4	2.0
Sulphate	mg/L	—	—	—	1.6	1.6	3.3	4.1	2.0	1.7	1.6	3.3	3.3	1.8	3.2
Hardness	mg(CaCO3)/L	—	—	—	21	21	22	23	22	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0029	0.0038	0.0014	0.0011	0.0010	0.0029	0.0029	0.0013	0.0028
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0029	0.0038	0.0014	0.0011	0.001	0.0029	0.0029	0.0013	0.0028
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.078	0.085	0.066	0.064	0.063	0.078	0.077	0.065	0.077
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.176	0.251	0.059	0.028	0.027	0.177	0.173	0.045	0.169
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00183	0.00269	0.00047	0.000122	0.000111	0.00184	0.00179	0.00031	0.00175
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.00079	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0072	0.0072	0.0071	0.0071	0.0071	0.0072	0.0072	0.0071	0.0072
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00017	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0019	**0.0023**	0.0013	0.0011	0.0011	0.0019	0.0019	0.0012	0.0018
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.024	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00093	0.0012	0.00049	0.00038	0.00038	0.00093	0.00092	0.00044	0.00091
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.0011	0.0010	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.015	0.016	0.013	0.013	0.013	0.015	0.015	0.013	0.015
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.00094	0.001	0.00076	0.00072	0.00072	0.00094	0.00093	0.00074	0.00092
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0023	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.7	0.7	0.69	0.68	0.68	0.7	0.7	0.69	0.7
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.7	1.8	1.7	1.6	1.6	1.7	1.7	1.7	1.7
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0011	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0011	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0011
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.000207	0.00026	0.000141	0.000086	0.000085	0.00022	0.000214	0.000192	0.00021
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.0004	0.00042	0.00038	0.00037	0.00037	0.00041	0.00041	0.0004	0.00041
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.0010	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00073	0.00074	0.00072	0.00071	0.00071	0.00073	0.00073	0.00073	0.00073
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 1-6.

[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		**0**	**0.01022**	**0.01518**	**0.00236**	**0.00032**	**0.00026**	**0.01024**	**0.00998**	**0.00142**	**0.00974**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	20	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.6	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	—	—	—	1.1	1.1	1.2	1.3	1.1	1.1	1.1	1.2	1.2	1.1	1.2
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	0.93	1.1	0.73	0.68	0.68	0.93	0.92	0.71	0.92
Sodium	mg/L	—	—	—	1.3	1.3	1.9	2.3	1.4	1.3	1.3	1.9	1.9	1.4	1.9
Sulphate	mg/L	—	—	—	1.6	1.6	3.1	3.9	2.0	1.7	1.6	3.1	3.1	1.8	3.1
Hardness	mg(CaCO3)/L	—	—	—	21	21	22	22	21	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0027	0.0036	0.0014	0.0011	0.0010	0.0027	0.0027	0.0012	0.0027
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0027	0.0036	0.0014	0.0011	0.001	0.0027	0.0027	0.0012	0.0027
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.076	0.082	0.066	0.063	0.063	0.076	0.075	0.065	0.075
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.177	0.252	0.059	0.028	0.027	0.178	0.174	0.045	0.17
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00176	0.00257	0.00046	0.000119	0.00011	0.00176	0.00172	0.0003	0.00168
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.00079	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0072	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00017	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0018	**0.0021**	0.0013	0.0011	0.0011	0.0018	0.0018	0.0012	0.0018
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.024	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00088	0.0011	0.00048	0.00038	0.00037	0.00088	0.00087	0.00043	0.00086
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.001	0.0010	0.001
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.015	0.016	0.013	0.013	0.013	0.015	0.015	0.013	0.015
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.00091	0.001	0.00076	0.00072	0.00072	0.00091	0.00091	0.00074	0.0009
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0023	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 1-6.

[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 13
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.71	0.72	0.69	0.68	0.68	0.71	0.71	0.7	0.71
Sodium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.4	1.4
Sulphate	mg/L	—	—	—	1.6	1.6	1.8	1.9	1.7	1.6	1.6	1.8	1.8	1.8	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0012	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0012	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0012
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0006	0.00081	0.00035	0.000142	0.000136	0.00063	0.00063	0.00055	0.00062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0013	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.024	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00042	0.00044	0.00039	0.00037	0.00037	0.00042	0.00042	0.00041	0.00042
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0010	0.0010	0.00099	0.00099	0.00099	0.0010	0.0010	0.00099	0.0010
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00074	0.00075	0.00072	0.00072	0.00072	0.00074	0.00074	0.00073	0.00074
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
(a) See Appendix 2.IV for the list of all parameters, guideline and notes.
(b) Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
(e) Locations of model basins are shown on Figure 1-6.
(f) Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 14
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	7.0	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.7	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	—	—	—	1.1	1.1	1.5	1.8	1.2	1.1	1.1	1.5	1.5	1.1	1.5
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	1.0	1.2	0.76	0.69	0.68	1.0	1.0	0.73	1.0
Sodium	mg/L	—	—	—	1.3	1.3	2.2	2.7	1.5	1.3	1.3	2.2	2.2	1.4	2.2
Sulphate	mg/L	—	—	—	1.6	1.6	3.8	4.9	2.1	1.7	1.7	3.8	3.8	1.9	3.7
Hardness	mg(CaCO3)/L	—	—	—	21	21	22	22	21	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0029	0.0038	0.0014	0.0011	0.0010	0.0029	0.0029	0.0013	0.0028
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0029	0.0038	0.0014	0.0011	0.001	0.0029	0.0029	0.0013	0.0028
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.078	0.085	0.066	0.064	0.063	0.078	0.077	0.065	0.077
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.176	0.251	0.059	0.028	0.027	0.177	0.173	0.045	0.169
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0065	0.0096	0.00156	0.00027	0.00023	0.0065	0.0064	0.00096	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.0008	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0072	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000038	0.000039	0.000036	0.000036	0.000036	0.000038	0.000038	0.000036	0.000038
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00018	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	**0.0022**	**0.0028**	0.0014	0.0012	0.0012	**0.0022**	**0.0022**	0.0013	**0.0022**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.001	0.0014	0.00052	0.00038	0.00038	0.001	0.001	0.00045	0.0010
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.0011	0.0010	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.016	0.018	0.014	0.013	0.013	0.016	0.016	0.013	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.001	0.0011	0.00078	0.00072	0.00072	0.001	0.0010	0.00075	0.00099
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0023	0.0023	0.0022	0.0022	0.0022	0.0023	0.0023	0.0022	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0053	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 15
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
		CCME	PWQO	MISA		1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.7	0.71	0.69	0.68	0.68	0.71	0.7	0.7	0.7
Sodium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Sulphate	mg/L	—	—	—	1.6	1.6	1.8	1.8	1.7	1.6	1.6	1.8	1.8	1.8	1.8
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0011	0.0012	0.0011	0.0010	0.0010	0.0012	0.0012	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0011	0.0012	0.0011	0.001	0.001	0.0012	0.0012	0.0011	0.0011
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0006	0.00081	0.00035	0.000142	0.000136	0.00063	0.00063	0.00054	0.00061
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.024	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00041	0.00043	0.00039	0.00037	0.00037	0.00042	0.00041	0.00041	0.00041
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.0010	0.00099	0.00099	0.00099	0.0010	0.0010	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00073	0.00074	0.00072	0.00072	0.00071	0.00074	0.00074	0.00073	0.00073
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 16
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
		CCME	PWQO	MISA		1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
						0	**0.01022**	**0.01518**	**0.00236**	**0.00032**	**0.00026**	**0.01024**	**0.00998**	**0.00142**	**0.00974**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	7.0	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.7	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	—	—	—	1.1	1.1	1.5	1.7	1.2	1.1	1.1	1.5	1.5	1.1	1.5
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	1.0	1.2	0.75	0.69	0.68	1.0	1.0	0.72	1.0
Sodium	mg/L	—	—	—	1.3	1.3	2.1	2.6	1.5	1.3	1.3	2.1	2.1	1.4	2.1
Sulphate	mg/L	—	—	—	1.6	1.6	3.7	4.6	2.1	1.7	1.7	3.7	3.6	1.9	3.6
Hardness	mg(CaCO3)/L	—	—	—	21	21	22	22	21	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0010	0.0027	0.0036	0.0014	0.0011	0.0010	0.0027	0.0027	0.0012	0.0027
Cyanide (total)	mg/L	—	—	—	0.001	0.001	0.0027	0.0036	0.0014	0.0011	0.001	0.0027	0.0027	0.0012	0.0027
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.076	0.082	0.066	0.063	0.063	0.076	0.075	0.065	0.075
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.176	0.251	0.059	0.028	0.027	0.177	0.173	0.045	0.169
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0065	0.0096	0.00155	0.00027	0.00023	0.0065	0.0063	0.00096	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.0008	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000038	0.000039	0.000037	0.000036	0.000036	0.000038	0.000038	0.000036	0.000038
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00017	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	**0.0021**	**0.0026**	0.0014	0.0012	0.0012	**0.0021**	**0.0021**	0.0013	**0.0021**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00097	0.0013	0.0005	0.00038	0.00038	0.00098	0.00096	0.00045	0.00095
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.0011	0.0010	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.016	0.017	0.013	0.013	0.013	0.016	0.016	0.013	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.00098	0.0011	0.00077	0.00072	0.00072	0.00098	0.00097	0.00075	0.00096
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0023	0.0023	0.0022	0.0022	0.0022	0.0023	0.0023	0.0022	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0053	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		**0**	**0.00044**	**0.00062**	**0.00032**	**0.00011**	**0.0001**	**0.00045**	**0.00044**	**0.00072**	**0.00042**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	-	-	-	-	-	-	-	-	-	-
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Chloride	mg/L	—	—	—	1.1	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-	-	-	-	-	-	-	-
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-	-	-	-	-	-	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00012	0.00014	0.0001	0.00008	0.000079	0.00012	0.00012	0.00015	0.00012
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	—	—	—	0.00071	-	-	-	-	-	-	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.
(d) Beryllium, Copper, Lead and Nickel CCME and/or PWQO criteria is hardness dependent.

Table 18
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.00374**	**0.0056**	**0.00128**	**0.00018**	**0.00015**	**0.00365**	**0.00352**	**0.00101**	**0.00337**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	-	-	-	-	-	-	-	-	-	-
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.4	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-	-	-	-	-	-	-	-
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-	-	-	-	-	-	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00052	0.00074	0.00022	0.000088	0.000085	0.0005	0.00049	0.00019	0.00047
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	—	—	—	0.00071	-	-	-	-	-	-	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
		CCME	PWQO	MISA		1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
						0	**0.00044**	**0.00062**	**0.00032**	**0.00011**	**0.0001**	**0.00045**	**0.00044**	**0.00072**	**0.00042**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	-	-	-	-	-	-	-	-	-	-
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-	-	-	-	-	-	-	-
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-	-	-	-	-	-	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00014	0.00017	0.00012	0.000085	0.000084	0.00014	0.00014	0.00019	0.00014
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	—	—	—	0.00071	-	-	-	-	-	-	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 20
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.00374**	**0.0056**	**0.00128**	**0.00018**	**0.00015**	**0.00365**	**0.00352**	**0.00101**	**0.00337**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	-	-	-	-	-	-	-	-	-	-
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.4	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-	-	-	-	-	-	-	-
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-	-	-	-	-	-	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0007	0.00102	0.00028	0.000097	0.000092	0.00069	0.00066	0.00024	0.00064
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00049	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	—	—	—	0.00071	-	-	-	-	-	-	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 21
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[(a)]			Marmion Baseline	Marmion Resevoir Mixing Basin[(e)]												
		CCME	PWQO	MISA		1 to 4[(f)]	2	3	4	5	6	7A	7B	7C	8	9	10	11
						Proportion												
						0.00143	0.00167	0.00168	0.00163	0.00517	0.0063	0.04841	0.0619	0.06322	0.00542	0.0054	0.00598	0.00535
Physical-Chemical																		
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	-	-	-	-	-	-	-	-	-	-	-	-	-
Major Ions																		
Calcium	mg/L	—	—	—	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.8	6.8	6.9	6.5	6.5	6.5	6.5
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg(CaCO3)/L	—	—	—	21	21	21	21	21	21	21	22	22	22	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-
Nutrients																		
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-	-	-	-	-	-	-	-	-	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.00007	0.00007	0.00007	0.00007
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.013	0.013	0.013	0.013
Dissolved Metals																		
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.031	0.031	0.04	0.043	0.044	0.031	0.031	0.031	0.031
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00079	0.00079	0.00084	0.00085	0.00086	0.00079	0.00079	0.00079	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.0005	0.0005	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000037	0.000037	0.000037	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.0005	0.00051	0.00051	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00019	0.00019	0.00019	0.00017	0.00017	0.00017	0.00017
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.29	**0.3**	**0.3**	0.24	0.24	0.24	0.24
Lead [(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.0003	0.0003	0.0003	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00037	0.00038	0.00038	0.00036	0.00036	0.00036	0.00036
Nickel [(d)]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000088	0.000088	0.000088	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	—	—	—	0.00071	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[(a)] See Appendix 2.IV for the list of all parameters, guideline and notes.
[(b)] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[(c)] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[(d)] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[(e)] Locations of model basins are shown on Figure 1-6.
[(f)] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 22
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]												
		CCME	PWQO	MISA		1 to 4[f]	2	3	4	5	6	7A	7B	7C	8	9	10	11
						Proportion												
						0.01633	**0.01259**	**0.01227**	**0.01165**	**0.0303**	**0.0367**	**0.0753**	**0.08495**	**0.08952**	**0.02916**	**0.02848**	**0.00813**	**0.02776**
Physical-Chemical																		
pH	—	6.5-9	6.5-8.5	—	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Alkalinity	mg(CaCO3)/L	—	-25%	—	19	-	-	-	-	-	-	-	-	-	-	-	-	-
Major Ions																		
Calcium	mg/L	—	—	—	6.4	6.5	6.5	6.5	6.5	6.6	6.7	6.9	7.0	7.0	6.6	6.6	6.5	6.6
Chloride	mg/L	—	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.6	1.6	1.6	1.6
Hardness	mg(CaCO3)/L	—	—	—	21	22	22	22	22	22	22	23	23	23	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-
Nutrients																		
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-	-	-	-	-	-	-	-	-	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.000067	0.000067	0.000067	0.00007	0.00007	0.00007	0.000067	0.000067	0.00007	0.00007	0.00007	0.00007
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.013	0.013	0.013	0.013
Dissolved Metals																		
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.033	0.033	0.033	0.032	0.037	0.038	0.046	0.049	0.05	0.036	0.036	0.032	0.036
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.00079	0.00079	0.00079	0.00082	0.00082	0.00087	0.00088	0.00089	0.00081	0.00081	0.00079	0.00081
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.0005	0.0005	0.0005	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000037	0.000037	0.000037	0.000037	0.000037	0.000037	0.000037	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00049	0.00049	0.00049	0.00049	0.0005	0.0005	0.00052	0.00052	0.00052	0.0005	0.0005	0.00049	0.0005
Cobalt	mg/L	—	0.0009	—	0.00017	0.00018	0.00017	0.00017	0.00017	0.00018	0.00018	0.00019	0.0002	0.0002	0.00018	0.00018	0.00017	0.00018
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.25	0.25	0.25	0.25	0.27	0.28	**<u>0.32</u>**	**<u>0.33</u>**	**<u>0.33</u>**	0.27	0.27	0.25	0.27
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00037	0.00037	0.00038	0.00038	0.00038	0.00037	0.00037	0.00036	0.00037
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000088	0.000088	0.000088	0.000088	0.000088	0.000088	0.000088	0.000087	0.000088
Strontium	mg/L	—	—	—	0.013	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	—	—	—	0.00071	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

<u>Underlined</u> values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
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[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 23
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0028**	**0.0039**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.3	7.3	7.3	7.3
Alkalinity	mg(CaCO3)/L	—	-25%	—	27	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	—	—	—	0.25	0.34	0.37	0.38
Magnesium	mg/L	—	—	—	0.9	0.9	1.0	1.0
Potassium	mg/L	—	—	—	0.65	0.8	0.81	0.8
Sodium	mg/L	—	—	—	0.67	1.0	1.1	1.1
Sulphate	mg/L	—	—	—	1.9	2.6	2.8	2.9
Hardness	mg(CaCO3)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0011	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.0011	0.0011	0.0011
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.08	0.1	0.1
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0007	0.001	0.0011
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00097	0.00097	0.00097
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00013	0.00013	0.00013
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0012	0.0013	0.0013
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0005	0.00063	0.0006
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00083	0.00084	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	<u>**0.0001**</u>	<u>**0.0001**</u>	<u>**0.0001**</u>	<u>**0.0001**</u>
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Uranium	mg/L	—	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

<u>Underlined</u> values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
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[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
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[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 24
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		0.0081	0.0095	0.0071
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.3	7.3	7.3	7.3
Alkalinity	mg(CaCO3)/L	—	-25%	—	27	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	—	—	—	0.25	0.5	0.55	0.5
Magnesium	mg/L	—	—	—	0.9	1.0	1.0	1.0
Potassium	mg/L	—	—	—	0.65	1.0	1.0	0.9
Sodium	mg/L	—	—	—	0.67	1.5	1.7	1.4
Sulphate	mg/L	—	—	—	1.9	3.8	4.2	4
Hardness	mg(CaCO3)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0012	0.0013	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.0012	0.0013	0.0012
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0021	0.0024	0.002
Phosphorus	mg/L	—	0.02	—	0.0082	0.0083	0.0083	0.0083
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00098	0.00098	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00014	0.00015	0.00014
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0018	0.0019	0.0016
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.001	0.0011	0.0009
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0009	0.00089	0.0009
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Uranium	mg/L	—	0.005	—	0.0025	0.0025	0.0026	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
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[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 25
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0028**	**0.0039**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.3	7.3	7.3	7.3
Alkalinity	mg(CaCO3)/L	—	-25%	—	27	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	—	—	—	0.25	0.45	0.52	0.5
Magnesium	mg/L	—	—	—	0.9	1.0	1.0	1.0
Potassium	mg/L	—	—	—	0.65	0.8	0.8	0.8
Sodium	mg/L	—	—	—	0.67	1.0	1.2	1.2
Sulphate	mg/L	—	—	—	1.9	2.7	3.0	3.0
Hardness	mg(CaCO3)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0011	0.0011	0.0011
Cyanide (total)	mg/L	—	—	—	0.001	0.0011	0.0011	0.0011
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.08	0.1	0.1
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0006	0.0008	0.0009
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0083	0.0083
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00097	0.00097	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00013	0.00013	0.00013
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0013	0.0015	0.0015
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0006	0.0007	0.0007
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00083	0.00084	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Uranium	mg/L	—	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
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[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Table 26
Water Quality Model Predictions

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0081**	**0.0095**	**0.0071**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.3	7.3	7.3	7.3
Alkalinity	mg(CaCO3)/L	—	-25%	—	27	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	11	11	10
Chloride	mg/L	—	—	—	0.25	0.8	0.9	0.7
Magnesium	mg/L	—	—	—	0.9	1.1	1.1	1.0
Potassium	mg/L	—	—	—	0.65	1.0	1.1	1.0
Sodium	mg/L	—	—	—	0.67	1.7	1.9	1.6
Sulphate	mg/L	—	—	—	1.9	4.1	4.5	4
Hardness	mg(CaCO3)/L	—	—	—	30	32	32	31
Cyanide (free)	mg/L	0.005	0.005	—	0.001	0.0012	0.0013	0.0012
Cyanide (total)	mg/L	—	—	—	0.001	0.0012	0.0013	0.0012
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0017	0.0019	0.0015
Phosphorus	mg/L	—	0.02	—	0.0082	0.0084	0.0084	0.0083
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00014	0.00015	0.00014
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	**0.0022**	**0.0024**	**0.002**
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.001	0.0012	0.001
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0009	0.00089	0.0009
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**<u>0.0001</u>**	**<u>0.0001</u>**	**<u>0.0001</u>**	**<u>0.0001</u>**
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Uranium	mg/L	—	0.005	—	0.0025	0.0026	0.0026	0.0026
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

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Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0016**	**0.0023**	**0.0024**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.3	7.3	7.3	7.3
Alkalinity	mg(CaCO3)/L	—	-25%	—	27	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	—	—	—	0.25	0.3	0.3	0.3
Magnesium	mg/L	—	—	—	0.9	0.9	0.9	0.9
Potassium	mg/L	—	—	—	0.65	0.7	0.7	0.7
Sodium	mg/L	—	—	—	0.67	0.7	0.7	0.7
Sulphate	mg/L	—	—	—	1.9	1.9	1.9	2
Hardness	mg(CaCO3)/L	—	—	—	30	30	30	30
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.000	0.000	0.000
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00012	0.00012	0.00012
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0009	0.0009	0.0009
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	0.009435	0.009435	0.009435
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0003	0.0003	0.0003
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0008	0.0008	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Uranium	mg/L	—	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Guideline values are provided for reference and relative comparison purposes only. Refer to the EIS/EA and subsequent documents for further discussion of appropriate guideline values.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0047**	**0.0055**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.3	7.3	7.3	7.3
Alkalinity	mg(CaCO3)/L	—	-25%	—	27	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	—	—	—	0.25	0.3	0.3	0.3
Magnesium	mg/L	—	—	—	0.9	0.9	0.9	0.9
Potassium	mg/L	—	—	—	0.65	0.7	0.7	0.7
Sodium	mg/L	—	—	—	0.67	0.7	0.7	0.7
Sulphate	mg/L	—	—	—	1.9	1.9	1.9	2
Hardness	mg(CaCO3)/L	—	—	—	30	30	30	30
Cyanide (free)	mg/L	0.005	0.005	—	0.001	-	-	-
Cyanide (total)	mg/L	—	—	—	0.001	-	-	-
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.000	0.000	0.000
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00012	0.00012	0.00012
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0009	0.0009	0.0009
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	0.009435	0.009435	0.009435
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0003	0.0003	0.0003
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0008	0.0008	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**<u>0.0001</u>**	**<u>0.0001</u>**	**<u>0.0001</u>**	**<u>0.0001</u>**
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Uranium	mg/L	—	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

<u>Underlined</u> values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
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[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TECHNICAL MEMORANDUM

DATE	November 21, 2013	**PROJECT No.**	13-1118-0010 (2016)
TO	Alix Drapack Osisko Hammond Reef Gold	**DOC. No.**	005 (Rev 0)
CC	Cathryn Moffett, Ken DeVos, Rein Jaagumagi		
FROM	Adam Auckland, Gerard Van Arkel	**EMAIL**	aauckland@golder.com; Gerard_VanArkel@golder.com

DRAFT – CONCEPTUAL DIFFUSER DESIGN AND MIXING ZONE ASSESSMENT FOR EFFLUENT DISCHARGE FROM THE OSISKO HAMMOND REEF GOLD (OHRG) PROJECT

1.0 BACKGROUND

In April 2013, Osisko Hammond Reef Gold (OHRG) requested that Golder Associates Ltd. (Golder) provide support in the development of responses to information requests received from federal and provincial regulators following review of the OHRG Environmental Impact Statement/Environmental Assessment Report (OHRG 2013). The support provided by Golder included technical review of the information requests and participation in meetings with the various regulators to discuss responses and request clarification on specific information requests.

Several of the information requests received from the Ontario Ministry of the Environment (MOE) identified the need for a detailed mixing assessment at the effluent discharge location to estimate effluent concentration gradients within Marmion Basin and to define how the effluent will be mixed vertically and laterally. This request for a more detailed effluent mixing assessment was re-iterated by Todd Kondrat (MOE) during a teleconference with Osisko and Golder on June 3, 2013 and in a letter from Jim Sutton (MOE) to Osisko received on June 6, 2013.

In response to this request and based on available information, Golder prepared a conceptual diffuser design and performed a preliminary mixing zone assessment using estimated effluent flows and characteristics to provide a better understanding of effluent mixing in the vicinity of the discharge location. A summary of the conceptual diffuser design and the results of the preliminary mixing zone assessment were presented to the government review team on July 2, 2013 (Osisko 2013) and are provided in this memorandum.

2.0 EFFLUENT DIFFUSER DESIGN CONSIDERATIONS

A conceptual diffuser design was prepared based on available information and in consideration the following:

- The bathymetry and shoreline characteristics at the selected discharge location;
- The effluent characteristics including discharge rates and frequency, temperature and water quality; and
- The characteristics of the Marmion Basin near the selected discharge location including temperature, water quality, currents and water levels.

2.1 Discharge Location

The proposed discharge location is situated at the south end of Sawbill Bay (Figure 1) where it exposed to a secondary flow path from the Upper Seine River Watershed thereby taking advantage of ambient mixing potential in the local receiving water.

For this preliminary assessment, the location for the proposed diffuser was selected at a location where the basin depth increases rapidly to minimize off-shore pipeline requirements and where discharge will be directed away from bays along the shoreline where poor ambient mixing conditions may exist. The bathymetry of the basin in the vicinity of the outfall and the proposed diffuser location are shown on Figure 2.

For a detailed assessment of the alternative locations considered for effluent discharge refer to Section 3.6 of the Alternative Assessment Report.

2.2 Receiving Water Characterization

2.2.1 Water Quality and Temperature

Total dissolved solids (TDS) concentrations in Marmion Basin are estimated to be about 40 mg/L (see Lake Water Quality TSD, Appendix 2.II). Near surface water temperatures vary seasonally with air temperature; however, due to the depth and volume of water in Marmion Basin, changes in temperature occur slowly. For this assessment, the near-surface water temperature in Marmion Basin is assumed to be equal to the average air temperature of the previous six weeks, with a minimum temperature of 3ºC based on a comparison of available near surface water temperature measurements in Marmion Basin and recorded air temperatures at Atikokan.

Thermal stratification, typical of lakes in the area, has been observed in areas of Marmion Basin including Sawbill Bay and Lynxhead Bay during the spring and summer. Based on water column measurements, thermal stratification has been observed to occur as shallow as 9 m below the surface (see Section 3.2.6.8 of the EIS/EA report).

2.2.2 Currents

Currents at the proposed discharge location were roughly estimated to range from stagnant to 1.0 cm/s based on exchange flows predicted by the lake-wide mixing model (see Section 3.0 of Lake Water Quality TSD) and the cross-sectional area of the basin at the diffuser location. This method of estimation assumes that flow is unidirectional and that flow velocities are uniform across the assumed basin cross-section. In reality, flows are not unidirectional and will normally be concentrated in deeper, central areas of a flow channel. For this reason, the estimated currents near the shoreline at the discharge location are considered as upper-bound estimates and a constant current of 0.5 cm/s has been assumed as a reasonable peak current velocity at the diffuser location.

2.2.3 Water Levels

Water levels in Marmion Basin are managed according to target levels established for the Raft Lake Dam as part of the Seine River Water Management Plan (Boileau, 2004). The target maximum and minimum water levels for Upper Marmion Reservoir are shown on Figure 3. Since the implementation of the Seine River Water Management Plan in 2005, minimum water levels in the spring have been maintained at or near 413.00 masl. Prior to its implementation, the water level reached a recorded minimum of 412.47 masl in the spring of 2001.

The monthly water level variation in Marmion Basin reflects the management of water levels at the Raft Lake Dam. The water level is drawn down between November and March to generate power and provide storage capacity for the spring melt. Water levels rise from April to June/July in response to spring runoff and to enhance walleye spawning opportunities and success.

Historical water levels for Upper Marmion Reservoir prior to and following the implementation of the Seine River Water Management Plan are shown in Figure 4 and Figure 5, respectively. A summary of the pertinent water levels considered for the preliminary diffuser design is provided in Table 1.

Table 1: Marmion Water Levels for Design Consideration

Description	Level (masl)	Comment
Maximum Recorded Water Level	415.72 (June 30, 2002)	Data provided by the US Army Corps of Engineers (USACE 2012)
Average Recorded Water Level	414.73	
Minimum Recorded Water Level	412.47 (March 29, 2001)	
Maximum Summer Operational Level	415.50	From Seine River Water Management Plan (Boileau, 2004)
Minimum Winter Operational Level	412.50	
Maximum Recorded Thermocline Elevation	406.20	Measured on June 8, 2011; Water surface at 415.20 masl on day of measurement (Golder, 2013a)

2.3 Effluent Characterization

2.3.1 Discharge Rates

Effluent discharge rates were predicted for a range of wet and dry conditions through a site water balance analysis based on a 28-year record of precipitation at Atikokan (1984 to 2011). This 28-year record is considered to capture the range of climatic conditions that would reasonably be expected to occur over the 11-year operational life of the mine. The simulation period included a wet year that is expected to occur once every 41 years and a dry year that would occur once every 71 years based on statistical analysis of the historical record. For the 28-year simulation period, the simulated effluent discharge rates are plotted against their predicted cumulative frequency of occurrence in Figure 6.

A frequency analysis was performed on the results of the 28-year water balance to estimate average, and extreme wet and dry conditions. The results of this frequency analysis are provided in Table 2.

Table 2: Estimated Effluent Discharge Rates for Return Periods

Return Period (years)		Effluent Discharge to Upper Marmion Lake(m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average		0.016	0.000	0.000	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Wet Return period	10	0.056	0.000	0.000	0.066	0.065	0.066	0.065	0.065	0.064	0.070	0.056	0.056
	25	0.072	0.000	0.001	0.091	0.091	0.091	0.091	0.090	0.094	0.086	0.072	0.072
	50	0.071	0.000	0.009	0.110	0.109	0.110	0.109	0.108	0.107	0.097	0.083	0.083
	100	0.063	0.000	0.039	0.123	0.122	0.123	0.122	0.126	0.130	0.107	0.092	0.092

2.3.2 Water Quality and Temperature

The TDS concentration of the effluent is estimated to range from approximately 400 mg/L to approximately 540 mg/L (see Lake Water Quality TSD, Appendix 2.II) depending on the hydrologic conditions and the baseline water quality assumptions.

The temperature of the effluent is expected to vary with the local ambient air temperature because, prior to discharge, the effluent will be stored on-site in relatively shallow ponds. For the purpose of this assessment, the effluent temperature is assumed to be equal to the average air temperature of the previous seven days (i.e., the 7-day moving average), with a minimum temperature of 2ºC.

2.3.3 Buoyancy

The higher effluent TDS concentration relative to the ambient TDS concentration in Marmion Basin is expected to result in a negatively buoyant or "sinking" plume most of the time. Temperature variation also generates density gradients between the effluent and Marmion Basin throughout the year. Temperature driven density gradients are predicted to result in a positively buoyant or "floating" plume for a short duration in the spring and early summer when the effluent is expected to be warmer than the water in Marmion Basin. Based on the Marmion Basin and effluent TDS and temperature assumptions discussed above, the anticipated discharge buoyancy conditions and their relative frequency of occurrence are shown on Figure 7 and are summarized as follows:

- A sinking plume (a negative density difference greater than 0.2 kg/m^3) is expected to occur about 78% of the time with a maximum negative density difference of 2.2 kg/m^3;
- A neutral plume (an absolute density difference of less than 0.2 kg/m^3) is expected to occur about 14% of the time; and
- A floating plume (a positive density difference greater than 0.2 kg/m^3) is expected to occur about 8% of the time with a maximum positive density difference of 1.7 kg/m^3.

3.0 CONCEPTUAL DIFFUSER DESIGN

3.1 Design Basis

The conceptual diffuser design was designed based on the following target criteria:

- Acceptable performance should be ensured over the full range of expected flows (estimated to range from approximately 0.005 m^3/s to 0.130 m^3/s for the 100-yr wet event);
- The depth of the diffuser should ensure that the effluent does not discharge below the thermocline during the summer stratified period causing accumulation of effluent in the bottom waters;
- The individual ports should be installed at a suitable height above the bottom to:
  - Minimize the re-suspension of sediments due to the turbulent mixing zone; and
  - Minimize the extent and magnitude of effluent plume contacting the sediment.
- Velocity effects on the surface should be minimized to avoid affecting the formation of a safe ice layer during the winter.

3.2 Proposed Design Configuration

To accommodate the anticipated range of flows, a multi-port diffuser is proposed where individual ports can be individually turned on and off. The proposed conceptual design includes:

- One 75 mm (3”) diameter port with a design flow of 0.01 m^3/s, and
- Three 150 mm (6”) diameter ports with a design flow of 0.04 m^3/s each.

The proposed diffuser operation methodology is presented in Figure 8. The design exit velocity for each port is 2.2 m/s. Over the full range of discharge rates, exit velocities will range from 1.1 m/s to 4.4 m/s and will be maintained within a range of 1.8 m/s to 3.0 m/s about 84% of the time. During periods when discharge is small (i.e., less than 0.005 m/s), it is recommended that the effluent be stored on-site and treated and released in batches to ensure adequate diffuser port exit velocities and mixing conditions are maintained.

Based on the bathymetry at the discharge location and temperature profiles measured in Sawbill Bay, the diffuser is proposed to be located approximately 40 m from shore and at an elevation of 407.20 masl. The proposed diffuser ports are angled 30° upwards, directed perpendicular to the shoreline and are located 0.5 m above the lake bed. A schematic cross-section of the proposed diffuser at the discharge location is provided in Figure 9. At the selected location, the diffuser ports are:

- Approximately 1.5 m above the maximum measured thermocline elevation in Sawbill Bay;
- Approximately 4.8 m below the minimum recorded water level in Marmion Basin, and
- Approximately 7.0 m below the average water level in Marmion Basin.

The distance between the diffuser ports is selected to be 10 m. Based on the results of a mixing modelling assessment, this spacing is sufficient to ensure that the individual discharge plumes from each of the ports do not interact in the near field mixing zone.

4.0 PRELIMINARY MIXING ASSESSMENT

4.1 Modelling Approach

A preliminary mixing modelling assessment was performed for the conceptual diffuser design using the CORMIX1. CORMIX1 is the component of the CORMIX modelling package used to represent single port outfalls (Doneker et al., 2007). CORMIX is a USEPA-supported hydrodynamic mixing zone model and decision support system for pollutant discharges into surface waters. It is broadly accepted as a powerful tool for accurate and reliable point source mixing analysis. The CORMIX model is able to predict plume geometry, boundary interaction and dilution characteristics within the initial mixing zone and the behaviour of the discharge plume at larger distances.

Although the proposed diffuser configuration includes multiple diffuser ports operated simultaneously, the single port CORMIX1 model was selected for use in this assessment because the diffuser ports are spaced far enough apart that the effluent plumes do not mix within the initial mixing zone.

4.2 Modelling Assumptions

The mixing assessment was carried out using the following assumptions:

- The diffuser ports are located in a local water depth of 5.3 m with the diffuser ports located 0.5 m above the bed (at a local water depth of 4.8 m). This depth corresponds with the minimum recorded surface water elevation in Marmion Basin and represents a worst-case boundary condition for mixing because shallower water depths reduce the water available for dilution of the effluent plume.
- The density in Marmion Basin is assumed to vertically uniform in the mixing zone because the diffuser is located above the thermocline.
- The effluent pollutant is a conservative substance (i.e., does not decay) with an initial concentration of 1.0.
- An ambient current of 0.5 m/s is assumed based on initial estimates (see Section 2.2.2).

4.3 Modelling Scenarios

The full range of discharge rates (Section 2.3.1) were assessed for the following buoyancy conditions (Section 2.3.3) for the both the small and large ports:

- A negatively buoyant discharge with an effluent density of 2.2 kg/m^3 lower than that of the receiving water;
- A neutrally buoyant discharge with an effluent density equal to the receiving water; and
- A positively buoyant discharge with an effluent density of 1.7 kg/m^3 higher than that of the receiving water.

4.4 Modelling Results

Interaction and attachment of the plume with the lake bed is predicted for both the neutral and negatively buoyant discharges. This boundary interaction causes a recirculation of effluent upwards into the plume and results in full vertical mixing. For the neutral and negatively buoyant discharges, the mixing results were comparable for all discharges in terms of plume dilution, behavior, shape, and trajectory.

Positively buoyant discharges are not predicted to attach to the bottom and rise to the surface within a shorter distance compared to the negative and neutral discharges. At the surface, the positively buoyant effluent spreads laterally in all directions due to the residual buoyancy forces and, as a result, higher dilution proportions are achieved in closer proximity to the diffuser compared to the negative and neutral discharges. For this reason, within the near field mixing zone, negative and neutrally buoyant discharges are considered to represent the worst-case scenario in terms of mixing and potential plume extent and only the mixing results for these conditions are presented in the memorandum.

4.4.1 Small Port Discharges

A single 75 mm (3”) diameter port will be utilized for discharges ranging between 0.005 m^3/s and 0.02 m^3/s (estimated to occur about 37% of the time). The resulting plume is expected to attach to the lake bed and be vertically fully mixed within the plume. Mixing throughout the full mixing layer depth (i.e., the depth from the water surface to the lake bed or top of thermocline) is expected within 30 to 50 m from the port. A plan view of the predicted plume geometry for the design discharge of 0.01 m^3/s is presented in Figure 10 and the predicted plume extents in terms of distance from the diffuser port are provided in Table 3 for different flows and dilution ratios.

4.4.2 Large Port Discharges

Three 150 mm (6") diameter ports will be utilized for discharges ranging between 0.02 m^3/s and 0.13 m^3/s (estimated to occur about 33% of the time). Each port will discharge at rates between 0.02 m^3/s and 0.06 m^3/s and discharges of high flows will be achieved through the simultaneous operation of multiple ports. The resulting plume is expected to attach to the lake bed and be vertically fully mixed within the plume. Mixing throughout the full mixing layer depth (i.e., the depth from the water surface to the lake bed or top of thermocline) is expected within 40 to 50 m from the port. At a spacing of 10 m between ports, the plumes are not predicted to interact until a dilution of greater than 50:1 is achieved. A plan view of the predicted plume geometry for all three ports at their design discharge of 0.04 m^3/s per port is presented in Figure 11. The predicted plume extents in terms of distance from each individual diffuser port are provided in Table 3 for different flows and dilution ratios.

Table 3: Predicted Plume Extents for Different Port Sizes, Discharge Rates and Dilution Ratios

Port Size	Discharge Rate (m^3/s)	Maximum Predicted Plume Extent (m)[1]		
		10:1	20:1	50:1
Small Port (3-inch)	0.005	5.4	10.8	23.3
	0.01	5.5	11.2	27.1
	0.02	5.5	11.3	28.4
Large Port (6-inch)	0.02	10.9	21.8	47.1
	0.04	10.9	22.5	51.2
	0.06	11.0	22.6	52.0

Notes:
[1]Plume extent defined as maximum straight line distance from the diffuser port

4.4.3 Far-field Mixing

Beginning at distances of about 30 m and 50 m, respectively, for the small and large ports (equivalent to dilution ratios of about 50:1), mixing is less influenced by the high exit velocity at the diffuser port but is more dependent on the ambient mixing conditions in Marmion Basin. This assessment has considered a constant unidirectional ambient current of 0.5 m/s, when lake mixing conditions would actually be more complex due to turbulence, wind-driven currents, local temperature and density gradients, and water level management in Marmion Basin. These additional factors would augment the mixing of the effluent outside the near field mixing zone allowing higher dilution rates to be achieved within shorter distances from the diffuser.

To estimate the potential extent of the effluent plumes in the far-field mixing zone, the general geometry of the plumes was extrapolated into the far-field region where full mixing was assumed. For the peak design discharge of 0.12 m^3/s, the estimated maximum extent of dilutions of 100:1 and 500:1 (i.e., mixing proportions of 1% and 0.2%, respectively) as well as the location where the effluent is estimated to equal the average long-term mixing proportion in Marmion Basin are shown on Figure 12 for the area around the discharge location. The small port plume for the design discharge of 0.1 m^3/s is also shown on Figure 12 for illustration purposes. The maximum extent of the effluent plumes overlaid on a map of Marmion Basin is provided in Figure 13 with the average mixing proportions for all of Marmion Basin, based on the results of the lake-wide mixing model (see Section 3.0 of the Lake Water Quality TSD).

4.4.4 Key Water Quality Parameters

Cyanide (CN) and copper (Cu) are of parameters of concern for the project because initial discharge concentrations (prior to discharge through the diffuser) may result in adverse effects to aquatic life. Site specific water quality objectives (SSWQO) for Marmion Basin have been proposed for these parameters based on preexisting chemical conditions and species present in Marmion Basin (see Section 5.2 of the Human Health and Ecological Risk Assessment TSD). The proposed SSWQO for cyanide and copper are 9.8 µg CN/L and 7.9 µg/L, respectively. The mixing assessment predicts that, for the maximum design discharge of 0.12 m^3/s, sufficient dilution to meet the SSWQO for cyanide and copper will be achieved at distances of 29 m and 18 m, respectively, from the diffuser ports (equal to dilution ratios of approximately 16:1 for copper and 26:1 for cyanide). For the maximum design discharge of 0.12 m^3/s, the predicted cyanide and copper concentrations near the diffuser and the average long-term cyanide and copper concentrations in Marmion Basin are provided on Figure 12 and Figure 13.

5.0 CONCLUSIONS

This conceptual diffuser design and preliminary mixing zone assessment supports the following conclusions:

- A multi-port diffuser consisting of one 75 mm (3") diameter port and three 150 mm (6") diameter ports will be able to accommodate the full range of anticipated discharge rates (0.005 m^3/s to 0.130 m^3/s) within an acceptable range of port exit velocities (1.1 m/s to 4.4 m/s);
- The effluent plume is expected to be negatively buoyant about 78% of the time due to a higher effluent TDS concentration. A positively buoyant plume is expected to occur only about 8% of the time in the spring/summer when effluent is warmed quicker than water in Marmion Basin;
- Bottom impingement and full vertical mixing is predicted for both negatively and neutrally buoyant discharges. Positively buoyant discharges are predicted rise more quickly to the surface and spread laterally in all directions, resulting in better mixing conditions in the near-field mixing zone (i.e., higher dilution rates achieved in a shorter distance from the diffuser port);
- At a spacing of 10 m between ports, the plumes are not predicted to interact with each other until a dilution of greater than 50:1 is achieved. Dilutions of 50:1 for the small and large port diameters are predicted to occur at distances of about 30 m and 50 m, respectively, from the diffuser port due to turbulent mixing and the dissipation of energy. Beyond this range, the plume behavior is more dependent on the ambient mixing conditions in Marmion Basin.
- SSWQO for cyanide and copper are predicted to be reached within distances of 29 m and 18 m, respectively, from the diffuser ports (equal to dilution ratios of approximately 16:1 for copper and 26:1 for cyanide at the maximum design discharge).

This assessment has been prepared to provide a high-level understanding of the expected mixing conditions at the proposed discharge location. The conceptual diffuser arrangement and location developed is subject to change during subsequent phases on engineering based on engineering design, future project development and new site information.

6.0 CLOSURE

We trust the above meets your immediate requirements. Please do not hesitate to contact the undersigned if you have any specific questions.

Adam Auckland; M.Sc.
Project Manager, Water Resources Specialist

Gerard Van Arkel, M.Eng., P.Eng.
Associate, Senior Water Resources Engineer

AA/GVA/sp

Attachments:
Figure 1: Site Layout and Proposed Outfall Location
Figure 2: Bathymetry in the Vicinity of the Proposed Outfall
Figure 3: Minimum and Maximum Operating Water Levels for Upper Marmion Reservoir
Figure 4: Upper Marmion Reservoir Annual Water Level Fluctuation Pre- Seine River Water Management Plan
Figure 5: Upper Marmion Reservoir Annual Water Level Fluctuation Post- Seine River Water Management Plan
Figure 6: Estimated Frequency of Effluent Discharge Rates for 28 Year Simulation Period
Figure 7: Estimated Frequency of Effluent Buoyancy Conditions
Figure 8: Proposed Diffuser Operation
Figure 9: Schematic Cross-section of Proposed Diffuser Port (not to scale)
Figure 10: Plan View of Predicted Small Port Effluent Plume (3-inch diffuser port; Q=0.01 m^3/s)
Figure 11: Plan View of Predicted Small Port Effluent Plume (6-inch diffuser ports; Q=0.04 m^3/s per port)
Figure 12: Maximum Extent of Plume Dilution near Outfall
Figure 13: Predicted Long Term Average Effluent Concentrations

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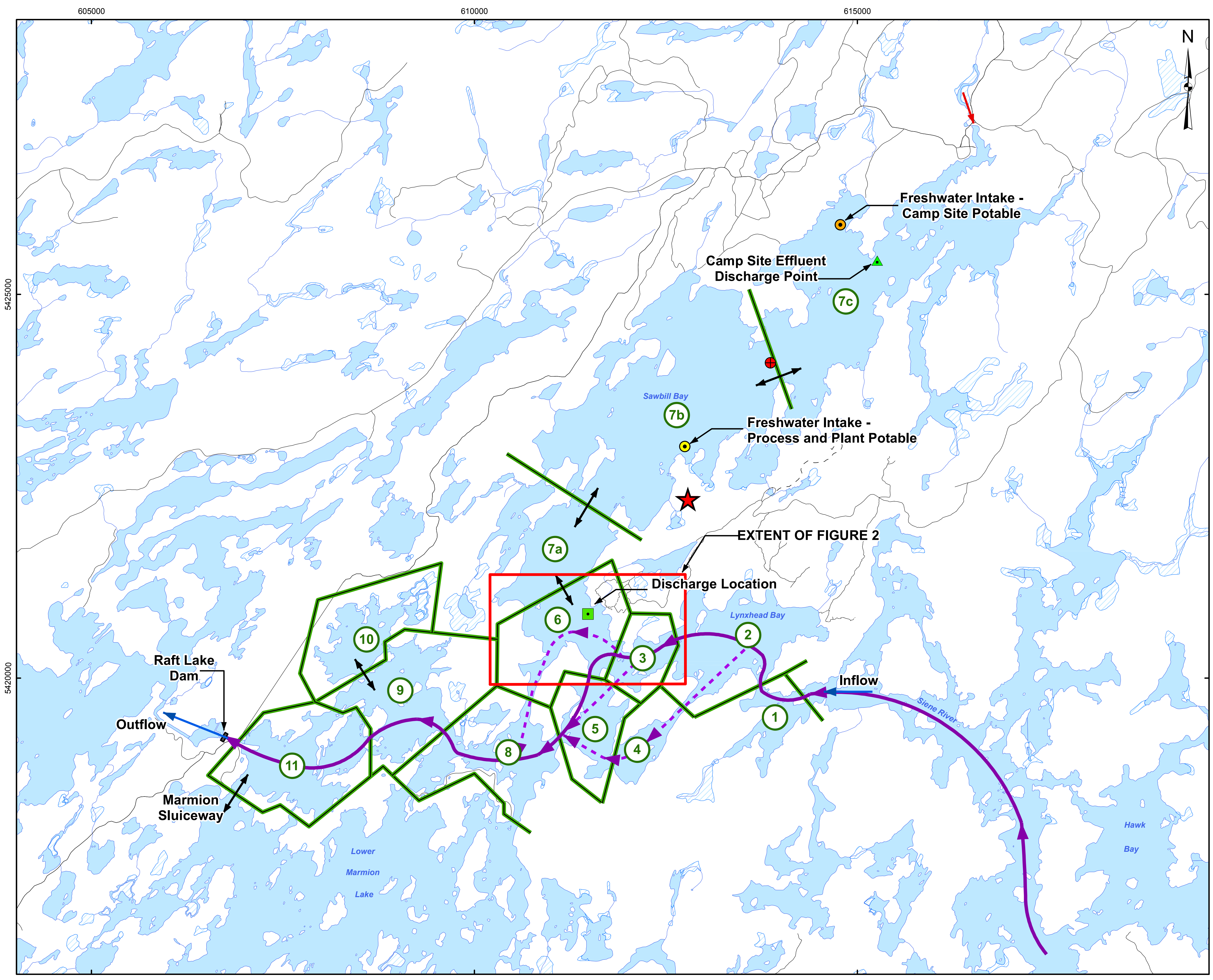
Golder Associates Ltd. (2013b). Hammond Reef Gold Project, Hydrology Technical Support Document. Report No. 10-1118-0020.

Osisko (Osisko Hammond Reef Gold). 2013. Meeting to Discuss Water Quality. 2 July 2013.

USACE (United States Army Corps of Engineers). (2012). Raft Lake on the Seine River near Atikokan, ON – DCP Real Time Data. Accessed Sept. 19, 2012. http://www.mvp-wc.usace.army.mil/dcp/RAFTL.html.



LEGEND

- Proposed Location of Mine Processing Plant
- ADCP Deployment Location (October 2010)
- Effluent Discharge Point
- Discharge Location
- Freshwater Intake - Camp Site Potable
- Freshwater Intake - Process and Plant Potable
- Main River Flow
- Secondary Flow Path
- Water Level Drive Exchange Flow
- Major Tributaries
- Road
- River/Stream
- Lake
- Wetland
- Model Compartment

NOTE:

This figure also shows model compartments used in the lake wide mixing model (see Lake Water Quality TSD) and the main and secondary flow paths through Upper Marmion Reservoir.

