Fortune Minerals Limited NICO Cobalt-Gold-Bismuth-Copper Project



Second Round Information Request Responses

Submitted to: Mackenzie Valley Review Board 200 Scotia Centre PO Box 938 Yellowknife, NWT, X1A 2N7 Canada

Report Number: 09-13

09-1373-1004



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INFORMATION REQUESTS TŁĮCHQ GOVERNMENT





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Report No. 09-1373-1004

INFORMATION REQUEST – TG_1

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Aluminum

Can Fortune please use either the CCME guideline for aluminum to provide additional rationale for the SSWQOs?

Response

Please refer to the response to information request EC_2-2.







INFORMATION REQUEST – TG_2

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Ammonia

Please provide additional rationale to support use of an average temperature value over the summer period as opposed to the expected maximum temperature or alternatively a higher temperature should be used to derive the SSWQO.

Response

At the time of the development of the site-specific water quality objectives (SSWQOs), ammonia was identified as a chemical of potential concern (CoPC) for the NICO Project because predicted concentrations in the influent to the Effluent Treatment Facility during operations and/or in the Pit Lake during post-closure were anticipated to be greater than baseline concentrations and/or Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life, and an SSWQO was developed for this parameter. Since the development of the SSWQOs, reverse osmosis technology has been selected as the water treatment option for the NICO Project. Predicted concentrations of ammonia in Nico Lake, Peanut Lake, Burke Lake, and the Marian River during all phases of the NICO Project (i.e., construction, operations, closure, and post-closure) are below the CCME CWQG for ammonia. As such, ammonia is no longer a CoPC for the NICO Project and a SSWQO is not required for this parameter. Based on this, additional rationale to support use of an average temperature value to derive the SSWQO has not been provided.





TG_2-1

INFORMATION REQUEST – TG_3

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Arsenic

Can Fortune please discuss whether an EC50 is an appropriate basis for setting the SSWQO and why?

Response

The EC50 (median effective concentration) of 50 micrograms per litre (μ g/L) over a 14-day exposure to the green algae *Scenedesmus obliquus* was chosen as the site-specific water quality objective (SSWQO) for arsenic. The Canadian Council of Ministers of the Environment (CCME) used the same study as the basis for their Canadian Water Quality Guideline (CWQG) for the Protection of Freshwater Aquatic Life for arsenic. A safety factor of 0.1 was applied to the EC50 to derive a guideline of 5 μ g/L.

Green algae (Phylum Chlorophyta), including Scenedesmus sp. were identified in the NICO Project area (Fortune 2011). The EC50 is considered appropriate for setting the SSWQO for arsenic for several reasons. First, the lowest estimates of toxicity for Scenedesmus sp. range from a 14-day EC50 of 50 µg/L for Scenedesmus obliguus to a 20-day effect level (effect level not defined) of 960 µg/L for Scenedesmus quadricus to a 12-day EC50 of 61 000 µg/L for Scenedesmus quadricauda (CCME 2001; U.S. EPA 2007). Of these 3 species, Scenedesmus quadricauda has been identified in the NICO Project area (Fortune 2011). Second, these toxicity values are based on laboratory toxicity tests using laboratory water to which the metalloid is introduced in a highly soluble (and bioavailable) form. It is extremely difficult to simulate under laboratory conditions the variations in natural conditions that would reflect the influence of materials, such as naturally occurring ligands on arsenic speciation and availability. As a result, in the laboratory tests, the concentration of arsenic likely exerts a more profound effect on the organisms being tested than is likely to be the case within a natural setting. For example, in tests with Scenedesmus obliguus, Chen and Dai (1994) calculated 96-h LC50s of 78.7, 159.3, 12 400, and 38 700 μ g/L for arsenic as arsenite, arsenate, monomethylarsenate, and dimethylarsenate, respectively. In Nico Lake, petavalent arsenic (arsenate) accounted for 50 to 70% of the dissolved concentrations in March 2008 and 88% of the dissolved concentrations in August 2008 (one sample was collected for arsenic speciation) (Fortune 2011). Trivalent arsenic (arsenite) was 3 to 5% of the dissolved concentration. In Peanut Lake, pentavalent arsenic accounted for 35 to 55% of the dissolved concentrations in March 2008 and 32 to 62% of the dissolved concentration in August 2008. Trivalent arsenic was 40 to 50% of the dissolved concentration in March 2008 and barely detectable in August 2008 (2% of dissolved concentration or less). As such, the benchmark of 50 µg/L is likely conservative for the NICO Project area. Third, in some waterbodies in the NICO Project area (including Nico Lake where the baseline concentration is about 20 µg/L), baseline concentrations of arsenic exceed the CCME guideline, indicating that the CCME guideline is likely conservative for the area. Based on the results for Scenedesmus guadricauda, an SSWQO of 50 µg/L is likely protective of green algae present in the NICO Project area waterbodies. Toxicity values for invertebrates and fish are generally much higher than those for algae (CCME 2001; U.S. EPA 2007) and as such, the SSWQO will be protective of other aquatic species in the NICO Project area.

TG_3-1





References

- CCME (Canadian Council of Ministers of the Environment). 2001. Canadian water quality guidelines for the protection of aquatic life: Arsenic. Updated. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
- Chen, F., W. Chen, and S. Dai. 1994. Toxicities of four arsenic species to *Scenedesmus obliquus* and influence of phosphate on inorganic arsenic toxicities. Toxicol. Environ. Chem. 41(1/2): 1-7.
- Fortune (Fortune Minerals Limited). 2011. NICO Colbalt-Gold-Bismuth-Copper Project: Developer's Assessment Report. Submitted to the Mackenzie Valley Review Board. May 2011.
- U.S. EPA (United States Environmental Protection Agency). 2007. ECOTOXicology Database System. Version 4.0. United States Environmental Protection Agency. Available at: http://www.epa.gov/ecotox/.







INFORMATION REQUEST – TG_4

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Cadmium

Please provide further clarification to demonstrate how hardness was considered in developing the cadmium SSWQO. If hardness was not considered, the SSWQO should be revised to take into account the low hardness in Nico and Peanut Lakes.

Response

At the time of the development of the site-specific water quality objectives (SSWQOs), cadmium was identified as a chemical of potential concern (CoPC) for the NICO Project because predicted concentrations in the influent to the Effluent Treatment Facility during operations and/or in the Pit Lake during post-closure were anticipated to be greater than baseline concentrations and/or Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life, and an SSWQO was developed for this parameter. Since the development of the SSWQOs, ion exchange technology and more recently, reverse osmosis technology has been selected as the water treatment option for the NICO Project.

The approach used in the aquatic risk assessment to identify CoPCs for the NICO Project included comparison of predicted concentrations to CWQGs followed by comparison to baseline concentrations if predicted concentrations were greater than CWQGs (Golder 2012). Where a parameter was predicted to be elevated 10% or more above the mean baseline concentration, the parameter was identified as a CoPC of the NICO Project. Comparison to a threshold of 10% above baseline concentrations was considered to represent a conservative evaluation of whether a measurable NICO Project-related impact of surface water quality could occur. Given spatial and temporal variability, field sampling variability, variability in laboratory methods, and the conservatism applied in the predictive water quality models, any predicted increase of less than 10% above baseline concentrations was considered unlikely to reflect a "significant" change in environmental quality as a result of the NICO Project.

Predicted concentrations of cadmium in Nico, Peanut, and Burke lakes, and the Marian River under both water treatment options during all phases of the NICO Project (i.e., construction, operations, closure, and post-closure) are below baseline concentrations plus 10%. As such, cadmium is not considered to be a CoPC for the NICO Project, and a SSWQO is not required for this parameter. Based on this, clarification on how hardness was considered in the development of the SSWQO for cadmium, revisions to the SSWQO have not been provided.

Reference

Golder (Golder Associates Ltd.). 2012. NICO Cobalt-Gold-Bismuth-Copper Project, Aquatic Risk Assessment. Prepared for Fortune Minerals Limited. London, ON.





INFORMATION REQUEST – TG_5

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Copper

Please provide the combination of inputs used in the BLM in order for the proposed SSWQO to be evaluated.

Response

The Tłįchǫ Government has requested the surface water input parameters for the copper Biotic Ligand Model (BLM) used to derive the Site-specific Water Quality Objective (SSWQOs) for copper. The copper BLM was used to derive SSWQOs for Nico Lake and Peanut Lake. The surface water quality input parameters for Nico Lake are provided in Table 1. The surface water quality input parameters for Peanut Lake are provided in Table 2. To facilitate the Tłįchǫ Government's review of the derivation of the copper SSWQOs using the copper BLM, the water quality criteria generated using the BLM for Nico Lake and Peanut Lake have also been provided (Tables 3 and 4 for Nico Lake and Peanut Lake, respectively).









	Sompling	Temperature		Cu	DOC	HA ^a	Ca	Mg	Na	К	SO4	CI	Alkalinity	S ^a
Waterbody Date	Date	°C	рН	ug/L	mg C/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L CaCO₃	mg/L
Nico Lake Inflow	18-Jun-2009	13.7	7.06	1	18.4	10	5.4	2.38	1.7	0.86	0.5	0.63	21.4	1E-10
Nico Lake Inflow	28-Aug-2009	12.2	7.35	1	22.2	10	7.41	3.46	2.4	0.68	0.5	1.07	35.1	1E-10
Nico Lake-Deep Top	15-Jun-2007	15.9	7.6	3.8	15.2	10	8.79	3.42	2.23	1.05	1.7	0.7	29	1E-10
Nico Lake-Deep Top	24-Mar-2008	1.35	7.5	1.9	18.4	10	11	4.9	3.2	1.5	6	1	43	1E-10
Nico Lake-Deep Top	18-Jun-2009	15.7	7.16	1.2	18.1	10	8.52	3.19	2.2	1.03	3.94	1.38	28.7	1E-10
Nico Lake-Deep Top	28-Aug-2009	14.7	7.67	2.3	19	10	7	3.28	2	0.82	3.44	0.51	31	1E-10
Nico Lake-Deep Top	05-Apr-2010	0.77	7.38	1.3	19.4	10	9.97	4.48	2.6	1.09	4.91	0.8	38.1	1E-10
Nico Lake-Shallow	18-Jun-2009	15.2	7.28	1.2	17.7	10	8.57	3.17	2.2	1.05	3.79	1.26	31.1	1E-10
Nico Lake-Shallow	28-Aug-2009	14.8	7.66	1.2	18.5	10	7.36	3.38	2.2	0.91	3.44	0.52	31.4	1E-10
Nico Lake-Shallow	05-Apr-2010	1.23	7.46	1.4	19	10	9.78	4.44	2.6	1.14	4.66	0.75	38.4	1E-10
Nico-Peanut Creek Outflow	18-Jun-2009	15.5	7.31	1.2	17	10	8.3	3.05	2.1	0.97	3.41	0.72	30.6	1E-10
Nico-Peanut Creek Outflow	28-Aug-2009	14.8	7.63	1.2	18.3	10	7.17	3.29	2.1	0.89	3.42	0.51	30.5	1E-10

Table 1: Surface Water Quality Input Parameters for Nico Lake for the Copper Biotic Ligand Model

^a Assumed value (BLM User's Guide and Reference Manual, February 2007).

Bold/Italicized text = <method detection limit (mdl).

Table 2: Surface Water Quality Input Parameters for Peanut Lake for the Copper Biotic Ligand Model

	Sompling	Temperature		Cu	DOC	HA ^a	Са	Mg	Na	К	SO4	CI	Alkalinity	S ^a
Waterbody	Date	°C	ug/L	mg C/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L CaCO₃	mg/L	
Peanut Lake-Deep Top	16-Jun-2007	15.9	7.6	1.7	12.2	10	6.86	3.16	2.57	1.23	0.5	0.8	31	1E-10
Peanut Lake-Deep Top	23-Mar-2008	7	7.5	1.1	13.5	10	8.5	4.2	3.7	1.7	1	1	41	1E-10
Peanut Lake-Deep Top	18-Jun-2009	16.8	7.34	1	14.8	10	7.25	2.91	2.4	1.12	1.63	1.12	31.6	1E-10
Peanut Lake-Deep Top	05-Apr-2010	1.02	7.42	1	13.1	10	8.6	4.08	3	1.37	1.05	0.87	40.8	1E-10
Peanut Lake-Shallow	18-Jun-2009	16.8	7.32	1	14.7	10	7.37	2.93	2.4	1.21	1.49	0.82	30.3	1E-10
Peanut Lake-Shallow	05-Apr-2010	0.77	7.32	1	12.2	10	8.37	4	3	1.51	0.62	0.89	41.7	1E-10
Peanut Lake Outflow	18-Jun-2009	16.2	7.37	1	14.1	10	6.45	3.05	2.3	1.14	1.33	0.76	31.6	1E-10
Peanut Lake Outflow	30-Aug-2009	17.4	7.77	1	16.1	10	6.8	3.26	2.4	0.98	1.15	0.63	34	1E-10

^a Assumed value (BLM User's Guide and Reference Manual, February 2007).

Bold/Italicized text = <method detection limit (mdl).



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Table 3: Water Quality Criteria for Copper for Nico Lake

Waterbody	Sampling Date	Final Acute Value	Criterion Maximum Concentration	Criterion Continuous Concentration	Copper Concentration	Acute Toxic Units
	2410	(FAV), ug/L	(CMC=FAV/2), ug/L	(CCC=FAV/ACR), ug/L	ug/L	(Acute TU=Cu/CMC)
Nico Lake Inflow	18-Jun-09	83.2453	41.6226	25.8526	1	0.024
Nico Lake Inflow	28-Aug-09	146.9819	73.4909	45.6466	1	0.0136
Nico Lake-Deep Top	15-Jun-07	133.3831	66.6915	41.4233	3.8	0.057
Nico Lake-Deep Top	24-Mar-08	138.5303	69.2651	43.0218	1.9	0.0274
Nico Lake-Deep Top	18-Jun-09	89.7905	44.8952	27.8852	1.2	0.0267
Nico Lake-Deep Top	28-Aug-09	184.474	92.237	57.2901	2.3	0.0249
Nico Lake-Deep Top	5-Apr-10	126.7743	63.3871	39.3709	1.3	0.0205
Nico Lake-Shallow	18-Jun-09	103.3893	51.6947	32.1085	1.2	0.0232
Nico Lake-Shallow	28-Aug-09	176.9121	88.456	54.9416	1.2	0.0136
Nico Lake-Shallow	5-Apr-10	137.0052	68.5026	42.5482	1.4	0.0204
Nico-Peanut Creek Outflow	18-Jun-09	103.3258	51.6629	32.0888	1.2	0.0232
Nico-Peanut Creek Outflow	28-Aug-09	169.0959	84.548	52.5143	1.2	0.0142

CMC = Criterion Maximum Concentration; CCC = Criterion Continuous Concentration; Cu = copper; ug/L = micrograms per litre





Table 4: Water Quality Criteria for Copper for Peanut Lake

Waterbody	Sampling Date	Final Acute Value	Criterion Maximum Concentration	Criterion Continuous Concentration	Copper Concentration	Acute Toxic Units
		(FAV), ug/L	(CMC=FAV/2), ug/L	(CCC=FAV/ACR), ug/L	ug/L	(Acute TU=Cu/CMC)
Peanut Lake-Deep Top	16-Jun-07	106.9479	53.474	33.2136	1.7	0.0318
Peanut Lake-Deep Top	23-Mar-08	102.4362	51.2181	31.8125	1.1	0.0215
Peanut Lake-Deep Top	18-Jun-09	94.0481	47.024	29.2075	1	0.0213
Peanut Lake-Deep Top	5-Apr-10	88.6467	44.3233	27.53	1	0.0226
Peanut Lake-Shallow	18-Jun-09	90.9343	45.4672	28.2405	1	0.022
Peanut Lake-Shallow	5-Apr-10	72.3789	36.1894	22.4779	1	0.0276
Peanut Lake Outflow	18-Jun-09	93.2855	46.6428	28.9707	1	0.0214
Peanut Lake Outflow	30-Aug-09	176.2766	88.1383	54.7443	1	0.0113

CMC = Criterion Maximum Concentration; CCC = Criterion Continuous Concentration; Cu = copper; ug/L = micrograms per litre





INFORMATION REQUEST – TG_6

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Iron

Can you please provide additional rationale for modifying the CCME along with more detail from the primary reference source.

Response

A site-specific water quality objective (SSWQO) of 1500 micrograms per litre (µg/L) was proposed for the NICO Project (Fortune 2011).

The Canadian Council of Ministers of the Environment (CCME) has established a Canadian Water Quality Guideline (CWQG) for the Protection of Freshwater Aquatic Life for iron of 300 µg/L based on a guideline developed by the International Joint Commission (IJC) and the Ontario Ministry of the Environment (Canadian Council of Resource and Environment Ministers [CCREM] 1987). The CCREM (1987) cites acute values for iron for aquatic insects that ranged from 320 to 16 000 µg/L. However, the most sensitive species was the mayfly (Ephemerella subvaria) and this species (and family) has not been identified in the NICO Project area (Fortune 2011). Gamarus minus did not exhibit any adverse effects on reproduction and growth an iron concentration of <3 milligrams per litre (Sykora et al. 1972; as cited in CCREM 1987) and this family has been identified in the NICO Project area (Fortune 2011). The CCREM goes on to note that chronic toxicity to fathead minnows was recorded in a study by Sykora et al. (1972; as cited in CCREM 1987) at an acid mine drainage site at 1500 µg/L (50% reduction in egg hatchability). Similar responses were noted in brook trout eggs at 12 000 µg/L, indicating that brook trout were much less sensitive than fathead minnows. The CCREM cites the safe concentration for brook trout juveniles as ranging between 7500 and 12 520 µg/L. Fish species of the family Salmonidae (the family to which brook trout belong) have been identified in the NICO Project area, however, fish species of the family Cyprinidae (the family to which fathead minnows belong) have not been identified in the NICO Project area (Fortune 2011).

Guay et al. (2000) undertook a review of the toxicity data for iron. A brief summary of this work is provided here. In the pH range of $6.0 \le pH \le 8.5$, which is applicable to the pH conditions for the NICO Project area, *Ephemeralla subvaria* and *Cheumatopsyche* sp. were the most sensitive aquatic insects to iron with LC50 values of 300 and 800 µg/L, respectively. These species (and families) have not been identified in the NICO Project area (Fortune 2011). The next most sensitive aquatic insects were *Acroneuria lycorias* and *Hydropsyche betteni* with 96-h LC50s of 16 000 µg/L. *Hydropsyche betteni* has been identified in the NICO Project area (Fortune 2011). For zooplankton, toxicity values ranged upwards from 3000 µg/L for *Gamarus minus*, which has been identified in the NICO Project area (Fortune 2011). For zooplankton, toxicity values ranged upwards from 3000 µg/L for *Gamarus minus*, which has been identified in the NICO Project area (Fortune 2011). For zooplankton, toxicity values ranged upwards from 3000 µg/L for *Gamarus minus*, which has been identified in the NICO Project area (Fortune 2011). For zooplankton, toxicity values ranged upwards from 3000 µg/L for *Gamarus minus*, which has been identified in the NICO Project area (Fortune 2011). For appeared to be the most sensitive to iron with a 96-h LC50 of 600 µg/L. No observed effect concentrations (NOECs) and lowest observed effect concentrations (LOECs) ranged upwards from 1500 µg/L for fathead minnows. For salmonids, NOECs ranged upwards from 1500 µg/L and LOECs ranged upwards from 3000 µg/L. Neither carp, fathead minnow, nor other species of the Cyprinidae family have been identified in the NICO Project area.

TG_6-1





Recognizing the short-comings of several guidelines for iron (that is, the guidelines are based on data for fish at sites receiving acid mine drainage with further support provided from acute data with a few fish species and a sensitive aquatic invertebrate), the complexity of iron chemistry (and thus toxicity) such that estimating toxicity from laboratory-based studies is difficult, and the need to protect aquatic life from both the direct (toxic) and indirect (physical) effects of iron, Linton et al. (2007) established bioassessment-based benchmarks for total iron using field-based research. In brief, quantile regression was used to model the decline in maximum abundance of organisms along a gradient of increasing iron concentrations for 8 different families of benthic invertebrates using data available from a biological monitoring program in streams of West Virginia. The benchmarks were derived based on benthic invertebrates given that these aquatic organisms have been demonstrated to be the most sensitive to iron. Using this approach, Linton et al. (2007) derived benchmarks of 210 µg/L (20% reduction in sensitive group) and 1700 µg/L (50% reduction in moderately sensitive group) for total iron. The benchmark of 210 µg/L allows no to minimal changes in community structure, and community functions are fully maintained. The benchmark of 1700 µg/L allows slight to moderate changes in community structure, and function is fully or largely maintained. It should be noted that none of the sensitive and moderately sensitive families included in the Linton et al. (2007) study were identified in the NICO Project study area (Fortune 2011). The tolerant families included in the Linton et al. (2007) study (Baetidae and Tipulidae) were identified in the NICO Project area (Fortune 2011). In their derivation of a guideline for total iron, the British Columbia Ministry of Environment (BCMOE 2008) used the work of Linton et al. (2007) as the basis for their guideline of 1000 µg/L. The benchmark of 1700 µg/L is also consistent with that derived by others (Randall et al. 1999).

