

APPENDIX I

Geotechnical Characterization

- Part I – Geology
- Part II – Seismicity
- Part III – Laboratory Test Results
- Part IV – Drill Hole and Test Pit Logs
- Part V – Seepage Analysis Results

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1. GEOLOGY

The Wolverine Lake area lies within the limits of the McConnell Glaciation (youngest of the four glaciations in Yukon Territory) and most of the geomorphic features in the area are related to this glaciation. McConnell glacial ice covered this area between 14,000 and 35,000 years ago. As the McConnell ice retreated and down-wasted, a complex network of ice tongues developed in valley bottoms. Morainal deposits are found at lower to mid-elevation and valley floors, and may contain a more complex assemblage of glacio-fluvial, colluvial and fluvial sediments (Mougeot 1996).

Figure I- 1-1, reproduced from Mougeot (1996), shows the quaternary surficial geology units in the area. This local mapping is in general agreement with the regional setting presented by Jackson (1993, 1994) and Dyke (1990). The main glacial soils in the vicinity of the tailings impoundment consist of up to 20 m of silty, sand and gravel, with cobbles overlying bedrock.

The area is underlain by bedrock strata generally paralleling the valley trend, i.e., striking in the direction of the valley. The bedrock consists of an interlayered sequence of volcanoclastic (rhyolite and quartz feldspar) and carbonaceous/argillic sediments, overlain with basalt. The iron formation, which hosts the ore zone, trends northwest-southeast throughout the project area.

Superimposed on the figure is the approximate exploration bedrock geology map prepared by Expatriate (2004). The area is underlain by bedrock strata generally paralleling the valley trend, i.e., striking in the direction of the valley. The bedrock consists of an interlayered sequence of volcanoclastic (rhyolite and quartz feldspar) and carbonaceous/argillic sediments, overlain with basalt. The iron formation, which hosts the ore zone, trends northwest-southeast throughout the project area.

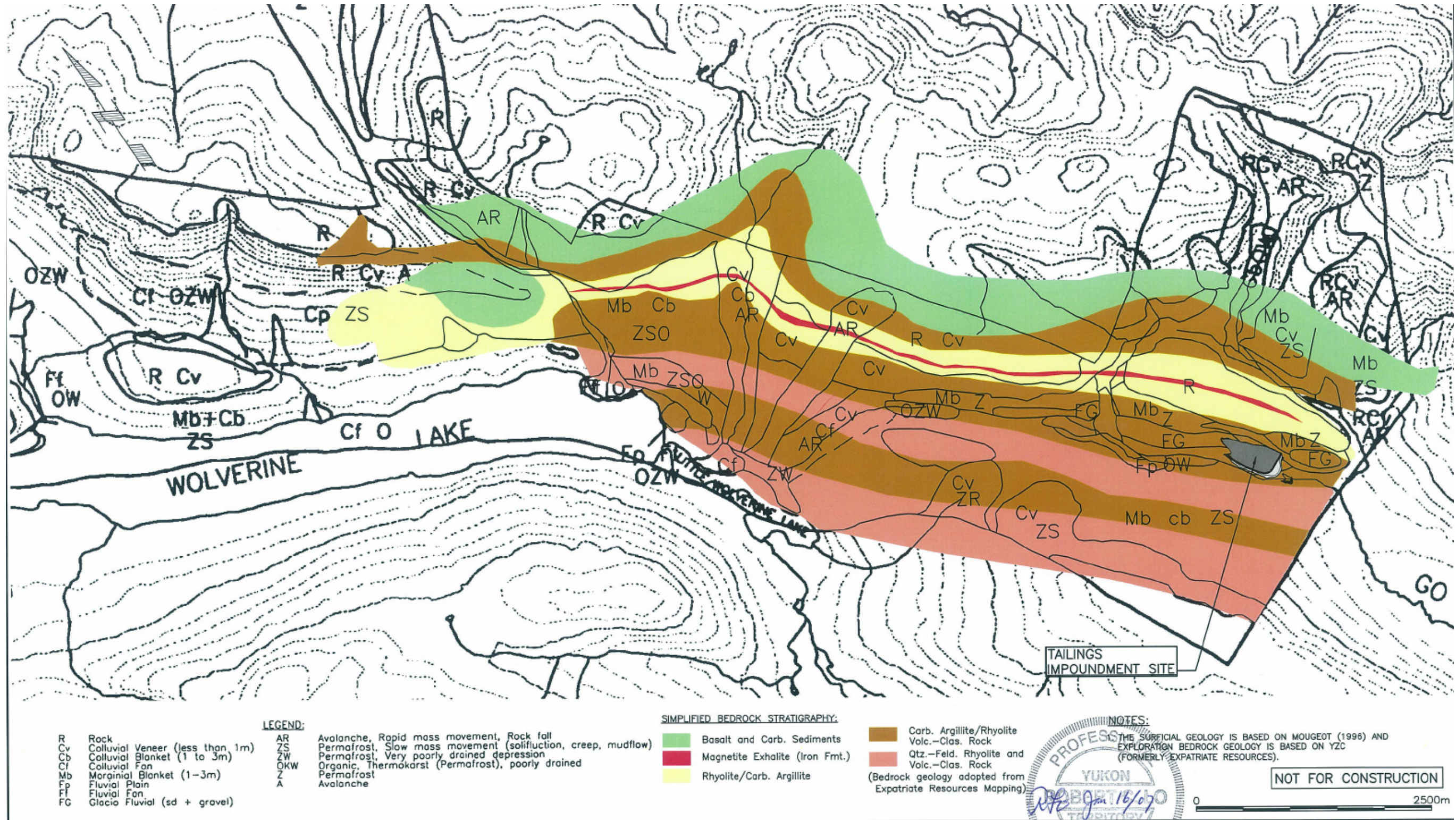


Figure I- 1-1 Surficial and Bedrock Geology Plan

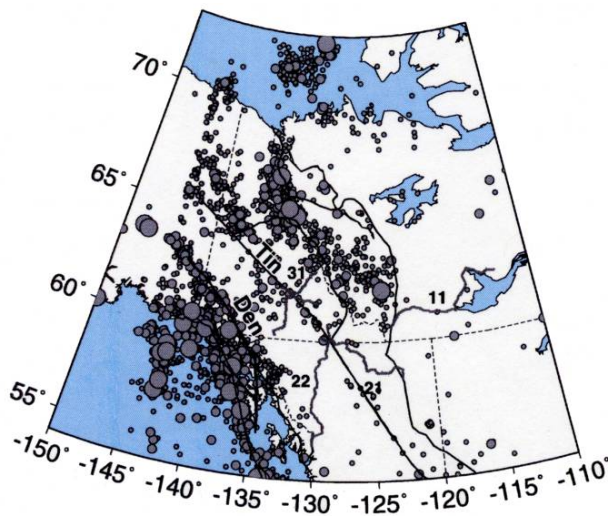
2. SEISMICITY

The regional seismicity is shown on Figure I- 2-1A, and the largest historical earthquakes (equal or greater than magnitude 6) are shown on Figure I- 2-1B (Cassidy et al. 2005). The most seismically active region is along the plate boundaries in the coastal and offshore area. The most significant inland seismicity occurs along segments of the Denali fault zone system, where the seismicity rate is an order of magnitude lower than that in the coastal region. The region between the Denali and Tintina systems is relatively aseismic, with relatively few and small earthquakes. There appears to be an alignment of epicentres along the Tintina fault, however; these are all very small earthquakes (ML less than 3), and most of the activity is at the northern end, close to the Alaskan border. Farther inland, the only significant seismicity is along the eastern edge of the Cordillera, more than 600 km from the active plate boundary. This fold and thrust belt seismicity is concentrated in two areas: the MacKenzie-Ogilvie mountains region and the Richardson Mountains region (Hyndman et al. 2005).

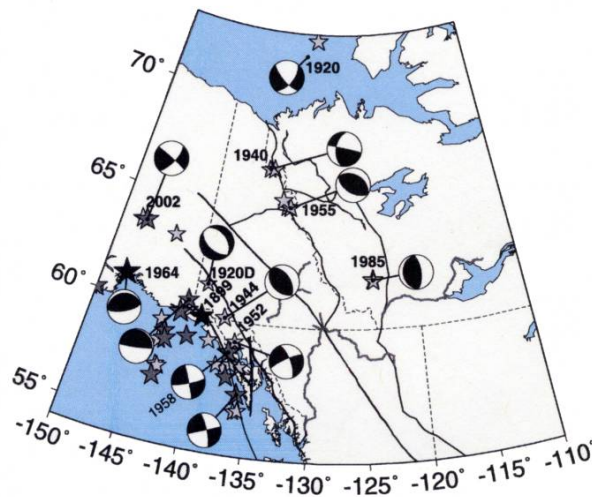
Data on recent earthquakes that occurred within about 600 km from the project site (61.41°N and 130.09°W) from September 1899 to December 2005 was extracted from the Canadian EPB/GSC/PGC database. The epicenters of these events, with magnitude equal to or greater than 3, are plotted on Figure I- 2-2. No earthquakes with magnitude greater than 5 have occurred within 200 km of the site. However, a magnitude 5 event did occur about 28 km northwest of the project site with a focal depth of 5 km on May 12, 1999.

The probabilistic seismic hazard assessment has been determined using both the GSC-H and GSC-R seismic source zonal models developed by the Geological Survey of Canada for the new National Building Code of Canada 2005 (Adams and Halchuk 2003). The GSC-H seismogenic zonal boundaries within Western Canada and the approximate location of the project site are shown on Figure I- 2-3. The model incorporated the work conducted by Atkinson (2004) for a site-specific seismic hazard analysis for Faro, Yukon (62.2°N and 133.2°W). In that analysis, an apparent linear alignment of seismicity in the region along the Tintina Trench fault system was grouped into a Tintina seismic source zone. Figure I- 2-4A shows the boundary of Tintina source zone and seismicity in the region, and Figure I- 2-4B shows the recurrence relationship used to

characterize the source zone. This Tintina source zone was incorporated in the model for computing site peak horizontal acceleration as shown in Table I- 2-1 and Figure I- 2-5. De-aggregation of the seismic hazard corresponding to the 10,000-year return period for the peak horizontal ground acceleration was carried out to evaluate relative contributions of earthquake sources in terms of magnitude and epicentral distance. Figure I- 2-6 presents the calculated magnitude-distance de-aggregation for the peak horizontal ground acceleration of 0.22 g at the Wolverine site. The mean magnitude is Mw 6.1, and mean epicentral distance is 34.8 km.

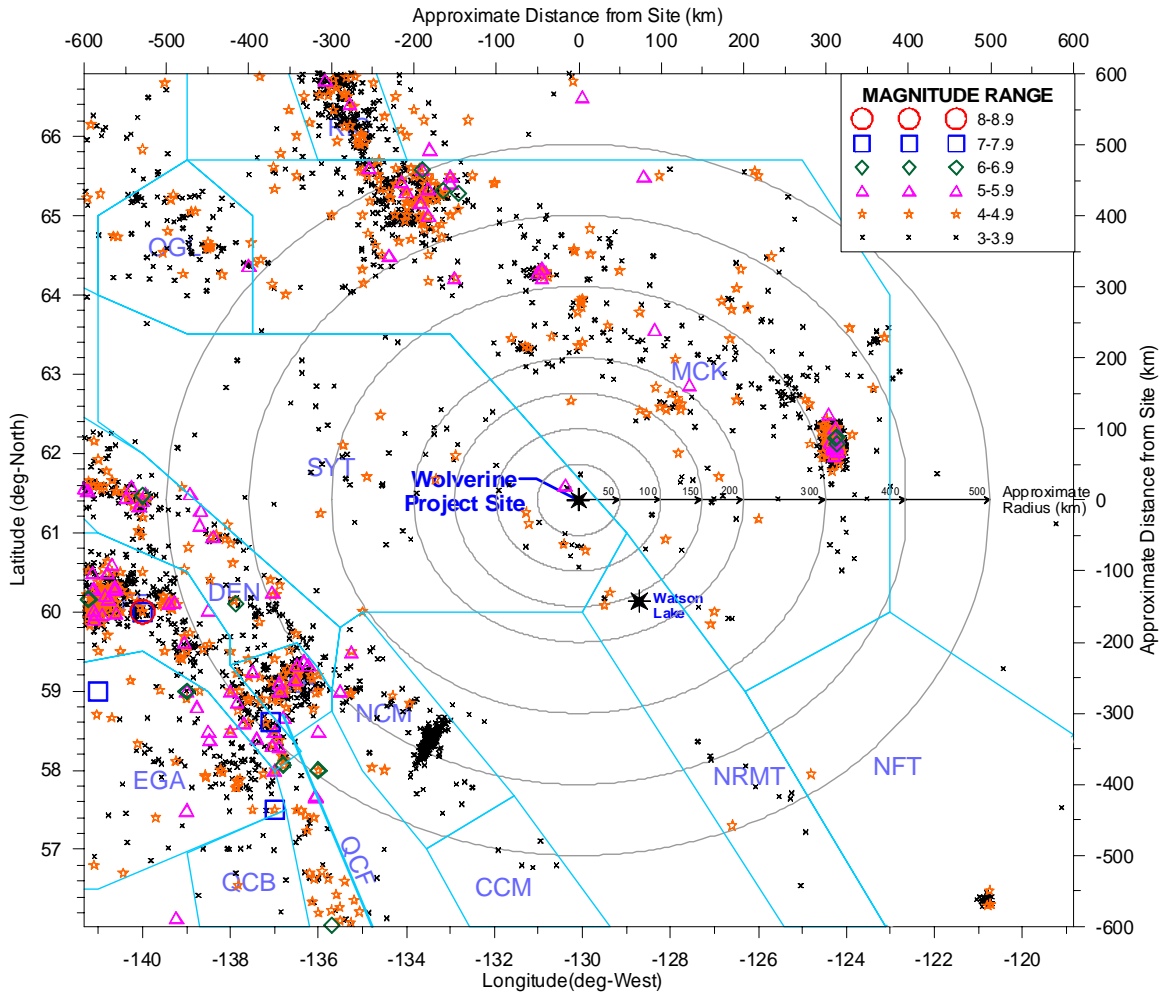


(A) – Seismicity of Northwestern Canada and Adjacent Parts of Alaska During the Period 1899-2002



(B) – Locations of the Largest (M>6) Earthquakes in the Northern Canadian Cordillera

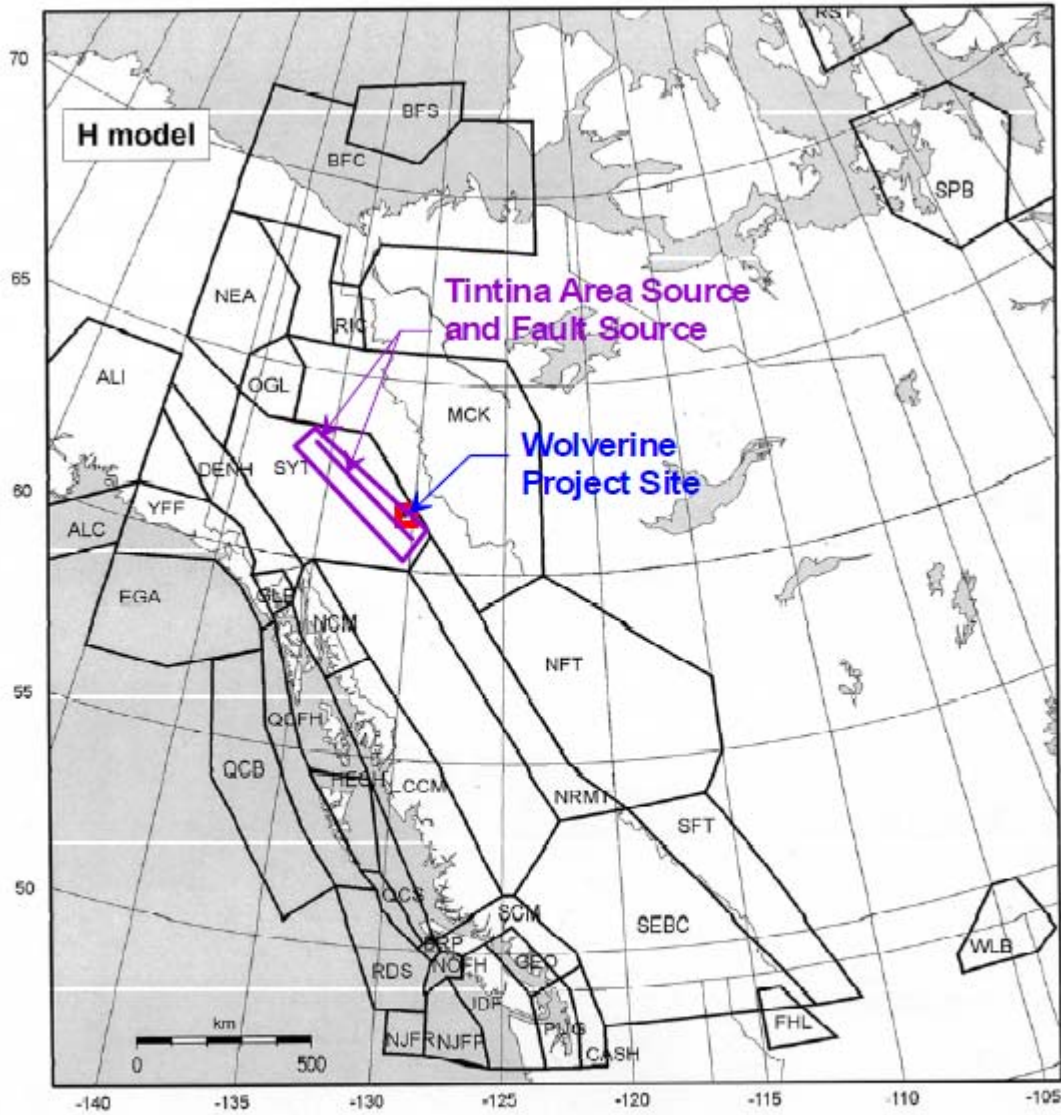
Figure I- 2-1 Regional Seismicity



Notes:
 1. Only earthquakes with magnitude $M > 3$ within a grid of 56.03° N- 66.79° N and 118.84° W- 141.33° W and from September 1899 to December 2005 are shown.
 2. Epicentre data taken from Canadian EPB/GSC/PGC database and
 3. Distances from project site are approximate, assuming one degree of latitude and longitude as 111.43 km and 53.37 km, respectively.

SYT GSC-H Model Seismic Source Zone Boundary
 GSC-H Model Seismic Source Zones

Figure I- 2-2 Location Map of Recent Regional Epicentres



Notes:
(1) This map is taken from Adams, J. and Halchuk, S. (2003),
Fourth Generation Seismic Hazard Maps of Canada, Geological
Survey of Canada Open File 4459.
(2) Area source zone and fault source for the Tintina
Trench are located approximately on this figure.

Figure I- 2-3 Seismogenic Zonal Map – 2005 NBCC H Seismicity Model

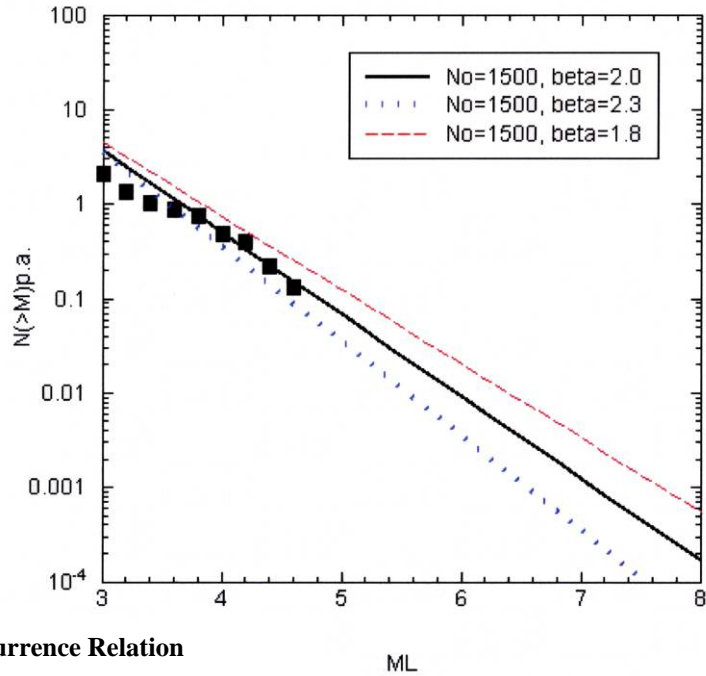
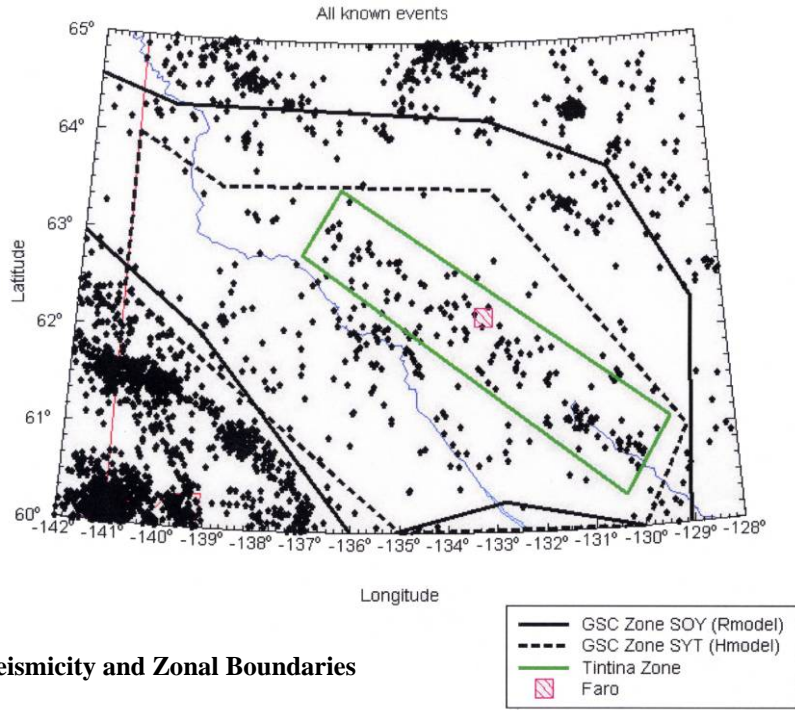


Figure I- 2-4 Characteristics of Tintina Source Zone

Table I- 2-1 Probabilistic Evaluation of Peak Horizontal Ground Acceleration at Project Site

ANNUAL PROBABILITY OF EXCEEDANCE	RETURN PERIOD (years)	PEAK GROUND ACCELERATION PGA (g)	
		GSC-H 2005 Model	GSC-H 2005 Model with Tintina Source zone
0.0021	475	0.08	0.097
0.001	1,000	0.10	0.12
0.00040	2,475	0.14	0.15
0.0001	10,000	0.20	0.22

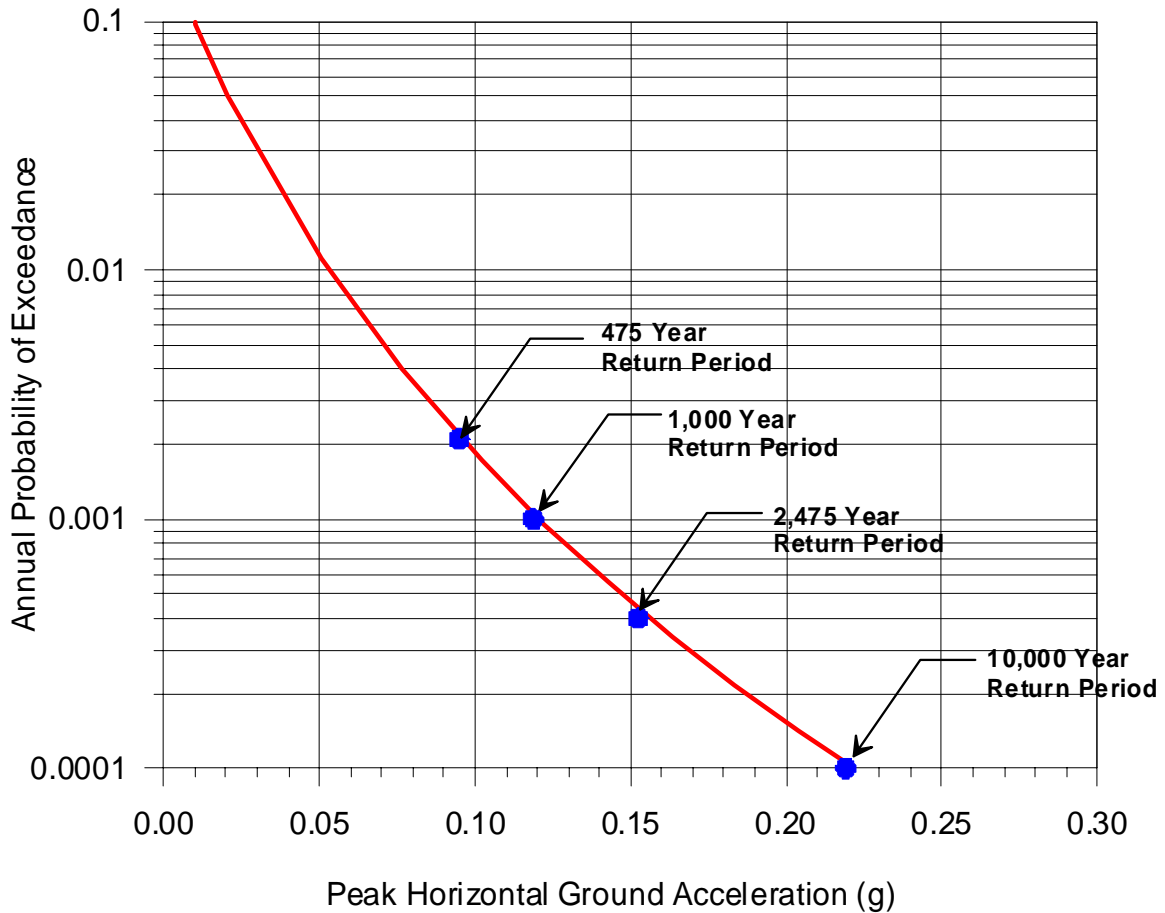


Figure I- 2-5 Peak Horizontal Ground Acceleration at Various Probability of Annual Exceedance

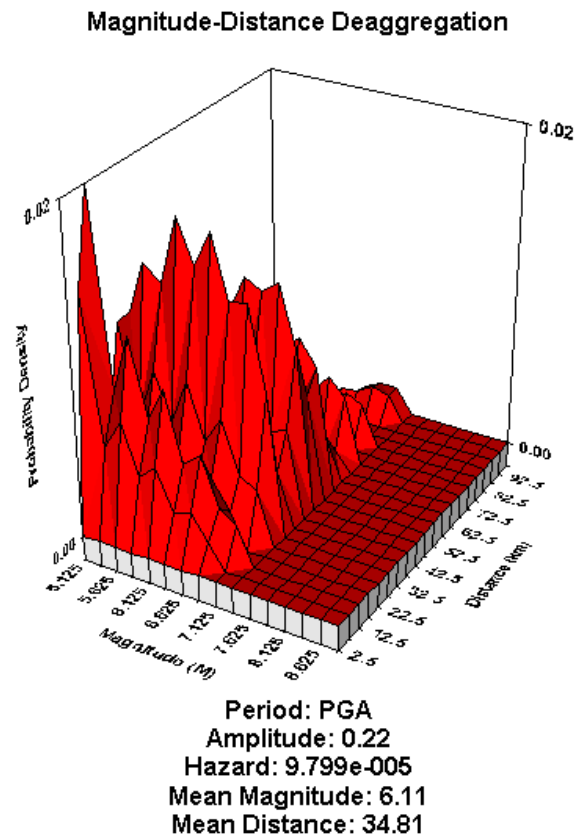


Figure I- 2-6 De-aggregation of Seismic Hazard for Peak Horizontal Ground Acceleration 10,000 year Return Period

Through the interior of the Yukon, there are only three focal mechanisms from recent moderate ($M_w = 4$ to 5) earthquakes in the vicinity of the Tintina fault system. They are a mixture of right-lateral strike slip and thrust earthquakes, and do not align with the orientation of the Tintina fault system. There has been no evidence found for active faulting along the Tintina fault or the Canadian segments of the Denali fault system (Cassidy et al. 2005). The Tintina fault has been a major strike slip fault through much of the Tertiary. Estimate of displacements for the Tintina Fault ranges from 425 km to 500 km. In the southern part of the Tintina Fault, a set of more northerly trending faults intersect the Tintina at acute angles. Near the Tintina Fault, the faults are steep and are right-lateral strike-slip. Near their southern extremities they appear to be steeply southwest dipping thrust faults. The Tintina Fault is interpreted, therefore, as a shallowly

rooted tear fault along which dextral slip took place as the supracrustal rocks were shortened above a basal detachment (Gabielse and Yorath 1992).