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000 1,500 2,000
SCALE 1:50,000 METRES

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
SITE LAYOUT AND PROPOSED OUTFALL LOCATION

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008	**FIGURE: 1**	
GIS	JO	10 Sep. 2013		
CHECK	KDV	10 Sep. 2013		
REVIEW	KDV	10 Sep. 2013		

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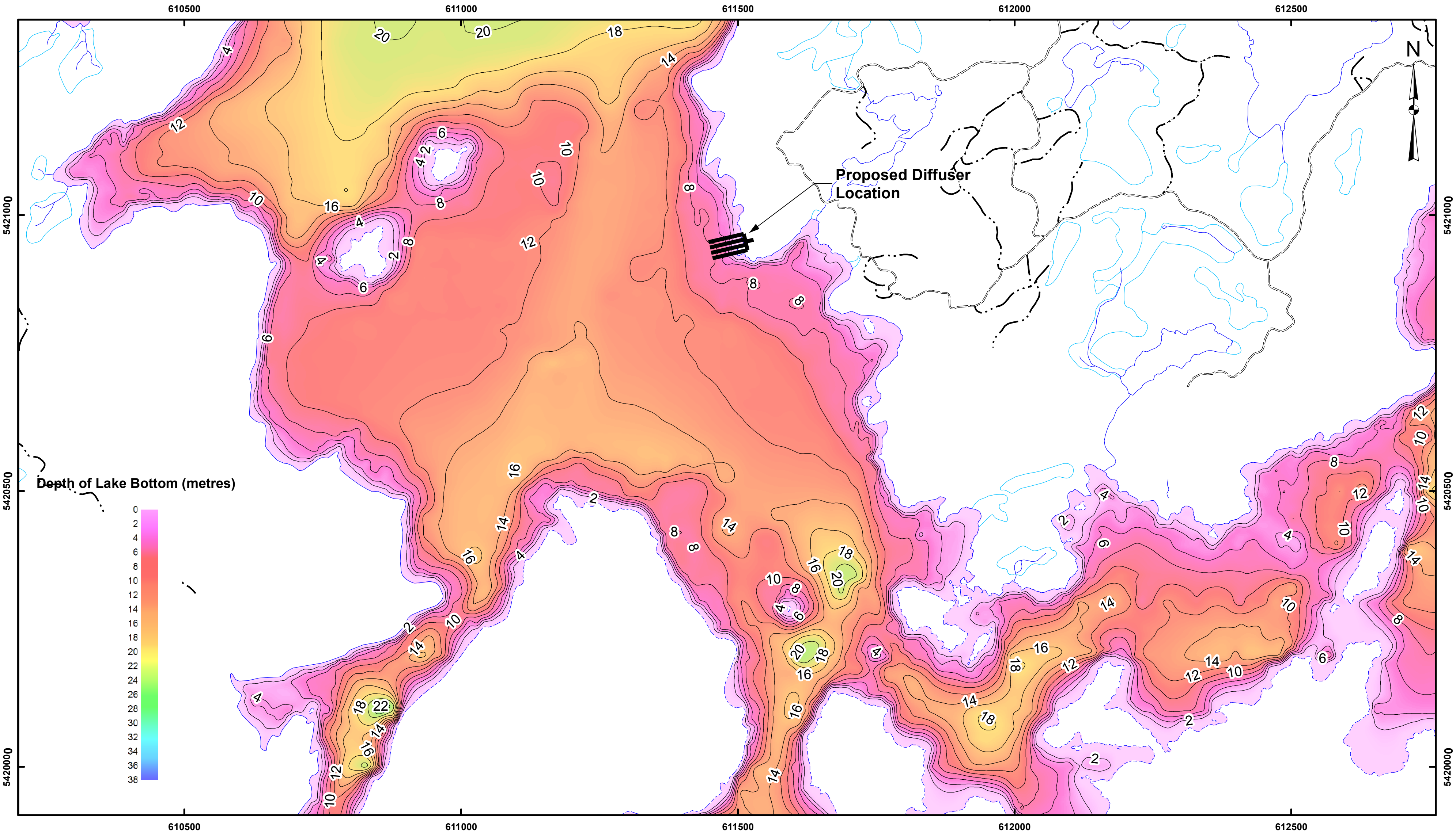

LEGEND

- Proposed Difuser Location
- Dirt Road - Double
- Dirt Road - Single
- Trail
- Lake
- Wetland/Swamp

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

NOTES:

1. Water level/Shoreline elevation used for Marmion Lake was 415.18 m.
2. The contours were derived from a 20 metre cell size for the grid files. Minor contour errors exist at the shorelines where departures are at the scale of the grid dimension.

100 50 0 100 200 300 400
SCALE 1:10,000 Meters

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

BATHYMETRY IN THE VICINITY OF THE PROPOSED OUTFALL

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	16 Mar. 2012	**FIGURE: 2**	
GIS	JO	10 Sep. 2013		
CHECK	KDV	10 Sep. 2013		
REVIEW	KDV	10 Sep. 2013		

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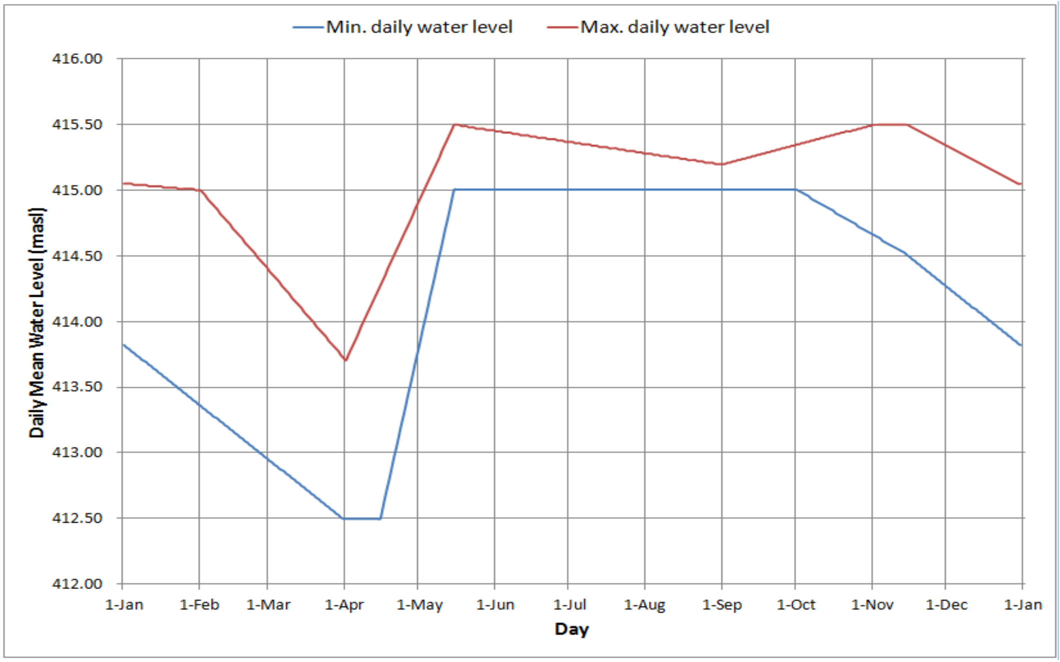


Figure 3: Minimum and Maximum Operating Water Levels for Upper Marmion Reservoir

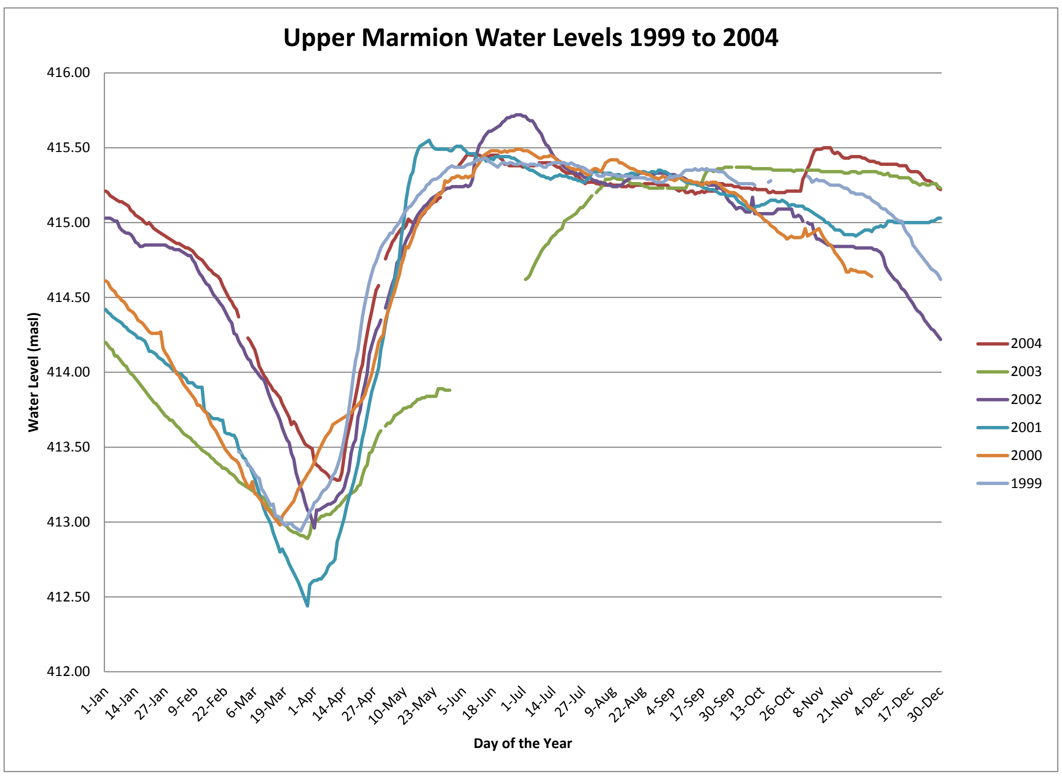


Figure 4: Upper Marmion Reservoir Annual Water Level Fluctuation Pre- Seine River Water Management Plan

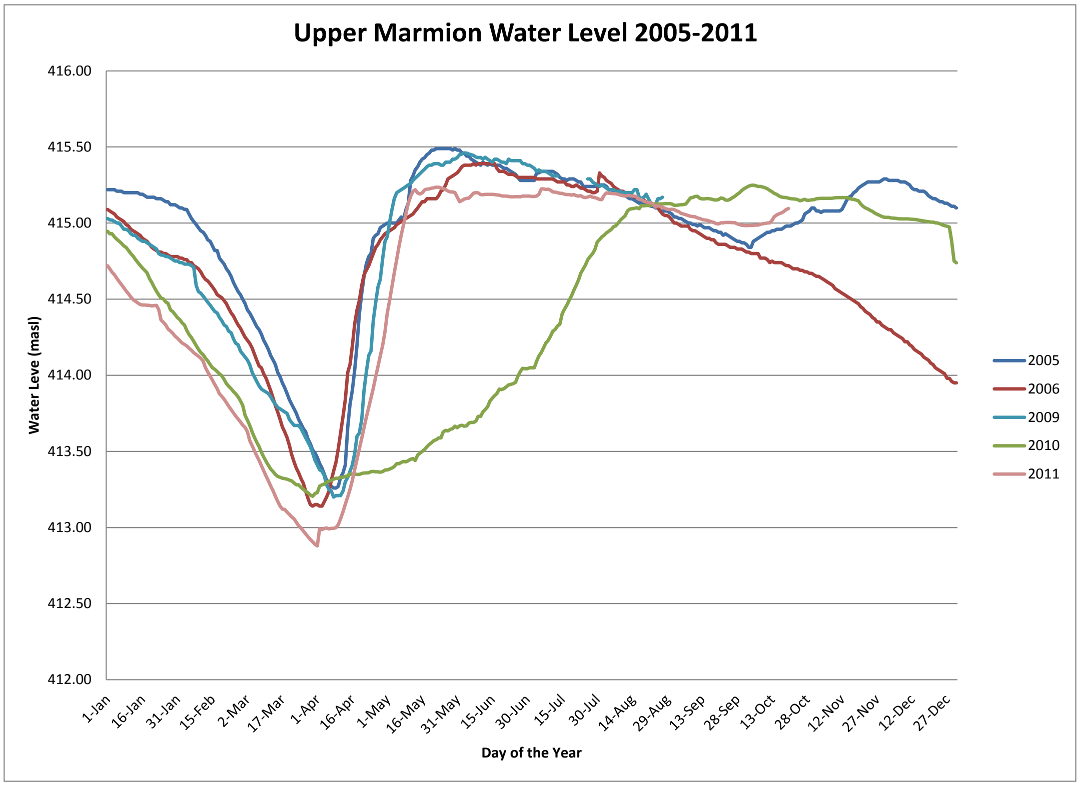


Figure 5: Upper Marmion Reservoir Annual Water Level Fluctuation Post- Seine River Water Management Plan

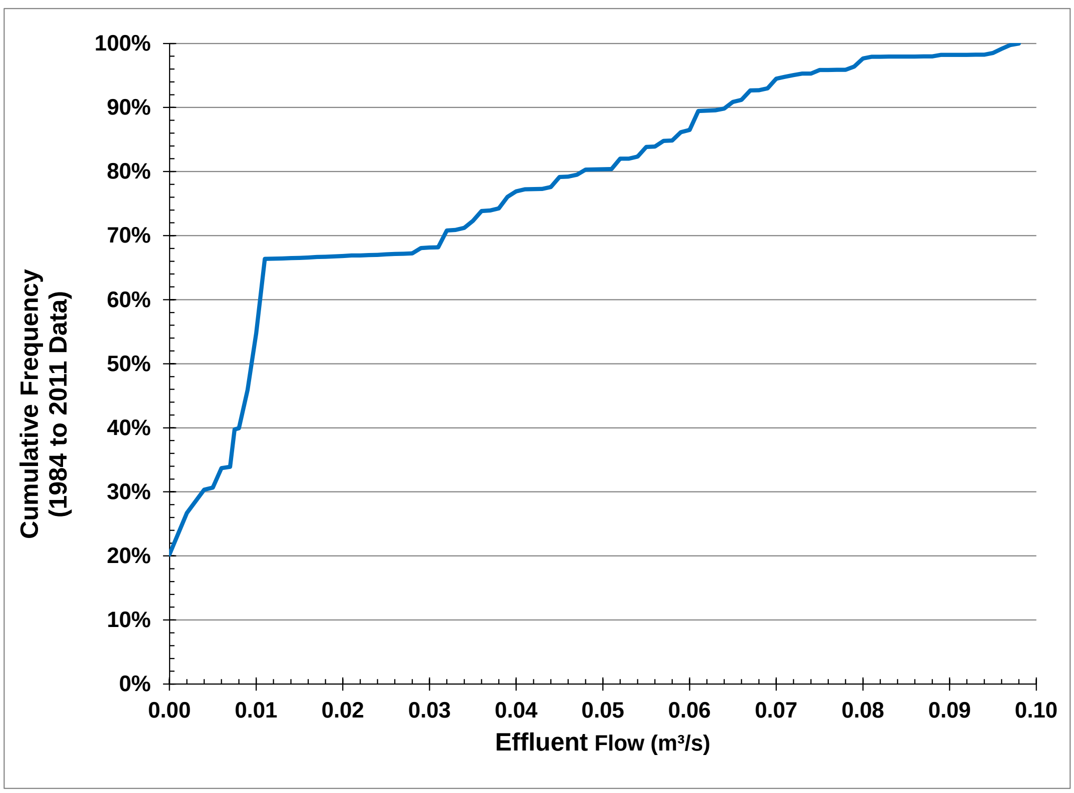


Figure 6: Estimated Frequency of Effluent Discharge Rates for 28 Year Simulation Period

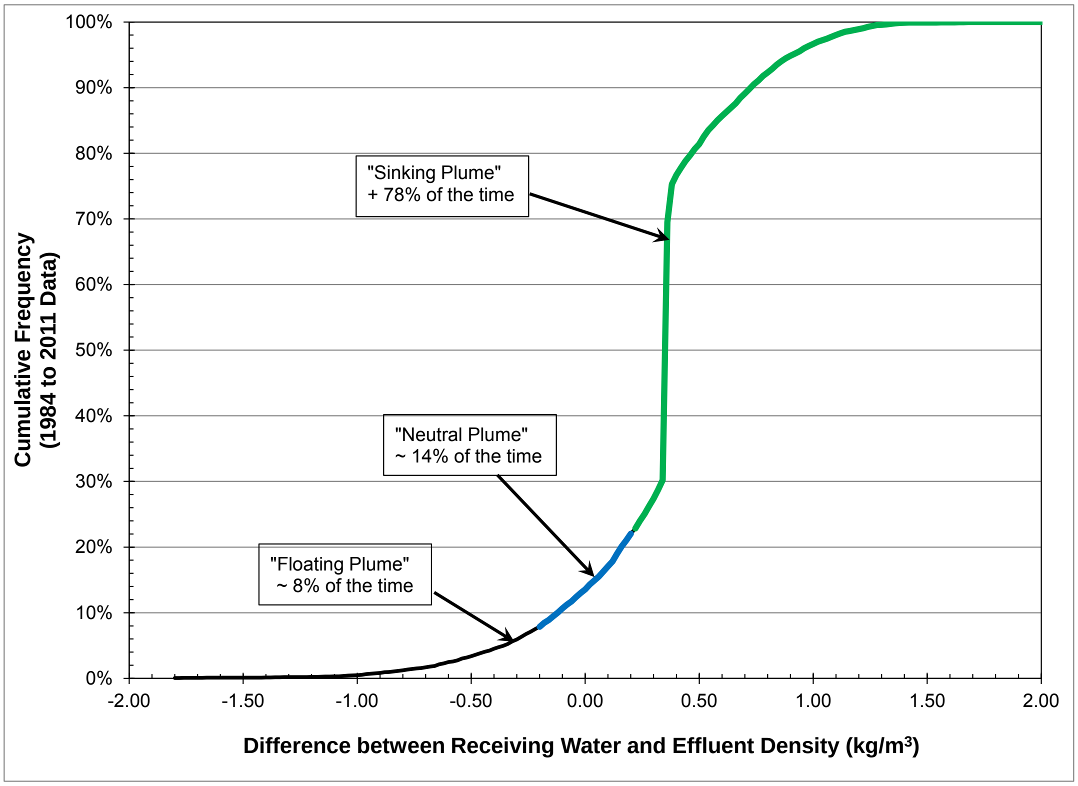


Figure 7: Estimated Frequency of Effluent Buoyancy Conditions

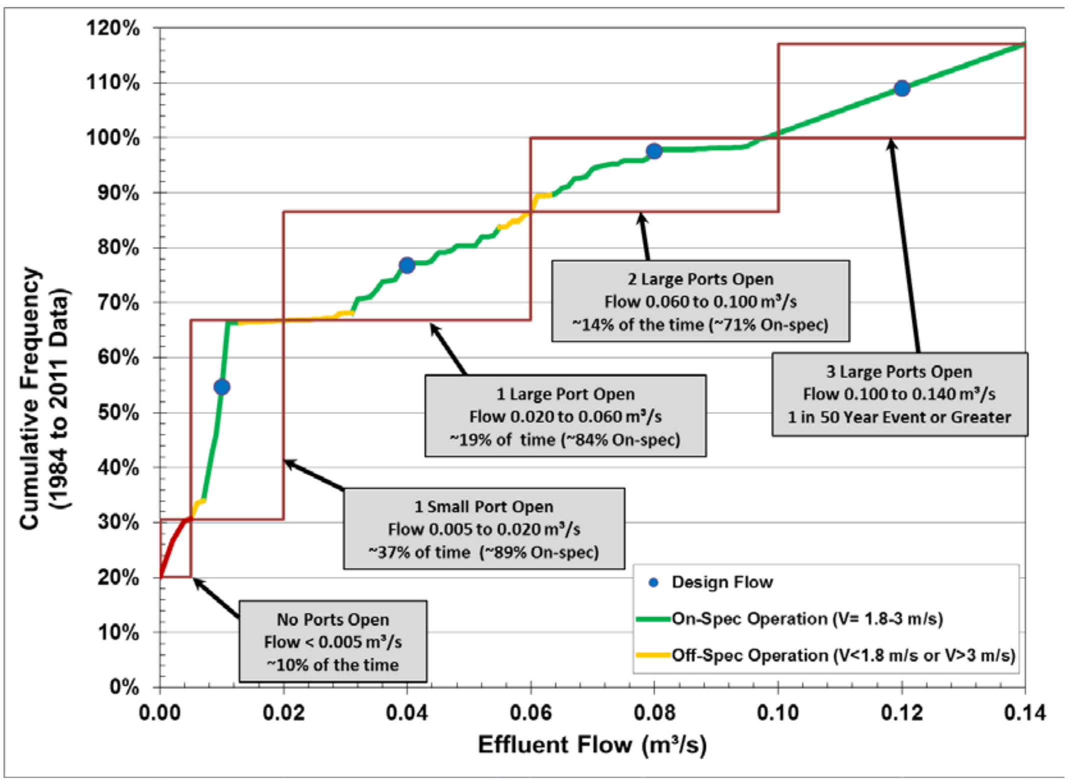


Figure 8: Proposed Diffuser Operation

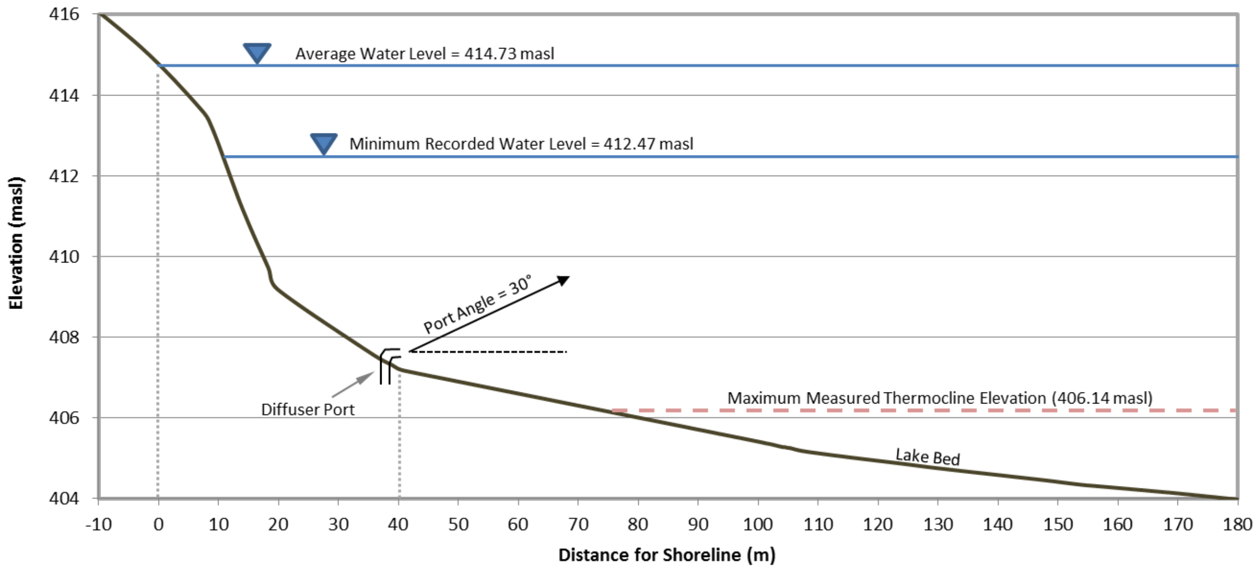


Figure 9: Schematic Cross-section of Proposed Diffuser Port (not to scale)

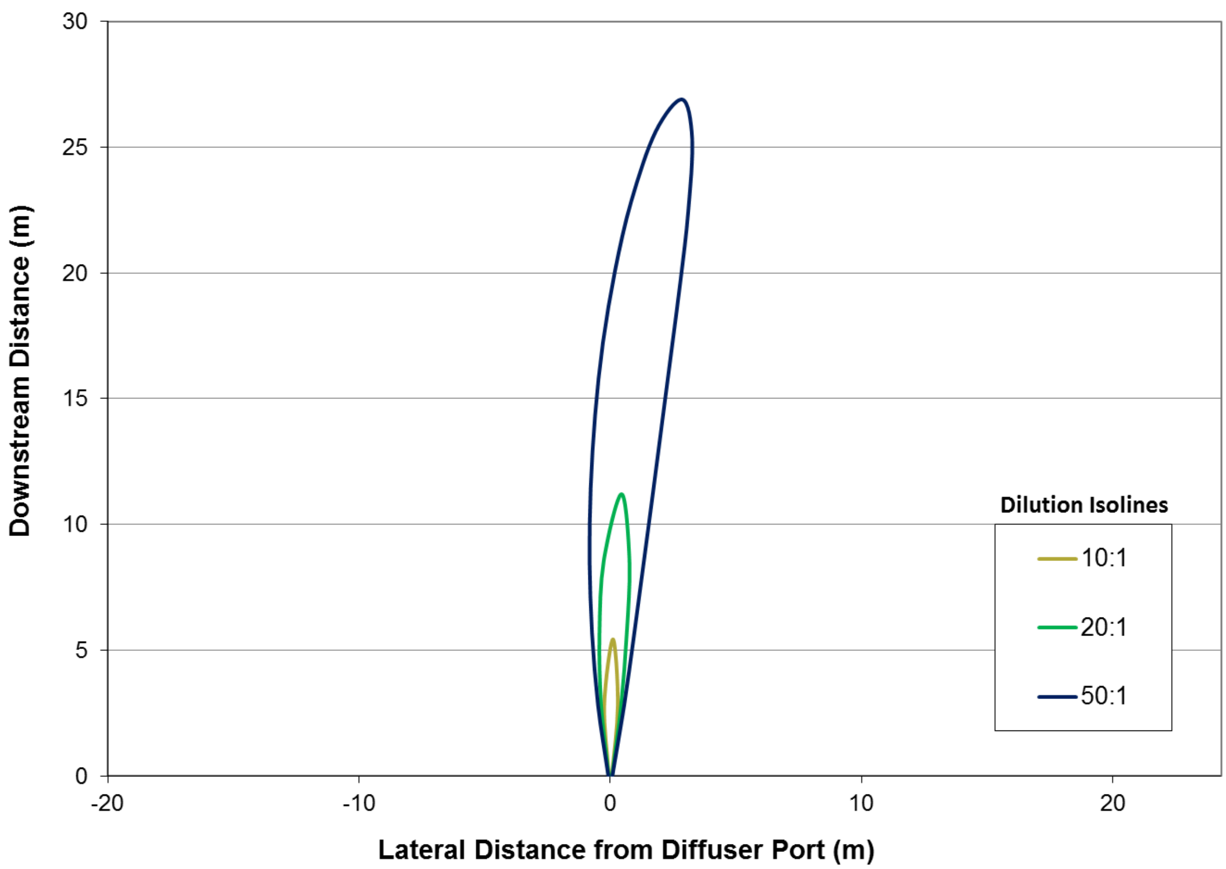


Figure 10: Plan View of Predicted Small Port Effluent Plume (3-inch diffuser port; Q=0.01 m^3/s)

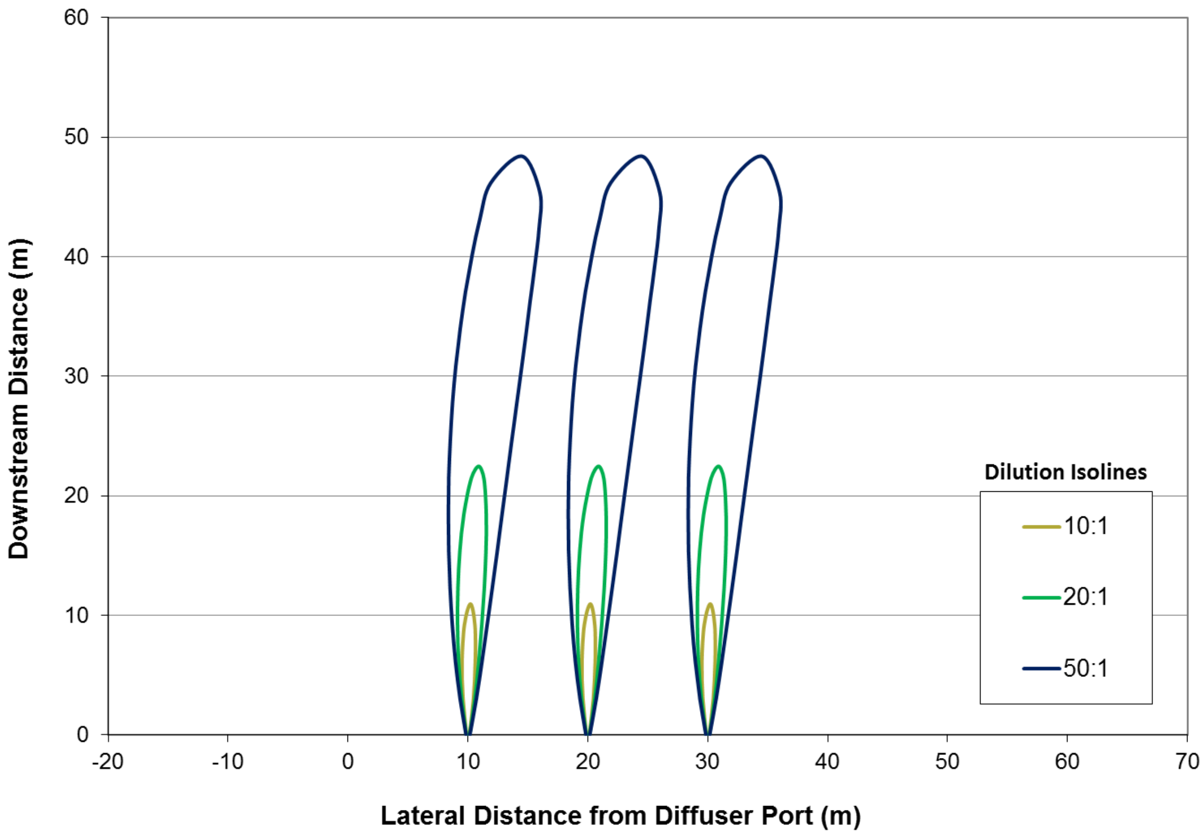
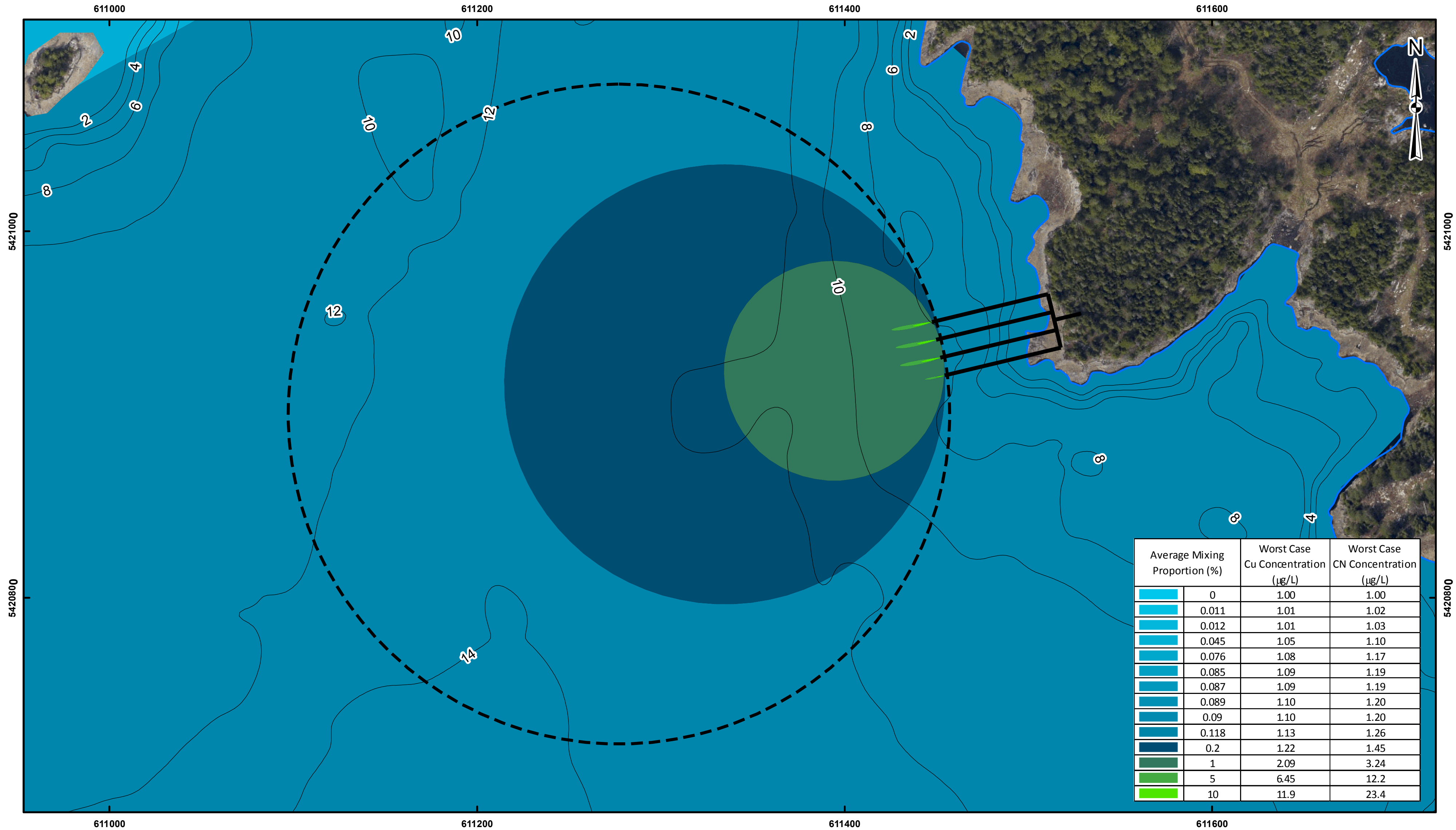


Figure 11: Plan View of Predicted Small Port Effluent Plume (6-inch diffuser ports; Q=0.04 m^3/s per port)



Average Mixing Proportion (%)	Worst Case Cu Concentration (µg/L)	Worst Case CN Concentration (µg/L)
0	1.00	1.00
0.011	1.01	1.02
0.012	1.01	1.03
0.045	1.05	1.10
0.076	1.08	1.17
0.085	1.09	1.19
0.087	1.09	1.19
0.089	1.10	1.20
0.09	1.10	1.20
0.118	1.13	1.26
0.2	1.22	1.45
1	2.09	3.24
5	6.45	12.2
10	11.9	23.4

LEGEND

- Conceptuial Effluent Pipeline
- Bathymetry Contour
- Shoreline

25 12.5 0 25 50 75 100

SCALE 1:3,000 Meters

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

NOTE:

Plume dilution shown for maximum design discharge (Q = 0.12m^3/s)

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

MAXIMUM EXTENT OF PLUME DILUTION NEAR OUTFALL

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	16 Mar. 2012		
GIS	JO	10 Sep. 2013		
CHECK	KDV	10 Sep. 2013		
REVIEW	KDV	10 Sep. 2013		

FIGURE: 12

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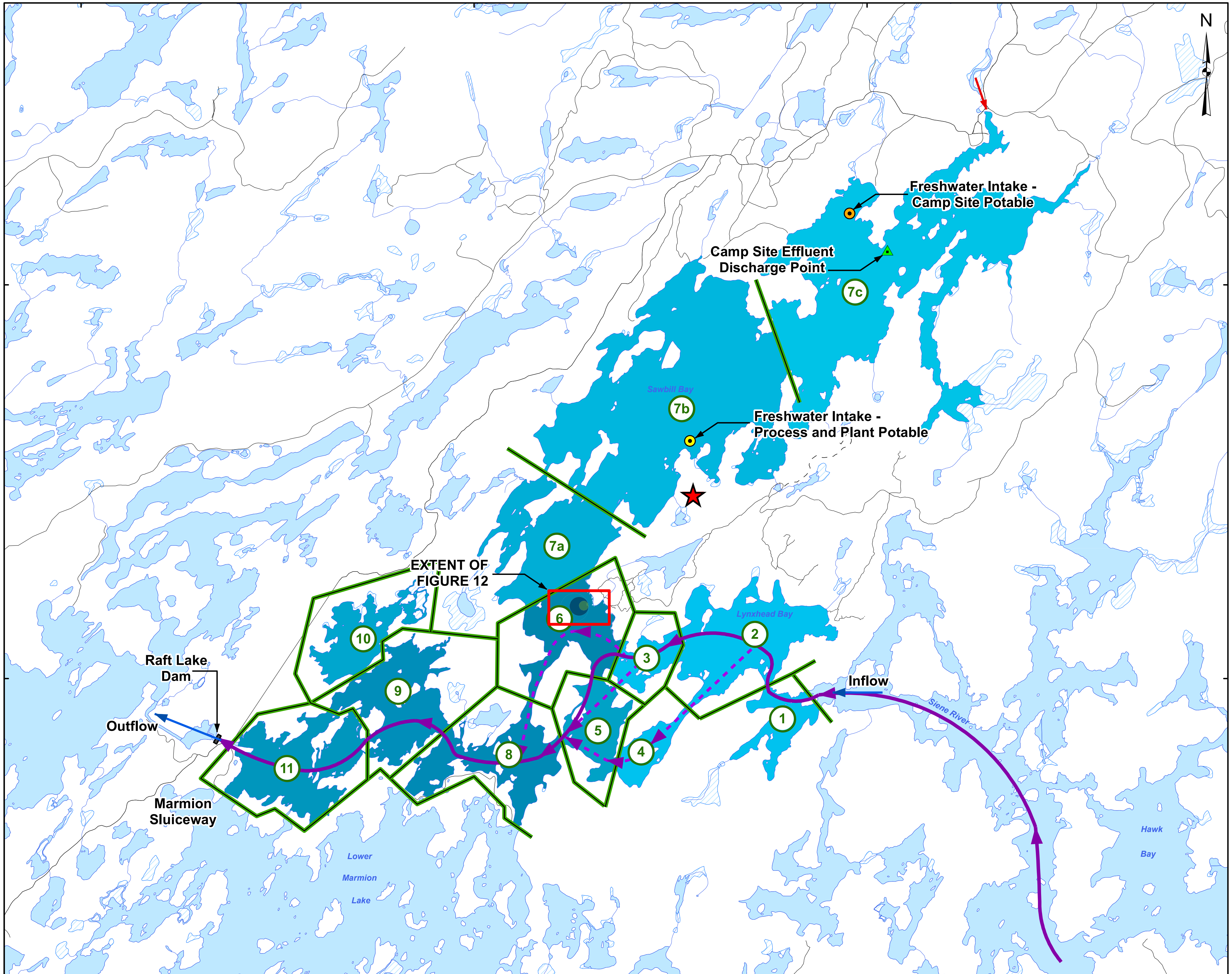

LEGEND

- Proposed Location of Mine Processing Plant
- Effluent Discharge Point
- Freshwater Intake - Camp Site Potable
- Freshwater Intake - Process and Plant Potable
- Main River Flow
- Secondary Flow Path
- Major Tributaries
- Road
- River/Stream
- Lake
- Wetland
- Model Compartment

	Average Mixing Proportion (%)	Worst Case Cu Concentration (µg/L)	Worst Case CN Concentration (µg/L)
	0	1.00	1.00
	0.011	1.01	1.02
	0.012	1.01	1.03
	0.045	1.05	1.10
	0.076	1.08	1.17
	0.085	1.09	1.19
	0.087	1.09	1.19
	0.089	1.10	1.20
	0.09	1.10	1.20
	0.118	1.13	1.26
	0.2	1.22	1.45
	1	2.09	3.24
	5	6.45	12.2
	10	11.9	23.4

NOTE:

Plume dilution shown for maximum design discharge ($Q = 0.12 m^3/s$)

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000 1,500 2,000
SCALE 1:50,000 METRES

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

PREDICTED LONG TERM AVERAGE EFFLUENT CONCENTRATIONS

Golder Associates
Mississauga, Ontario

PROJECT No. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008		
GIS	JO	11 Sep. 2013		
CHECK	KDV	11 Sep. 2013		
REVIEW	KDV	11 Sep. 2013		

FIGURE: 13

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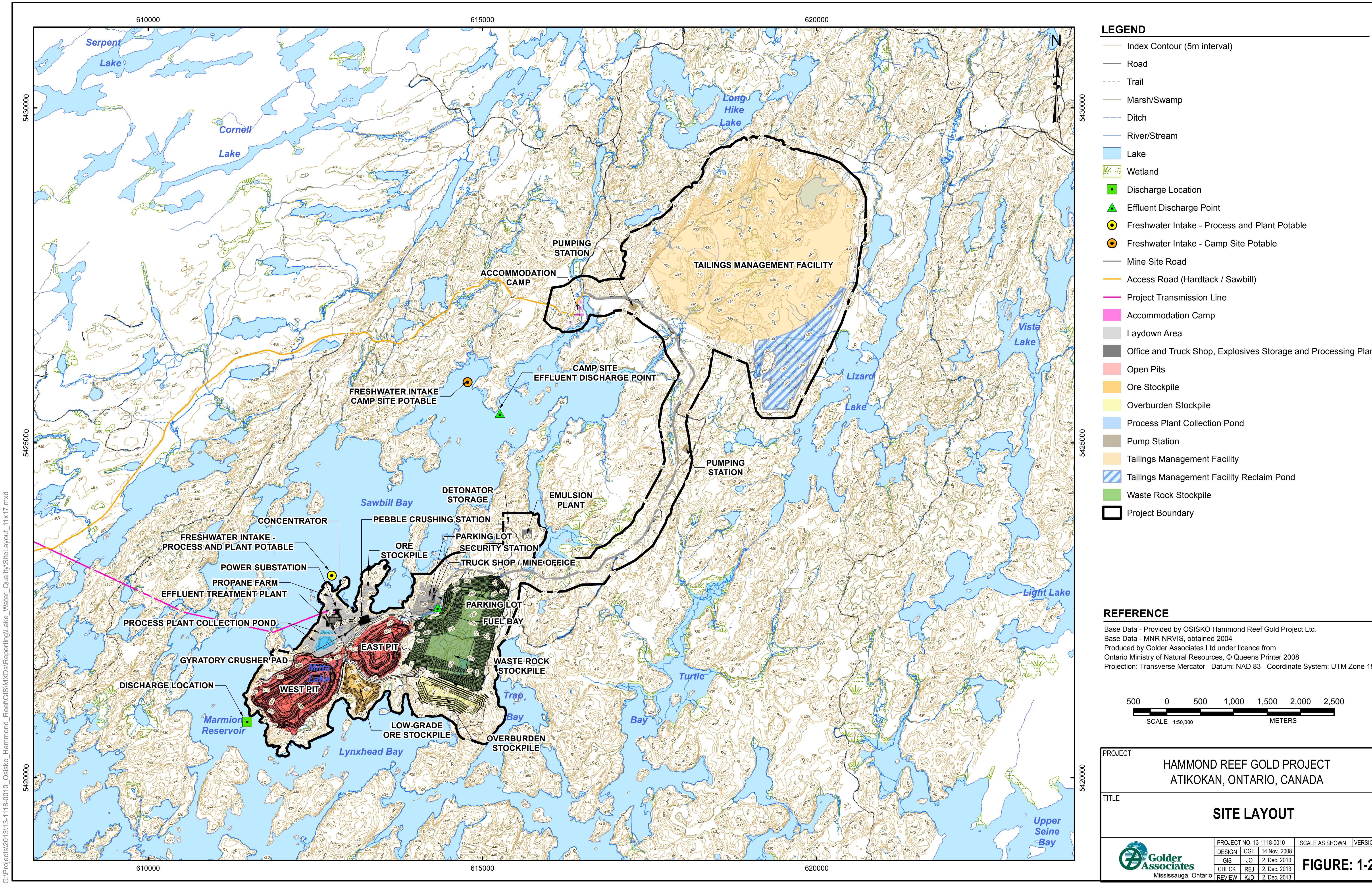

610000
615000
620000
5430000
5425000
5420000
Serpent Lake
Cornell Lake
Long Hike Lake
Vista Lake
Lizard Lake
Sawbill Bay
Turtle Bay
Trap Bay
Lynxhead Bay
Marmion Reservoir
Light Lake
Upper Seine Bay
Mitta Lake
N
PUMPING STATION
ACCOMMODATION CAMP
TAILINGS MANAGEMENT FACILITY
CAMP SITE EFFLUENT DISCHARGE POINT
FRESHWATER INTAKE CAMP SITE POTABLE
PUMPING STATION
DETONATOR STORAGE
EMULSION PLANT
CONCENTRATOR
PEBBLE CRUSHING STATION
FRESHWATER INTAKE - PROCESS AND PLANT POTABLE
ORE STOCKPILE
PARKING LOT
SECURITY STATION
TRUCK SHOP / MINE OFFICE
POWER SUBSTATION
PROPANE FARM
EFFLUENT TREATMENT PLANT
PARKING LOT
FUEL BAY
PROCESS PLANT COLLECTION POND
EAST PIT
GYRATORY CRUSHER PAD
WASTE ROCK STOCKPILE
DISCHARGE LOCATION
WEST PIT
LOW-GRADE ORE STOCKPILE
OVERBURDEN STOCKPILE
LEGEND
Index Contour (5m interval)
Road
Trail
Marsh/Swamp
Ditch
River/Stream
Lake
Wetland
Discharge Location
Effluent Discharge Point
Freshwater Intake - Process and Plant Potable
Freshwater Intake - Camp Site Potable
Mine Site Road
Access Road (Hardtack / Sawbill)
Project Transmission Line
Accommodation Camp
Laydown Area
Office and Truck Shop, Explosives Storage and Processing Plant
Open Pits
Ore Stockpile
Overburden Stockpile
Process Plant Collection Pond
Pump Station
Tailings Management Facility
Tailings Management Facility Reclaim Pond
Waste Rock Stockpile
Project Boundary
REFERENCE
Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N
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PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA
TITLE
SITE LAYOUT
Golder Associates
Mississauga, Ontario
PROJECT NO. 13-1118-0010
SCALE AS SHOWN
VERSION 2
DESIGN CGE 14 Nov. 2008
GIS JO 2. Dec. 2013
CHECK REJ 2. Dec. 2013
REVIEW KJD 2. Dec. 2013
FIGURE: 1-2
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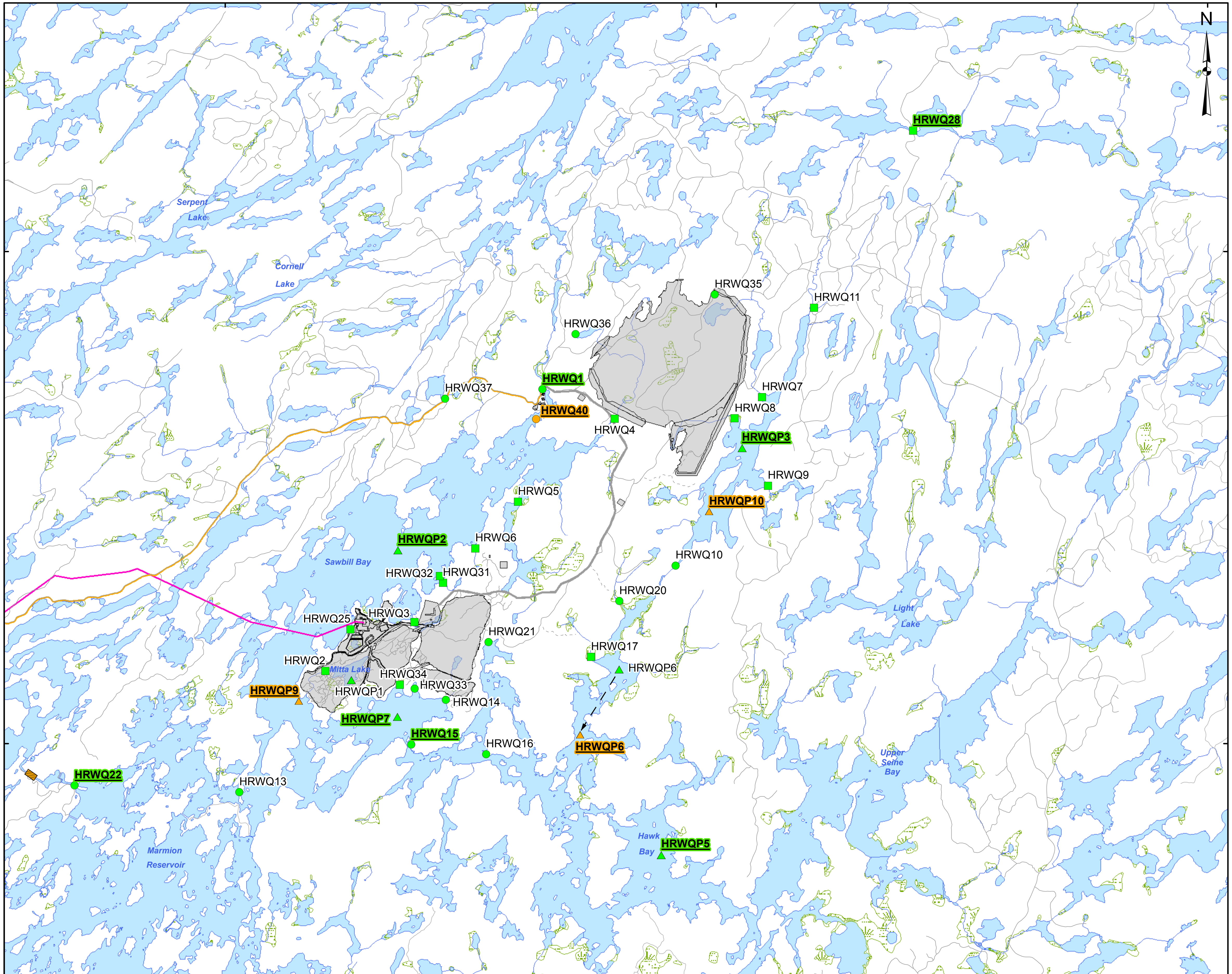

LEGEND

- New Surface Water Sample Location
- New Profile Sample Location
- Surface Water Sample Location
- Surface Water and Sediment Sample Location
- Profile Sample Location (Surface Water and Sediment)
- Raft Lake Cut Location
- Road
- Trail
- River/Stream
- Lake
- Wetland
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Project Transmission Line
- Project Facilities

SAMPLE LABELS

HRWQx, HRWQPx } 2013 Sample Location (New)

HRWQx, HRWQPx } 2013 Sample Location (Existing)

HRWQx 2010 - 2012 Sample Location

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

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PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
WATER QUALITY, SEDIMENT AND PROFILE SAMPLE LOCATIONS

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008	FIGURE: 1	
GIS	JO	11 Sep. 2013		
CHECK	REJ	11 Sep. 2013		
REVIEW	KJD	11 Sep. 2013		

Golder Associates
Mississauga, Ontario

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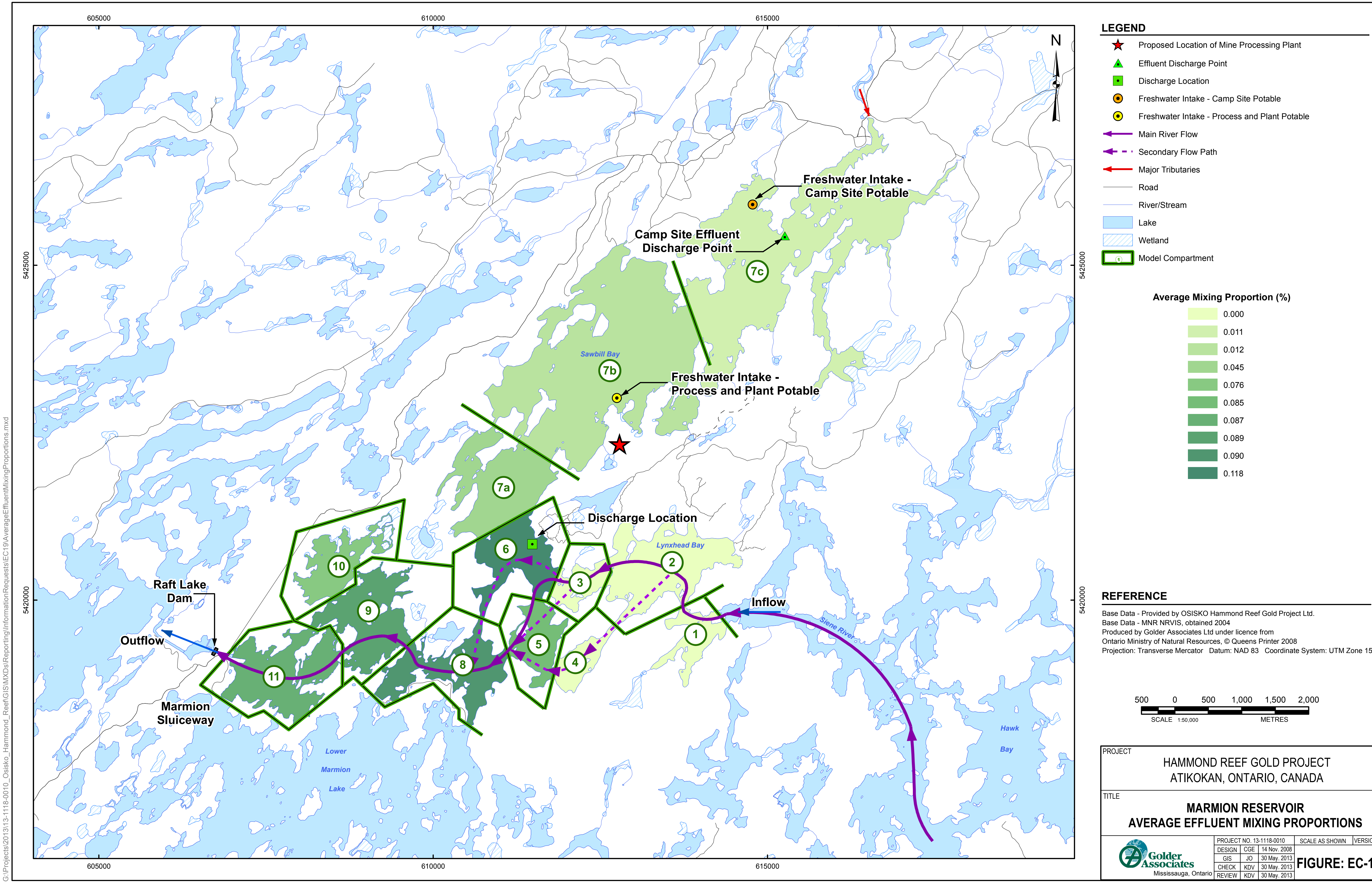

LEGEND
Proposed Location of Mine Processing Plant
Effluent Discharge Point
Discharge Location
Freshwater Intake - Camp Site Potable
Freshwater Intake - Process and Plant Potable
Main River Flow
Secondary Flow Path
Major Tributaries
Road
River/Stream
Lake
Wetland
Model Compartment
Average Mixing Proportion (%)
0.000
0.011
0.012
0.045
0.076
0.085
0.087
0.089
0.090
0.118
REFERENCE
Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N
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SCALE 1:50,000 METRES
Freshwater Intake - Camp Site Potable
Camp Site Effluent Discharge Point
Freshwater Intake - Process and Plant Potable
Discharge Location
Sawbill Bay
Lynxhead Bay
Inflow
Siene River
Raft Lake Dam
Outflow
Marmion Sluiceway
Lower Marmion Lake
Hawk Bay
1
2
3
4
5
6
7a
7b
7c
8
9
10
11
605000
610000
615000
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N
PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA
TITLE
MARMION RESERVOIR
AVERAGE EFFLUENT MIXING PROPORTIONS
PROJECT NO. 13-1118-0010 SCALE AS SHOWN VERSION 2
DESIGN CGE 14 Nov. 2008
GIS JO 30 May. 2013
CHECK KDV 30 May. 2013
REVIEW KDV 30 May. 2013
Golder Associates
Mississauga, Ontario
FIGURE: EC-19
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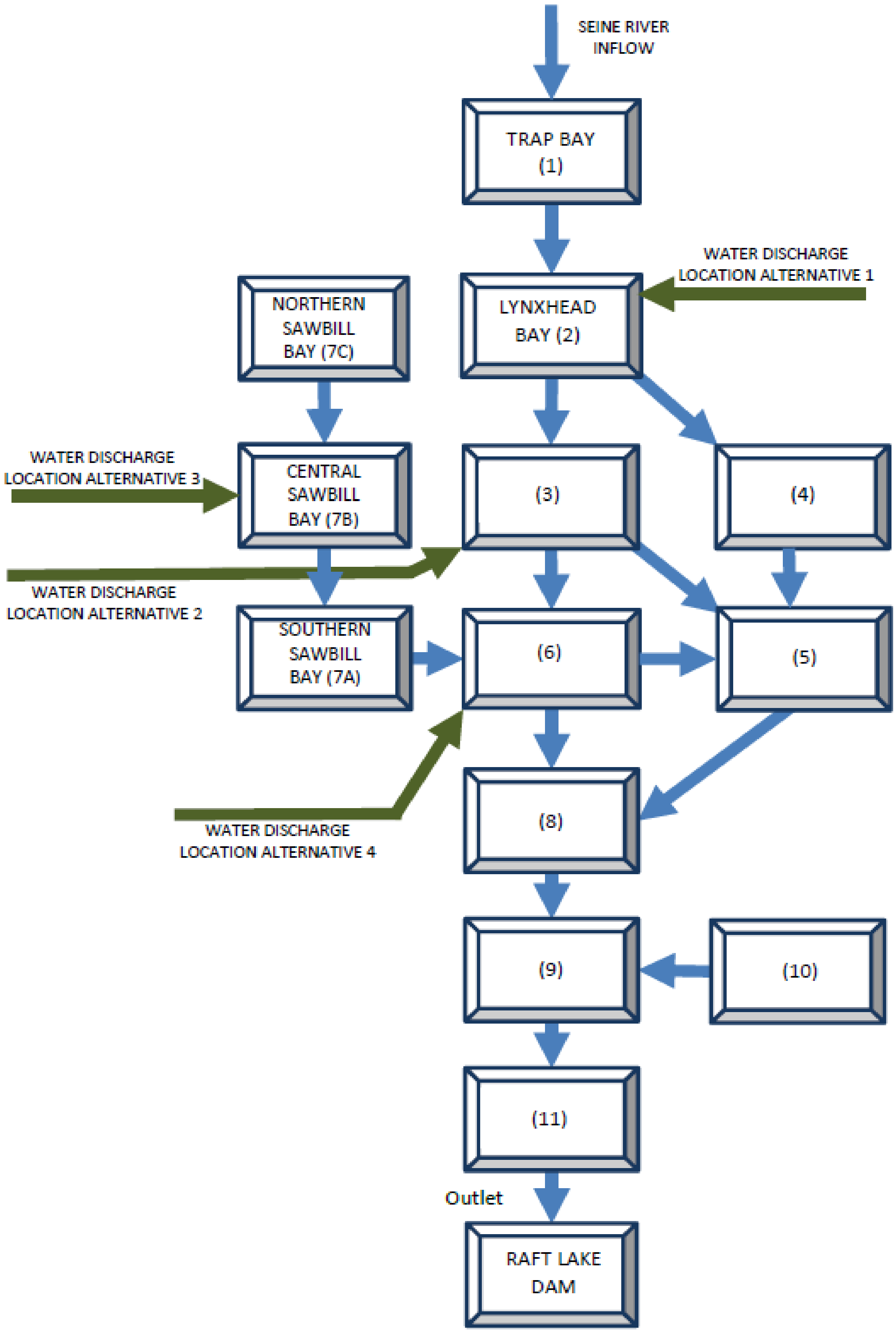

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

BOX MODEL FOR UPPER MARMION LAKE

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	GVA	12 Nov. 2012	**FIGURE: 3-1**	
GIS				
CHECK	REJ	30 May. 2013		
REVIEW	KJD	30 May. 2013		

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PART C

Lake Water Quality Technical Support Document, Version 1

February 2013

HAMMOND REEF GOLD PROJECT
Lake Water Quality Technical Support Document

VERSION 1

Submitted to:
Osisko Hammond Reef Gold Ltd.
155 University Avenue, Suite 300
Toronto, Ontario M5H 3B7

Project Number: 10-1118-0020

Document Number: 2012-076

Distribution:

Alexandra Drapack, Director Sustainable Development

Cathryn Moffett, Project Manager Sustainable Development

Hammond Reef Gold Project
Lake Water Quality Technical Support Document

Prepared by: Rachel James, M.Sc. | Date: February 15, 2013

Rachel James, M.Sc.
Environmental Specialist
Golder Associates Ltd.