To summarize, modification of the CCME CWQG to develop a SSWQO for iron of 1500 μ g/L is considered appropriate for the following reasons:

- The CWQG has not been updated since 1987 and it is based on data for fish from a site receiving acid mine drainage (which is not relevant to the NICO Project) with further support provided from acute data with a sensitive aquatic invertebrate. Both species (and families) upon which the guideline is based have not been identified in the NICO Project area.
- In consideration of a more recent toxicity data review (Guay et al. 2000), pH levels applicable to the NICO Project area and species (and families) known to occur in the NICO Project area (Fortune 2011), NOECs for iron range upwards from 1500 μg/L.
- Based on benchmarks that represent the most recent and best field-based research on the toxicity of iron (Linton et al. 2007), and that have been recently used in support of the development of the BCMOE guideline for total iron of 1000 µg/L (BCMOE 2008), a benchmark of 1700 µg/L would be protective of aquatic life identified in the NICO Project area.

Based on the above discussion, an SSWQO for iron of 1500 µg/L is considered appropriate for the NICO Project.

References

- BCMOE (British Columbia Ministry of Environment). 2008. Ambient water quality guidelines for iron. Science and Information Branch. Water Stewardship Division. Ministry of Environment. Victoria, BC.
- CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines.





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- Linton, T.K., M.A.W. Pacheco, D.O. McIntyre, W.H. Clement, and J. Goodrich-Mahoney. 2007. Development of bioassessment-based benchmarks for iron. Environ. Toxicol. Chem. 26:1291-1298.
- Randall S., D. Harper, and B. Brieriey. 1999. Ecological and ecophysiological impacts of ferric dosing in reservoirs. *Hydrobiol*. 395/396:355-364.





INFORMATION REQUEST – TG_7

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Lead

Please provide further clarification as to how toxicity data for aquatic biota other than fish (e.g. Hyalella azteca) was considered in the setting of the SSWQO.

Response

The site-specific water quality objective (SSWQO) for lead was re-evaluated with respect to other potential receptors (e.g., *Hyalella azteca*) and as a result of the change from the ion exchange to the reverse osmosis treatment system.

The development of the SSWQO for lead as presented in the Developer's Assessment Report (Fortune 2011) considered the toxicity data for fish, invertebrates, and algae summarized in Canadian Council of Resource and Environment Ministers (CCREM) (1987) which is the source of the current Canadian Water Quality Guideline (CWQG) for lead. Rainbow trout are the most sensitive to chronic lead exposure. In soft water, the CCREM provides a maximum acceptable toxicant concentration (MATC) of 4.1 to 7.6 micrograms per litre (μ g/L) based on blackening of the tails and spinal curvature in fingerlings (CCREM 1987). Aquatic invertebrates and algae are less sensitive. The CCREM indicates that reproduction of *Daphnia magna* was impaired by 16% at a concentration of 30 μ g/L in soft water, and adverse effects on algae range upwards from 500 μ g/L (CCREM 1987).

Hyalella azteca was not considered in setting the SSWQO for lead. This species is sensitive to acute and chronic lead exposure with a 96-h LC50 (median lethal concentration) of 1 μ g/L in soft water (Borgmann et al. 2005) and a 28- to 35-d IC25 (concentration that causes a 25% reduction in a non-lethal biological measurement) for reproduction of 2.8 μ g/L (Besser et al. 2005). The IC25 reported by Besser et al. (2005) is based on dissolved lead concentrations. These studies do not consider the demonstrated protective influence of dissolved organic carbon (DOC) on lead toxicity to aquatic organisms (Schwartz et al. 2004).

Predicted total concentrations of lead in Nico Lake, Peanut Lake, Burke Lake, and the Marian River are below the applicable Canadian Council of Ministers of the Environment (CCME) CWQG for the Protection of Freshwater Aquatic Life of 1 μ g/L for all phases of the NICO Project, with the exception of the lead concentration in Nico Lake during post-closure (Fortune 2011; Golder 2012). During post-closure, the lead concentration is predicted to reach 1.8 μ g/L in Nico Lake, only slightly above the CWQG. End of pipe projections for lead are below the CWQG (Golder 2012), therefore the slight exceedance of the CWQG in Nico Lake during post-closure is attributable to dust deposition. A number of very conservative assumptions were used in the air quality modelling which results in an overestimate of dust deposition. Together with the conservative assumptions used in the water quality modelling, these assumptions have likely resulted in an overestimation of lead concentrations in Nico Lake during post-closure

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likely will not exceed the CWQG. As such, the SSWQO for lead has been re-set to the current CWQG for lead (in waters in the hardness range of 0 to 60 mg/L as $CaCO_3$) of 1 μ g/L.

References

- Besser, J.M., W.G. Brumbaugh, E.L. Brunson, and C.G. Ingersoll. 2005. Acute and chronic toxicity of lead in water and diet to the amphipod *Hyalella azteca*. Environ. Toxicol. Chem. 24 (7): 1807-1815.
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INFORMATION REQUEST – TG_8

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Nitrate

- 8.1) Can Fortune please identify an SSWQO that is protective of early life stages of fish?
- 8.2) Please clarify whether the SSWQO value expressed as mg-N/L or mg-NO₃/L.

Response

Response 8.1

The site-specific water quality objective (SSWQO) for nitrate is based on a 10-d lowest observed effect concentration (LOEC; 15% reduction in tadpole body weight) of 133 milligrams (mg) NO₃⁻/L for the pacific tree frog. The pacific tree frog does not occur in the NICO Project area; however, the wood frog which is known to occur in the vicinity of the NICO Project, has a similar sensitivity to nitrate and for this reason, the data for the pacific tree frog was used to identify the SSWQO for nitrate.

The development of the SSWQO for nitrate considered the toxicity data for aquatic plants, invertebrates, amphibians, and fish (including early life stages) summarized in the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guideline for the Protection of Aquatic Life factsheet on the nitrate ion (CCME 2003). Based on the data provided in this fact sheet, 96-h LC50s (median lethal concentrations) for adult fish ranged from 5800 mg NO₃⁻⁷/L for chinook salmon to 8753 mg NO₃⁻⁷/L for the bluegill sunfish. Chronic (7-d) exposures of NO₃⁻ to larval fish resulted in LOECs for fathead minnows of 3176 mg NO₃⁻⁷/L and 6353 mg NO₃⁻⁷/L for growth and mortality endpoints, respectively. 7-d LC50 values of 4700 and 4800 mg NO₃⁻⁷/L were reported for fingerlings of rainbow trout and chinook salmon. Based on the review of the toxicity data provided for fish in CCME (2003), the chosen SSWQO for nitrate is well below the concentrations that would be expected to result in adverse effects on fish.

In 2009, the British Columbia Ministry of Environment updated their chronic guideline for nitrate (BCMOE 2009). The update included consideration of the work of McGurk et al. (2006) on the acute and chronic toxicity of nitrate to early life stages of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*). Both species of fish have been identified in the NICO Project area (Fortune 2011). In the chronic tests, McGurk et al. (2006) observed an effect on fry weight (10% decrease relative to control) at a concentration of 27 mg NO₃⁻/L (6.25 mg NO₃-N/L). The SSWQO for nitrate has been re-set to 27 mg NO₃⁻/L.

Response 8.2

The SSWQO for nitrate is expressed as $mg-NO_3^{-}/L$.





References

- BCMOE (British Columbia Ministry of Environment). 2009. Water Quality Guidelines for Nitrogen (Nitrate, Nitrite and Ammonia). Addendum to Technical Appendix. Water Stewardship Division. September 2009.
- CCME (Canadian Council of Ministers of the Environment). 2003. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Nitrate Ion. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
- McGurk, M.D, F. Landry, A. Tang, and C.C. Hanks. 2006. Acute and chronic toxicity of nitrate to early life stages of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*). Environ. Toxicol. Chem. 25 (8): 2187-2196.







INFORMATION REQUEST – TG_9

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Selenium

Can Fortune please identify an SSWQO that is protective of fish?

Response

The chronic water quality criterion developed by the United States Environmental Protection Agency (U.S. EPA 2009) of 5 micrograms per litre (μ g/L) was proposed as the site-specific water quality objective (SSWQO) for selenium for the NICO Project.

The U.S. EPA recently developed a draft chronic water quality criterion for selenium that is based on the concentration of selenium in fish tissue rather than the concentration of selenium in the water (U.S. EPA 2004). The U.S. EPA believes, as do other experts in the field, that a tissue-based criterion better addresses the highly bioaccumulative nature of selenium than a water-based criterion. The U.S. EPA's proposed tissue-based criterion of 7.91 microgram per gram is founded on the whole-body concentration of selenium in juvenile bluegill associated with winter mortality. Fish are the most sensitive aquatic organisms to chronic selenium exposure, and for this reason, the chronic criterion is based on fish and not other aquatic organisms, such as plants and aquatic invertebrates.

The U.S. EPA draft tissue-based criterion is based primarily on data from warm water fish species so there has been some debate as to whether the tissue criterion is applicable to cold water fish species such as would be applicable to the NICO Project. Recent work indicates that cold water fish species, including white sucker and northern pike which have been captured in the NICO Project area (Fortune 2011), are less or equally sensitive to selenium as warm water species (de Rosmond et al. 2005; Muscatello et al. 2006; Chapman 2007). Thus, the U.S. EPA (2004) draft criterion will provide a conservative level of protection for these cold water fish species.

Because baseline data for the NICO Project includes both water quality and fish tissue concentrations, the following approach has now been used to derive a SSWQO for selenium for the receiving environment (i.e., for Peanut Lake) that is protective of fish:

- Using baseline water and fish tissue concentrations, selenium bioaccumulation factors (BAFs) were calculated for all fish collected and analysed for tissue selenium concentrations from Peanut Lake (i.e., the concentration of selenium in the water that has resulted in the measured concentration in fish tissue);
- Assuming that selenium would continue to be accumulated by fish through the same pathways as under current conditions, the concentration in water (Peanut Lake) that would result in accumulation of selenium in fish tissues at the level of the U.S. EPA fish-tissue based criterion was calculated; and
- The calculated concentration in water was proposed as the SSWQO for selenium.

The details of the derivation are provided below:





Baseline fish tissue data for Peanut Lake includes both muscle and liver tissue data for northern pike and lake whitefish (Table 1). The U.S. EPA tissue-based criterion is based on a whole body concentration of selenium on a dry weight basis. As per guidance provided in the U.S. EPA draft criterion document (U.S. EPA 2004), the muscle tissue data was used to convert into an equivalent whole body concentration. The muscle tissue data for Peanut Lake was reported on a wet weight basis. The concentrations were converted to dry weight using a moisture content of 0.80, as recommended in the draft criterion document (U.S. EPA 2004). Whole body selenium concentrations were estimated from selenium concentrations in the muscle using the following equation developed by the U.S. EPA (2004):

 $[Se_{whole \ body}] = exp(0.1331 + (0.8937 \times In[Se_{muscle}]))$

- The average selenium water concentration was calculated for Peanut Lake (Table 2). Average water concentrations were used because the tissue concentrations represent integrated exposure, so they should be compared to temporally and spatially averaged water concentrations.
- BAFs were calculated for all fish collected from Peanut Lake by dividing the calculated whole body selenium concentrations by the average selenium water concentration (Table 1).
- SSWQOs were calculated by dividing the U.S. EPA tissue-based criterion of 7.91 mg/kg by the BAFs (Table 1).

The calculated SSWQOs for selenium ranged from 3.5 to 6.3 μ g/L for Peanut Lake. An SSWQO of 3.5 μ g/L is now proposed for the NICO Project.





Waterbody Code		Code Date		Muscle Se	Muscle Se	Whole Body Se (muscle) ^b	Mean Water Se Concentration ^c	BAF ^d	AWQC ^e	SSWQO
Name	Name (Muscle)			(mg/kg ww)	(mg/kg dw) ^a	(mg/kg dw)	(mg/L)	(L/kg)	(mg/kg)	(µg/L)
Peanut Lake	1	24-Sep-06	LKWH 001	0.100	0.5	0.6149	0.0003751	1639	7.9	4.8
Peanut Lake	H21284	18-Sep-07	LKWH	0.1	0.5	0.6149	0.0003751	1639	7.9	4.8
Peanut Lake	L820166-21	19-Nov-08	LKWH 001	0.117	0.585	0.7075	0.0003751	1886	7.9	4.2
Peanut Lake	23	19-Nov-08	LKWH 002	0.115	0.575	0.6967	0.0003751	1857	7.9	4.3
Peanut Lake	L820166-25	19-Nov-08	LKWH 003	0.090	0.45	0.5596	0.0003751	1492	7.9	5.3
Peanut Lake	L820166-27	19-Nov-08	LKWH 004	0.105	0.525	0.6423	0.0003751	1712	7.9	4.6
Peanut Lake	L820166-29	19-Nov-08	LKWH 005	0.098	0.49	0.6039	0.0003751	1610	7.9	4.9
Peanut Lake	L814228-11	19-Nov-08	LKWH 16	0.116	0.58	0.7021	0.0003751	1872	7.9	4.2
Peanut Lake	L814228-12	19-Nov-08	LKWH 17	0.138	0.69	0.8199	0.0003751	2186	7.9	3.6
Peanut Lake	L814228-13	19-Nov-08	LKWH 18	0.139	0.695	0.8253	0.0003751	2200	7.9	3.6
Peanut Lake	8	19-Nov-08	NRPK 14	0.102	0.51	0.6258	0.0003751	1668	7.9	4.7
Peanut Lake	9	19-Nov-08	NRPK 15	0.073	0.365	0.4641	0.0003751	1237	7.9	6.4
Peanut Lake	L814228-10	27-Aug-09	NRPK 19	0.125	0.625	0.7506	0.0003751	2001	7.9	3.9

Table 1: Derivation of a Site-Specific Water Quality Objective for Selenium

^a The wet weight concentrations were converted to dry weight using a moisture content of 0.80, as recommended in the U.S. EPA draft criterion document (U.S. EPA 2004).

^b As per guidance provided in the U.S. EPA draft criterion document (U.S. EPA 2004), the muscle tissue data was used to convert into an equivalent whole body concentration using the following equation:

 $[Se_{whole body}] = exp(0.1331+(0.8937*In[Se_{muscle}]))$

where [Se_{muscle}] = mg/kg dw.

^c The water chemistry data used in the derivation of a site-specific water quality objective for Se is provided in Table 2.

^d BAFs (bioaccumulation factors) were calculated using the following equation:

 $\mathsf{BAF} = [\mathsf{Se}_{\mathsf{wholebody}}] \div \mathsf{average} \ [\mathsf{Se}_{\mathsf{water}}]$

^e AWQC = Ambient Water Quality Criterion (U.S. EPA 2004).

^f SSWQOs (Site-specific water quality objectives) were calculated using the following equation:

SSWQO = AWQC÷BAF

LKWH = lake whitefish; NRPK = northern pike; Se = selenium; SSWQO = site-specific water quality objective; mg/kg ww = milligram per kilogram wet weight; mg/kg dw = milligram per kilogram dry weight; mg/L = milligram per litre; L/kg = litre per kilogram; mg/kg = milligram per kilogram; μg/L = microgram per litre



Table 2: Water Chemistry Data Used in the Derivation of a Site-Specific Water Quality Objective for Selenium

Waterbody Name	Sampling Location	Date Collected	Water Se Concentration		
			(µg/L)		
Peanut Lake	Deep Тор	14-Jun-2005	0.4		
Peanut Lake	Deep Тор	25-Jul-2005	0.4		
Peanut Lake	Deep Тор	06-Jun-2006	0.7		
Peanut Lake	Deep Тор	27-Jul-2006	0.4		
Peanut Lake	Deep Тор	16-Jun-2007	0.5		
Peanut Lake	Deep Тор	03-Aug-2007	0.5		
Peanut Lake	Deep Тор	23-Mar-2008	1		
Peanut Lake	Deep Тор	16-Aug-2008	0.04		
Peanut Lake	Deep Тор	15-Mar-2009	0.4		
Peanut Lake	Deep Тор	18-Jun-2009	0.4		
Peanut Lake	Deep Тор	30-Aug-2009	0.5		
Peanut Lake	Deep Тор	05-Apr-2010	0.4		
Peanut Lake	Shallow	11-Jul-2004	0.4		
Peanut Lake	Shallow	27-Jul-2006	0.4		
Peanut Lake	Shallow	16-Aug-2008	0.04		
Peanut Lake	Shallow	15-Mar-2009	0.4		
Peanut Lake	Shallow	18-Jun-2009	0.4		
Peanut Lake	Shallow	30-Aug-2009	0.5		
Peanut Lake	Shallow	05-Apr-2010	0.4		
Peanut Lake	Deep Bottom	14-Jun-2005	0.4		
Peanut Lake	Deep Bottom	25-Jul-2005	0.4		
Peanut Lake	Deep Bottom	06-Jun-2006	0.8		
Peanut Lake	Deep Bottom	27-Jul-2006	0.4		
Peanut Lake	Deep Bottom	16-Jun-2007	0.5		
Peanut Lake	Deep Bottom	23-Mar-2008	1		
Peanut Lake	Deep Bottom	16-Aug-2008	0.04		
Peanut Lake	Deep Bottom	18-Jun-2009	0.4		
Peanut Lake	Deep Bottom	30-Aug-2009	0.5		
Peanut Lake	Deep Bottom	05-Apr-2010	0.4		
Peanut Lake	Nico-Peanut Creek Outflow	14-Jun-2005	0.4		
Peanut Lake	Nico-Peanut Creek Outflow	06-Jun-2006	0.4		
Peanut Lake	Nico-Peanut Creek Outflow	23-Mar-2008	1		
Peanut Lake	Nico-Peanut Creek Outflow	15-Aug-2008	0.06		
Peanut Lake	Nico-Peanut Creek Outflow	17-Mar-2009	0.4		
Peanut Lake	Nico-Peanut Creek Outflow	18-Jun-2009	0.4		
Peanut Lake	Nico-Peanut Creek Outflow	28-Aug-2009	0.51		





Table 2: Water Chemistry Data Used in the Derivation of a Site-Specific Water Quality Objective for Selenium (continued)

Waterbody Name	Sampling Location	Date Collected	Water Se Concentration			
			(µg/L)			
Peanut Lake	Nico-Peanut Creek Outflow	08-Apr-2010	0.4			
Peanut Lake	Peanut Lake Outflow	14-Jun-2005	0.4			
Peanut Lake	Peanut Lake Outflow	07-Jun-2006	0.4			
Peanut Lake	Peanut Lake Outflow	16-Aug-2008	0.04			
Peanut Lake	Peanut Lake Outflow	16-Mar-2009	0.4			
Peanut Lake	Peanut Lake Outflow	18-Jun-2009	0.4			
Peanut Lake	Peanut Lake Outflow	30-Aug-2009	0.5			
Peanut Lake	Peanut Lake Outflow	08-Apr-2010	0.4			
Average Water Se Concentration (µg/L) 0.3751						

Note: 0.4 = method detection limit (mdl). Se = Selenium; μ g/L = microgram per litre

References

Chapman, P.M. 2007. Selenium thresholds for fish from cold waters. Hum Ecol Risk Assess. 13:20-24.

- de Rosmond, S.C., K. Liber, and A. Rosaasen. 2005. Relationship between embryo selenium concentration and early life stage development in white sucker (*Catostomus commersoni*) from a northern Canadian lake. Bull Envrion Contam Toxicol. 74:1134-1142.
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- Muscatello, J.R., P.M. Bennett, K.T. Himbeault, A.M. Belknap, and D.M. Janz. 2006. Larval deformities associated with selenium accumulation in northern pike (*Esox lucius*) exposed to metal mining effluent. Environ Sci Technol. 40:6506-6512.
- U.S. EPA (United States Environmental Protection Agency). 2004. Draft Aquatic Life Water Quality Criteria for Selenium – 2004. U.S. Environmental Protection Agency. Office of Water. Office of Science and Technology. November 2004. EPA-822-D-04-001. Washington, DC.
- U.S. EPA. 2009. National Recommended Water Quality Criteria (NAWQC): 2009. Office of Water. Office of Science and Technology. Washington, DC.

TG_9-5





INFORMATION REQUEST – TG_10

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Uranium

Can Fortune please identify an SSWQO that considers information on Hyalella azteca?