Two earthquake scenarios were considered for the deterministic evaluation for the site peak horizontal ground acceleration as shown in Table I- 2-2: a local earthquake at the site with magnitude 6; and a nearby earthquake at the Tintina Fault with magnitude M=7.2.

Table I- 2-2 Deterministic Evaluation of Peak Horizontal Ground Acceleration at Project Site

EARTHQUAKE SCENARIO	MAGNITUDE	EPICENTRAL DISTANCE (km)	FOCAL DEPTH (km)	PEAK GROUND ACCELERATION PGA (g)
Local	6	0	2.9	0.34
Tintina Fault	7.2	53	2.9	0.11

3. GEOTECHNICAL LABORATORY TESTS

Below are presented test geotechnical laboratory results for the following materials:

- Overburden soil samples retrieved from field investigations in the tailings impoundment areas including dam foundation and borrow materials; and
- Tailings material.

Index property tests for these materials are covered in Section 3.1, while their engineering properties are described in Section 3.2. Section 3.3 presents laboratory test data sheets either in figure or tabular form.

3.1 Index Property Tests

Overburden soil samples retrieved from test holes and test pits during field investigations were visually classified, and their water content and gradation determined. The logs of test holes and test pits presented in Appendix I – Part IV have incorporated these index properties. Similarly, gradation curves for damfill borrow and tailings materials were also obtained.

The tailings testing carried out in 2006 was on a 50:50 mixture of F11 and F12 (Zn, Rougher Scavenger Tail) and F23 and F32 (Zn 1st Cleaner Scavenger Tail). Additional tests were carried out in 2008 on a mixture of 80% rougher tailings and 20% cleaner tailings. Four specific gravity tests were also performed on the tailings samples.

3.2 Engineering Property Tests

Engineering property tests performed for each material are listed below:

- Damfill Borrow – standard Proctor compaction tests, triaxial permeameter tests, and consolidated-undrained triaxial shear tests with pore pressure measurement.
- Tailings – settling and consolidation tests, triaxial permeameter tests, and consolidated-undrained triaxial shear tests with pore pressure measurement.

For the damfill borrow and tailings materials, consolidated-undrained triaxial shear tests were carried out with permeability measurements after consolidation and pore pressure measurements

during shear. The density values and consolidation stresses used in the laboratory were selected to represent field condition.

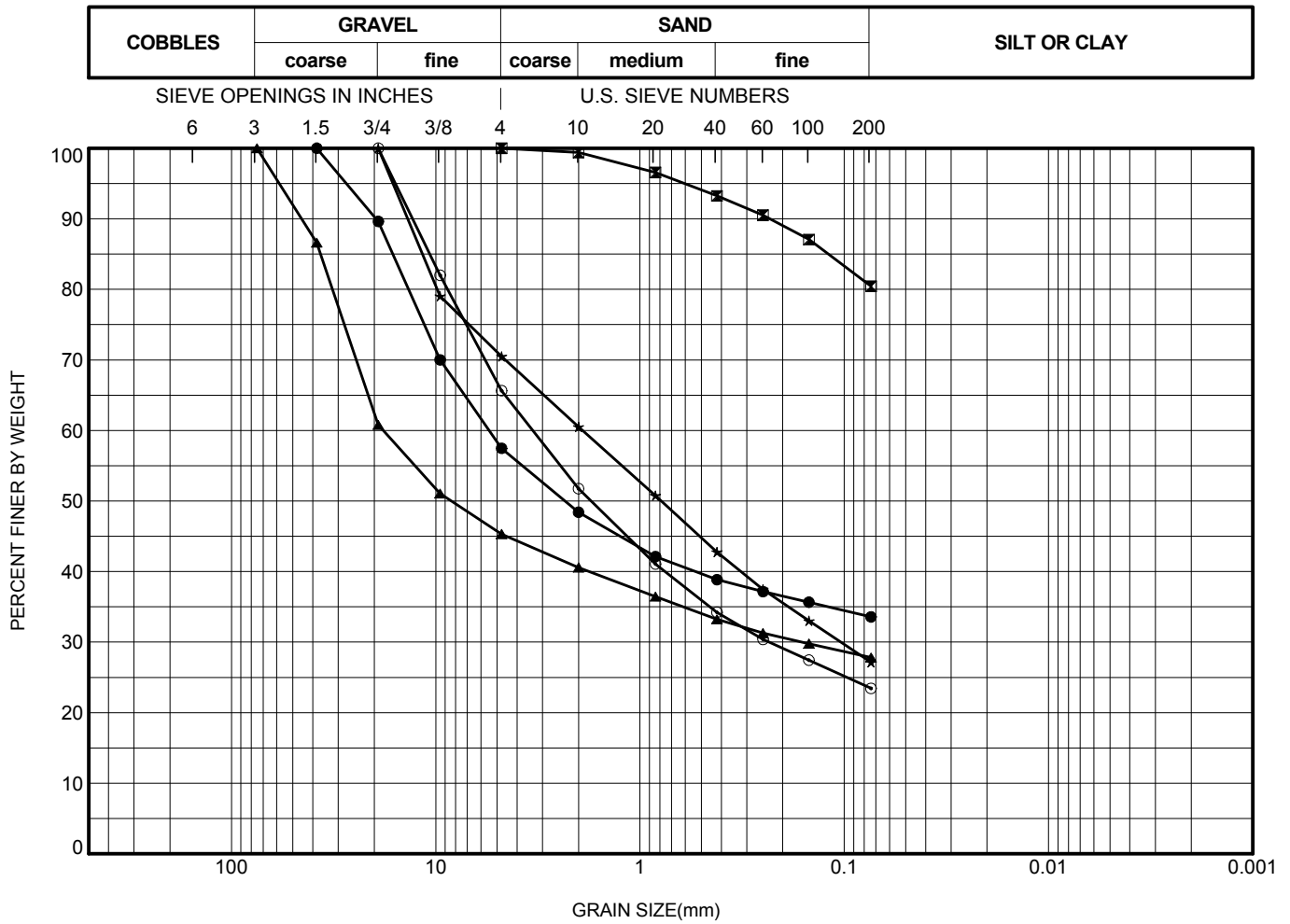
3.3 Test Data Sheets

Data sheets for the index property and engineering property tests are presented in the following pages. They are grouped according to material type in the following order:

- Overburden in Tailings Impoundment Areas;
- Damfill Borrow; and
- Tailings.

Overburden in Tailings Impoundment Areas

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05- 8	3.00	16.206	5.475	2.329				42.6	23.8	33.6
☒	TP05- 9	1.00	0.120						0.0	19.4	80.6
▲	TP05-12	1.00	36.578	18.043	8.379				54.7	17.5	27.9
★	TP05-14	1.00	11.607	1.914	0.786				29.5	43.2	27.3
⊙	TP05-15	2.00	10.691	3.349	1.735				34.4	42.1	23.5

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05- 8		3.00	10.8				
☒	TP05- 9		1.00	109.0				
▲	TP05-12		1.00	8.3				
★	TP05-14		1.00	12.1				
⊙	TP05-15		2.00	9.3				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

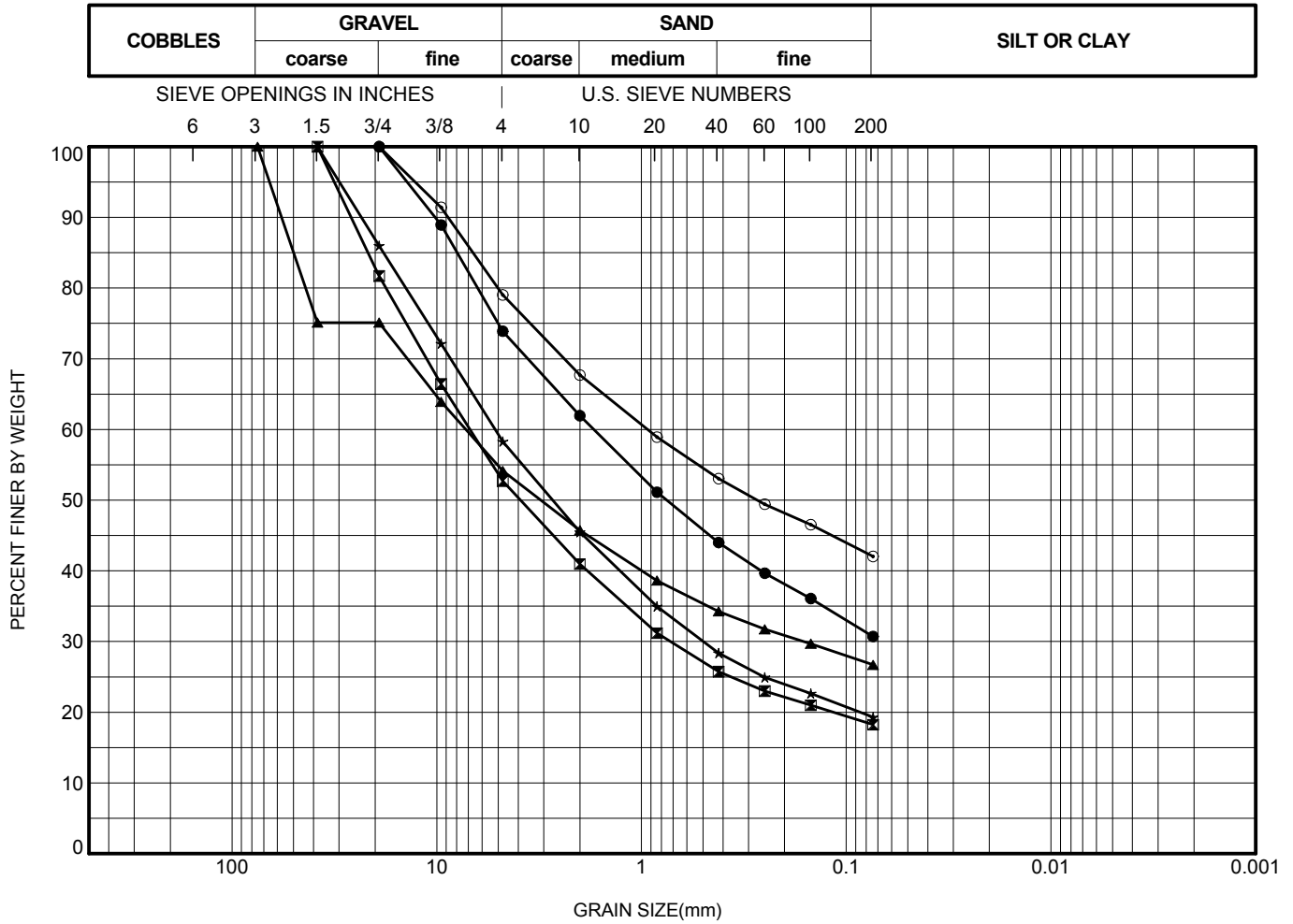
LOCATION: Yukon

FIGURE:

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GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-16	1.00	7.942	1.711	0.752				26.1	43.0	30.8
⊠	TP05-17	3.50	21.634	6.881	3.897				47.3	34.4	18.3
▲	TP05-18	1.50	49.939	7.213	3.104				45.9	27.4	26.8
★	TP05-19	1.50	18.172	5.184	2.716				41.7	38.9	19.4
⊙	TP05-20	2.00	6.647	0.934	0.272				21.0	36.9	42.1

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-16		1.00	9.1				
⊠	TP05-17		3.50	9.2				
▲	TP05-18		1.50	11.7				
★	TP05-19		1.50	22.0				
⊙	TP05-20		2.00	15.5				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

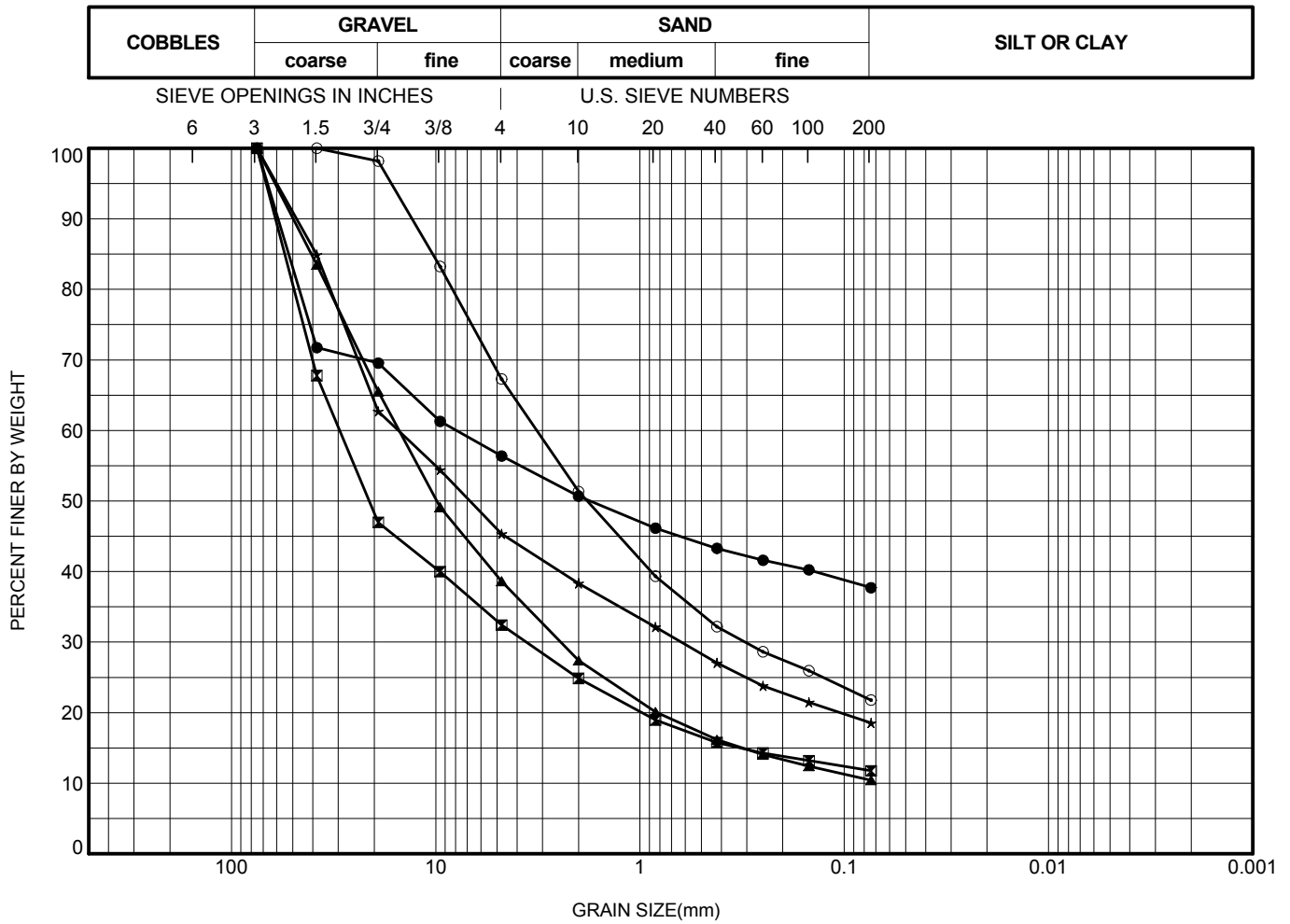
LOCATION: Yukon

FIGURE:

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GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-22	1.00	52.419	7.936	1.753				43.6	18.6	37.8
⊠	TP05-22	3.00	54.782	29.479	21.131	0.321	0.031	943.614	67.6	20.6	11.8
▲	TP05-23	0.50	40.591	15.107	9.876	0.316			61.4	28.1	10.5
★	TP05-23	2.50	38.359	15.225	6.795				54.7	26.7	18.6
⊙	TP05-24	1.80	10.335	3.202	1.814				32.7	45.4	21.9

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-22		1.00	11.7				
⊠	TP05-22		3.00	9.7				
▲	TP05-23		0.50	10.5				
★	TP05-23		2.50	7.6				
⊙	TP05-24		1.80	10.6				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

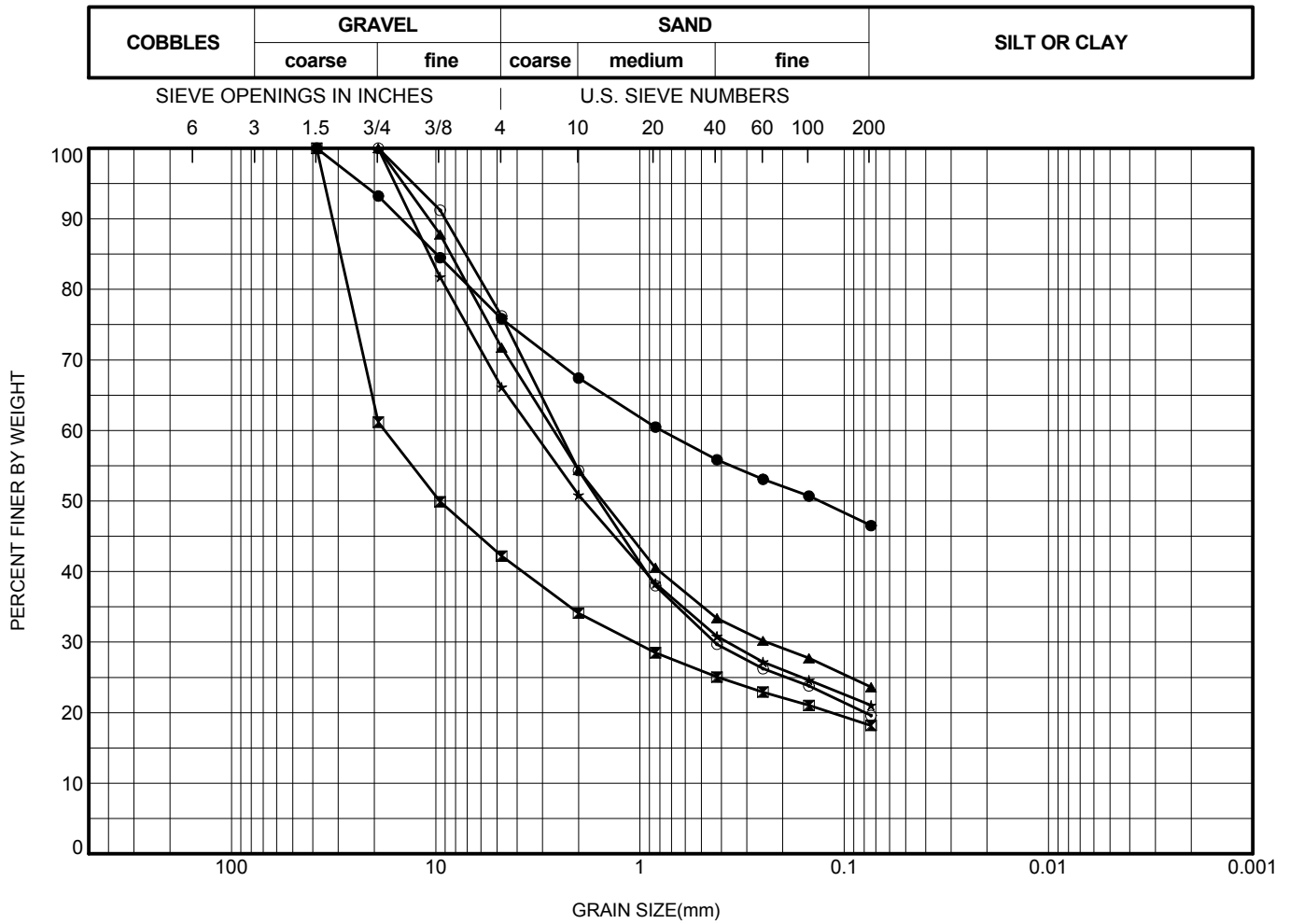
LOCATION: Yukon

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GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-25	1.20	9.920	0.782	0.133				24.2	29.2	46.6
⊠	TP05-26	1.50	29.226	17.767	9.579				57.8	23.9	18.2
▲	TP05-27	1.00	8.437	2.648	1.520				28.3	48.0	23.7
★	TP05-28	1.00	10.777	3.362	1.887				33.9	45.0	21.1
⊙	TP05-29	1.00	7.142	2.504	1.590				23.8	56.5	19.7

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-25		1.20	10.6				
⊠	TP05-26		1.50	8.4				
▲	TP05-27		1.00	10.9				
★	TP05-28		1.00	16.1				
⊙	TP05-29		1.00	19.8				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

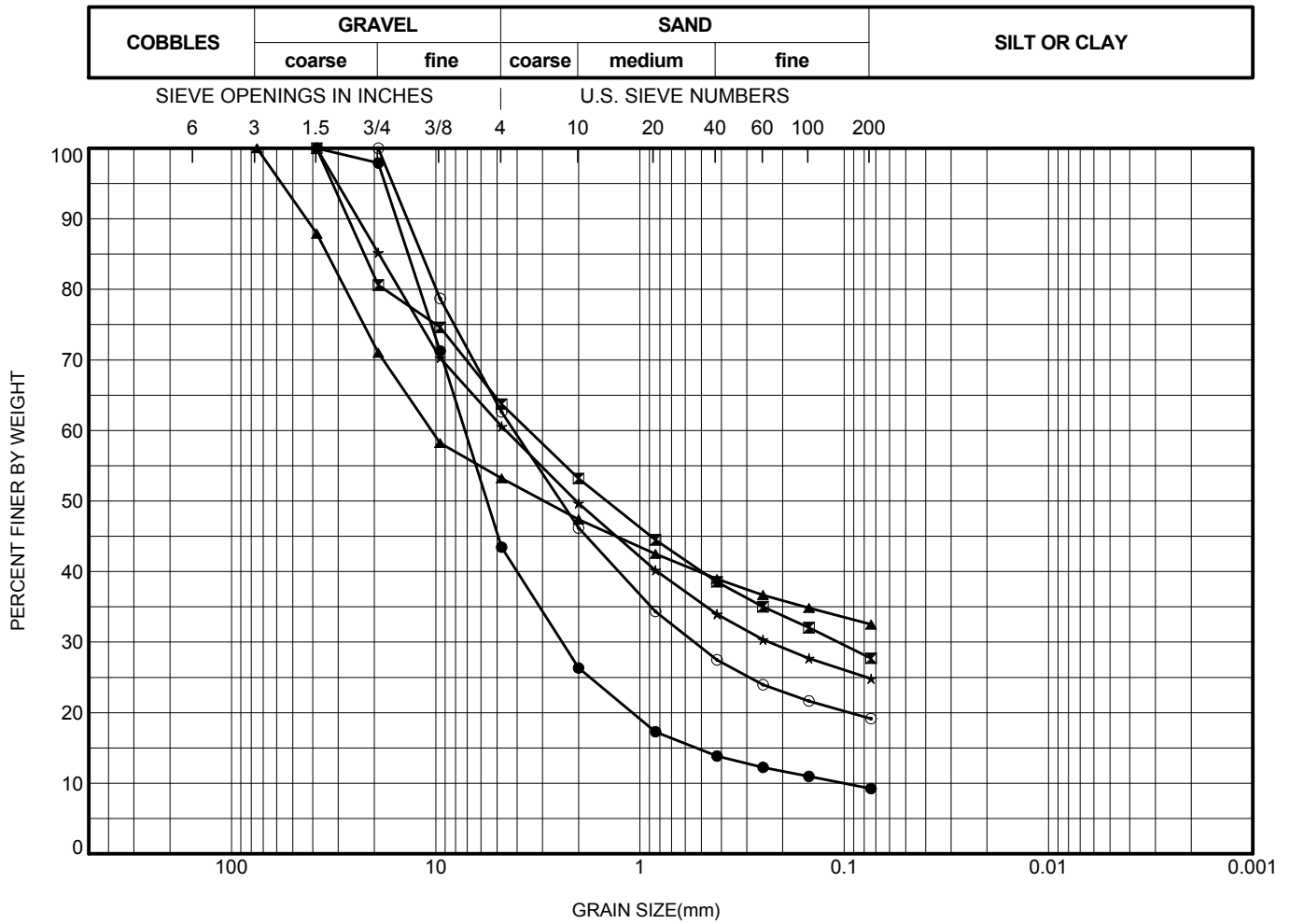
LOCATION: Yukon

FIGURE:

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GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-31	1.00	13.630	7.191	5.604	0.529	0.101	71.410	56.6	34.1	9.3
⊠	TP05-43	2.00	22.347	3.501	1.454				36.3	35.9	27.8
▲	TP05-44	2.00	33.884	10.489	2.949				46.8	20.7	32.6
★	TP05-45	2.00	18.927	4.551	2.055				39.5	35.7	24.9
⊙	TP05-46	2.00	11.695	4.142	2.446				37.4	43.4	19.2

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-31		1.00	9.3				
⊠	TP05-43		2.00	7.2				
▲	TP05-44		2.00	11.7				
★	TP05-45		2.00	9.5				
⊙	TP05-46		2.00	10.9				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