Reviewed by: Ken DeVos, M.Sc., P.Geo. | Date: February 15, 2013

Ken DeVos, M.Sc., P.Geo.
Principal, Project Director
Golder Associates Ltd.

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1.0 INTRODUCTION

Osisko Hammond Reef Gold Ltd. (OHRG) proposes the development of an open pit gold mine in north-western Ontario, herein referred to as the Hammond Reef Gold Project (Project). This Technical Support Document (TSD) is one of a series of reports in support of the Project's Environmental Impact Statement/Environmental Assessment Report (EIS/EA Report).

The following reports have been prepared to support the EIS/EA Report:

- Atmospheric Environment TSD.
- Geochemistry, Geology and Soil TSD.
- Hydrogeology TSD.
- Hydrology TSD.
- Water and Sediment Quality TSD.
- Site Water Quality TSD.
- **Lake Water Quality TSD.**
- Aquatic Environment TSD.
- Terrestrial Ecology TSD.
- Aboriginal Interests TSD.
- Cultural Heritage Resources TSD.
- Human Health and Ecological Risk Assessment TSD.
- Socio-economic Environment TSD.
- Alternatives Assessment Report.
- Conceptual Closure and Rehabilitation Plan.

The EIS/EA Report will summarize the findings of this TSD and of the above-listed supporting reports.

1.1 Purpose and Scope

The purpose of this TSD is to fulfill the assessment scope outlined in the Project's Terms of Reference (ToR) approved by the Ontario Minister of the Environment (July 2012), and in the Environmental Impact Statement Guidelines (EIS Guidelines) published by the Canadian Environmental Assessment Agency (CEA Agency) (December 2011).

This TSD provides description of the predicted conditions in the receiving water bodies including environmental processes, interrelations and interactions of subcomponents, and their predicted variability over Project phases.

Receiving water, including Upper Marmion Reservoir and Lizard Lake, is referred to herein as “lake” or "lake water". The assessment of receiving water quality is broken down into the following subcomponents:

- Lake Water Mixing (and Atmospheric Deposition Implications on Lake Water Quality).
- Upper Marmion Reservoir Water Quality.
- Raft Lake Dam Discharge Water Quality.
- Lizard Lake Water Quality.

The overall objective of the programs completed and described in this TSD is to provide specific information at a level sufficient for inclusion in the EIS/EA Report in order to guide decision making regarding the potential for environmental effects of the Project, or to allow for further analyses as part of other TSDs or work related to the environmental assessment. The information and findings developed from this assessment of lake water quality will be considered in other TSDs including the Aquatic Environment TSD. This TSD provides the basis and estimated concentrations for lake water quality only. The assessment of environmental effects, the determination of significance of these effects, and the proposed mitigation measures will be addressed in the EIS/EA Report and the Human Health and Ecological Risk Assessment TSD. An explanation of this approach is provided in Section 1.4 of this report.

1.2 Report Organization

This TSD is structured as follows:

- Section 1 presents the purpose and scope of the TSD, an overview of the Project, the general assessment approach, incorporation of traditional knowledge, Valued Ecosystem Components, and assessment boundaries of the TSD.
- Section 2 describes the methods used to predict changes to water quantity in Upper Marmion Reservoir.
- Section 3 describes the general mixing model results in Upper Marmion Reservoir.
- Section 4 provides the input conditions, layout and results of water quality modelling for Upper Marmion Reservoir during operations.
- Section 5 provides the input conditions, layout and results of water quality modelling for Upper Marmion Reservoir at post-closure.
- Section 6 describes the methods used to predict changes to water quantity in Lizard Lake.
- Section 7 describes the general mixing model results in Lizard Lake.
- Section 8 provides the input conditions, layout and results of water quality modelling for Lizard Lake during operations.
- Section 9 provides the input conditions, layout and results of water quality modelling for Lizard Lake at post-closure.
- Section 10 summarizes the findings of this report.

1.3 Project Overview

The Project overview and Project description is provided in Chapter 5 of the EIS/EA Report. Project aspects that influence the lake water quality predictions and evaluation are described in Sections 1.3 to 1.8.

1.3.1 Project Location

The Project is located within the Thunder Bay Mining District in north-western Ontario, approximately 170 kilometres (km) west of Thunder Bay and 23 km northeast of the town of Atikokan (Figure 1-1).

Access to the Hammond Reef property is presently via two routes: the Premier Lake Road, a gravel road that intersects Highway 623 near Sapawe and the Hardtack-Sawbill Road, a gravel road that intersects Highway 622 northwest of the Town of Atikokan. The Hammond Reef property is also accessible by water from the southwest end of the Marmion Reservoir at its access point from Highway 622. The existing Hardtack-Sawbill road located to the north of Finlayson Lake has been upgraded to provide an improved and more direct linkage to the Project Site in support of the expanded exploration program.

The Hammond Reef deposit is located mainly on a peninsula of land extending into the north end of the Upper Marmion Reservoir. The peninsula containing the deposit is surrounded by the Upper Marmion Reservoir on three sides with Sawbill Bay to the northwest and Lynxhead Bay to the southeast. The property also contains a number of smaller lakes. Mitta Lake is a small, steep-sided waterbody located atop mineralized zones of the deposit. Due to its location, the open pit mining activities require the draining of Mitta Lake.

1.3.2 Climate

The Project is located in a typical boreal climate region, which is characterized by long, usually very cold winters, and short, cool to mild summers. The annual temperature average is 1.6 degrees Celsius (°C) for Atikokan with a seasonal maximum of 16.2°C (average) for summer and a minimum of minus 15.4°C (average) for winter. Temperatures lower than minus 37°C have been recorded during the fall and winter. The annual normal total for precipitation is 788 millimetres (mm) (568 mm of rainfall and 220 mm of snowfall) for Atikokan with a seasonal maximum of 299 mm for the summer period.

1.3.3 Project Phases

The Project comprises four phases: construction, operations, closure and post-closure. With regards to the lake water quality assessment, the most relevant is the operations phase given the potential for Project Site discharge during this time period. At closure and into post-closure flooding and overflow of the open pits may also have some influence on downstream water quality.

Activities expected to have the greatest influence on the lake water quality include:

- Existing hydrologic environment of the Upper Marmion Reservoir.
- Discharge from the Project Site.
- Discharge from the accommodation camp.
- Possibility of seepage and runoff from other Project Site locations during operations, closure and post-closure.
- Flooding and overflow of the open pits at closure and post-closure.

Additional details regarding activities expected to take place in each phase of the Project are provided in Chapter 5 of the EIS/EA Report.

1.3.4 Project Components

The Project consists of eight main components:

- Mine, including two open pits (east pit and west pit).
- Waste Rock Management Facility (WRMF).
- Ore Processing Facility.
- Tailings Management Facility (TMF).
- Support and Ancillary Infrastructure.
- Water Management System.
- Linear Infrastructure.
- Borrow Sites.

Of these, the key components related to lake water quality are capture and direction of runoff from the Mine, WRMF, Ore Processing Facility, TMF and Water Management Systems to the discharge point within the Project Site. Borrow Pits are subject to a separate permitting process and are therefore not further included in this assessment.

Seepage from the WRMF and TMF will be captured as described in the Site Water Quality TSD; however, a conservative assessment of the possibility that some seepage bypasses the collection system is provided. Project components are shown in the Site Layout figure, Figure 1-2. A detailed description of Project components is provided in Chapter 5 of the EIS/EA Report.

1.3.5 Intake and Discharge Location

The locations of the discharge and intake points also play a role in overall water quality distribution in the lake and are shown in Figure 1-2. The primary water intake for processing and use at the Mine is located in the central portion of Sawbill Bay as shown on Figure 1-2. The main Project Site discharge is located in the south end of Sawbill Bay (Figure 1-2) based on the following considerations:

- Proximity to the Mine processing plant (shown on Figure 1-2) to minimize the length of pipeline required which would be important for winter maintenance.
- Proximity to sensitive habitat (e.g., avoid placing outfall close to or within sensitive areas).
- Proximity of deep water to shoreline to minimize length of pipeline within the receiving water.
- Availability of river flow or lake volume to minimize potential effluent effects.

In addition to the main plant intake and discharge a small amount of potable water is expected to be taken from the north end of Sawbill Bay, and will be balanced by discharge from the accommodation camp sewage treatment facility, also in the north end of Sawbill Bay.

1.4 General Assessment Approach

The Project has the potential to affect the lake water environment. The approach for this TSD follows six key steps:

- Step 1: Screening of Project activities to determine which activities have the potential to produce changes to the lake water environment.
- Step 2: Identify temporal and spatial boundaries within which potential changes to lake water quality may occur.
- Step 3: Identify parameters used to characterize these potential changes.
- Step 4: Design and carry out field studies and/or background research to characterize the existing lake water quality (Water and Sediment Quality TSD), and to support the prediction of changes to lake water (Geochemistry, Geology and Soil TSD, Hydrology TSD, Hydrogeology TSD).
- Step 5: Carry out predictive modelling of potential changes to the lake water environment during Project phases identified as upper bound scenarios (Site Water Quality TSD and included herein).
- Step 6: Outline the monitoring requirements for each Project phase to confirm predicted changes to the environment and to ensure that requirements are being met for identified parameters.

This TSD is intended to support the EIS/EA Report and as such does not assess the significance of potential effects on lake water quality, nor does it identify mitigation measures. These topics are addressed in the EIS/EA Report and in other TSDs.

1.5 Incorporation of Traditional Knowledge

Traditional knowledge in combination with other information sources is valuable in achieving a better understanding of the Project's potential effects on the biophysical and socio-economic environment. It also contributes to the description of the existing biophysical and human environment, natural cycles, resource distribution and abundance, and the use of land and water resources. Those aspects of traditional knowledge related to water quantity and water quality will be important when considering the results of the lake water quality assessment, in particularly as it relates to use of the resources as defined in the Aquatic Environment TSD; Terrestrial Ecology TSD, and Human Health and Ecological Risk Assessment (HHERA) TSD. A detailed discussion on traditional knowledge is included in the Aboriginal Interests TSD.

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.;
Projection: Transverse Mercator   Datum: NAD 83   Coordinate System: UTM Zone 15N

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SCALE 1:10,000,000 KILOMETRES

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Golder Associates
Mississauga, Ontario

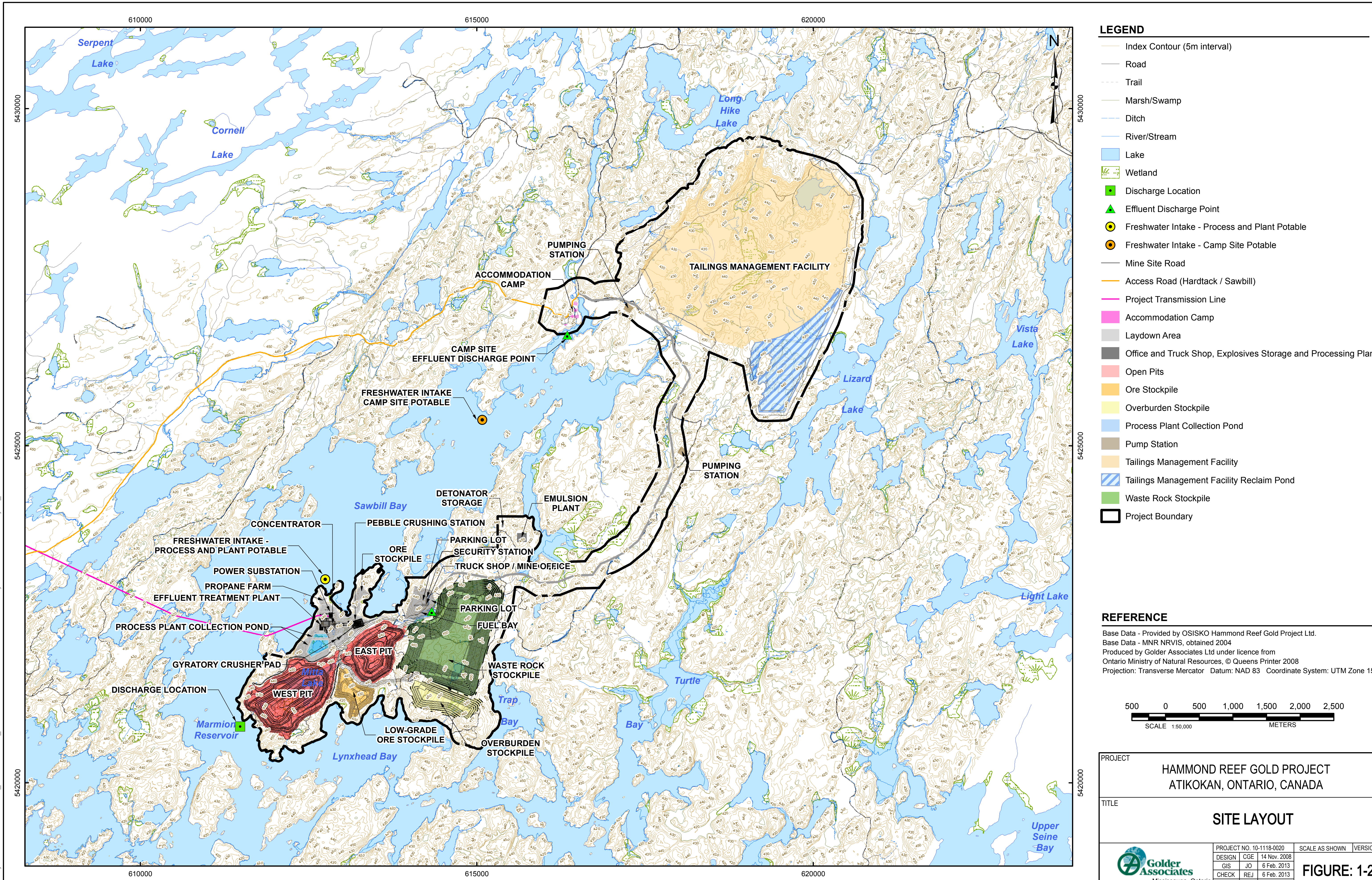
PROJECT No.	10-1118-0020	DATE	05 Feb. 2013
SCALE	AS SHOWN	VERSION 1	
DESIGN	CGE	GIS	JO
CHECK	REJ	REVIEW	KJD

TITLE

PROJECT LOCATION

PROJECT HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

FIGURE: 1-1



610000
615000
620000
5430000
5425000
5420000
Serpent Lake
Cornell Lake
Long Hike Lake
Vista Lake
Lizard Lake
Sawbill Bay
Light Lake
Turtle Bay
Trap Bay
Lynxhead Bay
Marmion Reservoir
Mitta Lake
Upper Seine Bay
N
PUMPING STATION
ACCOMMODATION CAMP
TAILINGS MANAGEMENT FACILITY
CAMP SITE EFFLUENT DISCHARGE POINT
FRESHWATER INTAKE CAMP SITE POTABLE
PUMPING STATION
DETONATOR STORAGE
EMULSION PLANT
CONCENTRATOR
PEBBLE CRUSHING STATION
FRESHWATER INTAKE - PROCESS AND PLANT POTABLE
ORE STOCKPILE
PARKING LOT
SECURITY STATION
TRUCK SHOP / MINE OFFICE
POWER SUBSTATION
PROPANE FARM
EFFLUENT TREATMENT PLANT
PARKING LOT
FUEL BAY
PROCESS PLANT COLLECTION POND
EAST PIT
GYRATORY CRUSHER PAD
WASTE ROCK STOCKPILE
DISCHARGE LOCATION
WEST PIT
LOW-GRADE ORE STOCKPILE
OVERBURDEN STOCKPILE
LEGEND
Index Contour (5m interval)
Road
Trail
Marsh/Swamp
Ditch
River/Stream
Lake
Wetland
Discharge Location
Effluent Discharge Point
Freshwater Intake - Process and Plant Potable
Freshwater Intake - Camp Site Potable
Mine Site Road
Access Road (Hardtack / Sawbill)
Project Transmission Line
Accommodation Camp
Laydown Area
Office and Truck Shop, Explosives Storage and Processing Plant
Open Pits
Ore Stockpile
Overburden Stockpile
Process Plant Collection Pond
Pump Station
Tailings Management Facility
Tailings Management Facility Reclaim Pond
Waste Rock Stockpile
Project Boundary
REFERENCE
Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N
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METERS
PROJECT
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ATIKOKAN, ONTARIO, CANADA
TITLE
SITE LAYOUT
Golder Associates
Mississauga, Ontario
PROJECT NO. 10-1118-0020
SCALE AS SHOWN
VERSION 1
DESIGN CGE 14 Nov. 2008
GIS JO 6 Feb. 2013
CHECK REJ 6 Feb. 2013
REVIEW KJD 31 Jan. 2013
FIGURE: 1-2
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1.6 Selection of Valued Ecosystem Components

The Valued Ecosystem Components (VECs) selected for the Lake Water Quality TSD are lake water quality and lake water quantity. Table 1-1, provides the rationale for selection of these VECs along with proposed indicators and measures.

Table 1-1: Valued Ecosystem Components Selected for the Lake Water Quality Environment

VEC	Rationale for Selection	Indicators	Measures
Lake Water Quality	Potential for change to overall lake water quality as result of Project activities	Changes in concentrations of key parameters at key locations	Analytical data for key parameters at key locations
Lake Water Quantity	Potential for influence change in overall lake water quality as result of Project activities due to changes in flow or volume	Changes in concentrations of key parameters at key locations due to changes in flow or volume	Analytical data for key parameters at key locations; water level and flow measurements

1.7 Effects Assessment

Changes to lake water quality may lead to or influence the assessment of effects of the Project, but are not in and of themselves the endpoints of the assessment. Therefore, potential effects of the Project on the VECs selected for water quality are not discussed in this TSD. The effects assessment on the endpoints of changes to water quality is presented in the EIS/EA Report and in the following TSDs:

- Aquatic Environment TSD.
- Terrestrial Ecology TSD.
- Socio-economic Environment TSD.

1.8 Temporal and Spatial Boundaries

1.8.1 Temporal Boundaries

Temporal boundaries define the temporal extents within which changes to the environment resulting from Project activities are considered. Temporal boundaries for the lake water quality assessment are directly related to the Project phases and the duration of these phases, namely:

- Construction phase: 30 months.
- Operations phase: 11 years.
- Closure phase: 2 years.
- Post-closure phase: 10 years.

Changes in water quality that may occur during the construction phase will be associated with development of infrastructure. These changes, if any, will be minor and encompassed by changes expected during operations. As such, a temporal boundary for the construction phase has not been established for lake water quality.

At closure, pumping from the open pits will cease and there will no longer be active discharge from the Project Site. As discussed in the Conceptual Closure and Rehabilitation Plan in the EIS/EA Report, it is expected that Project Site runoff will be directed to the open pits and it will take approximately 78 years for pit water levels to rise to an elevation of 420 metres above sea level (masl), the proposed spill over elevation from the pits to the environment. Once the water reaches the spill over elevation there will be discharge from the flooded open pits to the environment. The associated flow from the open pits, accounting for seepage and runoff from former Project facilities is discussed in the Site Water Quality TSD and the related water quality implications are described in this Lake Water Quality TSD.

1.8.2 Spatial Boundaries

Spatial boundaries define the geographical extents within which potential environmental changes may occur. As such, spatial boundaries become the Project's study area for the purposes of water quality evaluation. The study areas for the lake water quality evaluation were selected based on the following factors:

- The Project footprint.
- The proposed locations for water intakes and effluent discharges.
- Location of major lakes, streams and watershed divides.

This TSD has three study areas, as described in the following sections.

1.8.2.1 Regional Study Area

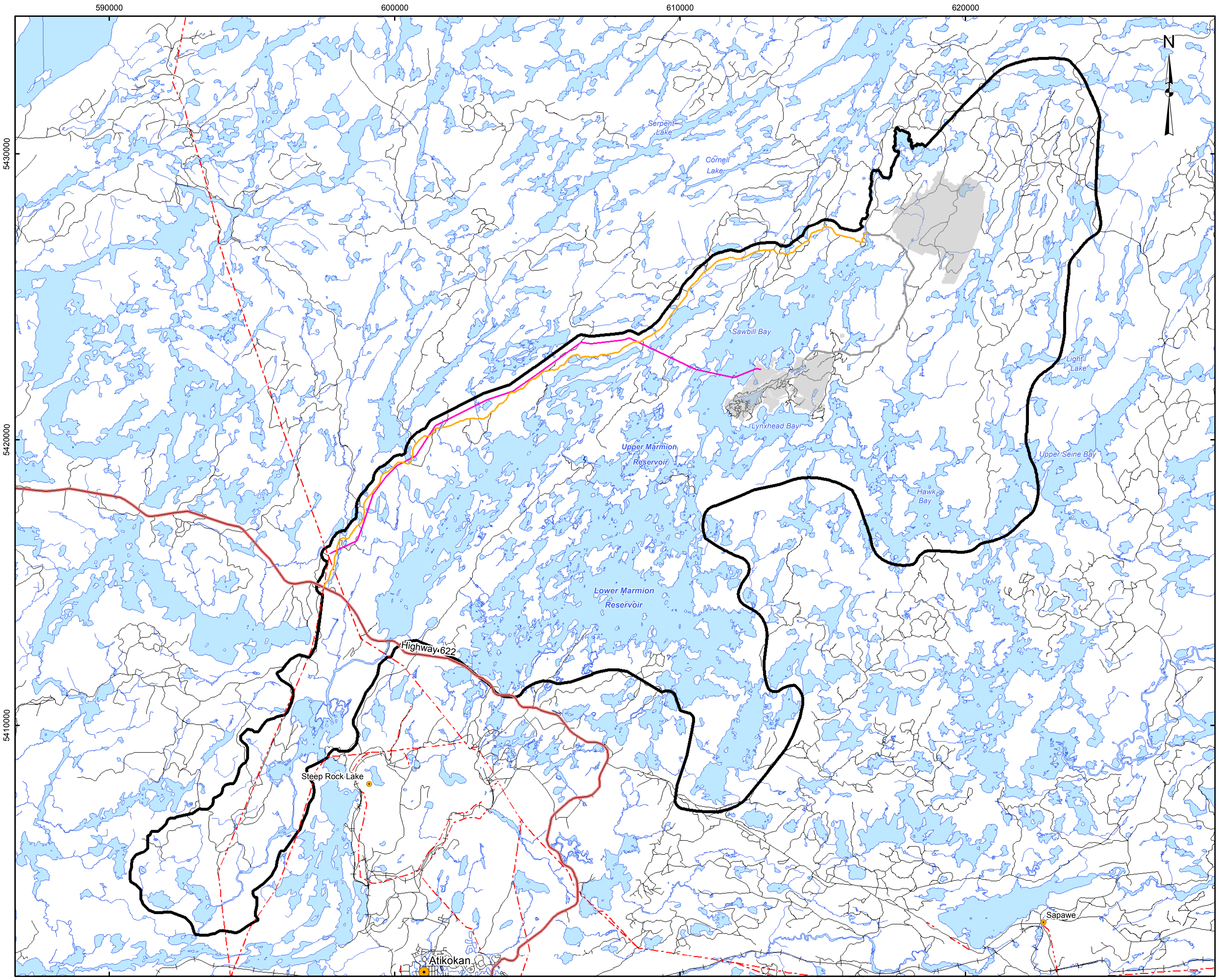
The lake water quality Regional Study Area (RSA) is delineated in Figure 1-3. The Project Site is located approximately 170 km west of Thunder Bay and 23 km northeast of the town of Atikokan. The RSA includes Upper and Lower Marmion Reservoir and the upstream watershed of the Seine River. The RSA extends south to Highway 622.

1.8.2.2 Local Study Area

The lake water quality Local Study Area (LSA) is delineated in Figure 1-4. The proposed Project Site at the Hammond Reef property is located on the south-west corner of Sawbill Bay. The Project Site is surrounded by Sawbill Bay on the north side and Seine River on the south side.

The Seine River forms a series of basins separated by shallow areas collectively called Upper Marmion Reservoir as shown on Figure 1-3.

Upper Marmion Reservoir is separated from Lower Marmion Reservoir by a series of dams constructed in the early 1950s (Boileau 2004). Flow between the Upper and Lower Marmion Reservoir is regulated by the Marmion Sluiceway also constructed in the early 1950s. Water levels in Lower Marmion Reservoir are controlled to maintain a minimum water level for the operation of the cooling water system at the Atikokan Generating Station located on the south shore of Lower Marmion Reservoir.



LEGEND

- City/Town
- Small Community
- Provincial Highway
- Road
- Existing Railway
- Power Transmission Line
- River/Stream
- Lake
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Project Transmission Line
- Project Facilities
- Water Quality Regional Study Area

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

2 1 0 2 4 6 8
KILOMETRES

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
WATER QUALITY REGIONAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	14 Nov. 2008	FIGURE: 1-3	
GIS	JO	5 Feb. 2013		
CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

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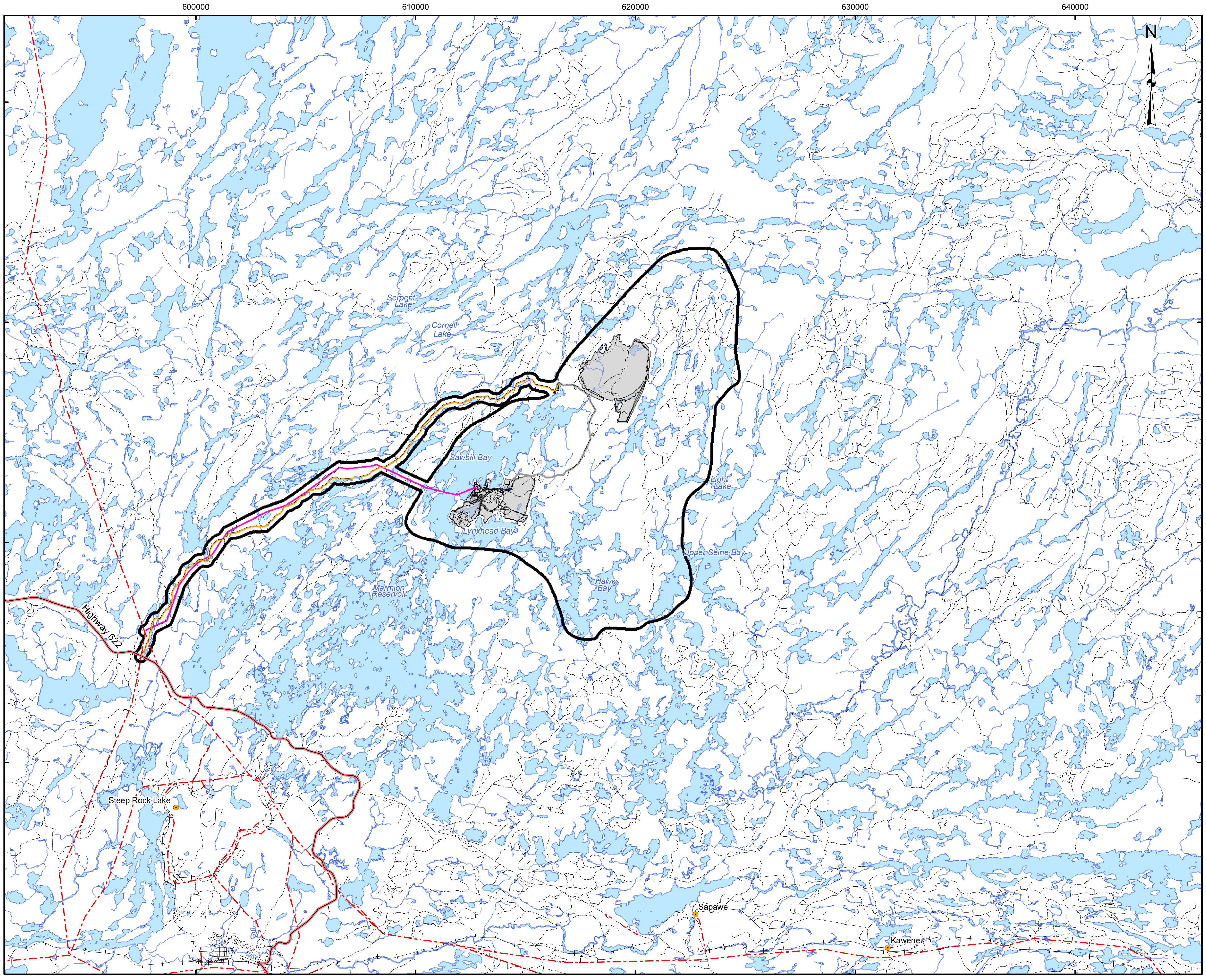

LEGEND

- Small Community
- Provincial Highway
- Road
- Existing Railway
- River/Stream
- Lake
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Project Transmission Line
- Project Facilities
- Water Quality Local Study Area

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

2.5 1.25 0 2.5 5 7.5
KILOMETRES

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
WATER QUALITY LOCAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
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CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

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The Seine River is regulated by the Raft Dam located approximately 30 km from the Project Site. The Raft Lake Dam was constructed in 1943 during the start of operations at the Steep Rock Mine (located north of the Town of Atikokan). During the construction of the Steep Rock Mine, the flow of the Seine River was diverted through the Raft lake Dam to Finlayson Lake and eventually returns to its original course just west of the Town of Atikokan. The inflow from the Seine River into Upper Marmion Reservoir is also regulated by the Lac Des Mille Lacs Dam (built in 1952) located approximately 80 km upstream of the Project Site.

The lake bathymetry of Upper Marmion Reservoir is partially shown on Figure 1-5. On Figure 1-6, the model compartments (basins) show the basins that constitute Upper Marmion Reservoir. The main flow path of the Seine River (indicated by the purple arrows) passes through all of the lake basins shown on Figure 1-6, with the exception of Sawbill Bay.

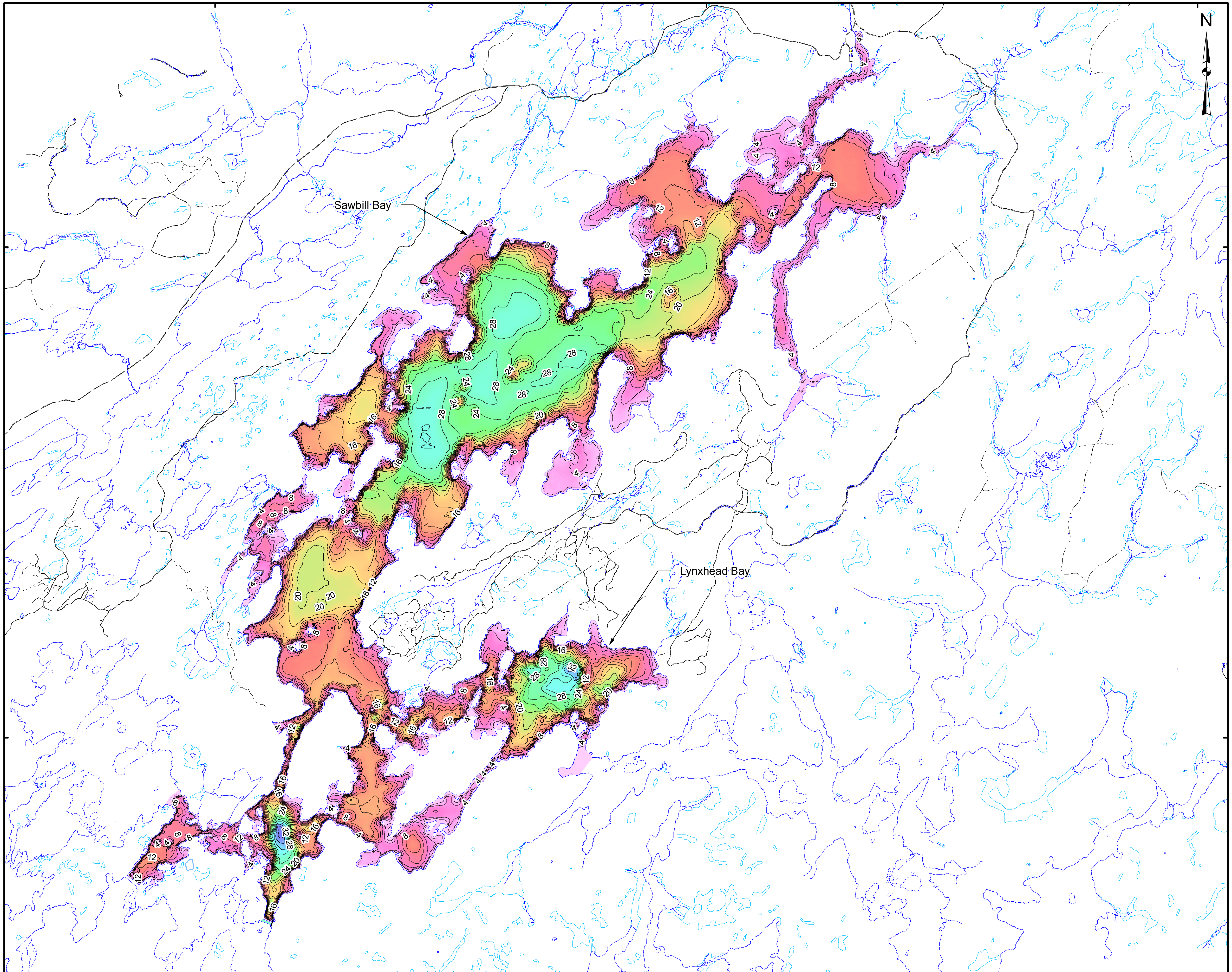
The upper reaches of Sawbill Bay are not on the main flow path of the Seine River and only interact with the river flow when the water level in Upper Marmion Reservoir changes, there is slightly more interaction at the south end of Sawbill Bay. For the remainder of the bay the majority of the interaction with the Seine River occurs either in the spring when the water level in Upper Marmion Reservoir is raised (e.g., flow from Seine River would flow into Sawbill Bay) or in the fall when the water level is lowered (e.g., flow from Sawbill Bay into Seine River flow). Other inflows into Sawbill are limited to local runoff and drainage from the Sawbill Creek watershed.

The LSA extends generally to the middle of Sawbill and Lynxhead Bays of Upper Marmion Reservoir on the west and south sides respectively, the Lizard Lake watershed area to the east is also included.

1.8.2.3 Mine Study Area

The Mine Study Area (MSA) encompasses the footprints of the Mine, WRMF, Ore Processing Facility, TMF and Water Management System, and the Support and Ancillary Infrastructure (Figure 1-2).

The Project components are relevant to the site water balance and water quality model and are described in detail in the Site Water Quality TSD. With respect to the Lake Water Quality TSD, the key Project activities are the intake and discharge of water from the Mine and/or accommodation camp.



LEGEND

- Lake Bottom Contours - 2 m interval
- Dirt Road - Double
- Dirt Road - Single
- Trail
- River/Stream
- Lake
- Wetland/Swamp

Depth of Lake Bottom (metres)

0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38

NOTES:

1. Water level/Shoreline elevation used for Marmion Lake was 415.18 m.
2. The contours were derived from a 20 metre cell size for the grid files. Minor contour errors exist at the shorelines where departures are at the scale of the grid dimension.

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

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SCALE 1:40,000 METRES

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

BATHYMETRY FOR SAWBILL BAY AND LYNXHEAD BAY

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
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GIS	JO	5 Feb. 2013		
CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

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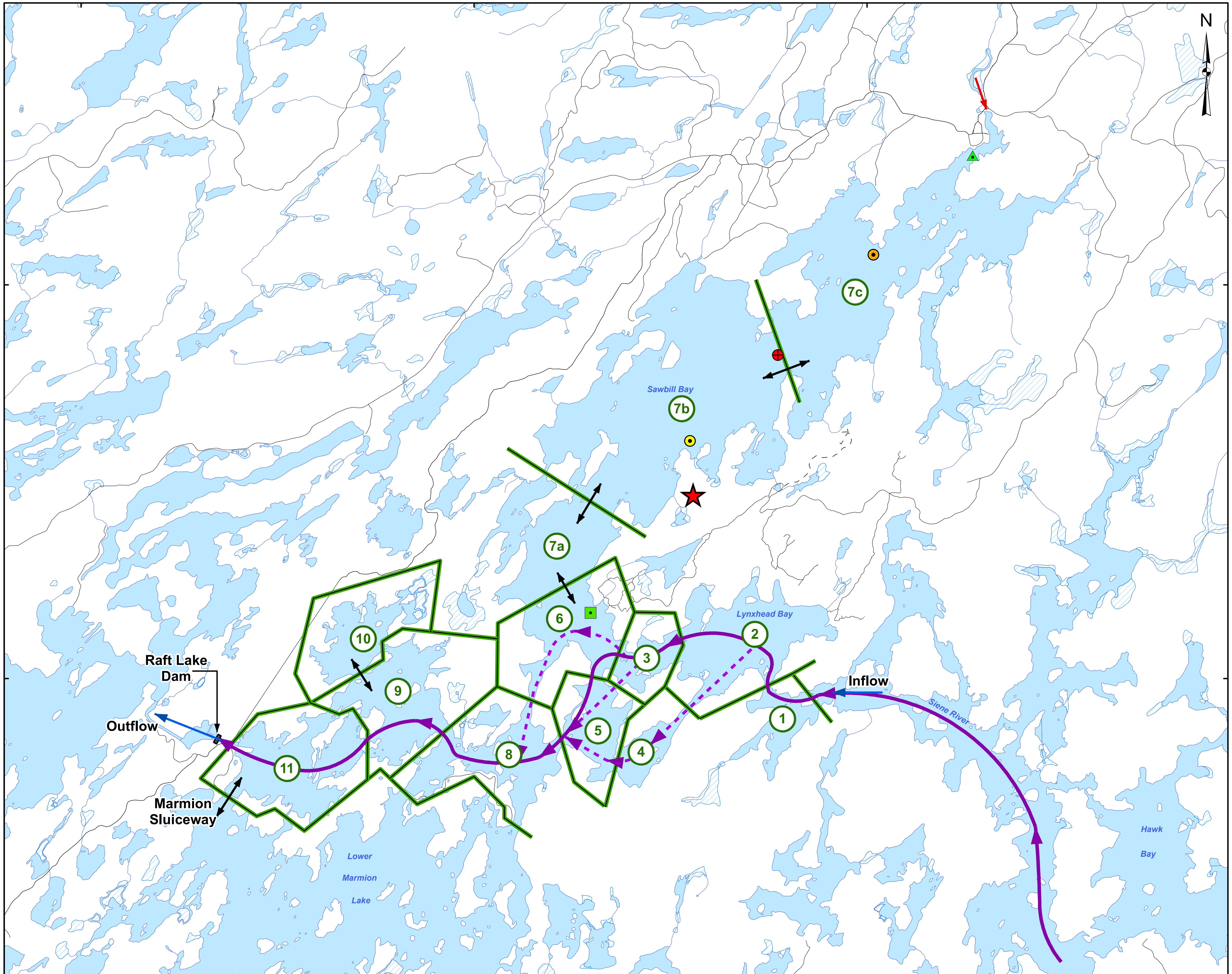

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

MODEL COMPARTMENTS
UPPER MARMION RESERVOIR

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	14 Nov. 2008	FIGURE: 1-6	
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2.0 GENERAL METHODOLOGY

The Lake Water Quality TSD is the last in a series of water- related TSDs. The Lake Water Quality TSD pulls together hydrology-related data (Hydrology TSD), lake water quality baseline data (Water and Sediment Quality TSD), and the site water quality predictions (Site Water Quality TSD) to develop preliminary estimates of mixing in the Upper Marmion Reservoir and Lizard Lake, and predictions of reservoir/lake water concentrations during operations and post-closure. This section provides a general discussion of the methodology as it relates to lake water quality predictions.

Methodologies related to baseline data collection and prediction of site water quality are provided in the Water and Sediment Quality TSD and the Site Water Quality TSD, respectively. Specific methods related to mixing models are provided in the respective sections in this document.

The general method used in development of lake water quality results is as follows:

- Define input flows to be used for water quality modelling (from the Hydrology TSD; Water and Sediment Quality TSD; and Site Water Quality TSD), including the following:
  - Average and low flow.
  - Average and maximum percentile water quality.
- Complete hydrodynamic modelling to determine mixing proportions throughout the basin(s) and lake bodies for each of the following key lake locations:
  - Upper Marmion Reservoir.
  - Lizard Lake.
- Define boundary scenarios to be run for lake water quality predictions for the following temporal conditions:
  - Operations (water flows and quality) and post closure (water flows and quality).
- Select key scenarios for site discharge water quality from the Site Water Quality TSD that will be used in combination with the proportions as defined in the mixing model.
- Complete the calculations to develop the final predicted lake water quality concentrations.

2.1 Hydrodynamic (Mixing or Box) Model(s)

In order to determine potential lake water concentrations at key locations, mixing models for each of Upper Marmion Reservoir and Lizard Lake were developed based on the general flow distribution and volumes of the lakes or areas in question, for the key time periods of interest. The primary objectives of this modelling are to:

- Evaluate the mixing characteristics that result from inflow, management of the water level, and wind driven dispersion (Sawbill Bay only).

- Provide a relative comparison of the proportion of mixing that can be expected in various locations such that these proportions can be used in monitoring concentration estimates.

Section 3 provides detailed information related to use of hydrology data and methods used to develop the results of the mixing model. Mixing model results are available for the following locations and time periods:

- Upper Marmion Reservoir baseline (pre-mining).
- Upper Marmion Reservoir during operations (assuming typical discharge and water intake).
- Upper Marmion Reservoir during post closure (steady state).
- Lizard Lake during operations.
- Lizard Lake during post closure.

2.2 Concentration Estimates

Concentration estimates for the lake basins build upon the mixing model results, by:

- Assigning a unit concentration to the discharge (assuming the lake water concentration is zero), to determine the proportion of flow from the discharge that will influence a given location under steady state conditions.
- Use the proportion of flow that is expected to mix, the concentration of the baseline water quality, and the concentration of the discharge to calculate an expected water quality within the lake basin using the following equation:

$$C(\text{basin}) = C(\text{baseline}) + (C(\text{discharge}) \times \text{mixing proportion (unitless)}) \qquad \text{Equation 1}$$

Scenarios used in evaluation of a range of conditions influencing lake water quality are indicated in Appendix 2.I and were developed based on our understanding as provided in the Hydrology TSD, Water and Sediment Quality TSD and the Site Water Quality TSD. Appendix 2.II provides the origin and summary of the baseline water quality and site discharge water quality data that were used in calculations.

Generally, input baseline values were calculated using the average of the baseline data (see Water and Sediment TSD), assuming values below the detection limit are equal to the detection limit for the sake of conservatism. Two exceptions to this approach are discussed in the Site Water Quality TSD, and are summarized as follows.

Baseline results reported elevated and variable detection limits for mercury and selenium. Statistics were calculated by assigning values below detection at concentrations equal to the detection limit. The calculation of predicted concentrations using these values for the average case in Marmion Reservoir during operations resulted in mercury (0.000034 mg/L) and selenium (0.0012 mg/L) concentrations that exceed Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines (CCME CWQG) for mercury (0.000026 mg/L) and selenium (0.001 mg/L). As such, the following correction to mercury and selenium detection limits was applied:

- Statistics were calculated using a ½ detection limit for mercury (0.000005 mg/L).
- Statistics were calculated using an assigned value for the selenium detection limit of 0.0005 mg/L based on the observed maximum value above detection.

The modified average values were used for input baseline water quality as well as in the modelling to derive site water quality inputs.

Calculated water quality is summarized in the appropriate section herein and is provided for all modelled parameters and lake basins in Appendix 2.III. Estimates of the implications of contaminants on water quality derived from accommodation camp discharge, TSS and aerial deposition are treated separately from the dissolved. This is discussed in Section 4.4.

2.3 Selection of Representative Model Scenarios:

Using the mixing results from the scenarios as described in Section 2.1 and the method to determine lake concentrations as indicated in Section 2.2, a number of combinations of lake water quality can be developed depending on the possible input scenarios (Appendix 2.I). From these scenarios an expected case and upper bound case scenario were determined.