Response

At the time of the development of the site-specific water quality objectives (SSWQOs), uranium was identified as a chemical of potential concern (CoPC) for the NICO Project because predicted concentrations in the influent to the Effluent Treatment Facility during operations and/or in the Pit Lake during post-closure were anticipated to be greater than baseline concentrations and/or Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life, and an SSWQO was developed for this parameter. Since the development of the SSWQOs, reverse osmosis technology has been selected as the water treatment option for the NICO Project. Predicted concentrations of uranium in Nico Lake, Peanut Lake, Burke Lake, and the Marian River during all phases of the NICO Project (i.e., construction, operations, closure, and post-closure) are below the CCME CWQG for uranium. As such, uranium is no longer a CoPC for the NICO Project and a SSWQO is not required for this parameter. Based on this, an SSWQO that considers information on *Hyalella azteca* has not been identified.





INFORMATION REQUEST – TG_11

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Zinc

Can Fortune please identify an SSWQO for zinc that considers information for aquatic biota such as *Hyalella azteca*?

Response

At the time of the development of the site-specific water quality objectives (SSWQOs), zinc was identified as a chemical of potential concern (CoPC) for the NICO Project because predicted concentrations in the influent to the Effluent Treatment Facility during operations and/or in the Pit Lake during post-closure were anticipated to be greater than baseline concentrations and/or Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQG) for the Protection of Aquatic Life, and an SSWQO was developed for this parameter. Since the development of the SSWQOs, reverse osmosis technology has been selected as the water treatment option for the NICO Project. Predicted concentrations of zinc in Nico, Peanut, and Burke lakes, and the Marian River during all phases of the NICO Project (i.e., construction, operations, closure, and post-closure) are below the CCME CWQG for zinc. As such, zinc is no longer a CoPC for the NICO Project and a SSWQO is not required for this parameter. Based on this, an SSWQO for zinc that considers information for aquatic biota, such as *Hyalella azteca*, has not been identified.





INFORMATION REQUEST – TG_12

Source: Tłįchǫ Government (TG)

Request

SSWQOs Developed for NICO Project: Effluent Treatment

- 12.1) As noted above, one aspect of the developments of the SSWQO that needs to be discussed is the level of protection used in setting the SSWQOs. For example, are the SSWQOs intended to correspond to a NOEC, LOEC, EC10, EC20 or some other level of protection?
- 12.2) Can Fortune please confirm in writing whether SSWQOs will be applied to effluent discharges (i.e., endof-pipe) or to the receiving environment?

Response

Response 12.1

The site-specific water quality objectives (SSWQOs) were derived from low-effect data, and generally used the following tiered approach (i.e., the most preferred acceptable to the least preferred acceptable endpoint):

- EC_x/IC_x representing a low-effects threshold
- EC₁₅₋₂₅/IC₁₅₋₂₅
- LOEC
- MATC
- EC_{26-49/}IC₂₆₋₄₉
- nonlethal EC₅₀/IC₅₀
- LC₅₀

Regression-based endpoints (EC/IC values), were given preference over hypothesis-based endpoints, such as lowest observed effect concentration (LOEC) values, if available. Generally, effects on no more than 20% of exposed individuals is considered to be an acceptable threshold level for negative effects (CCME 2007), and current risk assessment guidance recommends the use of IC_{20}/EC_{20} as permissible levels of effect (Suter et al. 1995). However, IC_{25}/EC_{25} values are commonly reported in the literature, and such variations are considered to be within the range of natural variability often observed in the field among normal, unexposed populations. Therefore, in the absence of an EC_x/IC_x result, EC_{15-25}/IC_{15-25} values were used.

In some instances, the primary literature reported no observed effect concentration (NOEC)/LOEC concentrations but not EC_x/IC_x values, but also provided data that permitted estimation of the effect level at the NOEC/LOEC. The LOEC corresponding to the desired effect level was preferentially used.

TG_12-1





The most sensitive acceptable and preferred effects endpoint for the most sensitive species was then used in the derivation of the SSWQO.

Response 12.2

The intent of the SSWQOs was that they be applied to the receiving environment for all potential inputs (e.g. dust deposition) and not to the effluent discharge (i.e., end-of-pipe).

References

- CCME (Canadian Council of Ministers of the Environment). 2007. A protocol for the derivation of water quality guidelines for the protection of aquatic life 2007. In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment. Winnipeg, MB, Canada.
- Suter, G.W. II, B.W. Cornaby, C.T. Hadden, R.N. Hull RN, M. Stack, and F.A. Safran. 1995. An approach for balancing health and ecological risks at hazardous waste sites. Risk Anal 15:221–231.





INFORMATION REQUEST – TG_13

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Reverse Osmosis

Please provide a description of how long-term operation of a water treatment plant would be accomplished and the costs associated with such endeavour. (This information is required to assess adequate financial assurance and to define care and monitoring requirements during the post-closure period [e.g., management of brine, sludge disposal, agency/group responsible for care and maintenance]).

Response

The baseline post-closure strategy is to develop passive treatment during active mining so that the technology is fully developed for the site at closure. The preferred passive treatment technology at closure is a wetlands type system as there are natural wetlands in the area. The wetlands approach for post-closure water treatment then provides the advantage of blending in the surroundings and also provides a net negative carbon footprint. During the passive treatment development program a second type of passive system will also be evaluated in the event the desired treatment cannot be effectively implemented with a strictly wetlands type approach. The second type of passive system is a biochemical reactor (BCR) type system that has been implemented in cold climates previously. The BCR is also a fully passive system that appears at the surface like a pond (or can be buried for insulation) and is a subsurface passive bioreactor. The BCR has some advantages over the wetlands type system in that it can operate during freezing conditions and allows for higher loading rates so that a smaller footprint is required.

Fortune Minerals Limited recognizes that both passive options require maintenance and upkeep. On a comparative basis the wetland type system would require maintenance on the order of 25 to 100 years while the BCR system will likely require maintenance and media replacement every 10 to 20 years. For the NICO Project media replacement is expected to cost approximately 65% of the initial constructed capital cost (provided below). Based on the projected water quality it is not expected that the spent media will be hazardous, however, media disposal costs are not included in the 65%. The quality of seepage water from the Co-Disposal Facility will improve over time starting at closure as entrained process water drains from the facility. The level of treatment required over time will be evaluated and likely will influence which treatment options are used and the schedules for maintenance.

Because of the low metals content and low sulfate content projected for the NICO waters the maintenance and media replacement is likely to be at the longer end of the ranges for either passive option. The preliminary projections for capital costs for each of these passive options would be as follows:

- Wetlands Only: \$3,120,000
- BCR and Wetlands Polish: \$5,460,000





Both types of passive systems are considered to have a high potential for success for post-closure treatment of water. Appropriately designed BCRs are effective in cold environments similar to those experienced at the NICO Site. Golder Associates Ltd. has designed and constructed multiple systems at cold sites in the Canadian Rocky Mountains (Rutkowski and Hanson 2010), central Montana (Blumenstein 2008), Peruvian Andes Mountains, Colorado (Reisman et al. 2008), Northern Ontario, and Pennsylvania. Although the reaction rates of the biological treatment decrease in response to lower temperatures, the processes do continue and are effective even when influent temperatures approach freezing. Multiple BCR systems function effectively with influent water temperatures of 1 or 2 degrees Celsius (° C) (Reisman et al. 2008). An existing pilot BCR for selenium removal in west central Alberta has been operating effectively for 2 winters with ambient and water temperatures as low as -40 degrees Fahrenheit (° F) and 1° C, respectively (Rutkowski and Hanson 2010). At cold sites, BCRs can be designed as buried cells covered with geomembrane and soil cover for insulation.

A full scale BCR built for selenium, thallium, zinc, and nitrate removal has been in continuous operation in central Montana from October 2007 through present. The BCR has operated providing successful contaminant removal through 3 winters, despite stretches in which the ambient air temperature stayed below freezing ($<32^{\circ}$ F and $<0^{\circ}$ C) for up to 14 consecutive days (Blumenstein et al. 2009). To ensure successful water treatment in such weather, all feed and effluent piping was buried below frost depth (1.3 m) to eliminate freezing concerns. Access to the buried piping and valving was provided via buried vaults that are filled with insulation and covered to protect from the harsh environmental conditions.

Cold weather performance of aerobic wetlands can vary as any freezing of the wetland surface will decrease oxygen transfer from the atmosphere to the water and will thereby affect dissolved oxygen and redox conditions in the wetland water and sediments. Natural wetlands have been shown to alternate between metal removal and metal release on a seasonal basis (August et al. 2002) due to changing redox conditions. Although engineered wetlands can reduce seasonal variability, redox sensitive metals such as arsenic, selenium, and iron, can be susceptible to re-mobilization in engineered systems. It is unclear how the lack of flow during winter months at the NICO Site would affect the potential for seasonal variability for metal removal. Pilot testing will be conducted over several seasons during the active mining period to characterize seasonal performance of the aerobic wetland.

In addition, both passive options provide flexibility with regard to the contaminants treated. Selenium and the nitrogen compounds are not projected to be present in post-closure waters. If these constituents are present, however, they would be treated by either passive system proposed.

Continued operation of the reverse osmosis system past closure is not expected to be efficient if active treatment is required post-closure. The reverse osmosis system is included during mining years to reduce the volume of water for the biological treatment step which is required for removal of selenium and the nitrogen compounds. Selenium and nitrogen compounds are not expected to require treatment post-closure. Therefore, if active post-closure treatment is required it may be more efficient to treat the water with just the chemical precipitation step or even the ion exchange system. This system would only be considered is the passive treatment systems were shown to be inaffective, which is considered unlikely given the known effectiveness of these systems described above. Because the infrastructure and source of local operations personnel will not be readily available during closure a simpler operational system such as ion exchange or media adsorption would be more cost-effective.





References

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- Rutkowski, T., and R. Hanson. 2010. Biological treatment of nitrate and selenium: two pilot case studies of active and passive water treatment. Proceeding of the 2010 International Water Conference (IWC). San Antonio, TX. October 2010.





INFORMATION REQUEST – TG_14

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Closure Cover for Co-Disposal Facility (CDF)

The rationale for not providing an impermeable liner over the CDF at closure remains weak. Can Fortune either provide sufficient and appropriate evidence that seepage in the post-closure period will not negatively impact the receiving environment or provide evidence on how to establish a low permeability cover on the CDF.

Response

Fortune Minerals Limited proposes to use locally available glacial till to provide the low permeability material for the soil cover over the Co-Disposal Facility at closure. Glacial till is a geologically stable material for the long-term. The use of glacial till also readily supports vegetation, which will restore the site to an acceptable post-closure land use.

By contrast, all geomembrane liners have a finite life time. They will deteriorate over a time frame of one or 2 centuries and therefore may require replacement in the long-term. While geomembranes can achieve a lower rate of infiltration than soil covers, they cannot attain zero infiltration because defects inevitably occur during placement. For this reason, the U.S. EPA specifies a minimum number of defects which must be considered in any liner system. Thus, geomembranes could potentially reduce, but not eliminate, the volume of toe seepage.

The proposed soil cover is anticipated to reduce the net infiltration rate to 10 to15% of the total precipitation. On this basis, the volume of toe seepage after closure is estimated to be relatively small at about 47 000 cubic metres per year. For scale, this flow is less than 10% of the volume of water that currently flows from the Grid Ponds area into Nico Lake. This water will be treated in Wetland Treatment Systems before being released to Nico Lake. Conservative water quality modelling indicates that the environmental impacts of this toe seepage will be acceptable considering that current arsenic levels entering Nico Lake from the Grid Ponds is approximately 0.087 milligrams per litre and the projected arsenic levels from the wetland treatment system bench scale test are 0.068 milligrams per litre without any refinements to the system. With a 90% reduction in flows, the overall mass of metals entering Nico Lake from Co-Disposal Facility toe seepage will be substantially less than current baseline conditions.





INFORMATION REQUEST – TG_15

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Co-disposal Concept

Can Fortune please explain the mitigations that will be used to address the following concerns related to the operation of the CDF:"

- a) Formation of ice lenses that will impact long-term settlement, occupy valuable storage space and delay or make final cover applications problematic
- b) Management of lower density tailings at a time when thickener performance is not as modelled. This results in much more water in the impoundment, more ice formations, poorer densities, etc.
- c) Seepage from horizontal layers and rock dyke drains (permeability not controlled by low permeability tailings, water flows horizontally not vertically through the deposit in the short and long term)
- d) Tracking of contamination by equipment entering and leaving the CDF
- e) Freeze drying and dusting is a significant concern at Northern mines and is exacerbated by having tailings piled and exposed to the wind as compared with disposed in a basin. At sites such as Nanisivik, the only method found effective for controlling dusting in winter was either to have the tailings flooded over or covered with heavy layer of ice
- f) Many mines find additional ore and process longer than originally proposed. How much more ore can be excavated and processed before the CDF is visible above the ridge?
- g) Oxygen flux into the co-disposal pile may well not be the limiting factor for acid rock drainage production. As such, there is no certainty the sulphide oxidation rates will be reduced. Can Fortune provide data on rates of sulphide oxidation projected along with evidence that will be limited by oxygen in the CDF?

Response

<u>Response a</u>

Thickening of tailings will significantly reduce the volume of bleed water available that may freeze. At NICO, the tailings is planned to be dewatered to 75% solids content. With this solids content, every year approximately 545 383 cubic metres (m³) of water will be sent to the Co-Disposal Facility (CDF) along with the tailings solids, of which about 446 222 m³ will be locked up in the tailings voids, leaving only about 99 160 m³ of bleed water. This bleed water will be aggressively reclaimed from the individual deposition cells (by comparison, if the NICO tailings were deposited as a conventional slurry at 35% solids content, 3 038 562 m³ of water would have been send to the CDF every year, of which 495 802 m³ would have been locked up in the tailings voids, leaving about 2 542 760 m³ of bleed water.) It is evident from the volume of bleed water available that thickened tailings facilities are less prone to ice formation than conventional tailings facilities. No ice entrainment issue have been





reported at either the Kidd Creek or the Musselwhite thickened tailings facilities. Both these facilities are located in northern climates with extended periods of cold weather. The proposed thin thickened tailings deposition in NICO will therefore reduce the potential for ice entrainment.

If ice entrainment occurs in a particular cell, the primary mitigative measure will be to defer further deposition of tailings and mine rock to allow the ice to thaw in the following summer season. The cell by cell placement method that is proposed would readily accommodate such a measure. Under the worst case condition, if ice was entrained and covered such that it became perennial, then the grade of the top of the CDF would become slightly higher to accommodate the volume of ice. The presence of ice within the CDF would not be expected to interfere with equipment trafficability, so it should not impede dozer placement of the final cover. If subsequent thawing of entrained ice caused closed depressions in the final surface, then additional fill would be placed to restore a profile that drained properly.

<u>Response b</u>

It is possible that the thickener will on occasion temporarily produce tailings at a lower solids content than is called for in the design. This would result in a temporary increase in the volume of bleed water. The water will be aggressively reclaimed from the active deposition cell. A temporary decrease in solids content would result in a concurrent increased demand for reclaim water at the process plant, so increased reclaim would be an operating requirement. The proposed cell by cell deposition procedure can readily allow capture of the bleed water for reclaim. Mitigative measures for entrained ice were discussed above.

Response c

It is expected that, within individual cells of the CDF, the flow of water will predominantly be horizontal along the rock layers. The pattern of cells will be staggered to somewhat interrupt the horizontal flow. Overall, the horizontal component of the internal flow will still be stronger than the vertical component. Ultimately, the internal seepage will enter the Perimeter Dyke and will report at the toe, where it will be collected in the Seepage Collection Ponds.

<u>Response d</u>

Rock haul trucks will frequently move into and out of the CDF. However, they will only travel on haul roads or cell dykes composed of mine rock. They will not, and cannot traffic directly on top of the tailings. Equipment that may traffic on tailings (i.e., dozers and excavators) will generally be stationed on the CDF and will leave occasionally for service. The water balance schematics (Figure 3.9-6 in the Developer's Assessment Report [DAR]) illustrates that all runoff from the active area of the site will be collected into the Surge Pond. From the Surge Pond, the water will either be reclaimed to the Process Plant or the excess water will be treated in the Effluent Treatment Facility prior to release to the environment. Therefore, even if small volumes of tailings are tracked off of the CDF by equipment, the affected runoff will be collected and treated.

Response e

Freeze drying and dusting are primarily associated with coarse sandy tailings on the top of segregated beaches. Thickened tailings are less susceptible to freeze drying and dusting than conventional tailings because they do not segregate and produce sandy beaches. The experience with thickened tailings at Kidd Creek and Musselwhite support this observation. Additionally, at any given time during operations, most of the area of the CDF will be covered by mine rock so that the area of exposed tailings will be small. The areas of tailings that will be exposed will generally be depressed below the level of the surrounding rock cell berms. For these reasons,

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the proposed CDF is expected to produce much less dust than would be produced by a conventional slurry beach deposit of tailings.

Response f

The CDF has to be raised by about 50 metres (m) before it becomes visible from the inlet of the Hislop Lake. However, the facility can be raised only to maximum additional height of 25 m, which is elevation 335 m. Beyond this elevation the crest width of the CDF becomes too narrow for the mine fleet to safely operate. The CDF is therefore capable of providing an additional storage capacity for 4.5 M-m³ of tailings and mine rock.

<u>Response g</u>

Fortune has conducted humidity cell and field cell tests on co-disposed material to determine the rate of sulphide oxidation. The rates are provided in Annex A Section 5.7.7, Table 5-15 of the DAR. These results have been used in the assessment and predictions. Testing continues and will be used if necessary to further refine the CDF Management Plan in terms of deposition techniques to limit sulphide oxidation. Furthermore monitoring of water quality trends in the seepage from the CDF will be collected as part of the environmental monitoring program for the NICO Project. It is anticipated that the requirements for water quality monitoring will be defined as part of the permitting process.

With respect to evidence related to reduction of oxygen available for sulphide oxidation within the CDF, the limiting of oxygen influx into fine grained materials (and course grained materials) is a common method for reducing sulphide oxidation and is described in many literature studies. A good summary is provided in Alakangas et al. (2008). The rate of oxygen diffusion is defined by Fick's first law:

 $F=-D_{eff}(dC/dz)$

Where:

F is oxygen flux in moles/m²/s D_{eff} is the effective diffusion coefficient (m²/s) dC / dz is the concentration gradient

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For the CDF, the thickness of non-acid generating materials above the PAG waste rock, based on Ficks law alone, will result in orders of magnitude drop in oxygen availability, should this not be the rate-limiting factor, then that would indicate that the rate of oxidation is very low.

In either case (limited oxygen supply or low rate of intrinsic oxidation) the slow oxidation rate will allow for use of buffering capacity from the various minerals within the pile, thus buffering and limiting release of acidity. Furthermore the pile on the whole has more neutralization potential then acid generation potential. Monitoring will certainly be undertaken during operations and modifications to the construction of the pile could be investigated should monitoring show that there are upset conditions.

References:

Alakangas, L., A. Lundberg, and B. Öhlander. 2008. Pilot-scale studies of different covers on unoxidised sulphide-rich tailings, Northern Sweden: Oxygen Diffusion. Journal of International Mine Water Association. 25(3) 171-183.





INFORMATION REQUEST – TG_16

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Thiosalts

Can Fortune please provide a discussion on the potential impacts thiosalts have on the pH of the tailings discharges or seepage from the CDF, and the significance of those impacts?

Response

Thiosalts are not expected at the site or as a result of this process. Ongoing monitoring will be completed during operations to determine if thiosalts are being formed. If thiosalts, or their end products, are observed in the monitoring data then adjustments to the process or treatment system to pre-oxidize the thiosalt are possible mitigation strategies that could be investigated to address the issue.





INFORMATION REQUEST – TG_17

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Humidity Cell Data and Seepage Quality

Can Fortune please provide the necessary modelling to support the assertions regarding seepage quality?

Response

Seepage quality within the NICO Project site is modelled as part of the water quality model. The water quality model inputs, wiring, and results are described in the Site Water Quality Predictions section of the Developer's Assessment Report (Appendix 7.II). Specifically, seepage water quality inputs are addressed in Section 7.II.3.5. The selected inputs are conservative and based on the results of the geochemistry baseline (Annex A of the Developer's Assessment Report). The inputs vary based on the material in question.




INFORMATION REQUEST – TG_18

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Sulphide-Sulphur Cutoff

- 18.1) Where are data presented that demonstrates the basis for selection of the mine rock classes?
- 18.2) Can Fortune provide additional information on monitoring of waste rock to assure the proper waste class is defined to all rock removed from the pit?
- 18.3) What quantities of Type 1 waste are expected to be available?
- 18.4) Where does the 20 m buffer for Type 3 waste rock use come from in the classification?

Response

Response 18.1

Data demonstrating the basis for the selection of the mine rock classes is included in the Mine Rock Management Plan (Appendix 3.I of the Developer's Assessment Report [DAR]) in Section 3.I.5. Specifically, Table 3.I.5-1 lists the rationale for classification based on the acid generation potential and metal leaching potential of all mine rock samples. Detailed geochemical information is provided in Annex A. Modelling based on the cut-off criteria and geochemistry data is provided in Appendix 7.II of the DAR.