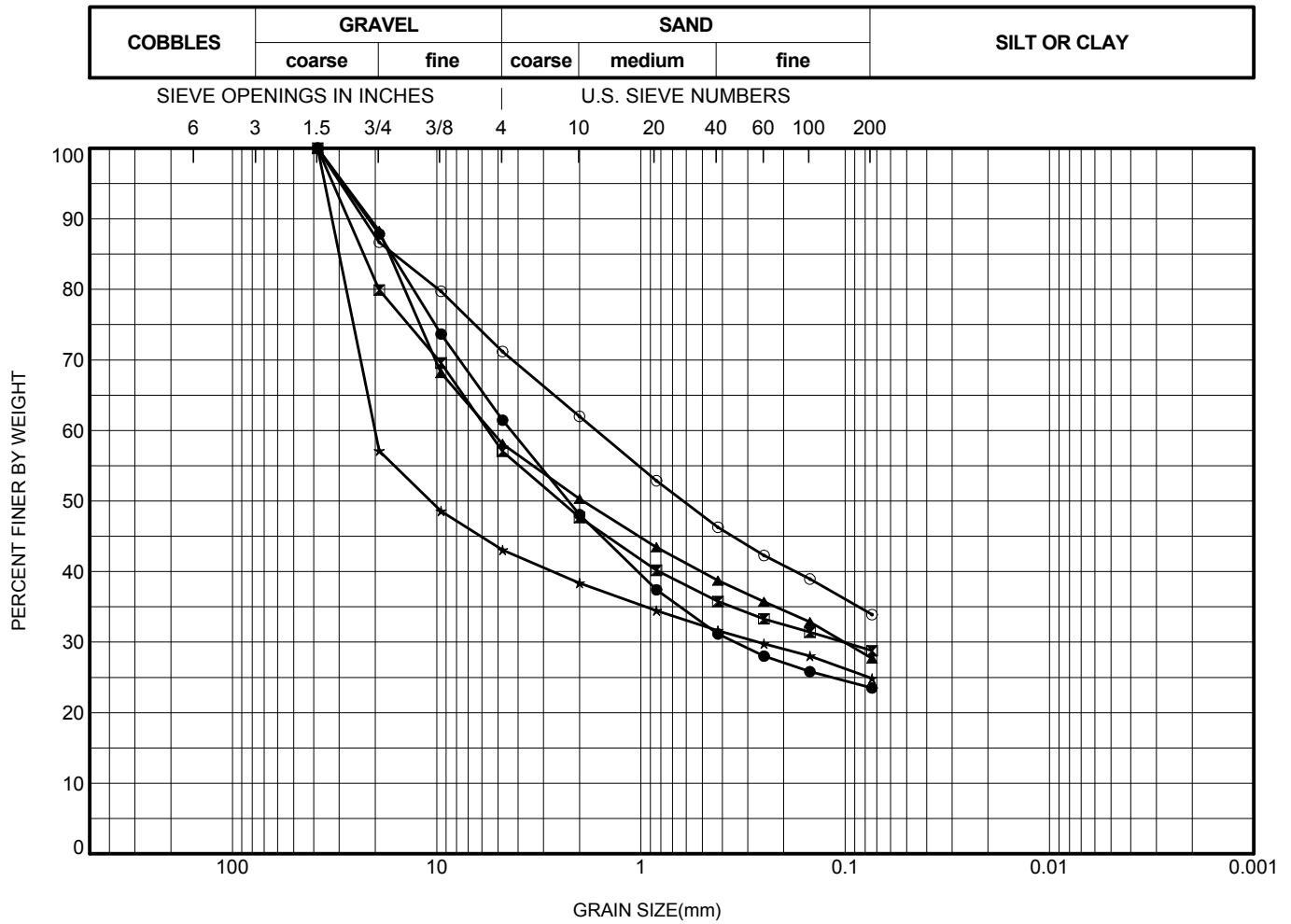
LOCATION: Yukon

FIGURE:

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GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-47	2.00	16.609	4.332	2.267				38.6	37.9	23.5
⊠	TP05-48	2.00	22.764	5.606	2.482				43.0	28.2	28.8
▲	TP05-72	2.50	17.039	5.427	1.926				41.9	30.3	27.8
★	TP05-74	1.50	29.973	20.007	10.698				57.0	18.1	24.9
⊙	TP05-75	1.50	16.153	1.655	0.621				28.8	37.2	34.0

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-47		2.00	11.8				
⊠	TP05-48		2.00	9.7				
▲	TP05-72		2.50	8.2				
★	TP05-74		1.50	7.7				
⊙	TP05-75		1.50	10.2				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

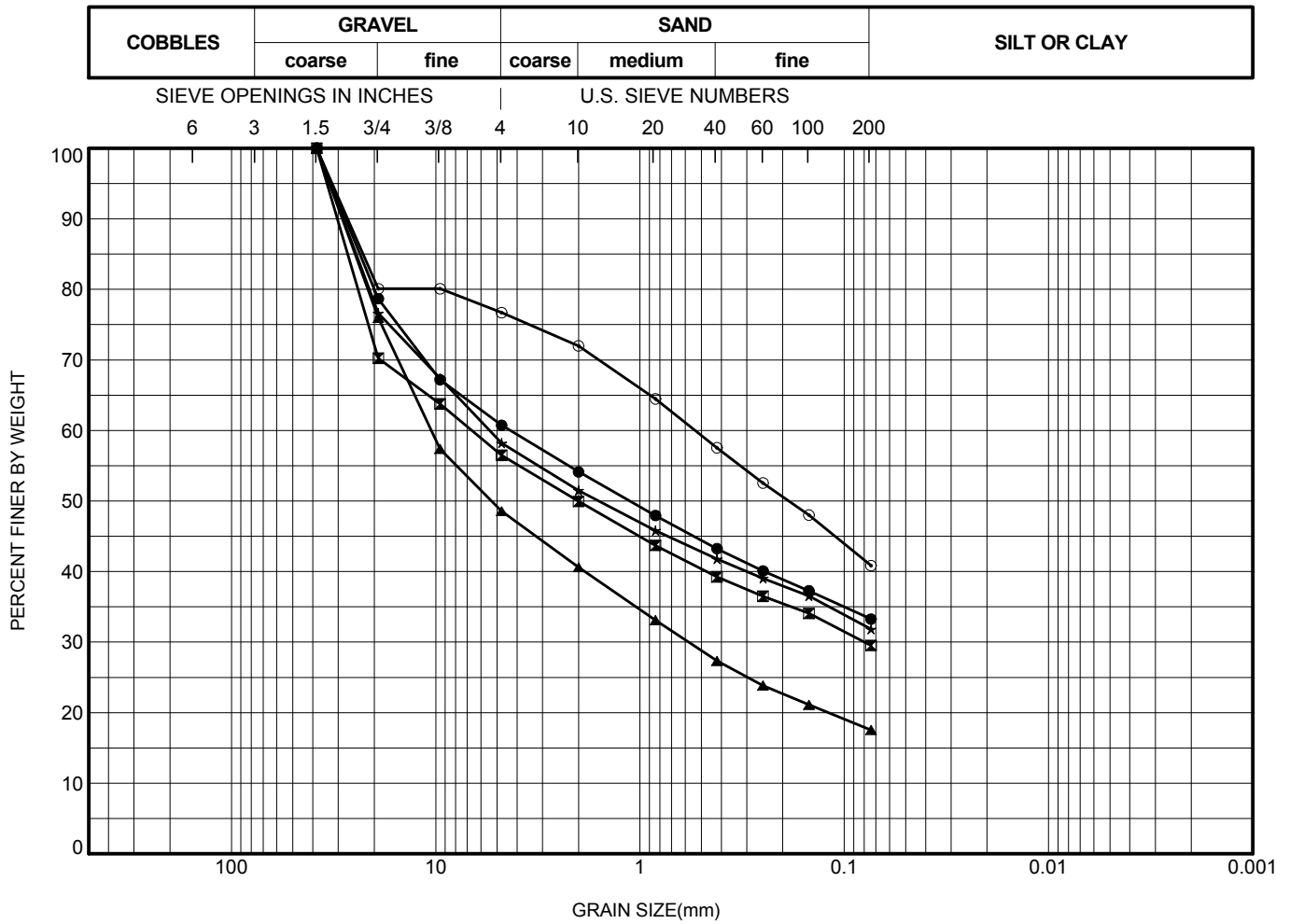
LOCATION: Yukon

FIGURE:

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GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-76	1.50	23.460	4.323	1.121				39.3	27.4	33.3
⊠	TP05-77	1.50	26.940	6.658	2.016				43.5	26.8	29.6
▲	TP05-83	1.80	24.775	10.503	5.330				51.5	30.9	17.6
★	TP05-84	1.50	24.488	5.453	1.595				41.8	26.3	31.9
⊙	TP05-85	1.50	22.662	0.537	0.187				23.3	35.7	41.0

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-76		1.50	10.3				
⊠	TP05-77		1.50	7.3				
▲	TP05-83		1.80	6.2				
★	TP05-84		1.50	10.6				
⊙	TP05-85		1.50	17.9				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

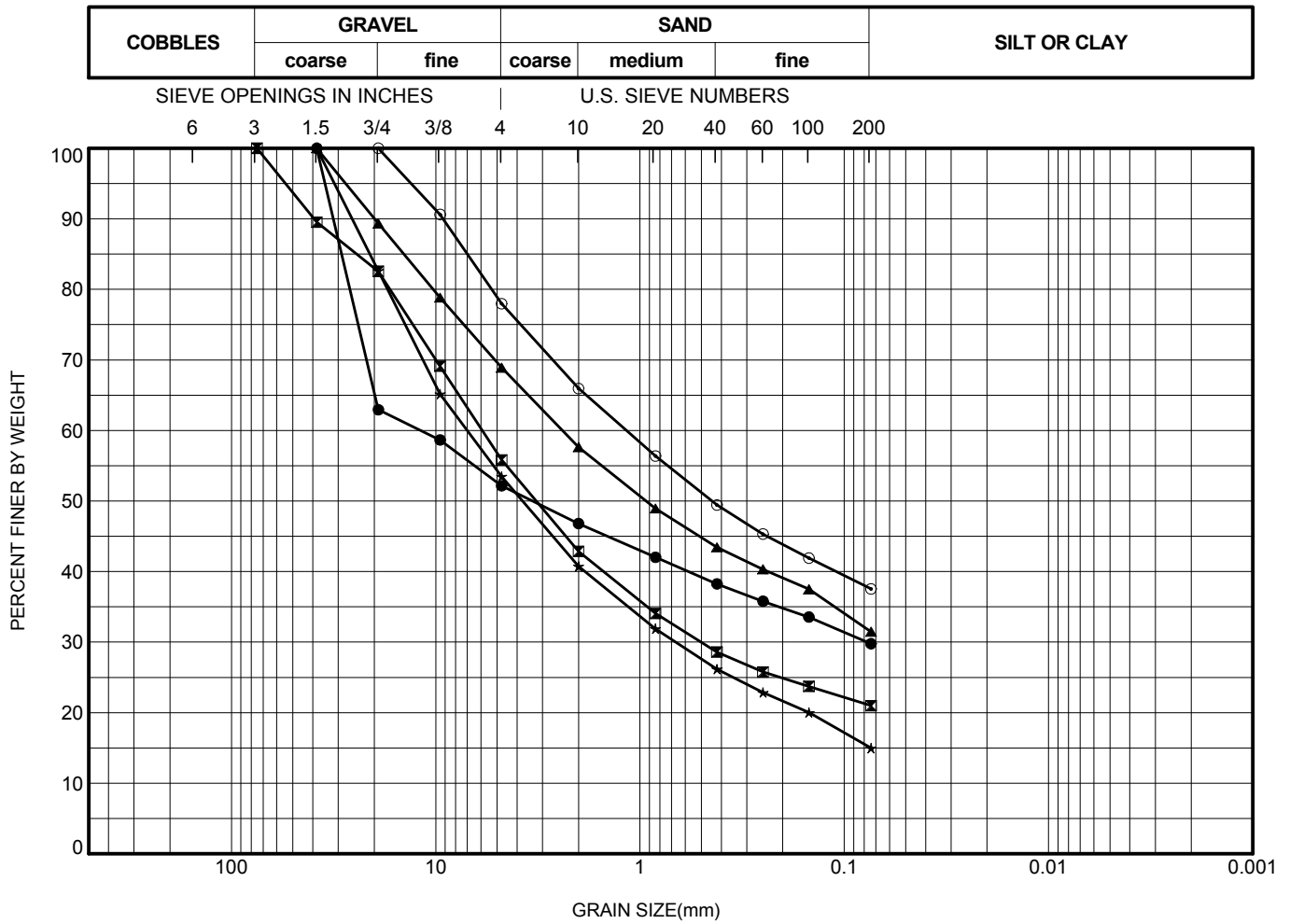
LOCATION: Yukon

FIGURE:

DRAWN BY: DL

CHECKED BY:

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-86	1.50	28.853	11.841	3.357				47.9	22.3	29.8
⊠	TP05-87	3.30	24.359	5.917	3.223				44.2	34.8	21.0
▲	TP05-89	1.50	14.318	2.400	0.934				31.1	37.3	31.6
★	TP05-89	3.00	20.991	7.008	3.758	0.074			46.6	38.4	15.1
⊙	TP05-91	1.00	7.000	1.167	0.444				22.1	40.3	37.6

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-86		1.50	8.8				
⊠	TP05-87		3.30	1.6				
▲	TP05-89		1.50	8.9				
★	TP05-89		3.00	3.0				
⊙	TP05-91		1.00	12.7				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

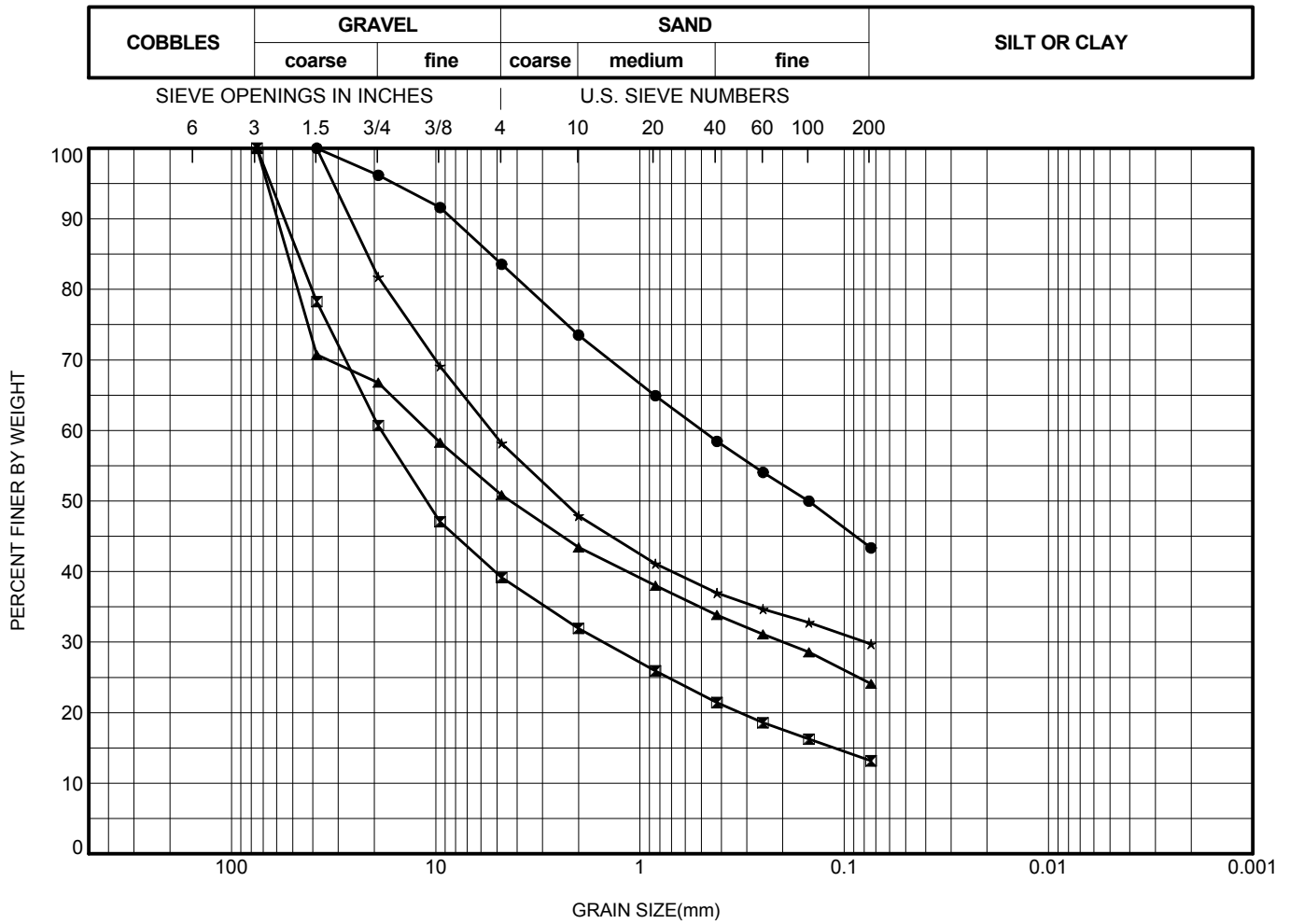
LOCATION: Yukon

FIGURE:

DRAWN BY: DL

CHECKED BY:

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-93	1.50	5.389	0.496	0.150				16.5	40.1	43.5
☒	TP05-95	2.30	47.083	18.443	11.066	0.112			60.9	25.9	13.2
▲	TP05-96	1.50	53.074	10.953	4.311				49.2	26.7	24.2
★	TP05-97	1.50	21.618	5.340	2.389				41.8	28.4	29.8

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-93		1.50	13.0				
☒	TP05-95		2.30	4.6				
▲	TP05-96		1.50	11.0				
★	TP05-97		1.50	7.7				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Pit Samples

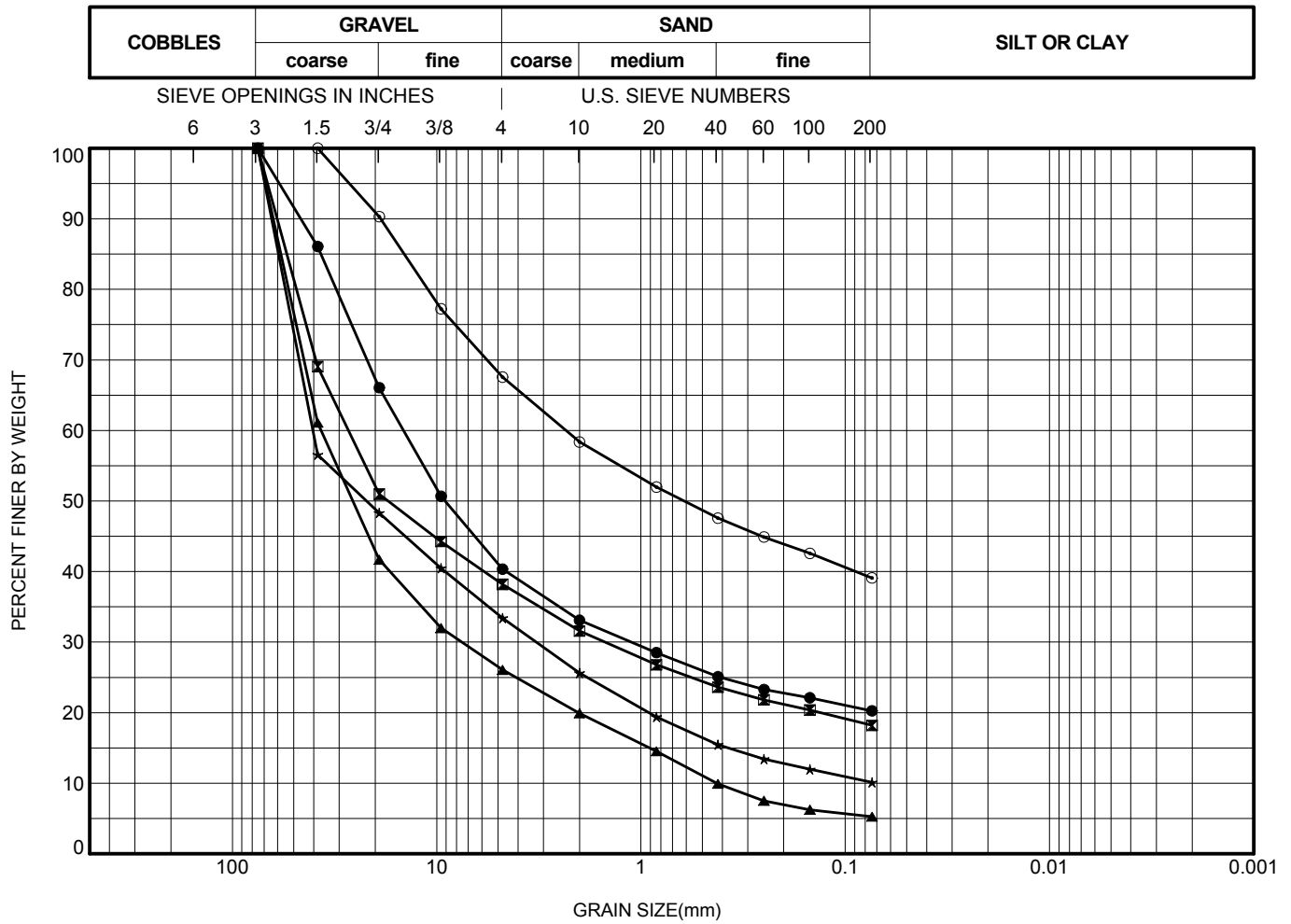
LOCATION: Yukon

FIGURE:

DRAWN BY: DL

CHECKED BY:

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	Borrow 1	0.00	36.810	14.520	9.100				59.7	20.0	20.3
⊠	Borrow 2	0.00	54.083	27.000	17.265				61.8	19.9	18.2
▲	Borrow 3	0.00	57.821	36.732	25.698	0.906	0.426	86.306	73.9	20.8	5.3
★	Go Creek Dam	0.00	59.415	40.298	22.024	0.373	0.071	569.587	66.6	23.2	10.2
⊙	MW05-6	0.00	14.399	2.332	0.615				32.5	28.4	39.2

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	Borrow 1	East	0.00	7.7				
⊠	Borrow 2	Central	0.00	9.0				
▲	Borrow 3	West	0.00	5.5				
★	Go Creek Dam		0.00	2.5				
⊙	MW05-6		0.00	11.4				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - General Borrow Materials

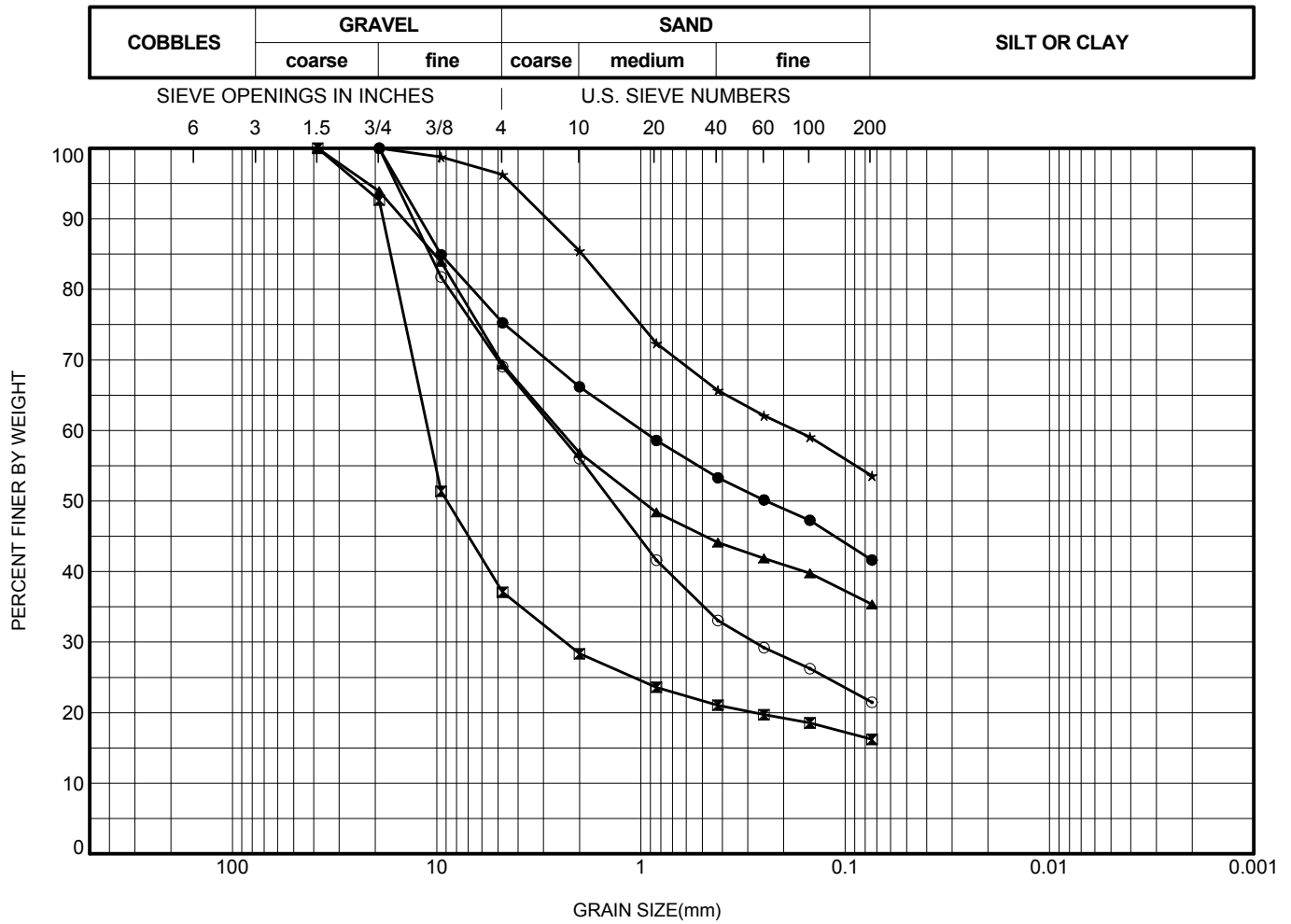
LOCATION: Yukon

FIGURE:

DRAWN BY: DL

CHECKED BY:

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TH05-1	11.45	9.557	0.988	0.244				24.8	33.5	41.7
⊠	TH05-3	1.00	16.788	11.010	8.902				62.9	20.8	16.3
▲	TH05-3	6.10	10.274	2.490	0.991				30.7	33.9	35.4
★	TH05-3	8.90	1.945	0.175					3.8	42.6	53.7
⊙	TH05-5	1.80	10.773	2.609	1.393				31.0	47.5	21.6

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _P	PI	REMARKS / SAMPLE DESCRIPTION
●	TH05-1		11.45	14.5				
⊠	TH05-3		1.00	11.5				
▲	TH05-3		6.10	12.3				
★	TH05-3		8.90	12.2				
⊙	TH05-5		1.80	13.7				