Scenarios described herein are as follows:

- Upper Marmion Basin during operations.
- Upper Marmion Basin post closure.
- Upper Marmion Basin runoff.
- Lizard Lake operations.
- Lizard Lake post-closure.

Results for each of these scenarios are summarized in Sections 4 through 8.

2.4 Assumptions and Limitations

The following assumptions were made:

- Operations input water quality for TMF seepage was derived from the water quality from thickened tailings during operations with geochemical controls applied using PHREEQC (Site Water Quality TSD).
- Post-closure input water quality for TMF seepage was derived from the average of steady state conditions of the final five weeks of humidity cell testing (Site Water Quality TSD).
- Climatic variations were not applied to TMF seepage values as seepage water quality is assumed to be independent of surface climate impacts.
- It was assumed that no discharge will occur in 1-in-10 year dry climate, therefore predictive mixing does not apply (see Table 4-2).

- Cyanide will degrade along a seepage pathway from the TMF to Lizard Lake. This is conservatively estimated in the Site Water Quality TSD.

2.5 Guidelines and Indicators

The full set of modelled parameters and guidelines are provided in Appendix 2.IV. The parameters as provided within the summary tables herein include pH, alkalinity, hardness, major ions (calcium, chloride, magnesium, potassium, sodium, sulphate, free cyanide – TMF seepage only, and total cyanide), nutrients (nitrate, ammonia, unionized ammonia and phosphorus), and dissolved metals (aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silicon, silver, strontium, thallium, tin, titanium, tungsten, uranium, vanadium, zinc, and zirconium).

The following describes the guidelines used to compare the modelled water quality prediction results:

- Existing baseline water quality concentrations.
- Ontario Provincial Water Quality Objectives (PWQO) (MOEE 1999).
- Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines (CCME CWQG) for the protection of aquatic life (CCME 2007).
- Municipal/Industrial Strategy for Abatement (MISA) Effluent Monitoring and Effluent Limits for the Metal Mining Sector Ontario Regulation 560/94.

There are many reasons why a parameter may exceed a given guideline including detection limits as used in the model calculations, naturally elevated baseline conditions, and expected site discharge concentrations due to mining. If a guideline is exceeded then it is necessary to evaluate the reasons why and conduct further assessment of potential impacts as provided in the EIS/EA Report and other relevant TSDs.

3.0 HYDRODYNAMIC MODEL(S)

Hydrodynamic modelling consisted of the development of screening models and was carried out to determine mixing proportions throughout the basin(s) and lake bodies for each of the following key lake locations:

- Upper Marmion Reservoir.
- Lizard Lake.

The following sections outline the development of the hydrodynamic models. It is considered under the Project's specific conditions that these models are effective and appropriate in developing lake water mixing proportions.

3.1 Marmion Reservoir Screening Model

In order to determine potential lake water concentrations at key locations within Upper Marmion Reservoir a hydrodynamic screening model was developed based on the general flow distribution and volumes of the Upper Marmion Reservoir with objectives as defined in Section 2.1.

3.1.1 Assumptions and Limitations

The following points outline the assumptions used in this assessment as well as the limitations in the findings:

- Trap Bay was used as the upstream boundary of the model.
- Natural inflows to the model domain were limited to upstream inflow into Trap Bay and local runoff into Sawbill Bay. Runoff into other compartments was assumed to be small and/or negligible.
- The monthly mean inflow was estimated from flow records at the Lac des Mille Dam and estimations of unregulated inflows between Lac des Mille and the LSA.
- Flows into and from Lower Marmion Reservoir through the sluiceway were not included in this assessment (i.e., outflows and water levels in the model are primarily governed by the Raft Lake Dam).
- For comparison purposes, an effluent discharge of 100 mg/L of a non-specific parameter was used.
- The bathymetric data were assumed to be relative to a water surface elevation of 415.18 masl.
- Bathymetric data for model compartments 9, 10, and 11 were sourced from Ministry of Natural Resources (MNR) in April 2012.
- The monthly average water level at the Raft Lake Dam was assumed to be consistent with the Seine River Management Plan where possible. The hydrologic modelling completed to develop the input data assumed that a minimum flow of 10 m^3/s from the Raft Lake Dam was required for downstream users.
- The water level at the Raft Lake Dam was assumed to be representative of all the compartments in the model.
- The model did not include any daily variation in water level that may result in small exchange flows between the model basins.

- For the purposes of evaluation all site flows (including water reporting to Lizard Lake), were assumed to enter Upper Marmion Reservoir at the site discharge in compartment 6. This model is treated independently of the Lizard Lake mixing model but conservatively includes all discharge that might report to Lizard Lake. Lizard Lake is also evaluated independently as described in Section 3.3 and in other relevant sections of this document.

3.1.2 Mixing Model (Box / Basin Model)

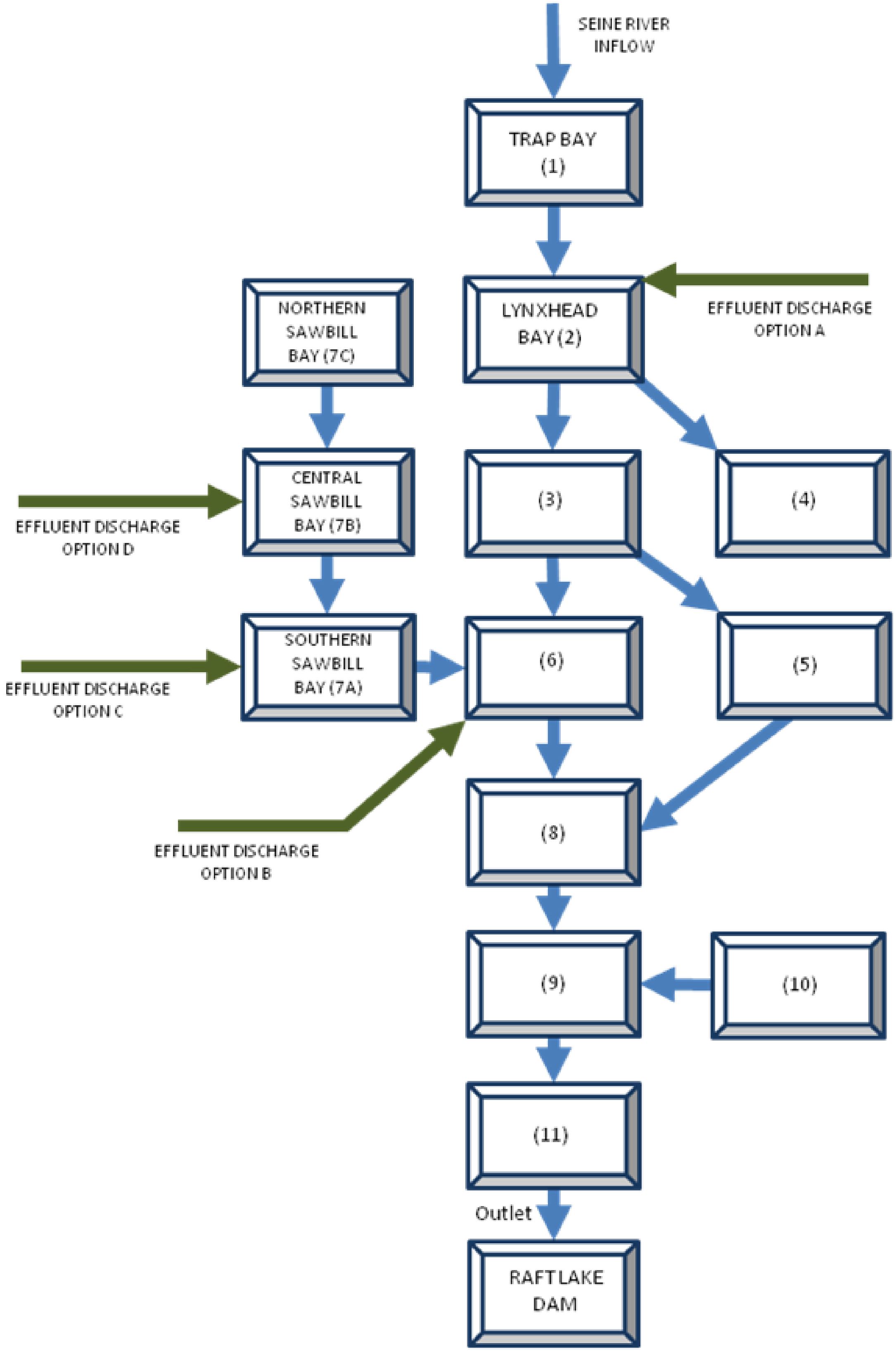
A spreadsheet based box model was used for this assessment. Figure 1-6 shows the model compartments used. The divisions between the basins were based on lake bathymetry and were positioned at locations where shallow depths would tend to hydraulically separate the compartments. Each basin in the model was assumed to be well-mixed with no vertical stratification.

Figure 3-1 shows a schematic of the model, including the connecting flows that were used in the mass balance and the four effluent discharge locations considered. Connecting flows were allowed to move in either direction depending on the inflows and changes in water elevation (e.g., backflow into Sawbill Bay during filling of Upper Marmion Reservoir during spring). These reverse flows were also incorporated into the mass balance (effluent modelling).

The model was based on the following data:

- Bathymetric data collected by Golder in 2010 and 2011 was used where available. Since data for Compartments 9, 10, and 11 were not readily available, the model was based on estimated values for these compartments. Data for Compartments 9, 10 and 11 are currently being sourced from MNR for future assessments.
- Daily water level data for Raft Lake Dam was assumed to follow the Seine River Management Plan (Boileau 2004). A detailed description regarding the development of the 28 year synthetic data record is provided in Section 3.1.3.3.
- Junctions: Split percentage of flow at junctions was estimated from field measurements as discussed in Section 3.1.3.1.
- Current speed and direction data collected by an Acoustic Doppler Current Profiler (ADCP) in October 2010 was used to estimate the wind driven exchange flows between model compartments 7B and 7C.
- Inflows to Upper Marmion Reservoir were based on Lac des Mille Dam outflows plus unregulated flows from intermediate drainage area on a monthly basis (January 1984 to December 2011). Runoff into Sawbill Bay (SW-01 and SW-11) was estimated based on correlation with 2010-2011 monthly mean discharges recorded at the regional WSC Atikokan River at Atikokan. A detailed description regarding the development of the 28-year synthetic data record is provided in Section 3.1.3.3.
- Outflows from the Raft Lake Dam were estimated based on monthly inflows and maintaining the water level as close to the management plan as possible. A detailed description regarding the development of the 28-year synthetic data record is provided in Section 3.1.3.3.

- Mine intake and discharge flow rates were estimated based on mine water balances for average, dry and wet years. A detailed description regarding the development of the 28-year data record is provided in Section 3.1.3.3.



PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

**BOX MODEL FOR
UPPER MARMION LAKE**

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	24 May. 2012	**FIGURE: 3-1**	
GIS	JO	5 Feb. 2013		
CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

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3.1.3 Primary and Secondary Data Used in Mixing Evaluation

Primary and secondary data used in the evaluation of mixing within the lake is provided and described in the Hydrology TSD. Several sources of data were used that had been collected during various field programs. These data included:

- The distribution of the Seine River flow through various lake basins,
- Circulation patterns in lakes, and
- Current variations over time.

3.1.3.1 Distribution of Seine River Flow through Lake Basins

As seen on Figure 1-6, the flow of the Seine River through Upper Marmion Reservoir can follow either a main flow path or one of three secondary paths. The following paragraphs provide estimates of the distribution of the flow that was based on a set of instantaneous flow measurements taken on May 18, 2011. On this date, the water level at the Raft Lake Dam was reported to be 415.22 m which is approximately 0.6 m higher than the average water level (Julita 2012).

Downstream flow from Lynxhead Bay can either flow to the south into Basin 4 or to the west into Basin 3. On May 18, 2012, the flow from Lynxhead Bay into Basin 4 was approximately 30% of the flow recorded at Lynxhead Narrows. However, since this connecting channel is relatively shallow (see Figure 1-5), the fraction of the total flow is expected to be lower when the water level is closer to average. For purposes of the model, it was assumed that the flow from Lynxhead Bay to Basin 4 was 20% of the flow leaving Lynxhead Bay. The remaining 80% was assumed to flow directly into Basin 3.

Water from Basin 3 can either flow to the south directly into Basin 5 or to the west into Basin 6. The channel connecting Basin 3 to Basin 5 was too shallow to complete a flow measurement (see Figure 1-5). For purposes of the model, it was assumed that the flow from Basin 3 to Basin 4 was only 1% of the flow leaving Basin 3. The remaining 99% was assumed to flow directly into Basin 6

Water from Basin 6 can either flow to the south into either Basin 5 or Basin 8. On May 18, 2012, the flow from Basin 6 into Basin 8 was approximately 28% of the total flow from Basin 6 into Basin 5 and Basin 8. For purposes of the model, it was assumed that the flow from Basin 6 into Basin 8 was 28% of the flow leaving Basin 6 while the remaining 72% was assumed to flow into Basin 5.

3.1.3.2 Current Data

In lake situations, the movement of effluent after being released is generally controlled by the currents within the lake. Lake currents can be the result of many factors including wind, inflows, outflows, stratification and temperature gradients. In most typical lakes, the surface currents are the result of winds and the highest current speeds occur when a strong wind persists along the major axis of a lake.

The following sections describe the results of two types of current data collected in Upper Marmion Reservoir:

- Surface circulation patterns were estimated through the use of drogues.
- Temporal and vertical variations were estimated through the use of Acoustic Doppler Current Profilers (ADCPs).

3.1.3.2.1 Drogue Data and Lake Circulation Patterns

Lake circulation and surface current patterns were recorded in Sawbill Bay and Lynxhead Bay using drogues equipped with Global Positioning System (GPS) tracking units. Drogues are a surface buoy that is fitted with an underwater sail. The underwater sail will cause the drogue to move with the currents while the location is recorded by the GPS.

The results of these studies are provided in Table 3-1, while the observed drogue paths are provided on Figure 3-2 for Sawbill Bay and on Figure 3-3 for Lynxhead Bay. Drogue studies were also completed in Turtle Bay, Hawk Bay, Light Bay and Upper Seine Bay, but were not included in this study since they were not within the LSA.

As shown on Figure 3-2, during the October 2010 drogue study, the drogues moved to the northeast in the same direction as the wind. The drogue studies shown on Figure 3-3 indicate a general counter-clockwise circulation pattern in Lynxhead Bay. The drogues also show that some of the currents are influenced by the Seine River flowing into the bay from Lynxhead Narrows and exiting to the west and southwest which is consistent with the flow distribution discussed in Section 3.1.2.1.

Drogues can also be used to estimate the top-layer dispersion coefficients by measuring the rate at which a cluster of drogues spread out (disperse) as they move with the current. The spread of the drogues is referred to as the variance and was calculated using the following equations in the X and Y directions:

$$\sigma_{xi}^2 = \frac{\sum_j (X_{ij} - \overline{X}_i)^2}{N-1} \qquad \text{Equation 2}$$

$$\sigma_{yi}^2 = \frac{\sum_j (Y_{ij} - \overline{Y}_i)^2}{N-1} \qquad \text{Equation 3}$$

Where:

X_{ij} = position X of Drogue *j* at time *i* (m);
Y_{ij} = position Y of Drogue *j* at time *i* (m);
σ_{xi} = variance in direction X at time *i* (m^2);
σ_{yi} = variance in direction Y at time *i* (m^2);
$\overline{X}_i$ = mean X position of drogues at time *i* (m);
$\overline{Y}_i$ = mean Y position of drogues at time *i* (m); and
N = number of drogues.

The direction independent variation in location can be estimated as:

$$\sigma_i^2 = \frac{\sigma_{xi}^2 + \sigma_{yi}^2}{2} \qquad \text{Equation 4}$$

The dispersion coefficient (*K*) can be estimated by:

$$K_i = \frac{1}{2}\frac{\partial \sigma_i^2}{\partial t} \cong \frac{1}{2}\frac{\Delta \sigma_i^2}{\Delta t} \qquad \text{Equation 5}$$

The estimates of dispersion rates are provided in Table 3-1 for Sawbill Bay and Lynxhead Bay. Overall, the average dispersion rates estimated were consistent with those reported in literature (Stevens 2004). Generally, as the drogues were deployed and retrieved, they were observed travelling in a cluster consistent with the direction of the wind unless one or more of the drogues became immobile (e.g., run ashore).

Table 3-1: Drogue Study Results for Upper Marmion Reservoir

Parameter	Units	Sawbill Bay	Lynxhead Bay				
Deployment Reference	—	S1	L0	L1	L2	L3	L4
Date	—	Oct 7, 2010	Oct 7, 2010	May 19, 2011	May 19, 2011	May 19, 2011	May 19, 2011
Duration	hr	5.2	2.1	2.7	3.1	2.4	1.8
Average speed	m/s	0.070	0.033	0.096	0.033	0.079	0.063
Average direction[(a)]	degrees	49	95	267	271	6	213
Average distance travelled	M	1308	539	940	365	689	394
Average dispersion rate (K)	m^2/s	0.040	0.023[(d)]	0.012	0.023	0.14	0.007
Observed wind speed[(b)]	km/hr	5-7	6-8	N/A[(c)]	N/A[(c)]	N/A[(c)]	N/A[(c)]
Observed wind direction[(e)]	Dir	NE	E	E	ENE	E	E

Notes:

(a) Direction measured in degrees clockwise from North.

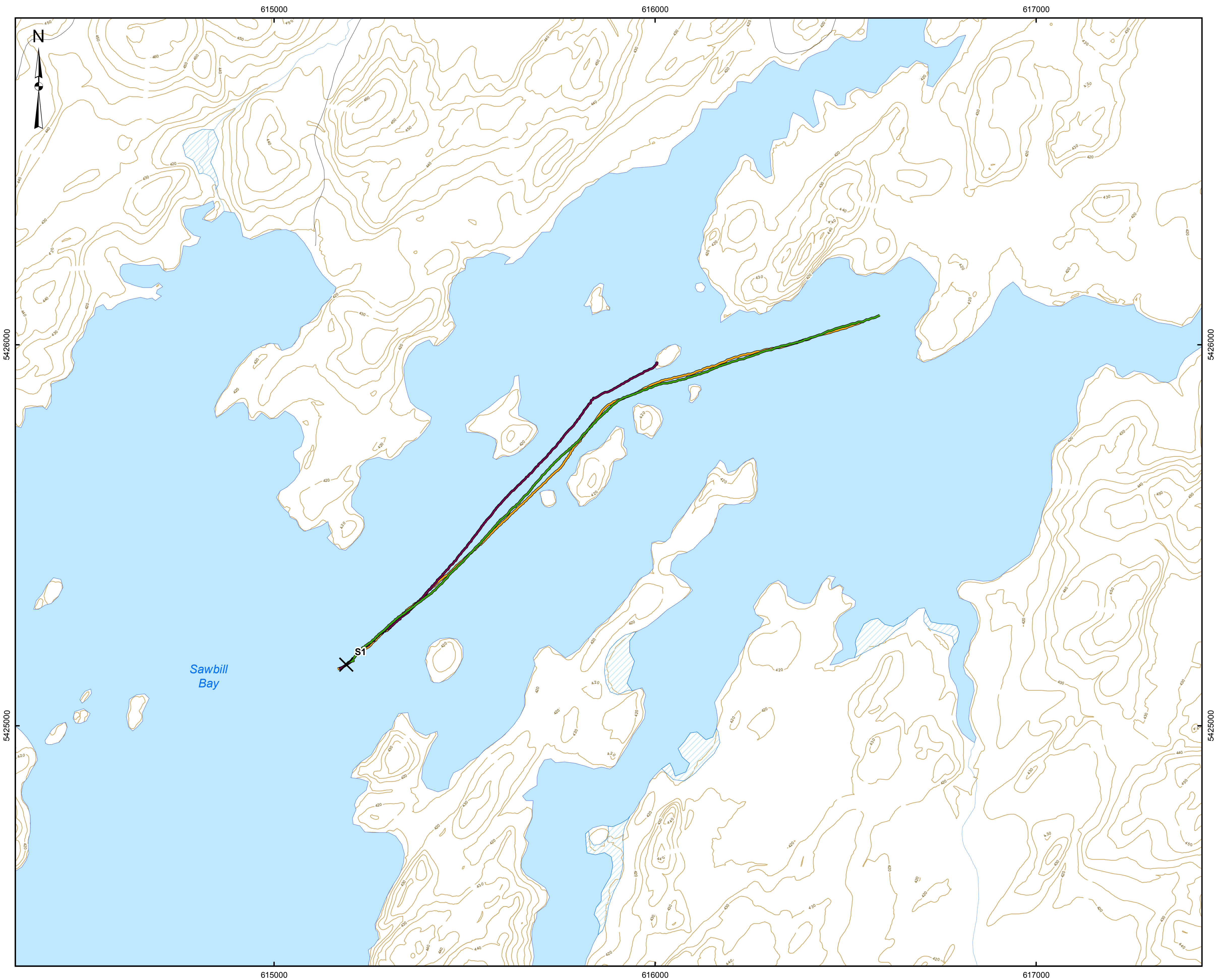
(b) Observation taken during deployment.

(c) Not available: Wind Speed not measured during 2011 field program.

(d) Estimated for first half of dataset only due to unreliable GPS data.

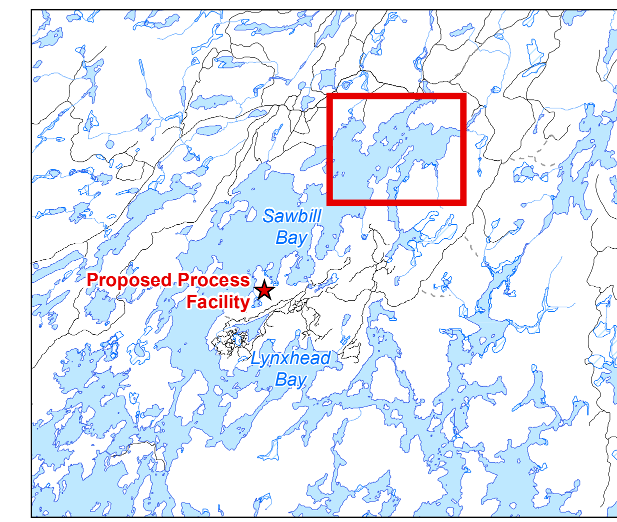
(e) Wind direction describes the direction to wind is blowing towards.

"—" Not applicable



LEGEND

- Proposed Process Facility
- Approximate Drogue Deployment Location
- Drogue Path S1-1 (October 7, 2010)
- Drogue Path S1-2 (October 7, 2010)
- Drogue Path S1-3 (October 7, 2010)
- Index Contour (5m interval)
- River/Stream
- Lake
- Wetland



REFERENCE

Base Data - Provided by Brett Resources
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

250 0 250 500
SCALE 1:10,000 METRES

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
DROGUE TRACKS SAWBILL BAY

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	14 Nov. 2008	FIGURE: 3-2	
GIS	JO	5 Feb. 2013		
CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

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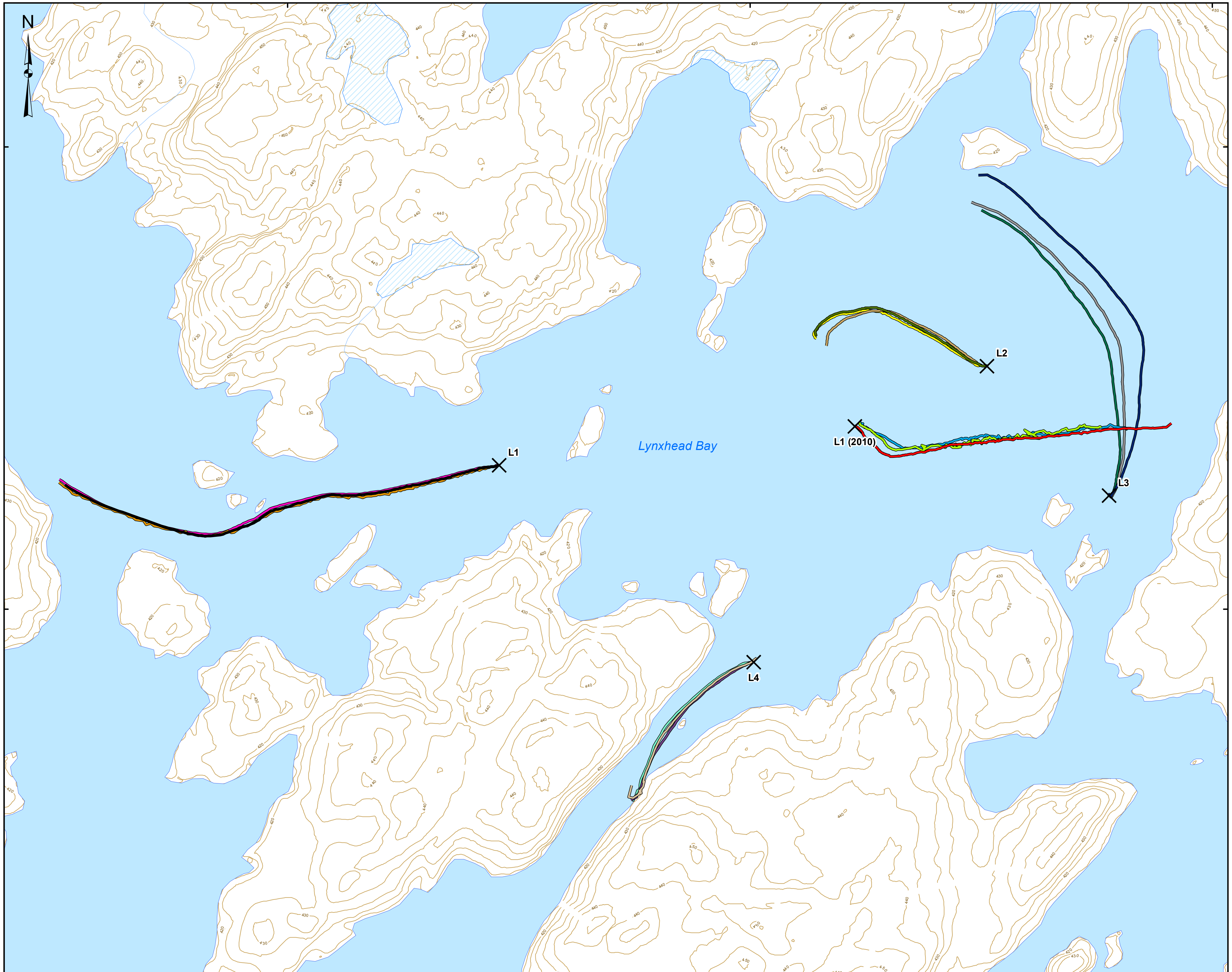
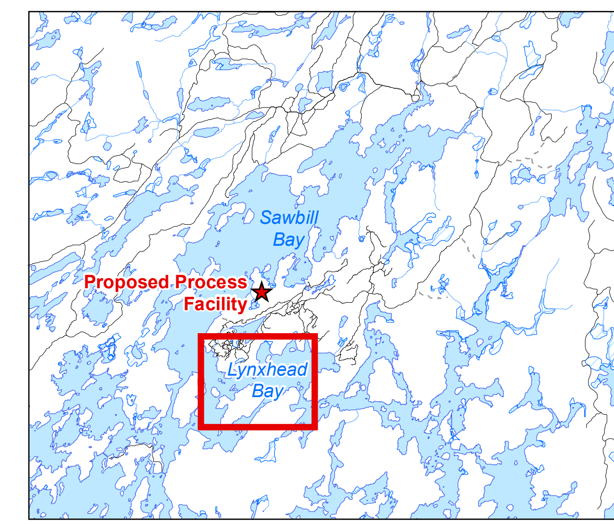


LEGEND

- Proposed Process Facility
- Approximate Drogue Deployment Location
- Drogue Track L0-1 (October 7, 2010)
- Drogue Track L0-2 (October 7, 2010)
- Drogue Track L0-3 (October 7, 2010)
- Drogue Track L1-1 (May 19, 2011)
- Drogue Track L1-2 (May 19, 2011)
- Drogue Track L1-3 (May 19, 2011)
- Drogue Track L2-1 (May 19, 2011)
- Drogue Track L2-2 (May 19, 2011)
- Drogue Track L2-3 (May 19, 2011)
- Drogue Track L3-1 (May 19, 2011)
- Drogue Track L3-2 (May 19, 2011)
- Drogue Track L3-3 (May 19, 2011)
- Drogue Track L4-1 (May 19, 2011)
- Drogue Track L4-2 (May 19, 2011)
- Drogue Track L4-3 (May 19, 2011)
- Index Contour (5m Interval)
- River/Stream
- Road
- Lake
- Wetland



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Base Data - Provided by Brett Resources (April, 2010)
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

200 0 200 400
METRES

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
DROGUE TRACKS LYNXHEAD BAY

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	14 Nov. 2008		
GIS	JO	5 Feb. 2013		
CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

Golder Associates
Mississauga, Ontario

FIGURE: 3-3

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3.1.3.2.2 Continuous and Vertical Profile Current Data

Water current velocities (speed and direction) in Sawbill Bay were measured using Acoustic Doppler Current Profilers (ADCPs) in October of 2010. The location of the deployment is shown on Figure 1-6 while a summary of the deployment details are provided Table 3-2.

Table 3-2: Acoustic Doppler Current Profiler Deployment Details for Sawbill Bay

	Sawbill Bay
Dates	October 4, 2010 – October 28, 2010
Instrument Type	RD Instruments (RDI)
Water depth	26.5 m
Sensor height in frame	0.6 m
Vertical Cell Size	2.0 m
Number of cells	13 total/11 Used[a]
Averaging interval	10 min
Sampling interval	6 samples/hour (10 minutes)

Notes:
[a] The surface and bottom cells did not provide accurate data.

Additional current data were also collected in Hawk Bay and Turtle Bay using ADCP but is not within the area of interest for the screening level model and are not included in this report.

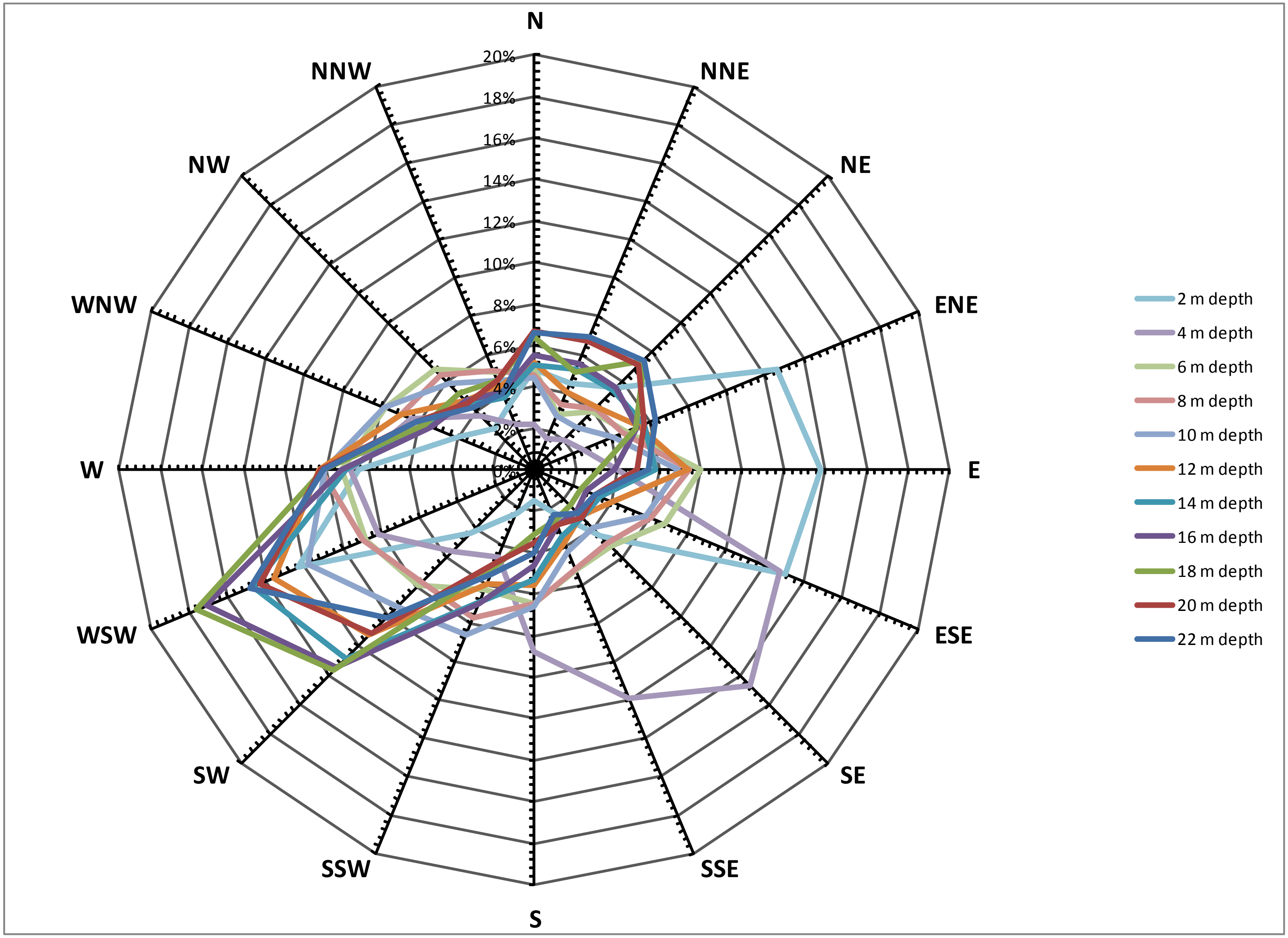
The frequencies at which current directions occur for each of the depths are provided on Figure 3-4. Figure 3-4 shows that at depths below 4 m, the currents predominantly move in a south-westerly direction. This current pattern is likely associated with inflows from Sawbill Creek moving through Sawbill Bay to the outlet of Upper Marmion Reservoir at the Raft Lake Dam.

In contrast, the currents at the surface (2 m depth) predominantly moved to the east and the currents at a depth of 4 m predominantly moved to the southeast. There is likely the result of wind generated currents that are aligned with the prevailing winds from the west. These surface current frequencies are consistent with the observed drogue paths discussed previously.

Current speeds in Sawbill Bay were measured to range from stagnant to over 0.7 m/s at the ADCP location. The frequencies at which current speeds occur at each of the depths are provided on Figure 3-5. Figure 3-5 shows that at depths below 6 m, the distribution of current speeds is consistent with depth and is usually less than 0.04 m/s (4 cm/s). The average current speed at depth of 6 m or more is approximately 0.018 m/s (1.8 cm/s).

At a depth of 4 m, the average current speed is approximately 0.034 m/s (3.4 cm/s) which is roughly double that observed at deeper locations. At this depth, the current speed is typically less than 0.08 m/s (8 cm/s).

However, the highest current speed is recorded at the surface (2 m depth) where the average current speed increases to approximately 0.4 m/s (40 cm/s). While the current speeds are typically less than 0.6 m/s (60 cm/s), when a strong wind persists of periods of several hours or more, surface current speeds of 0.8 m/s (80 cm/s) or more were recorded.



PROJECT	HAMMOND REEF GOLD PROJECT ATIKOKAN, ONTARIO, CANADA
TITLE	**MEASURED CURRENT DIRECTIONS IN SAWBILL BAY (OCTOBER 2010)**

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			VERSION 1
DESIGN	JO	24 Sep. 2012	
GIS	JO	5 Feb. 2013	**FIGURE: 3-4**
CHECK	REJ	5 Feb. 2013	
REVIEW	KJD	5 Feb. 2013	

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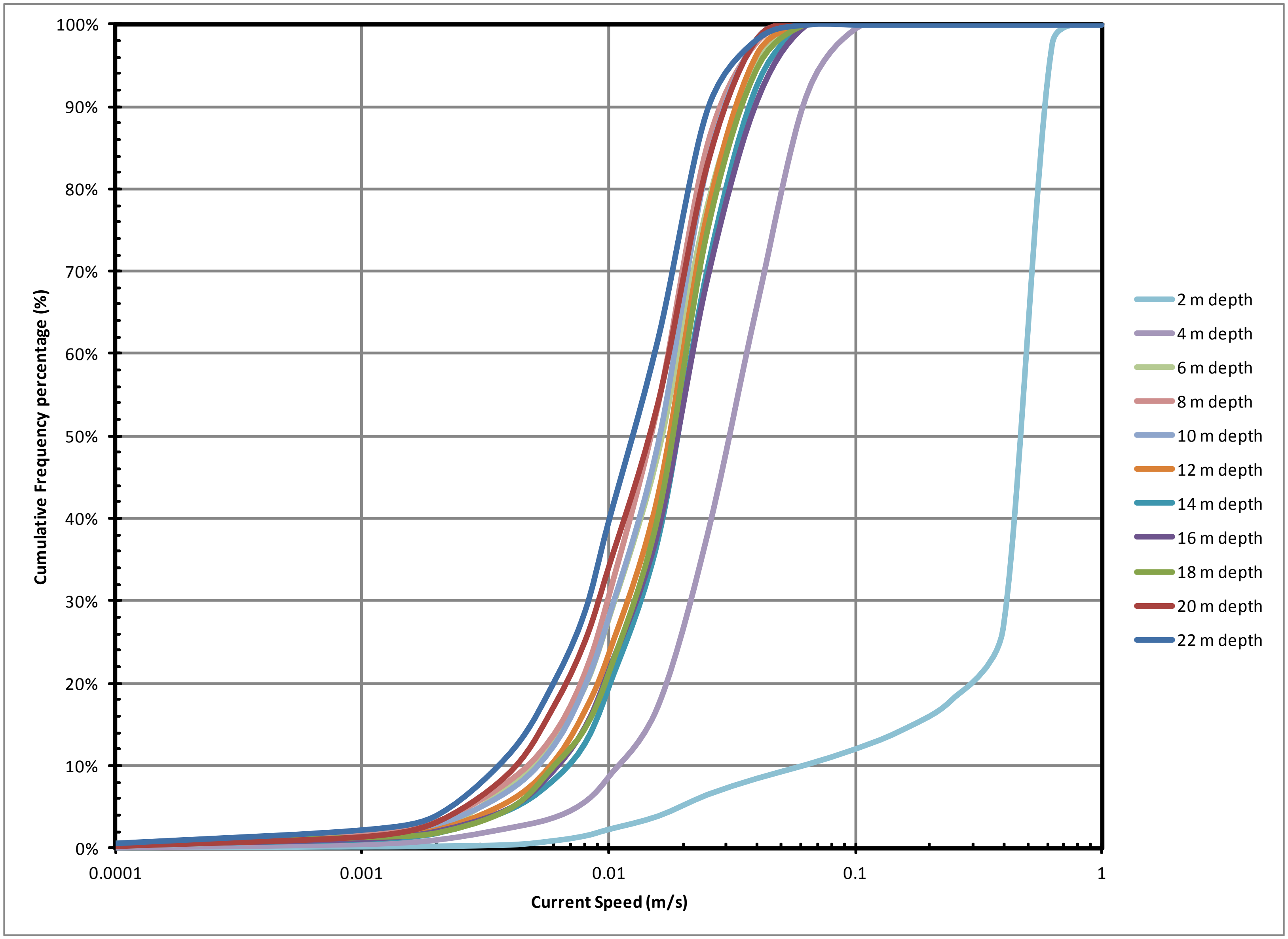

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

MEASURED CURRENT SPEEDS IN SAWBILL BAY (OCTOBER 2010)

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			VERSION 1
DESIGN	JO	24 Sep. 2012	
GIS	JO	5 Feb. 2013	
CHECK	REJ	5 Feb. 2013	
REVIEW	KJD	5 Feb. 2013	

FIGURE: 3-5

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3.1.3.3 Development of 28-Year Data Record

The screening level model was used to assess the potential impacts of the Mine effluent under various climatic conditions. This was achieved by developing a 28-year simulation period that would capture climatic conditions that would be reasonably expected to occur over the 13-year operational life of mine. In other words, the most extreme conditions in the 28-year simulation would have approximately a one in three probability of occurring during the lifespan of the Mine.

The selection of the January 1984 to December 2011 period was selected since it provided the most complete base dataset for the simulation. It was also believed that the most recent precipitation and flow data would provide more reasonable estimations of future conditions.

A summary of the precipitation based return periods for Atikokan are provided in Table 3-3. In Table 3-3 the wettest and driest years are highlighted to show that the simulation period includes a wet year that occurs once every 41 years (1996) and a dry year that occurs once every 72 years (1998).

Table 3-3: Precipitation Return Periods for Simulation Period

Year	Average Raft Lake Flow (m^3/s)	Wet or Dry Year	Return Period (Years)[(a)]
1984	29.30	Dry	2.7
1985	55.30	Wet	23.5
1986	36.50	Wet	2.5
1987	17.60	Dry	13.5
1988	32.80	Dry	2.1
1989	35.60	Wet	2.3
1990	32.80	Dry	2.1
1991	26.90	Dry	3.4
1992	49.00	Wet	9.7
1993	34.10	Wet	2.1
1994	34.00	Wet	2.1
1995	28.00	Dry	3.1
1996	**58.90**	**Wet**	**40.9**
1997	26.30	Dry	3.7
1998	**10.80**	**Dry**	**71.7**
1999	35.30	Wet	2.3
2000	33.80	Wet	2.1
2001	50.00	Wet	10.8
2002	34.10	Wet	2.1
2003	17.90	Dry	12.9
2004	34.60	Wet	2.2
2005	42.80	Wet	4.5
2006	22.10	Dry	6.4
2007	27.30	Dry	3.3
2008	48.00	Wet	8.3

Table 3-3: Precipitation Return Periods for Simulation Period (Continued)

Year	Average Raft Lake Flow (m³/s)	Wet or Dry Year	Return Period (Years)[a]
2009	48.00	Wet	8.3
2010	23.60	Dry	5.3
2011	25.60	Dry	4.0

Notes:
[a] Return period based on annual precipitation recorded at Atikokan.
Blue shading represents the wettest and driest years.

The annual precipitation return periods are plotted against time on Figure 3-6. Figure 3-6 shows that the most extreme dry and wet years occur in a cycle of approximately four years (e.g., time between peaks). This suggests that dry periods more than a few years in length are not expected to occur. As a result, using the model to represent an extended dry period (e.g., 10 years or more) would provide overly conservative predictions.

3.1.3.3.1 Upper Marmion Reservoir Water Levels

For this assessment, it was assumed that the water levels in Upper Marmion Reservoir would follow the management plan outlined in the Seine River Management Plan (Boileau 2004) where possible. The only exception to this condition occurred when there was insufficient inflow to Upper Marmion Reservoir to maintain a minimum flow of at least 10 m³/s below the Raft Lake Dam to satisfy the requirements of downstream users.

The predicted monthly water levels are provided on Figure 3-7 for the 28-year simulation period. In general the water levels are maintained in accordance with the management plan. The most noticeable exception occurs in 1998 when the water level is predicted to decrease to 413.34 masl which is approximately 0.7 m below the management rule. As noted previously, 1998 is the driest year in the 28-year simulation period and has a return period of approximately 72 years.

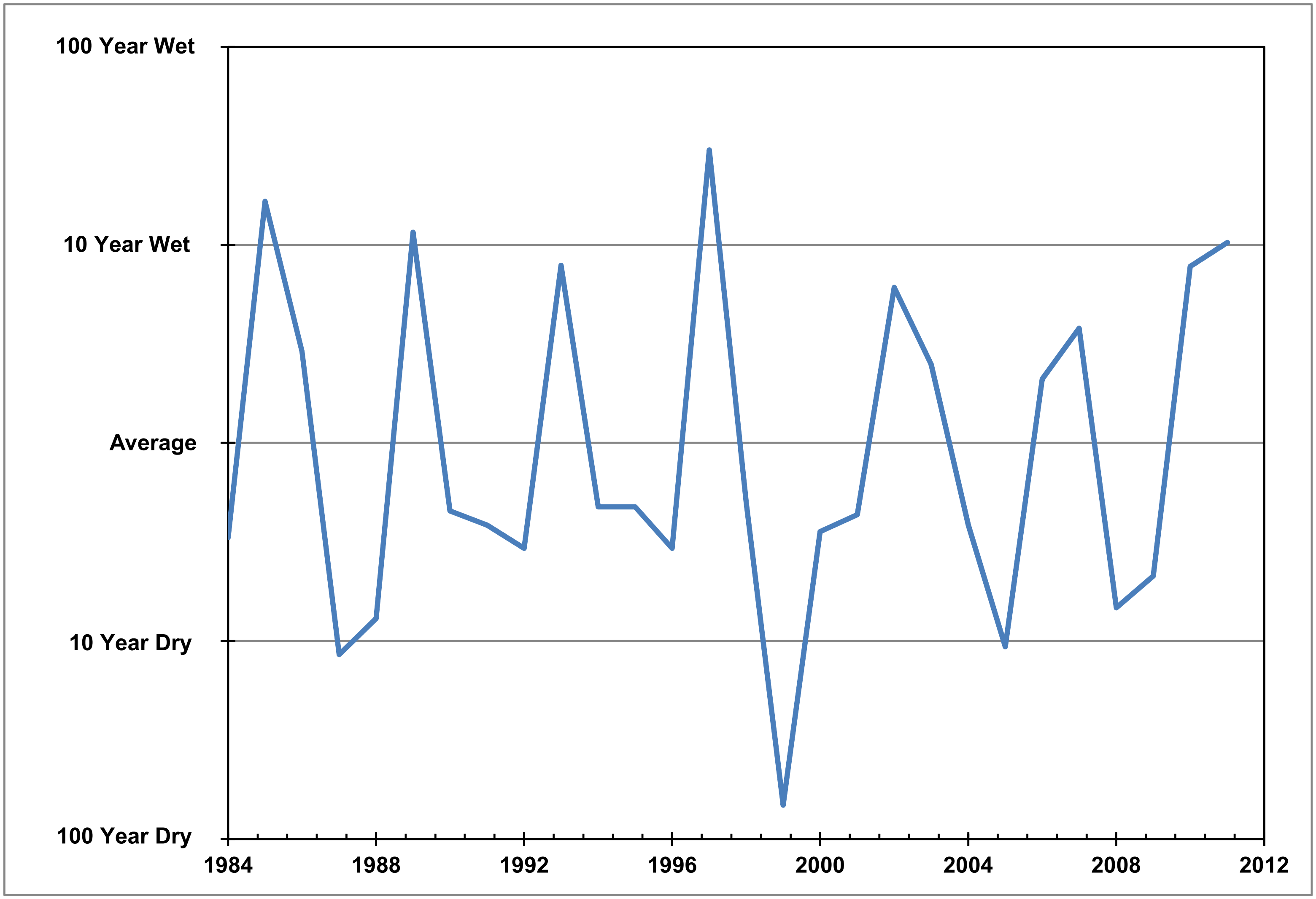
As with the mine intake and discharge flows, the monthly water levels were converted to daily values and the monthly values were linearly transitioned over a one week period between months to avoid numerical instabilities.

3.1.3.3.2 Upper Marmion Reservoir Inflows and Outflows

The following points outline the methods used to generate in daily inflows and outflows for the 28-year simulation period.

- Inflows to Upper Marmion Reservoir from the Seine River were based on Lac des Mille Dam outflows plus unregulated flows from intermediate drainage area on a monthly basis (1984 to 2011).
- Runoff into Sawbill Bay (SW-01 and SW-11) was estimated based on correlation with 2010-2011 monthly mean discharges recorded at the regional Water Survey of Canada (WSC) Atikokan River at Atikokan.
- Outflows from the Raft Lake Dam were estimated based on monthly inflows and maintaining the water level as close to the management plan as possible.

As in the previous sections, the monthly inflows and outflows were converted to daily values and the monthly values were linearly transitioned over a one week period between months to avoid numerical instabilities.



PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

RETURN PERIODS

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			VERSION 1
DESIGN	JO	24 Sep. 2012	
GIS	JO	5 Feb. 2013	
CHECK	REJ	5 Feb. 2013	
REVIEW	KJD	5 Feb. 2013	

FIGURE: 3-6

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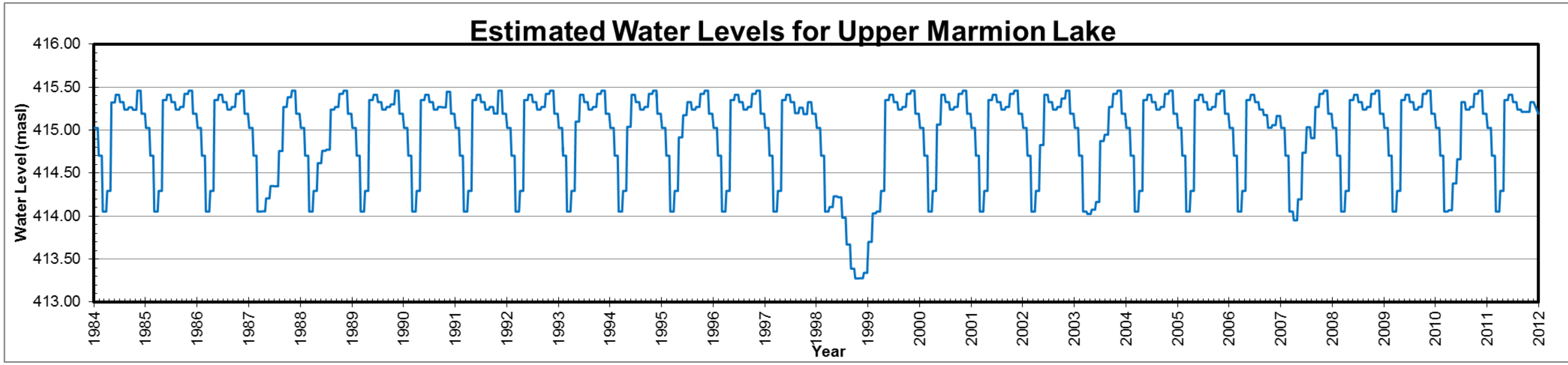


Figure 3-7: Estimated Daily Mean Water Levels at Raft Lake Dam for 28 Year Simulation

The estimated flows into Upper Marmion Reservoir and outflow at the Raft Lake Dam are provided on Figure 3-8 while the estimated runoff flows into Sawbill Bay are provided on Figure 3-9.

3.1.3.4 Estimation of Sawbill Bay Exchange Flows

As mentioned previously, the model divisions between the compartments were based on lake bathymetry and were positioned at locations where shallow depths would tend to hydraulically separate the compartments. The only case where this wasn't true was the division between the central and northern basins of Sawbill Bay. Since approximately 60% of the total volume of Upper Marmion Reservoir is contained within these two basins, it was felt that more detail was required with respect to the effects of the effluent in Sawbill Bay. As such, estimates of wind driven exchange flows between for the northern and central basins of Sawbill Bay were required to complete the modelling.

ADCP data collected between October 4, 2010 and October 28, 2010 was used to estimate the wind driven exchange flows between the central and northern basins of Sawbill Bay. The deployment location of the ADCP is shown on Figure 1-6.