Response 18.2

Mine rock monitoring is described in Section 3.1.6 of the Mine Rock Management Plan (Appendix 3.1). A preliminary mine rock schedule will be developed on a weekly basis, and confirmed with the results of operational monitoring by the mine geologist. The schedule may be modified based on the results of analytical testing of the samples collected by the mine geologist.

Mine rock contact water quality will be assessed as part of the environmental monitoring program for the NICO Project, as described in Section 3.I.8 of the Mine Rock Management Plan (Appendix 3.I of the DAR). It is anticipated that the requirements for water quality monitoring will be defined as part of the permitting process.

Fortune Minerals Limited will continue to refine the mine rock monitoring and testing plan during the permitting process and operations as a part of the environmental management protocols for the NICO Project.

Response 18.3

A preliminary summary of mine rock production is included in Table 3.I.5-3 of the Mine Rock Management Plan (Appendix 3.I). A total of 25 Mt of Type 1 Mine Rock is estimated for extraction throughout the 20 year mine life.







Response 18.4

The 20 metre buffer zone was selected somewhat arbitrarily as this distance will result in a substantial (more than an order of magnitude) reduction in the potential influx of oxygen (as discussed in Information Request TG-15) into any very minor amounts of possible Type 3 material that may end up near the edges of the Co-Disposal Facility. The materials within this buffer zone will also be available to provide excess neutralization potential to maintain neutral conditions in any seepage which does pass through this zone.







INFORMATION REQUEST – TG_19

Source: Tłįchǫ Government (TG)

Request

Effluent Treatment and Closure Concepts for the NICO Project: Wetland Treatment

- 19.1) Will Fortune change its position and state that RO will be the long-term treatment system until such time as it can be demonstrated that wetlands will meet performance objectives?
- 19.2) Fortune should discuss whether downstream polishing will be required to precipitate residual iron and TSS released from the anaerobic treatment system.
- 19.3) Wetlands, although they are considered to be a passive treatment system, will require long-term care and maintenance (e.g. disposal of sludges). Fortune should describe the mechanism that will be used to ensure the long-term care and maintenance of the site beyond simply stating that sufficient money will be set aside.
- 19.4) Fortune currently plans to research wetlands during operations; however, seepage quality could deteriorate over tens of years (i.e., seepage quality during operations may be "cleaner" than during the post-closure period). How will Fortune factor in the potential worst-cast seepage quality scenario during the wetlands studies that will take place during operations?

Response

Response 19.1

The design of the active treatment system is driven by the presence of selenium, ammonia, and nitrate/nitrite in the water projected for the mining years. The water quality predicted for the post-closure years does not have elevated levels of selenium, ammonia, and nitrate/nitrite so the reverse osmosis (RO) system is not required if active treatment is required post-closure.

As discussed previously, the post-closure strategy is to develop passive treatment during active mining so that the technology is fully developed for the site at closure. The preferred passive treatment technology at closure is a wetlands type system as there are natural wetlands in the area. The wetlands approach for post-closure water treatment then provides the advantage of blending in the surroundings and also provides a net negative carbon footprint. During the passive treatment development program a second type of passive system will also be evaluated in the event the desired treatment cannot be effectively implemented with a strictly wetlands type approach. The second type of passive system is a biochemical reactor (BCR) type system that has been implemented in cold climates (although not sub arctic or arctic). The BCR is also a fully passive system that appears at the surface like a pond and is a subsurface passive bioreactor. The BCR has some advantages over the wetlands type system in that it can operate during freezing conditions and allows for higher loading rates so that a smaller footprint is required. The cost of implementing either passive configuration was projected to be similar for the NICO Project and the wetlands was selected as the first choice due to the factors stated above. More detail is given on post-closure passive treatment in the response to Information Request TG-13.



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Response 19.2

Residual iron and total suspended solids are not expected to be released from either the active biological system or the passive biological system. Both the active biological system for brine treatment and the passive biological system (either wetlands or BCR) include anaerobic steps for metals removal and aerobic steps for polishing, reaeration, and ammonia removal (if required). The active biological treatment system will include filtration as part of the system package. The wetlands component of the passive biological treatment provides both aeration and filtration integral to a wetland design.

Response 19.3

Fortune Minerals Limited (Fortune) recognizes that both passive options require maintenance and upkeep. On a comparative basis the wetland type system would require maintenance on the order of 25 to 100 years while the BCR system will likely require maintenance and media replacement every 10 to 20 years. The quality of seepage water from the Co-Disposal Facility will improve over time starting at closure as entrained process water drains from the facility. The level of treatment required over time will be evaluated and likely will influence which treatment options are used and the schedules for maintenance.

More detailed information on the post-closure passive system including costs is provided in the response to Information Request TG-13. Details of expected operations and maintenance for a wetland and/or BCR passive system are provided below:

Wetlands

- Periodic sampling to characterize treatment efficiency:
 - Likely intermediate sampling points to determine water quality as water passes through the wetlands.
 - More frequent sampling initially (weekly or every other week).
 - Less frequent sampling once treatment efficiency is better characterized (monthly or quarterly).
- Ensure large plants (particularly trees) don't grow on the surface of the wetlands which could compromise the integrity of the liner, if required by the post-closure water quality. A natural wetland design, with no liner, will be used if water quality improves as projected by modelling.
- When contaminant breakthrough is observed in the treated effluent and/or the organic substrate present in the wetland has been spent, the organic substrate/media in the wetland will need to be removed and disposed of, replaced with fresh organic substrate/media.
 - Based on the water quality expected for the closure wastewater, it is expected that the spent substrate/media would pass a TCLP-type test and could be disposed of in an industrial landfill.
 - Wetlands life is designed for 25-100 year life between substrate/media change-out, based on the expected water quality, the change-out is predicted to be closer to the 100 year number.

<u>BCR</u>

- Periodic sampling to characterize treatment efficiency:
 - More frequent sampling initially (weekly or every other week).





- Less frequent sampling once treatment efficiency is better characterized (monthly or quarterly).
- Ensure large plants (particularly trees) don't grow on the surface/cover of the BCR cell.
- When contaminant breakthrough is observed in the treated effluent and/or the organic substrate present in the BCR has been spent, the organic substrate/media in the BCR will need to be removed and disposed of, replaced with fresh organic substrate/media.
 - Based on the water quality expected for the closure wastewater, it is expected that the spent substrate/media would pass a TCLP-type test and could be disposed of in an industrial landfill.
 - BCR cell life is designed for 10 to 20 year life between substrate/media change-out, based on the expected water quality, the change-out is predicted to be closer to the 20 year number.

Response 19.4

Current water quality predictions show that water quality is expected to improve or be maintained over closure and post-closure conditions. There is no current evidence to suggest it will get worse over time. Predictions are based on appropriate inclusion of both acid generating and non acid generating materials.

It is expected that Fortune will factor in the potential worst cast seepage quality scenario by considering the available geochemical results to determine possible worst case conditions (Annex A of the Developer's Assessment Report) and will consider water quality predictions as provided in Appendix 7.II and monitoring data collected over the life of mine. Evaluation of trends in monitoring data during operations and periodic updating of predictions will allow for appropriate evaluation and prediction of long-term behavior regarding performance of the wetlands.

Table 1 shows the water quality projections for the mining years and post-closure. Note that these projections are the worst case for each of the years shown and for the active mining years the maximum of the worst case values is used for the active treatment facility evaluation. The projections indicate that the worst case water will occur during mining which will be used for the pilot testing of the passive treatment systems. Similar the post-closure projections used for evaluation purposes are also maximum projected values expected to improve as entrained process water purges from the facility.

Evaluation of both the active mining water quality and the post-closure water quality indicates that passive treatment could effectively treat either water quality to the site-specific water quality objectives. The primary differences with regard to water treatment between the post-closure water quality and active mining water quality are selenium and nitrogen. For active treatment these constituents limit the effective treatment technologies. For passive treatment, these constituents are readily removed by the multitude of treatment mechanisms that are present in passive systems. These mechanisms include anaerobic and aerobic biological treatment, hydroxide precipitation, sulfide precipitation, filtration, plant uptake, and adsorption. This range of removal mechanisms present in passive treatment systems makes the systems robust with regard to changes in influent quality and constituents present.

Relative to many mining influenced waters the projected level of constituents is low and although there may be a factor of 2, 5, or even 10 difference in the projected levels of some constituents the loading to the system is still relatively low. Therefore, the design of the passive water treatment system is not significantly impacted by the range of water quality expected at the NICO Project. Temperature will have a greater impact on the design of the



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passive system than the range of metals loading projected. The temperature will be factored into the design based on the kinetics from the pilot testing. The temperature influence, reduced microbial activity in colder temperatures, will be the same regardless of the influent quality.





Table 1: Site-Specific Water Quality Objectives and Predicted Effluent Treatment Facility Influent Water Characterization and Post-Closure Water Characterization

Constituent	Units	Effluent Treatment Goals based on Site-Specific Water Quality Objectives for End-of-Pino		Maximum Site Predicted E	Water Quality		ETF Influent Design Basis	ETF Influent Design Basis	Maximum Site Water Quality Predicted Post-Closure Influent
		February 2011	2013 ^ª	2013 ^b	2030 ^a	2030 ^b	Worst Case	Early Project	Closure
рН	s.u.	6.5 to 9	5.5	-	5.5	-	5.5	5.5	5.9
Temperature	°C	-	-	-	-	-	-	-	-
Alkalinity	mg/L as CaCO ₃	-	5.12	-	22.15	-	22.15	5.1	3.66
Aluminum	mg/L	0.410	1.5	2.4	3.6	5.8	5.8	2.400	0.21
Ammonia	mg/L	4.16	15	15	15	15	15	15	0.95
Antimony	mg/L	0.03	0.018	0.028	0.032	0.051	0.051	0.028	0.003
Arsenic	mg/L	0.05	0.26	0.41	0.45	0.72	0.72	0.41	0.37
Barium	mg/L	-	0.10	0.16	0.13	0.21	0.21	0.16	0.04
Beryllium	mg/L	-	0.00082	0.00131	0.00195	0.00309	0.00309	0.00131	0.00287
Boron	mg/L	-	0.14	0.22	0.37	0.59	0.59	0.22	0.14
Cadmium	mg/L	0.00015	0.00046	0.00074	0.00033	0.00053	0.00074	0.00074	0.00287
Calcium	mg/L	-	20.9	33.2	45.8	72.5	72.5	33.2	46.9
Chloride	mg/L	353	37	58	68	107	107	58	152
Chromium	mg/L	-	0.0041	0.0066	0.0040	0.0063	0.0066	0.0066	0.0143
Cobalt	mg/L	0.01	0.280	0.450	0.300	0.470	0.470	0.450	0.01
Copper	mg/L	0.022	0.018	0.028	0.020	0.032	0.032	0.028	0.012
Iron	mg/L	1.5	4.7	7.5	5.9	9.3	9.3	7.5	9.0
Lead	mg/L	0.0076	0.0046	0.0072	0.0097	0.0153	0.0153	0.0072	0.0143
Magnesium	mg/L	-	8.0	12.7	15.6	24.7	24.7	12.7	19.9
Manganese	mg/L	-	0.166	0.264	0.175	0.278	0.278	0.26	0.870
Mercury	mg/L	-	0.000118	0.000118	0.000098	0.000156	0.000156	0.00012	0.000574
Molybdenum	mg/L	-	0.035	0.055	0.069	0.110	0.110	0.055	0.014
Nickel	mg/L	-	0.012	0.019	0.021	0.034	0.034	0.019	0.006

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Table 1: Site-Specific Water Qual	ty Objectives and Predicted Effluent Treatment Facility Influent Water Characterization and Post-Closure	Э
Water Characterization (ontinued)	

Constituent	Units	Effluent Treatment Goals based on Site-Specific Water Quality Objectives		Maximum Site Predicted E	Water Quality	ETF Influent Design Basis	ETF Influent Design Basis	Maximum Site Water Quality Predicted Post-Closure Influent	
		February 2011	2013 ^a	2013 ^b	2030 ^a	2030 ^b	Worst Case	Early Project	Closure
Nitrate	mg/L as NO₃	133	62.0	62.0	62.0	62.0	62.0	62.0	0.9
Nitrite	mg/L	-	11.3	17.9	22.6	35.7	35.7	17.9	0.1
Phosphorous	mg/L	-	0.085	0.135	0.167	0.264	0.264	0.135	0.424
Potassium	mg/L	-	167.5	265.4	332.6	527.0	527.0	265.4	5.8
Selenium	mg/L	0.005	0.031	0.049	0.080	0.127	0.127	0.049	0.0013
Silver	mg/L	-	0.00164	0.00260	0.00089	0.00141	0.00260	0.0026	0.01400
Sodium	mg/L	-	22	35	76	120	120	35	15
Strontium	mg/L	-	0.076	0.120	0.210	0.332	0.332	0.120	0.150
Sulfate	mg/L	500	98	156	266	421	421	156	27
Thallium	mg/L	-	0.0163	0.0259	0.0081	0.0128	0.0259	0.0259	0.1400
Tin	mg/L	-	0.033	0.052	0.022	0.035	0.052	0.052	0.140
Uranium	mg/L	0.027	0.044	0.070	0.077	0.122	0.122	0.070	0.1400
Vanadium	mg/L	-	0.0022	0.0035	0.0030	0.0047	0.0047	0.0035	0.0029
Zinc	mg/L	0.11	0.063	0.100	0.073	0.116	0.116	0.100	0.067

^a Calculated based on mixing of inputs from various site facilities in Surge Pond. Assumes minimal mass added from water using in mill as process water (i.e., freshwater or treated water used for make-up water in the mill).

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^b Calculated to evaluate the effect of accumulation of mass from recycled water from the Surge Pond through the mill as process water.

x.x Denotes values greater than site specific water quality guidelines.

ETF = Effluent Treatment Facility; mg/L = milligram per litre; °C = degree Celsius







INFORMATION REQUESTS NORTH SLAVE MÉTIS ALLIANCE





INFORMATION REQUEST – NSMA_2-1

Source: North Slave Métis Alliance (NSMA)

Request

How might the anticipated spread of wood bison in a north-westerly direction along linear corridors associated with the project and other reasonably foreseeable developments affect boreal and/or tundra caribou? What monitoring and mitigation is planned? How will North Slave Métis be involved and their traditional knowledge incorporated in monitoring plans, programs, and decision making?

Response

The historic range of Northwest Territories wood bison over the last 5000 years has overlapped Lac la Martre (ENR 2010), and their distribution is bound to the east by the eastern limit of the Taiga Plains Ecozone (ESWG 1995). The NICO Project is located within the Taiga Shield Ecozone and outside of the historic distribution of wood bison (ENR 2010) and is not within the current distribution of the Mackenzie bison population (ENR 2012). Wood bison were not observed during terrestrial and aquatic baseline studies (including aerial surveys and snow-track surveys) in the NICO Project regional study area from 1998 through 2010.

The conceptual Wildlife Effects Monitoring Plan (WEMP) includes routine surveys of the NICO property and communication with site staff to record the presence and interaction of all wildlife, which would include observations of wood bison, if present. The WEMP also includes systematic aerial surveys for caribou, which have recorded observations of moose and would likely also detect wood bison. Thus, the occurrence of wood bison in the regional study area would be recorded and reported as part of the WEMP.

The distributions of wood bison and woodland and wintering barren-ground caribou overlap but the habitat requirements for these species are different. Therefore, if wood bison expanded their current range, the negligible interaction between these species is not expected to result in adverse effects to woodland or barren-ground caribou.

Fortune Minerals Limited position regarding North Slave Métis Alliance involvement in monitoring programs is provided in response to NSMA 2-2.

References

- ENR (Environment and Natural Resources). 2010. Wood bison management strategy for the Northwest Territories. Government of Northwest Territories, Department of Environment and Natural Resources, Yellowknife, NWT.
- ENR. 2012. Mackenzie Bison Population. Internet http://www.enr.gov.nt.ca/_live/pages/wpPages/Mackenzie_Bison.aspx. Accessed: 2 May 2012.
- ESWG (Ecological Stratification Working Group) 1995. A national framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa, ON.



May 2012





INFORMATION REQUEST – NSMA_2-2

Source: North Slave Métis Alliance (NSMA)

Request

In what way, exactly, will North Slave Métis be involved in monitoring wildlife and habitat and in making decisions about mitigation measures? How will decisions be made regarding monitoring programs. mitigation measures and closure requirements that may differentially affect one species relative to another, and how will Métis traditional knowledge, including cultural values, be incorporated in those decisions?

Response

In its Information Request (IR) 2-1, the Government of the Northwest Territories (GNWT) stated that "Recently some developers have expressed interest in contributing to existing or planned GNWT caribou monitoring programs in place of, for example, flying expensive aerial surveys in the immediate area of their property. In recognition of the potential impacts of increased road access on caribou harvest beyond the local footprint of mines, would Fortune Minerals Limited (Fortune) be willing to discuss with GNWT this type of contribution? Cost-sharing could be used toward monitoring of the Bathurst and Bluenose-East caribou herds, monitoring and management of harvest, and cumulative effects assessment at larger spatial scales, all of which are on-going or planned by GNWT with co-management partners such as the Tłįcho government and the YKDFN."

It is difficult for Fortune to state exactly how members of the North Slave Métis Alliance (NSMA) may be involved in the Wildlife Effects Monitoring Plan (WEMP) for the NICO Project at this time given the current conceptual WEMP will likely undergo an evolution. As shown above, Fortune is being requested to consider alternatives to traditional monitoring methods, such as aerial surveys, which may impact the objectives and programs for the WEMP. Fortune would welcome the input of the NSMA when the discussions on the details of the WEMP occur as described in IR response GNWT 2-2.

Fortune cannot comment on how Métis traditional knowledge and cultural values may be incorporated into the WEMP as it has not yet received the report from the NSMA on this subject.







INFORMATION REQUESTS YELLOWKNIVES DENE FIRST NATION





INFORMATION REQUEST – YKDFN_1.1

Source: Yellowknives Dene First Nation (YKDFN)

Request

Submission of Incinerator Management Plans

YKDFN are again asking for the submission of an incinerator management plan, which contains commitments on how the company will respond to events of non-compliance with the guidelines and how they intend to monitor the local environment for effects.

Response

A response to this question was prepared and provided to the YKDFN on the 25th of April, 2012. It is excerpted here for your reference.

Fortune has committed to purchasing an incinerator that is capable of meeting the Canadian emissions standards for dioxins and furans emissions. Acquiring the appropriate equipment is part one. A second and equally important part of the issue is the operation of the "compliant" incinerator. Care is required to operate any incinerator in such a manner that it will meet the emissions criteria. Waste loading practices, burn-times, control of residence time, temperature control, waste segregation and other factors are all considerations in meeting the standard.

The operational management of the incinerator will be directed by the Incineration Management Plan (IMP) that Fortune has committed to producing in due course. It will be developed consistent with the Environment Canada Technical Guidance Document on Batch Incineration and in cooperation with representatives from Environment and Natural Resources and Environment Canada. Those representatives are currently Ms. Aileen Stevens and Mr. Dave Fox, respectively.

Testing the incinerator will be carried out under typical load conditions, including during the incineration of sewage sludge if it is ultimately decided that disposal of the sludge will be by incineration. It is expected that testing under these conditions would represent a worst-case scenario.

In the event that the monitoring shows non-compliance with the standard, the pending IMP will direct an appropriate response. It may include different waste segregation practices, different operating parameters, or any other of number of variables that contribute to the emissions profile of the incinerator. It is also important to note that incinerator emissions testing is very expensive and every effort will be made to ensure that the equipment and waste management practices result in compliant emissions to avoid unnecessary emissions testing. The frequency of testing has yet to be determined, but it would be reasonable to anticipate that there may be a few years between compliant tests. Frequency of testing will be one of the parameters that will be addressed in the IMP.

Further to the 25 April 2012 response, Fortune is also pleased to resubmit some of the details of the incinerator package that has been chosen for use at the NICO Project. Appended to this response, you will find a report detailing the findings of an incinerator emissions test conducted by Environment Canada. It is entitled





"Characterization of Emissions From the Eco Waste Solutions Thermal Waste Oxidizer Burlington, Ontario". The same technology that was tested in Ontario by Environment Canada, as documented in the attached report has been selected for use at the NICO Project.

Also, as stated above, further details on the standard operating procedures, thresholds, and triggers for response to potentially unfavourable emissions releases will be developed during the regulatory phase of the application. The planning will be conducted consistent with the Environment Canada Technical Guidance Document on Batch Incineration and in cooperation with representatives from Environment and Natural Resources and Environment Canada.

Specific monitoring of environmental effects associated with incineration (apart from periodic stack testing) is not currently proposed; however, various options for doing so may be considered if the need to do so arises.