CU = COEFFICIENT OF UNIFORMITY = D60/D10

PARTICLE SIZES, e.g. D85, in mm

Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - Test Hole Samples

LOCATION: Yukon

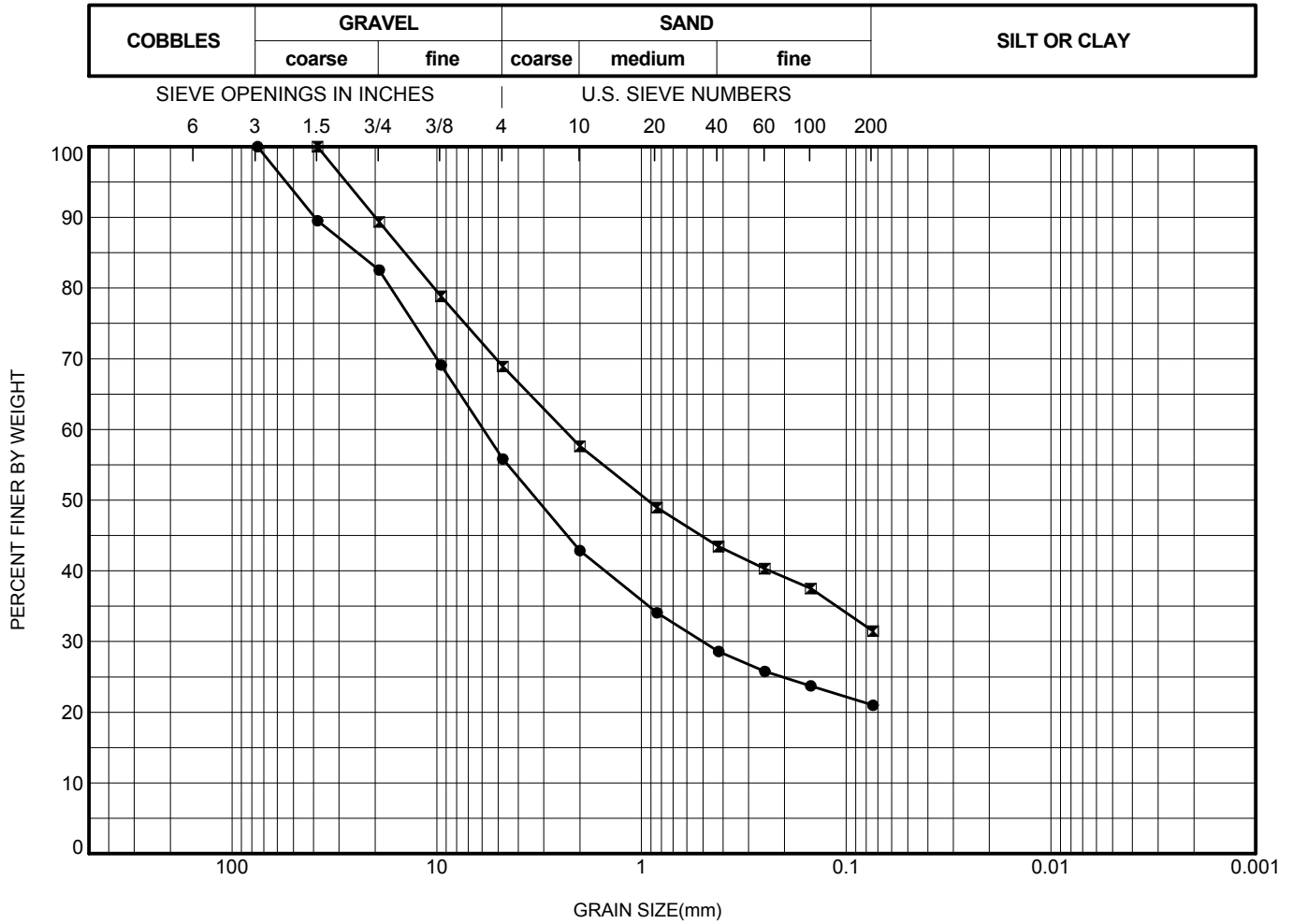
FIGURE:

DRAWN BY: DL

CHECKED BY:

Damfill Borrow

GRAIN SIZE DISTRIBUTION



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	TP05-87	3.30	24.359	5.917	3.223				44.2	34.8	21.0
⊠	TP05-89	1.50	14.318	2.400	0.934				31.1	37.3	31.6

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _P	PI	REMARKS / SAMPLE DESCRIPTION
●	TP05-87		3.30					
⊠	TP05-89		1.50					

CU = COEFFICIENT OF UNIFORMITY = D60/D10 PARTICLE SIZES, e.g. D85, in mm Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01

PROJECT: Wolverine - DAM FILL

LOCATION: Yukon

FIGURE:

DRAWN BY: DL

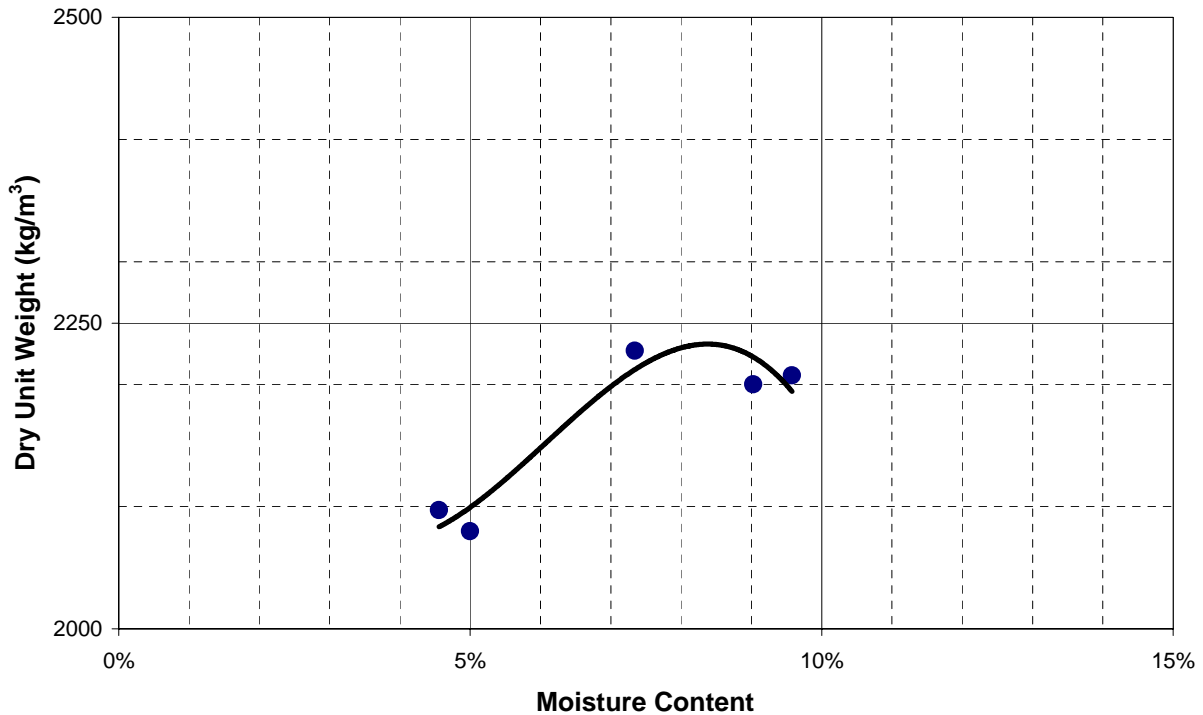
CHECKED BY:


COMPACTION TEST

Sample Description:

TRIAL NUMBER	1	2	3	4	5	6
Unit Weight Determination						
Wet Wt. Sample & Mold (g)	11592	11608	11651	11171	11152	
Weight of Mold (g)	6515	6515	6515	6515	6515	
Wet Wt. of Sample (g)	5077	5093	5136	4656	4637	
Volume of Mold (cm ³)	2123.48	2123.48	2123.48	2123.48	2123.48	
Wet Unit Wt. (kg/m ³)	2390.9	2398.4	2418.7	2192.6	2183.7	
Dry Unit Wt. (kg/m ³)	2227.3	2199.8	2207.2	2097.0	2079.7	
Moisture Content Determination						
Container No.	1	2	3	4	5	
Wet Wt. Sample & Tare (g)	627.42	392.24	552.74	464.31	105	
Dry Wt. Sample & Tare (g)	591.05	369.84	512.96	448.7	100	
Wt. of Water (g)	36.37	22.4	39.78	15.61	5	
Tare Container (g)	95.85	121.71	97.67	106.3	0	
Dry Wt. of Soil (g)	495.2	248.13	415.29	342.4	100	
Moisture Content (%)	7.3%	9.0%	9.6%	4.6%	5.0%	

Compaction Test



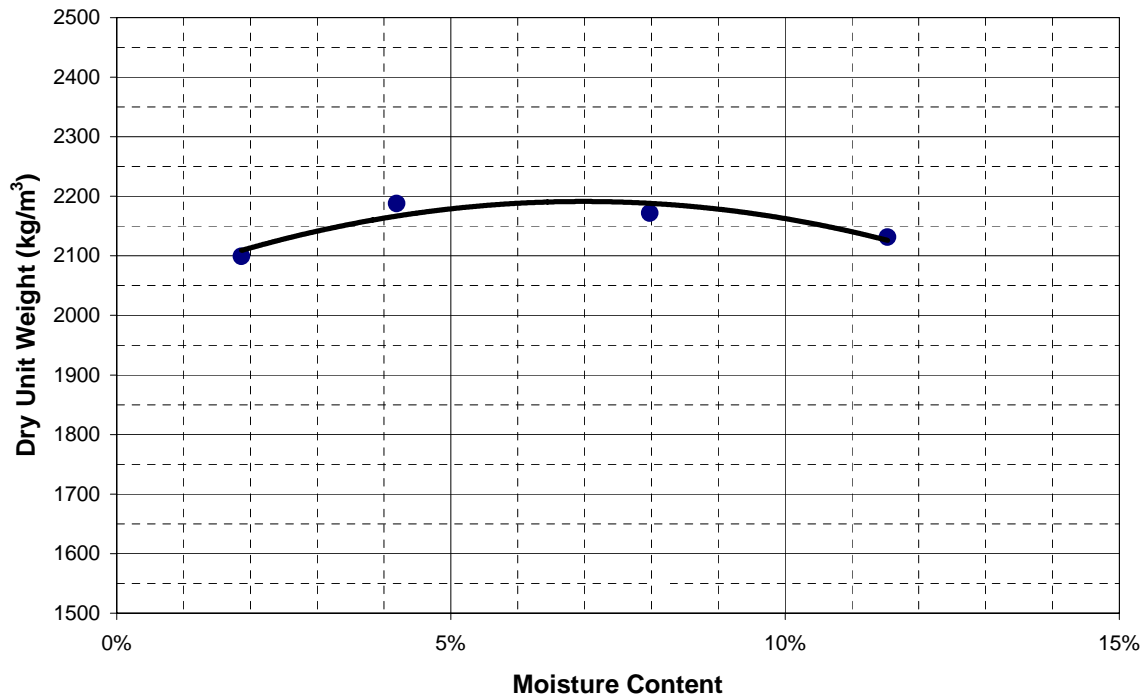
 Klohn Crippen Berger	JOB NO.: M09234A02
	PROJECT: Wolverine - DAM FILL (TP05-87)
	LOCATION: Yukon
	DATE: 31-Aug-05
	TESTED BY: DL

COMPACTION TEST

Sample Description: **TP05 - 89** 1.5 m

TRIAL NUMBER	1	2				
Unit Weight Determination						
Wet Wt. Sample & Mold (g)	6350	6411	6441	6219		
Weight of Mold (g)	4231	4231	4231	4231		
Wet Wt. of Sample (g)	2119	2180	2210	1988		
Volume of Mold (cm ³)	929.623	929.623	929.623	929.623		
Wet Unit Wt. (kg/m ³)	2279.4	2345.0	2377.3	2138.5		
Dry Unit Wt. (kg/m ³)	2187.8	2171.8	2131.5	2099.3		
Moisture Content Determination						
Container No.						
Wet Wt. Sample & Tare (g)	959.93	809.79	1001.51	216.62		
Dry Wt. Sample & Tare (g)	926.21	770.17	927.86	212.95		
Wt. of Water (g)	33.72	39.62	73.65	3.67		
Tare Container (g)	121.38	273.37	289.29	16.35		
Dry Wt. of Soil (g)	804.83	496.8	638.57	196.6		
Moisture Content (%)	4.2%	8.0%	11.5%	1.9%		

Compaction Test



JOB NO.:	M09234A02	
PROJECT:	Wolverine - DAM FILL (TP05-89)	
LOCATION:	Yukon	
DATE:	19-Sep-05	
TESTED BY:	DL	CHECKED BY: JG



HYDRAULIC CONDUCTIVITY TEST USING A FLEXIBLE WALL PERMEAMETER
 (Triaxial Permeability Test) (ASTM D5084-00)

PROJECT NO: M09234A2 TRIAXIAL CELL:
 PROJECT: Woverine Project PRESSURE PANEL:
 SAMPLE INFORMATION: Tailings sample, prepared by moist tamping technique.

Test No.:
 Tested by: Ganan
 Date: November 24, 2005

DATE / TIME	TIME INTERVAL (sec)	BASE BURETTE (IN FLOW)		TOP BURETTE (OUT FLOW)		BASE PRESSURE (kPa)	TOP PRESSURE (kPa)	CELL PRESSURE (kPa)	HEAD LOSS (cm)	GRADIENT i	COEF. OF PERMEABILITY (cm/sec) k
		READING (cm)	VOLUME (cm ³)	READING (cm)	VOLUME (cm ³)						
	t		Q _{in}		Q _{out}				h	i	k
11/24/05 11:45		64.05		46.10		205	200	300	68.9	5.4	
	13500		2.90		2.58						1E-06
11/24/05 15:30		63.80		47.10		205	200	300	67.6	5.3	
	6720		1.16		1.29						1E-06
11/24/05 17:22		63.70		47.60		205	200	300	67.0	5.3	
	56280		10.44		10.56						1E-06
11/25/05 9:00		62.80		51.70		205	200	300	62.0	4.9	
11/25/05 9:00		62.75		51.70		210	200	300	112.9	8.8	
	8100		2.90		2.58						1E-06
11/25/05 11:15		62.50		52.70		210	200	300	111.6	8.7	
	13500		4.64		4.38						1E-06
11/25/05 15:00		62.10		54.40		210	200	300	109.5	8.6	
11/25/05 15:00		62.10		40.50		210	200	300	123.4	9.7	
	8100		3.48		3.09						1E-06
11/25/05 17:15		61.80		41.70		210	200	300	121.9	9.6	
	148500		47.56		47.90						1E-06
11/27/05 10:30		57.70		60.30		210	200	300	99.2	7.8	

Base Burette Area: $A_{in} (cm^2) = 11.6$ Top Burette Area: $A_{out} (cm^2) = 2.575$ Sample Area: $A (cm^2) = 31.4873$ Sample Length: $L (cm) = 12.76$

Hydraulic Conductivity (Coef. of Permeability), $k = \ln(h_1/h_2) \times (A_{in} \times A_{out} \times L) / (A \times t \times (A_{in} + A_{out}))$ by ASTM D5084-00, method C
 (Back pressure saturation applied on the test specimen before consolidation)
 (Permeability Test was performed after consolidation at 100 kPa confining pressure.)



HYDRAULIC CONDUCTIVITY TEST USING A FLEXIBLE WALL PERMEAMETER (Triaxial Permeability Test) (ASTM D5084-00)

PROJECT NO: M09234A2

TRIAxIAL CELL:

Test No.: TX271205

PROJECT: Woverine Project

PRESSURE PANEL:

Tested by: Ganan

SAMPLE INFORMATION: TP05-89 sample, prepared by moist tamping technique.

Date: November 19, 2005

DATE / TIME	TIME INTERVAL (sec)	BASE BURETTE (IN FLOW)		TOP BURETTE (OUT FLOW)		BASE PRESSURE (kPa)	TOP PRESSURE (kPa)	CELL PRESSURE (kPa)	HEAD LOSS (cm)	GRADIENT i	COEF. OF PERMEABILITY (cm/sec) k
		READING (cm)	VOLUME (cm ³)	READING (cm)	VOLUME (cm ³)						
		t	Q _{in}	Q _{out}							
12/19/05 11:50		63.50		45.90		310	300	750	119.4	9.4	
	5100		4.17		4.00						2.7E-06
12/19/05 13:15		63.15		47.45		310	300	750	117.5	9.3	
	6900		5.95		5.55						2.8E-06
12/19/05 15:10		62.65		49.60		310	300	750	114.9	9.1	
	8100		5.95		6.20						2.7E-06
12/19/05 17:25		62.15		52.00		310	300	750	112.0	8.8	
12/19/05 17:25		62.15		41.20		310	300	750	122.8	9.7	
	5100		4.17		4.39						2.8E-06
12/19/05 18:50		61.80		42.90		310	300	750	120.7	9.5	
12/19/05 19:35		61.75		43.45		305	300	750	69.2	5.5	
	50100		18.45		18.46						2.3E-06
12/20/05 9:30		60.20		50.60		305	300	750	60.5	4.8	
	9900		4.76		4.13						2.9E-06
12/20/05 12:15		59.80		52.20		305	300	750	58.5	4.6	
	11700		4.76		4.65						2.8E-06
12/20/05 15:30		59.40		54.00		305	300	750	56.3	4.4	
12/20/05 15:30		59.40		40.60		305	300	750	69.7	5.5	
	62700		26.18		27.11						2.7E-06
12/21/05 8:55		57.20		51.10		305	300	750	57.0	4.5	

Base Burette Area:

Top Burette Area:

Sample Area:

Sample Length:

A_{in} (cm²) = 11.9

A_{out} (cm²) = 2.582

A (cm²) = 31.4082

L (cm) = 12.68

Hydraulic Conductivity (Coef. of Permeability), $k = \ln(h_1/h_2) \times (A_{in} \times A_{out} \times L) / (A \times t \times (A_{in} + A_{out}))$ by ASTM D5084-00, method C
(Back pressure saturation applied on the test specimen before consolidation)
(Permeability Test was performed after consolidation at 450 kPa confining pressure.)



HYDRAULIC CONDUCTIVITY TEST USING A FLEXIBLE WALL PERMEAMETER
 (Triaxial Permeability Test) (ASTM D5084-00)

PROJECT NO: M09234A2

TRIAxIAL CELL:

Test No.: TX271205

PROJECT: Woverine Project

PRESSURE PANEL:

Tested by: Ganan

SAMPLE INFORMATION: TP05-89 sample, prepared by moist tamping technique.

Date: January 10, 2006

DATE / TIME	TIME INTERVAL (sec)	BASE BURETTE (IN FLOW)		TOP BURETTE (OUT FLOW)		BASE PRESSURE (kPa)	TOP PRESSURE (kPa)	CELL PRESSURE (kPa)	HEAD LOSS (cm)	GRADIENT i	COEF. OF PERMEABILITY (cm/sec) k
		READING (cm)	VOLUME (cm ³)	READING (cm)	VOLUME (cm ³)						
		t	Q _{in}	Q _{out}							
1/9/06 10:40		66.60		45.20		210	200	1000	123.2	9.7	
	4800		3.57		3.87						2.6E-06
1/9/06 12:00		66.30		46.70		210	200	1000	121.4	9.6	
	4800		4.16		4.00						2.8E-06
1/9/06 13:20		65.95		48.25		210	200	1000	119.5	9.4	
	4200		2.98		3.23						2.6E-06
1/9/06 14:30		65.70		49.50		210	200	1000	118.0	9.3	
	10200		8.33		8.00						2.8E-06
1/9/06 17:20		65.00		52.60		210	200	1000	114.2	9.0	
1/9/06 17:20		65.00		43.80		204.5	200	1000	67.0	5.3	
	4800		1.79		1.55						2.0E-06
1/9/06 18:40		64.85		44.40		204.5	200	1000	66.3	5.2	
	52200		19.63		19.37						2.5E-06
1/10/06 9:10		63.20		51.90		204.5	200	1000	57.1	4.5	

Base Burette Area:

Top Burette Area:

Sample Area:

Sample Length:

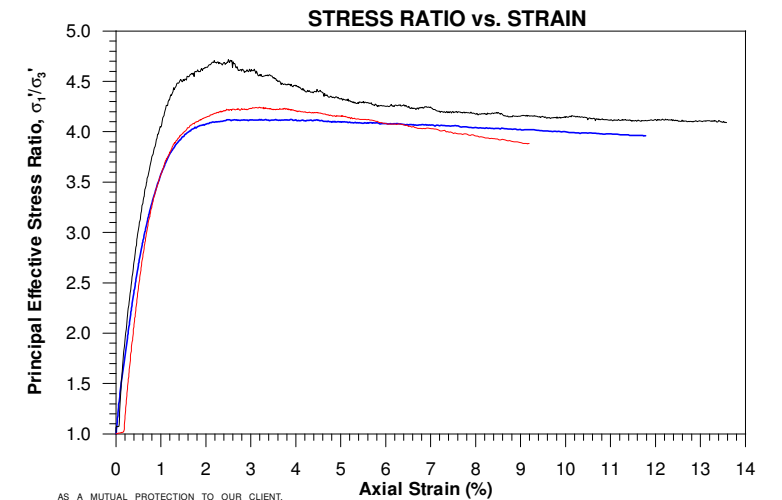
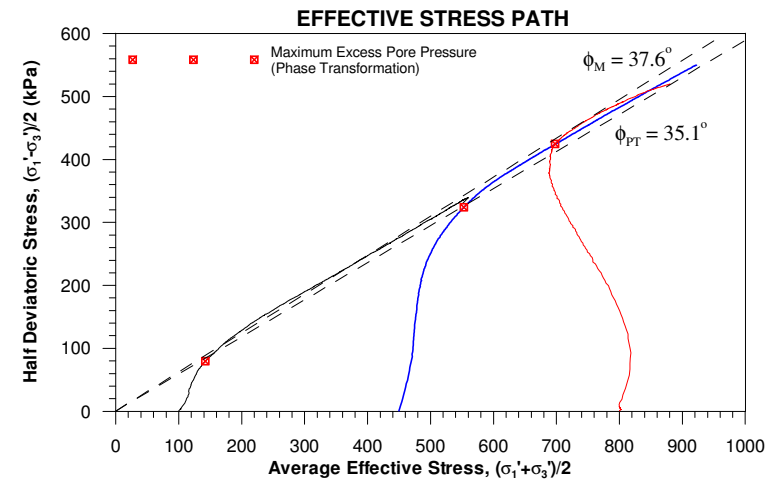
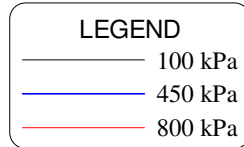
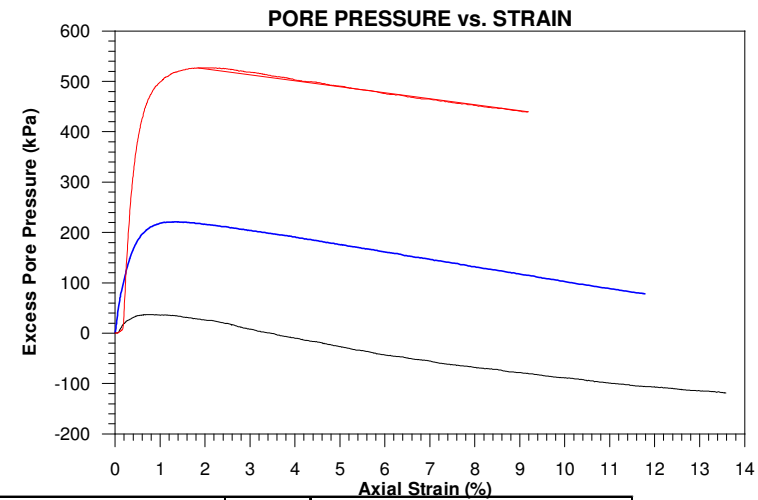
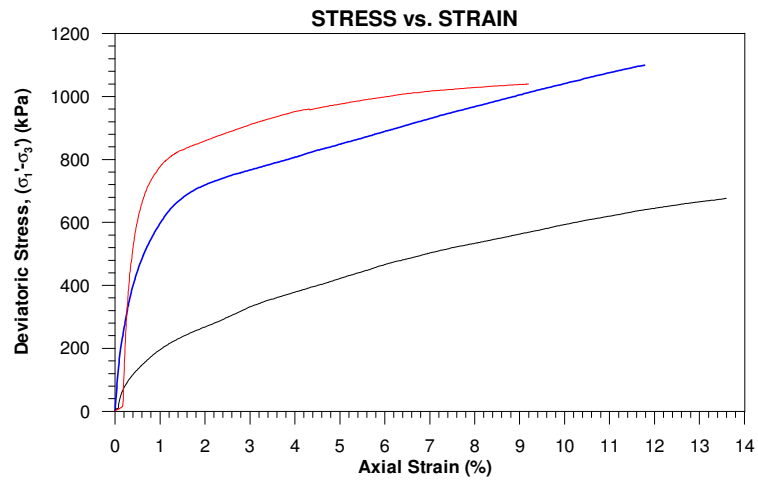
A_{in} (cm²) = 11.9

A_{out} (cm²) = 2.582

A (cm²) = 31.2181

L (cm) = 12.69

Hydraulic Conductivity (Coef. of Permeability), $k = \ln(h_1/h_2) \times (A_{in} \times A_{out} \times L) / (A \times t \times (A_{in} + A_{out}))$ by ASTM D5084-00, method C
 (Back pressure saturation applied on the test specimen before consolidation)
 (Permeability Test was performed after consolidation at 800 kPa confining pressure.)



AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

SPECIMEN INFORMATION	UNITS	DATA		
Dam Fill - TP05-89				
Initial Water Content	%	10.3	9.0	9.0
Initial Dry Density	kg/m ³	2130	2119	2109
Skempton's B Parameter		0.90	0.95	0.95
Back Pressure	kPa	200	300	200
Consolidation Stress (σ'_c)	kPa	100	450	800
(at start of shear)				
Dry Density	kg/m ³	2146	2149	2150
Specimen Height	mm	127.6	126.8	126.9
Specimen Area	mm ²	3148.7	3140.8	3121.8
Final Water Content	%	11.2	11.3	11.6

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED _____

KLOHN-CRIPPEN		DATE
DESIGNED		
DRAWN		
CHECKED		
RECOMMENDED		
APPROVED		

CLIENT

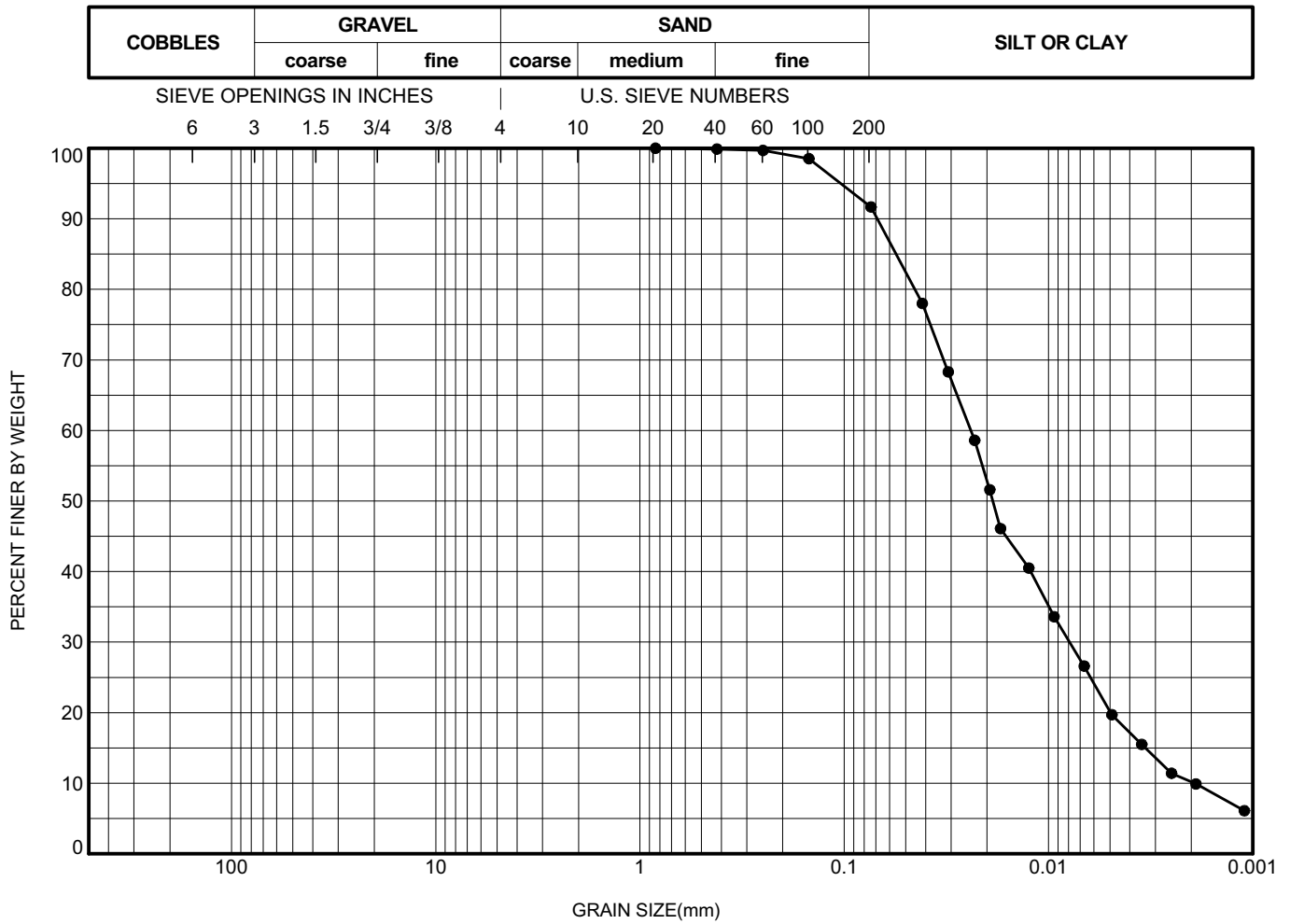


Yukon Zinc CORPORATION

PROJECT			
WOLVERINE TAILINGS IMPOUNDMENT			
TITLE			
CIUC TRIAXIAL TEST RESULTS DAM FILL (TP05-89) SAMPLE			
DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
December 2005	M09234A02	FIG	

Tailings

GRAIN SIZE DISTRIBUTION



HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
● Tailings	0.00							0.0	8.2	91.8

HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _P	PI	REMARKS / SAMPLE DESCRIPTION
● Tailings		0.00					

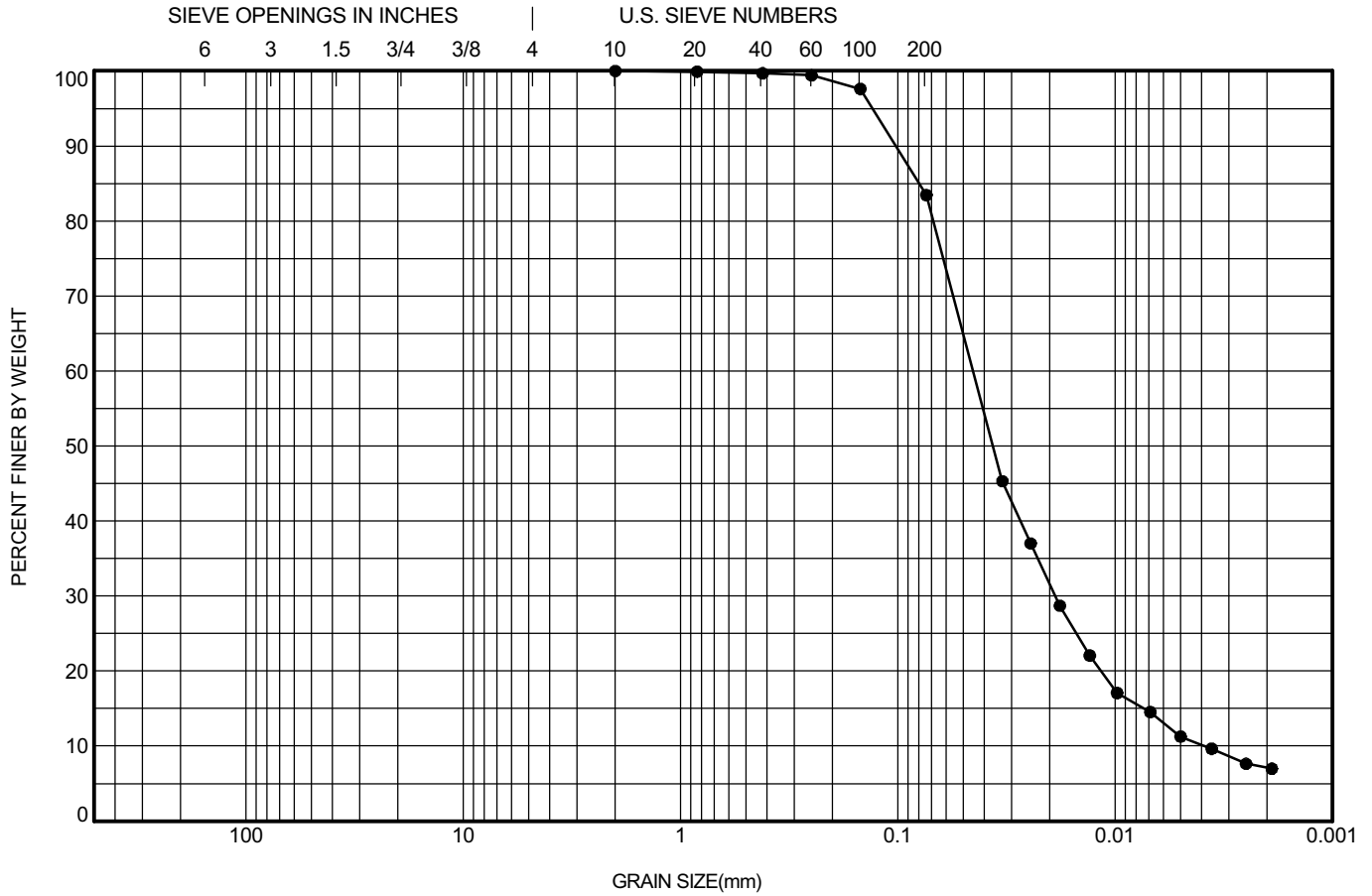
CU = COEFFICIENT OF UNIFORMITY = D60/D10 PARTICLE SIZES, e.g. D85, in mm Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A02 01 01
 PROJECT: Wolverine - Tailings Sample
 LOCATION: Yukon
 FIGURE:
 DRAWN BY: JG CHECKED BY:

GRAIN SIZE DISTRIBUTION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



	HOLE	DEPTH (m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	Tailing	0.00	0.080						0.0	16.3	83.7

	HOLE	SAMPLE	DEPTH (m)	W%	W _L	W _p	PI	REMARKS / SAMPLE DESCRIPTION
●	Tailing		0.00					F11&F12 (20%), F23&F32 (80%)

CU = COEFFICIENT OF UNIFORMITY = D60/D10 PARTICLE SIZES, e.g. D85, in mm Tested by Wet Sieving Method (ASTM D1140 & D422)



PROJECT NO.: M09234A04

PROJECT: Wolverine Project - Tailings

LOCATION: Yukon

FIGURE:

DRAWN BY: BY


CHECKED BY:

SPECIFIC GRAVITY OF SOIL SOLIDS (ASTM-D854)

Sample No.	#1		
Flask No.	KL2	KL3	
Volume of Flask @ 20° C ml	500	500	
Method of Air removal	Boiling	Boiling	
De-airing Period hr	2	2	
Test temperature ° C	22.6	22.6	
Mass of Flask+Water (M _a) g	675.46	675.96	
Mass of Flask+Water+Soil (M _b) g	748.55	751.50	
Mass of Dish/Flask+Soil	277.13	281.12	
Mass of Dish/Flask	177.20	177.49	
Mass of Dry Soil (M _o) g	99.93	103.63	
Correction factor (K) @ Test Temperature	0.9998	0.9998	
Specific Gravity of Solids @ 20° C	3.72	3.69	
Average Specific Gravity of Solids @ 20° C	3.71		

Sample No.			
Flask No.			
Volume of Flask @ 20° C ml			
Method of Air removal			
De-airing Period hr			
Test temperature ° C			
Mass of Flask+Water (M _a) g			
Mass of Flask+Water+Soil (M _b) g			
Mass of Dish/Flask+Soil			
Mass of Dish/Flask			
Mass of Dry Soil (M _o) g			
Correction factor (K) @ Test Temperature			
Specific Gravity of Solids @ 20° C			
Average Specific Gravity of Solids @ 20° C			

Specific Gravity of Solids @ 20° C = $(K \times M_o) / (M_o + M_a - M_b)$

 Klohn Crippen Berger	JOB NO.: M09234A02
	PROJECT: Wolverine - Tailings Sample
	LOCATION: Yukon
	DATE: December 13, 2005
	TESTED BY: JG CHECKED BY: GAN

SPECIFIC GRAVITY OF SOIL SOLIDS (ASTM-D854)

Sample No.	Tailings*					
Flask No.	KL-2	KL-3				
Volume of Flask @ 20° C ml	500	500				
Method of Air removal	Boiling	Boiling				
De-airing Period hr	2	2				
Test temperature ° C	16.9	16.9				
Mass of Flask+Water (M _a) g	675.15	675.53				
Mass of Flask+Water+Soil (M _b) g	728.62	725.89				
Mass of Dish/Flask+Soil	249.19	245.30				
Mass of Dish/Flask	177.18	177.47				
Mass of Dry Soil (M _o) g	72.01	67.83				
Correction factor (K) @ Test Temperature	1.0055	1.0055				
Specific Gravity of Solids @ 20° C	3.905	3.904				
Average Specific Gravity of Solids @ 20° C	3.90					

Sample No.						
Flask No.						
Volume of Flask @ 20° C ml						
Method of Air removal						
De-airing Period hr						
Test temperature ° C						
Mass of Flask+Water (M _a) g						
Mass of Flask+Water+Soil (M _b) g						
Mass of Dish/Flask+Soil						
Mass of Dish/Flask						
Mass of Dry Soil (M _o) g						
Correction factor (K) @ Test Temperature						
Specific Gravity of Solids @ 20° C						
Average Specific Gravity of Solids @ 20° C						

* Combined tailings F11 & F12 (20%), F23 & F32 (80%)

Specific Gravity of Solids @ 20° C = $(K \times M_o) / (M_o + M_a - M_b)$

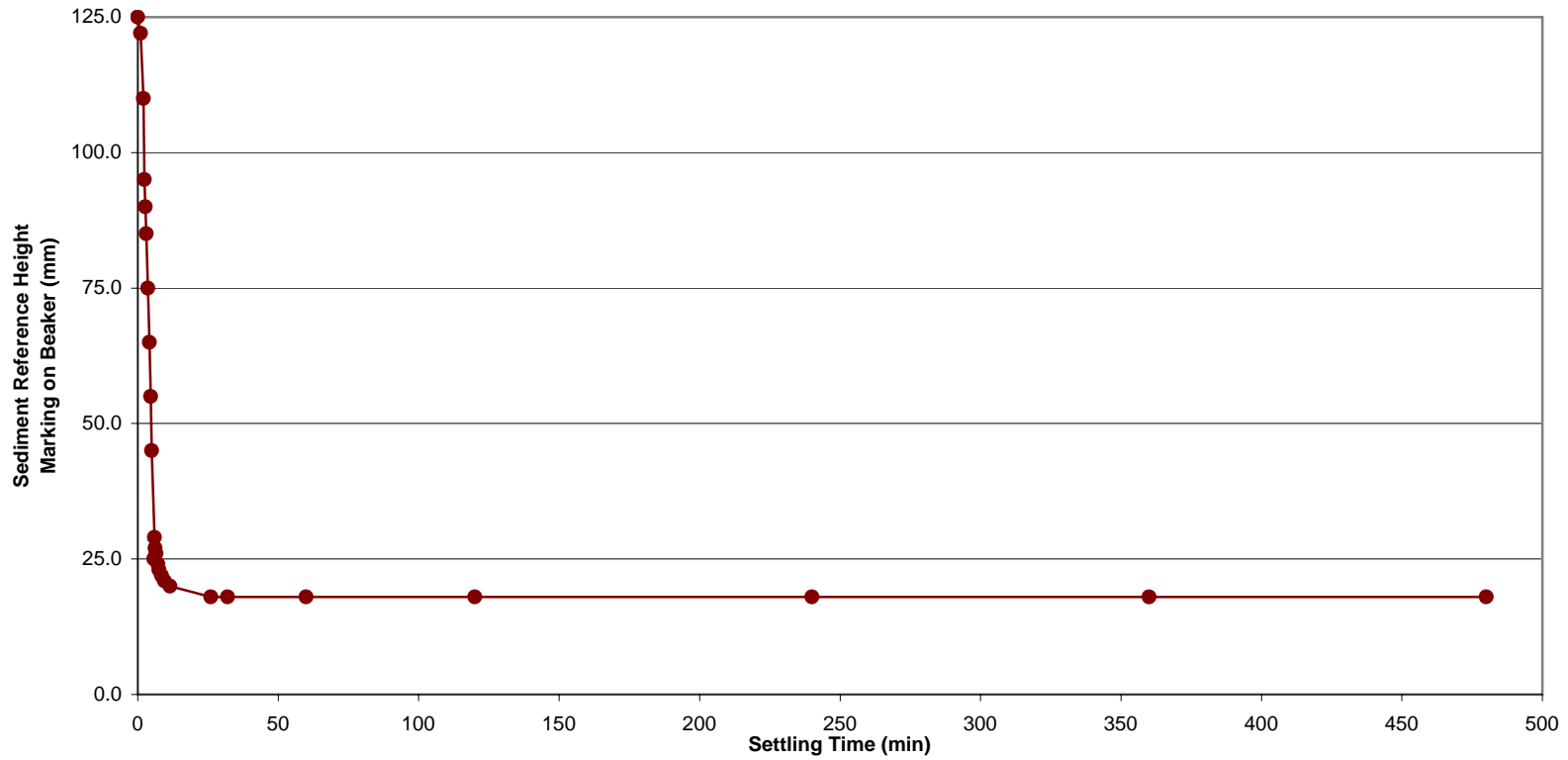


JOB NO.: M09234A04	
PROJECT: Wolverine Project - tailings	
LOCATION: Yukon	
DATE: 26-Oct-08	
TESTED BY: BY	CHECKED BY:



Klohn Crippen Berger

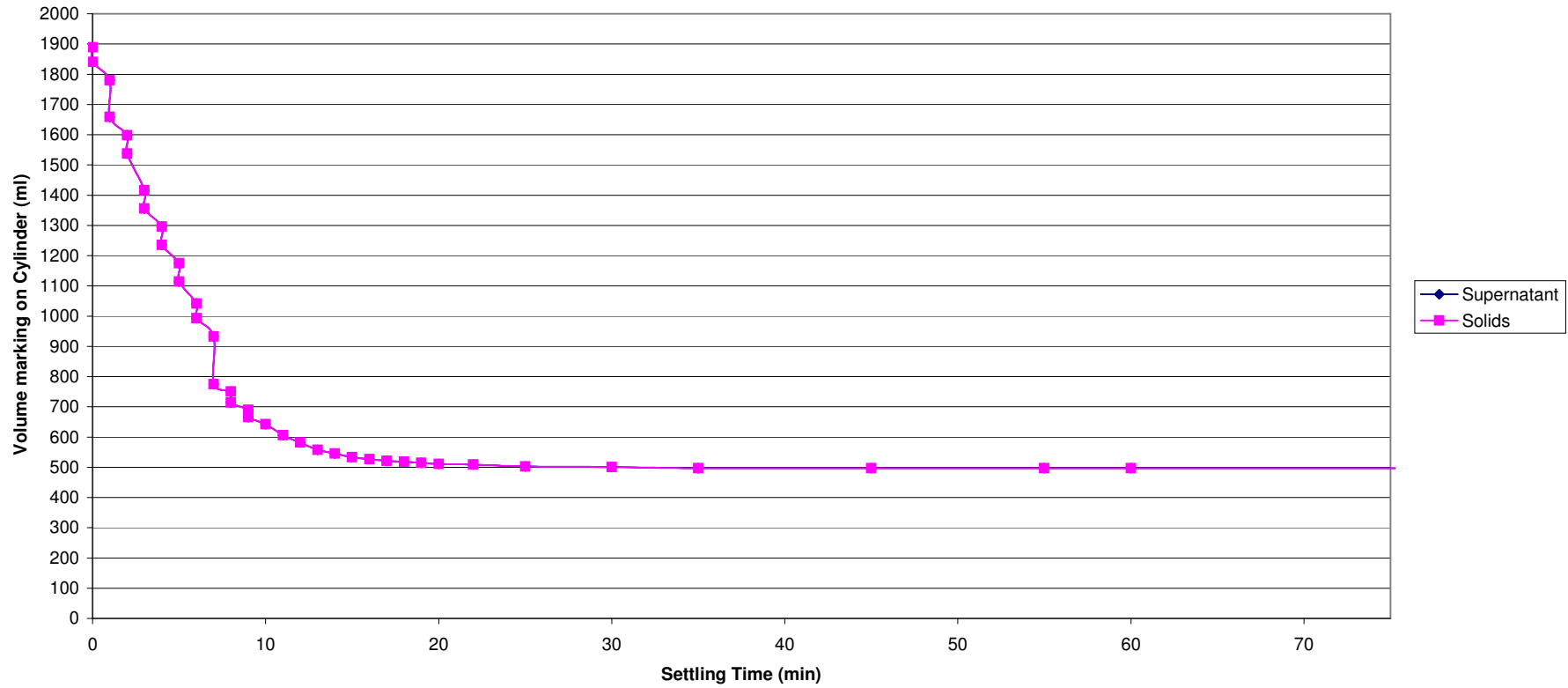
Settling Test for Tailings Samples (14 % Initial Solid Content)




Note: Water Content at the end of
Settling Test is 54%

—●— Tailings

Settling Test for Tailings @ 30% solids



 Klohn Crippen Berger	JOB NO.:	M09234	DATE	24-Oct-08
	PROJECT:	Wolverine	LOCATION:	
	DETAIL:	30% solid content		
	DESCRIPTION:	Tailings with F11 and F12 (20%); F23 and F32 (80%)		
	TESTED BY:	JG	CHECKED BY:	BY

CONSOLIDATION

PROJECT NO: M09234A04
 PROJECT: Wolverine Project - Tailings
 SAMPLE NO.: Tailing Mix (F11 and F12 (20%) + F23 and F32 (80%))
 DEPTH:
 LOADING MACHINE NO.: Machine #9

Initial water content : 41.00 % (based on trimmings)
 Final water content : 20.35 % (based on sample at end of test)

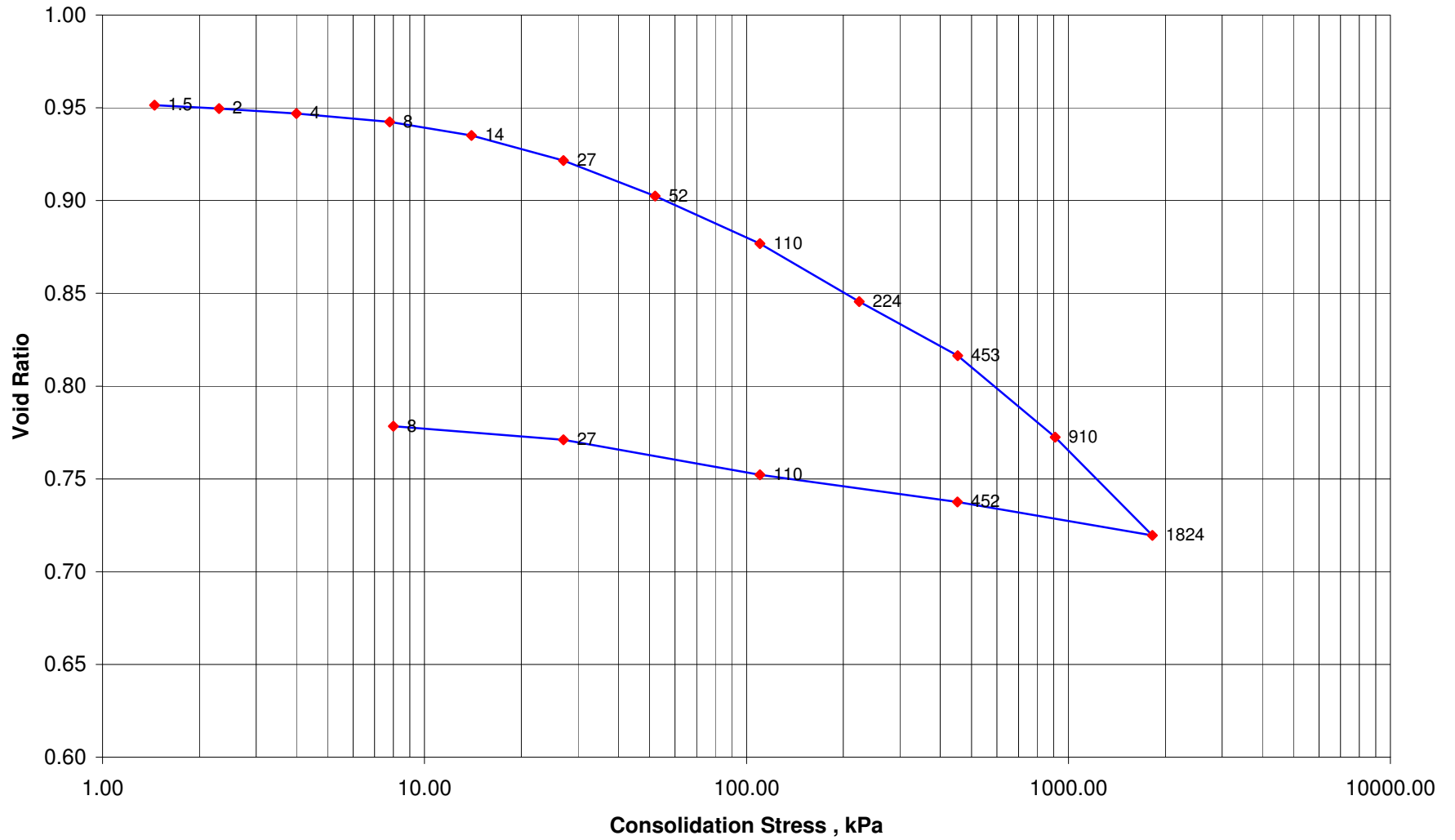
Initial Specimen Height (mm): 15.880
 Height of Solid (mm): 5.490 (Initial dry mass = 82.77 g, Specimen area = 3861.7 mm², SG=3.90)
 Initial void ratio: 1.589 * Calibration to be done after test
 Void Ratio Factor 0.1821 ** Estimated t₉₀

Pressure (kPa)		Change in Height Corrected (mm)	Final Height (mm)	Change in Void Ratio	Change in Void Ratio Acc	Void Ratio	t ₉₀ ** (min)	Cv (cm ² /sec)	Mv (cm ² /N)	k (cm/sec)	Cc
From	To										
0.0	1.5	3.500	12.380	0.6375	0.6375	0.951					
1.5	2	0.010	12.370	0.0018	0.6393	0.950					
2	4	0.015	12.355	0.0027	0.6421	0.947					
4	8	0.025	12.330	0.0046	0.6466	0.942	0.05	1.1E-01	1.4E-02	1.5E-05	0.016
8	14	0.040	12.290	0.0073	0.6539	0.935	0.01	5.4E-01	9.9E-03	5.2E-05	0.029
14	27	0.074	12.216	0.0135	0.6674	0.922	0.5	1.0E-02	1.1E-02	1.1E-06	0.047
27	52	0.105	12.110	0.0192	0.6866	0.902	1.4	3.7E-03	7.7E-03	2.8E-07	0.067
52	110	0.140	11.970	0.0255	0.7121	0.877	0.2	2.2E-02	5.4E-03	1.2E-06	0.078
110	224	0.172	11.798	0.0314	0.7435	0.846	0.5	9.8E-03	2.9E-03	2.8E-07	0.102
224	453	0.160	11.638	0.0291	0.7726	0.816	1.4	3.4E-03	1.4E-03	4.6E-08	0.095
453	910	0.241	11.397	0.0440	0.8166	0.772	2.8	1.7E-03	1.1E-03	1.7E-08	0.145
910	1824	0.290	11.820	0.0529	0.8695	0.720	3.6	1.4E-03	3.8E-02	5.3E-07	0.118
1824	452	-0.099	11.919	-0.0181	0.8514	0.738					
452	110	-0.080	11.999	-0.0146	0.8368	0.752					
110	27	-0.104	12.103	-0.0189	0.8179	0.771					
27	8	-0.040	12.143	-0.0073	0.8106	0.778					



PROJECT NO: M09234A04
 PROJECT: Wolverine Project - Tailings
 LOCATION: Yukon
 FIGURE: DATE TESTED: November 10, 2008
 TESTED BY: Juan CHECKED BY:

Tailings Mix 20 %(F11, F12) - 80 % (F23, F32)
e - log(p)





HYDRAULIC CONDUCTIVITY TEST USING A FLEXIBLE WALL PERMEAMETER
 (Triaxial Permeability Test) (ASTM D5084-00)

PROJECT NO: M09234A02 TRIAXIAL CELL: Test No.:
 PROJECT: Woverine Project PRESSURE PANEL: Tested by: Ganan
 SAMPLE INFORMATION: Tailings sample, prepared by moist tamping technique. Date: 11/2/05

DATE / TIME	TIME INTERVAL (sec)	BASE BURETTE (IN FLOW)		TOP BURETTE (OUT FLOW)		BASE PRESSURE (kPa)	TOP PRESSURE (kPa)	CELL PRESSURE (kPa)	HEAD LOSS (cm)	GRADIENT i	COEF. OF PERMEABILITY (cm/sec) k
		READING (cm)	VOLUME (cm ³)	READING (cm)	VOLUME (cm ³)						
	t		Q _{in}		Q _{out}				h	i	k
11/2/05 11:00		66.00		45.40		260	250	350	122.4	9.6	
	900		22.04		22.40						9E-05
11/2/05 11:15		64.10		54.10		258	248	350	111.8	8.8	
	900		20.88		19.57						8E-05
11/2/05 11:30		62.30		61.70		258	248	500	102.4	8.1	
11/2/05 11:40		63.30		43.80		255	250	350	70.4	5.5	
	900		10.44		10.30						7E-05
11/2/05 11:55		62.40		47.80		255	250	350	65.5	5.2	
	900		9.86		9.27						7E-05
11/2/05 12:10		61.55		51.40		256	251	350	61.1	4.8	
11/2/05 13:10		61.50		42.00		255	250	350	70.4	5.5	
	900		9.86		10.30						7E-05
11/2/05 13:25		60.65		46.00		255	250	350	65.6	5.2	
	900		9.86		9.27						7E-05
11/2/05 13:40		59.80		49.60		256	251	350	61.1	4.8	

Base Burette Area: Top Burette Area: Sample Area: Sample Length:
 A_{in} (cm²) = 11.6 A_{out} (cm²) = 2.575 A (cm²) = 30.95 L (cm) = 12.69

Hydraulic Conductivity (Coef. of Permeability), $k = \ln(h_1/h_2) \times (A_{in} \times A_{out} \times L) / (A \times t \times (A_{in} + A_{out}))$ by ASTM D5084-00, method C
 (Back pressure saturation applied on the test specimen before consolidation)
 (Permeability Test was performed after consolidation at 100kPa confining pressure.)