The following assumptions and simplification were used for the estimate of the exchange flow:

- Exchange flows were assumed to occur at a direction of 45º which is the approximate alignment of the long-axis of Sawbill Bay and is perpendicular to the cross-section that was assumed to separate the two basins.
- The estimate only includes the upper 6 m of the water column (top 3 layers measured by the ADCP). This is based on an initial review of the ADCP data that suggests the largest wind driven currents occur in these layers.
- It was assumed that one half the width of the cross-section contributed to the exchange flows. Since the water level in Sawbill Bay remains fairly constant (e.g., the exchange flows are much larger than the inflows), it was assumed that the other half of the cross section would have an equal and opposite exchange flow.

The resulting exchange flows ranged from less than 1,000,000 m³/d on days with calm winds to over 20,000,000 m³/s on windy days. The typical average exchange flow was approximated to be 10,000,000 m³/d.

When the volumes of the two basins are compared to the estimated exchange flows, the residence time for each of the two basins is less than 10 days, This indicates that the northern and central basin are not hydraulically separated and can be represented as a single basin.

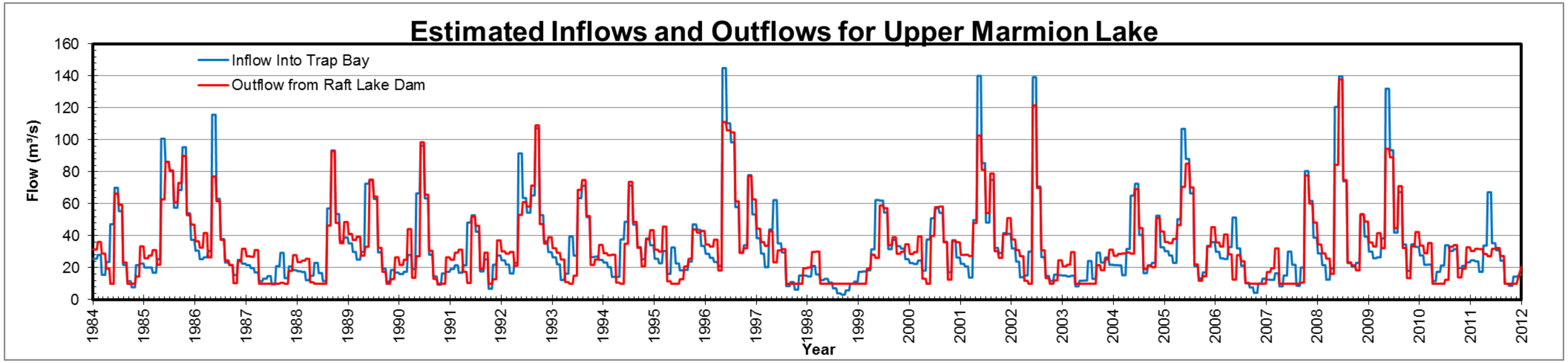


Figure 3-8: Estimated Daily Mean Inflows and Outflows to Upper Marmion Reservoir for 28 Year Simulation

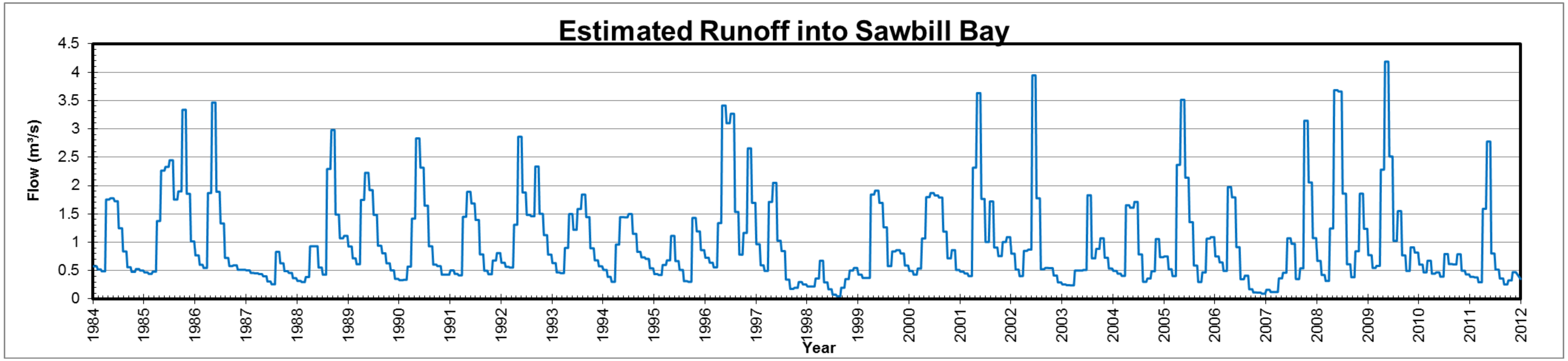


Figure 3-9: Estimated Daily Mean Inflows Runoff into Sawbill Bay for 28 Year Simulation

3.2 Hydrodynamic Modelling Results – Upper Marmion Reservoir

A summary of the compartment (basin) volumes and average residence times based on the output from the screening level model is provided in Table 3-4. Most of the basins in the modelled area have a residence time of less than 10 days. The exceptions are the northern and central basins of Sawbill Bay and unnamed basin #10 which have residence times that are over 300 days. Since the northern and central basins of Sawbill can be represented as a single basin (as determined above), Table 3-4 also shows that the residence time for these two basins is approximately 910 days when they are treated as a single model basin.

The estimated residence time for the entire modelled area of 73 days is biased by the long residence time of Sawbill Bay (which represents 65% of the total volume). If Sawbill Bay is excluded from the calculation, then the residence time of the remainder of the system is estimated to be 23 days. Consequently, the main flow-through portion of the lake can expect to see responses to effluent loads on a short time frame (e.g., one month) while Sawbill Bay is expected to respond to effluent discharges on a longer time frame (e.g., years).

Table 3-4: Summary of Basin Volumes and Residence Time

Basin	Common Name	Volume		Residence Time (days)
		(m³)	% of Total	
1	Trap Bay	2,300,000	1.1%	0.78
2	Lynxhead Bay	19,900,000	9.1%	6.8
3	—	2,400,000	1.1%	1.0
4	—	1,500,000	0.7%	2.6
5	—	4,600,000	2.1%	2.3
6	—	9,100,000	4.2%	12
7a	Southern Sawbill Bay	16,600,000	7.6%	110
7b	Central Sawbill Bay	90,900,000	41.5%	730[a]
7c	Northern Sawbill Bay	43,500,000	19.9%	310[a]
7b & 7c	Central and Northern Sawbill Bay	134,400,000[b]	61.4%[b]	910[b]
8	—	10,500,000	4.8%	3.5
9	—	6.700,000	3.1%	2.2
10	—	3,100,000	1.4%	1200
11	—	7,900,000	3.6%	2.6
Total	**Upper Marmion Reservoir**	**219,000,000**	—	**73**

Notes:
(a) Estimated residence time for Central and Northern Sawbill Bay does not include effect of wind driven exchange flows.
(b) Estimated volume and residence time when model basins 7B and 7C are considered as one basin in the model.
"—" Not applicable

3.3 Hydrodynamic Modelling for Lizard Lake

The objectives of this model are similar to that for Marmion Reservoir as a whole; the model, however, is focussed only on Lizard Lake.

3.3.1 Assumptions and Limitations

The following points outline the assumptions used in this assessment as well as the limitations (in addition to the ones listed for the Marmion Reservoir model):

- The model only considered the Lizard Lake watershed.
- Outflow from Lizard Lake was predicted using a rating curve developed in (Hydrology TSD).
- The total daily inflows into Lizard Lake were estimated using a Hydrologic Engineering Center – Hydrologic Modelling System (HEC-HMS) model developed in the (Hydrology TSD).
- It was assumed that 28% of the inflow was direct runoff that was divided equally for each model basin. The remaining 72% was assumed to be tributary runoff that drained into the northern basin of Lizard Lake.
- It was assumed that 90% of the dam seepage was intercepted by the collection system and directed to a treatment facility. It was assumed that the remaining 10% of the seepage drained directly into Lizard Lake.
- A seepage concentration of 100 mg/L of a non-specific parameter was used strictly for comparative purposes.

3.3.2 Mixing Model (Box / Basin Model)

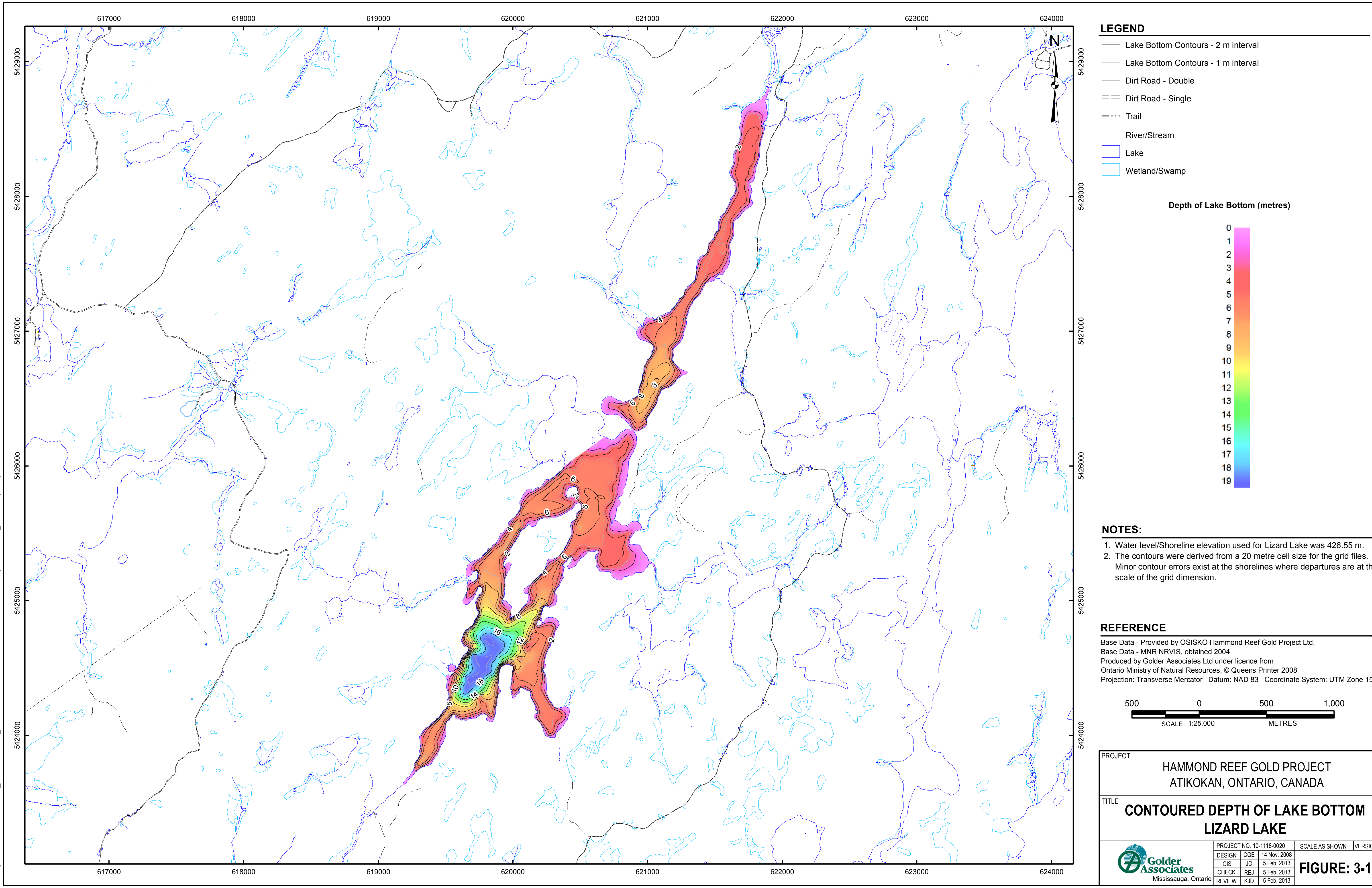
The lake bathymetry of Lizard Lake is partially shown on Figure 3-10. On Figure 3-11, the model compartments (basins) show the basins that constitute Lizard Lake. The main flow path of Lizard Lake (indicated by the purple arrows) passes through all of the lake basins shown on Figure 3-11.

A spreadsheet based “box model” was used for this screening level assessment. Figure 3-12 shows the model compartments (“boxes”) that were used. The divisions between the compartments were based on lake bathymetry and were positioned at locations where shallow depths would tend to hydraulically separate the shallows from the deeper lake basins. Each compartment in the model was assumed to be well mixed with no vertical stratification.

A water balance was used to estimate the water level and storage volume of each basin using daily inflows and outflows. The outflows from Lizard Lake were predicted using the rating curve shown in Figure 3-13 (developed in Hydrology TSD).

The model was based on the following data:

- Bathymetric data collected by Golder in 2010 and 2011.
- Total daily inflow to Lizard Lake was developed using a HEC-HMS model (developed in Hydrology TSD) for the period July 1982 to December 2011. The estimated total inflows are presented on Figure 3-14.
- Dam seepage rates summarized in Table 3-5 were based in a seepage analysis (Site Water Quality TSD).



617000
618000
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621000
622000
623000
624000
5429000
5428000
5427000
5426000
5425000
5424000
N
LEGEND
Lake Bottom Contours - 2 m interval
Lake Bottom Contours - 1 m interval
Dirt Road - Double
Dirt Road - Single
Trail
River/Stream
Lake
Wetland/Swamp
Depth of Lake Bottom (metres)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
NOTES:
1. Water level/Shoreline elevation used for Lizard Lake was 426.55 m.
2. The contours were derived from a 20 metre cell size for the grid files. Minor contour errors exist at the shorelines where departures are at the scale of the grid dimension.
REFERENCE
Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N
500 0 500 1,000
SCALE 1:25,000
METRES
PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA
TITLE
CONTOURED DEPTH OF LAKE BOTTOM
LIZARD LAKE
Golder Associates
Mississauga, Ontario
PROJECT NO. 10-1118-0020
SCALE AS SHOWN
VERSION 1
DESIGN CGE 14 Nov. 2008
GIS JO 5 Feb. 2013
CHECK REJ 5 Feb. 2013
REVIEW KJD 5 Feb. 2013
FIGURE: 3-10
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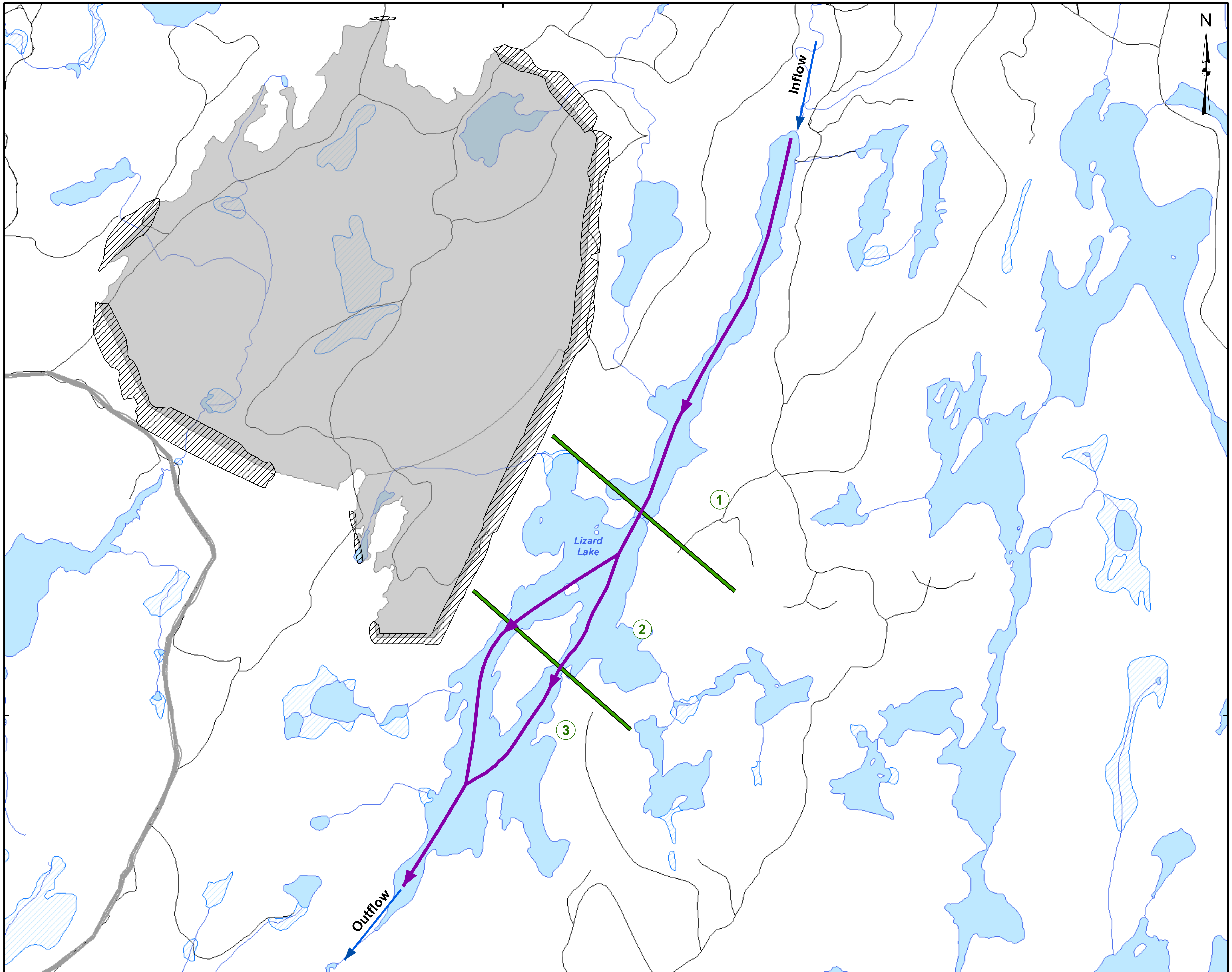

LEGEND

- Main River Flow
- Model Compartment Boundary
- Road
- River/Stream
- Lake
- Wetland
- Tailings Management Facility
- Tailings Management Facility Dam

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000
SCALE 1:25,000 METRES

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
SITE LAYOUT MODEL COMPARTMENTS LIZARD LAKE

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1118-0020			SCALE AS SHOWN	VERSION 1
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GIS	JO	5 Feb. 2013		
CHECK	REJ	5 Feb. 2013		
REVIEW	KJD	5 Feb. 2013		

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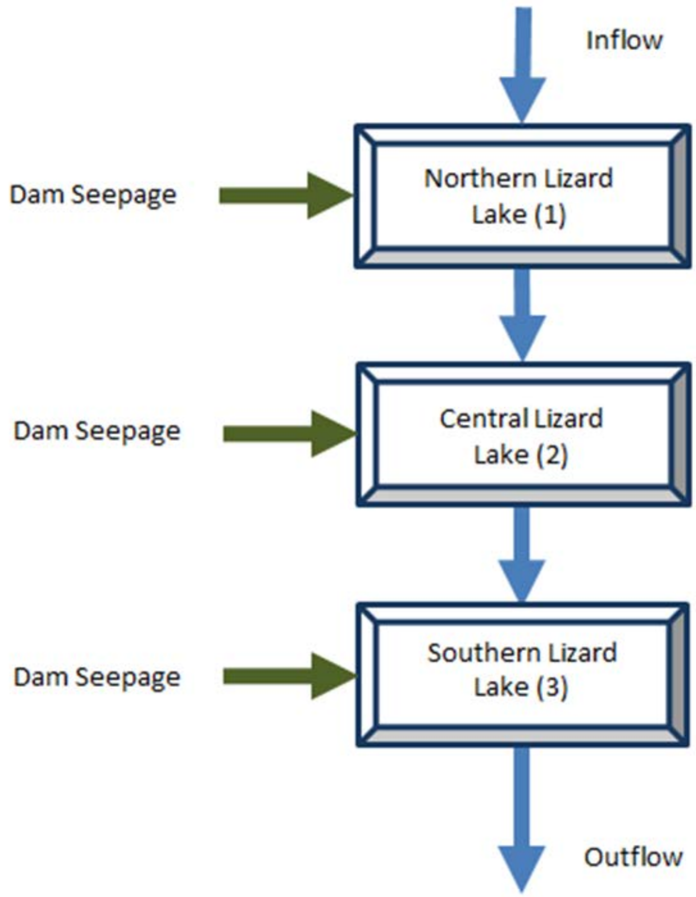

Figure 3-12: Schematic Box Model for Lizard Lake

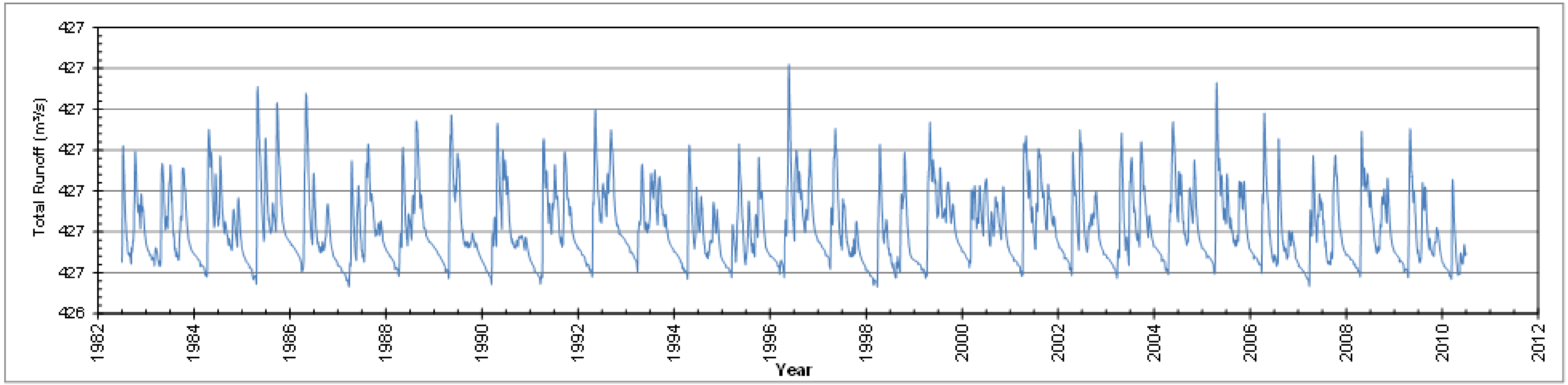

Figure 3-13: Rating Cure for Lizard Lake

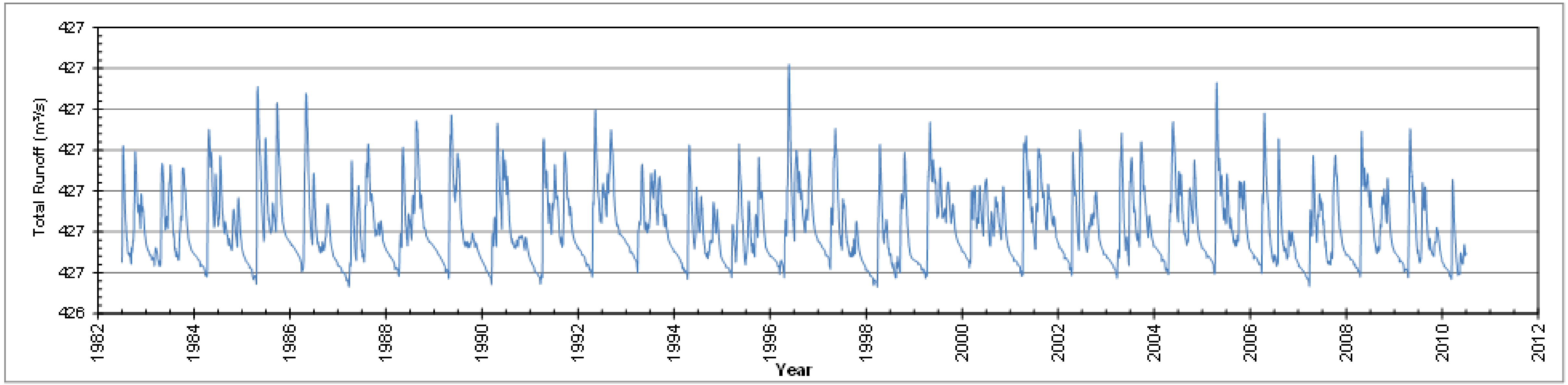

Figure 3-14: Predicted Total Inflows Lizard Lake

Table 3-5: Estimated Seepage Rates into Lizard Lake for Operational Phase

Lake Basin	Dam	Length (m)	Total Seepage per Dam[a] (m³/d)	Total Seepage to Lake Basins[b] (m³/s)
Northern	R1	229	10.2	0.00109
	R2	453	20.3	
	R3	1,419	63.4	
Central	Q1	1,614	72.2	0.00084
Southern	Q2	687	30.7	0.00070
	P1	362	16.2	
	B-1	313	14.0	
		Totals	**227.0**	**0.00263**

Notes:
(a) Seepage rates provided in Site Water Quality TSD.
(b) Total seepage to lake assumes that 90% of seepage is directed to treatment plant via collection system.

3.4 Hydrodynamic Modelling Results – Lizard Lake

A summary of the compartment (basin) volumes and average residence times based on the output from the screening level model is provided in Table 3-6. Table 3-6 shows that approximately 60% of the total volume of Lizard Lake is in the southern basin. As a result, the retention time of the southern basin is approximately double of the retention times of the central and northern basins. The total retention time of Lizard Lake is approximately half of a year (184 days).

Table 3-6: Summary of Basin Volumes and Retention Times

	Lizard Lake			
	Northern	**Central**	**Southern**	**Total**
Model Basin	**1**	**2**	**3**	
Approximate Volume (m³)	1,970,000	2,310,000	6,100,000	10,390,000
Fraction of Total Volume	19%	22%	59%	100%
Average Inflow (m³/s)	0.52	0.58	0.65	0.65
Retention Time (days)	44	46	108	184

Over the 30-year simulation period, the water level in Lizard Lake is expected to have a range of approximately 0.6 m between 426.4 masl and 427.0 masl as shown on Figure 3-15.

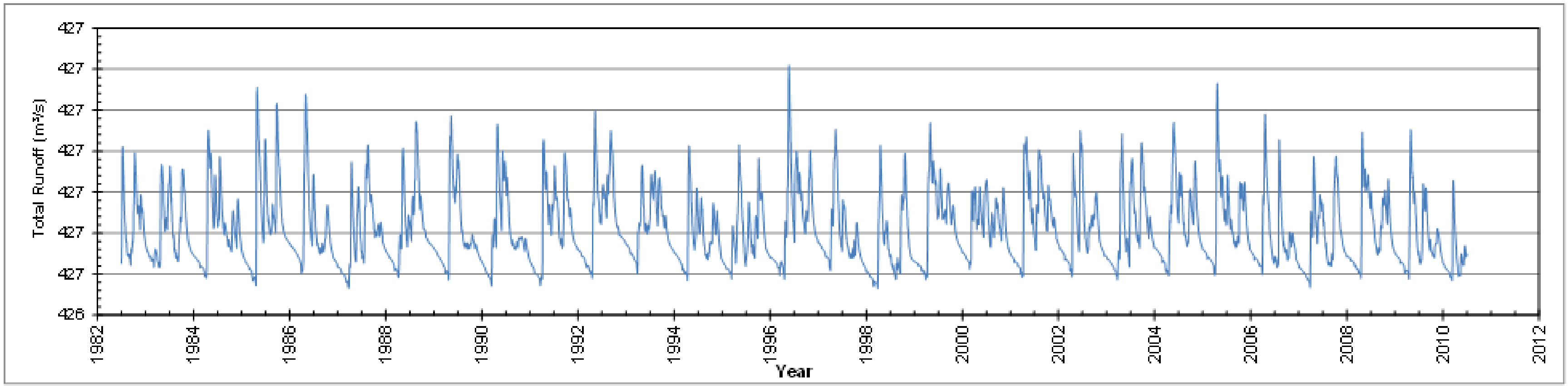

Figure 3-15: Predicted Water Levels in Lizard Lake

4.0 WATER QUALITY PREDICTIONS – MARMION RESERVOIR – OPERATIONS

4.1 Input Data (Operations)

4.1.1 Mine Intake and Discharge Flows

Mine intake and discharge flows were predicted for a range of wet and dry conditions (Site Water Quality TSD). The results for the monthly average intake and discharge predictions are provided in Table 4-1 and Table 4-2, respectively.

Table 4-1 shows that under most of the conditions, the average monthly intake flow will be 301.5 m^3/hr. Under dry conditions, the intake flow is predicted to be as high as 898 m^3/hr. Table 4-2 shows that no effluent discharge is expected under dry conditions or during some of the winter months. The discharge rate is expected to increase in extremely wet conditions.

Monthly average intake and discharge flows were estimated for the 28-year simulation period by using the annual return values on Table 3-3 to select the appropriate flows from Table 4-1 and Table 4-2. To provide a continuous record and more reasonable representation, values were interpolated based on the return period (e.g., for 1987 which has a precipitation return period of 13.5 years, the intake flows were interpolated between the 10-year and 25-year values in Table 4-1). The predicted daily mean intake and discharge flows for the 28-year simulation are provided in Figure 4-1.

Since the model uses a daily time step, the monthly intake and discharge flows were converted to daily values. To avoid numerical instabilities in the model, the monthly values were linearly transitioned over a one week period between months.

Table 4-1: Estimated Monthly Mine Intake Flows for Return Period Conditions for Operational Phase

Return Period[a]		Estimated Mine Intake from Sawbill Bay (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	864.8	898.0	832.4	301.5	349.9	301.5	301.5	301.5	301.5	397.3	684.3	800.2
	50	861.6	898.0	826.2	301.5	301.5	301.5	301.5	301.5	301.5	301.5	477.6	791.4
	25	858.0	898.0	819.1	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	558.1
	10	490.9	898.0	808.2	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Average[b]		301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Wet return period	10	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
	25	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
	50	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
	100	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5

Notes:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

Table 4-2: Estimated Monthly Mine Discharge Flows for Return Period Conditions for Operational Phase

Return Period[a]		Estimated Mine Discharge into South End of Sawbill Bay (m^3/h)											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Dry Return Period	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average[b]		56.3	0.0	0.0	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3
Wet return period	10	202.0	0.0	0.4	236.7	235.6	236.7	235.6	235.6	230.5	250.9	202.0	202.0
	25	259.2	0.0	3.2	328.6	326.4	328.6	326.4	322.6	339.6	309.6	259.2	259.2
	50	255.4	0.0	32.9	394.9	391.8	394.9	391.8	389.8	386.4	349.1	297.7	297.7
	100	228.5	0.0	139.9	442.9	439.3	442.9	439.3	452.8	467.2	384.1	331.8	331.8

Notes:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

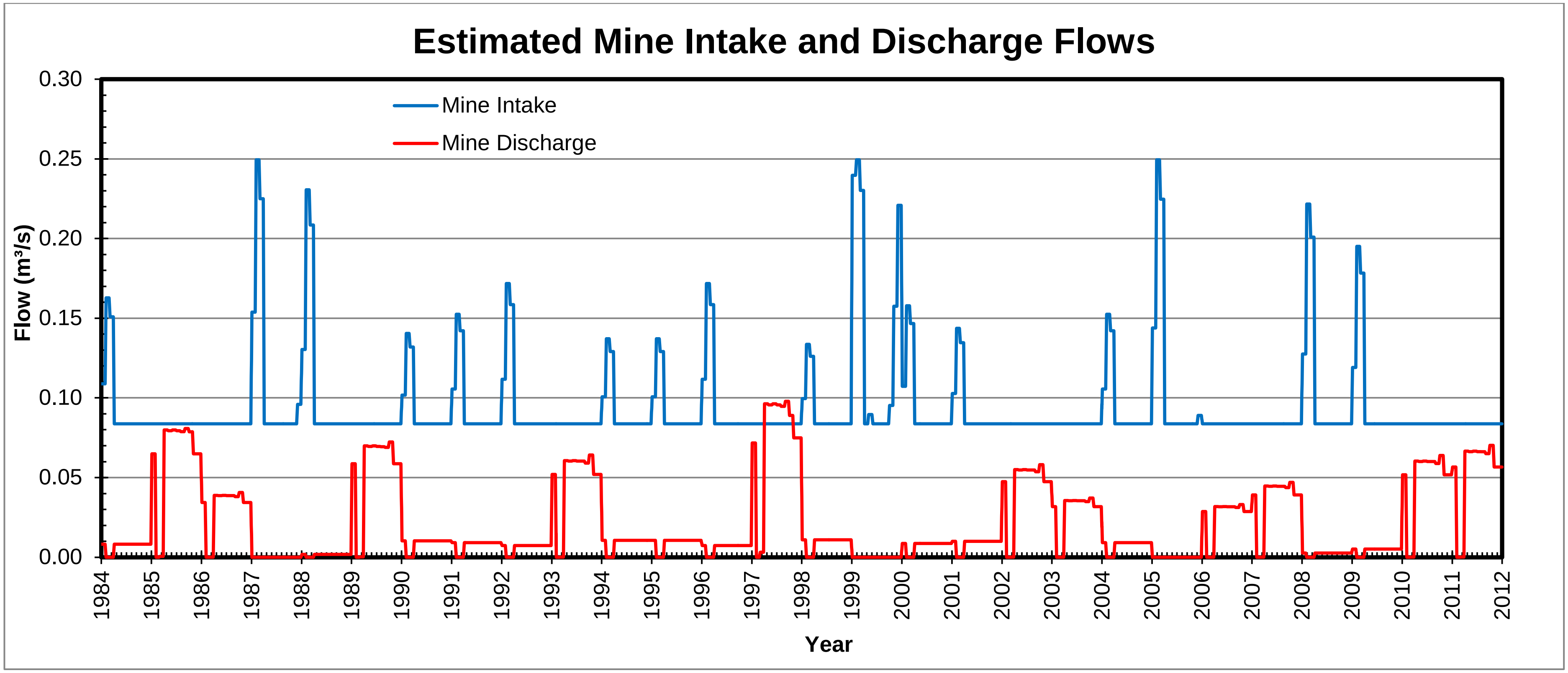

Figure 4-1: Estimated Mine Intake and Discharge Flows

4.2 Effluent Mixing for Upper Marmion Reservoir during Operations

As stated in Section 1.3.5, this assessment considers a discharge location in the south end of Sawbill Bay and an intake location in central Sawbill Bay (shown on Figure 1-6). In order to develop an estimate of expected mixing proportions for a given discharge concentration, a particle tracking type of evaluation was used whereby, for purposes of this assessment, the effluent was set at a constant value of 100 particles per unit volume. When examining the results presented in this section, a predicted particle concentration can be interpreted as being equivalent to the percentage of the plume concentration (e.g., a predicted concentration of 1 particle per unit volume is representative of 1% of the initial effluent concentration).

Figure 4-2 shows the predicted proportions (in %) for the effluent discharge in the southern end of Sawbill Bay (Basin 6), central Sawbill Bay (Basin 7B) and at the Raft Lake Dam (Basin 11). These results for all the model basins are summarized in Table 4-3.

By examining Figure 4-2 and Table 4-3 the following observations are made:

- The implementation of an average exchange flow (1,000,000 m^3/day) to the model results in the central and northern basins of Sawbill Bay (Basins 7B and 7C) having similar effluent mixing indicating that the two basins are well mixed and can be represented as a single basin.
- The predicted mixing proportion (average of 0.087%) at the Raft Lake Dam (Figure 4-2) is slightly lower to the concentration (average of 0.12% mixed) in the southern end of Sawbill Bay (Basin 6). The pattern at the outflow lags behind by approximately one month.
- The predicted mixing proportions in Northern and Central Sawbill Bay (Figure 4-2) gradually increase over time and reach a maximum annual average of approximately 0.027% at the end of the 28-year period. The rate of increase is approximately 0.001% per year.
- As expected, when the effluent is discharged into the south end of Sawbill Bay (Basin 6), an impact on the water quality at Lynxhead Bay is not expected.
- As expected, the maximum proportion of effluent occurs in the southern end of Sawbill Bay (Basin 6) where the effluent is discharged. The maximum predicted mixed proportion (1.52% effluent) occurs in October of 1997 (14^{th} year of the assessment period).
- The peak values seen on Figure 4-2 typically occur during the transition between wet and dry periods (e.g., once every four years).

Table 4-3 also provides a statistical summary of the frequency at which the predicted mixing proportions occur in the model basins. These are provided in more detail graphically for the south end of Sawbill Bay, central Sawbill Bay and at the Raft Lake Dam on Figure 4-3.

From Table 4-3, it is expected that the peak values occur infrequently (e.g., the peak mixing of 1.52% occurs less than 1% of the time). Near the discharge at the south end of Sawbill Bay (Basin 6), the effluent mixing proportion is expected to be below 0.5% more than 95% of the time.

Table 4-3: Summary of Effluent Mixing Proportions (%) in Marmion Reservoir Model Compartments for Operational Phase

Model Basin[a] Location	1 to 4[b] Upstream of Discharge	5	6 South End of Sawbill Bay	7A Southern Sawbill Bay	7B Central Sawbill Bay	7C Northern Sawbill Bay	8	9	10	11 Outflow
Minimum (%)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average (%)	0.000	0.085	0.118	0.045	0.012	0.011	0.090	0.089	0.076	0.087
Maximum (%)	0.000	1.022	1.518	0.236	0.032	0.026	1.024	0.998	0.142	0.974
Percentiles										
1.0%	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2.5%	0.000	0.000	0.000	0.006	0.001	0.001	0.000	0.000	0.006	0.000
5.0%	0.000	0.000	0.000	0.007	0.005	0.004	0.000	0.000	0.042	0.000
10.0%	0.000	0.001	0.001	0.009	0.006	0.005	0.001	0.001	0.051	0.001
50.0%	0.000	0.028	0.038	0.024	0.012	0.011	0.030	0.030	0.074	0.030
90.0%	0.000	0.245	0.338	0.116	0.020	0.018	0.258	0.251	0.119	0.244
95.0%	0.000	0.318	0.438	0.150	0.024	0.022	0.334	0.324	0.126	0.319
97.5%	0.000	0.424	0.591	0.179	0.027	0.023	0.438	0.428	0.127	0.416
99.0%	0.000	0.644	0.907	0.210	0.027	0.026	0.655	0.630	0.132	0.617

Notes:

Effluent mixing proportions are presented as a percentage. Calculations are based on a constant effluent discharge of 100 particles per unit volume for a non-specific conservative parameter.

(a) Locations of model basins are shown on Figure 1-6.

(b) Model basins upstream of discharge point were not predicted to be influenced by the effluent.

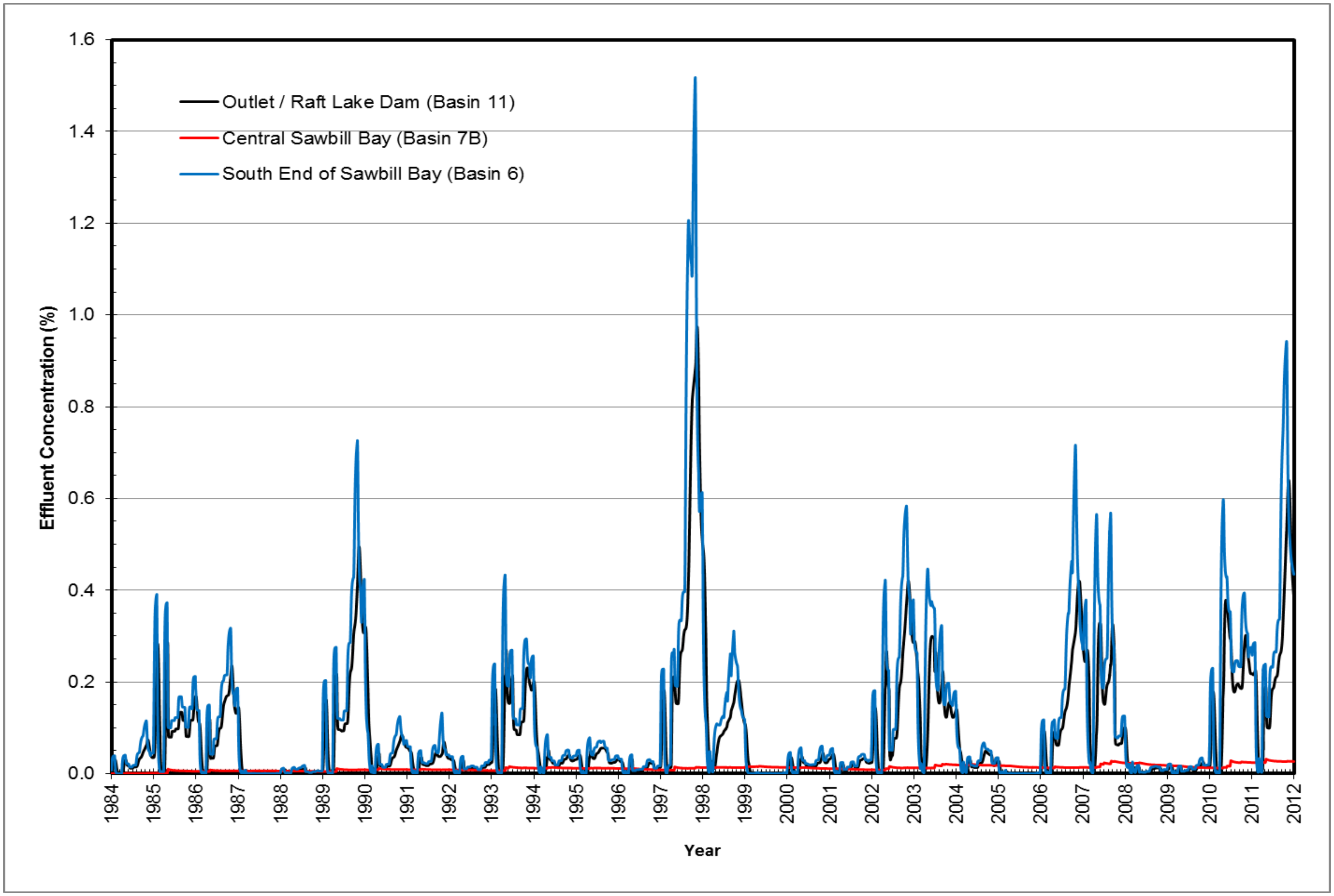

Figure 4-2: Predicted Effluent Concentrations in Upper Marmion Reservoir during Operations

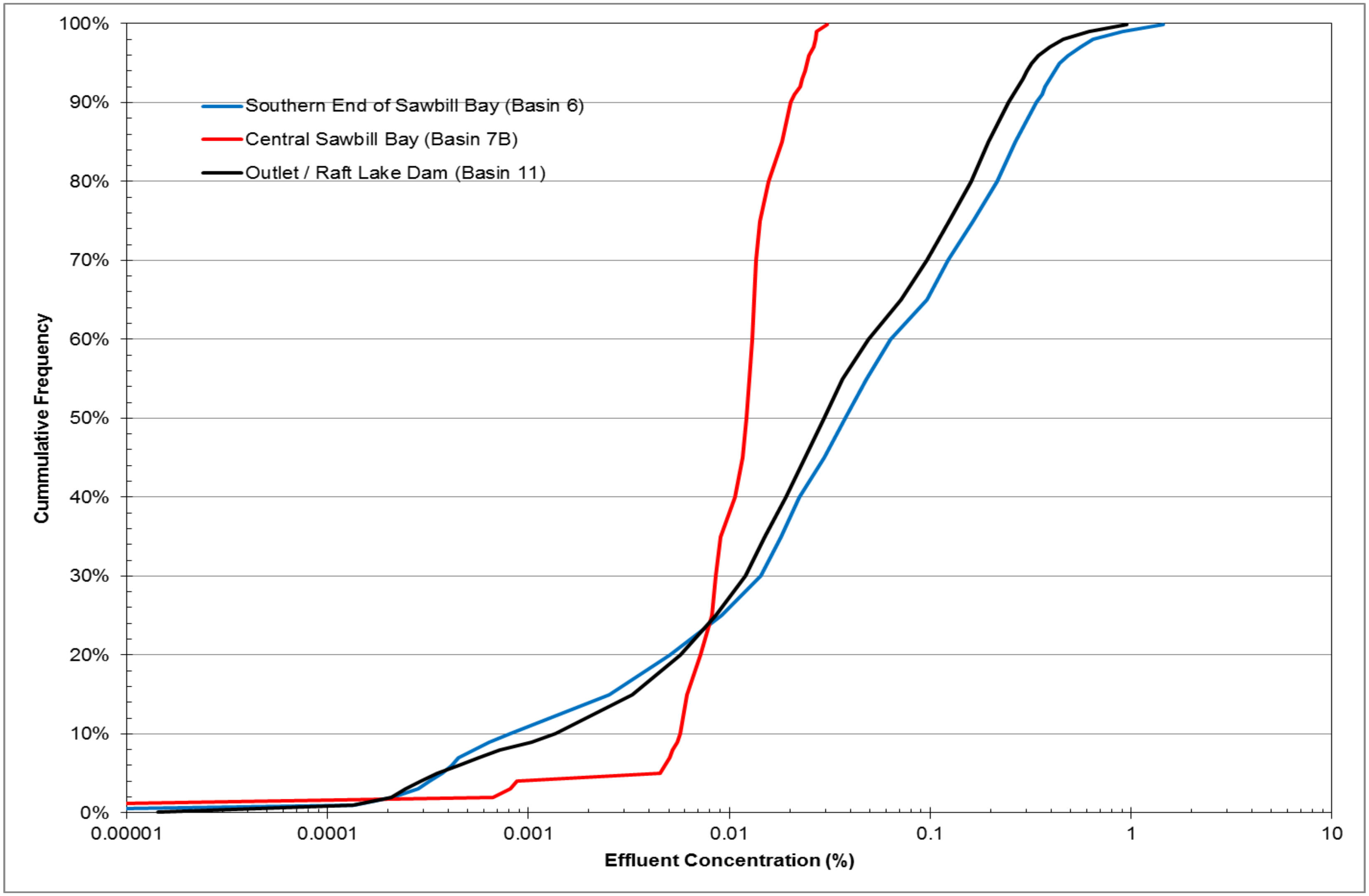

Figure 4-3: Frequencies of Predicted Effluent Concentrations in Upper Marmion Reservoir during Operations

4.3 Water Quality Predictions for Upper Marmion Reservoir during Operations

Table 4-4 presents a summary of the average and maximum mixing proportions (%) (Section 4-2) that were applied to the mixing of site discharge inputs in each Upper Marmion Reservoir basin for the operational scenario (see Figure 1-6). Average and maximum mixing proportions were used to bracket a range in mixing scenarios.

Table 4-4: Average and Maximum Mixing Proportions of site discharge in zones of Upper Marmion Reservoir during Operations

Identifier	Zone	**1 to 4[2]**	**5**	**6**	**7A**	**7B**	**7C**	**8**	**9**	**10**	**11**
i	Average	0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
ii	Maximum	0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974

The following sections present the results of water quality prediction modelling. See Appendix 2.III for all water quality prediction results. Results in the below sections will be discussed for Basin 6, which represents the basin within Upper Marmion Reservoir that will have the highest proportion of effluent following mixing and Basin 11 which represents the predicted outflow from the Raft Lake Dam.

4.3.1 Scenario 1 – Average Case

Results for average water quality predictions, identified as Run 2ai in Appendix 2.I, are presented in Table 4-5. Run 2ai applied average baseline Upper Marmion Reservoir water quality, average site discharge concentration, steady-state climatic conditions, and average mixing for the operational scenario.

Table 4-5: Run 2ai Results for Average Water Quality Predictions in Basin 6 of Upper Marmion Reservoir for Operational Scenario.

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Reservoir Baseline	Basin 6 (near discharge)	Basin 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Proportion (%)	
						0.00118	0.00087
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 7.8	6.5 – 7.8
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	+5-25	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.71	0.7
Sodium	mg/L	—	—	—	1.3	1.4	1.3
Sulphate	mg/L	—	—	—	1.6	1.8	1.8
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**0.0059**	**0.0057**
Cyanide (total)	mg/L	—	—	—	0.002	0.0029	0.0027
Nutrients							
Nitrate-N	mg/L	13	—	—	0.063	0.065	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.041	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.00027	0.00022
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00043	0.00041
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.0010	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00074	0.00073
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.

[a] See Appendix 2.IV for the list of all parameters, guidelines and notes.

[b] Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of average site discharge to Upper Marmion Reservoir for the operational scenario are lower than the MISA guidelines. Predicted results are marginally greater than average Marmion Reservoir baseline concentrations. Results are summarized with respect to CCME CWQG and PWQO guidelines and average Upper Marmion Reservoir baseline water quality as follows:

- The concentrations of free cyanide ranged from 0.0051 to 0.0059 mg/L, and are greater than the CCME CWQG and PWQO guidelines (both values of 0.005 mg/L) for basins 5 to 11 within Upper Marmion Reservoir.
- Predicted free cyanide concentrations are also marginally greater than the baseline concentration of free cyanide (0.005 mg/l).

4.3.2 Scenario 2 – Upper Bound Case

Results for upper bound case water quality predictions, identified as Run 2cii in Appendix 2.I, are presented in Table 4-6. Run 2cii applied average baseline Upper Marmion Reservoir water quality, maximum percentile site discharge concentrations, average climatic conditions, and maximum mixing for the operational scenario.

Table 4-6: Run 2cii Results for Upper Bound Case Water Quality Predictions in Basin 6 and 11of Upper Marmion Reservoir for Operational Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Reservoir Baseline	Basin 6 (near discharge)	Basin 11 (near Raft Lake Dam)
		CCME CWQG	<u>PWQO</u>	MISA		Proportion (%)	
						0.01518	**0.00974**
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 8.3	6.5 – 8.3
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	+5-25	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							**-**
Calcium	mg/L	—	—	—	6.4	6.7	6.6
Chloride	mg/L	120	—	—	1.1	1.8	1.5
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.4	1.4
Potassium	mg/L	—	—	—	0.68	1.2	1.0
Sodium	mg/L	—	—	—	1.3	2.7	2.2
Sulphate	mg/L	—	—	—	1.6	4.9	3.7
Hardness	mg($CaCO_3$)/L	—	—	—	21	22	22
Cyanide (free)	mg/L	0.005	0.005	—	0.005	<u>**0.016**</u>	<u>**0.012**</u>
Cyanide (total)	mg/L	—	—	—	0.002	0.013	0.0093
Nutrients							**-**
Nitrate-N	mg/L	13	—	—	0.063	0.085	0.077
Ammonia-N	mg/L	—	—	—	0.023	0.251	0.17
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.0096	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							**-**
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0072	0.0071
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000039	0.000038
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00019
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	**0.0028**	**0.0022**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.0014	0.0010
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.0011	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.018	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000085	0.000085
Tin	mg/L	—	—	—	0.00071	0.0011	0.00099
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0023	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0053	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

<u>Underlined</u> values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.

[a] See Appendix 2.IV for the list of all parameters, guidelines and notes.