ATTACHMENT A

Characterization of Emissions From the Eco Waste Solutions Thermal Waste Oxidizer Burlington, Ontario







Characterization of Emissions From the Eco Waste Solutions Thermal Waste Oxidizer Burlington, Ontario

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> Report ERMD 2002-03 February 2003 Emissions Research and Measurement Division Environmental Technology Advancement Directorate



Environment Environmement Canada Canada



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Any comments concerning its content should be directed to:

Environment Canada Emissions Research and Measurement Division Environmental Technology Advancement Directorate Environmental Technology Centre Ottawa, Ontario K1A 0H3

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The Emissions Research and Measurement Division would like to express their appreciation to Jean Lucas and the operating staff of Eco Waste Solutions for their cooperation and assistance during the test program at the thermal waste oxidizer. Special thanks are extended to the Analysis and Ambient Air Quality Division at the Environmental Technology Centre for performing the dioxin, furan, PAH, chlorobenzenes, octachlorostyrene and volatile organic compounds analyses. Philip Analytical Services Inc. of Burlington, Ontario performed the metals analysis.

1. INTRODUCTION

In cooperation with the National Office of Pollution Prevention, the Emissions Research and Measurement Division (ERMD) conducted characterization of the Eco Waste Oxidizer manufactured by Eco Waste Solutions of Burlington, Ontario. The Eco Waste Oxidizer uses a two-step thermal oxidation process. In the first step, municipal solid waste is burned in the dual primary chambers under starved oxygen conditions and relatively low temperatures (500 to 650°C) in order to preserve metal and glass for later recycling. Each of the two primary chambers in this oxidizer has a capacity of two tonnes of waste. Once the waste starts burning, the process becomes self-fuelling until the volume is reduced by over 90 percent. In the second step, smoke and gases from the two parallel primary chambers are treated in the afterburner or secondary chamber at an operating temperature of 1000°C and a minimum of 2 seconds residence time to ensure complete oxidation of the combustion products.

The Eco Waste Oxidizer is configured to treat the flue gases from the afterburner in a water quench system followed by a packed tower scrubber to remove acid gases and metals. However, the scrubber system was bypassed in this study. The main purpose of this study was to characterize the emissions from a well-operated incinerator without control technology.

The Emissions Research and Measurement Division (ERMD) conducted source testing at this facility for various target compounds. These pollutants included particulate, metals, acid gases, dioxins and furans (PCDDs/PCDFs), polycyclic aromatic hydrocarbons (PAHs), selected chlorobenzenes (CBs), octachlorostyrene (OCS), volatile organic compounds (VOCs) and flue gases (CO₂, O₂, CO, SO₂ and NO_x). The semi-volatile and volatile organic compounds included Track 1 and CEPA toxic compounds.

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2. SAMPLING SITE AND LOCATION

Sampling was conducted on the stack exhaust located above the roof of the Eco Waste facility. Samples were extracted from the two existing ports. The sampling location is illustrated in Figure 1. Sampling was conducted from two 4-inch ports positioned approximately 36 inches above the temporary platform and 15 feet above the roof. The stack sampling location met the "eight and two" criteria.



Figure 1 Sampling Location – Eco Waste Solutions Oxidizer

3. SAMPLING METHODS

3.1 General

The Method 5 train formed the basis of the manual methods used to collect particulate, acid gases, metals and semi-volatile organics during the sampling phase. The train consisted of a probe, heated filter enclosure, leak-free vacuum line, vacuum gauge, flow control valves, vacuum pump and a dry gas and orifice meter. Stack gas and orifice pressures were measured with an inclined manometer and micromanometer. Temperatures were measured in the hot box,

impinger train outlet and at the inlet and outlet of the dry gas meter. In the case of the SVOCs, the temperature was also monitored at the Amberlite XAD-2 inlet. All trains were assembled in the ERMD mobile lab.

Leak-checks were conducted at the beginning and at the end of each run or whenever a train joint was opened. Sampling was conducted from two traverses at isokinetic sampling rates with readings recorded every five minutes. Sampling duration for the particulate/metals and organic runs was 2 and 4 hours respectively.

3.2 Particulate/Acid Gases/Metals Train Description

EPA Method 29, "Determination of Metal Emissions from Stationary Sources", was used to determine particulate and metal emissions. Particulate emissions were collected in the probe and on the heated filter. The condensation and collection of the gaseous fraction was accomplished using seven impingers connected in series. The first impinger was filled with 100 mL deionized water to trap acid gases, followed by two impingers containing 100 mL of an acidic solution of hydrogen peroxide (5% HNO₃/10% H₂O₂), followed by an empty impinger, followed by two impingers containing 100 mL each of an acidic solution of potassium permanganate (4% KMnO₄/10% H₂SO₄) and finally followed by a silica gel impinger. A schematic of the sampling train is shown in Figure 2.



Figure 2 Particulate/Acid Gases/Metals Sampling Train

The glassware was pre-cleaned following the meticulous procedure detailed in the method. Eight samples from each test were obtained from the recovery procedure and submitted for analysis. These samples include the particulate filter, aliquots of the first impinger water, rinses of the front- and back-half glassware with various portions of acetone, nitric acid, acidified potassium permanganate and hydrochloric acid that are detailed in the method. As well, aliquots of the reagents used in the sampling train and in the recovery procedure were submitted for blank analysis.

Glass bottles with Teflon-lined caps were used for storage of acidified KMnO₄ containing samples and blanks. No metal components were used in this method. In its place, Teflon probe fittings and filter supports and quartz nozzles and probes were utilized to avoid contamination of the train and samples.

3.3 SVOC Train Description

The Environment Canada Report EPS 1/RM/2 "Reference Method for Source Testing: Measurement of Releases of Semi-volatile Organic Compounds from Stationary Sources" was used to determine the emissions of dioxins, furans, polycyclic aromatic hydrocarbons, chlorobenzenes and octachlorostyrene from the stack. A schematic of the sampling train is shown in Figure 3.



Figure 3 Dioxin, Furan, PAH, CB and OCS Sampling Train

This method is the most widely accepted for the measurement of organic compounds with boiling points above 100°C. Gaseous organics were trapped in a single adsorbent tube containing about 40 grams of Amberlite XAD-2 resin. As the temperature of the resin must be kept below 20°C for optimal collection efficiency, the hot gases leaving the filter enclosure were cooled by passing them through a condenser cooled with ice bath water. The tube containing the XAD-2 resin was also water-cooled. Condensate formed in the cooling coil percolated through the resin bed and was collected in a condensate trap. An impinger containing ethylene glycol inserted downstream of the Amberlite acted as a back-up collection media in the event of breakthrough of organics through the resin. The resin tube was covered with aluminum foil during sampling and storage to prevent photodegradation of the trapped organics. All glassware joints were wrapped with Teflon tape as vacuum greases are not permitted for organic sampling. Sampling duration was four hours. Quartz nozzles and liners were used in the sampling train.

3.3.1 Glassware Cleaning and Proofing

Prior to the test program, all train glassware, probe brushes, glass wool and aluminum foil were cleaned following the rigorous procedure in the Reference Method. The glassware cleaning procedures were verified by analyzing the proofing rinses of the sampling trains. Pre-cleaned and proofed commercial sample storage bottles were used for this test. Four complete sets of train glassware were prepared for this survey. The XAD-2 was pre-cleaned and analyzed for contamination prior to the survey. All reagents were distilled-in-glass grade. Details of the cleaning and proofing procedures are given in Report EPS 1/RM/2.

3.3.2 Sample Recovery

Following the completion of each run, the organic train was recovered in the ERMD mobile laboratory. During the transportation between the sampling site and the lab, all openings were sealed with pre-cleaned glass plugs or caps or aluminum foil. The recovery procedures involved the brushing and rinsing of the train components with acetone and hexane. Only Teflon wash bottles were used during sample recovery. The loaded filter was carefully removed from the holder, sealed in pre-cleaned foil and stored in a pre-cleaned glass petri dish. Amberlite tubes were capped and re-wrapped in aluminum foil. Liquid samples were stored in pre-cleaned amber bottles to prevent photodegradation of the organics. Bottle lids were lined with Teflon. All samples were kept refrigerated following recovery. The sample recovery procedures are detailed in Figure 4. All samples were forwarded to the Analysis and Air Quality Division (AAQD) of Environment Canada for organic analysis.



Sample	Component(s)	Recovery Procedure
1	1,2,3,4	Wash and brush 3 times each with acetone (A) and hexane (H). Rinse 3 times each with A and H.
2	5	Remove filter carefully from filter holder. Place on pre-cleaned foil. Fold in half and crimp the foil edges. Place in pre-cleaned petri dish. Seal petri dish.
3	6,7	Soak 5 minutes each with A and H. Rinse 3 times each with A and H.
4	8	Cap ends and wrap in foil.
5	9,10,11,12	Empty contents into container and rinse 3 times with HPLC water.
6	6 to 15 except 8	Rinse three times each with A and H.

Mark liquid levels on all bottles and wrap all the caps with tape.

All sample containers are pre-cleaned amber glass bottles with pre-cleaned Teflon lid liners.

Figure 4 Recovery Procedure for Dioxins, Furans, PAHs, CBs and OCS

In addition to the regular sampling trains, a blank train was assembled for the tests. The blank train was treated in the same manner as the sampling trains except that no stack gases were sampled. However, a volume of ambient air, equal to that drawn during the leak checks was drawn through the blank train. Essentially, the blank train serves as a check for background levels of organics originating from ambient air, handling of train glassware and rinsing agents.

3.4 Volatile Organic Compounds (VOCs)

VOCs are classified as those organics having saturated vapour pressures at 25°C greater than 10⁻¹ mm Hg. The method is based on the collection of a gaseous sample in a previously cleaned, verified and evacuated 6-liter, stainless-steel canister. The canister's interior surface is covered by pure chrome-nickel oxide which is formed during the SUMMA® passivating process. This vessel provides a stable sample collection and storage media for many organic compounds.

A modified method TO-14 (*Compendium Method TO-14 Quality Assurance Division*, *Environmental Monitoring Systems Laboratory*, U.S. EPA, May 1988) was used as the basis for the VOC sampling train. The train consisted of a stainless-steel probe connected by Teflon tubing to the canister. The gases were drawn by a Teflon-coated pump through a critical orifice (hypodermic needle) into the canister (Figure 5).

Two canisters were collected for each SVOC run corresponding to the first and second halves of the traverses. Sampling duration for the VOC samples was variable, ranging from 50 to 70 minutes. The sample was collected into the evacuated canister to a final pressure of 18 to 19 psig. Following sample collection, the canister valve was closed and the canisters were transported to the AAQD laboratory for analysis.



Volatile Organic Compounds Sampling Train Figure 5

3.5 **Flue Gases**

An integrated gaseous sample method was employed to collect a representative sample from the stack. This was accomplished by drawing sample gas through a 30-inch Inconel probe located directly in the exhaust stream. Following particulate removal in a heated filter and conditioning (drying and cooling) of the sample gas, the sample gas was drawn through a stainless steel/Teflon head pump into a high volume aluminized Tedlar sample bag. A sampling rate of 1 liter per minute was used over a 30-minute sampling period per sample. A schematic of the system is shown in Figure 6.

Each integrated sample was then analyzed using both an ECOM Model KD (electrochemical analysis of O₂, CO, SO₂ and NO and NO₂) and a Nova Model 306 BD (infrared analysis of CO₂),



to determine target species concentration. Each instrument was individually calibrated twice a day using two ranges of certified gas standards. Initial calibration was carried out prior to the commencement of sampling, once all equipment had reached operating conditions, while final calibration was performed at the end of sampling.

Dwn.Bv A.R.Meadov

Figure 6 Flue Gas Monitoring System

4. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

All stack sampling equipment was calibrated prior to sampling using accepted techniques. Items that were calibrated included:

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- Dry Gas Meter (γ)
- Orifice (K₀)
- Pitot Tubes (C_p)
- Barometers (P_{bar})
- Inclined Gauges (Δp)
- Nozzle Diameters (N_d)
- Temperature Readers (T)

The dry gas and orifice meters were calibrated using a spirometer. Pitot tubes were calibrated at the National Research Council wind tunnel. Barometers and inclined gauges were calibrated against a standard reference mercury barometer and an inclined manometer respectively. Thermocouple readers were calibrated using an ice bath and boiling water. Nozzle openings were measured by averaging three measurements with a vernier caliper. In addition to the above, the sampling consoles and inclined gauges were checked for leaks and the operation of all probe and box heaters was verified.

5. ANALYTICAL METHODS

5.1 Particulate and Metals

Particulate was determined gravimetrically following desiccation of the front-half acetone rinse and loaded filter. Acid gases were determined by ion chromatography analysis of the first impinger contents. Chloride and fluoride were expressed as HCl and HF. The samples were acid digested, and appropriate fractions were analyzed for mercury by cold vapour atomic absorption spectroscopy (CVAAS) and the remainder of the metals was analyzed by inductively coupled argon plasma emission spectroscopy (ICAP). The front- and back-half components were analyzed separately.

5.2 Semi-volatile Organic Compounds

Upon receipt in the laboratory the samples were inspected to ensure integrity and proper labeling. The samples were then entered into the laboratory information management system (LIMS) where they were assigned a laboratory code. The code was then entered onto each of the containers which were then stored in a fridge at 4°C until sample processing proceeds.

Typically the train samples are divided into the front-half (probe rinse, filter, and front-half filter holder rinse) and back-half sections (back-half filter holder rinse, XAD, condensate trap, glycol impinger and back-half glassware rinses). The solvent fractions were dried by passage through sodium sulphate and reduced in volume by rotary evaporation. The solids (filter and XAD) were air dried prior to a 20-hour soxhlet extraction using cyclohexane/toluene (8:2 v/v). Prior to extraction, each sample was spiked with

a solution containing a known amount of carbon-13 labelled dioxin/furans and chlorobenzenes as well as deuterated PAH. These were used to assess losses incurred during the extraction and sample cleanup procedures. Analytical results for dioxin/furan and chlorobenzenes/octachlorostyrene were corrected for the recovery of these surrogates. PAH results were not corrected for surrogate recovery.

After extraction, the solvent extracts of the solids were reduced in volume and combined with the train rinses prior to cleanup. The samples were split into two equal fractions. One fraction was used for PAH cleanup and analysis while the other was used for dioxin/furan and chlorobenzene/octachlorostyrene cleanup and analysis.

The PAH cleanup involved passing the sample extract through an activated silica column. Co-extracted compounds which may cause interference during analysis were eluted out of the column while the PAHs were retained on the column. A more polar solvent was then applied to the column to elute the PAHs. The cleaned sample extract was concentrated to 500 μ L and an internal standard was added to monitor instrumental performance and was used to correct for any variations in injection and sample volume. The sample was analyzed using low resolution mass spectroscopy. Calibration standards containing various known amounts of the analytes were injected into the instrument before, during and after the samples were injected. These standards were used to determine the concentrations of the analytes in the sample. The accuracy of the standards was periodically assessed using standard reference materials.

The dioxin/furan and chlorobenzene/octachlorostyrene cleanup is more rigorous since the concentrations of the dioxin/furans are much lower than other compounds that may be present in the extract. These co-extractants could interfere with the final analysis. Initially the sample extract was passed through a multi-bed silica column containing layers of acid, base and silver nitrate. Some of the co-extractants were retained on the column and others may be reduced or oxidized. Sulphur containing compounds were removed by the silver nitrate. The extract was then passed through an alumina column to separate out the dioxin/furans from other compounds such as PCBs and chlorobenzenes/octachlorostyrene. The fraction containing the chlorobenzenes/octachlorostyrene was reduced to 500 μ L and an internal standard was added to monitor instrumental performance and to correct for any variations in injection and sample volume. The sample was analyzed using low resolution mass spectroscopy. The fraction instrumental performance and to correct for any sample volume. The sample was analyzed using low resolution and sample volume. The sample was analyzed using low resolution mass spectroscopy. The fraction was added to monitor instrumental performance in injection and sample volume. The sample was analyzed using low resolution mass added to monitor instrumental performance and to correct for any variations in injection and sample volume. The sample was analyzed using low resolution mass added to monitor instrumental performance and to correct for any variations in injection and sample volume. The sample was analyzed using low resolution and sample volume. The sample was analyzed using high resolution mass spectroscopy.

As a part of quality assurance and quality control, a method blank is usually processed along with the samples to assess cross contamination. A control sample, usually a standard reference material containing a known amount of analytes, may also be processed along with the samples to check extraction, cleanup and analytical efficiency. The division also participates in interlaboratory studies. The results of these studies are used to compare the results obtained in-house with the results obtained from several different laboratories. These studies involve various analytes from a variety of matrices. The division is accredited by CAEAL for the analysis of PAH and dioxin/furan.

5.3 Volatile Organic Compounds

The stack samples in canisters were analyzed using thermal desorption technique with a highresolution gas chromatograph and quadrupole mass-selective detector (GC-MSD) as described in EPA Methods TO-15 and TO-17. A Dynatherm Analytical Instruments ACEM Model 900 thermal desorption system was used for sample preconcentration. Sorbent tubes packed with 20/35 mesh Tenax-TA, 60/80 mesh Carboxen 1000 and 60/80 mesh Carbosieve SIII were used for sample concentration. An Agilent 5890 series II gas chromatograph and an Agilent 5972 MSD were used for species identification and quantification. Volatile organic compounds were separated on a 60 meter, 0.32 mm I.D. fused silica capillary column with a 1.0 µm film thickness of J&W DB-1 bonded liquid phase.

Air from the canister was drawn through the LiOH packed tube and concentrated onto a sorbent. Sample volumes were measured with a mass flow controller at a fixed flow rate, 100 mL/min. Normally, 500 mL of stack sample was passed through a LiOH tube to remove acid and CO_2 from stack gas and then concentrated onto the sorbent tube. Ten mL of internal standard was loaded onto the sorbent tube at the same time. The sorbent tube was purged with 500 mL of UHP air to flush out CO_2 from the sorbent tube. The sorbent tube was loaded onto ACEM Model 900 thermal desorption system. An internal flow of helium purges the tube of residual water vapour and air prior to transfer of the collected analytes to a capillary packed trap for refocusing, then into a GC-MS equipped with wide-bore capillary column and mass spectrometer.

Optimum results were obtained by temperature programming the GC column. Column temperature was initially held for 3 min at -60° C, then raised to 250° C at a rate of 8° C min⁻¹. The GC-MSD was operated in the selected ion monitoring mode (SIM). Identification of target analytes by SIM is based on a combination of chromatographic retention time and relative abundance of selected monitored ions. Two or three characteristic ions were monitored for each of approximately 145 hydrocarbon compounds found in urban air samples. Since the MSD acquires data for only target ions, this detection technique is considered highly specific and sensitive.

An instrument calibration standard was made from gas standards prepared in the laboratory of Environment Canada from three multi-component liquid mixtures and gas mixture cylinders purchased from Scott Environmental Technology Inc. Quantification was based on five-point linear regression calibration curves.

6. **RESULTS**

6.1 General Sampling Data

The general sampling data for the test program is presented in Table 1. This table includes the average velocity, volumetric flow rate (referenced to 25°C and 101.3 kPa), average stack temperature and average moisture. Average oxygen and carbon dioxide levels were determined from the flue gas samples by the procedure described in Section 3.5. The traverse data for each run and summaries are presented in Appendix I. Operating temperatures for the dual primary and single secondary chambers are also included in Appendix I.

The sampling strategy was devised to collect the samples over different segments of the cycle. This approach provides a more realistic profile of the emissions during the incineration cycle. During the first two days, the SVOC sampling was commenced at the start of the cycle. The particulate/metals run followed with the sampling on the second day commencing about 1 hour later than the sample collected on the first day. On the third day, sampling started with the particulate/metals followed by the SVOC run. The sampling for each test day commenced 35, 23 and 15 minutes following ignition of the primary burners. One VOC canister was collected during each SVOC traverse. The sampling schedule is illustrated in Figure 7.



Figure 7 Eco Waste Sampling Schedule

The waste for the three days was delivered and piled outside the facility. Waste loaded to each primary chamber is recorded in Table 1. Two scenarios were used for the purpose of calculating emission rates -100 and 250 cycles per year. These correspond to 2 and 5 cycles per week.