**HYDRAULIC CONDUCTIVITY TEST USING A FLEXIBLE WALL PERMEAMETER
(Triaxial Permeability Test) (ASTM D5084-00)**

PROJECT NO: M09234A2 TRIAXIAL CELL: Test No.:
 PROJECT: Woverine Project PRESSURE PANEL: Tested by: Ganan
 SAMPLE INFORMATION: Tailings sample, prepared by moist tamping technique. Date: 11/2/05

DATE / TIME	TIME INTERVAL (sec)	BASE BURETTE (IN FLOW)		TOP BURETTE (OUT FLOW)		BASE PRESSURE (kPa)	TOP PRESSURE (kPa)	CELL PRESSURE (kPa)	HEAD LOSS (cm)	GRADIENT i	COEF. OF PERMEABILITY (cm/sec) k
		READING (cm)	VOLUME (cm ³)	READING (cm)	VOLUME (cm ³)						
		t	Q _{in}	Q _{out}							
11/7/05 14:00		67.50		41.00		205	200	475	77.4	6.3	
	1800		2.32		2.45						7E-06
11/7/05 14:30		67.30		41.95		205	200	475	76.3	6.2	
	1800		2.32		2.19						7E-06
11/7/05 15:00		67.10		42.80		205	200	475	75.2	6.1	
	3600		4.64		4.38						7E-06
11/7/05 16:00		66.70		44.50		205	200	475	73.1	5.9	
	3600		4.64		4.12						7E-06
11/7/05 17:00		66.30		46.10		205	200	475	71.1	5.8	
	5400		5.80		6.44						7E-06
11/7/05 18:30		65.80		48.60		205	200	475	68.1	5.5	
11/8/05 9:15		65.80		42.80		210	200	475	124.8	10.1	
	900		2.32		0.77						4E-06
11/8/05 9:30		65.60		43.10		210	200	475	124.3	10.1	
	1800		3.48		5.15						9E-06
11/8/05 10:00		65.30		45.10		210	200	475	122.0	9.9	
	1800		3.48		3.86						7E-06
11/8/05 10:30		65.00		46.60		210	200	475	120.2	9.7	
	3600		7.54		7.21						7E-06
11/8/05 11:30		64.35		49.40		210	200	475	116.8	9.5	
	5400		11.02		11.07						7E-06
11/8/05 13:00		63.40		53.70		210	200	475	111.5	9.0	

Base Burette Area: A_{in} (cm²) = 11.6 Top Burette Area: A_{out} (cm²) = 2.575 Sample Area: A (cm²) = 29.782 Sample Length: L (cm) = 12.34

Hydraulic Conductivity (Coef. of Permeability), $k = \ln(h_1/h_2) \times (A_{in} \times A_{out} \times L) / (A \times t \times (A_{in} + A_{out}))$ by ASTM D5084-00, method C
 (Back pressure saturation applied on the test specimen before consolidation)
 (Permeability Test was performed after consolidation at 275kPa confining pressure.)



HYDRAULIC CONDUCTIVITY TEST USING A FLEXIBLE WALL PERMEAMETER
 (Triaxial Permeability Test) (ASTM D5084-00)

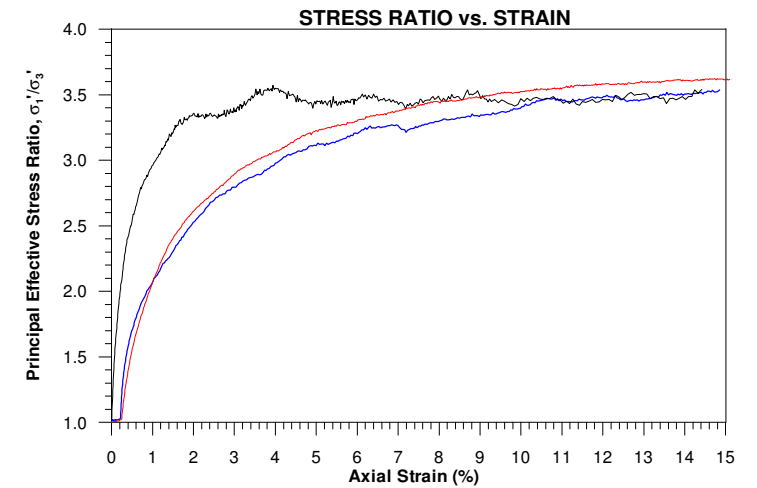
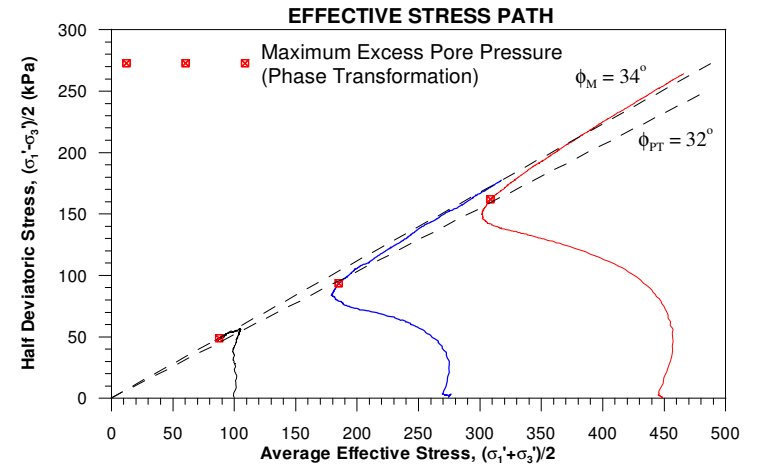
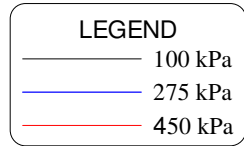
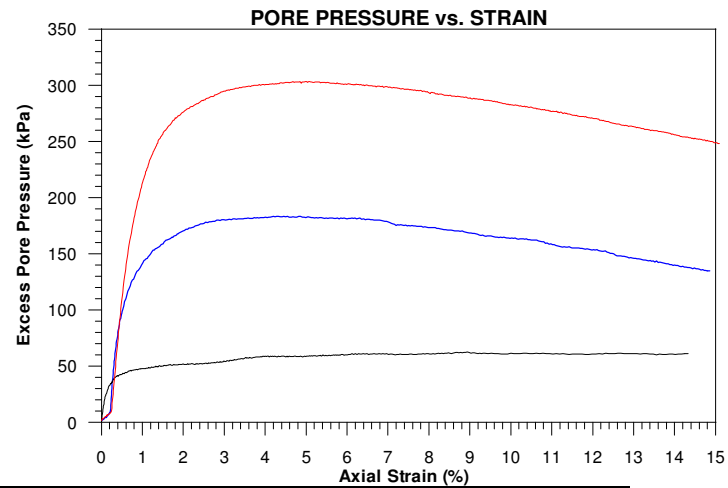
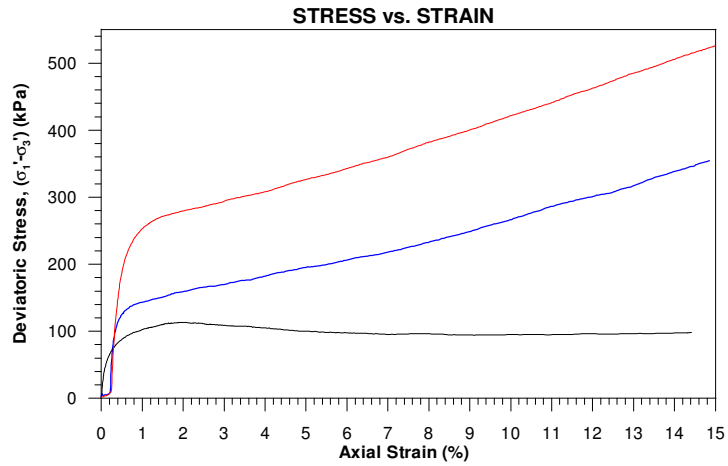
PROJECT NO: M09234A2 TRIAXIAL CELL:
 PROJECT: Woverine Project PRESSURE PANEL:
 SAMPLE INFORMATION: Tailings sample, prepared by moist tamping technique.

Test No.:
 Tested by: Ganan
 Date: Nov 17, 2005

DATE / TIME	TIME INTERVAL (sec) t	BASE BURETTE (IN FLOW)		TOP BURETTE (OUT FLOW)		BASE PRESSURE (kPa)	TOP PRESSURE (kPa)	CELL PRESSURE (kPa)	HEAD LOSS (cm) h	GRADIENT i	COEF. OF PERMEABILITY (cm/sec) k
		READING (cm)	VOLUME (cm ³)	READING (cm)	VOLUME (cm ³)						
			Q _{in}		Q _{out}						
11/17/05 10:25		68.20		39.90		205	199	650	89.4	7.2	
	2100		2.90		3.09						7.1E-06
11/17/05 11:00		67.95		41.10		205	199	650	87.9	7.1	
	3600		5.22		5.15						7.1E-06
11/17/05 12:00		67.50		43.10		205	199	650	85.5	6.9	
	5400		7.54		7.98						7.5E-06
11/17/05 13:30		66.85		46.20		205	199	650	81.7	6.6	
	3600		4.64		4.63						6.9E-06
11/17/05 14:30		66.45		48.00		205	199	650	79.5	6.4	
	3600		4.64		4.89						7.4E-06
11/17/05 15:30		66.05		49.90		205	199	650	77.2	6.2	
11/17/05 15:30		66.00		49.95		210	199	650	128.0	10.3	
	2100		5.22		5.28						8.5E-06
11/17/05 16:05		65.55		52.00		210	199	650	125.5	10.1	
	5100		12.18		12.10						8.3E-06
11/17/05 17:30		64.50		56.70		210	199	650	119.8	9.6	

Base Burette Area: $A_{in} \text{ (cm}^2\text{)} = 11.6$ Top Burette Area: $A_{out} \text{ (cm}^2\text{)} = 2.575$ Sample Area: $A \text{ (cm}^2\text{)} = 28.8882$ Sample Length: $L \text{ (cm)} = 12.45$

Hydraulic Conductivity (Coef. of Permeability), $k = \ln(h_1/h_2) \times (A_{in} \times A_{out} \times L) / (A \times t \times (A_{in} + A_{out}))$ by ASTM D5084-00, method C
 (Back pressure saturation applied on the test specimen before consolidation)
 (Permeability Test was performed after consolidation at 450kPa confining pressure.)



AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

SPECIMEN INFORMATION	UNITS	DATA		
Tailings Sample				
Initial Water Content	%	18.5	17.6	17.6
Initial Dry Density	kg/m ³	1848	1858	1842
Skempton's B Parameter		0.96	0.98	0.98
Back Pressure	kPa	250	200	200
Consolidation Stress (σ'_c) (at start of shear)	kPa	100	275	450
Dry Density	kg/m ³	1905	2036	2080
Specimen Height	mm	126.9	123.4	124.5
Specimen Area	mm ²	3095.2	2978.2	2888.8
Final Water Content	%	23.2	19.6	19.2

TO BE READ WITH KLOHN-CRIPPEN REPORT DATED _____

KLOHN-CRIPPEN	DATE
DESIGNED	
DRAWN	
CHECKED	
RECOMMENDED	
APPROVED	

CLIENT

PROJECT	WOLVERINE TAILINGS IMPOUNDMENT			
TITLE	CIUC TRIAXIAL TEST RESULTS TAILINGS SAMPLE			
DATE OF ISSUE	PROJECT No.	DWG. No.	REV.	
November 2005	M09234A02	FIG.		

4. FIELD INVESTIGATIONS

4.1 Summary

Geotechnical site investigations for the tailings facility were carried out from July to September 2005 and drill hole and test pit logs are included in Section 4.2. Geotechnical investigations for the tailings facility included 6 drill holes, 2 groundwater monitoring wells and 23 test pits, summarized as follows:

- Test Holes TH05-7 to TH05-11 were drilled along the dam alignment, and TH05-12 was drilled inside the tailings impoundment.
- Test Pits TP05-71 to TP05-83, TP05-94 and TP05-95 were excavated in the footprint of tailings dam, TP05-84 to TP05-86 excavated in the footprint of the seepage dam, and TP05-91 to TP05-93, TP05-96 and TP05-97 excavated along the diversion ditches and spillway channels.
- Groundwater monitoring well MW05-6 was drilled upstream of the impoundment, while MW05-7 drilled near the downstream toe of the tailings dam.

The site investigation programs were mainly carried out using a 420D Cat backhoe mounted on rubber tires, and a BBS-25A diamond drill rig. Locations of test pits, test holes and groundwater monitoring wells for the tailings facility are shown in Drawing D-3002. Subsoil profiles in the tailings facility area are provided in Drawing D-3003.

The drilling program consisted of Standard or Large Penetration (SPT's and LPT's) tests and falling-head permeability tests in overburden materials, and packer permeability tests and diamond drill coring with HQ₃ or NQ₂ core barrel in bedrock. The penetration tests were carried out to retrieve soil samples for further laboratory testing (see Section 3) and to evaluate *in situ* soil density. Similarly, core samples of bedrock were obtained by diamond coring. *In situ* permeability of subsoil and bedrock were obtained by the falling-head and packer tests.

Most of the test pits were excavated to a maximum depth of about 5 m using the backhoe. In areas inaccessible to the backhoe, shallower test pits were excavated manually or drilled manually using a hand-operated auger drill to a maximum depth of 1 m. All test hole and test pit

locations were surveyed using a GPS unit, and the ground surface elevations were estimated using the site contour map with 2 m contour intervals. Samples retrieved from the drill holes and test pits were further tested in Klohn Crippen Bergers's laboratory in Vancouver. Geotechnical laboratory testing included visual classification, moisture content, gradation, standard Proctor compaction, triaxial permeability and shear strength tests (see Section 3).

Two 25 mm diameter, 30 cm long piezometer tips were installed in most test holes with 25 mm Schedule 40 PVC riser pipes. One 55 mm diameter well screen with Schedule 80 PVC well pipe was installed in each monitoring well. A pressure gauge with a by-pass valve set up was installed at the top of each artesian installation. Temperature profiles were also recorded at test holes.

SPT and LPT and falling-head and packer permeability test results are summarized in Table I-4-1 through Table I-4-5.

Falling-head permeability tests were conducted through the bottom of the monitoring wells or test holes and the test results appear to overestimate the in situ permeability, based on comparison with gradations. This may be due to the boundary condition at the test hole bottom/seal contact, which could increase the measured permeability values significantly.

Table I- 4-1 Summary of Large and Standard Penetrometer Test Results

TEST HOLE	DEPTH (m)	SPT or LPT	SPT OR LPT BLOW COUNT PER FOOT, N	CONVERTED SPT BLOW COUNT, N	CONVERTED (N1) 60
TH05-7	1.52	LPT	101	65	112
	3.05	LPT	81	52	89
	4.57	LPT	29 blows per 6"	-	-
	6.10	LPT	30 blows per 5"	-	-
	9.14	LPT	35 blows per 6"	-	-
	12.19	LPT	30+ blows per 1"	-	-
	15.24	LPT	32+ blows per 4"	-	-
	18.29	LPT	21+ blows per 2"	-	-
	21.34	LPT	37 blows per 3"	-	-
24.38	LPT	21 blows per 3"	-	-	
TH05-8	1.52	LPT	20+ blows per 6"	-	-
	3.05	LPT	47 blows per 12"	-	-
	4.57	LPT	48+ blows per 12"	-	-
	6.10	LPT	42+ blows per 10"	-	-
	9.14	LPT	50+ blows per 12"	-	-
	12.19	LPT	30+ blows per 6"	-	-
	15.24	LPT	60 blows per 6"	-	-
	18.29	LPT	80+ blows per 9"	-	-
TH05-9	1.52	SPT	57	57	97
	3.05	SPT	51	51	86
	4.57	SPT	125	125	172
	6.10	SPT	20 blows per 6"	-	-
	9.14	SPT	26 blows per 5"	-	-
	12.19	SPT	23 blows per 2"	-	-
	15.24	SPT	23 blows per 4"	-	-
	18.29	SPT	23 blows per 2"	-	-
	21.34	SPT	26 blows per 2"	-	-
	24.38	SPT	24 blows per 3.5"	-	-
	27.43	SPT	24 blows per 2.5"	-	-
30.48	SPT	25 blows per 3"	-	-	
TH05-10	1.52	SPT	20+ blows per 6"	-	-
	3.05	SPT	20+ blows per 6"	-	-

Table I- 4-2 Summary of Falling-Head Permeability Test Results

TEST HOLE NO.	TEST SECTION DEPTH (m)		TEST SECTION DIAM. (mm)	k
	from	to		cm/sec
TH05-7	1.52	1.52	101.6	7.8E-02
	3.05	3.05	101.6	8.4E-03
	4.57	4.57	101.6	6.9E-02
	6.10	6.10	101.6	2.7E-02
	9.14	9.14	101.6	2.9E-02
	12.19	12.19	101.6	7.7E-03
	15.24	15.24	101.6	1.0E-02
	18.29	18.29	101.6	2.8E-04
	21.34	21.34	101.6	1.4E-03
TH05-8	24.38	24.38	101.6	4.3E-03
	1.52	1.52	101.6	1.7E-01
	3.05	3.05	101.6	7.0E-02
	4.57	4.57	101.6	2.9E-02
TH05-9	6.10	6.10	101.6	6.9E-03
	1.52	1.52	76.2	1.3E-02
	3.05	3.05	76.2	2.3E-02
	6.10	6.10	76.2	9.5E-03
	9.14	9.14	76.2	5.7E-02
	12.19	12.19	76.2	1.0E-01
	15.24	15.24	76.2	4.1E-01
	18.29	18.29	76.2	5.2E-02
	21.34	21.34	76.2	1.5E-02
	24.38	24.38	76.2	5.7E-02
TH05-10	27.43	27.43	76.2	9.2E-02
	30.48	30.48	76.2	3.1E-03
	1.52	1.52	76.2	5.7E-03
	4.57	4.57	76.2	4.4E-02
	6.10	6.10	76.2	5.0E-02
	9.14	9.14	76.2	3.4E-02
	12.19	12.19	76.2	2.5E-02
	15.24	15.24	76.2	5.0E-02
TH05-11A	18.29	18.29	76.2	7.1E-02
	31.09	31.09	76.2	3.6E-03
	33.53	33.53	76.2	4.0E-03
	3.05	3.05	76.2	1.2E-01
TH05-11B	4.57	4.57	76.2	3.6E-03
	6.10	6.10	76.2	7.7E-03
	9.14	9.14	76.2	4.1E-03
	6.10	6.10	76.2	6.6E-02
	9.14	9.14	76.2	6.0E-03
	12.19	12.19	76.2	1.1E-02
	28.35	28.35	76.2	2.6E-02
	30.48	30.48	76.2	1.9E-03
	36.58	36.58	76.2	6.8E-03
	42.67	42.67	76.2	1.8E-02
TH05-12	1.52	1.52	76.2	2.6E-01
	3.05	3.05	76.2	6.1E-04
	6.10	6.10	76.2	4.1E-03
	9.14	9.14	76.2	3.1E-03
TH05-12	12.19	12.19	76.2	1.1E-02
	18.29	18.29	76.2	1.4E-02
	21.34	21.34	76.2	1.6E-02
	24.38	24.38	76.2	1.5E-02

Table I- 4-3 Summary of Packer Permeability Test Results

TEST HOLE NO.	TEST SECTION DEPTH (m)		TEST SECTION DIAM. (mm)	AVERAGE k
	From	from		m/s
TH05-8	24.70	30.80	96.0	5.5E-07
TH05-9	30.50	35.10	75.7	3.1E-06
TH05-10	35.05	38.10	75.7	1.5E-06
TH05-11	44.20	46.30	75.7	1.4E-07
TH05-12	27.58	29.60	75.7	1.6E-07

Table I- 4-4 Summary of Falling-Head Permeability Test Results – Monitoring Wells

TEST HOLE NO.	DEPTH (m)		HOLE DIA. (mm)	k
	From	to		cm/sec
MW05-3A	1.07	1.52	96	2.8E-04
	2.60	3.05	96	0.0E+001
	4.12	4.57	96	0.0E+001
	5.65	6.10	96	1.7E-04
	8.69	9.14	96	4.9E-04
	11.74	12.19	96	3.5E-04
	14.79	15.24	96	0.0E+001
	17.84	18.29	96	0.0E+001
MW05-5A	3.05	3.05	76	1.0E-01
	6.10	6.10	76	1.2E-02
	9.14	9.14	76	6.7E-03
	12.19	12.19	76	8.0E-03
	15.24	15.24	76	6.3E-03
	18.29	18.29	76	6.6E-03
MW05-6	1.52	1.52	102	2.0E-04
	3.05	3.05	102	7.8E-04
	4.57	4.57	102	3.6E-03
	6.10	6.10	102	1.3E-03
	9.14	9.14	102	4.8E-03
	12.19	12.19	102	2.3E-04
	15.24	15.24	102	3.1E-03
	18.29	18.29	102	1.4E-02
21.34	21.34	102	1.8E-02	

- Notes:**
1. No visible change in piezometric head during test.
 2. MW05-3A is located northwest of the impoundment.

Table I- 4-5 Summary of Packer Permeability Test Results – Monitoring Wells

TEST HOLE NO.	DEPTH (m)		HOLE DIA. (mm)	AVERAGE k
	From	to		m/s
MW05-5	21.10	26.50	76	4.7E-07
MW05-6A	21.30	25.70	96	1.2E-07
MW05-7A	24.70	30.20	96	3.6E-07

Notes: 1. No visible change in piezometric head during test.

4.2 Site Investigation Data

Test hole and test pit logs are included below for the test holes, test pits, and monitoring wells summarized in Section 4.1.

Test Hole and Test Pit Logs



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-7

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 8/6/2005 FINISHED: 8/8/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 442660m N 6808160m	GROUND ELEVATION: 1305 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 31.4 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: HQ Core ROCK: HQ Core
LOGGED BY: EA	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (d)=diametrical	TEMPERATURE	FIELD/LAB DATA								
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	CORE RECOVERY %	WATER CONTENT %						
					Dip Angle		R.Q.D. %		5	10			15						
0.304.8			TOPSOIL - organics.																
1			SILT-SAND-GRAVEL-COBBLE, with occasional boulders.																
2		1	- LPT N = 101 blows at 1.52 m depth.																
3		2	- LPT N = 81 blows at 3.05 m depth.																
4																			
5		3	- LPT N = 29+ blows for first 6" at 4.57 m depth.																
6		4	- LPT N = 30+ blows for first 5" at 6.1 m depth.																
7																			
8																			
9																			
10		5	- LPT N = 35+ blows for first 6" at 9.14 m depth.																
11																			
12																			
13			- LPT N = 30+ blows for first 1" at 12.19 m depth.																
14																			
15																			
16			- LPT N = 32+ blows for first 4" at 15.24 m depth.																
17																			
18																			
19			- LPT N = 21+ blows for first 2" at 18.29 m depth.																
20																			

KC ROCK-81@4 WOLVERINE TEST HOLES - NOV 17 05J ROCK-LOG.GDT 28/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-7

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) <small>(a)=axial; (d)=diametrical</small>	TEMPERATURE	FIELD/LAB DATA							
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	Dip Angle 30 60	0 6 12	25 50 75	SPT/LPT N ● CORE RECOVERY %	WATER CONTENT % ○ R.Q.D. %		
			(continued from previous page)															
21			- LPT N = 37+ blows for first 3" at 21.34 m depth.															
22																		
23																		
24																		
24.4																		
24.4																		
24.4																		
25			- LPT N = 21+ blows for first 3" at 24.38 m depth.															
25			BEDROCK.															
26		ARMS	- Grey, laminated, strongly foliated, siliceous argillite, angular gravel, with quartz veins between 24.4 m and 27.4 m depth.															
27																		
28		ARMS	- Same as above, with some black graphitic argillite.															
29																		
30																		
31																		
31.4																		
31.4																		
31.4																		
32			End of Hole at: 31.4 m															
33			Notes:															
34			1. The SPT/LPT N values indicated are the field measured LPT N values.															
35			2. Piezometer stickup length for TH05-07A is ___ m. Water level could not be measured in piezometer TH05-7A due to gasoline in piezometer.															
36																		
37			3. Piezometer TH05-7B was not installed in overburden because the 70' casing could not be removed.															
38																		
39			4. ARMS = massive argillite.															
40																		
41																		
42																		
43																		
44																		
45																		

KC: ROCK-S@4 WOLVERINE TEST HOLES - NOV 17.GPJ Rock-LOG.GDT 2/8/05

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS/TY J: JOINT M: SCHIST/TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-8

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 8/2/2005 FINISHED: 8/5/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 442565m N 6808139m	GROUND ELEVATION: 1290 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 30.8 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: HQ Core ROCK: HQ Core
LOGGED BY: EA	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial, (d)=diametrical	TEMPERATURE	FIELD/LAB DATA							
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	SPT/LPT N	WATER CONTENT %					
					Dip Angle			CORE RECOVERY %		R.Q.D. %								
0.2			TOPSOIL - organics.															
1			SILT-SAND-GRAVEL-COBBLE, low plastic silt, fine to coarse sand and gravel, occasional boulders, flat, subrounded to subangular gravel, grey to green, dry to moist (TILL-like).															
2			- LPT N = 20+ blows for first 6" at 1.52 m depth.															
3		1	- LPT N = 47 blows for 12" at 3.05 m depth.															
4																		
5		2	- LPT N = 48+ blows over first 12" at 4.57 m depth.															
6																		
7		3	- LPT N = 42+ blows over first 10" at 6.10 m depth.															
8																		
9																		
10		4	- LPT N = 50+ blows over first 12" at 9.14 m depth.															
11																		
12			- LPT N = 30+ blows over first 6" at 12.19 m depth.															
13																		
14																		
15		5	- LPT N = 60 blows over first 6" at 15.24 m depth.															
16																		
17																		
18																		
19		6	- LPT N = 80+ blows over first 9" at 18.29 m depth.															
20																		

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO

KC: ROCK-SIG4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/8/06



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-8

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA		ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)-axial; (c)-diametrical	TEMPERATURE	FIELD/LAB DATA						
					10-6	10-4	10-2	SEE BOTTOM OF FORM FOR CODES				SPT/LPT N ● CORE RECOVERY %	WATER CONTENT % ○ R.Q.D. %					
								Dip Angle 30 60					25	50	75	5	10	15
(continued from previous page)																		
21			1,270.2 BEDROCK. - Weak bedrock encountered at 19.8 m depth.															
22																		
23																		
24				Piezometer 8B														
25			- Black, well foliated, massive and highly fractured argillite encountered between 24.4 m and 27.4 m depth.															
26		ARMS																
27																		
28			- Black, weakly foliated, massive argillite (mudstone) encountered between 27.4 m and 29.4 m depth. Note: last 30 cm of core run encountered milky white bull quartz vein.															
29		ARMS/ QTVN																
30				Piezometer 8A														
31			30.8 1,259.2 End of Hole at: 30.8 m															
32			Notes:															
33			1. The SPT/LPT N values indicated are the field measured LPT N values.															
34			2. Piezometer stickup lengths are as follows:															
35			- TH05-8A = 0.20 m; - TH05-8B = 0.17 m.															
36			3. Water levels measured in piezometers TH05-8A and B after installation were artesian.															
37			4. ARMS = massive argillite; QTVN = quartz vein.															
38																		
39																		
40																		
41																		
42																		
43																		
44																		
45																		