[b] Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of upper bound case site discharge to Upper Marmion Reservoir for the operational scenario are lower than the MISA guidelines. In general, the predicted results are marginally greater than average Upper Marmion Reservoir baseline concentrations. Results are summarized with respect to CCME CWQG and PWQO guidelines and average Upper Marmion Reservoir baseline water quality as follows:

- The concentrations of free cyanide ranged from 0.0052 to 0.016 mg/L, and are greater than the CCME CWQG and PWQO guidelines (both values of 0.005 mg/L) for basins 5 to 11 within Upper Marmion Reservoir.
  - Predicted free cyanide concentrations are also greater than the baseline concentration of free cyanide (0.005 mg/l).
- The concentration of copper is greater than the CCME CWQG (0.002 mg/L) for the maximum predicted water quality (0.0028 mg/L) within Upper Marmion Reservoir, occurring in Basin 6.
  - Predicted concentrations of copper also exceeds the CCME CWQG in Basins 5, 6, 8, 9 and 11 (all values of 0.0022 mg/L).

4.4 Additional Inputs

The following sections discuss the input data, calculations and results for the modelling of accommodation camp discharge (i.e., camp sewage), total suspended solids (TSS) and air deposition in Upper Marmion Reservoir. The predicted concentrations of nutrients (from camp discharge) and solid phase metals (from TSS and air deposition) during operations were calculated and added to the dissolved species for the predicted upper bound case concentrations, model Run 2cii (Table 4-6).

4.4.1 Accommodation Camp Discharge

The following section describes the calculations for predicted nutrient concentrations that were used to assess the effects of the mixing of accommodation camp discharge in Upper Marmion Reservoir from the Project during operations.

The phosphorus treatment capacity of the Kodiak STP Bionest system provided in the vendor quotation (Kodiak, 2012), assuming a concentration of total phosphorus of 6 – 10 mg/L in sewage feed to treatment, will result in a total phosphorus discharge concentration of 4 – 8 mg/L (by correspondence, February 5, 2013). The predicted concentration of total phosphorus in Sawbill Bay using an input of 8 mg/L is 0.2 mg/L, which exceeds the PWQO guideline of 0.02 mg/L by one order of magnitude. Therefore a phosphorus removal system will be required to further reduce total phosphorus in discharge to Sawbill Bay. This additional treatment system is capable of reducing total phosphorus to 1 mg/L (assuming 6 – 10 mg/L total phosphorus input) (by correspondence, February 5, 2013).

Water quality and flow rate inputs from accommodation camp discharge were conservatively assigned values based on the sewage treatment plant (STP) design criteria (Kodiak, 2012) as follows:

- Design flow of 300 m^3/day (assuming 250 L/d per person for 1200 people).

- Discharge chemistry as follows: 10 mg/L nitrate, 10 mg/L ammonia, 15 mg/L carbonaceous biochemical oxygen demand (cBOD), and 15 mg/L TSS.
- Discharge total phosphorus of 1 mg/L (assuming employment of phosphorus removal system in addition to the Kodiak Bionest, see below).

The following calculations were carried out based on the principles of steady state mixing in Basin 7c and Basin 11 of Upper Marmion Reservoir (see Figure 1-6). This assumes accommodation camp discharge will be discharged off of a peninsula at the north end of Basin 7c (see Figure 1-2).

$$C_{IN(t)} \times Q_{IN(t)} = M_{IN(t)} \quad \text{Equation 6}$$

$$M_{IN(t)} / Q_{OUT(t)} = C_{OUT(t)} \quad \text{Equation 7}$$

Where:

$C_{IN(t)}$ = outflow chemistry (mg/L);
$Q_{IN(t)}$ = sewage discharge rate into Upper Marmion Reservoir (L/d);
$M_{IN(t)}$ = contaminant mass into Upper Marmion Reservoir (mg);
$Q_{OUT(t)}$ = SW-01 flow rate (L/d) (Mix 1) and Raft Lake Dam discharge rate (L/d) (Mix 2); and
$C_{OUT(t)}$ = contaminant concentration at Raft Lake Dam (mg/L).

The total predicted nutrient concentrations due to the mixing of accommodation camp discharge in Sawbill Bay were calculated as follows:

[Total Nutrients] = [Predicted Accommodation Camp Sewage] + [Predicted Run 2cii Nutrients - Basin 7c]
Equation 8

It should be noted that the predicted nutrient concentrations for Run 2cii include nitrate and ammonia site water quality inputs to Upper Marmion Basin produced as a result of explosives usage and cyanide treatment. Therefore, the predicted concentrations (C_{OUT}) provided in this section estimate the net nitrate and ammonia predicted concentrations for operations.

Table 4-7 presents the predicted nutrient mixing concentrations calculated in Equation 7, using average input values identified above and an average flow rate of water out of basin 7c of 1.28 x 10^7 L/d. This flow rate was conservatively assigned a 7-day 1 in 20 year low flow for the hydrology monitoring station SW-01, (Hydrology TSD). Table 4-7 also presents the sum of average baseline nutrient concentrations and predicted sewage input concentrations in Sawbill Bay (from Equation 8).

Table 4-7: Predicted Mixing and Predicted Total Nutrient Concentrations for Mixing In Sawbill Bay

Parameter	Units	Receiving WQ Guidelines[a]			Basin 7c		
		ODWS [b]	***CCME CWQG***	PWQO	**Predicted Mixing**	**Run 2cii**	**Predicted + Run 2cii**
Nitrate	mg/L	10	13	—	0.23	0.086	0.32
Ammonia	mg/L	—	—	—	0.23	0.020	0.26
Unionized Ammonia[c]	mg/L	—	0.02	0.02	0.00016	0.00010	0.00026
Phosphorus	mg/L	—	—	0.02	0.02	0.009	0.03
cBOD	mg/L	—	—	—	0.35	—	0.35
TSS	mg/L	—	+5-25	—	0.35	2.24	2.59

Notes:
(a) See Appendix 2.IV for detailed notes for water quality guidelines.
(b) Ontario Drinking Water Standards
(c) Unionized ammonia calculated as f x [NH_3 + NH_4]: f = 1/(10pKa-pH +1), where f is the fraction of NH_3; pKa = 0.09018 + 2729.92/T; T = ambient water temperature in Kelvin (K = °C + 273.16).
"—" = Site water quality data was not modelled for this parameter.

The concentration of total phosphorus (0.03 mg/L) calculated from baseline + predicted mixing concentrations in Sawbill Bay is greater than the PWQO guidelines (0.02 mg/L). Phosphorus levels will be further managed by using low phosphorus soaps and detergents. All other parameters have predicted total concentrations below the ODWS, CCME CWQG and PWQO guidelines.

The total predicted nutrient concentrations at Raft Lake Dam due to the mixing of accommodation camp discharge in Upper Marmion Reservoir were calculated as follows:

[Total Nutrients] = [Predicted Accommodation Camp Sewage] + [Predicted Run 2cii Nutrients - Basin 11]
Equation 9

Table 4-8 presents the predicted nutrient concentrations calculated in Equation 7, using average input values identified above and an average Raft Lake Dam discharge rate of 8.64 x 10^8 L/d. Table 4-8 also presents the sum of average baseline nutrient concentrations and predicted sewage input concentrations at Raft Lake Dam (from Equation 9).

Table 4-8: Predicted Mixing and Predicted Total Nutrient Concentrations for Mixing at Raft Lake Dam

Parameter	Unit	Receiving WQ Guidelines[a]			Predicted Output	Basin 11	Basin 11
		ODWS[b]	*CCME CWQG*	PWQO	Predicted Mixing	Run 2cii	Predicted + Run 2cii
Nitrate	mg/L	10	13	—	0.0035	0.068	0.07
Ammonia	mg/L	—	—	—	0.0035	0.020	0.02
Unionized Ammonia[c]	mg/L	—	0.02	0.02	0.0000023	0.00008	0.00008
Phosphorus	mg/L	—	—	0.02	0.0003	0.011	0.01
cBOD	mg/L	—	—	—	0.0052	—	0.01
TSS	mg/L	—	+5-25	—	0.0052	2.17	2.18

Notes:
(a) See Appendix 2.IV for detailed notes for water quality guidelines.
(b) Ontario Drinking Water Standards
(c) Unionized ammonia calculated as ƒ x [NH_3 + NH_4]: ƒ = 1/(10pKa-pH +1), where ƒ is the fraction of NH_3; pKa = 0.09018 + 2729.92/T; T = ambient water temperature in Kelvin (K = °C + 273.16).
"—" = Site water quality data was not modelled for this parameter.

The predicted total nutrient concentrations at Basin 11 (Raft Lake Dam) are below the ODWS, CCME CWQG and PWQO guidelines. In general, the results from the mixing calculations indicate that the dilution of accommodation camp discharge in Upper Marmion Reservoir will result in Raft Lake Dam nutrient concentrations that are below baseline concentrations and within the receiving water quality guidelines.

4.4.2 Total Suspended Solids and Air Deposition

4.4.2.1 Total Suspended Solids

The effects of the mixing of TSS in Upper Marmion Reservoir produced from the Project during the processing of ore were assessed based on predicted concentrations of solid phase metals. Appendix 4.I presents the input data employed in calculations below. Input data was assigned as follows:

- Solid phase chemistry: an average concentration for solid phase metals was calculated from static geochemical test results for waste rock and tailings (Appendix 2.III in the Geochemistry, Geology and Soils TSD).
- TSS: the maximum discharge concentration for TSS of 0.0149 g/L was assigned based on a maximum permitted MISA TSS discharge concentration of 0.015 g/L (O.Reg. 560/94).
- Basin Mixing Proportions (Section 4.3 for basins presented in Figure 1-6).

The mixing of total suspended solids at the maximum MISA discharge concentration was calculated as follows:

$$[\text{Solid Phase Metal}] = [TSS_{max}] \times [Me_{WR+T}] \times \text{Basin Mixing Proportion}_{avg} \qquad \text{Equation 10}$$

Where:

$[TSS_{max}]$ = maximum permitted TSS discharge concentration, as per MISA regulation (0.0149 g/L);
$[Me_{WR+T}]$ = the average concentration of waste rock and tailings solid phase chemistry (ug/g);

Basin Mixing Proportion$_{avg}$ as described in Section 4.3 for basins presented in Figure 1-6; and
[Dissolved Metal] = concentration of dissolved metals (mg/L) taken from the predicted mixing results for Run 2cii (operational upper bound case, Table 4-6).

4.4.2.2 Air Deposition

The effects of the mixing of dust and air emissions from Project operations in Upper Marmion Reservoir were assessed based on predicted concentrations of metals emitted during the processing of ore. Predictions focused on contributions from atmospheric sources to water (wet deposition).

Appendix 4.II presents the input data employed in calculations below. Input data was assigned as follows:

- The wet deposition rates ($Q_{IN(t)}$) were predicted using particulate deposition modelling discussed in the Atmospheric Environment TSD.
  - In brief, the modelled deposition rates represent a maximum scenario from any phase of the Project (i.e., construction, operations, closure and post-closure).
- The effective deposition area ($A_{eff(t)}$) was assumed to be 1/4 of the surface area of the deposition basin (basin 11), equal to 1.15×10^7 m^2 (Hydrology TSD).
- The average annual discharge rate at Raft Lake Dam, equal to 9.46×10^{11} L/y.

The mixing of the wet deposition of metals in the Seine River (basin 11, see Figure 1-6) at the Raft Lake Dam was calculated as followed:

$$Q_{IN(t)} \times A_{eff(t)} = M_{IN(t)} \quad \text{Equation 11}$$

$$M_{IN(t)} / Q_{OUT(t)} = C_{OUT(t)} \quad \text{Equation 12}$$

Where:

$A_{eff(t)}$ = effective deposition area (m^2);
$Q_{IN(t)}$ = annual wet deposition rate to Seine River at the Raft Lake Dam (mg/m^2/y);
$M_{IN(t)}$ = contaminant mass in (mg);
$Q_{OUT(t)}$ = Raft Lake Dam discharge rate (L/y); and
$C_{OUT(t)}$ = contaminant concentration at Raft Lake Dam (mg/L).

4.4.2.3 Predicted TSS and Air Deposition Mixing Concentrations

The total predicted metal concentrations due to the mixing of average solid phase metals from waste rock and tailings, and the wet deposition of metals in Marmion Reservoir are calculated by:

[Total Metals] = [Site Solid Phase Metals] + [Wet Deposition Metals] + [Run 2cii Dissolved Metals] Equation 13

Table 4-8 presents the predicted TSS and air deposition metal concentrations calculated in Equations 10 and 11 and 12, using input values identified above and an average Raft Lake Dam discharge rate of 8.64×10^8 L/d. Table 4-8 also presents the sum of average baseline concentrations and predicted input concentrations at Raft Lake Dam (from Equation 13).

Table 4-8: Predicted Mixing Concentration of Total Suspended Solids and Air Deposition in Upper Marmion Reservoir

Parameter	Unit	Receiving WQ Guidelines			Marmion Reservoir Baseline	Basin 6 (near discharge)	Basin 11 (near Raft Lake Dam)	Basin 6 (near discharge)	Basin 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Mixing Proportion (%)		Mixing Proportion (%)	
						0.01518	0.00974	0.01518	0.00974
					Measured	Predicted Upper Bound Case - Run 2cii		Predicted - TSS and Air Deposition + Run 2cii	
Metals					**Dissolved Metals**			**Total Metals**	
Aluminum	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.031	0.03	0.031	0.030
Antimony	mg/L	—	0.02	—	0.00078	-	-	-	-
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0072	0.0071	0.0072	0.0071
Beryllium	mg/L	—	0.011-1.1	—	0.00028	-	-	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-	-	-
Boron	mg/L	1.5	0.2	—	0.014	-	-	-	-
Cadmium	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000039	0.000038	0.000039	0.000038
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00019	0.00020	0.00019
Copper	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	**0.0028**	**0.0022**	**0.0028**	**0.0022**
Iron	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24
Lead	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	-	-	-	-
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.0014	0.0010	0.0014	0.0010
Nickel	mg/L	0.025-0.15	0.025	1	0.00099	0.0011	0.0011	0.0011	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.00051	0.0005	0.00051	0.00050
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.018	0.016	0.018	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000085	0.000085	0.000085	0.000085
Tin	mg/L	—	—	—	0.00071	0.0011	0.00099	0.0011	0.00099
Titanium	mg/L	—	—	—	0.0012	-	-	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-	-	-
Uranium	mg/L	—	0.005	—	0.0022	0.0023	0.0023	0.0023	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0053	0.0052	0.0053	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-	-	-

Notes:
Bold values exceed CCME CWQG. Underlined values exceed PWQO guidelines.
N/R - Parameter was not reported in source data.
[a] Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life.
[b] Provincial Water Quality Objectives.
[c] Municipal/Industrial Strategy for Abatement

4.4.3 Summary of Mixing of Additional Inputs

In summary, the prediction of the mixing of additional inputs in Upper Marmion Reservoir indicates that the dilution of TSS, air deposition in Upper Marmion Reservoir will not result in measurable increases relative to the dissolved water quality prediction values. Camp discharge has some potential to increase nutrient concentrations as evaluated within the EIS/EA document.

5.0 WATER QUALITY MODELLING FOR UPPER MARMION RESERVOIR – PIT LAKE DISCHARGE – POST-CLOSURE

This section predicts and assesses the effects of discharge from the pit lake once filled. Under the current project description, the overflow from the pit lake will discharge to the southern end of Sawbill Bay (Basin 6). The discharge location is expected to be along the shoreline near the proposed Mine effluent discharge.

5.1 Input Data for Pit Lake Discharge (Post-closure)

The discharge rates for the pit lake (once completely filled) were predicted for a range of wet and dry conditions (Site Water Quality TSD). The results for the monthly average overflow rate predictions are provided in Table 5-1.

Table 5-1 shows that there is little or no discharge expected under dry conditions or during some of the months. The discharge rate is expected to increase during extremely wet conditions and during the spring freshette.

Monthly average overflow rates were estimated for the 28-year simulation period by using the annual return values on Table 3-3 to select the appropriate flows from Table 5-1. To provide a continuous record and more reasonable representation, values were interpolated based on the return period (e.g., for 1987 which has a precipitation return period of 13.5 years, the intake flows were interpolated between the 10 year and 25 year values in Table 5-1). The predicted daily mean intake and discharge flows for the 28-year simulation are provided in Figure 5-1.

Since the model uses a daily time step, the monthly intake and discharge flows were converted to daily values. To avoid numerical instabilities in the model, the monthly values were linearly transitioned over a one week period between months.

Table 5-1: Estimated Monthly Pit Lake Discharge Flows for Return Period Conditions for Post-closure Phase

Return Period[(a)]		Estimated Pit Lake Drainage into South End of Sawbill Bay (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	6.0	1.0	11.0	22.0	0.0	0.0	0.0	0.0	14.0	36.0	32.0	15.0
	50	6.0	1.0	12.0	34.0	0.0	0.0	0.0	0.0	21.0	41.0	34.0	17.0
	25	7.0	1.0	13.0	48.0	0.0	0.0	0.0	0.0	29.0	47.0	37.0	18.0
	10	8.0	1.0	14.0	68.0	0.0	0.0	0.0	0.0	42.0	56.0	41.0	20.0
Average[(b)]		10.0	1.0	19.0	126.0	0.0	0.0	0.0	16.0	78.0	82.0	52.0	27.0
Wet return period	10	12.0	1.0	23.0	185.0	0.0	49.0	11.0	54.0	114.0	108.0	64.0	33.0
	25	13.0	1.0	25.0	207.0	0.0	64.0	25.0	68.0	128.0	118.0	68.0	35.0
	50	14.0	1.0	26.0	222.0	0.0	74.0	34.0	77.0	137.0	124.0	71.0	37.0
	100	14.0	1.0	27.0	235.0	6.0	83.0	42.0	85.0	145.0	130.0	74.0	38.0

Notes:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

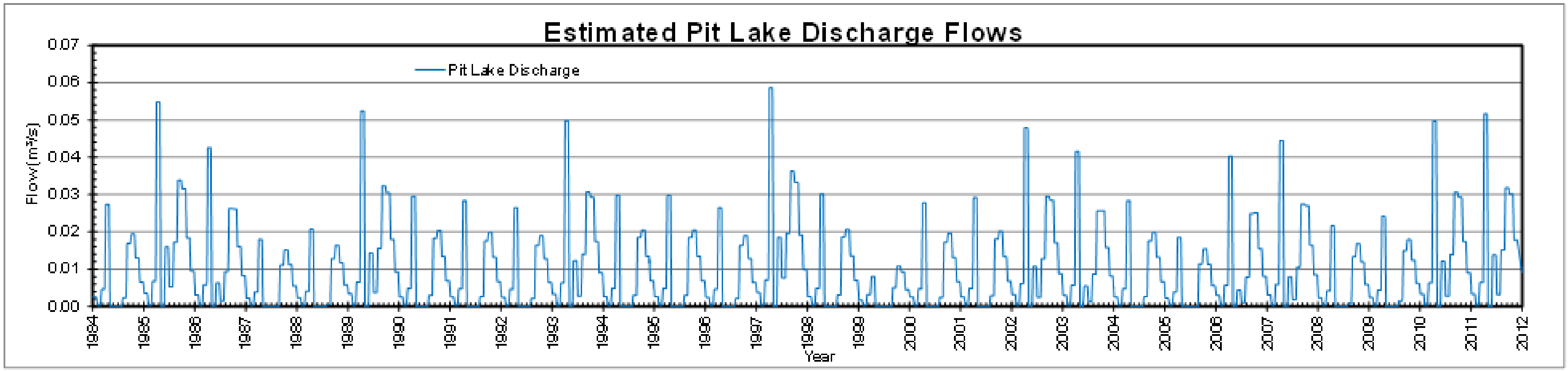

Figure 5-1: Estimated Pit Lake Discharge for Post-closure

5.2 Effluent Mixing for Marmion Reservoir during Post-closure

In order to develop an estimate of expected mixing proportions for a given discharge concentration, a particle tracking type of evaluation was used whereby, for purposes of this assessment, the effluent was set at a constant value of 100 particles per unit volume. When examining the results presented in this section, a predicted particle concentration can be interpreted as being equivalent to the percentage of the plume concentration (e.g., a predicted concentration of 1 particle per unit volume is representative of 1% of the initial effluent concentration).

Figure 5-2 shows the predicted proportions (in%) for the effluent discharge in the southern end of Sawbill Bay (Basin 6), central Sawbill Bay (Basin 7B) and at the Raft Lake Dam (Basin 11). These results for all the model basins are summarized in Table 5-2.

By examining Figure 5-2 and Table 5-2 the following observations are made:

- The predicted mixing proportion (average of 0.042%) at the Raft Lake Dam (Figure 5-2) is slightly lower to the concentration (average of 0.062% mixed) in the southern end of Sawbill Bay (Basin 6). The pattern at the outflow lags behind by approximately one month.
- The predicted mixing proportions in northern Sawbill Bay (Figure 5-2) gradually increase over time and reach a maximum annual average of approximately 0.015% at the end of the 28-year period.
- As expected, when the pit lake discharge is released into the south end of Sawbill Bay (Basin 6), an impact on the water quality at Lynxhead Bay is not expected.
- As expected, the maximum proportion occurs in the southern end of Sawbill Bay (Basin 6) where the pit lake overflow is located effluent is discharged (0.56%).

Table 5-2 also provides a statistical summary of the frequency at which the predicted concentrations occur in the model basins. These are provided in more detail graphically for the south end of Sawbill Bay, central Sawbill Bay and at the Raft Lake Dam on Figure 5-3.

From Table 5-2, it is expected that the peak values occur infrequently (e.g., the peak mixing of 0.56% occurs less than 1% of the time). Near the discharge at the south end of Sawbill Bay (Basin 6), the effluent mixing proportion is expected to be below 0.25% more than 95% of the time.

Table 5-2: Summary of Effluent Mixing Proportions (%) in Upper Marmion Reservoir Model Compartments for Post-closure Pit Lake Outflow

Model Basin[(a)] Location	1 to 4[(b)] Upstream of Discharge	5	6 South End of Sawbill Bay	7A Southern Sawbill Bay	7B Central Sawbill Bay	7C Northern Sawbill Bay	8	9	10	11 Outflow
Minimum (%)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average (%)	0.000	0.044	0.062	0.032	0.011	0.010	0.045	0.044	0.072	0.042
Maximum (%)	0.000	0.374	0.560	0.128	0.018	0.015	0.365	0.352	0.101	0.337
Percentiles										
1.0%	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.001	0.000

Table 5-2: Summary of Effluent Mixing Proportions (%) in Upper Marmion Reservoir Model Compartments for Post-closure Pit Lake Outflow (Continued)

Model Basin[a] Location	1 to 4[b] Upstream of Discharge	5	6 South End of Sawbill Bay	7A Southern Sawbill Bay	7B Central Sawbill Bay	7C Northern Sawbill Bay	8	9	10	11 Outflow
2.5%	0.000	0.000	0.001	0.010	0.002	0.002	0.000	0.000	0.019	0.000
5.0%	0.000	0.001	0.001	0.012	0.005	0.004	0.001	0.001	0.048	0.001
10.0%	0.000	0.001	0.001	0.014	0.006	0.006	0.001	0.001	0.054	0.001
50.0%	0.000	0.021	0.028	0.029	0.011	0.010	0.022	0.022	0.073	0.021
90.0%	0.000	0.120	0.166	0.056	0.015	0.013	0.123	0.118	0.090	0.113
95.0%	0.000	0.172	0.252	0.066	0.015	0.014	0.174	0.166	0.094	0.158
97.5%	0.000	0.245	0.349	0.075	0.016	0.014	0.238	0.221	0.094	0.209
99.0%	0.000	0.294	0.422	0.090	0.016	0.015	0.288	0.275	0.095	0.260

Notes:

(a) Location of model basins shown on Figure 1-6.

(b) Model basins upstream of discharge point were not predicted to be influenced by the effluent.

(c) Effluent concentrations are presented as a percentage of the effluent concentration. Calculations are based on a constant effluent concentration of 100 mg/L for a non-specific conservative parameter.

5.3 Water Quality Prediction for Upper Marmion Reservoir during Post-closure

Table 5-3 presents a summary of the average and maximum mixing proportions (Section 5-2) that were applied to the mixing of pit lake discharge inputs in each Marmion Reservoir basin (see Figure 1-6) for the post-closure scenario.

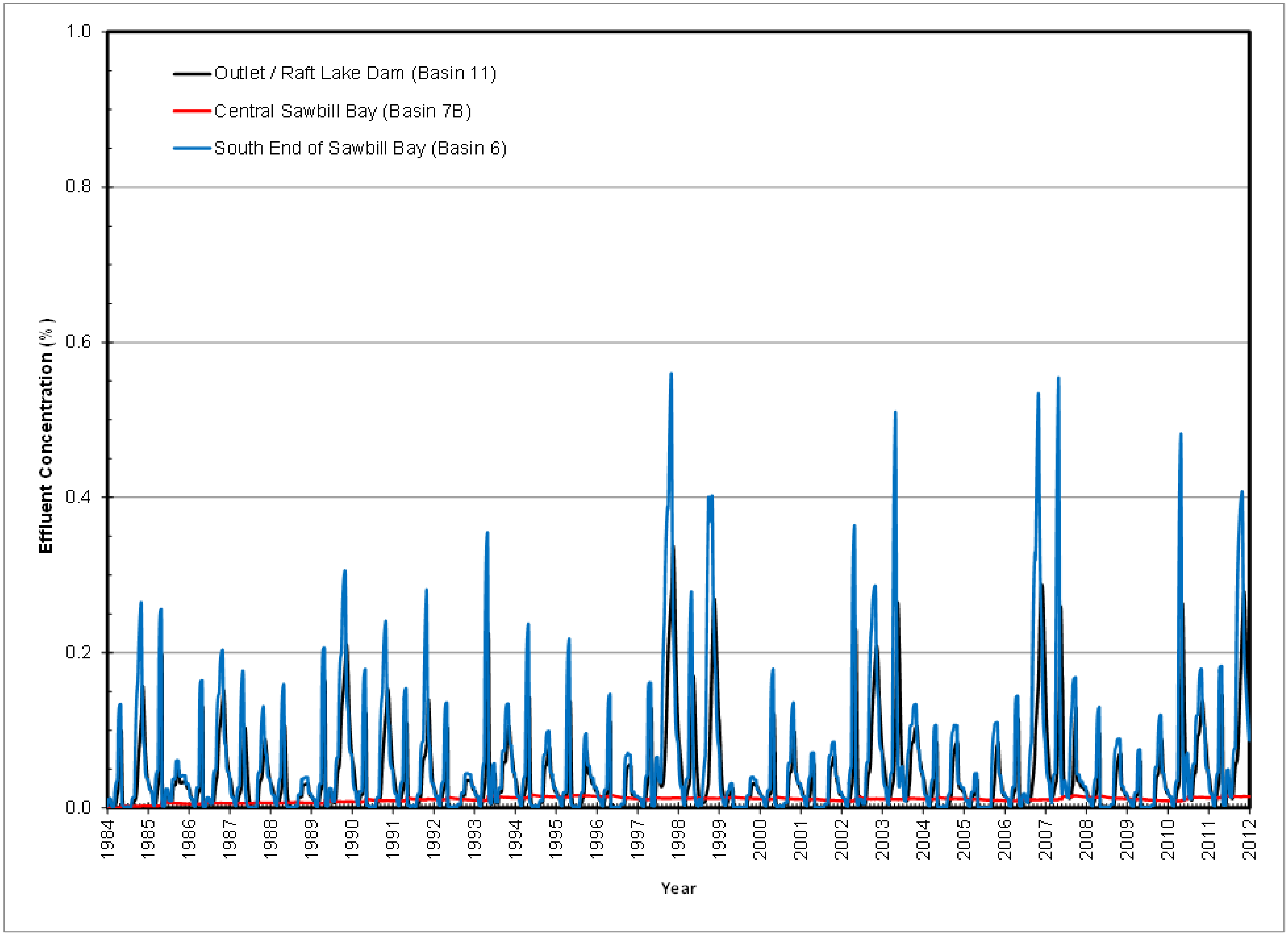

Figure 5-2 Predicted Pit Lake Effluent Concentrations in Upper Marmion Reservoir for Post-closure

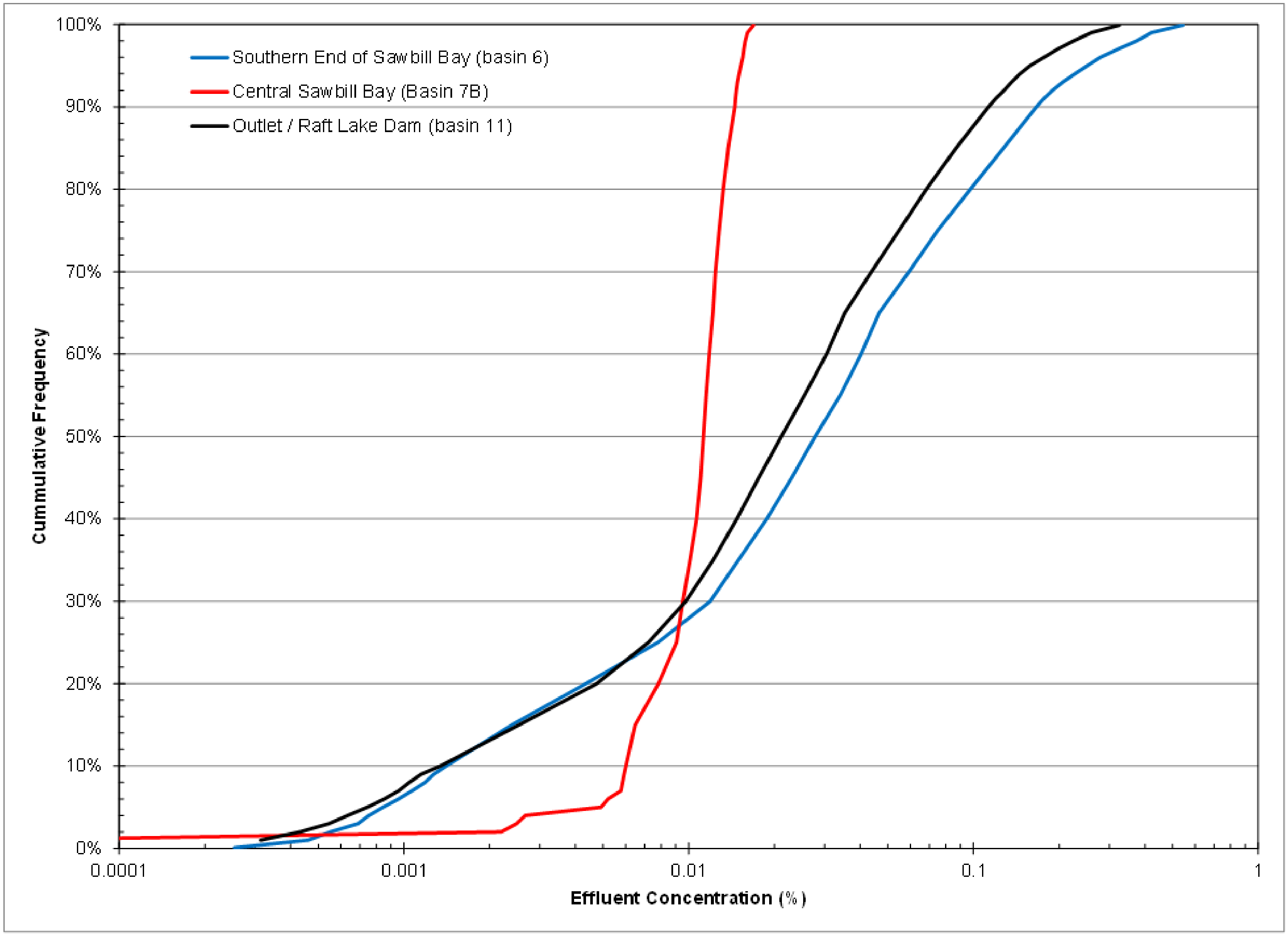

Figure 5-3 Frequencies of Predicted Pit Lake Discharge Concentrations in Upper Marmion Reservoir for Post-closure

Table 5-3: Average and Maximum Mixing Proportions of Pit Lake discharge in zones of Upper Marmion Reservoir during Post-closure

Identifier	Zone	1 to 4[2]	5	6	7A	7B	7C	8	9	10	11
i	Average	0.000	0.044	0.062	0.032	0.011	0.010	0.045	0.044	0.072	0.042
ii	Maximum	0.000	0.374	0.560	0.128	0.018	0.015	0.365	0.352	0.101	0.337

The following sections present the results of water quality prediction modelling for the post-closure scenario. See Appendix 2.III for all water quality prediction results. Results in the below sections will be discussed for Basin 6, which represents the basin within Upper Marmion Reservoir that will have the highest proportion of effluent following mixing and Basin 11 which represents the predicted outflow from the Raft Lake Dam.

5.3.1 Scenario 1 – Average Case / Average Mixing

Results for average post-closure water quality predictions, identified as Run 2ki in Appendix 1.I, are presented in Table 5-4. Run 2ki applied average baseline Marmion Reservoir water quality, pit lake discharge for the average case, and average mixing for the post-closure scenario.

Table 5-4: Run 2ki Results for Average Case Pit Lake Discharge Water Quality Predictions in Basin 6 of Upper Marmion Reservoir for Post-closure Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Basin – 6 (near discharge)	Basin – 11 (near Raft Lake Dam)
		CCME CWQG	PWQO	MISA		Proportion (%)	
						0.00062	0.00042
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 7.1	6.5 – 7.1
DOC	% wt	—	—	—	8.8	-	-
TOC	% wt	—	—	—	9.3	-	-
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	-	-
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	+5-25	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.4	6.4
Chloride	mg/L	120	—	—	1.1	1.05	1.05
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	-	-
Cyanide (total)	mg/L	—	—	—	0.002	-	-
Nutrients							
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.00014	0.00012
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.0008
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-
Tin	mg/L	—	—	—	0.00071	-	-
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.

(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.

(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of average case site discharge to Upper Marmion Reservoir for the post-closure scenario are lower than the CCME CWQG, PWQO and MISA guidelines. Predicted results are marginally greater than average Upper Marmion Reservoir baseline concentrations.

5.3.2 Scenario 2 – Upper Bound Case / Maximum Mixing

Results for average post-closure water quality predictions, identified as Run 2lii in Appendix 2.I, are presented in Table 5-5. Run 2lii applied average baseline Upper Marmion Reservoir water quality, pit lake discharge for the upper bound case, and maximum mixing for the post-closure scenario.

Table 5-5: Run 2lii Results for Upper Bound Case Pit Lake Discharge Water Quality Predictions in Basin 6 of Upper Marmion Reservoir for Post-closure Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Reservoir Baseline	Basin – 6 (near discharge)	Basin – 11 (near Raft Lake Dam)
		CCME CWQG	<u>PWQO</u>	MISA		Proportion (%)	
						0.00560	0.00337
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 7.0	6.5 – 7.0
DOC	% wt	—	—	—	8.8	-	-
TOC	% wt	—	—	—	9.3	-	-
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	-	-
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	+5-25	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	-	-
Cyanide (total)	mg/L	—	—	—	0.002	-	-
Nutrients							
Nitrate	mg/L	13	—	—	0.063	0.063	0.063
Ammonia	mg/L	—	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.00102	0.00064
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00049	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-
Tin	mg/L	—	—	—	0.00071	-	-
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:
<u>Underlined</u> values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.
"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.
(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.
(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of upper bound case site discharge to Upper Marmion Reservoir for the post-closure scenario are lower than the CCME CWQG, PWQO and MISA guidelines. Predicted results are marginally greater than average Upper Marmion Reservoir baseline concentrations for some parameters.

6.0 WATER QUALITY MODELLING FOR UPPER MARMION RESERVOIR – FACILITY RUNOFF – POST-CLOSURE

6.1 Input Data for Facility Runoff (Post-closure)

The total runoff from the facility was predicted for a range of wet and dry conditions (Site Water Quality TSD). The results for the monthly total runoff rate predictions are provided in Table 6-1.

Table 6-1 shows that the total runoff is lowest during the winter (February) and the highest during the spring freshette (April). Table 6-1 also shows that even during the driest years, there is still runoff from the site.

Monthly average overflow rates were estimated for the 28-year simulation period by using the annual return values on Table 3-3 to select the appropriate flows from Table 6-1. To provide a continuous record and more reasonable representation, values were interpolated based on the return period (e.g., for 1987 which has a precipitation return period of 13.5 years, the intake flows were interpolated between the 10-year and 25-year values in Table 4-1). The predicted daily mean intake and discharge flows for the 28-year simulation are provided in Figure 6-1.

Since the model uses a daily time step, the monthly intake and discharge flows were converted to daily values. To avoid numerical instabilities in the model, the monthly values were linearly transitioned over a one week period between months.

Table 6-1: Estimated Monthly Total Facility Runoff for Return Period Conditions for Post-closure Phase

Return Period[a]		Estimated Total Runoff from Facility (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	34	1	66	740	400	413	286	478	637	378	212	98
	50	37	1	72	821	438	453	320	519	681	403	228	107
	25	41	1	79	913	481	499	359	566	732	433	246	117
	10	46	1	90	1054	546	569	419	638	810	477	274	132
Average[b]		62	1	120	1451	730	765	588	842	1029	603	352	175
Wet return period	10	78	1	151	1856	918	966	760	1049	1253	732	432	219
	25	84	1	162	2006	988	1040	824	1126	1335	779	461	235
	50	88	1	170	2106	1034	1090	867	1177	1391	811	481	246
	100	91	1	177	2196	1076	1134	904	1223	1440	840	499	256

Notes:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

The total site runoff (post-closure) is based on runoff from nine areas and can drain into several of the modelled basins. Table 6-2 provides a summary of the individual areas and the percentage of each area that drains into one of five modelled basins. These preliminary runoff rates are based on information provided in the Site Water Quality TSD.

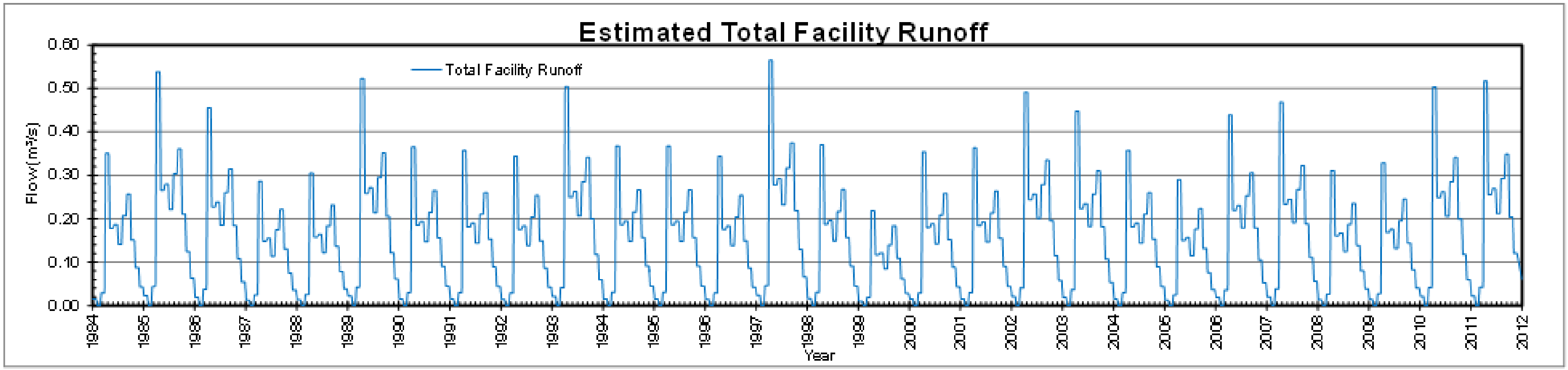

Figure 6-1: Estimated Facility Runoff Flow for Post-closure

Since the post-closure site drainage is not final, the total drainage percentages have been rounded off to the nearest 5%. Since the Marmion Reservoir model does not include Lizard Lake, any runoff that was expected to drain to Lizard Lake was assumed to drain into Trap Bay (Basin 1).

Table 6-2 shows that the majority of the site runoff is expected to drain into Sawbill Bay. Approximately 55% of the site runoff is expected to drain into northern Sawbill Bay (Basin 7C).

Table 6-2 Assumed Partitioning of Facility Runoff to Upper Marmion Reservoir Model Basins

Facility	Estimated Runoff Percentage to Model Basin				
	Lizard Lake	Lynxhead Bay 2	South End of Sawbill Bay 6	Northern Sawbill Bay 7C	Trap Bay 1
Open Pit	0.0	0.0	5.1	0.0	0.0
Waste Rock Stockpile	0.0	1.3	8.3	0.0	12.8
TMF	5.8	0.0	0.0	55.7	0.0
Detonator Storage Area	0.0	0.0	0.0	0.0	0.0
Emulsion Plant	0.0	0.0	0.0	0.2	0.0
Process Plant	0.0	0.0	4.2	0.0	0.0
Overburden	0.0	1.4	0.0	0.0	1.4
Low-Grade Ore Stockpile	0.0	1.8	0.1	0.0	0.0
ICP	0.0	0.0	1.7	0.0	0.0
Total	**5.8**	**4.6**	**19.5**	**55.9**	**14.2**
Rounded Values Used[1]	**0[2]**	**5**	**20**	**55**	**20[2]**

Notes:

Percentages rounded to nearest 5%.

Runoff into Lizard Lake was assumed to drain to Trap Bay (Lizard Lake is included in Upper Marmion Lake Model).

ICP – Intermediate Control Pond

6.2 Effluent Mixing for Marmion Reservoir During Post-closure

In order to develop an estimate of expected mixing proportions for a given runoff concentration, a particle tracking type of evaluation was used whereby, for purposes of this assessment, the runoff was set at a constant value of 100 particles per unit volume. When examining the results presented in this section, a predicted particle concentration can be interpreted as being equivalent to the percentage of the plume concentration (e.g., a predicted concentration of 1 particle per unit volume is representative of 1% of the initial effluent concentration).

Figure 6-2 shows the predicted proportions (in %) for the runoff discharge in the southern section of Sawbill Bay (Basin 6), central Sawbill Bay (Basin 7B) and at the Raft Lake Dam (Basin 11). These results for all the model basins are summarized in Table 6-3.

By examining Figure 6-2 and Table 6-3 the following observations are made:

- The highest percentages occur in the northern and central areas of Sawbill Bay. This was expected since Sawbill Bay has a long residence time (Table 3-4) and a large portion of the site drains into Sawbill Bay.

- The predicted mixing proportions in northern Sawbill Bay (Figure 6-2) gradually increase over the first 10 years and eventually reach a semi-stable value of approximately 7% for the rest of the 28-year period.
- The predicted mixing proportion (average of 0.535%) at the Raft Lake Dam (Figure 6-2) is slightly lower to the concentration (average of 0.620% mixed) in the southern end of Sawbill Bay (Basin 6). The pattern at the outflow lags behind by approximately one month.
- Since approximately 20% of the runoff drains into Trap Bay and an additional 5% drains into Lynxhead Bay, an average concentration of 0.167% is expected to occur in Lynxhead Bay.

Table 6-3 also provides a statistical summary of the frequency at which the predicted concentrations occur in the model basins. These are provided in more detail graphically for the south end of Sawbill Bay, central Sawbill Bay and at the Raft Lake Dam on Figure 6-3.

From Table 6-3, it is expected that the peak values occur infrequently (e.g., the peak mixing of 0.56% occurs less than 1% of the time). Near the discharge at the south end of Sawbill Bay (Basin 6), the effluent mixing proportion is expected to be below 0.25% more than 95% of the time.

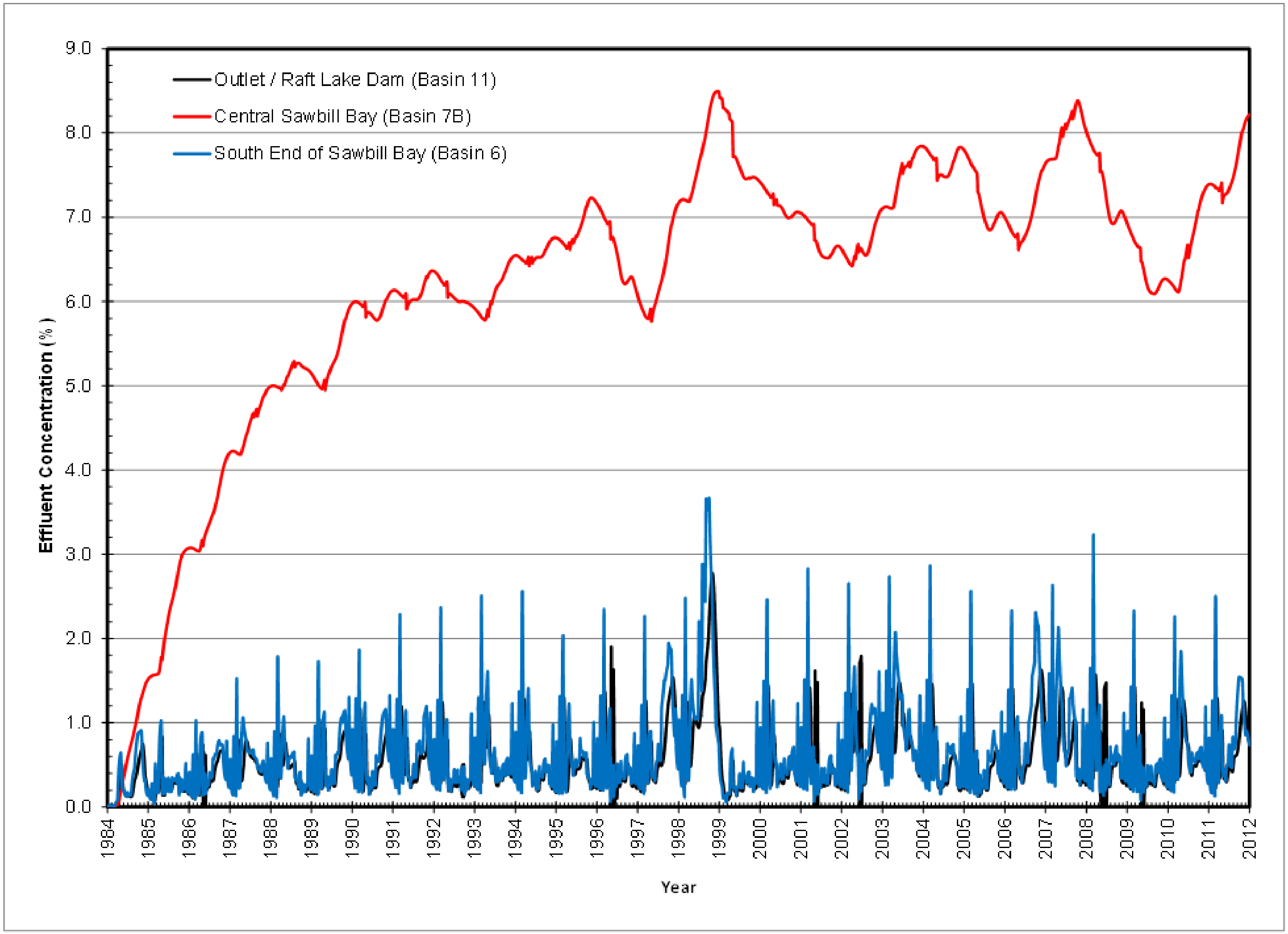

Figure 6-2: Predicted Facility Runoff Concentrations in Upper Marmion Reservoir for Post-closure

Table 6-3: Summary of Mixing Proportions (%) in Upper Marmion Reservoir Model Compartments for Post-closure Facility Runoff

Model Basin[a] Location	1 Trap Bay	2 Lynxhead Bay	3	4	5	6 South End of Sawbill Bay	7A Southern Sawbill Bay	7B Central Sawbill Bay	7C Northern Sawbill Bay	8	9	10	11 Outflow
Minimum (%)	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Average (%)	0.143	0.167	0.168	0.163	0.517	0.630	4.841	6.190	6.322	0.542	0.540	0.598	0.535
Maximum (%)	1.633	1.259	1.227	1.165	3.030	3.670	7.530	8.495	8.952	2.916	2.848	0.813	2.776
Percentiles													
1.0%	0.000	0.002	0.000	0.002	0.003	0.076	0.024	0.068	0.496	0.054	0.004	0.002	0.003
2.5%	0.000	0.003	0.000	0.004	0.096	0.140	0.509	0.997	1.576	0.120	0.118	0.094	0.118
5.0%	0.000	0.007	0.002	0.007	0.136	0.176	1.282	1.989	2.724	0.169	0.167	0.247	0.171
10.0%	0.000	0.016	0.008	0.016	0.177	0.222	2.815	3.931	4.169	0.209	0.212	0.341	0.217
50.0%	0.080	0.095	0.108	0.096	0.415	0.491	5.170	6.601	6.635	0.450	0.457	0.647	0.456
90.0%	0.360	0.411	0.410	0.400	0.970	1.203	6.452	7.736	7.902	0.992	1.006	0.747	0.992
95.0%	0.491	0.529	0.521	0.513	1.304	1.577	6.643	8.021	8.204	1.326	1.290	0.781	1.258
97.5%	0.683	0.702	0.688	0.665	1.589	1.968	6.935	8.226	8.535	1.528	1.469	0.794	1.429
99.0%	0.928	0.838	0.823	0.802	1.969	2.502	7.168	8.383	8.684	1.788	1.681	0.804	1.716

Notes:

Effluent concentrations are presented as a percentage of the effluent concentration a non-specific conservative parameter.

[a] Location of model basins shown on Figure 1-6.