Process Conditions		Day 1		Da	y 2	Day 3		
Date (Oct 2002	2)	2	.3	24		2	5	
Mass loaded Primary 1		9	14	90)9	9	12	
(kg)	Primary 2	9	916		17	9	17	
Time	Secondary	08	:55	09	:25	09	:30	
Burners On	Primary	09	:10	09	:38	10	:03	
Primary Temp	erature (°C)		See ten	nperature pro	ofiles in App	endix I		
Secondary Ter	mperature (°C)		See ten	nperature pro	ofiles in App	oendix I		
Sampling Conditions		SVOC 1	Part/M-1	SVOC 2	Part/M-2	Part/M-3	SVOC 3	
Date (Oct 2002	2)	23	23	24	24	25	25	
Sampling Time	e (local)	09:45 - 13:53	15:07 - 17:15	10:01 - 14:10	16:07 - 18:11	10:18 - 12:24	13:16 - 17:26	
Test Duration (min)		240	120	240	120	120	240	
Isokineticity (%)	96.1	96.0	99.4	96.9	100.3	100.3	
Sample Volum	ne (m^3)	4.075	1.891	3.894	1.903	1.983	4.043	
Stack Gas Ch	aracteristics			•				
Flow Rate (m ³	/min)	71.64	66.79	65.73	66.72	67.04	67.74	
Actual Velocit	y (m/s)	6.78	5.90	5.98	5.88	6.25	6.13	
Temperature (°C)	705	666	669	671	688	675	
Moisture (%)		10.09	7.59	10.10	6.92	10.25	8.13	
Oxygen (%)		13.9	15.2	13.9	14.7	14.3	14.8	
Carbon Dioxic	le (%)	4.5	3.2	4.5	3.6	4.5	3.7	
Molecular We	ight (lb/lb-mole)	29.28	29.12	29.28	29.16	29.29	29.18	

Table 1 Summary of General Stack Sampling Data

All volumes are expressed on a dry basis referenced to 25°C and 101.325 kPa.

6.2 Particulate, Acid Gases and Metals

The concentrations of particulate, acid gases and metals are shown in Table 2. Particulate emissions ranged from 6 to 23 mg/m³ (average 10.5 mg/m³) corrected to 11 percent oxygen. The largest particulate level was observed in the third run where the sample was collected at the beginning of the burn cycle. Particulate levels for the two runs collected towards the end of the burn were 6.0 and 2.9 mg/m³ with the latter value corresponding to the run collected closest to the end of the cycle. HCl levels ranged from 97 to 262 mg/m³ with the higher value measured during the beginning of the burn. HF concentrations varied between 1.7 and 3.3 but the higher levels were measured towards the latter part of the batch cycle.

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The front- and back-half fractions were analysed separately. As expected, all the mercury was associated with the back-half fraction. With the exception of three metals, the majority was consistently found in the front-half of the train. Two of these three metals, manganese and nickel, exhibited partitioning towards the front-half of the train in the run that was collected at the beginning of the cycle (77 and 84% respectively). The partitioning was skewed towards the back-half in the first and second runs for manganese (88/74%) and nickel (59/61%) respectively. In contrast, selenium distribution was skewed toward the back-half when the sample was collected at the start of the burn (70% in the back-half) compared to the two runs (71 and 66% in the front-half) collected towards the end of the cycle. Two metals, beryllium and thallium were not detected in the train samples. Mercury was detected in all runs but was very variable. Levels varied between 4.7 and 72.2 μ g/m³. For most of the metals, the levels in Run 3 (start of burn) were substantially higher than concentrations measured towards the end of the burn. No difference was noted for chromium.



The average (see note in Table 2) metal concentrations for the three runs are illustrated in Figure

8. Values are plotted on a logarithmic y-axis. Lead, copper, zinc and cadmium accounted for the majority of the reported metals (246, 214, 140 and 120 μ g/m³ respectively). Four metals, mercury, antimony, chromium and manganese, showed average concentrations between 10 and 100 μ g/m³. The remainder of the metals were below 10 μ g/m³ of which cobalt was below 1 μ g/m³. As mentioned previously, beryllium and thallium were not detected

Figure 8 Average Metal Concentrations (corrected to 11% oxygen)

Pollutant	Part/M-1		Part/M-2		Part/M-3		Average*		
Particulate (mg/m ³)	6	6.0		2.9		22.7		10.5	
HCl / HF (mg/m ³)	97	3.3	113	4.0	262	1.7	157	3.0	
HCl / HF (ppm)	65	4.0	76	4.9	175	2.0	105	3.6	
Metals (µg/m ³)					1				
Mercury	11	.2	72	.2	4.7		29.4		
Antimony	32	2.6	92	2.3	90).8	71	.9	
Arsenic	0.9		0.	0.9		2.2		1.3	
Barium	0.2		3.2		5.3		2.9		
Beryllium	0.0		0.0		0.0		0.0		
Cadmium	21.7		35.4		303		120		
Chromium	56.5		49.2		53.4		53.1		
Cobalt	0	.3	0.2		0.5		0.3		
Copper	13	38	161		343		214		
Lead	62	.1	160		515		246		
Manganese	11	.6	10.4		21.0		14.4		
Nickel	2.9		2.7		10.2		5	.3	
Selenium	2.1		2.	.7	3	.6	2	.8	
Silver	3	.3	3.5		4	4.3		3.7	
Thallium	0	.0	0.0		0.0		0.0		
Zinc	57	'.7	88.0		274		140		

Table 2 Summary of Particulate, Acid Gases and Metals Concentrations (corrected to 11% oxygen)

All volumes are expressed on a dry basis referenced to 25°C and 101.325 kPa. "0" denotes not detected. * The average was based on the mean of the three runs.

6.3 Flue Gases

The concentrations of oxygen, carbon dioxide, carbon monoxide, nitrogen oxides and sulphur dioxide are summarized in Table 3. Carbon monoxide, nitrogen oxides and sulphur dioxide are corrected to 11 percent oxygen. The values summarized in Table 3 represent the arithmetic average of the half-hour integrated bag samples. Detailed data for all the runs is given in Appendix I.

Run	O ₂ (%)	CO ₂ (%)	CO* (ppm)	NO* (ppm)	NO ₂ * (ppm)	NO _x * (ppm)	SO ₂ * (ppm)
Part/M-1	15.2	3.2	9	50	4	54	0
Part/M-2	14.7	3.6	6	47	3	51	0
Part/M-3	14.3	4.5	4	45	4	49	0
SVOC 1	13.9	4.5	0	36	2	38	0
SVOC 2	13.9	4.5	3	40	3	43	2
SVOC 3	14.8	3.7	4	40	3	43	0
Ave**	14.4	4.1	3.6	41.7	3.0	44.7	0.5
Std Dev**	0.5	0.5	2.7	8.0	1.7	9.6	1.9

Table 3	Summary	of Flue G	Gas Concen	trations
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* Corrected to 11% oxygen. ** All data points

In general, oxygen levels were 13.5 to 14 % at the start of the burn and increased to 15% by the end of the daily testing. Carbon dioxide followed the reverse trend, starting around 4.6 to 4.9% and decreasing to 3.1 to 3.5%. Sulphur dioxide was detected in only three of the integrated bag samples (SVOC 2). Carbon monoxide levels were below 10 ppm with only one bag sample slightly above 10 ppm. On average, NO represented 93% of the total NO_x. NO_x levels showed a declining trend for the first four to five hours after the start of the daily sampling after which they increased for the remainder of the burn.

6.4 Dioxins and Furans

PCDD/PCDF data is reported on the basis of the seventeen 2,3,7,8-substituted dioxin and furan congeners. This data is further transformed by multiplying each of the 17 congeners by their respective toxicity equivalency factor (International-TEF or I-TEF). The factors range from 1.0 for 2,3,7,8- TCDD to 0.001 for OCDD and OCDF. The sum of all the 17 factored compounds is known as the TEQ. Analytical results of the loaded trains, field blank train, proofing and method blank samples are presented in Appendix II.

The emission summaries for the TEQ dioxins and furans are given in Table 4. The front- and back-half components of the SVOC train which correspond to the particulate and gaseous
fractions respectively in the sample gas were combined for analysis. Train catches were corrected for the blank train. The blank train level was less than 0.35 pg TEQ/m^3 .

The levels of the 17 congeners are shown in Figure 9. In all runs, the furan TEQ outweighed the dioxin TEQ. On a train total basis, the 10 furan compounds were very consistent representing 81 to 88% of the total train TEQ. Four furan congeners, 2,3,7,8-T4CDF, 2,3,4,7,8-P5CDF, 1,2,3,4,7,8-H6CDF and 2,3,4,6,7,8-H6CDF accounted for 67 to 71% of the total TEQ. On the TEQ basis, the 2,3,4,7,8-P5CDF congener was the largest component (26 to 30% of total) followed equally by 1,2,3,4,7,8-H6CDF (14 to 17%) and 2,3,4,6,7,8-H6CDF (14 to 18%). The 2,3,7,8-T4CDD congener was detected in all runs and accounted for 2.6 to 5.2% of the total TEQ. The congener profiles among the three runs are essentially identical.

Varying TEQ concentrations were measured during the testing. The highest level (71 pg TEQ/m^3) was measured in SVOC 3 which started about three hours after the ignition of the primary chambers. TEQ concentrations for the two tests conducted shortly after ignition were 10 and 36 pg TEQ/m^3 . The simple average concentration was 38.9 pg TEQ/m^3 . All concentrations are at 11% oxygen.





Compound	SVOC 1	SVOC 2	SVOC 3
2378-T4CDD	0.41	0.92	3.69
12378-P5CDD	0.35	0.92	3.48
123478-H6CDD	0.05	0.29	0.96
123678-H6CDD	0.11	0.59	1.24
123789-H6CDD	0.14	0.56	2.81
1234678-H7CDD	0.12	0.71	1.17
OCDD	0.03	0.18	0.19
2378-T4CDF	1.03	3.84	6.73
12378-P5CDF	0.15	0.56	0.85
23478-P5CDF	2.81	10.82	18.63
123478-H6CDF	1.42	5.36	12.06
123678-H6CDF	5CDF 0.65 2.		4.45
234678-H6CDF	1.77	5.15	10.31
123789-H6CDF	0.13	0.70	0.63
1234678-H7CDF	0.44	1.30	2.56
1234789-H7CDF	0.23	0.69	0.88
OCDF	0.13	0.37	0.33
TOTAL	9.98	35.73	70.98

Table 4Concentrations of Dioxins and Furans
(pg TEQ/m³ @11% oxygen)

All values are expressed on a dry basis referenced to 25°C and 101.325 kPa. Totals may not add due to rounding.

6.5 Chlorobenzenes and Octachlorostyrene

The analysis of the SVOC train samples also included chlorobenzenes (CBs) and octachlorostyrene (OCS). Chlorobenzene compounds included 1,2,3,5-tetrachlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,2,3,4-tetrachlorobenzene, pentachlorobenzene and hexachlorobenzene. Concentrations for the five selected chlorobenzenes and octachlorostyrene are summarized in Table 5 and Figure 10. Both train fractions were combined for the analysis of selected chlorobenzenes and octachlorostyrene. Pentachlorobenzene represented the largest component of the chlorobenzene isomers. Total selected CBs ranged between 3.4 and 44 ng/m³. Similar to the TEQ dioxins and furans, the highest level for each of the detected compounds was measured in the run collected three hours after ignition. OCS was not detected in any of the three runs. Chlorobenzene concentrations are not corrected to 11 % oxygen.

Compound	SVOC 1	SVOC 2	SVOC 3
1,2,3,5-Tetrachlorobenzene	0.7	2.8	10.1
1,2,4,5-Tetrachlorobenzene	0.0	0.8	3.5
1,2,3,4-Tetrachlorobenzene	0.7	3.3	7.2
Pentachlorobenzene	1.2	3.6	17.3
Hexachlorobenzene	0.7	1.8	5.9
Total selected CBs	3.4	12.3	44.0
Octachlorostyrene	0.0	0.0	0.0

Table 5Concentrations of Chlorobenzenes and Octachlorostyrene (ng/m³)

Concentrations are expressed on a dry basis referenced to 25°C and 101.325 kPa.

"0" denotes not detectable.





6.6 Polycyclic Aromatic Hydrocarbons (PAHs)

PAH concentrations are summarized in Table 6. As mentioned previously, the front- and backhalves of the sampling train were combined for analysis. Train catches were corrected for the PAHs detected in the blank train. Due to the low PAH loadings from this source, the PAH contribution from the blank, was substantial ranging from 44 to 66% of the uncorrected train catch. PAH analytical results of the loaded trains, blank train, proofing and control samples are presented in Appendix II.

Retene, a compound associated with wood combustion was added to the PAH list. The lighter half of the reported PAHs accounted for 82 to 99 % of the total. The heaviest PAH compound detected in at least one of the runs was benzo(g,h,i)perylene. Fluorene, phenanthrene, fluoranthene, pyrene and retene were the most abundant compounds accounting for 70 to 86% of all the reported PAHs for the three runs. Phenanthrene accounted for 33 to 42% of the total.

The totals for each train were low, ranging from 15 to 39 ng/m³ (simple average 29 ng/m³). These concentrations are not corrected to 11% oxygen. The highest levels were found in the runs that commenced sampling shortly after ignition of the primary. Little difference was noted between Run 1 and Run 2. A plot of the detected PAHs above 1 ng/m³ is shown in Figure 11.





Compound	SVOC 1	SVOC 2	SVOC 3
Acenapthylene	0.8	0.7	0.1
Acenapthene	0.0	0.0	0.2
Fluorene	1.3	1.7	0.8
2-Methyl-Fluorene	1.2	1.5	1.1
Phenanthrene	12.8	14.5	6.1
Anthracene	1.5	0.7	0.2
Fluoranthene	3.5	4.6	1.5
Pyrene	3.0	3.4	1.5
Retene	6.5	2.4	2.7
Benzo(a)Fluorene	0.0	0.2	0.2
Benzo(b)Fluorene	0.0	0.0	0.0
1-Methyl-Pyrene	0.0	0.2	0.1
Benzo(g,h,i)Fluoranthene	0.0	0.3	0.0
Benzo(a)Anthracene	0.5	0.4	0.0
Triphenylene	0.4	0.3	0.1
Chrysene	1.1	1.0	0.1
7-Methyl-Benzo(a)Anthracene	0.0	0.0	0.0
Benzo(b)Fluoranthene	2.4	2.0	0.0
Benzo(k)Fluoranthene	0.5	0.0	0.0
Benzo(e)Pyrene	0.9	0.7	0.0
Benzo(a)Pyrene	0.0	0.0	0.0
Perylene	0.0	0.0	0.0
3-Methyl-Cholanthrene	0.0	0.0	0.0
Indeno(1,2,3-cd)Pyrene	1.3	0.0	0.0
Dibenzo(a,h)Anthracene	0.0	0.0	0.0
Benzo(b)Chrysene	0.0	0.0	0.0
Benzo(g,h,i)Perylene	0.9	0.0	0.0
Anthanthrene	0.0	0.0	0.0
TOTAL	38.6	34.7	14.9

Table 6Concentrations of PAHs (ng/m³)
(corrected for blank train)

Values expressed on a dry basis referenced to 25°C and 101.325 kPa. "0" denotes not detectable.

6.7 Volatile Organic Compounds (VOCs)

The full VOC target list contains 145 compounds, however this list was pared down for reporting purposes as many of the species are of lesser interest. Normally the list is reduced to include BTEX (benzene, ethylbenzene, toluene and xylenes) and halogenated hydrocarbons. Benzene and some halogenated hydrocarbons such as vinyl chloride, 1,3-butadiene, dichloromethane, tri and tetrachloroethene, carbon tetrachloride, 1,1,1-trichloroethane, 1,2-dichloroethane and hexachlorobutadiene are classified as CEPA-toxic substances. Naphthalene, a PAH compound, was also included since it is not reliably determined using the modified Method 5 type train. The full list of VOC concentrations is given in Appendix II.

The emission data for VOCs of interest is summarized in Table 7. Two canister samples were collected during each SVOC run. These are reported separately in Table 7.

Common d	SVOC 1		SVC	DC 2	SVC	Overall	
Compound	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Average
Chloromethane	0.79	4.56	1.34	2.31	1.57	0.85	1.90
Vinyl chloride	0.00	1.72	0.26	1.07	0.36	0.44	0.64
1,3 Butadiene	0.00	11.00	0.00	0.00	0.00	0.00	1.83
Dichloromethane	2.55	2.64	2.24	2.82	1.43	1.03	2.12
Benzene	1.79	99.80	1.60	1.43	1.87	0.95	17.91
Toluene	5831	2072	1258	2660	1170	713	2284
Chlorobenzene	0.10	3.72	0.12	0.26	0.09	0.07	0.73
Ethylbenzene	1.88	17.64	0.79	1.08	0.52	0.28	3.70
Total Above	5838	2213	1265	2668	1176	717	2313
All reported VOCs	5871	3213	1293	2695	1191	731	2499

Table 7 Concentrations of Selected VOCs (µg/m³)

All values are expressed on a dry basis referenced to 25°C and 101.325 kPa. Compounds denoted in bold are CEPA-toxic compounds.

With the exception of sample 2 in SVOC 1, the VOCs reported in Table 7 accounted for +98% of the total VOCs. A high level of propene (verified by reanalysis) was measured in second sample of the first SVOC run. Three CEPA-toxic compounds, 1,2-dichloroethane and 1,1,1-trichloroethane and hexachlorobutadiene were analyzed for but not detected. Other toxics such as carbon tetrachloride, tri and tetra chloroethene were detected but at levels below those usually found in ambient air. Two of the naphthalene results showed levels slightly above ambient.

Toluene, normally found in combustion sources, was the most abundant compound accounting for practically all the detected volatile organic compounds. The higher toluene value in the first canister of the first SVOC run was confirmed by reanalyzing the canister. Except for the benzene, toluene and ethylbenzene reported above, other components of BTEX were detected but were found to be around those levels normally found in ambient air.

No agreement was evident among the three pairs of canisters. Using pair averages, the total VOCs for each of the three runs were 4540, 1994 and 960 μ g/m³. The average VOC level is in the order of 600 ppb on a volume/volume basis. The highest levels of VOCs were measured in

the samples collected at the start of the cycle (SVOC1 and SVOC 2). No pattern was evident between the first and second canister of each SVOC run.

6.8 Estimated Emission Rates

The annual emission rates for the particulate/metals and organic runs are given in Table 9. One of the difficulties associated with the calculation of the emission rates is the estimation of the concentration over the oxidizer cycle for each of the pollutants. Pollutant levels are a result of feed material, process operation and the portion of the burn cycle in a batch process. In this program, sampling was staggered as much as possible to provide a more representative variation of the emissions over the cycle.

Normally, the concentration used for calculating emission rates is the arithmetic average of three runs. In this case, this approach may introduce a bias for some of the pollutants as two of the runs were essentially duplicates of the same portion of the cycle. A selective average was also calculated based on the average between the two runs collected during the same part of the cycle and the remaining run. A comparison of these two averaging techniques is illustrated in Table 8.

Pollutant	Three Ave	e Run rage	Selective Average			
Particulate/Acid Gases/Metals						
Particulate (mg/m ³)	6.'	78	8.	87		
HCl / HF (mg/m ³)	100.3	1.8	118.9	1.6		
Mercury	18.	.27	14	.49		
Antimony	45.	.70	49.	.40		
Arsenic	0.8	86	1.0	01		
Barium	1.8	89	2.1	30		
Cadmium	78	.9	109.7			
Chromium	33.00		33.66			
Cobalt	0.2	20	0.23			
Copper	13	5.4	159.5			
Lead	159	9.7	205.6			
Manganese	9.0	09	10.32			
Nickel	3.3	3.39		23		
Selenium	1.	75	1.90			
Silver	2.33		2.46			
Zinc	90	.3	11.	3.3		
Organics						
Dioxins and Furans (pg TEQ/m ³)	25.	25.35		.95		
PAHs (ng/m ³)	29.	40	25.78			
CBs (ng/m ³)	19.	.93	25.95			
VOCs ($\mu g/m^3$)	24	99	2115			

 Table 8 Effect of Averaging Method on Uncorrected Concentrations

Table 8 shows that the selective approach results in higher average concentrations for particulate, HCl, most metals, dioxins and furans and chlorobenzenes. VOCs and PAHs display the opposite bias. The difference for mercury is irrelevant as the emissions are probably directly related to the feed input. Neither method is invalid but this exercise serves to illustrate that the assumptions have an impact on emission levels. For the purpose of this program, the simple average of three runs will be used to estimate annual emissions. Two scenarios were used for estimating annual emission rates -100 and 250 cycles per year.