KC-ROCK-SIG@ WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/8/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'Y J: JOINT M: SCHIST'Y S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-9

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 8/12/2005 FINISHED: 8/19/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 442454m N 6808092m	GROUND ELEVATION: 1303 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 35.05 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: NQ Core ROCK: NQ Core
LOGGED BY: EA	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC		DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) <small>(a)=axial; (d)=diametrical</small>	TEMPERATURE	FIELD/LAB DATA					
					10-6	10-4				10-2	SEE BOTTOM OF FORM FOR CODES	CORE RECOVERY %	WATER CONTENT %		
					Dip Angle		SPT/LPT N		R.Q.D. %						
						30	60			25	50	75	5	10	15
0.3			TOPSOIL - organics.												
1.302.8			SILT-SAND-GRAVEL-COBBLE, low plastic silt, fine to coarse sand and gravel, occasional boulders, flat, subrounded to subangular gravel, grey to green, dry to moist (TILL-LIKE).												
1		1													
2															
3		2													
4															
5		3													
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16		4													
17															
18															
19		5													
20															

KC ROCK-SIG@ WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/6/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'Y J: JOINT M: SCHIST'Y S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-9

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (c)=circumferential	TEMPERATURE	FIELD/LAB DATA											
					10-6	10-4	10-2	SEE BOTTOM OF FORM FOR CODES			SPT/LPT N			WATER CONTENT %								
								Dip Angle			CORE RECOVERY %			R.Q.D. %								
			30	60																		
(continued from previous page)																						
21																						
22			- LPT N = 26 blows over first 2" at 21.34 m depth.																			
23																						
24																						
25			- LPT N = 24 blows over first 3.5" at 24.38 m depth.																			
26																						
27																						
28		6	- LPT N = 24 blows over first 2.5" at 27.43 m depth.																			
29																						
30																						
30.1																						
30.1			1,272.9 BEDROCK.																			
31			- LPT N = 25 blows over first 3" at 30.48 m depth.																			
32			- 5 cm of black carbonaceous argillite (minor pyrite) encountered between 30.5 m and 32.0 m depth.																			
33			- Dark grey siliceous argillite encountered between 32.0 m and 35.1 m depth.																			
34																						
35																						
35.1			1,268.0 End of Hole at: 35.1 m																			
36																						
37			Notes:																			
38			1. The SPT/LPT N values indicated are the field measured SPT N values.																			
39			2. Piezometer stickup lengths are as follows:																			
40			- TH05-9A = 0.21 m;																			
41			- TH05-9B = 0.31 m.																			
42			3. Water levels measured in piezometers TH05-9A and B after installation were 10.72 m and 3.67 m, respectively.																			
43			4. OVBN = overburden; ARMS = massive argillite.																			
44			5. Two separate holes were drilled for the piezometer installation in overburden and bedrock.																			
45																						

KC-ROCK-SIG4 WOLVERINE TEST HOLES - NOV 17 GPJ ROCK-LOG.GDT 2/8/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-10

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 8/19/2005 FINISHED: 8/25/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 442328m N 6808233m	GROUND ELEVATION: 1308 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 38.1 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: NQ Core ROCK: NQ Core
LOGGED BY: EA/RB	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA SEE BOTTOM OF FORM FOR CODES Dip Angle 30 60	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (σ_{Fmax}), (σ_c)=diametrical	TEMPERATURE	FIELD/LAB DATA								
					10-6	10-4	10-2				SPT/LPT N ● CORE RECOVERY %	WATER CONTENT % ○ R.Q.D. %							
					25	50	75					5	10	15					
0-2			TOPSOIL - organics.																
2-307.8			OVERBURDEN consisting of SILT/CLAY, SAND, GRAVEL, COBBLE, with occasional boulders. - SPT N = 20+ blows over first 6" at 1.52 m depth. - SPT N = 20+ blows over first 6" at 3.05 m depth.																
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			

KC. ROCK-SIG@ WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/8/05

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-10

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) <small>(a)=axial; (c)=diametrical</small>	TEMPERATURE	FIELD/LAB DATA								
					10-6	10-4	10-2	SEE BOTTOM OF FORM FOR CODES			SPT/LPT N ●	CORE RECOVERY %	WATER CONTENT %						
					Dip Angle 30 60		5						10	15					
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32			32.0 1,276.0 BEDROCK.																
33			- Carbonaceous between 32.6 m and 35.1 m depth.																
34																			
35			- 80% of core run is gouge; carbonaceous between 35.1 m and 38.1 m depth.																
36																			
37																			
38			38.1 1,269.9 End of Hole at: 38.1 m	Piezometer 10A															
39																			
40			Notes:																
41			1. The SPT/LPT N values indicated are the field measured SPT N values.																
42			2. Piezometer stickup lengths are as follows: - TH05-10A = 0.54 m; - TH05-10B = 0.60 m.																
43			3. Water levels measured in piezometers TH05-10A and B after installation were 1.09 m and 5.49 m, respectively.																
44																			
45																			

KC: ROCK-SIGMA WOLVERINE TEST HOLES - NOV 17 GPJ ROCK-LOG.GDT 2/0/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-11

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 8/26/2005 FINISHED: 8/31/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 442248m N 6808417m	GROUND ELEVATION: 1312.5 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 46.3 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: NQ Core ROCK: NQ Core
LOGGED BY: RB	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (σ _p -axial; (σ _p)-diametrical)	TEMPERATURE	FIELD/LAB DATA										
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	CORE RECOVERY %	SPT/LPT N			WATER CONTENT %					
					Dip Angle		30 60		0 6 12	25 50 75			5 10 15								
0.3			TOPSOIL - organics.																		
1.3			TILL-LIKE OVERBURDEN consisting of SILT/CLAY, SAND, GRAVEL, COBBLE, with occasional boulders.																		
12.3				Piezometer 11B																	

KC, ROCK-SIG@4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/6/05

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-11

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA SEE BOTTOM OF FORM FOR CODES	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (d)=diametrical	TEMPERATURE	FIELD/LAB DATA									
					10-6	10-4	10-2				Dip Angle		SPT/LPT N			WATER CONTENT %				
			(continued from previous page)																	
21																				
22																				
23																				
24																				
25																				
26																				
27																				
28																				
29																				
30																				
31																				
32																				
33																				
34																				
35																				
36																				
37																				
38																				
39																				
40			39.6 1,272.9 BEDROCK.																	
41			- Between 39.6 m and 42.7 m depth: upper one-third is subangular pebbles to cobbles, lower two-third is foliated rhyolite overlying tuffaceous argillite.																	
42																				
43				Piezometer 11A																
44																				
45																				

KC ROCK-SIG4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/8/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-11

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (c)=diametrical	TEMPERATURE	FIELD/LAB DATA								
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	SPT/LPT N			WATER CONTENT %				
					Dip Angle		CORE RECOVERY %					R.Q.D. %							
			(continued from previous page)																
46			46.3 1,266.2 End of Hole at: 46.3 m																
47			Notes:																
48			1. No SPT or LPT testing was carried out in TH05-11 due to abundance of cobbles and boulders.																
49			2. Two separate holes were drilled for the overburden and bedrock piezometers to facilitate installation and increased reliability of piezometric data.																
50			3. Piezometer stickup lengths are as follows:																
51			- TH05-11A = 0.40 m;																
52			- TH05-11B = 0.39 m.																
53			4. Water levels measured in piezometers TH05-11A and B after installation were 9.37 m and 8.50 m, respectively.																
54																			
55																			
56																			
57																			
58																			
59																			
60																			
61																			
62																			
63																			
64																			
65																			
66																			
67																			
68																			
69																			
70																			

KC ROCK-SIG: WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/8/05

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-12

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 8/9/2005 FINISHED: 8/12/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 422438m N 6808331m	GROUND ELEVATION: 1305.5 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 29.6 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: NQ Core ROCK: NQ Core
LOGGED BY: EA/RB	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) <small>(a)=axial; (d)=diametrical</small>	TEMPERATURE	FIELD/LAB DATA								
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	SPT/LPT N ●	WATER CONTENT % ○						
					Dip Angle 30 60		CORE RECOVERY %	R.Q.D. %											
			9.305.3 TOPSOIL - organics. OVERBURDEN.																
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			

KC: ROCK-91@4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/8/05

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: TH05-12

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (d)=diametrical	TEMPERATURE	FIELD/LAB DATA								
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	SPT/LPT N			WATER CONTENT %				
					Dip Angle		CORE RECOVERY %					R.Q.D. %							
		30 60																	
(continued from previous page)																			
21																			
22																			
23																			
24			24.1 1,281.4 BEDROCK.																
25																			
26																			
27																			
28																			
29																			
30			29.6 1,275.9 End of Hole at: 29.6 m																
31																			
32																			
33																			
34																			
35																			
36																			
37																			
38																			
39																			
40																			
41																			
42																			
43																			
44																			
45																			

KC ROCK-SIG4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK.LOG.GDT 2/8/05

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO

TEST PIT LOG

				Su - kPa													
				20	60	100	140	180									
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005		FINISHED: 7/21/2005			VANE PEAK		FIELD		LAB		UC/2		
				EXCAVATOR TYPE: 420D Cat Backhoe						REMOULD		◇		□		▲ P.PEN/2	
				GROUND ELEV. (m): ~ 1317.5						* % FINES							
				COORDINATES (m): N 6808187 E 442732						W _p %		W%		W _L %			
				DESCRIPTION OF MATERIALS						x - - - - - x		o - - - - - o		x - - - - - x			
0.5			0.20	TOPSOIL - organics and moss.													
1.0		1		GRAVEL and COBBLE, fine to coarse gravel, some silt and sand, with about 20% coarse sand, yellow, dry to moist.													
1.5																	
2.0			1.70	GRAVEL, fine to coarse, sandy silty matrix, trace clay, occasional cobbles and boulders up to 0.5 m size, dense, subrounded to subangular, green, dry to moist (TILL-LIKE).													
2.5		2															
3.0			3.00	End of Hole at 3.00 m.													
3.5																	
4.0																	
4.5																	
5.0																	

KC_TEST_PIT-SI TESTPITS TP05-51 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake

LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-71

TEST PIT LOG

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/20/2005 FINISHED: 7/20/2005		INSTRUMENT	Su - kPa				
				EXCAVATOR TYPE: 420D Cat Backhoe	GROUND ELEV. (m): ~ 1304.5		20	60	100	140	180
				COORDINATES (m): N 6808183 E 442654		DETAILS	VANE	FIELD	LAB	UC/2	
				DESCRIPTION OF MATERIALS			PEAK	REMO	REMO	REMO	REMO
							* % FINES				
							W _p %	W%	W _L %		
							x	o	x		
							20	40	60	80	
0.15			TOPSOIL.								
			- organics and black organic rich mud.								
0.25			VOLCANIC ASH, white.								
0.5			GRAVEL and COBBLE, fine to coarse gravel, some fine to coarse sand, flat, subangular to subrounded gravel, brown, moist.								
1.0		1				o					
1.30			GRAVEL, fine to coarse, silty clayey matrix, medium dense to dense, angular to subangular, grey, moist (TILL).								
1.5											
2.0											
2.5		2				o					
3.0			End of Hole at 3.00 m.								
3.5											
4.0											
4.5											
5.0											


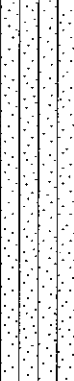


KC_TEST_PIT-SI TESTPITS TP05-51 TO 106.GPJ KC_DATA.GDT 2/9/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-72

TEST PIT LOG

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/20/2005 FINISHED: 7/20/2005		Su - kPa								
				EXCAVATOR TYPE: 420D Cat Backhoe		VANE PEAK	FIELD	LAB	UC/2	P.PEN/2	20	60	100	140
GROUND ELEV. (m): ~ 1304				COORDINATES (m): N 6808116 E 442685		* % FINES								
DESCRIPTION OF MATERIALS				INSTRUMENT DETAILS		W _p %	W%	W _L %						
						x	o	x						
						20	40	60						
0.15				TOPSOIL - peat and organics.										
				SILT and SAND, some gravel, medium dense, brown.										
1.50				GRAVEL, fine to coarse, sandy silty matrix, occasional cobbles and boulders, dense, angular to subangular, grey, moist (TILL-LIKE).										
3.00		1		End of Hole at 3.00 m.										

KC_TEST_PIT-SI TESTPITS TP05-S1 TO 106.GPJ KC_DATA.GDT 2/20/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake

LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-73

TEST PIT LOG

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/20/2005 FINISHED: 7/20/2005		Su - kPa					
				EXCAVATOR TYPE: 420D Cat Backhoe	GROUND ELEV. (m): ~1298	20	60	100	140	180	
				COORDINATES (m): N 6808142 E 442641		VANE PEAK	FIELD	LAB	▲ UC/2		
				DESCRIPTION OF MATERIALS		REMOLD	★ % FINES		△ P.PEN/2		
						W _p %	W%	W _L %			
						x	o	x			
						20	40	60	80		
0.5			TOPSOIL. - organics.								
1.0			SILT-SAND-GRAVEL, low to medium plastic silt, fine to coarse sand and gravel, clayey, occasional cobbles and boulders, dense, subrounded to subangular, green to grey, moist (TILL-LIKE).								
1.5		1									
2.0			- Encountered a 2.0 m size boulder at 2.0 m depth.								
2.5											
3.0			3.00 End of Hole at 3.00 m.								
3.5											
4.0											
4.5											
5.0											

KC_TEST_PIT-SI TESTPITS TP05-S1 TO 10s.GPJ KC_DATA.GDT 2/2/08



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake

LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-74

TEST PIT LOG

				Su - kPa										
				20	60	100	140	180						
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/20/2005 FINISHED: 7/20/2005		INSTRUMENT DETAILS	VANE PEAK		FIELD		LAB		UC/2	
				EXCAVATOR TYPE: 420D Cat Backhoe			REMO	◇	□	▲	△	P.PEN/2		
				GROUND ELEV. (m): ~ 1293			* % FINES		W _p %	W%	W _L %			
				COORDINATES (m): N 6808160 E 442564			x	o	x					
DESCRIPTION OF MATERIALS														
			TOPSOIL - peat and organics.											
0.5			0.25 SILT-SAND-GRAVEL, medium plastic silt, fine to coarse sand and gravel, clayey, occasional cobbles, dense, subrounded to subangular, green to grey (TILL-LIKE).											
1.0			- Between 0.25 m and 1.0 m depth, approximately 20% gravel.											
1.5		1	- Between 1.0 m and 3.5 m depth, approximately 5% gravel.											
2.0														
2.5														
3.0														
3.5			3.50 End of Hole at 3.50 m.											
4.0														
4.5														
5.0														

KC_TEST_PIT-SI TESTPITS TP05-51 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake




LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-75

TEST PIT LOG

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS	Su - kPa																																		
						20	60	100	140	180																														
				STARTED: 7/20/2005	FINISHED: 7/20/2005																																			
				EXCAVATOR TYPE: 420D Cat Backhoe		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>VANE PEAK</td> <td>FIELD</td> <td>LAB</td> <td colspan="2">UC/2</td> </tr> <tr> <td>REMOULD</td> <td>◇</td> <td>□</td> <td colspan="2">△ P.PEN/2</td> </tr> <tr> <td colspan="5" style="text-align: center;">★ % FINES</td> </tr> <tr> <td>W_p%</td> <td>W%</td> <td>W_L%</td> <td colspan="2"></td> </tr> <tr> <td>×</td> <td>○</td> <td>×</td> <td colspan="2"></td> </tr> <tr> <td>20</td> <td>40</td> <td>60</td> <td colspan="2">80</td> </tr> </table>					VANE PEAK	FIELD	LAB	UC/2		REMOULD	◇	□	△ P.PEN/2		★ % FINES					W _p %	W%	W _L %			×	○	×			20	40	60	80	
VANE PEAK	FIELD	LAB	UC/2																																					
REMOULD	◇	□	△ P.PEN/2																																					
★ % FINES																																								
W _p %	W%	W _L %																																						
×	○	×																																						
20	40	60	80																																					
				GROUND ELEV. (m): ~1289																																				
				COORDINATES (m): N 6808036 E 442624																																				
				DESCRIPTION OF MATERIALS																																				
				TOPSOIL - peat and organics. 0.20																																				
				CLAY, silty, sandy, wet. 0.50																																				
				SILT-SAND-GRAVEL, medium plastic silt, fine to coarse sand and gravel, clayey, occasional cobbles, dense, subrounded to subangular, green to grey (TILL-LIKE). 3.00																																				
		1		End of Hole at 3.00 m.																																				

KC_TEST_PIT-SI TESTPITS TP05-51 TO 105.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake

LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-76

TEST PIT LOG

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/20/2005 FINISHED: 7/20/2005		Su - kPa					
				EXCAVATOR TYPE: 420D Cat Backhoe	GROUND ELEV. (m): ~ 1294	20	60	100	140	180	
				COORDINATES (m): N 6808090 E 442529		VANE PEAK	FIELD	LAB	▲ UC/2		
				DESCRIPTION OF MATERIALS		REMOULD	◇	□	△ P.PEN/2		
						* % FINES					
						W _p %	W%	W _L %			
						x	o	x			
						20	40	60	80		
0.15			TOPSOIL - organics.								
0.15 - 2.80		1	SILT-SAND-GRAVEL, medium plastic silt, fine to coarse sand and gravel, clayey, occasional cobbles, dense, subrounded to subangular, green to grey (TILL-LIKE).				o				
2.80			End of Hole at 3.00 m.								



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake

LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-77

TEST PIT LOG

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		Su - kPa				
				EXCAVATOR TYPE: 420D Cat Backhoe	GROUND ELEV. (m): ~1300	20	60	100	140	180
				COORDINATES (m): N 6808156 E 442453		VANE PEAK	FIELD	LAB	UC/2	
				DESCRIPTION OF MATERIALS		REMO	◇	□	P.PEN/2	
						* % FINES		W _p %	W%	W _L %
						x	o	x		
						20	40	60	80	
0.0 - 0.20			~	TOPSOIL - organics.						
0.20 - 1.80			●	GRAVEL, fine to medium, sandy, silty, trace clay, occasional cobbles, angular to subangular, brown to grey.						
1.80 - 2.00		1	●	GRAVEL POCKET, coarse, subrounded, small water seep.						
2.00 - 2.50			●	GRAVEL, fine to coarse, sandy silty matrix, trace clay, occasional cobbles, dense, subrounded to subangular, green, moist (TILL-LIKE).						
2.50 - 3.50				End of Hole at 3.50 m.						
3.50 - 5.00										

KC_TEST_PIT-SI TESTPITS TP05-51 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-78

TEST PIT LOG

Su - kPa

20 60 100 140 180

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		INSTRUMENT	Su - kPa			
				EXCAVATOR TYPE: 420D Cat Backhoe			VANE PEAK	FIELD	LAB	UC/2
				GROUND ELEV. (m): ~ 1295			REMOLD	♦	□	▲
				COORDINATES (m): N 6808007 E 442495						△
				DESCRIPTION OF MATERIALS			* % FINES			
							W _p %	W%	W _L %	
							x	o	x	
							20	40	60	80
0.5			0.15	TOPSOIL. - organics.						
1.0				GRAVEL, fine to coarse, sandy silty matrix, trace clay, occasional cobbles and boulders up to 0.5 m size, dense, subrounded to subangular, green, moist (TILL-LIKE).						
1.5		1								
2.0				End of Hole at 2.80 m.						
2.5										
3.0				End of Hole at 2.80 m.						
3.5										
4.0				End of Hole at 2.80 m.						
4.5										
5.0				End of Hole at 2.80 m.						

KC_TEST_PIT(S)_TESTPITS TP05-51 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-79

TEST PIT LOG

				Su - kPa				
				20	60	100	140	180
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		VANE FIELD LAB		
				EXCAVATOR TYPE: 420D Cat Backhoe		PEAK ♦ ■	▲ UC/2	
				GROUND ELEV. (m): ~ 1306		REMO ◇ □	△ P.PEN/2	
				COORDINATES (m): N 6808097 E 442395		* % FINES		
DESCRIPTION OF MATERIALS				W _p %	W%	W ₁ %		
				x - - - - - o - - - - - x				
				20	40	60	80	

DEPTH (m)	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0.0 - 0.30	[Pattern]	TOPSOIL. - peat and organics.	
0.30 - 0.35	[Pattern]	VOLCANIC ASH, white.	
0.35 - 3.00	[Pattern]	GRAVEL, fine to coarse, sandy silty matrix, trace clay, occasional cobbles and boulders up to 0.5 m size, dense, subrounded to subangular, green, moist (TILL-LIKE).	o
3.00 - 5.00		End of Hole at 3.00 m.	



KC_TEST_PIT-SI TESTPITS TP05-51 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-80

TEST PIT LOG

				Su - kPa								
				20	60	100	140	180				
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005	FINISHED: 7/21/2005				INSTRUMENT DETAILS			
				EXCAVATOR TYPE: 420D Cat Backhoe				VANE PEAK		FIELD	LAB	▲ UC/2
				GROUND ELEV. (m): ~ 1305.5				REMOLD		◇	□	△ P.PEN/2
				COORDINATES (m): N 6808291 E 442343				* % FINES				
				DESCRIPTION OF MATERIALS				W _p %		W%	W _L %	
				x	o	x	x					
				20	40	60	80					
0.5			 TOPSOIL. - peat and organics.									
			0.20  0.25 VOLCANIC ASH, white.									
			GRAVEL, fine to coarse, sandy silty matrix, trace clay, low to medium plastic silt/clay, occasional cobbles, medium dense, subrounded to subangular, yellow to green, moist (TILL-LIKE).									
1.0			- Dense to very dense between 1.0 m and 3.5 m depth.									
1.5		1						o				
2.0												
2.5												
3.0												
3.5			3.50									
			End of Hole at 3.50 m.									
4.0												
4.5												
5.0												

KC_TEST_PIT-SI TESTPITS TP05-81 TO 106.GPJ KC_DATA.GDT 2/2/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-81

TEST PIT LOG

				Su - kPa				
				20	60	100	140	180
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		VANE PEAK FIELD LAB		
				EXCAVATOR TYPE: 420D Cat Backhoe		◆	■	▲ UC/2
				GROUND ELEV. (m): ~ 1310		◇	□	△ P.PEN/2
				COORDINATES (m): N 6808291 E 442281		* % FINES		
				DESCRIPTION OF MATERIALS		W _p %	W%	W _L %
		x - - - - - o - - - - - x						
		20	40	60	80			

DEPTH (m)	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
0.10	○ x	TOPSOIL. - organics. GRAVEL, silty, brown.		
0.60	○ x	COBBLE, some boulders, trace to some sand (approximately 10% coarse sand).		
2.00	○ x	GRAVEL, fine to coarse, sandy silty matrix, trace clay, low to medium plastic silt/clay, occasional cobbles and boulders up to 1 m size, very dense, subrounded to subangular, yellow to green, moist (TILL-LIKE).		
3.50	○ x	End of Hole at 3.50 m.		