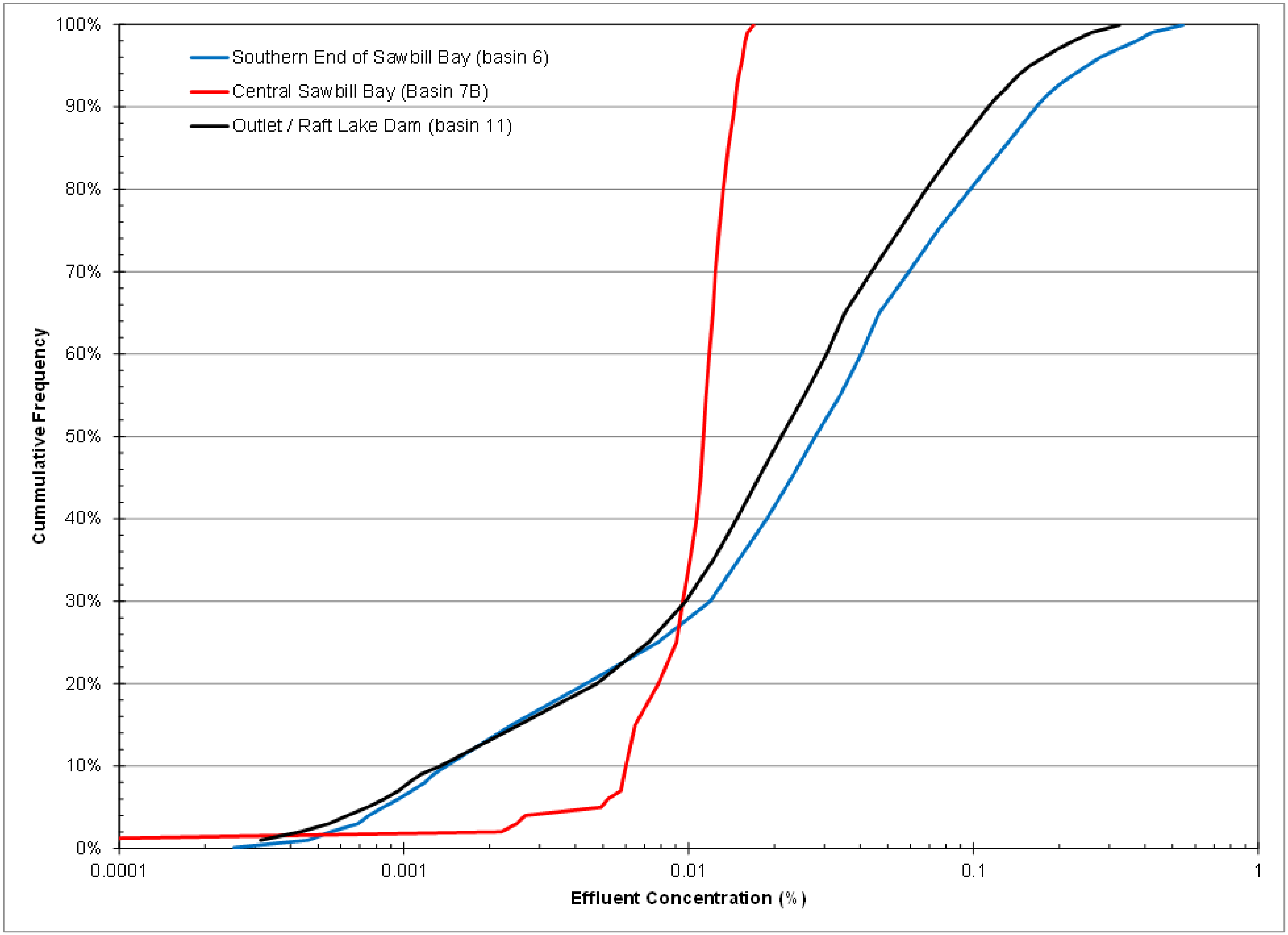

Figure 6-3: Frequencies of Predicted Facility Runoff Concentrations in Upper Marmion Reservoir for Post-closure

6.3 Water Quality Prediction for Upper Marmion Reservoir During Post-closure

Table 6-4 presents a summary of the average and maximum mixing proportions (Section 5-2) that were applied to the mixing of site runoff discharge to each Upper Marmion Reservoir basin (see Figure 1-6) for the post-closure scenario.

The following sections present the results of water quality prediction modelling. See Appendix 2.III for all water quality prediction results. Results in the below sections will be discussed for Basin 7C which represents the basin within Upper Marmion Reservoir that will receive the highest concentration of effluent for this scenario, and for Basin 11 which represents the predicted outflow from the Raft Lake Dam.

Table 6-4: Average and Maximum Mixing Proportions of Site Runoff Discharge in Zones of Upper Marmion Reservoir during Post-closure

Identifier	Zone	1 to 4[2]	5	6	7A	7B	7C	8	9	10	11
i	Average	0	0.00085	0.00044	0.00062	0.00032	0.00011	0.0001	0.00045	0.00044	0.00072
ii	Maximum	0	0.01022	0.00374	0.0056	0.00128	0.00018	0.00015	0.00365	0.00352	0.00101

6.3.1 Scenario 1 – Site Runoff – Post-closure

Results for site runoff post-closure water quality predictions, identified as Run 2mii in Appendix 2.I, are presented in Table 6-5. Run 2mii applied average baseline Upper Marmion Reservoir water quality, site runoff discharge, and maximum mixing for the post-closure scenario.

Table 6-5: Run 2mii Results for Site Runoff Discharge Water Quality Predictions in Basin 7C of Upper Marmion Reservoir for Post-closure Scenario

Parameter	Unit	Receiving WQ Guidelines[(a)]			Marmion Reservoir Baseline	Basin - 7C (near discharge)	Basin – 11 (near Raft Lake Dam)
						Proportion (%)	
		CCME CWQG	PWQO	MISA		0.08952	0.02776
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	—	6.5	6.5 – 6.8	6.5 – 6.8
DOC	% wt	—	—	—	8.8	-	-
TOC	% wt	—	—	—	9.3	-	-
Acidity	mg/L	—	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	-	-
Conductivity	µS/cm	—	—	—	49	-	-
Total Suspended Solids	mg/L	+5-25	—	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	—	53	-	-
Major Ions							
Calcium	mg/L	—	—	—	6.4	7.0	6.6
Chloride	mg/L	120	—	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	—	0.031	-	-
Magnesium	mg/L	—	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.7	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	23	22
Cyanide (free)	mg/L	0.005	0.005	—	0.005	-	-
Cyanide (total)	mg/L	—	—	—	0.002	-	-
Nutrients							
Nitrate	mg/L	13	—	—	0.063	0.063	0.063
Ammonia	mg/L	—	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00007
Phosphorus	mg/L	—	0.02	—	0.013	0.014	0.013
Dissolved Metals							
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.05	0.036
Antimony	mg/L	—	0.02	—	0.00078	0.00089	0.00081
Arsenic	mg/L	0.005	0.1	1	0.00049	0.0005	0.00049
Barium	mg/L	—	—	—	0.0071	-	-
Beryllium [(d)]	mg/L	—	0.011-1.1	—	0.00028	-	-
Bismuth	mg/L	—	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000037	0.000036
Chromium (total)	mg/L	0.009	0.009	—	0.00048	0.00052	0.0005
Cobalt	mg/L	—	0.0009	—	0.00017	0.0002	0.00018
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	**0.33**	0.27
Lead [(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.0003	0.0003
Manganese	mg/L	—	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00038	0.00037
Nickel [(d)]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0012	0.0012
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000088	0.000088
Strontium	mg/L	—	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000084	-	-
Tin	mg/L	—	—	—	0.00071	-	-
Titanium	mg/L	—	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	—	0.0045	-	-
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	-	-
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	—	0.0015	-	-

Notes:
Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.
"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.
(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.
(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of site runoff discharge to Upper Marmion Reservoir for the post-closure scenario are lower than the MISA guidelines. In general, the predicted results are marginally greater than average Upper Marmion Reservoir baseline concentrations for some parameters. Results are summarized with respect to CCME CWQG, PWQO guidelines and average Upper Marmion Reservoir baseline water quality as follows:

- Predicted concentrations of iron are greater than both the CCME CWQG and PWQO guidelines (both values are 0.3 mg/L) for the predicted water quality (ranging from 0.32 to 0.33 mg/L) within Upper Marmion Reservoir, occurring in Basins 7a, 7b and 7c.
  - Predicted iron concentrations (ranging from 0.25 to 0.33 mg/L in all basins) are marginally greater than baseline (0.24 mg/L) water quality.

7.0 WATER QUALITY MODELLING FOR LIZARD LAKE – OPERATIONS

7.1 Input Data (Operations)

TMF seepage rates for the operational phase are summarized in Table 3-5. TMF seepage rates were based on a preliminary seepage analysis (Site Water Quality TSD) and were assumed to drain to one of the three basins of Lizard Lake.

Although it is currently considered that the seepage collection system will be effective in directing seepage from the TMF back to the Ore Processing Facility for reuse in the process and/or discharge to Upper Marmion Reservoir if necessary, for the purposes of impact evaluation for Lizard Lake only, it was assumed that 10% of the seepage reporting to the collection system would have the potential to bypass the system.

This is a conservative assumption that will be confirmed during operations through monitoring. As the seepage collection system is an engineered system, mitigation through enhanced seepage capture could be implemented if necessary depending on the monitoring results.

7.2 Seepage Model – Lizard Lake Concentration Proportions

In order to develop an estimate of expected mixing proportions for a given TMF seepage concentration, a particle tracking type of evaluation was used whereby, for purposes of this assessment, the seepage was set at a constant value of 100 particles per unit volume. When examining the results presented in this section, a predicted particle concentration can be interpreted as being equivalent to the percentage of the plume concentration (e.g., a predicted concentration of 1 particle per unit volume is representative of 1% of the initial effluent concentration).

Figure 7-1 shows the predicted proportions (in%) for the TMF seepage in the three Lizard Lake basins. These results for all the model basins are summarized in Table 7-1.

By examining Figure 7-1 and Table 7-1 the following observations are made:

- The highest average seepage concentrations occur in southern Lizard Lake (0.41%).
- The highest predicted seepage concentrations occur in central Lizard Lake (0.95%) and northern Lizard Lake (0.81%). This is likely the result of the relatively low volumes of the northern and central basins when compared to the volume of the southern basin (see Table 3-6).
- Figure 7-1 shows that the predicted seepage concentrations in Lizard Lake are fairly consistent over the 30-year period and reach a semi-stable (only seasonal variations) within two years.

Table 7-1 also provides a statistical summary of the frequency at which the predicted concentrations occur in the model basins. These are provided in more detail graphically on Figure 7-2.

From Table 7-1, it is expected that the peak values occur seasonally and that the seepage concentration in central Lizard Lake expected to be below 0.71% more than 95% of the time.

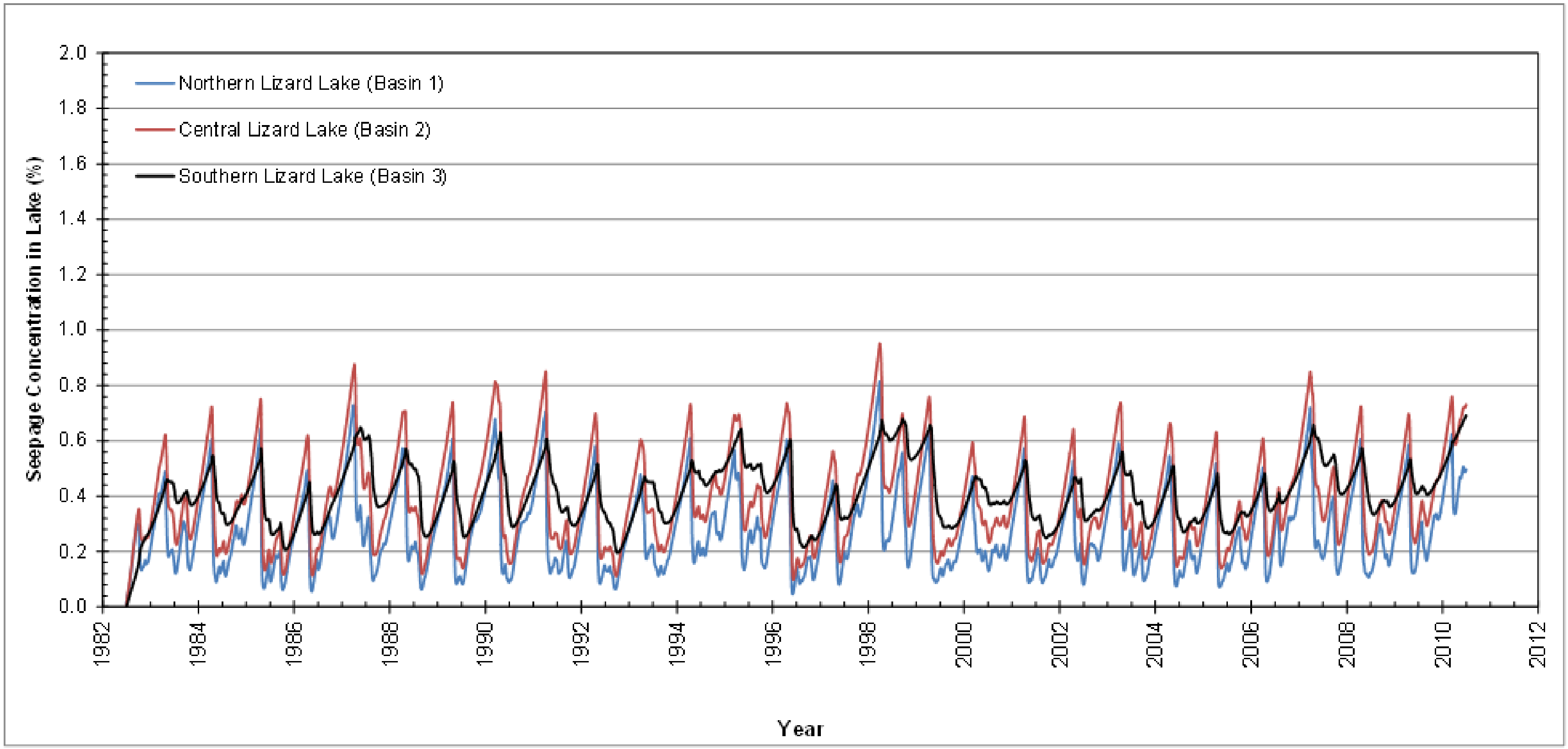

Figure 7-1: Predicted TMF Seepage Concentrations in Lizard Lake during Operations

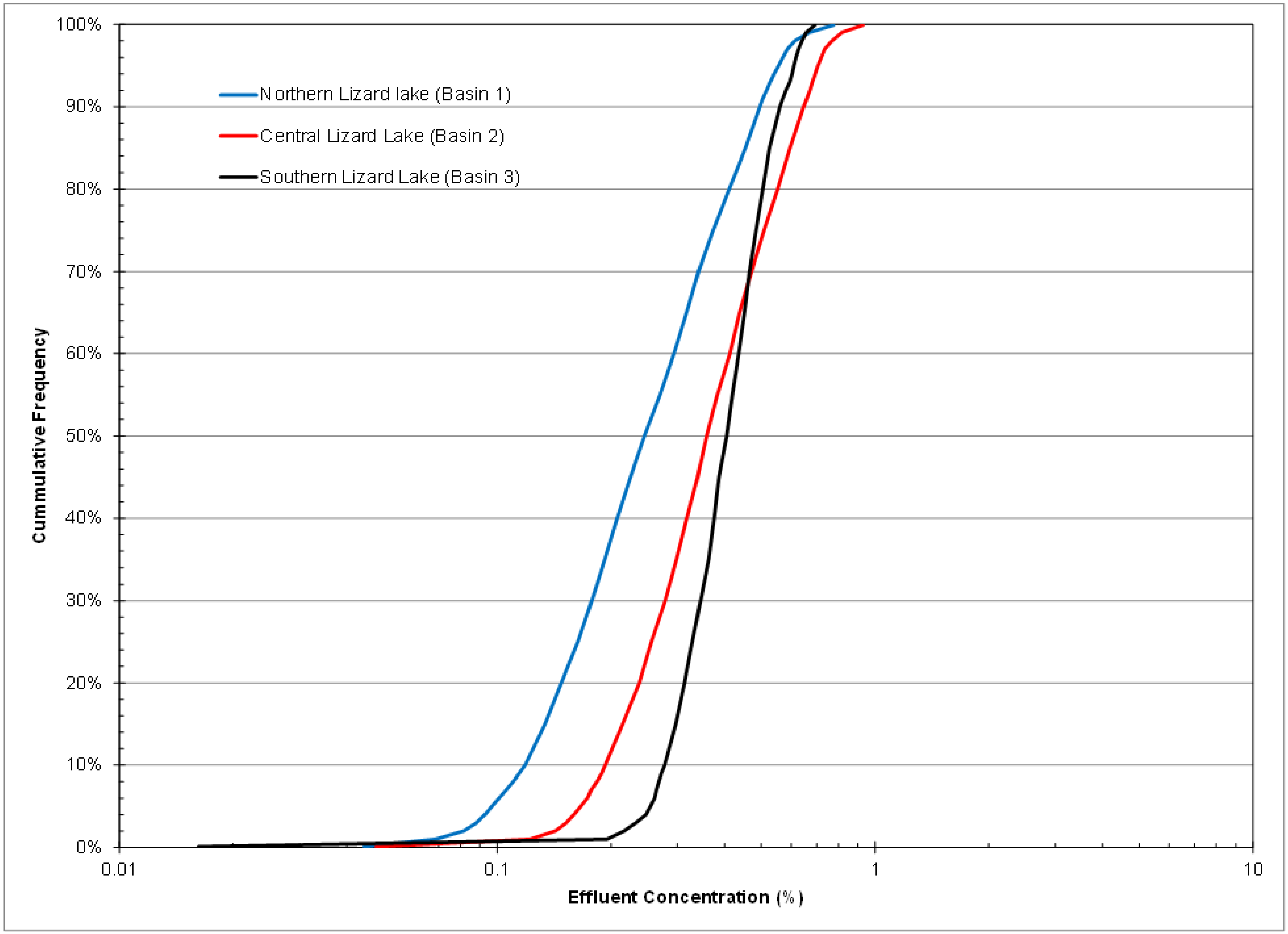

Figure 7-2: Frequencies of Predicted TMF Seepage Concentrations in Lizard Lake during Operations

Table 7-1: Summary of Seepage Mixing Proportions (%) in Lizard Lake Model Compartments for Operational Phase

—	Lizard Lake		
—	**Northern**	**Central**	**Southern**
Model Basin	**1**	**2**	**3**
Minimum	0.01	0.00	0.00
Average	0.28	0.39	0.41
Maximum	0.81	0.95	0.71
Percentiles for Cumulative Frequencies			
1.0%	0.07	0.12	0.20
2.5%	0.09	0.15	0.22
5.0%	0.10	0.17	0.25
10.0%	0.12	0.19	0.28
50.0%	0.25	0.36	0.40
90.0%	0.50	0.65	0.56
95.0%	0.56	0.71	0.61
97.5%	0.60	0.75	0.63
99.0%	0.67	0.82	0.66

Notes:

Effluent concentrations are presented as a percentage of the effluent concentration a non-specific conservative parameter.

(a) Location of model basins shown on Figure 3-11.

7.3 Impact Assessment

Table 7-2 presents a summary of the average and maximum mixing proportions (Section 7-2) that were applied to the mixing of water quality inputs in each Lizard Lake compartment (Figure 3-11).

Table 7-2: Average and Maximum Mixing Proportions in Compartments of Lizard Lake

Proportion Identifier	**Mixing Condition**	**Mixing Zone**		
		Lizard Lake		
		Northern	**Central**	**Southern**
i	Average (%)	0.0028	0.0039	0.0041
ii	Maximum (%)	0.0081	0.0095	0.0071

The following sections present the results of water quality prediction modelling. See Appendix 2.III for all water quality prediction results.

7.3.1 Scenario 1 – Average Case

Results for average operational water quality predictions in Lizard Lake, identified as Run 3gi in Appendix 2.I, are presented in Table 7-3. Run 2gi applied average baseline Lizard Lake water quality, average TMF seepage discharge, and average mixing for the operational scenario.

Table 7-3: Run 3gi Results for Average TMF Seepage Water Quality Predictions in Lizard Lake for Operational Scenario

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO	MISA		Proportion (%)		
						0.0028	0.0039	0.0041
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0 – 7.8	7.0 – 7.8	7.0 – 7.8
Acidity	mg/L	—	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	27	-	-	-
Conductivity	µS/cm	—	—	—	63	-	-	-
Total Suspended Solids	mg/L	+5-25	—	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	—	55	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.34	0.37	0.38
Fluoride	mg/L	—	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	—	0.9	0.94	0.96	0.96
Potassium	mg/L	—	—	—	0.65	0.76	0.81	0.82
Sodium	mg/L	—	—	—	0.67	0.97	1.1	1.1
Sulphate	mg/L	—	—	—	1.9	2.6	2.8	2.9
Carbonate (CO_{32}-)	mg/L	—	—	—	5.0	-	-	-
Bicarbonate ($H(CO_3)$-)	mg/L	—	—	—	30	-	-	-
Hardness	mg($CaCO_3$)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**0.005**	**0.005**	**0.005**
Cyanide (total)	mg/L	—	—	—	0.002	0.0051	0.0063	0.0065
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.078	0.10	0.1
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.00075	0.001	0.0011
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00097	0.00097	0.00097
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Beryllium [d]	mg/L	—	0.011-1.1	—	0.00023	-	-	-
Bismuth	mg/L	—	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00013	0.00013	0.00013
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0012	0.0013	0.0013
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.00054	0.00063	0.00065
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00083	0.00084	0.00084
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	—	0.005	-	-	-
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	—	0.002	-	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.

[a] See Appendix 2.IV for the list of all parameters, guidelines and notes.

[b] Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of average case TMF seepage to Lizard Lake for the operational scenario are lower than the MISA guidelines. In general, the predicted results are marginally greater than average Lizard Lake baseline concentrations for some parameters. Results are summarized with respect to CCME CWQG, PWQO guidelines and average Lizard Lake baseline water quality as follows:

- Predicted concentrations of free cyanide are equal to the CCME CWQG and PWQO guidelines (both values are 0.005 mg/L) within all basins of Lizard Lake.
  - Predicted free cyanide concentrations also equal baseline (0.005 mg/L) water quality.
  - Note that all baseline concentrations of free cyanide were below the detection limit (0.005 mg/L) which is equal to the CCME CWQG and PWQO guidelines.
- Predicted and baseline concentrations of silver are equal to both the CCME CWQG and PWQO guidelines (both are 0.0001 mg/L) in all basins within Lizard Lake.
  - Note that all baseline concentrations of silver were below the detection limit, but that the average of analytical detection limits (0.000102 mg/L) exceeds the CCME CWQG (0.001 mg/L).

7.3.2 Scenario 2 – Upper Bound Case

Results for upper bound case operational water quality predictions for Lizard Lake, identified as Run 3hii in Appendix 2.I, are presented in Table 7-4. Run 2hii applied average baseline Lizard Lake water quality, maximum TMF seepage discharge, and maximum mixing for the operational scenario.

Table 7-4: Run 3hii Results for Maximum TMF Seepage Water Quality Predictions in Lizard Lake for Operational Scenario

Parameter	Unit	Receiving WQ Guidelines[(a)]			Lizard Lake Baseline	Northern	Central	Southern
						Proportion (%)		
		CCME CWQG	PWQO	MISA		**0.0081**	**0.0095**	**0.0071**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0 – 7.7	7.0 – 7.7	7.0 – 7.7
DOC	% wt	—	—	—	8.2	-	-	-
TOC	% wt	—	—	—	8.5	-	-	-
Acidity	mg/L	—	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	27	-	-	-
Conductivity	µS/cm	—	—	—	63	-	-	-
Total Suspended Solids	mg/L	+5-25	—	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	—	55	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	11	11	10
Chloride	mg/L	120	—	—	0.25	0.81	0.91	0.74
Fluoride	mg/L	—	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	—	0.9	1.1	1.1	1.0
Potassium	mg/L	—	—	—	0.65	1.0	1.1	1.0
Sodium	mg/L	—	—	—	0.67	1.7	1.9	1.6
Sulphate	mg/L	—	—	—	1.9	4.1	4.5	3.9
Hardness	mg($CaCO_3$)/L	—	—	—	30	32	32	31
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**<u>0.006</u>**	**<u>0.006</u>**	**<u>0.006</u>**
Cyanide (total)	mg/L	—	—	—	0.002	0.003	0.003	0.003
Nutrients								
Nitrate	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia	mg/L	—	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0017	0.0019	0.0015
Phosphorus	mg/L	—	0.02	—	0.0082	0.0084	0.0084	0.0083
Dissolved Metals								
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00098	0.00099	0.00098
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Beryllium [(d)]	mg/L	—	0.011-1.1	—	0.00023	-	-	-
Bismuth	mg/L	—	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00014	0.00015	0.00014
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	**0.0022**	**0.0024**	**0.002**
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.001	0.0012	0.00096
Nickel [(d)]	mg/L	0.025-0.15	0.025	1	0.0008	0.00087	0.00089	0.00087
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	—	0.005	-	-	-
Uranium	mg/L	0.015	0.005	—	0.0025	0.0026	0.0026	0.0026
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	—	0.002	-	-	-

Notes:
<u>Underlined</u> values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.
"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.
(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.
(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of upper bound case TMF seepage to Lizard Lake for the operational scenario are lower than the MISA guidelines. In general, the predicted results are marginally greater than average Lizard Lake baseline concentrations for some parameters. Results are summarized with respect to CCME CWQG, PWQO guidelines and average Lizard Lake baseline water quality as follows:

- The concentration of predicted free cyanide is greater than both the CCME CWQG and PWQO guidelines (both values are 0.005 mg/L) for the predicted water quality (0.006 mg/L) within all basins of Lizard Lake.
  - The predicted concentration of free cyanide exceeds baseline (0.005 mg/L) water quality.
  - Note that all baseline concentrations of free cyanide were below the detection limit (0.005 mg/L) which is equal to the CCME CWQG and PWQO guidelines.
- The concentrations of copper are greater than the CCME CWQG (0.002 mg/L) for the predicted upper bound case water quality (ranging from 0.0020 to 0.0024 mg/L) in all basins within Lizard Lake.
- The concentration of silver is equal to both the CCME CWQG and PWQO guidelines (both are 0.0001 mg/L) for the baseline (0.0001 mg/L) and predicted average case (0.0001 mg/L) in all basins within Lizard Lake.
  - Note that all baseline concentrations of silver were below the detection limit, but that the average of analytical detection limits (0.000102 mg/L) exceeds the CCME CWQG (0.001 mg/L).

8.0 WATER QUALITY MODELLING FOR LIZARD LAKE – POST-CLOSURE

8.1 Input Data (Post-closure)

TMF seepage rates for the post-closure phase are summarized in Table 8-1. TMF seepage rates were based on a preliminary seepage analysis (Site Water Quality TSD) and were assumed to drain to one of the three basins of Lizard Lake.

Although it is currently considered that the seepage collection system will be effective in directing seepage from the TMF back to the Ore Processing Facility for reuse in the process and/or discharge to Upper Marmion Reservoir if necessary, for the purposes of impact evaluation for Lizard Lake only, it was assumed that 10% of the seepage reporting to the collection system would have the potential to bypass the system.

This is a conservative assumption that will be confirmed during operations through monitoring. As the seepage collection system is an engineered system, mitigation through enhanced seepage capture could be implemented if necessary depending on the monitoring results.

Table 8-1: Estimated TMF Seepage Rates into Lizard Lake for Post-closure Phase

Lake Basin	Dam	Length (m)	Total Seepage per Dam[a] (m^3/d)	Total Seepage to Lake Basins[b] (m^3/s)
Northern	R1	229	5.9	0.00063
	R2	453	11.7	
	R3	1,419	36.6	
Central	Q1	1,614	41.6	0.00048
Southern	Q2	687	17.7	
	P1	362	9.3	
	B-1	313	8.1	
		Totals	**131.0**	**0.00152**

Notes:
[a] Seepage rates provided by (reference).
[b] Total seepage to lake assumes that 90% of seepage is directed to treatment plant via collection system.

8.2 Water Quality Prediction for Lizard Lake at Post-closure

In order to develop an estimate of expected mixing proportions for a given TMF seepage concentration, a particle tracking type of evaluation was used whereby, for purposes of this assessment, the seepage was set at a constant value of 100 particles per unit volume. When examining the results presented in this section, a predicted particle concentration can be interpreted as being equivalent to the percentage of the plume concentration (e.g., a predicted concentration of 1 particle per unit volume is representative of 1% of the initial effluent concentration).

Figure 8-1 shows the predicted proportions (in %) for the TMF seepage in the three Lizard Lake basins. These results for all the model basins are summarized in Table 8-2.

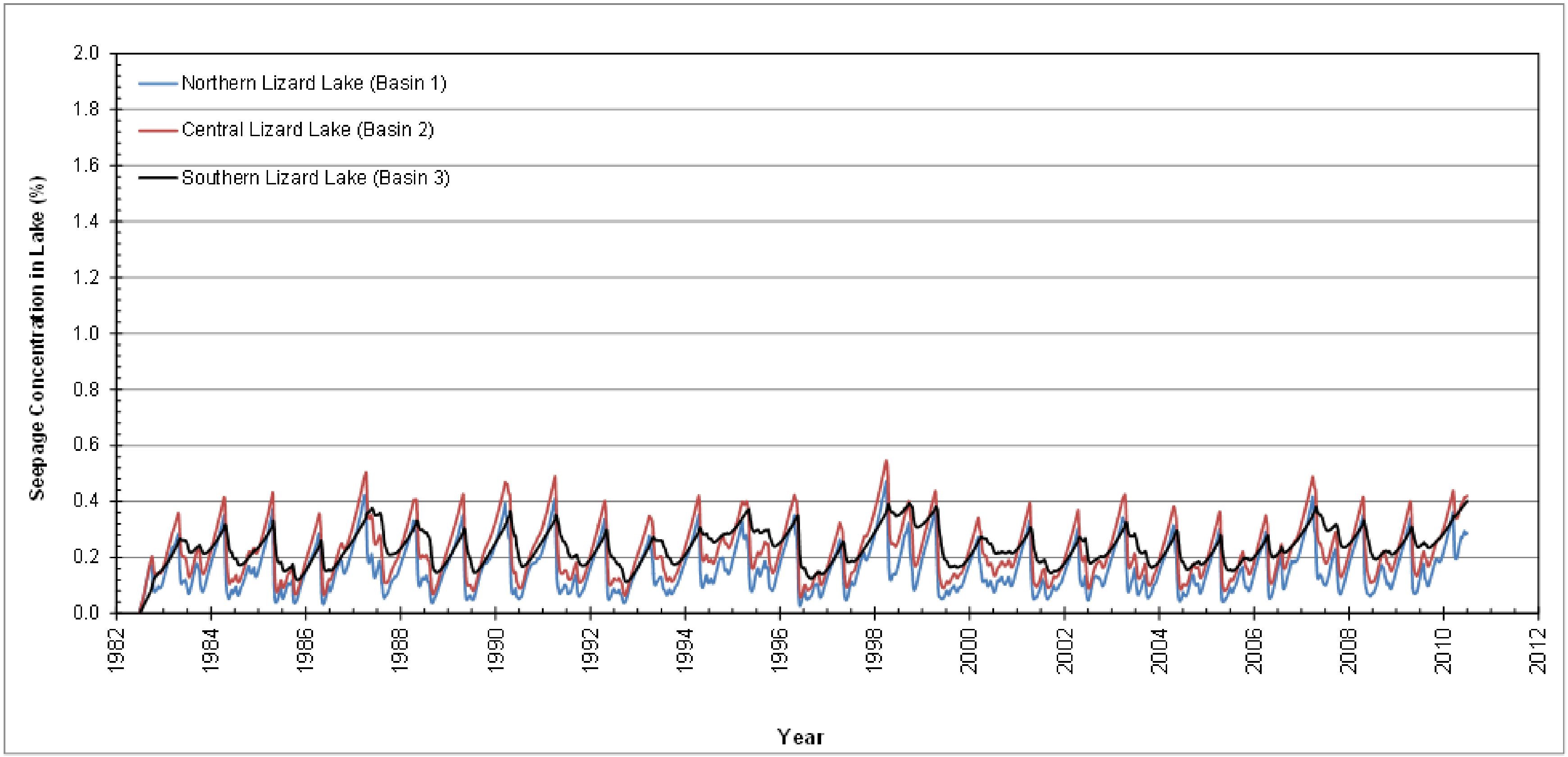

Figure 8-1: Predicted Seepage Concentrations in Lizard Lake for Post-closure

By examining Figure 8-1 and Table 8-2 the following observations are made:

- The highest average seepage concentrations occur in southern Lizard Lake (0.24%).
- The highest predicted seepage concentrations occur in central Lizard Lake (0.55%) and northern Lizard Lake (0.47%). This is likely the result of the relatively low volumes of the northern and central basins when compared to the volume of the southern basin (see Table 3-6).
- Figure 8-1 shows that the predicted seepage concentrations in Lizard Lake are fairly consistent over the 30-year period and reach a semi-stable (only seasonal variations) within two years.

Table 8-2 also provides a statistical summary of the frequency at which the predicted concentrations occur in the model basins. These are provided in more detail graphically on Figure 8-2.

From Table 8-2, it is expected that the peak values occur seasonally and that the seepage concentration in central Lizard Lake expected to be below 0.41% more than 95% of the time.

Table 8-2: Summary of TMF Seepage Mixing Proportions (%) in Lizard Lake Model Compartments for Post-closure Phase

—	Lizard Lake		
—	**Northern**	**Central**	**Southern**
Model Basin	**1**	**2**	**3**
Minimum	0.00	0.00	0.00
Average	0.16	0.23	0.24
Maximum	0.47	0.55	0.41
Percentiles for Cumulative Frequencies			
1.0%	0.04	0.07	0.11
2.5%	0.05	0.08	0.13
5.0%	0.06	0.10	0.15
10.0%	0.07	0.11	0.16
50.0%	0.14	0.21	0.23
90.0%	0.29	0.37	0.32
95.0%	0.32	0.41	0.35
97.5%	0.35	0.43	0.37
99.0%	0.39	0.47	0.38

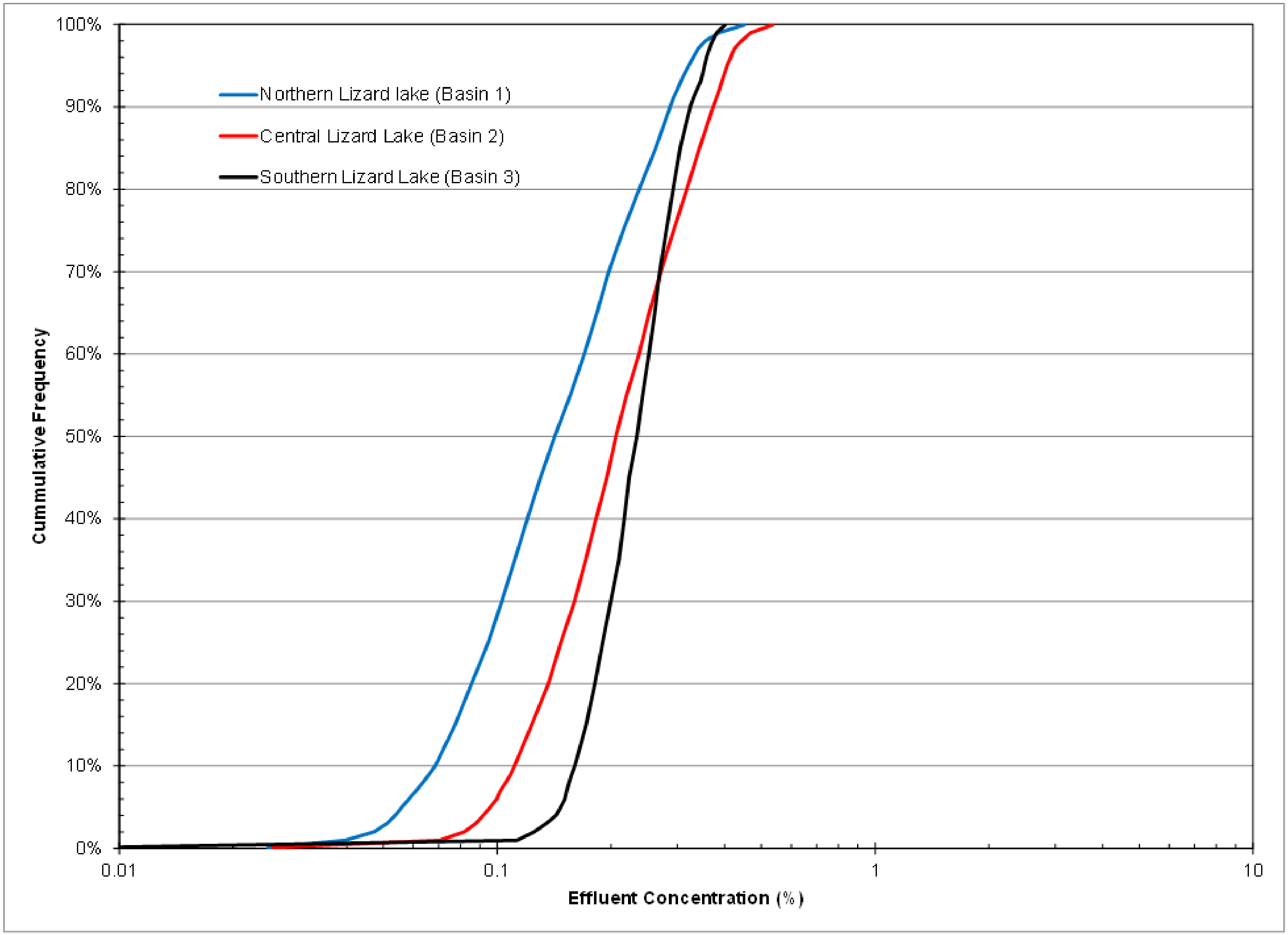

Figure 8-2: Frequencies of Predicted Seepage Concentrations in Lizard Lake for Post-closure

8.3 Impact Assessment

Table 8-3 presents a summary of the average and maximum mixing proportions (Section 8-2) that were applied to the mixing of TMF seepage in each Lizard Lake basin (Figure 3-11) for the post-closure scenario.

Table 8-3: Average and Maximum Mixing Proportions in Compartments of Lizard Lake

Identifier	Zone	Mixing Zone		
		Lizard Lake – Post Closure		
		Northern	Central	Southern
i	Average	0.0016	0.0023	0.0024
ii	Maximum	0.0047	0.0055	0.0041

The following sections present the results of water quality prediction modelling. See Appendix 2.III for all water quality prediction results.

8.3.1 Scenario 1 – Average Case – Post-closure

Results for average case TMF seepage post-closure water quality predictions of Lizard Lake, identified as Run 2nii in Appendix 2.I, are presented in Table 8-4. Run 2nii applied average baseline Lizard Lake water quality, average TMF seepage discharge, and maximum mixing for the post-closure scenario.

Table 8-4: Run 3nii Results for Average TMF Seepage Water Quality Predictions in Lizard Lake for Post-closure Scenario

Parameter	Unit	Receiving WQ Guidelines[(a)]			Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO	MISA		Proportion (%)		
						0.0047	**0.0055**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0 – 7.3	7.0 – 7.3	7.0 – 7.3
Acidity	mg/L	—	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	27	-	-	-
Conductivity	µS/cm	—	—	—	63	-	-	-
Total Suspended Solids	mg/L	+5-25	—	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	—	55	-	-	-
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.3	0.3	0.3
Fluoride	mg/L	—	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	—	0.9	0.9	0.9	0.9
Potassium	mg/L	—	—	—	0.65	0.7	0.7	0.7
Sodium	mg/L	—	—	—	0.67	0.7	0.7	0.7
Sulphate	mg/L	—	—	—	1.9	1.9	1.9	2
Hardness	mg($CaCO_3$)/L	—	—	—	30	30	30	30
Cyanide (free)	mg/L	0.005	0.005	—	0.005	-	-	-
Cyanide (total)	mg/L	—	—	—	0.002	-	-	-
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	4.65E-05	65E-05	65E-05
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Beryllium [(d)]	mg/L	—	0.011-1.1	—	0.00023	-	-	-
Bismuth	mg/L	—	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00012	0.00012	0.00012
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0009	0.0009	0.0009
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	0.009435	0.009435	0.009435
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0003	0.0003	0.0003
Nickel [(d)]	mg/L	0.025-0.15	0.025	1	0.0008	0.0008	0.0008	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	—	0.005	-	-	-
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	—	0.002	-	-	-

Notes:

Underlined values exceed PWQO guidelines. **Bold** values exceed CCME CWQG.

"-" = Site water quality data was not modelled for this parameter. "—" = Receiving water quality guidelines do not exist for this parameter.

(a) See Appendix 2.IV for the list of all parameters, guidelines and notes.

(b) Aluminum CCME CWQG and PWQO guidelines range is pH dependent. See Appendix 2.IV for details.

(c) Cadmium CCME CWQG is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Appendix 2.IV for details.

All predicted concentrations of average/maximum mixing case TMF seepage to Lizard Lake for the post-closure scenario are lower than the MISA guidelines. In general, the predicted results are marginally greater than average Lizard Lake baseline concentrations for some parameters. Results are summarized with respect to CCME CWQG, PWQO guidelines and average Marmion Reservoir baseline water quality as follows:

- The concentration of silver is equal to both the CCME CWQG and PWQO guidelines (both are 0.0001 mg/L) for the baseline (0.0001 mg/L) and predicted average case (0.0001 mg/L) in all basins within Lizard Lake.
  - Note that all baseline concentrations of selenium were below the detection limit, but that the average of analytical detection limits (0.000102 mg/L) exceeds the CCME CWQG (0.001 mg/L).

9.0 CONCLUSIONS AND RECOMMENDATIONS

As stated in Section 2.5, there are many reasons why a parameter may exceed a given guideline including detection limits as used in the model calculations, naturally elevated baseline conditions, and expected site discharge concentrations due to mining. If a guideline is exceeded then it is necessary to evaluate the reasons why and conduct further assessment of potential impacts as provided in the EIS/EA Report and other relevant TSDs. Table 9-1 provides a summary of parameters that exceed CCME CWQG and/or PWQO Guidelines in predicted water quality for all cases in Upper Marmion Reservoir and Lizard Lake for operational and post-closure scenarios.

Although a more detailed model may provide finer scale discretization of water quality, given the observed results and minimal influence of Project Site discharge on overall water quality it is considered that a more detailed lake water model is not required at this time.

Table 9-1: Summary of Parameters that Exceed CCME CWQG and/or PWQO Guidelines in Predicted Water Quality for all Cases in Upper Marmion Reservoir and Lizard Lake for Operational and Post-closure Scenarios.

Water Quality Prediction Scenario			Parameters	Guidelines: CCME CWQG[(a)]	Guidelines: PWQO[(b)]	Total Number (Basins)	Predicted Concentrations Exceeding Guidelines: CCME CWQG[(a)] Number	CCME CWQG[(a)] Percent	PWQO[(b)] Number	PWQO[(b)] Percent	Basin Location (CCME CWQG)	Basin Location (PWQO)
Operations	Marmion Reservoir	2ai – Average Case/Site Discharge	Free Cyanide	0.005	0.005	10	9	90%	9	90%	Basins locations: 5,6, 7A,7B,7C, 8,9,10, 11	Basins locations: 5,6, 7A,7B,7C, 8,9,10, 11
Operations	Marmion Reservoir	2cii – Upper Bound Case/Site Discharge	Free Cyanide	0.005	0.005	10	9	90%	9	90%	Basins locations: 5,6, 7A,7B,7C, 8,9,10, 11	Basins locations: 5,6, 7A,7B,7C, 8,9,10, 11
Operations	Marmion Reservoir	2cii – Upper Bound Case/Site Discharge	Dissolved Copper	0.002-0.004	0.001-0.005	11	5	45%	0	0%	Basin locations:	None
Operations	Lizard Lake	3gi – Average Case/TMF Seepage	Free Cyanide	0.005	0.005	3	3	100%	3	100%	All basin locations	All basin locations
Operations	Lizard Lake	3hii – Upper Bound Case /TMF Seepage	Free Cyanide	0.005	0.005	3	3	100%	3	100%	All basin locations	All basin locations
Operations	Lizard Lake	3hii – Upper Bound Case /TMF Seepage	Dissolved Copper	0.002-0.004	0.001-0.005	3	3	100%	0	0%	All basin locations	None
Post-Closure	Marmion Reservoir	2ki – Expected Pit Lake Discharge	No exceedances									
Post-Closure	Marmion Reservoir	2lii – Upper Bound Case Pit Lake Discharge	No exceedances									
Post-Closure	Marmion Reservoir	2mi – Average Site Runoff/Average Mixing	Dissolved Iron	0.3	0.3	11	2	18%	2	18%	Basin locations: 7B,7C	Basin locations: 7B,7C
Post-Closure	Marmion Reservoir	2mii – Average Site Runoff/Maximum Mixing	Dissolved Iron	0.3	0.3	11	3	27%	3	27%	Basin locations: 7A,7B,7C	Basin locations: 7A,7B,7C
Post-Closure	Lizard Lake	3ni – Average TMF Seepage/Average Mixing	No exceedances									
Post-Closure	Lizard Lake	3nii – Average TMF Seepage/Maximum Mixing	No exceedances									

Notes:

(a) Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines (CCME CWQG) for the protection of aquatic life (CCME, 2007).

(b) Ontario Provincial Water Quality Objectives (PWQO) (MOEE 1999)

10.0 REFERENCES

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11.0 GLOSSARY OF TERMS

Table 11-1: Glossary of Terms

Term	Definition
Baseline	Conditions that would prevail if no actions were taken. (U.S. Department of Interior 2012)
Discharge	The release or extraction of water from an aquifer. Typical mechanisms of natural discharge are evapotranspiration by phreatophytes, springs and drains to surface water bodies. Pumping is a man-caused discharge. (University of Idaho 2012)
Effluent	Partially or completely treated wastewater flowing out of a treatment facility, reservoir, or basin. (U.S. Department of Interior 2012)
Impoundment	Body of water created by a dam. (U.S. Department of Interior 2012)
Intake	Any structure through which water can be drawn into a waterway. Any structure in a reservoir, dam, or river through which water can be discharged. (U.S. Department of Interior 2012)
Mineralized (mineralization)	The conversion of organic compounds into inorganic, plant-available compounds such as ammonium. This is accomplished by soil organisms as they consume organic matter and excrete wastes. (USDA 2012)
Potable Water	Water that is safe and satisfactory for drinking and cooking. (U.S. Department of Interior 2012)
Precipitation	As used in hydrology, precipitation is the discharge of water, in a liquid or solid state, out of the atmosphere, generally onto a land or water surface, It is the common process by which atmospheric water becomes surface or subsurface water. The term "precipitation" is also commonly used to designate the quantity of water that is precipitated. Precipitation includes rainfall, snow, hail and sleet, and is therefore a more general term than rainfall. (NOAA 2012)
Reservoir	A man-made facility for the storage, regulation and controlled release of water. (NOAA 2012)
Runoff	The portion of precipitation, snow melt, or irrigation that flows over the soil, eventually making its way to surface water supplies. Liquid water that travels over the surface of the Earth, moving downward due to the law of gravity; runoff is one way in which water that falls as precipitation returns to the ocean. (U.S. Department of Interior 2012)
Seepage	The interstitial movement of water that may take place through a dam, its foundation or abutments. (NOAA 2012)
Sluiceway	An opening in a diversion dam used to discharge heavy floating debris safely past the dam. (U.S. Department of Interior 2012)
Stratification	Thermal layering of water in lakes and streams. Lakes usually have three zones of varying temperature, the epilimnion, the metalimnion, and the hypolimnion. The formation of separate layers (of temperature, plant, or animal life) in a lake or reservoir. (U.S. Department of Interior 2012)
Toe Drain	A drain which carries seepage away from the dam and can allow seepage quantities to be measured. (NOAA 2012)
Tributary	River or stream flowing into a larger river or stream. (U.S. Department of Interior 2012)
Water Balance	An analytical tool whereby the sum of the system inflows equals the sum of the system outflows. A summation of inputs, outputs, and net changes to a particular water resource system over a fixed period. (U.S. Department of Interior 2012)
Watershed	Land area from which water drains toward a common watercourse in a natural basin. (NOAA 2012)

12.0 ABBREVIATIONS, ACRONYMS AND INITIALISMS

Table 12-1: List of Abbreviations, Acronyms and Initialisms

Acronym	Definition
ADCP	Acoustic Doppler Current Profiler
CEA Agency	Canadian Environmental Assessment Agency
CCME CWQG	Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines
EA	Environmental Assessment
EIS	Environmental Impact Statement
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modelling System
HHERA	Human Health and Ecological Risk Assessment
ICP	Intermediate Control Pond
LSA	Local Study Area
MISA	Municipal/Industrial Strategy for Abatement
MNR	Ministry of Natural Resources
MOEE	Ministry of the Environment and Energy
MSA	Mine Study Area
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
ODWS	Ontario Drinking Water Standards
OHRG	Osisko Hammond Reef Gold Ltd.
PHREEQC	Computer program written in the C programming language designed to perform low-temperature geo-chemical calculations
PWQO	Provincial Water Quality Objectives
RDI	RD Instruments
REF	Reference
RSA	Regional Study Area
STP	Sewage Treatment Plant
TMF	Tailings Management Facility
ToR	Terms of Reference
TSD	Technical Support Document
USACE	United Stated Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VEC	Valued Ecosystem Component
WQ	Water Quality
WRMF	Waste Rock Management Facility
WSC	Water Survey of Canada

13.0 UNITS

Table 13-1: List of Units

Unit	Abbreviation
degrees Celsius	°C
centimetres per second	cm/s
kilometre	km
metre	m
metres per second	m/s
square metres	m^2
cubic metres per day	m^3/d
cubic metres per hour	m^3/hr
cubic metres per second	m^3/s
metres above sea level	masl
milligrams per litre	mg/L
millimetre	mm

APPENDIX 2.I

Water Quality Model Layout

TABLE 1
Water Quality Model Layout

Scenario	Temporal Condition	Receiving Water Quality Data	Climatic Condition	Water Quality - Source Data	Mixing Proportion
2ai 2aii	Operations	Marmion Reservoir average baseline water quality	Average	Predicted reclaim tank water quality at steady state condition	Mixing proportions were developed based on hydraulic mixing model results for Marmion Basin and Lizard Lake. Average and Maximum mixing proportions were used to bracket a range in mixing scenarios.
2bi 2bii			1-in-10 year wet	Predicted reclaim tank water quality at steady state condition	
2ci 2cii			Average	Predicted reclaim tank water quality at maximum percentile condition	
2di 2dii			1-in-10 year wet	Predicted reclaim tank water quality at maximum percentile condition	
3gi 3gii		Lizard Lake average baseline water quality	N/A	Predicted TMF seepage water quality at steady state condition	
3hi 3hii			N/A	Predicted TMF seepage water quality at maximum percentile condition	
2ki 2kii	Post-Closure	Marmion Reservoir average baseline water quality	N/A	Predicted expected case Pit Lake discharge[(a)]	
2li 2lii				Predicted worst case Pit Lake discharge[(b)]	
2mi 2mii				Predicted Site Runoff water quality at steady state[(c)]	
3ni 3nii		Lizard Lake average baseline water quality		Predicted TMF seepage water quality at steady state condition	

Notes:

N/A = Condition does not apply.

(a) Expected case water quality assumes runoff is diverted directly from the TMF surface to the environment (no diversion to open pits) and with stratification of pit lakes. See Site WQ TSD for further discussion.

(b) Worst case scenario water quality was observed for the scenario with no diversion of TMF water to open pits and with mixing of pit lakes. See Site WQ TSD for further discussion.

(c) During closure, the surface of the TMF will be revegetated, therefore the surface runoff was assigned the water quality of natural runoff.