BASIS: AVERAGE OF THREE RUNS Ten hour cycle 100 and 250 batches per year Stack flow rate - average of all runs								
Average* Annual Emission Rate								
Pollutant	Concentration	100 batches	250 batches					
Particulate, Acid Gases and Metals								
Particulate	6.78 mg/m ³	27.5 kg/year	68.8 kg/year					
HCl	100.2 mg/m^3	407 kg/year	1017 kg/year					
HF	1.83 mg/m^3	7.4 kg/year	18.5 kg/year					
	$(\mu g/m^3)$	<u>(g/year)</u>	<u>(g/year)</u>					
Metals								
Mercury	18.3	74	185					
Antimony	45.7	185	463					
Arsenic	0.9	3	9					
Barium	1.9	8	19					
Beryllium	not detected	-	-					
Cadmium	78.9	320	800					
Chromium	33.0	134	335					
Cobalt	0.2	1	2					
Copper	136.4	553	1384					
Lead	159.7	648	1619					
Manganese	9.1	37	92					
Nickel	3.4	14	34					
Selenium	1.7	7	18					
Silver	2.3	9	24					
Thallium	not detected	-	-					
Zinc	90.3	366	916					
Organics								
Dioxins and Furans (TEQ)	25.35 pg TEQ/m ³	0.103 mg/year	0.257 mg/year					
TCB (3 isomers)	9.73 ng/m ³	0.039 g/year	0.099 g/year					
РСВ	7.38 ng/m ³	0.030 g/year	0.075 g/year					
НСВ	2.82 ng/m^3	0.011 g/year	0.029 g/year					
PAHs	29.4 ng/m ³	0.119 g/year	0.298 g/year					
OCS	not detected	-	-					
VOCs	2499 μg/m ³	10.1 kg/year	25.3 kg/year					

 Table 9
 Estimated Annual Emission Rates

*Uncorrected concentrations at reference conditions used to calculate emission rates.

7. SUMMARY

Concentration data is summarized below. The relative abundances (on a logarithmic scale) for the organic compounds and metals are illustrated in Figure 12.

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Compound	Concent	ration															
PCDDs/PCDFs*	38.9 pg T	EQ/m ³						VO	Cs								
CBs (5 isomers)	19.9 ng	g/m ³			F	PAHs											
OCS	0 ng/	m ³															
PAHs	29.4 ng	g/m ³			C	Bs											
VOCs	2499 μ	g/m ³															
Particulate* HCl*	10.5 m 157 m	g/m^3 g/m^3			TEQ			Co	ncen	trati	on (g/m³)				
HF* * at 11% oxygen 0 denotes not detected.	3.0 mg	<u>g/m³</u>	1.6	5-13	1.E-	11	1.	E-09	1	I.E-07	•	1.E-	05	1.	E-03	1	.E-01
Metals* (µg/m ³)		1.E+03	1														
Mercury	29.38					C	Cond	entr	atior	ı (ug	J/m ³)					
Antimony Arsenic	71.9																
Barium	2.9	1.E+02					-			┤┟							
Beryllium	0.0																
Cadmium	120.0																
Chromium	53.1																
Cobalt	0.3	1.E+01	H H	~			Ε	┥_┟		e	σ	-					1
Copper	214.2		5				miu	ium		ddo	Lea	e					uc L
Leau	243.3 14 A		In .				ad	E S		Ö		les					Z
Nickel	53	1.E+00	Mer	₹	╵╴╸		0	- E	alt			gar	e	ε	5		
Selenium	2.8			ji ji	j.	Ę			Cob			lan	lick	niu	ilve	c	
Silver	3.7			Ise	Ba	ýllíť						2	2	sele	S	liun	
Thallium				Ā		e.								05		lal	
i namum	0.0					m										<u> </u>	
Zinc	0.0 139.8	1.E-01				•		Ţ	, Ц,					,	, LLI,	È	



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APPENDIX I

(Only available with hard copy) Waste Oxidizer Temperature Data

Flue Gas Monitoring Data

SVOC Traverse Data

Particulate /Metals Traverse Data

APPENDIX II

(Only available with hard copy) Anion, Particulate and Metals Analysis

Dioxin, Furan, CB and OCS Analytical Report

VOC Analytical Data

INFORMATION REQUEST – YKDFN_2.1

Source: Yellowknives Dene First Nation (YKDFN)

Request

Caribou Cumulative Effects – Cumulative Study Extent

- 1) YKDFN request that the CE study be completed in a manner that truly reflects the full range of impacts to caribou across their range.
- 2) During Technical Session and subsequent discussions, Golder stated that the level of development would be higher within the treeline and that they had evidence to support that which wasn't ready for submission. The technical memo seems to suggest that the level of development is higher on the barrens. Can the company provide a plain language discussion which clarifies the situation?

Response

Response 1

Fortune Minerals Limited has undertaken the requested cumulative effects analysis, which added an analysis of the potential for cumulative effects in the entire annual range of the Bathurst caribou herd (as well as the Caribou Study Area used in the Developer's Assessment Report [DAR], which considers their winter range below the treeline). The analysis is described in the Informal Undertaking 'Disturbance to Bathurst Caribou from Future Development and Multiple Spatial Scales' (added to the Review Board Public Registry on 13 April, 2012). This analysis included 3 new assessment cases, 4 metrics to describe the level of development, and 3 potential future developments (including the 211 km Bathurst Inlet Port and Road [BIPR] Project), which were not included in the DAR.

The results of this additional analysis supported the results and conclusions of the DAR. For example, the impact assessment in the DAR was based upon the estimate that 0.20% of the Caribou Study Area (i.e., the caribou winter range below the treeline) would be directly affected by previous and existing developments including the NICO Project. Expanding the assessment area to the annual range of the Bathurst herd, and to include new reasonably foreseeable future developments (including the BIPR) resulted in an estimate that 0.26% of the annual range would be directly affected (or 0.15% if winter roads are excluded from the analysis, which represents spring, summer, autumn, and early winter conditions). This negligible difference in direct loss of habitat does not change the impact predictions made in the DAR.

With regards to the Back River and Hackett River projects, these 2 exploration camps were included in both the DAR and the Informal Undertaking as exploration camps (with a 5 km zone of influence). They were not included as future operating mines because a mine layout (i.e., project footprint) is not available for either project.

Response 2

The Informal Undertaking described above indicates that the proportion of the landscape affected by direct habitat loss and indirect habitat change is similar within both the Caribou Study Area used in the DAR (the area of the Bathurst caribou winter range below the treeline), the Bathurst herd winter range, and the Bathurst herd





annual range. For example, the level of direct and indirect habitat effects to caribou is roughly similar in all 3 areas when winter roads are included in the analysis (ranging from 0.22 to 0.26% for direct habitat loss, and 9.4 to 10.7% for combined direct and indirect habitat loss).

The Informal Undertaking does not suggest that the level of development is higher on the barrenlands. Rather, the levels of disturbance are notably lower when winter roads are removed from the analysis, which represents the spring, summer, fall, and early winter conditions when Bathurst caribou are using the barrenlands. This indirectly indicates that the level of development is a little lower on the barrenlands during the seasons when the Bathurst caribou herd are there. The same conclusion is made in the technical memo that is referred to by the reviewer.





INFORMATION REQUEST – YKDFN_2.2

Source: Yellowknives Dene First Nation (YKDFN)

Request

Demographic Impacts

YKDFN request that the company complete an analysis which considers and predicts the impacts from direct and indirect development to the Bathurst Caribou herd population.

Response

The analyses and information presented in the Developer's Assessment Report (DAR) addresses direct and indirect impacts to the Bathurst caribou herd (see Section 8 of the DAR). Although existing and future levels of industrial development may have negligible-to-low impacts to caribou habitat (directly through footprints and indirectly through zones of influence), there are no significant implications for caribou abundance and harvest opportunities for traditional and non-traditional users. As indicated in Adamczewski et al. (2009), recent declines in the Bathurst caribou herd were likely a function of natural population cycles, exacerbated by a continued harvest of about 4000 to 5000 cows per year despite the decline.

In the DAR, pathways (or hypotheses) were proposed stating that industrial development may affect caribou abundance through direct mortalities, habitat loss (direct and indirect), and indirectly through the energetic costs of disturbance. However, available information and analyses suggests that the effects from these pathways on caribou are negligible to low (i.e., the direct and indirect linkages to industrial development are weak). Cumulative effects analyses showed that direct habitat losses in the Bathurst annual and seasonal ranges are very low, almost unmeasurable at the scale of the assessment that was considered (i.e., conservatively estimated at around 0.20%). Given the low density of developments on the landscape and the behaviour of caribou, the energetic implications of existing and future developments for caribou reproduction are relatively small compared to influences of weather-related factors (Section 8.5.4 of the DAR). Importantly, the risk of caribou mortality at a mine during any particular year from construction through operation is extremely low. Historical data shows that the number of direct caribou mortalities from mines and vehicle collisions has been very low (DAR page 8-59). These results have been summarized in the DAR and again in responses to earlier information requests and questions raised at the technical meeting. The key point is that there will likely be no measureable impact to the abundance and distribution of the Bathurst herd population with the application of the NICO Project.

It is well recognized that the main factors affecting caribou demographics are changes to the rates of calf survival, cow survival, and cow fecundity, and these are likewise affected by hunting from traditional and non-traditional users, and natural factors such as climate and insect activity levels, and predation by carnivores such as wolves (e.g., Adamczewski et al. 2009; Bergerud et al. 2008). The evidence presented in the DAR indicates that industrial development has a weak influence on the demographics of the Bathurst caribou herd.

Fortune Minerals Limited recognizes the importance of caribou to the YKDFN (and other communities), particularly with respect to the harvesting of caribou. An analysis of the influence of industrial development,







previous and current harvest rates, predation, changes in forage conditions on seasonal ranges, and other factors (e.g., insect levels) for projecting future harvest levels is not within the scope of the Terms of Reference. This type of analysis is not the responsibility of industry, and should be appropriately left to the agencies responsible for making public interest decisions (if appropriate data are available for making confident management decisions). By focusing the assessment on effects to abundance and distribution of caribou (and other wildlife populations), the DAR was also able to evaluate the impacts from the NICO Project on the continued opportunity for traditional and non-traditional use of caribou (sustainability of the population for harvesting).

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INFORMATION REQUEST – YKDFN_2.3

Source: Yellowknives Dene First Nation (YKDFN)

Request

Roads and Caribou

- 1) YKDFN request that the company complete an analysis that examines the likelihood of road/collared caribou interactions for the entire period.
- 2) When the company discusses the likelihood of caribou and road interaction, YKDFN requests that the company also consider the results of the aerial surveys and the snow track surveys, which seem to show clear use of the NPAR corridor.

Response

To further investigate potential caribou interactions with the NICO Project Access Road (NPAR) and proposed Tłįchǫ Road Route, satellite telemetry and GPS collar data from 1996 to 2010 for the Bathurst herd were analyzed using Geographic Information System software. Only data from the Bathurst caribou herd was used, as this herd has the most available collar data, and is most likely to be influenced by the NICO Project (see Developer's Assessment Report, Section 8.1.3.2).

The following criteria and assumptions were made in the analysis.

- Encounters with the proposed Tłįchǫ Road Route and the NPAR were assessed separately, and together. It should be noted that these analyses are predictions of future encounters based on the historical distribution of Bathurst caribou. Since neither of these roads currently occur on the landscape, there is uncertainty about actual future encounter rates, particularly with respect to the variation in the annual distribution of wintering caribou and associated changes in population size. In addition, there is uncertainty related to the assumption that collared animals represent the distribution and movement of all animals in the Bathurst herd.
- The Bathurst winter dispersal and northern migration periods, November 1 to May 31 (a span of 211 days), were used to define the temporal boundary of the analysis, which includes the time when caribou are more mobile during the early winter and northern migration (Gunn et al. 2003).
- Studies have indicated that caribou in a tundra environment may avoid roads by up to 4 kilometres (km) during the sensitive calving season (Dau and Cameron 1986; Cameron et al. 1992, 2005). All caribou collar locations within 5 km of either side of the proposed Tłįchǫ Road Route and the NPAR were considered to have encountered the road. This distance was selected to include both the potential area of avoidance, and the area where caribou may be observed from the road by hunters.

Using the criteria above, the encounter rate and residency time of collared caribou within 5 km of the proposed Tłįchǫ Road Route and NPAR were estimated. Encounter rate was calculated as the proportion (%) of the total number of collared animals encountering the 5 km buffer. Residency time was calculated as the proportion of the





total time for all collared animals spent within 5 km buffer. For the temporal boundary of the analysis, information from 125 collared caribou over 14 winter seasons was available to estimate encounter rates and residency times. The number of collars available for analysis in each year ranged from 8 to 23.

The results indicated that 3 collared caribou encountered the proposed (hypothetical) NPAR since 1996 (Figure YKDFN 2.3-1). Collared animals encountered the proposed NPAR in the winters of 1998-1999 and 2004-2005. Residency times within the 5 km buffer represent less than 0.1% of total collar time for those winter seasons. In general, the results indicate a low potential for interaction between caribou and the NPAR as most caribou activity has occurred north and east of the NICO Project in years when collared caribou are in the western part of their winter range.









Collared animals encountered the proposed (hypothetical) Tłįchǫ Road Route in 7 of the 14 winter seasons analyzed. The encounter rate was estimated for each of these seven winter seasons (Table 1). The resulting encounter rates, measured as the number of collared caribou entering the 5 km buffer, ranged from 4.3% in the winter season of 2009-2010 to 37.5% in the winter season of 1996-1997. Average (geometric mean) encounter rate over all winter seasons for which there were encounters was 11.5%, but 1.1% when all 14 winter seasons were included (i.e., 1996 to 2010). All of the encounters occurred with between Hislop Lake and the community of Gamètì, and none occurred below Hislop Lake (Figure YKDFN 2.3-1). The predicted residency times for winter seasons in which there were encounters ranged from less than 0.1 to 1.4%. The number of entries and exits shows that collared caribou may pass through the 5 km zone several times in a single winter season.

The results of this analysis predict that caribou presence in the vicinity of the proposed Tłįchǫ Road Route and NPAR is variable from year to year, and that there is a low frequency of caribou encountering the hypothetical NPAR between winter dispersal and spring migration. Residency time within the 5 km buffer around the proposed all-weather roads appears to be a small component of the overall 211 day period considered. No temporal trends in the encounter rate or residency time are apparent. The analysis also suggests that interaction with all-weather roads will likely be limited to above Hislop Lake, which is north of the section of the proposed Tłįchǫ Road Route and NPAR that will be used by NICO Project traffic.

Winter- season	Number of Collared Animals	Number of Collared Animals Encountering the Road Buffer ^a	Number of Entries and Exits of the Road Buffer	Total Collar Time (hours) ^b	Encounter Rate ^c (%)	Residency Time ^d (%)
1996-1997	8	3	6	37,309	37.5	0.4
1998-1999	19	6	18	84,480	31.6	0.5
1999-2000	14	1	2	67,355	7.1	0.8
2004-2005	23	3	11	57,367	13.0	1.4
2006-2007	21	2	4	79,687	9.5	0.2
2007-2008	17	1	2	77,153	5.9	<0.1
2009-2010	23	1	2	61,030	4.3	<0.1

 Table 1: Encounters between Collared Caribou and Proposed Tłįcho Road Route and NICO Project

 Access Road from 1996 through 2010

^a Including a 5 km area on either side of the road.

^bCumulative time for all collars from November 1 to May 31.

^c Measured as percent of collared animals encountering the 5 km buffer.

^d Measured as the percent of total collar time spent within 5 km road buffer.

The YKDFN has requested consideration of results from aerial surveys with respect to assessment of road interaction by caribou. Results from aerial survey data (caribou observed or snow tracks) indicate that caribou use habitat within and adjacent to the proposed NPAR, and therefore are likely to interact with the road when it is in operation. However, the probability of interactions will likely vary from year to year, as demonstrated by the analysis of collared animals and the general trend in the number of caribou observed during aerial surveys from 2004 to 2010, which corresponds to winter distribution of caribou and change in population size.





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INFORMATION REQUEST – YKDFN_2.4

Source: Yellowknives Dene First Nation (YKDFN)

Request

Study Area

YKDFN request that the project explain how they can achieve the same objectives as the similarly sized Gahcho Kue project while having a much smaller study area. Part of this discussion should include how these respective levels of information will allow the listed objectives to be met.

Response

The YKDFN have requested why the size of the study area used for aerial surveys is larger for the Gahcho Kué Project than it is for the NICO Project. This is because information in the peer-reviewed literature indicates that the zone of influence from development is larger in treeless environments than in boreal environments. This information was presented in the Report of Meeting between Golder Associates Ltd. and the YKDFN regarding the NICO Project (report dated 27 February 2012). It is reasonable to expect that a zone of influence would be larger in environments where there is a lack of vegetation cover for restricting visual disturbances and for absorbing human-related noises. Thus, it is appropriate that the study area be larger for the Gahcho Kué Project than for the NICO Project.

Justification for the size of regional study area is provided in the responses to the first round Information Request YKDFN_2.6. It is anticipated that the dimensions of the regional study area for the NICO Project are sufficient for monitoring caribou, as mine-related influences on caribou should be well within the regional study area. In other words, it is anticipated that the regional study area will extend well beyond the zone of influence of the NICO Project, and provide an appropriate scale for monitoring the potential change in caribou distribution from the NICO Project.







INFORMATION REQUEST – YKDFN_2.5

Source: Yellowknives Dene First Nation (YKDFN)

Request

Cumulative Effects Monitoring and Adaptive Management Linkages

YKDFN request that the GNWT and AANDC complete a cumulative effects monitoring plan with appropriate linkages to adaptive management mitigations.

Response

No action required from Fortune Minerals Limited.





INFORMATION REQUEST – YKDFN_3.1

Source: Yellowknives Dene First Nation (YKDFN)

Request

Security Bonds

The YKDFN would like the company and AANDC to discuss why the full amount of security would not be required for this project, given the current lack of financial flexibility.

Response

Fortune Minerals Limited (Fortune) is working with Aboriginal Affairs and Northern Development Canada (AANDC) regarding the security bond for the NICO Project. Aboriginal Affairs and Northern Development Canada described the principles and process for the development of reclamation security in their response to the Yellowknives Dene First Nation. Fortune is not in a position to address this information request at this time without further consultation and meetings with AANDC.







INFORMATION REQUEST – YKDFN_3.2

Source: Yellowknives Dene First Nation (YKDFN)

Request

The lack of collectively developed goals and objectives, a list of mine components, and a lack of recognized information gaps greatly limits the ability of the parties to approach this project in a cradle to grave manner (i.e. designing for closure). YKDFN request that the company reconsider their approach to closure planning and provide the parties with a plan that is more appropriate and useful both during the EA but also into the future. This would be consistent with the best practices and provide an opportunity for early incorporation of lessons learned in other developments.

Response

Fortune Minerals Limited (Fortune) submitted a conceptual closure and reclamation plan (CRP) in the Developer's Assessment Report (DAR) as required under the terms of reference (TOR). On 15 July 2011, the Mackenzie Valley Review Board stated that the DAR was in conformity with the TOR, which includes the level of detail provided on closure and reclamation. It should be recognized that Fortune is designing the NICO Project with closure in mind as demonstrated by the design of the Co-Disposal Facility and other mine elements, and its recognition of the potential issues associated with water quality during post-closure.

Fortune is continuing to work on refining closure techniques as demonstrated by its recent submission on the public registry of the results of the bench scale testing of passive treatment techniques (i.e., wetlands).

For the regulatory phase of permitting, the process of the development of an interim CRP is outlined in the Draft Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories. This process calls for the review of closure objectives and criteria with a closure and reclamation planning working group, which would likely be composed of the various interested parties and staff from the Wek'èezhii Land and Water Board. According to the draft guidelines, an interim CRP would typically be required within 12 months after the issuance of the water license. This interim CRP would need to be updated every 3 years. A final CRP is required 2 years prior to closure.

Fortune believes that the CRP will be a living document that will evolve over time. If we look back at the history of closure and reclamation goals and objectives over the last 20 years in the Northwest Territories, we see that standards and methods for addressing closure issues have changed considerably. Fortune expects that this evolution in closure and reclamation planning will continue over the 18 year mine life of the NICO Project. With a CRP review period every 3 years and the requirement for a final CRP 2 years prior to closure, Fortune is confident it can capture input from the communities in the area of the mine and other interested parties as the mine progresses towards eventual closure.







INFORMATION REQUESTS ENVIRONMENT CANADA





INFORMATION REQUEST – EC_2-1

Source: Environment Canada (EC)

Request

Site Specific Water Quality Objectives (SSWQOs)

EC requests that further work be done on identifying water quality objectives that are based on the lowest feasible concentrations in the receiving environment, taking into account ambient conditions (including sensitive local species) and reasonably achievable effluent quality and source predictions.

Response

The site-specific water quality objectives (SSWQOs) presented in the Developer's Assessment Report (DAR) are aquatic health-based chronic effects benchmarks that take into account toxological information available for a range of aquatic species that are applicable to the receiving environment. These were derived for the DAR both to guide the design of the water treatment system for the Effluent Treatment Facility and to support the assessment of potential effects of all project sources on water quality and aquatic health.

Additional work will be done to continue to refine SSWQOs and develop effluent quality criteria (EQCs) as part of the water license permitting process. These objectives and EQCs will take into account ambient conditions, including characteristics of Peanut Lake (e.g., volume and variability in flow rates and residence time) that may limit achievable levels of mixing within Peanut Lake, and reasonably achievable effluent quality and source predictions. Fortune Minerals Limited has already scheduled a meeting with representatives from Aboriginal Affairs and Northern Development Canada, the Wek'eezhii Land and Water Board, and Environment Canada to discuss a path forward on this subject.