APPENDIX 2.II

Water Quality Model Inputs

TABLE 1
Water Quality Model Inputs

Parameter	Units	Predicted Site Inputs - Operations						Predicted Site Inputs - Post-Closure				Receiving Water Body	
		Reclaim Tank				TMF Seepage		Pit Lake Flooding - Discharge to Marmion		Site Runoff to Marmion	TMF Seepage	Average Baseline	
		Average / Steady State	10 year wet / Steady State	Average / Maximum	10 year wet / Maximum	Steady State	Maximum	Expected	Upper Bound			Marmion	Lizard
Physical-Chemical													
pH	—	7.8	7.7	8.3	8.3	7.8	7.7	7.1	7.0	6.8	7.3	6.5	7.0
DOC	% wt	—	—	—	—	—	—	—	—	—	—	8.8	8.2
TOC	% wt	—	—	—	—	—	—	—	—	—	—	9.3	8.5
Acidity	mg/L	—	—	—	—	—	—	—	—	—	—	2.9	2.9
Alkalinity	mg(CaCO3)/L	104	96	64	64	—	—	—	—	—	—	19	27
Conductivity	µS/cm	—	—	—	—	—	—	—	—	—	—	49	63
Total Suspended Solids	mg/L	—	—	—	—	—	—	—	—	—	—	4.5	2.1
Total Dissolved Solids	mg/L	—	—	—	—	—	—	—	—	—	—	53	55
Major Ions													
Calcium	mg/L	21	20	20	20	28	36	11	12	13	6	6.4	10
Chloride	mg/L	21	19	49	45	31	69	3	3	1	0	1.1	0.25
Fluoride	mg/L	—	—	—	—	—	—	—	—	—	—	0.031	0.03
Magnesium	mg/L	11	10	10	10	16	21	2	1	2	3	1.3	0.9
Potassium	mg/L	28	26	37	34	40	47	1	1	1	3	0.68	0.65
Sodium	mg/L	73	66	93	85	106	129	1	1	1	0	1.3	0.67
Sulphate	mg/L	168	152	217	202	242	280	1	1	2	0	1.6	1.9
Hardness[(a)]	mg(CaCO3)/L	100	93	94	93	136	176	34	36	40	27	21	30
Cyanide (free)[(b)]	mg/L	0.75	0.68	0.75	0.68	0.1	0.1	—	—	—	—	0.005	0.005
Cyanide (total)	mg/L	0.75	0.68	0.75	0.68	0.1	0.1	—	—	—	—	0.002	0.002
Nutrients													
Nitrate-N[(a)]	mg/L	1.5	1.3	1.5	1.3	0.00004	0.00004	0.00050	0.00050	—	—	0.063	0.034
Nitrite-N[(a)]	mg/L	—	—	—	—	—	—	—	—	—	—	0.02	0.02
Ammonia-N	mg/L	15.0	15.1	15.0	15.0	20	20	—	—	—	—	0.023	0.022
Un-ionized ammonia	mg/L	0.173	0.165	0.63	0.63	0.25	0.2	0.12	0.17	—	—	0.000067	0.000047
Phosphorus	mg/L	0.019	0.018	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.01	0.013	0.0082
Organics													
Oil and Greases	mg/L	—	—	—	—	—	—	—	—	—	—	2.5	2.4
Phenols	mg/L	—	—	—	—	—	—	—	—	—	—	0.0022	0.0016
Micro-organisms													
Escherichia coli	per 100mL	—	—	—	—	—	—	—	—	—	—	1.5	0.88
Total coliforms	per 100mL	—	—	—	—	—	—	—	—	—	—	239	40

TABLE 1
Water Quality Model Inputs

Parameter	Units	Predicted Site Inputs - Operations						Predicted Site Inputs - Post-Closure				Receiving Water Body	
		Reclaim Tank				TMF Seepage		Pit Lake Flooding - Discharge to Marmion		Site Runoff to Marmion	TMF Seepage	Average Baseline	
		Average / Steady State	10 year wet / Steady State	Average / Maximum	10 year wet / Maximum	Steady State	Maximum	Expected	Upper Bound			Marmion	Lizard
Dissolved Metals													
Aluminum	mg/L	0.013	0.013	0.010	0.0093	0.02	0.01	0.001	0.001	0.25	0.01	0.03	0.018
Antimony	mg/L	0.0017	0.0016	0.0021	0.002	0.002	0.003	0.0008	0.0006	0.002	0.0002	0.00078	0.00097
Arsenic	mg/L	0.000041	0.000047	0.000001	0.0000015	0.0001	0.00003	0.0010	0.0010	0.0006	0.0002	0.00049	0.00043
Barium	mg/L	0.012	0.011	0.011	0.0085	—	—	—	—	—	—	0.0071	0.0069
Beryllium	mg/L	—	—	—	—	—	—	—	—	—	—	0.00028	0.00023
Bismuth	mg/L	—	—	—	—	—	—	—	—	—	—	0.00054	0.00058
Boron	mg/L	0.0012	0.0015	0.0036	0.0049	0.00002	0.00002	0.00900	0.00500	0.01900	0.00080	0.014	0.011
Cadmium	mg/L	0.000017	0.000017	0.0002	0.00021	0.000017	0.000028	0.00002	0.00002	0.00005	0.00001	0.000036	0.00003
Chromium	mg/L	0.0002	0.00021	0.00009	0.00009	0.0002	0.0002	0.0005	0.0006	0.0009	0.0005	0.00048	0.00049
Cobalt	mg/L	0.002	0.0018	0.0023	0.0021	0.003	0.003	0.0002	0.0001	0.0005	0.0001	0.00017	0.00012
Copper	mg/L	0.075	0.068	0.11	0.1	0.11	0.16	0.0	0.0	0.0	0.0	0.0011	0.00087
Iron	mg/L	0.000067	0.000069	0.000075	0.000058	0.0001	0.00008	0.0008	0.0006	1.3000	0.0030	0.24	0.053
Lead	mg/L	0.00012	0.00011	0.00032	0.0003	0.0002	0.0004	0.00005	0.00005	0.0004	0.00003	0.00029	0.00024
Manganese	mg/L	0.037	0.036	0.065	0.066	—	—	0.0004	0.0005	0.0006	0.00003	0.024	0.0094
Mercury	mg/L	0.000009	0.000009	0.000009	0.000009	0.00001	0.00001	0.00002	0.00002	0.000005	0.00001	0.000005	0.000005
Molybdenum	mg/L	0.056	0.051	0.066	0.06	0.08	0.09	0.001	0.001	0.001	0.002	0.00036	0.00032
Nickel	mg/L	0.0077	0.007	0.009	0.0083	0.01	0.01	0.001	0.001	0.001	0.00	0.00099	0.0008
Selenium	mg/L	0.0007	0.0006	0.001	0.001	0.0008	0.001	0.001	0.001	0.0005	0.0005	0.0005	0.0012
Silicon	mg/L	—	—	—	—	—	—	—	—	—	—	2.6	2.1
Silver	mg/L	0.000016	0.000017	0.000013	0.000014	0.00001	0.00001	0.00005	0.00004	0.00010	0.00001	0.000087	0.0001
Strontium	mg/L	0.22	0.21	0.33	0.32	—	—	—	—	—	—	0.013	0.015
Thallium	mg/L	0.00015	0.00014	0.00014	0.00013	—	—	—	—	—	—	0.000084	0.000068
Tin	mg/L	0.023	0.021	0.029	0.027	—	—	—	—	—	—	0.00071	0.00055
Titanium	mg/L	—	—	—	—	—	—	—	—	—	—	0.0012	0.0013
Tungsten	mg/L	—	—	—	—	—	—	—	—	—	—	0.0045	0.005
Uranium	mg/L	0.0051	0.0047	0.0069	0.0066	0.007	0.009	0.001	0.001	0.002	0.0008	0.0022	0.0025
Vanadium	mg/L	0.000037	0.000044	0.00026	0.00039	0.00004	0.000002	—	—	—	—	0.0005	0.00037
Zinc	mg/L	0.0019	0.0019	0.0093	0.01	0.002	0.002	0.002	0.003	0.003	0.002	0.0052	0.0055
Zirconium	mg/L	—	—	—	—	—	—	—	—	—	—	0.0015	0.002

Notes:
— = Site water quality data was not modeled for this parameter.
(a) Hardness for site water quality and TMF seepage was calculated using the formula: Hardness, mg equivalent/L CaCO3 = ([Ca,mg/l]*2.497) + ([Mg,mg.l]*4.116). (REF: USEPA)
(b) Free cyanide was modeled using PHREEQC based on solution chemistry and the concentration of total cyanide.

APPENDIX 2.III

Water Quality Predictions

TABLE 1
Operations Marmion Site Discharge - Run 2ai
Average Climate/Steady State Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.7	0.71	0.69	0.68	0.68	0.7	0.7	0.7	0.7
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.7	1.8	1.7	1.6	1.6	1.8	1.8	1.7	1.8
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	**0.0056**	**0.0059**	**0.0053**	**0.0051**	**0.0051**	**0.0057**	**0.0057**	**0.0056**	**0.0057**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.0026	0.0029	0.0023	0.0021	0.0021	0.0027	0.0027	0.0026	0.0027
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00021	0.00027	0.000144	0.000087	0.000086	0.00022	0.00022	0.000198	0.00022
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00041	0.00043	0.00039	0.00037	0.00037	0.00041	0.00041	0.0004	0.00041
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.0010	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00073	0.00074	0.00072	0.00071	0.00071	0.00073	0.00073	0.00073	0.00073
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 1-6.

[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 2

Operations Marmion Site Discharge - Run 2aii
Average Climate/Steady State Concentration/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8	6.5-7.8
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	20	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.7	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	120	—	—	1.1	1.1	1.3	1.4	1.1	1.1	1.1	1.3	1.3	1.1	1.2
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	0.96	1.1	0.74	0.68	0.68	0.96	0.95	0.71	0.94
Sodium	mg/L	—	—	—	1.3	1.3	2.0	2.4	1.5	1.3	1.3	2.0	2.0	1.4	2.0
Sulphate	mg/L	—	—	—	1.6	1.6	3.3	4.1	2.0	1.7	1.6	3.3	3.3	1.8	3.2
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	22	23	22	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	**<u>0.013</u>**	**<u>0.016</u>**	**<u>0.0068</u>**	**<u>0.0052</u>**	**<u>0.0052</u>**	**<u>0.013</u>**	**<u>0.012</u>**	**<u>0.0061</u>**	**<u>0.012</u>**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.0097	0.013	0.0038	0.0022	0.0022	0.0097	0.0095	0.0031	0.0093
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.078	0.085	0.066	0.064	0.063	0.078	0.077	0.065	0.077
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.176	0.251	0.059	0.028	0.027	0.177	0.173	0.045	0.169
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00183	0.00269	0.00047	0.000122	0.000111	0.00184	0.00179	0.00031	0.00175
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.00079	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0072	0.0072	0.0071	0.0071	0.0071	0.0072	0.0072	0.0071	0.0072
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00017	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0019	**0.0023**	0.0013	0.0011	0.0011	0.0019	0.0019	0.0012	0.0018
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.024	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00093	0.0012	0.00049	0.00038	0.00038	0.00093	0.00092	0.00044	0.00091
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.0011	0.0010	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.015	0.016	0.013	0.013	0.013	0.015	0.015	0.013	0.015
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.00094	0.001	0.00076	0.00072	0.00072	0.00094	0.00093	0.00074	0.00092
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0023	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

<u>Underlined</u> values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 1-6.

[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 3
Operations Marmion Site Discharge - Run 2bi
10 Year Wet Climate/Steady State Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.7	0.7	0.69	0.68	0.68	0.7	0.7	0.69	0.7
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.7	1.8	1.7	1.6	1.6	1.7	1.7	1.7	1.7
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	**0.0056**	**0.0058**	**0.0053**	**0.0051**	**0.0051**	**0.0056**	**0.0056**	**0.0055**	**0.0056**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.0026	0.0028	0.0023	0.0021	0.0021	0.0026	0.0026	0.0025	0.0026
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.000207	0.00026	0.000141	0.000086	0.000085	0.00022	0.000214	0.000192	0.00021
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.0004	0.00042	0.00038	0.00037	0.00037	0.00041	0.00041	0.0004	0.00041
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.0010	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00073	0.00074	0.00072	0.00071	0.00071	0.00073	0.00073	0.00073	0.00073
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 1-6.

[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 4
Operations Marmion Site Discharge - Run 2bii
10 Year Wet Climate/Steady State Concentraiton/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7	6.5-7.7
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	20	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.6	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	120	—	—	1.1	1.1	1.2	1.3	1.1	1.1	1.1	1.2	1.2	1.1	1.2
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	0.93	1.1	0.73	0.68	0.68	0.93	0.92	0.71	0.92
Sodium	mg/L	—	—	—	1.3	1.3	1.9	2.3	1.4	1.3	1.3	1.9	1.9	1.4	1.9
Sulphate	mg/L	—	—	—	1.6	1.6	3.1	3.9	2.0	1.7	1.6	3.1	3.1	1.8	3.1
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	22	22	21	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	**0.012**	**0.015**	**0.007**	**0.005**	**0.005**	**0.012**	**0.012**	**0.006**	**0.012**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.009	0.012	0.0036	0.0022	0.0022	0.009	0.0088	0.003	0.0086
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.076	0.082	0.066	0.063	0.063	0.076	0.075	0.065	0.075
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.177	0.252	0.059	0.028	0.027	0.178	0.174	0.045	0.17
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00176	0.00257	0.00046	0.000119	0.00011	0.00176	0.00172	0.0003	0.00168
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.00079	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0072	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00017	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0018	**0.0021**	0.0013	0.0011	0.0011	0.0018	0.0018	0.0012	0.0018
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.024	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00088	0.0011	0.00048	0.00038	0.00037	0.00088	0.00087	0.00043	0.00086
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.001	0.0010	0.001
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.015	0.016	0.013	0.013	0.013	0.015	0.015	0.013	0.015
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.00091	0.001	0.00076	0.00072	0.00072	0.00091	0.00091	0.00074	0.0009
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0023	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 5

Operations Marmion Site Discharge - Run 2ci

Average Climate/ Maximum Percentile Concentration/Average mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
		CCME	PWQO	MISA		1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.71	0.72	0.69	0.68	0.68	0.71	0.71	0.7	0.71
Sodium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.4	1.4
Sulphate	mg/L	—	—	—	1.6	1.6	1.8	1.9	1.7	1.6	1.6	1.8	1.8	1.8	1.8
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	**0.0056**	**0.0059**	**0.0053**	**0.0051**	**0.0051**	**0.0057**	**0.0057**	**0.0056**	**0.0057**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.0026	0.0029	0.0023	0.0021	0.0021	0.0027	0.0027	0.0026	0.0027
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0006	0.00081	0.00035	0.000142	0.000136	0.00063	0.00063	0.00055	0.00062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0013	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.024	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00042	0.00044	0.00039	0.00037	0.00037	0.00042	0.00042	0.00041	0.00042
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0010	0.0010	0.00099	0.00099	0.00099	0.0010	0.0010	0.00099	0.0010
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00074	0.00075	0.00072	0.00072	0.00072	0.00074	0.00074	0.00073	0.00074
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
(a) See Appendix 2.IV for the list of all parameters, guideline and notes.
(b) Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
(e) Locations of model basins are shown on Figure 1-6.
(f) Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 6
Operations Marmion Site Discharge - Run 2cii
Average Climate/Maximum Percentile Concentraiton/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.7	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	120	—	—	1.1	1.1	1.5	1.8	1.2	1.1	1.1	1.5	1.5	1.1	1.5
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	1.0	1.2	0.76	0.69	0.68	1.0	1.0	0.73	1.0
Sodium	mg/L	—	—	—	1.3	1.3	2.2	2.7	1.5	1.3	1.3	2.2	2.2	1.4	2.2
Sulphate	mg/L	—	—	—	1.6	1.6	3.8	4.9	2.1	1.7	1.7	3.8	3.8	1.9	3.7
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	22	22	21	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	**0.013**	**0.016**	**0.0068**	**0.0052**	**0.0052**	**0.013**	**0.012**	**0.0061**	**0.012**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.0097	0.013	0.0038	0.0022	0.0022	0.0097	0.0095	0.0031	0.0093
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.078	0.085	0.066	0.064	0.063	0.078	0.077	0.065	0.077
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.176	0.251	0.059	0.028	0.027	0.177	0.173	0.045	0.169
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0065	0.0096	0.00156	0.00027	0.00023	0.0065	0.0064	0.00096	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.0008	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0072	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000038	0.000039	0.000036	0.000036	0.000036	0.000038	0.000038	0.000036	0.000038
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00018	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	**0.0022**	**0.0028**	0.0014	0.0012	0.0012	**0.0022**	**0.0022**	0.0013	**0.0022**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.001	0.0014	0.00052	0.00038	0.00038	0.001	0.001	0.00045	0.0010
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.0011	0.0010	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.016	0.018	0.014	0.013	0.013	0.016	0.016	0.013	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.001	0.0011	0.00078	0.00072	0.00072	0.001	0.0010	0.00075	0.00099
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0023	0.0023	0.0022	0.0022	0.0022	0.0023	0.0023	0.0022	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0053	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 7
Operations Marmion Site Discharge - Run 2di
10 Yr Wet/Maximum Percentile Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	0.00085	0.00118	0.00045	0.00012	0.00011	0.0009	0.00089	0.00076	0.00087
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.7	0.71	0.69	0.68	0.68	0.71	0.7	0.7	0.7
Sodium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Sulphate	mg/L	—	—	—	1.6	1.6	1.8	1.8	1.7	1.6	1.6	1.8	1.8	1.8	1.8
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	0.0056	0.0058	0.0053	0.0051	0.0051	0.0056	0.0056	0.0055	0.0056
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.0026	0.0028	0.0023	0.0021	0.0021	0.0026	0.0026	0.0025	0.0026
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.064	0.065	0.064	0.063	0.063	0.064	0.064	0.064	0.064
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.036	0.041	0.03	0.025	0.025	0.037	0.037	0.035	0.036
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0006	0.00081	0.00035	0.000142	0.000136	0.00063	0.00063	0.00054	0.00061
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0012	0.0012	0.0012	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.024	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00041	0.00043	0.00039	0.00037	0.00037	0.00042	0.00041	0.00041	0.00041
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.0010	0.00099	0.00099	0.00099	0.0010	0.0010	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084	0.000084
Tin	mg/L	—	—	—	0.00071	0.00071	0.00073	0.00074	0.00072	0.00072	0.00071	0.00074	0.00074	0.00073	0.00073
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 8
Operations Marmion Site Discharge - Run 2dii
10 Year Wet Climate/Maximum Percentile Concentration/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines(a)			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.01022	0.01518	0.00236	0.00032	0.00026	0.01024	0.00998	0.00142	0.00974
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3	6.5-8.3
Alkalinity	mg($CaCO_3$)/L	—	-25%	—	19	19	19	19	19	19	19	19	19	19	19
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.6	6.7	6.5	6.4	6.4	6.6	6.6	6.5	6.6
Chloride	mg/L	120	—	—	1.1	1.1	1.5	1.7	1.2	1.1	1.1	1.5	1.5	1.1	1.5
Magnesium	mg/L	—	—	—	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.4	1.3	1.4
Potassium	mg/L	—	—	—	0.68	0.68	1.0	1.2	0.75	0.69	0.68	1.0	1.0	0.72	1.0
Sodium	mg/L	—	—	—	1.3	1.3	2.1	2.6	1.5	1.3	1.3	2.1	2.1	1.4	2.1
Sulphate	mg/L	—	—	—	1.6	1.6	3.7	4.6	2.1	1.7	1.7	3.7	3.6	1.9	3.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	22	22	21	21	21	22	22	21	22
Cyanide (free)	mg/L	0.005	0.005	—	0.005	0.005	0.012	0.015	0.007	0.005	0.005	0.012	0.012	0.006	0.012
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.009	0.012	0.0036	0.0022	0.0022	0.009	0.0088	0.003	0.0086
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.076	0.082	0.066	0.063	0.063	0.076	0.075	0.065	0.075
Ammonia-N	mg/L	—	—	—	0.023	0.023	0.176	0.251	0.059	0.028	0.027	0.177	0.173	0.045	0.169
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0065	0.0096	0.00155	0.00027	0.00023	0.0065	0.0063	0.00096	0.0062
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00079	0.0008	0.00078	0.00078	0.00078	0.00079	0.00079	0.00078	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Barium	mg/L	—	—	—	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000038	0.000039	0.000037	0.000036	0.000036	0.000038	0.000038	0.000036	0.000038
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00019	0.0002	0.00017	0.00017	0.00017	0.00019	0.00019	0.00017	0.00019
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	**0.0021**	**0.0026**	0.0014	0.0012	0.0012	**0.0021**	**0.0021**	0.0013	**0.0021**
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.025	0.025	0.025	0.024	0.024	0.025	0.025	0.025	0.025
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00097	0.0013	0.0005	0.00038	0.00038	0.00098	0.00096	0.00045	0.00095
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.0011	0.0011	0.001	0.00099	0.00099	0.0011	0.0011	0.0010	0.0011
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	—	0.013	0.013	0.016	0.017	0.013	0.013	0.013	0.016	0.016	0.013	0.016
Thallium	mg/L	0.0008	0.0003	—	0.000084	0.000084	0.000085	0.000085	0.000084	0.000084	0.000084	0.000085	0.000085	0.000084	0.000085
Tin	mg/L	—	—	—	0.00071	0.00071	0.00098	0.0011	0.00077	0.00072	0.00072	0.00098	0.00097	0.00075	0.00096
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0023	0.0023	0.0022	0.0022	0.0022	0.0023	0.0023	0.0022	0.0023
Vanadium	mg/L	—	0.006	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0053	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 9
Post-closure Marmion Pit Lake Discharge - Run 2ki
Average Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines(a)			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
		CCME	PWQO	MISA		Proportion									
						0	**0.00044**	**0.00062**	**0.00032**	**0.00011**	**0.0001**	**0.00045**	**0.00044**	**0.00072**	**0.00042**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Chloride	mg/L	120	—	—	1.1	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00012	0.00014	0.0001	0.00008	0.000079	0.00012	0.00012	0.00015	0.00012
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.001	0.001	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 10
Post-closure Marmion Pit Lake Discharge - Run 2kii
Average Concentration/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines(a)			Marmion Baseline	Marmion Resevoir Mixing Basin (e)									
						1 to 4[(f)]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.00374	0.0056	0.00128	0.00018	0.00015	0.00365	0.00352	0.00101	0.00337
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1	6.5-7.1
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.4	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00052	0.00074	0.00022	0.000088	0.000085	0.0005	0.00049	0.00019	0.00047
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[(b)]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[(c)]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[(d)]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[(d)]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel[(d)]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
(a) See Appendix 2.IV for the list of all parameters, guideline and notes.
(b) Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
(e) Locations of model basins are shown on Figure 1-6.
(f) Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 11
Post-closure Marmion Pit Lake Discharge - Run 2li
Upper Bound Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		0	0.00044	0.00062	0.00032	0.00011	0.0001	0.00045	0.00044	0.00072	0.00042
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.00014	0.00017	0.00012	0.000085	0.000084	0.00014	0.00014	0.00019	0.00014
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 12
Post-closure Marmion Pit Lake Discharge - Run 2lii
Upper Bound Concentration/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]									
						1 to 4[f]	5	6	7A	7B	7C	8	9	10	11
						Proportion									
		CCME	PWQO	MISA		**0**	**0.00374**	**0.0056**	**0.00128**	**0.00018**	**0.00015**	**0.00365**	**0.00352**	**0.00101**	**0.00337**
Physical-Chemical															
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0	6.5-7.0
Major Ions															
Calcium	mg/L	—	—	—	6.4	6.4	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.4	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	21	21	21	21
Nutrients															
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.0007	0.00102	0.00028	0.000097	0.000092	0.00069	0.00066	0.00024	0.00064
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Dissolved Metals															
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00048	0.00048	0.00049	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 13
Post-closure Marmion Runoff - Run 2mi
Site Runoff at Steady State Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin (e)												
		CCME	PWQO	MISA		1	2	3	4	5	6	7A	7B	7C	8	9	10	11
						Proportion												
						0.00143	0.00167	0.00168	0.00163	0.00517	0.0063	0.04841	0.0619	0.06322	0.00542	0.0054	0.00598	0.00535
Physical-Chemical																		
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8
Major Ions																		
Calcium	mg/L	—	—	—	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.8	6.8	6.9	6.5	6.5	6.5	6.5
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	21	21	21	21	21	21	22	22	22	21	21	21	21
Nutrients																		
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.000067	0.00007	0.00007	0.00007	0.00007
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.013	0.013	0.013	0.013
Dissolved Metals																		
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.03	0.03	0.03	0.03	0.031	0.031	0.04	0.043	0.044	0.031	0.031	0.031	0.031
Antimony	mg/L	—	0.02	—	0.00078	0.00078	0.00078	0.00078	0.00078	0.00079	0.00079	0.00084	0.00085	0.00086	0.00079	0.00079	0.00079	0.00079
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.0005	0.0005	0.00049	0.00049	0.00049	0.00049
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000037	0.000037	0.000037	0.000036	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.0005	0.00051	0.00051	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00019	0.00019	0.00019	0.00017	0.00017	0.00017	0.00017
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.29	**<u>0.3</u>**	**<u>0.3</u>**	0.24	0.24	0.24	0.24
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.00029	0.0003	0.0003	0.0003	0.00029	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00036	0.00037	0.00038	0.00038	0.00036	0.00036	0.00036	0.00036
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000087	0.000088	0.000088	0.000088	0.000087	0.000087	0.000087	0.000087
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

<u>Underlined</u> values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
(a) See Appendix 2.IV for the list of all parameters, guideline and notes.
(b) Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
(c) Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
(d) Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
(e) Locations of model basins are shown on Figure 1-6.
(f) Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 14
Post-closure Marmion Runoff - Run 2mii
Site Runoff at Steady State/Maximum Concentration

Parameter	Unit	Receiving WQ Guidelines[a]			Marmion Baseline	Marmion Resevoir Mixing Basin[e]												
						1	2	3	4	5	6	7A	7B	7C	8	9	10	11
						Proportion												
		CCME	PWQO	MISA		**0.01633**	**0.01259**	**0.01227**	**0.01165**	**0.0303**	**0.0367**	**0.0753**	**0.08495**	**0.08952**	**0.02916**	**0.02848**	**0.00813**	**0.02776**
Physical-Chemical																		
pH	—	6.5-9	6.5-8.5	—	6.5	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8	6.5-6.8
Major Ions																		
Calcium	mg/L	—	—	—	6.4	6.5	6.5	6.5	6.5	6.6	6.7	6.9	7.0	7.0	6.6	6.6	6.5	6.6
Chloride	mg/L	120	—	—	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Magnesium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Potassium	mg/L	—	—	—	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Sodium	mg/L	—	—	—	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sulphate	mg/L	—	—	—	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.6	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	—	21	22	22	22	22	22	22	23	23	23	22	22	21	22
Nutrients																		
Nitrate-N	mg/L	13	—	—	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000067	0.000067	0.000067	0.000067	0.000067	0.00007	0.00007	0.00007	0.000067	0.000067	0.00007	0.00007	0.00007	0.00007
Phosphorus	mg/L	—	0.02	—	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.013	0.013	0.013	0.013
Dissolved Metals																		
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.03	0.033	0.033	0.033	0.032	0.037	0.038	0.046	0.049	0.05	0.036	0.036	0.032	0.036
Antimony	mg/L	—	0.02	—	0.00078	0.0008	0.00079	0.00079	0.00079	0.00082	0.00082	0.00087	0.00088	0.00089	0.00081	0.00081	0.00079	0.00081
Arsenic	mg/L	0.005	0.1	1	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	0.0005	0.0005	0.0005	0.00049	0.00049	0.00049	0.00049
Boron	mg/L	1.5	0.2	—	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Cadmium[c]	mg/L	see notes	0.0001-0.0005	—	0.000036	0.000036	0.000036	0.000036	0.000036	0.000037	0.000037	0.000037	0.000037	0.000037	0.000037	0.000037	0.000036	0.000036
Chromium (total)	mg/L	0.01	0.01	—	0.00048	0.00049	0.00049	0.00049	0.00049	0.0005	0.0005	0.00052	0.00052	0.00052	0.0005	0.0005	0.00049	0.0005
Cobalt	mg/L	—	0.0009	—	0.00017	0.00018	0.00017	0.00017	0.00017	0.00018	0.00018	0.00019	0.0002	0.0002	0.00018	0.00018	0.00017	0.00018
Copper[d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	—	0.24	0.25	0.25	0.25	0.25	0.27	0.28	**0.32**	**0.33**	**0.33**	0.27	0.27	0.25	0.27
Lead[d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00029	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Manganese	mg/L	—	—	—	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00036	0.00036	0.00036	0.00036	0.00036	0.00037	0.00037	0.00038	0.00038	0.00038	0.00037	0.00037	0.00036	0.00037
Nickel[d]	mg/L	0.025-0.15	0.025	1	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.000087	0.000087	0.000087	0.000087	0.000087	0.000088	0.000088	0.000088	0.000088	0.000088	0.000088	0.000088	0.000087	0.000088
Uranium	mg/L	0.015	0.005	—	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Zinc	mg/L	0.03	0.02	1	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guidelines are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 1-6.
[f] Model basins upstream of discharge point were not predicted to be influenced by effluent.

TABLE 15
Operations Lizard Lake TMF Seepage - Run 3gi
Steady State Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin [e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		0.0028	0.0039	0.0041
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7-7.8	7-7.8	7-7.8
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.34	0.37	0.38
Magnesium	mg/L	—	—	—	0.9	0.9	1.0	1.0
Potassium	mg/L	—	—	—	0.65	0.8	0.81	0.8
Sodium	mg/L	—	—	—	0.67	1.0	1.1	1.1
Sulphate	mg/L	—	—	—	1.9	2.6	2.8	2.9
Hardness	mg(CaCO^3)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**0.005**	**0.005**	**0.005**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.002	0.002
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.08	0.1	0.1
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0007	0.001	0.0011
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00097	0.00097	0.00097
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00013	0.00013	0.00013
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0012	0.0013	0.0013
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0005	0.00063	0.0006
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00083	0.00084	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guideline are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 3-11.

TABLE 16

Operations Lizard Lake TMF Seepage - Run 3gii
Steady State Concentration/ Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin[e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		0.0081	0.0095	0.0071
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7-7.8	7-7.8	7-7.8
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.5	0.55	0.5
Magnesium	mg/L	—	—	—	0.9	1.0	1.0	1.0
Potassium	mg/L	—	—	—	0.65	1.0	1.0	0.9
Sodium	mg/L	—	—	—	0.67	1.5	1.7	1.4
Sulphate	mg/L	—	—	—	1.9	3.8	4.2	4
Hardness	mg(CaCO3)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**<u>0.006</u>**	**<u>0.006</u>**	**<u>0.006</u>**
Cyanide (total)	mg/L	—	—	—	0.002	0.003	0.003	0.003
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0021	0.0024	0.002
Phosphorus	mg/L	—	0.02	—	0.0082	0.0083	0.0083	0.0083
Dissolved Metals								
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00098	0.00098	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00014	0.00015	0.00014
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0018	0.0019	0.0016
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.001	0.0011	0.0009
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0009	0.00089	0.0009
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**<u>0.0001</u>**	**<u>0.0001</u>**	**<u>0.0001</u>**	**<u>0.0001</u>**
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0026	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

<u>Underlined</u> values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guideline are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 3-11.

TABLE 17

Operations Lizard Lake TMF Seepage - Run 3hi

Maximum Percentile Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin[e]		
						Northern	Central	Southern
		CCME	PWQO	MISA		Proportion		
						0.0028	**0.0039**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0-7.7	7.0-7.7	7.0-7.7
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.45	0.52	0.5
Magnesium	mg/L	—	—	—	0.9	1.0	1.0	1.0
Potassium	mg/L	—	—	—	0.65	0.8	0.8	0.8
Sodium	mg/L	—	—	—	0.67	1.0	1.2	1.2
Sulphate	mg/L	—	—	—	1.9	2.7	3.0	3.0
Hardness	mg($CaCO^3$)/L	—	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**0.005**	**0.005**	**0.005**
Cyanide (total)	mg/L	—	—	—	0.002	0.002	0.002	0.002
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.08	0.1	0.1
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0006	0.0008	0.0009
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0083	0.0083
Dissolved Metals								
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.00097	0.00097	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00013	0.00013	0.00013
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0013	0.0015	0.0015
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0006	0.0007	0.0007
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.00083	0.00084	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.

— = Receiving water quality guideline do not exist for this parameter.

Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.

[a] See Appendix 2.IV for the list of all parameters, guideline and notes.

[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.

[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.

[d] Copper, lead and nickel guideline are hardness-dependent. See Appendix 2.IV for details.

[e] Locations of model basins are shown on Figure 3-11.

TABLE 18

Operations Lizard Lake TMF Seepage - Run 3hii
Maximum Percentile Concentration/Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin[e]		
		CCME	PWQO	MISA		Northern	Central	Southern
						Proportion		
						0.0081	0.0095	0.0071
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0-7.7	7.0-7.7	7.0-7.7
Major Ions								
Calcium	mg/L	—	—	—	10	11	11	10
Chloride	mg/L	120	—	—	0.25	0.8	0.9	0.7
Magnesium	mg/L	—	—	—	0.9	1.1	1.1	1.0
Potassium	mg/L	—	—	—	0.65	1.0	1.1	1.0
Sodium	mg/L	—	—	—	0.67	1.7	1.9	1.6
Sulphate	mg/L	—	—	—	1.9	4.1	4.5	4
Hardness	mg($CaCO^3$)/L	—	—	—	30	32	32	31
Cyanide (free)	mg/L	0.005	0.005	—	0.005	**0.006**	**0.006**	**0.006**
Cyanide (total)	mg/L	—	—	—	0.002	0.003	0.003	0.003
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.0017	0.0019	0.0015
Phosphorus	mg/L	—	0.02	—	0.0082	0.0084	0.0084	0.0083
Dissolved Metals								
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00014	0.00015	0.00014
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	**0.0022**	**0.0024**	**0.002**
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.001	0.0012	0.001
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0009	0.00089	0.0009
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Uranium	mg/L	0.015	0.005	—	0.0025	0.0026	0.0026	0.0026
Vanadium	mg/L	—	0.006	—	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guideline are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 3-11.

TABLE 19

Post-Closure Lizard Lake TMF Seepage - Run 3ni
Steady State Concentration/Average Mixing

Parameter	Unit	Receiving WQ Guidelines(a)			Lizard Lake Baseline	Lizard Lake Mixing Basin (e)		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0016**	**0.0023**	**0.0024**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0-7.3	7.0-7.3	7.0-7.3
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.3	0.3	0.3
Magnesium	mg/L	—	—	—	0.9	0.9	0.9	0.9
Potassium	mg/L	—	—	—	0.65	0.7	0.7	0.7
Sodium	mg/L	—	—	—	0.67	0.7	0.7	0.7
Sulphate	mg/L	—	—	—	1.9	1.9	1.9	2
Hardness	mg(CaCO^{3})/L	—	—	—	30	30	30	30
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	—	0.022	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.000	0.000	0.000
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00012	0.00012	0.00012
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0009	0.0009	0.0009
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	0.009435	0.009435	0.009435
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0003	0.0003	0.0003
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0008	0.0008	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	—	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055

Notes:

Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guideline are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 3-11.

TABLE 20
Post-Closure Lizard Lake TMF Seepage - Run 3nii
Steady State Concentration/ Maximum Mixing

Parameter	Unit	Receiving WQ Guidelines[a]			Lizard Lake Baseline	Lizard Lake Mixing Basin[e]		
						Northern	Central	Southern
						Proportion		
		CCME	PWQO	MISA		**0.0047**	**0.0055**	**0.0041**
Physical-Chemical								
pH	—	6.5-9	6.5-8.5	—	7.0	7.0-7.3	7.0-7.3	7.0-7.3
Major Ions								
Calcium	mg/L	—	—	—	10	10	10	10
Chloride	mg/L	120	—	—	0.25	0.3	0.3	0.3
Fluoride	mg/L	—	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	—	0.9	0.9	0.9	0.9
Potassium	mg/L	—	—	—	0.65	0.7	0.7	0.7
Sodium	mg/L	—	—	—	0.67	0.7	0.7	0.7
Sulphate	mg/L	—	—	—	1.9	1.9	1.9	2
Hardness	mg($CaCO^3$)/L	—	—	—	30	30	30	30
Nutrients								
Nitrate-N	mg/L	13	—	—	0.034	0.034	0.034	0.034
Un-ionized ammonia	mg/L	0.019	0.02	—	0.000047	0.000	0.000	0.000
Phosphorus	mg/L	—	0.02	—	0.0082	0.0082	0.0082	0.0082
Dissolved Metals								
Aluminum[b]	mg/L	0.005-0.1	0.015-0.075	—	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	—	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	—	0.0069	-	-	-
Beryllium (d)	mg/L	—	0.011-1.1	—	0.00023	-	-	-
Bismuth	mg/L	—	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	—	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	—	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.01	0.01	—	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	—	0.00012	0.00012	0.00012	0.00012
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.6	0.00087	0.0009	0.0009	0.0009
Iron (total)	mg/L	0.3	0.3	—	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.4	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	—	0.0094	0.009435	0.009435	0.009435
Mercury	mg/L	0.000026	0.0002	—	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	—	0.00032	0.0003	0.0003	0.0003
Nickel [d]	mg/L	0.025-0.15	0.025	1	0.0008	0.0008	0.0008	0.0008
Selenium	mg/L	0.001	0.1	—	0.0005	0.0005	0.0005	0.0005
Silicon	mg/L	—	—	—	2.1	-	-	-
Silver	mg/L	0.0001	0.0001	—	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	—	0.000068	-	-	-
Tin	mg/L	—	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	—	0.005	-	-	-
Uranium	mg/L	0.015	0.005	—	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	—	0.00037	-	-	-
Zinc	mg/L	0.03	0.02	1	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	—	0.002	-	-	-

Notes:
Underlined values exceed PWQO guideline. **Bold** values exceed CCME guideline. Shaded values exceed MISA guideline.
— = Receiving water quality guideline do not exist for this parameter.
Some parameters that cannot be measured in the laboratory to accurately reflect field conditions were not modelled. As such, these parameters are not presented.
[a] See Appendix 2.IV for the list of all parameters, guideline and notes.
[b] Aluminum PWQO and CCME guideline range is pH dependent. See Appendix 2.IV for details.
[c] Cadmium CCME guideline is calculated using a formula (See Appendix 2.IV) that is hardness-dependent.
[d] Copper, lead and nickel guideline are hardness-dependent. See Appendix 2.IV for details.
[e] Locations of model basins are shown on Figure 3-11.

APPENDIX 2.IV

Water Quality – Proposed Suite of Analytes, Method Detection Limits and Applicable Receiving Water Guidelines

TABLE 1
Proposed Suite of Analytes, Method Detection Limits and Applicable Receiving Water Guidelines

Parameter[a]	Unit	Receiving WQ Guidelines					
		ONTARIO DRINKING WATER STANDARDS[b][c]				CCME Water Guidelines[d]	PWQO[e]
		MAC	IMAC	AO	OG		
Field Parameters							
Temperature	°C	—	—	—	—	—	±10[f]
pH	—	—	—	—	6.5–8.5	6.5-9	6.5-8.5
Conductivity	uS/cm	—	—	—	—	—	—
Dissolved Oxygen	mg/L	—	—	—	—	5.5-9.5[g]	4-8[h]
ORP	mV	—	—	—	—	—	—
Physical-Chemical							
pH	—	—	—	—	—	6.5-9	6.5-8.5
DOC	% wt	—	—	5	—	—	—
TOC	% wt	—	—	—	—	—	—
Acidity	mg($CaCO_3$)/L	—	—	—	—	—	—
Alkalinity	mg($CaCO_3$)/L	—	—	—	30–500	—	-25%[f]
Conductivity	µS/cm	—	—	—	—	—	—
Total Suspended Solids	mg/L	—	—	—	—	+5-25[f][i]	—
Total Dissolved Solids	mg/L	—	—	500	—	—	—
Major Ions							
Calcium	mg/L	—	—	—	—	—	—
Chloride	mg/L	—	—	250	—	120-640	—
Fluoride	mg/L	1.5[j]	—	—	—	—	—
Magnesium	mg/L	—	—	—	—	—	—
Potassium	mg/L	—	—	—	—	—	—
Sodium	mg/L	—	—	200[k]	—	—	—
Sulphate	mg/L	—	—	500[l]	—	—	—
Carbonate (CO_3^{2-})	mg/L	—	—	—	—	—	—
Bicarbonate ($H(CO_3)^-$)	mg/L	—	—	—	—	—	—
Hardness	mg($CaCO_3$)/L	—	—	—	80–100	—	—
Cyanide (free)	mg/L	0.2	—	—	—	0.005	0.005
Cyanide (total)	mg/L	—	—	—	—	—	—
Nutrients							
Nitrate-N	mg/L	10[m]	—	—	—	13[n][o]-550	—
Nitrite-N	mg/L	1[m]	—	—	—	0.06[p]	—
Ammonia-N	mg/L	—	—	—	—	0.019[q]	0.02[r]
Un-ionized ammonia	mg/L	—	—	—	—	—[q]	—[r]
Phosphate	mg/L	—	—	—	—	—	—
ortho-Phosphate	mg/L	—	—	—	—	—	—
Phosphorus	mg/L	—	—	—	—	0.004-0.1[s]	0.02[n]
Organics							
Oil and Greases	mg/L	—	—	—	—	—	physically non-detect
Phenols	mg/L	—	—	—	—	0.004	0.005[n]

TABLE 1
Proposed Suite of Analytes, Method Detection Limits and Applicable Receiving Water Guidelines

Parameter[a]	Unit	Receiving WQ Guidelines					
		ONTARIO DRINKING WATER STANDARDS[b][c]				CCME Water Guidelines[d]	PWQO[e]
		MAC	IMAC	AO	OG		
Micro-organisms[t]							
Escherichia coli	per 100 mL	—	—	—	—	—	100[u]
Total coliforms	per 100 mL	—	—	—	—	—	—
Metals[v]							
Aluminum	mg/L	—	—	—	0.1	0.005-0.1[w]	0.015-0.075[n][x]
Antimony	mg/L	—	0.006	—	—	—	0.02[n]
Arsenic	mg/L	—	0.025	—	—	0.005	0.1
Barium	mg/L	1	—	—	—	—	—
Beryllium	mg/L	—	—	—	—	—	0.011-1.1[y]
Bismuth	mg/L	—	—	—	—	—	—
Boron	mg/L	—	5	—	—	1.5-29[z]	0.2[n]
Cadmium	mg/L	—	0.005	—	—	0.000017[n][aa]	0.0001-0.0005[n][ab]
Chromium (VI)	mg/L	—	—	—	—	0.001	0.001
Chromium (III)	mg/L	—	—	—	—	0.0089	0.0089
Chromium (total)	mg/L	0.05	—	—	—	—	—
Cobalt	mg/L	—	—	—	—	—	0.0009
Copper	mg/L	—	—	1	—	0.002-0.004[ac]	0.001-0.005[n][ad]
Iron (total)	mg/L	—	—	0.3	—	0.3	0.3
Lead	mg/L	0.01[ae]	—	—	—	0.001-0.007[af]	0.001-0.005[n][ag]
Manganese	mg/L	—	—	0.05	—	—	—
Mercury	mg/L	0.001	—	—	—	0.000026	0.0002
Methyl mercury	mg/L	—	—	—	—	0.000004[n]	—
Molybdenum	mg/L	—	—	—	—	0.073[n]	0.04[n]
Nickel	mg/L	—	—	—	—	0.025-0.15[ah]	0.025
Selenium	mg/L	0.01	—	—	—	0.001	0.1
Silicon	mg/L	—	—	—	—	—	—
Silver	mg/L	—	—	—	—	0.0001	0.0001
Strontium	mg/L	—	—	—	—	—	—
Thallium	mg/L	—	—	—	—	0.0008	0.0003[n]
Tin	mg/L	—	—	—	—	—	—
Titanium	mg/L	—	—	—	—	—	—
Tungsten	mg/L	—	—	—	—	—	0.03[n]
Uranium	mg/L	0.02	—	—	—	0.015-0.033	0.005[n]
Vanadium	mg/L	—	—	—	—	—	0.006[n]
Zinc	mg/L	—	—	5	—	0.03	0.02[n]
Zirconium	mg/L	—	—	—	—	—	0.004[n]
Strontium	mg/L	—	—	—	—	—	—
Thallium	mg/L	—	—	—	—	—	—
Tin	mg/L	—	—	—	—	—	—
Titanium	mg/L	—	—	—	—	—	—
Tungsten	mg/L	—	—	—	—	—	—
Uranium	mg/L	—	—	—	—	—	—
Vanadium	mg/L	—	—	—	—	—	—
Zinc	mg/L	—	—	—	—	—	—
Zirconium	mg/L	—	—	—	—	—	—

TABLE 1

Proposed Suite of Analytes, Method Detection Limits and Applicable Receiving Water Guidelines (Notes)

Notes:

— = A dash indicates that guidelines do not apply for this parameter.

Applicable guideline:

(a) Total concentrations are assumed, unless stated otherwise.

(b) Ontario Regulation (O.Reg.) 169/03: Ontario Drinking Water Standards (ODWS). Last amendment: O.Reg. 327/08. http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_030169_e.htm.

(c) MAC: Maximum Acceptable Concentration; IMAC: Interim Maximum Acceptable Concentration; AO: Aesthetic Objective; OG: Operational Guideline. The lowest values of the four sub-guideline for Ontario Drinking Water Standards were used in the results appendix (1.II) to simplify the screening of values.

(d) Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines for the Protection of Aquatic Life, Update 7.1 (December 2007). Updated as per CCME publications at www.http://ceqg-rcqe.ccme.ca/, visited 17 Janurary 2013.

(e) Provincial Water Quality Objectives, Ministry of Environment and Energy (February 1999).

(f) Compared to baseline conditions.

(g) Dissolved oxygen for warm-water biota: early life stages = 6000 µg·L-1; other life stages = 5500 µg·L-1
for cold-water biota: early life stages = 9500 µg·L-1; other life stages = 6500 µg·L-1

(h)

Dissolved Oxygen Concentration				
Temperature	Cold Water Biota		Warm Water Biota	
°C	% Saturation	mg/L	% Saturation	mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	57	5	47	4
25	63	5	48	4

(i) Under clear flow: + 25 mg·L-1 from background levels for any short-term exposure (e.g., 24-h period).
average + 5 mg·L-1 from background levels for longer term exposures (24 h<discharge<30 d).
Under high flow: + 25 mg·L-1 from background levels at any time when background levels between 25 and 250 mg·L-1.
+ 10% of background levels when background is >250 mg·L-1.

(j) Where Fluoride is added to drinking water, it is recommended that the concentration be adjusted to 0.5-0.8 mg/L the optimum level for control of tooth decay. Where supplies contain naturally occurring fluoride at levels highers than 1.5 mg/L but less than 2.4 mg/L the Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposre to fluoride from other sources.

(k) The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.

(l) When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.

(m) Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).

(n) Interim Guideline

(o) Guidelines are expressed in µg nitrate·L-1. These values are equivalent to 2900 µg nitrate-nitrogen·L-1, and 3600 µg nitrate-nitrogen·L-1, for freshwater and marine respectively.

TABLE 1
Proposed Suite of Analytes, Method Detection Limits and Applicable Receiving Water Guidelines (Notes)

(p) Guideline is expressed as µg nitrite-nitrogen·L-1. This value is equivalent to 197 µg nitrite·L-1.

(q) Un-ionized ammonia. Total ammonia:

Temp (°C)	pH							
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10
0	231	73.0	23.1	7.32	2.33	0.749	0.250	0.042
5	153	48.3	15.3	4.84	1.54	0.502	0.172	0.034
10	102	32.4	10.3	3.26	1.04	0.343	0.121	0.029
15	69.7	22.0	6.98	2.22	0.715	0.239	0.089	0.026
20	48.0	15.2	4.82	1.54	0.499	0.171	0.067	0.024
25	33.5	10.6	3.37	1.08	0.354	0.125	0.053	0.022
30	23.7	7.50	2.39	0.767	0.256	0.094	0.043	0.021

(r) ƒ = 1/(10pKa-pH +1), where ƒ is the fraction of NH3; pKa = 0.09018 + 2729.92/T; T = ambient water temperature in Kelvin (K = °C + 273.16)

(s) Ultra-oligotrophic <4 µg·.L-1; oligotrophic 4-10 µg·.L-1; mesotrophic 10-20 µg·.L-1; meso-eutrophic 20-35 µg·.L-1; eutrophic 35-100 µg·.L-1; hyper-eutrophic >100 µg·.L-1

(t) Not applicable to groundwater quality samples.

(u) Based on a geometric mean of at least 5 samples; based on a recreational water quality guideline.

(v) Guidelines apply to total metal concentrations , however, application of guidelines to dissolved metal concentrations can be employed as a screening tool.

(w) Aluminium guideline = 5 µg.L-1 at pH<6.5
= 100 µg.L-1 at pH>=6.5
(x) Aluminium guideline = 15 µg.L-1 at 4.5<pH<5.5
= +10% of background at 5.5<pH<6.5
= 75 µg/L-1 at 6.5<pH<9

(y) Beryllium guideline = 11 µg/L-1 at hardness<75 mgCaCO3/L
= 1100 µg/L-1 at hardness>75 mgCaCO3/L

(z) Respectively for long term and short term exposure.

(aa) Guideline based on Cd=10^{0.86[log(hardness)]-3.2}

(ab) Cadmium guideline = 0.1 µg/L-1 at hardness<100 mgCaCO3/L
= 0.5 µg/L-1 at hardness>100 mgCaCO3/L

(ac) Copper guideline = 2 µg·L-1 at a water hardness of 0–120 mg·L-1 (soft to medium) as CaCO3
= 3 µg·L-1 at a water harness of 120–180 mg·L-1 (hard) as CaCO3
= 4 µg·L-1 at a water harness >180 mg·L-1 (very hard) as CaCO3

(ad) Copper guideline = 1 µg/L-1 at hardness<20 mgCaCO3/L
= 5 µg/L-1 at hardness>20 mgCaCO3/L

(ae) This standard applies to water at the point of consumption. Since lead is a component in some plumbing systems, first flush water may contain higher concentrations of lead than watre that has been flushed for five minutes.

TABLE 1

Proposed Suite of Analytes, Method Detection Limits and Applicable Receiving Water Guidelines (Notes)

(af) Lead guideline	= 1 µg·L-1 at a water harness of 0–60 mg·L-1 (soft) as CaCO3 = 2 µg·L-1 at a water harness of 60–120 mg·L-1 (medium) as CaCO3 = 4 µg·L-1 at a water harness of 120–180 mg·L-1 (hard) as CaCO3 = 7 µg·L-1 at a water harness >180 mg·L-1 (very hard) as CaCO3
(ag) Lead guideline	= 1 µg/L-1 at hardness<30 mgCaCO3/L = 3 µg/L-1 at 30<hardness<80 mgCaCO3/L = 5 µg/L-1 at hardness>80 mgCaCO3/L
(ah) Nickel guideline	= 25 µg·L-1 at a water hardness of 0–60 mg·L-1 (soft) as CaCO3 = 65 µg·L-1 at a water hardness of 60–120 mg·L-1 (medium) as CaCO3 = 110 µg·L-1 at a water hardness of 120–180 mg·L-1 (hard) as CaCO3 = 150 µg·L-1 at a water hardness >180 mg·L-1 (very hard) as CaCO3