INFORMATION REQUEST – EC_2-2

Source: Environment Canada (EC)

Request

Site Specific Water Quality Objectives (SSWQOs) - Aluminum

EC requests recalculation of the SSWQO for aluminum be done, with consideration of the 2007 CCME protocol. Further review of other parameters would also be appropriate.

Response

Site-specific water quality objectives (SSWQOs) for aluminum of 420 micrograms per litre (μ g/L) and 410 μ g/L were derived for Nico and Peanut lakes, respectively using the equation that is currently provided by the British Columbia Ministry of Environment, Lands and Parks (BCMELP) to derive water quality guidelines for dissolved aluminum at a pH of less than 6.5 (BCMELP 1994). In Nico Lake, the pH ranges from 7.1 to 7.8 (Fortune 2011). In Peanut Lake, the pH ranges from 7.0 to 7.8 (Fortune 2011). The pH ranges in Nico and Peanut lakes are outside the pH range for which the equation provided by the BCMELP is applicable. Still, the SSWQOs are considered protective of aquatic life in Nico and Peanut lakes.

The toxicity of aluminum is highly dependent on pH. However, there are relatively few studies in the pH ranges measured in Nico and Peanut lakes, that is, most studies have been conducted at low pH where the toxicity of aluminum tends to be greatest. The toxicity data provided in the CCME guideline derivation for aluminum (CCREM 1987) was reviewed. Adverse effects on survival (37% mortality) were observed using the chironomid Tanytarius dissimilis following 55 days of exposure to 800 µg/L aluminum at pH 6.8 (Lamb and Bailey 1981; as cited in CCREM 1987). Reproduction in Daphnia magna was impaired by 50% at a concentration of 680 µg/L aluminum at pH 6.5 to 7.5 following 3 weeks of exposure (Schofield and Trojnar 1980, as cited in CCREM 1987). The results of the study by Biesenger and Christensen (1972) were not included in the CCME guideline derivation; however, they demonstrated a 50% and 16% impairment in reproduction in Daphnia magna following 21 days of exposure to 680 µg/L and 320 µg/L aluminum, respectively at pH 7.4 to 8.2. This result is consistent with that of the Schofield and Trojnar study (1980, as cited in CCREM 1987). Daphnia magna appear to be more sensitive to the effects of aluminum than other cladocerans. For example, Holopedium gibberum, the most abundant cladocerna in Nico Lake (Fortune 2011) was found in an acidified Ontario lake with an aluminum concentration of 490 µg/L (Bleiwas 1983; as cited in Havas and Likens 1985). This species has also been shown to be tolerant to aluminum in laboratory tests. Exposure to 1000 µg/L at pH 6.5 resulted in no adverse effects on survival (Havas and Likens 1985).

Aquatic plants appear to be less sensitive than invertebrates. At circumneutral pH and an aluminum concentration of $2500 \mu g/L$, root growth of Eurasian watermilfoil (*Myriophyllum spicatum L*.) was reduced by 50% (Stanley, 1974; as cited in CCREM, 1987).

There were no studies cited in the CCME guideline derivation for aluminum for fish in the pH range measured in Nico and Peanut lakes, and in general these studies are lacking for fish. The available data suggests that fish are more sensitive to the effects of aluminum than invertebrates. Freeman and Everhart (1971) exposed rainbow







trout juveniles to aluminum for 45 days at pH 7.0. At 500 μg/L, rainbow trout weight averaged 67.5% less than the weight of the control fish. Hunn et al. (1987) exposed eyed embryos of brook trout (Salvelinus fontinalis) to a pH value of 7.81 without and with aluminum (283 µg/L) in extremely soft water (hardness <9 milligrams per litre [mg/L] as CaCO₃, which is consistent with hardness measured in Nico and Peanut lakes) for 60 days. Exposure to aluminum significantly decreased the growth of brook trout after 45 and 60 days. Mean length and weight were decreased by approximately 4% and 15%, respectively. There were no significant effects of aluminum on embryo mortality and hatchability. Kane and Rabeni (1987) exposed small mouth bass (Micropterus dolomieui) larvae to 252 µg/L aluminum at pH 7.3 in a 30 day chronic test. There were no significant effects of aluminum on survival or growth. Sublethal effects on small mouth bass were demonstrated, including deformities, reduced activity and abnormal swimming behaviour. In a 16 day test with juvenile rainbow trout (Oncorhynchus mykiss), exposure to 940 μ g/L at a water hardness of 84.8 mg/L as CaCO₃ was associated with a significant reduction in specific growth rate (approximately 50%) (Gundersen et al. 1994). Roy et al. (2000) studied the toxicity of aluminum in the Saguenay River, Quebec, in relation to discharges from an aluminum smelter. In waters downstream of the effluent outfalls, concentrations ranging from 470 to 540 µg/L in soft neutral-pH (pH 7.0 to 7.3) waters had no significant effect on Ceriodaphnia dubia and fathead minnow (Pimephales promelas) survival and growth.

Complexation is an important factor in reducing aluminum bioavailability and toxicity. For example, the complexation of aluminum by dissolved organic carbon (DOC) matter reduces the bioavailability and toxicity of aluminum to fish in neutral to slightly basic water (Gundersen et al. 1994; Winter et al. 2004). As well, the formation of dissolved aluminosilicates has been shown to reduce the bioavailability and toxicity of aluminum to fish (Burchall et al. 1989).

Dissolved organic carbon concentrations in both Nico Lake and Peanut Lake are relatively high (ranging from approximately 10 to 20 mg carbon/L). Aluminum in both the solid phase of the tailings and waste rock for the NICO Project is primarily bound with silicate minerals (Fortune 2011). Based on these mineralogical results, the aluminum-bearing particulate in water is most likely in the form of silicates (Fortune 2011). As well, dissolved aluminum is likely to be present bound to DOC or as dissolved aluminosilicates which forms at pH values greater than or equal to 4. This is in contrast to most of the toxicity tests described above which used soluble aluminum salts that speciate to AI^{3+} or $AI(OH)_{4^-}$, which are considered the most toxic forms of aluminum.

Given the mitigating effects of DOC and silicates on aluminum toxicity and that toxic effects on invertebrates and fish were not noted in waters of similar hardness, and pH to Nico and Peanut lakes receiving effluent discharges from an aluminum smelter, the SSWQOs of 420 and 410 μ g/L are considered protective of aquatic life.

A review of the SSWQOs for other parameters has been conducted. The review is addressed in the responses to TG 1 through TG 11.

References

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INFORMATION REQUEST – EC_2-3

Source: Environment Canada (EC)

Request

Effluent Quality Estimates

EC requests further explanation for the high concentrations predicted of nitrate, nitrite, and sulfate. Are there options for increased retention or aeration in the aerobic step of the active biological treatment system, in order to reduce nitrite concentrations?

Response

The influent water quality used for the water treatment evaluation during mining years is conservatively based on the maximum values projected for each constituent based on geochemical modelling. These worst case influent concentrations were then used to predict end-of-pipe (EOP) concentrations for all constituents. For nitrate and sulphate the projected EOP concentrations are below levels that will cause harm to the environment (i.e., below site-specific water quality objectives for nitrate and sulphate). The water treatment efforts have been based on geochemistry evaluations while several other parallel evaluations have been completed. For the nitrogen species, the geochemistry modelling was superseded by the blasting residue analysis and nitrite concentrations were not predicted to be present and therefore were not in the Developer's Assessment Report (DAR) (i.e., all the nitrogen mass was accounted for so that nitrite was not predicted to be present). The influent ammonia and nitrate concentrations account for the expected mass of nitrogen and nitrate as per the blasting residue analysis presented in the DAR. Nitrite is not expected to be detectable in the Effluent Treatment Facility influent and therefore will not be in the effluent. These predictions are consistent with experience and nitrogen treatment requirements at other mine sites. Because the blasting residue analysis was a parallel effort to the water treatment evaluation, the nitrite was overlooked and is still present in the water treatment tables.

Nitrate will be removed in the biological treatment system to non-detect levels. Removal efficiencies were inadvertently omitted from the brine treatment system projections. In addition, the removal of nitrate in the reverse osmosis (RO) system was also re-evaluated. Experience with RO treatment of mining influenced waters at other sites has shown that removal of nitrate can exceed ninety percent with new RO membranes. As the membranes are cleaned the impact on nitrate removal is typically more severe than most other elements and can be reduced to less than 80% over time (months to years). This experience, however, is with the treatment of high sulfate (in excess of 5000 mg/L), high total dissolved solid (TDS) waters with a high scaling potential that require cleaning frequently. The projections for the NICO site are a much lower TDS water with a lower scaling potential so that cleaning will not be required as frequently. In addition, the use of an microfilter prior to the RO system will also serve to protect the RO and reduce the membrane cleaning frequency. Therefore, the removal for nitrate has been increased to an average of 90% for the RO system and a removal efficiency of 99% for the biological treatment system has been added.

Sulfate will be removed at a high efficiency in the RO so that the brine may be concentrated sufficiently to allow for some removal as calcium sulfate in the chemical precipitation (lime treatment) step. While sulfate can also be removed in an anaerobic biological treatment step it is not encouraged in the fixed film anaerobic brine treatment





step. To efficiently remove selenium biologically the Oxidation Reduction Potential is controlled within a fixed range that does not encourage the sulfate reducing bacteria so sulfate removal is controlled at low levels in a selenium treatment system.

The removal of sulfate in the chemical precipitation step could be improved by adding barium with one mole of barium removing one mole of sulfate. Barium, however, is added as either barium chloride or barium carbonate. If barium chloride is used 2 moles of chloride are added for every mole of sulfate removed. If barium carbonate is used then chloride may also be added because increased hydrochloric acid would be required to reduce the pH after the lime precipitation step due to increased alkalinity. So the result would be trading sulfate for chloride with a reduced sulfate concentration and an increased chloride concentration.

Tables 1 and 2 as submitted in Undertaking 1 have been revised to reflect the discussion above. A row has also been added to show nitrate as N, as well as the ion for clarity.





Table 1: Projected Effluent Quality for Effluent Treatment Facility Options, Worst Case - REVISED MAY 2012

Constituent	Units	Site Specific Water Quality Objectives	Effluent Treatment Facility Influent Design Basis	Reverse Osmosis with Brine Treatment by Chemical Precipitation and Biotreatment - Early Years	Reverse Osmosis with Brine Treatment by Chemical Precipitation and Biotreatment - Worst Case
рн Талаа алабила	s.u.	5.5	5.5	6.5 10 9	0.5 10 9
Alkolipity		15	10	- 0.10	-
Aluminum	mg/L as CaCO ₃	- 0.41	5 9	0.19	0.007
Anuminum	mg/L	0.41	5.0 15.0	0.10	0.377
Antimony	mg/L	4.10	0.05	2	2
Anumony	mg/L	0.05	0.05	0.0041	0.008
Arsenic	mg/L	0.05	0.72	0.011	0.010
Dariullium	mg/L	-	0.21	0.009	0.012
Beryllium	mg/L	-	0.00309	0.00003	0.00006
Boron	mg/L	-	0.00074	0.134	0.000011
Cadmium	mg/L	0.00015	0.00074	0.000011	0.000011
	mg/L	-	72.5	78	117
Chioride	mg/L	353	107	58	107
Chromium	mg/L	-	0.0066	0.00026	0.00026
Cobait	mg/L	0.010	0.470	0.0050	0.0052
Copper	mg/L	0.022	0.032	0.0006	0.0007
Iron	mg/L	1.5	9.3	0.19	0.24
Lead	mg/L	0.008	0.015	0.0001	0.0002
Magnesium	mg/L	-	24.7	0.476	0.926
Manganese	mg/L	-	0.28	0.00312	0.00291
Mercury	mg/L	-	0.00016	0.00001	0.00001
Molybdenum	mg/L	-	0.110	0.009	0.017
Nickel	mg/L	-	0.034	0.001	0.001
Nitrate	mg/L as NO₃	133	62	6.76	6.76
Nitrate	mg/L as N		14.00	1.53	1.53
Phosphorous	mg/L	-	0.264	0.022	0.044
Potassium	mg/L	-	527	265	527
Selenium	mg/L	0.005	0.127	0.003	0.003
Silver	mg/L	-	0.00260	0.0006	0.001
Sodium	mg/L	-	120	35	120
Strontium	mg/L	-	0.332	0.0051	0.014
Sulfate	mg/L	500	421	117	317
Thallium	mg/L	-	0.0259	0.00038	0.00038
Tin	mg/L	-	0.052	0.008	0.008
Uranium	mg/L	0.027	0.122	0.001	0.002
Vanadium	mg/L	-	0.0047	0.00013	0.00017
Zinc	mg/L	0.11	0.116	0.003	0.003

mg/L = milligram per litre; °C = degree Celsius





Table 2: Removal Efficiencies fo	r Treatment Processes	- REVISED MAY 2012
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Constituent	Reverse Osmosis Removal Efficiency	Chemical Precipitation and Biotreatment Removal Efficiency (Brine)
рН		
Temperature		
Alkalinity	0.97	0.99
Aluminum	0.98	0.95
Ammonia	0.85	0.85
Antimony	0.97	0.88
Arsenic	0.98	0.97
Barium	0.98	0.96
Beryllium	0.99	0.99
Boron	0.60	0.65
Cadmium	0.99	0.99
Calcium	0.98	Increase
Chloride	0.96	0.00
Chromium	0.97	0.99
Cobalt	0.99	0.999
Copper	0.98	0.99
Iron	0.99	0.99
Lead	0.99	0.99
Magnesium	0.99	0.97
Manganese	0.99	1.000
Mercury	0.96	0.99
Molybdenum	0.98	0.86
Nickel	0.98	0.98
Nitrate	0.90	0.99
Nitrite	0.90	0.99
Phosphorous	0.97	0.86
Potassium	0.96	0.00
Selenium	0.98	0.95
Silver	0.97	0.80
Sodium	0.94	0.00
Strontium	0.98	0.97
Sulfate	0.99	0.25
Thallium	0.99	1.00
Tin	0.97	0.88
Uranium	0.99	1.00
Vanadium	0.97	0.99
Zinc	0.98	0.99







INFORMATION REQUEST – EC_2-4

Source: Environment Canada (EC)

Request

Mixing Zone in Peanut Lake

What is the extent of the mixing zone in Peanut Lake, given the revised treatment system?

Response

The extent of the mixing zone has not changed with the revised treatment system. The volume of the treated effluent from the Reverse Osmosis system will be the same as stated for the Ion Exchange treatment system. A mixing zone within Peanut Lake was not developed within the Developer's Assessment Report (DAR). However, based on the following discussion, it is proposed that the outlet of Peanut Lake could represent the extent of mixing zone for Effluent Treatment Facility (ETF) discharge under average hydrological conditions.

Peanut Lake is a small receiving waterbody (i.e., total volume estimated at 824 400 cubic metres with an average depth of 3.5 m [Annex C of the DAR]), with a directional single port diffuser planned for the ETF discharge. These receiving environment conditions are unlike those for other mining operations in the region where discharge to the receiving environment is through a multi-port diffuser to a much larger lake (e.g., Snap Lake Mine, where the volume of Snap Lake receiving treated effluent discharge is about 100 times larger than Peanut Lake). As noted in Appendix 7.IV of the DAR, continued mixing is influenced by wind shear stress and other lake mixing processes, which will limit effective mixing within a prescribed area beyond the Near Field Region of the ETF outfall (where dispersion of the effluent plume is dominated by discharge momentum and buoyancy force). As a result the establishment of a conventional mixing zone within Peanut Lake is challenging.

Furthermore, the effective mixing of treated effluent within Peanut Lake will be highly dependent on hydrological conditions (i.e., limited during periods of low background surface water flows). Based on the 26-year daily baseline flow time series used in the receiving water quality model (described in Section 7.6.3.1 and Annex G, Section 5.6 of the DAR), baseline residence times in Peanut Lake exceed one year in every 6; inflows to Peanut Lake in the driest year account for less than 25% of the total volume of Peanut Lake. The water quality modelling results presented in Section 7.6.3.3 of the DAR also indicated that effective mixing of treated effluent within Peanut Lake may be limited during periods of low background surface water flows (i.e., dry conditions), as receiving environment concentrations in Peanut Lake were higher in dry years.

Fortune Minerals Limited (Fortune) recognized early in the design of the NICO Project that Peanut Lake is a small receiving environment that could not accept large volumes of effluent. For this reason, Fortune refined water management plans at the NICO Project to minimize effluent volumes and improve water quality to the maximum extent possible. Proactive changes to the NICO Project design that have led to improvements in potential receiving environment water quality include the following:

 a decision not to have a hydrometallurgical processing facility on-site, which removed a large source of chemical loading to the ETF;







- design changes to maximize recycling of process water to reduce fresh water requirements and effluent discharge rates. It should be noted that ETF discharge rates presented in the DAR are more than 90% lower than early site water balance estimates; and
- refinements in ETF treatment design options (i.e. change to reverse osmosis) to improve overall effluent quality despite increasing influent concentrations with higher levels of recycling, thereby reducing loading in the ETF discharge.

As such, the NICO Project design has evolved to incorporate numerous environmental design features and mitigation that have reduced the volume of and overall loading from the ETF discharge, with the goal of reducing potential impacts to water quality and aquatic health. Fortune will continue to look for economically feasible opportunities to further improve design and mitigation throughout the detailed design phase of the NICO Project.

Fortune will work with regulators and stakeholders during the water licensing phase to come to an agreement on an appropriate mixing zone that would apply to the ETF discharge to Peanut Lake.







INFORMATION REQUEST – EC_2-5

Source: Environment Canada (EC)

Request

Contaminants Associated with Dust Deposition

What mitigation measures can be implemented to reduce contaminant loadings associated with dust deposition?

Response

There are a number of measures that can be implemented under the appropriate circumstances to reduce contaminant loadings associated with dust deposition. In general, they relate to suppression of emissions. Techniques for dust suppression include practices, such as road watering in season, consistent covering of loads that can be subject to wind erosion, the good repair and loading practices of haulage vehicles, maintenance of appropriate speed limits, and an ongoing state of good repair of haul-road surfaces. Operations under winter conditions substantially reduce the potential for fugitive dust emissions. Fortune Minerals Limited (Fortune) has committed to the development of an Air Quality Management Plan in the regulatory phase of the project, and the details of the management of contaminant loading will be considered and documented as a section in the Air Quality Management Plan.

Ongoing air quality monitoring and dust deposition monitoring will also be conducted to demonstrate that dust deposition rates remain well-managed.

As per a conference call between Fortune and Aboriginal Affairs and Northern Development Canada (AANDC) on 18 April 2012, AANDC was to provide Fortune with information from other operators who have completed trials on different types of dust suppressants in the North (i.e., specifically for ramps), pending approval for distribution from the Land and Water Board, which would be reviewed as possible mitigation measures for the NICO Project.






INFORMATION REQUESTS GOVERNMENT OF THE NORTHWEST TERRITORIES





FORTUNE MINERALS LIMITED NICO DEVELOPER'S ASSESSMENT REPORT SECOND ROUND INFORMATION REQUEST RESPONSES

INFORMATION REQUEST – GNWT_2-1

Source: Government of the Northwest Territories (GNWT)

Request

Caribou, Road, Access, and Cumulative Effects

Recently some developers have expressed interest in contributing to existing or planned GNWT caribou monitoring programs in place of, for example, flying expensive aerial surveys in the immediate area of their property. In recognition of the potential impacts of increased road access on caribou harvest beyond the local footprint of mines, would Fortune Minerals willing to discuss with GNWT this type of contribution? Cost-sharing could be used toward monitoring of the Bathurst and Bluenose-East caribou herds, monitoring and management of harvest, and cumulative effects assessment at larger spatial scales, all of which are on-going or planned by GNWT with co-management partners such as the Tlicho government and the YKDFN.

Response

Fortune Minerals Limited is willing to discuss alternatives for the NICO Project conceptual Wildlife Effects Monitoring Plan with the GNWT and co-management partners.







FORTUNE MINERALS LIMITED NICO DEVELOPER'S ASSESSMENT REPORT SECOND ROUND INFORMATION REQUEST RESPONSES

INFORMATION REQUEST – GNWT_2-2

Source: Government of the Northwest Territories (GNWT)

Request

Conceptual Wildlife Effects Monitoring Program

How will Fortune Minerals continue to work with the GNWT as the Wildlife Effects Monitoring Program (WEMP) is developed during the permitting phase, to a level that is satisfactory to the GNWT?

Response

Fortune Minerals Limited will meet with the Government of the Northwest Territories and co-management partners to discuss the details of the Wildlife Effects Monitoring Plan during the permitting phase until the plan meets regulatory requirements and the requirements specific to the NICO Project.