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-82

KC_TEST_PIT-SI TESTPITS TP05-S1 TO 106.GPJ KC_DATA.GDT 2/2/06

TEST PIT LOG

				Su - kPa													
				20	60	100	140	180									
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005		FINISHED: 7/21/2005			VANE PEAK		FIELD		LAB		▲ UC/2		
				EXCAVATOR TYPE: 420D Cat Backhoe		REMOVED		◇		□		△ P.PEN/2					
				GROUND ELEV. (m): ~ 1317		* % FINES		W _p %		W%		W _L %					
				COORDINATES (m): N 6808507 E 442212		x - - - - - o - - - - - x		20		40		60		80			
				DESCRIPTION OF MATERIALS		INSTRUMENT		DETAILS									
0.5			0.25	TOPSOIL. - peat and organics.													
			0.80	GRAVEL and COBBLE, coarse gravel, some sand, brown.													
1.0				GRAVEL and BOULDERS, fine to coarse, sandy, some silt, occasional cobbles, very dense, subrounded to angular gravel, boulders between 0.6 m and 1.0 m size, greenish grey, wet (TILL-LIKE).													
2.5		1															
3.0			2.90	End of Hole at 2.90 m.													
4.0																	
4.5																	
5.0																	

KC_TEST_PIT-SI TESTPITS TP05-83 TO 106.GPJ KC_DATA.GDT 2/2/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02

PROJECT: Wolverine FD and EA

LOCATION: Wolverine Lake

LOGGED BY: MSR

CHECKED BY:

SHEET 1 OF 1

HOLE NO.: TP05-83

TEST PIT LOG

Su - kPa

20 60 100 140 180

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		INSTRUMENT	DETAILS	Su - kPa						
				EXCAVATOR TYPE: 420D Cat Backhoe				VANE PEAK	FIELD	LAB	UC/2	P. PEN/2		
				GROUND ELEV. (m): ~ 1320				* % FINES						
				COORDINATES (m): N 6807979 E 442656				W _p %	W%	W _L %				
				DESCRIPTION OF MATERIALS				x	o	x				
								20	40	60	80			
0.10			TOPSOIL. - organics.											
			SAND and GRAVEL, silty.											
0.30			GRAVEL, fine to coarse, silty/clayey and sandy, medium plastic silt/clay, dense, flat, subrounded to angular, yellow to grey, wet (TILL-LIKE). - Water encountered at 2.70 m depth.											
0.5			1											
1.0														
1.5														
2.0														
2.5														
2.80				End of Hole at 2.80 m.										
3.0														
3.5														
4.0														
4.5														
5.0														

KC_TEST_PIT-SI TESTPITS TP05-84 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-84

TEST PIT LOG

				Su - kPa							
				20	60	100	140	180			
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		VANE PEAK REMOLD		FIELD LAB		UC/2 P.PEN/2	
				EXCAVATOR TYPE: 420D Cat Backhoe		◆	■	▲	△		
				GROUND ELEV. (m): ~ 1288		* % FINES					
				COORDINATES (m): N 6807966 E 442629		W _p %	W%	W _L %			
				DESCRIPTION OF MATERIALS		x	o	x			
		20	40	60	80						
0.20			TOPSOIL - peat and organics.								
0.5			COBBLE and BOULDER.								
1.00			SILT/CLAY, medium plastic, sandy and gravelly, fine to coarse sand and gravel, stiff, green to black.								
1.5		1					o				
2.0											
2.30			End of Hole at 2.30 m.								
2.5											
3.0											
3.5											
4.0											
4.5											
5.0											

KC_TEST_PIT-SI TESTPITS TP05-81 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-85

TEST PIT LOG

				Su - kPa										
				20	60	100	140	180						
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005		FINISHED: 7/21/2005			VANE PEAK		FIELD	LAB	UC/2 P.PEN/2	
				EXCAVATOR TYPE: 420D Cat Backhoe		REMOULD		◇	□	* % FINES				
				GROUND ELEV. (m): ~ 1289				W _p %	W%			W _L %		
				COORDINATES (m): N 6807952 E 442602		x	o	x						
DESCRIPTION OF MATERIALS				INSTRUMENT		DETAILS								
0.5			TOPSOIL. - organics.											
1.0			0.25	GRAVEL, fine to coarse, silty/clayey and sandy, medium plastic silt/clay, occasional cobbles and boulders up to 0.4 m size, dense, flat, subrounded to subangular, yellow to grey, moist to wet (TILL-LIKE).										
1.5		1												
2.0														
2.5														
3.0			2.90	End of Hole at 2.90 m.										
3.5														
4.0														
4.5														
5.0														

KC_TEST_PIT-SI TESTPITS TP05-S1 TO 106.GPJ KC_DATA.GDT 2/2/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-86

TEST PIT LOG

Su - kPa

20 60 100 140 180

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/21/2005 FINISHED: 7/21/2005		INSTRUMENT	DETAILS	Su - kPa						
				EXCAVATOR TYPE: 420D Cat Backhoe				VANE PEAK	FIELD	LAB	▲ UC/2 △ P.PEN/2			
				GROUND ELEV. (m): ~ 1357.5				◊	◆	■				
				COORDINATES (m): N 6809620 E 441475				◊	◆	■				
DESCRIPTION OF MATERIALS				* % FINES										
								W _p %	W%	W _L %				
								×	○	×	20	40	60	80
			TOPSOIL. - peat and organics.											
0.5			0.30											
			SAND and SILT, fine to coarse sand, low to medium plastic silt, gravelly, trace to some clay, occasional cobbles, dense, yellow to green, moist to wet (TILL-LIKE). - Ground was frozen to 1.0 m depth.											
1.0		1							○					
1.5														
2.0			1.70											
			End of Hole at 1.70 m.											
2.5														
3.0														
3.5														
4.0														
4.5														
5.0														

KC_TEST_PIT-SI TESTPITS TP05-51 TO 105.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-91

TEST PIT LOG

				Su - kPa									
				20	60	100	140	180					
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/30/2005		FINISHED: 7/30/2005			INSTRUMENT DETAILS	VANE PEAK	FIELD	LAB	UC/2
				EXCAVATOR TYPE: Manual		REMO	REMO	REMO		PEN/2			
				GROUND ELEV. (m):		* % FINES							
				COORDINATES (m):		W _p %	W%	W _L %		X	X		
				DESCRIPTION OF MATERIALS		20	40	60		80	X		
0.5			0.01	TOPSOIL. - organics. SAND, medium, some cream coloured patches of ash (20%), trace silt, grey.									
			0.37	TOPSOIL. - organics.									
			0.40	GRAVEL and COBBLE, fine to coarse gravel, some sand and silt, trace clay, occasional boulders, angular to subrounded, grey to brown, moist (TILL-LIKE).									
1.0			0.90	End of Hole at 0.90 m.									
1.5													
2.0													
2.5													
3.0													
3.5													
4.0													
4.5													
5.0													

KC_TEST_PIT-SI TESTPITS TP05-S1 TO 105.GPJ KC_DATA.GDT 2/2/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: EA/RB	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-92

TEST PIT LOG

						Su - kPa										
						20	60	100	140	180						
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 5/15/2005 FINISHED: 5/15/2005		INSTRUMENT DETAILS	VANE PEAK		FIELD		LAB		UC/2			
				EXCAVATOR TYPE: 420D Cat Backhoe				REMOVED		◊		◻		▲		
				GROUND ELEV. (m): ~ 1337.5				*		% FINES		○		△		
				COORDINATES (m): N 6809089 E 441893				W _p %	W%	W _L %	x	o	x			
DESCRIPTION OF MATERIALS						20	40	60	80							
0.5			TOPSOIL - peat and organics.	0.20												
			SILT/CLAY, medium plastic, some sand, grey to brown, moist.													
		1		0.80					○							
1.0			SAND and SILT, fine to coarse sand, low to medium plastic silt, some fine to coarse gravel, some clay, yellow, moist.													
1.5																
		2							○							
2.0																
				2.20												
2.5			End of Hole at 2.20 m.													
3.0																
3.5																
4.0																
4.5																
5.0																

KC_TEST_PIT-SI TESTPITS TP05-51 TO 105.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-93

TEST PIT LOG

				Su - kPa								
				20	60	100	140	180				
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 5/14/2005		FINISHED: 5/14/2005			VANE FIELD LAB			
				EXCAVATOR TYPE: 420D Cat Backhoe		PEAK		REMO		UC/2		P.PEN/2
				GROUND ELEV. (m): ~ 1320		* % FINES		W _p %		W%		W _L %
				COORDINATES (m): N 6808558 E 442134		X - - - - - O - - - - - X		20		40		60
DESCRIPTION OF MATERIALS				INSTRUMENT		DETAILS						
0.5			0.10	TOPSOIL. - peat and organics.								
1.0				GRAVEL, fine to coarse, sandy silty matrix, trace clay, occasional cobbles and boulders up to 0.6 m size, dense, subrounded to subangular, green, moist (TILL-LIKE).								
1.5												
2.0												
2.5		1										
3.0			2.80	End of Hole at 2.80 m.								
3.5												
4.0												
4.5												
5.0												

KC_TEST_PIT-SI TESTPITS TP05-94 TO 106.GPJ KC_DATA.GDT 2/5/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-94

TEST PIT LOG

Su - kPa

20 60 100 140 180

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 5/14/2005 FINISHED: 5/14/2005		INSTRUMENT	Su - kPa										
				EXCAVATOR TYPE: 420D Cat Backhoe			VANE PEAK	FIELD	LAB	▲ UC/2 △ P.PEN/2							
				GROUND ELEV. (m): ~ 1311			REMOLD	◇	□								
				COORDINATES (m): N 6808446 E 442158			* % FINES										
DESCRIPTION OF MATERIALS				W _p %	W%	W _L %											
			▽▽▽	0.20	TOPSOIL. - peat and organics.												
			△△△	0.30	VOLCANIC ASH, white.												
0.5			●●●		GRAVEL, fine to coarse, sandy silty matrix, low plastic, trace clay, occasional cobbles, dense, subrounded to subangular, green, moist (TILL-LIKE).												
1.0			●●●														
1.5			●●●														
2.0			●●●														
2.5		1	●●●							○							
3.0			●●●	3.00	End of Hole at 3.00 m.												
3.5																	
4.0																	
4.5																	
5.0																	

KC_TEST_PIT-SI TESTPITS TP05-95 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-95

TEST PIT LOG

						Su - kPa													
						20	60	100	140	180									
DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 7/30/2005 FINISHED: 7/30/2005		INSTRUMENT DETAILS	VANE PEAK		FIELD	LAB	▲ UC/2 △ P.PEN/2								
				EXCAVATOR TYPE: Manual			◆	■											
				GROUND ELEV. (m):			* % FINES		W _p %	W%	W _L %								
				COORDINATES (m):			x	o	x										
DESCRIPTION OF MATERIALS						20	40	60	80										
0.5			0.15	TOPSOIL. - organics.															
			0.80	GRAVEL and COBBLE, fine to coarse, sandy silty matrix, low plasticity, trace clay, angular to subrounded gravel, light brown, moist (TILL-LIKE).															
1.0				End of Hole at 0.80 m.															
1.5																			
2.0																			
2.5																			
3.0																			
3.5																			
4.0																			
4.5																			
5.0																			

KC_TEST_PIT-SI TESTPITS TP05-S1 TO 108.GPJ KC_DATA.GDT 2/2/08



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: EA/RB	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-96

TEST PIT LOG

Su - kPa

20 60 100 140 180

DEPTH (m)	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 5/13/2005 FINISHED: 5/13/2005		INSTRUMENT	Su - kPa						
				EXCAVATOR TYPE: 420D Cat Backhoe			VANE PEAK	FIELD	LAB	UC/2			
				GROUND ELEV. (m): ~ 1312.5									
				COORDINATES (m): N 6807978 E 442847									
				DESCRIPTION OF MATERIALS		DETAILS	* % FINES						
							W _p %	W%	W _L %				
						x	o	x	x				
						20	40	60	80				
0.5			0.10	TOPSOIL. - organics.									
1.0				GRAVEL, fine to coarse, sandy silty matrix, low plasticity, trace clay, occasional cobbles and boulders, angular to subrounded, light greenish grey, dry to moist (TILL-LIKE).									
1.5		1											
2.0													
2.5													
3.0			3.00	End of Hole at 3.00 m.									
3.5													
4.0													
4.5													
5.0													

KC_TEST_PIT-SI TESTPITS TP05-97 TO 106.GPJ KC_DATA.GDT 2/3/06



KLOHN CRIPPEN

PROJECT NO.: M09234A02	
PROJECT: Wolverine FD and EA	
LOCATION: Wolverine Lake	
LOGGED BY: MSR	CHECKED BY:
SHEET 1 OF 1	HOLE NO.: TP05-97

Monitoring Wells



GEOLOGIC LOG OF DRILL HOLE NO.: MW05-6A

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 7/25/2005 FINISHED: 7/29/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 441657m N 6809312m	GROUND ELEVATION: 1348 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 25.7 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: HW Casing ROCK: 100mm dia. Tricone
LOGGED BY: EA/RB	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (c)=diametrical	TEMPERATURE	FIELD/LAB DATA												
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	SPT/LPT N ●	WATER CONTENT % ○	CORE RECOVERY %			R.Q.D. %						
																				Dip Angle 30 60			
1			Overburden																				
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							
13																							
14																							
15																							
16																							
17																							
18																							
19																							
20							20.1 1,327.9 Bedrock																
21																							
22																							
23																							
24																							
25																							
26			25.7 1,322.3 End of Hole at: 25.7 m																				
27																							
28																							
29																							
30																							

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO

KC_ROCK-LSI@4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/9/06



GEOLOGIC LOG OF DRILL HOLE NO.: MW05-6B

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 7/25/2005 FINISHED: 7/29/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 441657m N 6809312m	GROUND ELEVATION: 1348 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 13.6 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: HW Casing ROCK: 100mm dia. Tricone
LOGGED BY: EA/RB	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial, (d)=diametrical	TEMPERATURE	FIELD/LAB DATA							
					10-6	10-4	10-2	SEE BOTTOM OF FORM FOR CODES			SPT/LPT N	WATER CONTENT %						
					Dip Angle			CORE RECOVERY %			R.Q.D. %							
					30	60	60				5	10	15					
1			Overburden															
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14			13.6 1,334.4															
15			End of Hole at: 13.6 m															
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO

KC-ROCK-SIG4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 23/06



GEOLOGIC LOG OF DRILL HOLE NO.: MW05-7A

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 7/30/2005 FINISHED: 8/1/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH:	DIP (from horiz): -90
CO-ORDINATES: E 442633m N 6807943m	TOP OF PIPE ELEVATION: m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	GROUND ELEVATION: 1286 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	TOTAL DEPTH OF HOLE: 30.2 m
LOGGED BY: EA/RB	DRILLING METHOD SOIL: HW Casing ROCK: 100mm dia. Tricone
CHECKED BY:	DRILLING FLUID: Water
	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONT- INUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)-axial; (d)-diametrical	TEMPERATURE	FIELD/LAB DATA											
					10-6	10-4	10-2	SEE BOTTOM OF FORM FOR CODES			SPT/LPT N	WATER CONTENT %										
					Dip Angle						CORE RECOVERY %	R.Q.D. %										
			30 60			0 6 12	25 50 75	5 10 15														
1			Overburden																			
2																						
3																						
4																						
5																						
6																						
7																						
8																						
9																						
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21																						
22																						
23																						
24																						
24.5			24.5																			
25			1,261.5 Bedrock																			
26																						
27																						
28																						
29																						
30																						

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO

KC_ROCK-SIG4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/3/06



GEOLOGIC LOG OF DRILL HOLE NO.: MW05-7A

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) (a)=axial; (c)=diametrical	TEMPERATURE	FIELD/LAB DATA							
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	SPT/LPT N			WATER CONTENT %			
					Dip Angle			30				60	CORE RECOVERY %			R.Q.D. %		
			(continued from previous page)							0	6	12	25	50	75	5	10	15
31			End of Hole at: 30.2 m															
32																		
33																		
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KC-ROCKSI@4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/28/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK
 CORE LOSS FRACTURED/BROKEN CORE DIP ANGLES MEASURED WITH RESPECT TO



GEOLOGIC LOG OF DRILL HOLE NO.: MW05-7B

CLIENT: Yukon Zinc Corporation	PROJECT NO.: M09234A02
PROJECT: Wolverine Feasibility Design and Environmental Assessment	DATE HOLE STARTED: 7/30/2005 FINISHED: 8/1/2005
LOCATION:	DATUM: NAD27
DIRECTION AZIMUTH: DIP (from horiz): -90	TOP OF PIPE ELEVATION: m
CO-ORDINATES: E 442633m N 6807943m	GROUND ELEVATION: 1286 m
MANUFACTURER'S DRILL DESIGNATION: BBS 25A	TOTAL DEPTH OF HOLE: 4.6 m
DRILLING CONTRACTOR: Advanced Drilling Ltd.	DRILLING METHOD SOIL: HW Casing ROCK: 100mm dia. Tricone
LOGGED BY: EA/RB	DRILLING FLUID: Water
CHECKED BY:	HOLE DIA.:

DEPTH (m)	SYMBOL	SAMPLE No.	LITHOLOGY	PIEZOMETER DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC			DISCONTINUITY DATA	ROCK STRENGTH BASED ON POINT LOAD TEST (MPa) <small>(a)=axial; (d)=diametrical</small>	TEMPERATURE	FIELD/LAB DATA							
					10-6	10-4	10-2				SEE BOTTOM OF FORM FOR CODES	CORE RECOVERY %	SPT/LPT N			WATER CONTENT %		
													Dip Angle			R.Q.D. %		
1			Overburden															
2																		
3																		
4			4.6 1,281.4															
5			End of Hole at: 4.6 m															
6																		
7																		
8																		
9																		
10																		
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KC ROCK-3@4 WOLVERINE TEST HOLES - NOV 17.GPJ ROCK-LOG.GDT 2/3/06

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

CORE LOSS
 FRACTURED/BROKEN CORE
 DIP ANGLES MEASURED WITH RESPECT TO

5. POTENTIAL SEEPAGE EFFECTS ON GROUNDWATER

The tailings impoundment is designed to retain water and minimize seepage through the use of a geosynthetic liner beneath the facility and along the interior face of the dam. The design criteria for seepage from the impoundment is presented in Section 3 of the main text, and is based upon the potential leaching of cadmium and selenium into the receiving waters. A design criteria of <0.5 L/s was determined to be protective of the receiving waters.

5.1 Liner Defect Analysis – Design Basis

The tailings impoundment will be lined with a geosynthetic liner, and seepage will be influenced by the presence of liner defects and, potentially, very long-term degradation effects.

Klohn Crippen Berger Ltd. utilized an in-house program that assesses the leakage through liner defects, which considers the “inflow” constraint by the presence of the low permeability tailings. Figure I- 5-1 presents leakage values for tailings with a permeability of 10^{-7} m/s, assuming a conservative level of quality control in liner construction and placement. The figure indicates that, for impoundment tailings permeability of 10^{-7} m/s, and for a tailing impoundment head of 20 m, the leakage rate could be in the order of 20 L/year/hectare. For the Wolverine tailings impoundment of 16 hectares, leakage through the liner is expected to be extremely low and on the order of 0.00001 L/s, which is negligible.

The use of the liner ensures that the potential risk of effects to groundwater or surface water from seepage is very low to negligible. Nonetheless, a sensitivity analysis was carried out to determine the effects of liner degradation and/or the use of a soil liner or no liner at all, and the results are presented in the following section.

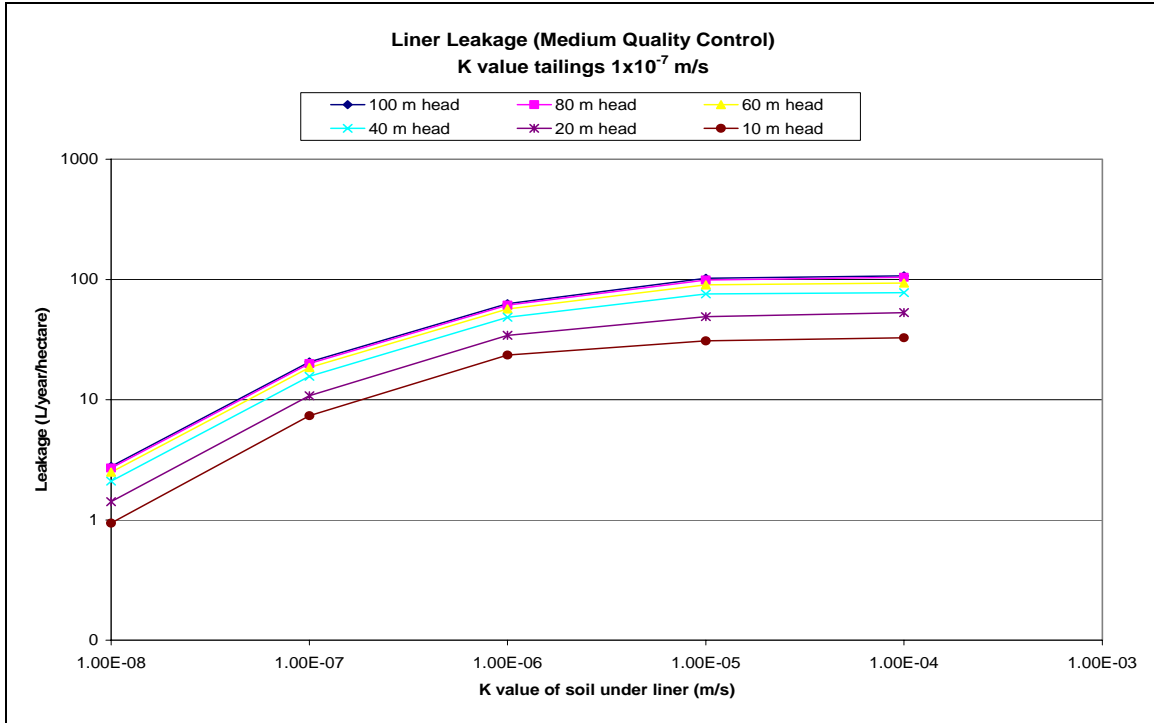


Figure I- 5-1 Linear Leakage (Medium Quality Control) K Value Tailings 1×10^{-7} m/s

5.2 Conventional Seepage Analysis – Sensitivity Analysis

The estimate of seepage from the impoundment was assessed using both conventional seepage analysis and liner defect analyses. With the use of a liner system, the conventional SEEP/W model does not apply, however the SEEP/W model is useful for assessing the sensitivity of the seepage to various lining alternatives.

Seepage analysis was carried out using the 2-D SEEP/W program on a representative upstream-downstream section along the thalweg of the impoundment area through the maximum transverse section of the dam, which is shown in plan in Drawing D-3002. The properties used for the analyses are summarized in Table I- 5-1.

Table I- 5-1 Summary of Engineering Properties

MATERIAL	HYDRAULIC CONDUCTIVITY k (m/s)
Overburden	3.0E-05
Bedrock	1.0E-07
General Dam Fill	5.0E-07
Glacial Till	1.0E-07
Tailings	7.0E-08
Liner	Varies

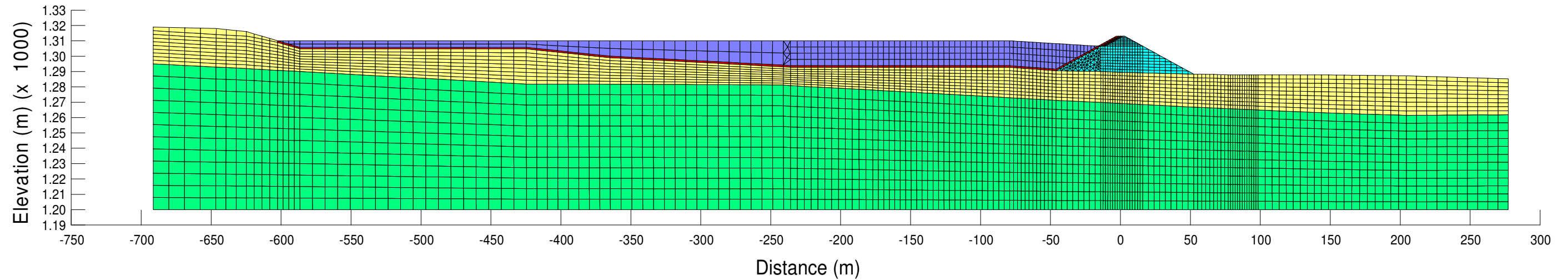
Figure I- 5-1 and Figure I- 5-2 show the SEEP/W finite element model mesh and setup, and model output. The seepage analysis was carried out for the initial dam design section, which included a central low permeability core zone. Sensitivity analysis was carried out for the following conditions, and the results are summarized in Table I- 5-2.

- “Degraded” geomembrane liner with an “equivalent” permeability of 10^{-10} m/s, which simulates a potential long-term condition in which portions of the geomembrane liner degrades;
- Soil liner, with a permeability of 10^{-8} m/s, which assumes the placement of a low permeability soil or clay enhanced soil liner over the impoundment basin; and
- No liner and a basin permeability of 10^{-6} m/s, which simulates the case of no liner and no special treatment of the impoundment foundation.

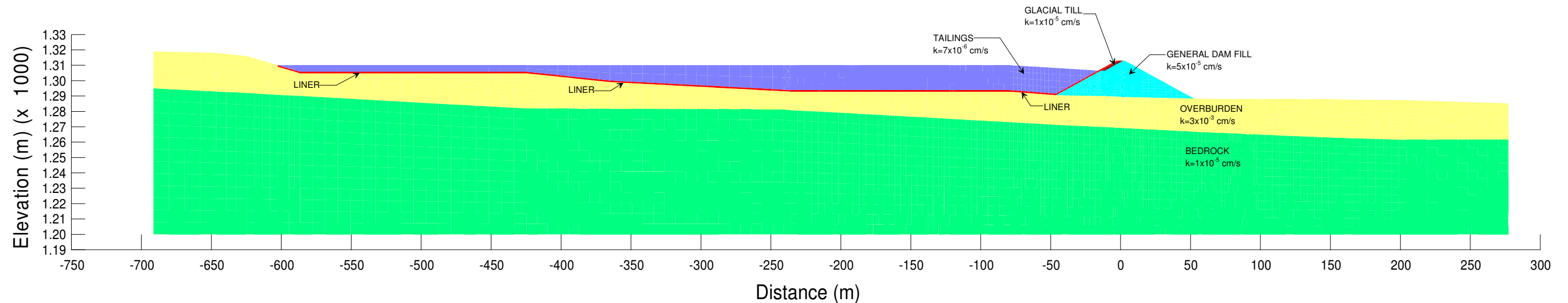
Table I- 5-2 Summary of Seep/W Seepage Sensitivity Analysis

ANALYSIS CONDITION	BASIN/LINER PERMEABILITY (m/s)	TOTAL SEEPAGE (L/sec)
A - “Degraded” geomembrane liner	10^{-10}	0.13
B - Compacted soil liner	10^{-8}	3.8
C - Unlined facility	10^{-6}	6.8

Note: Estimation of total seepage was based on an equivalent dam width of 250 m with constant maximum dam section. Liner was modelled as 1-m thick to minimize numerical modelling difficulty.





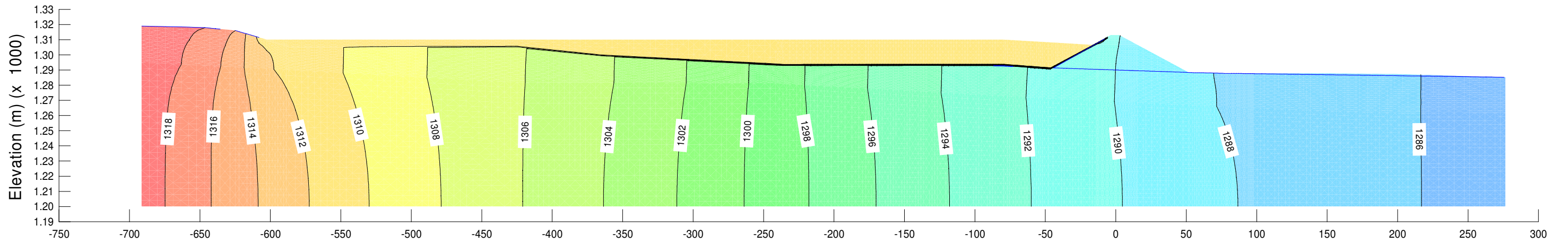
FEM MESH USED IN THE SEEPAGE ANALYSES



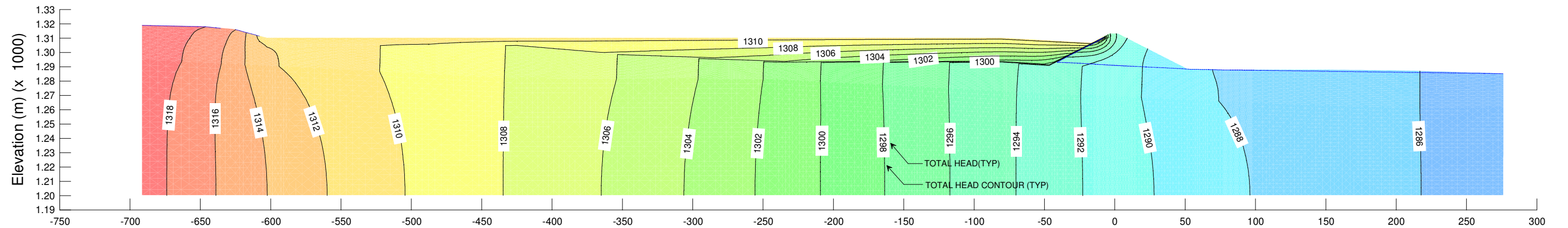
SEEPAGE MODEL WITH MATERIAL UNITS AND THEIR HYDRAULIC CONDUCTIVITIES

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED

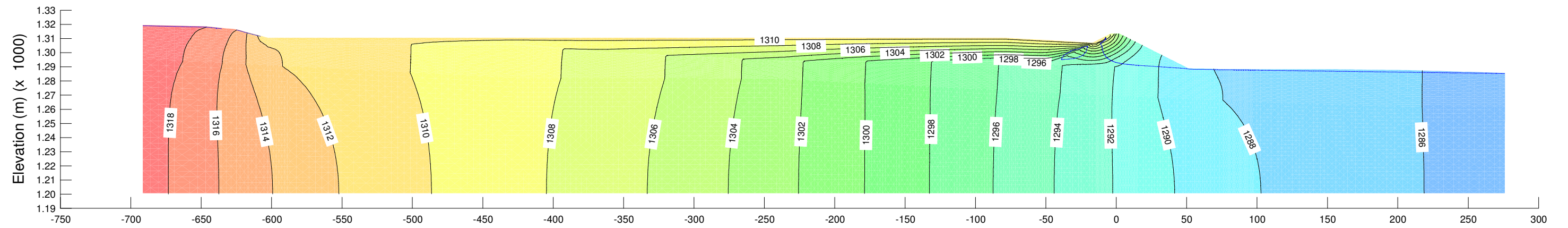
<p>AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORT AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.</p>	CLIENT			PROJECT	WOLVERINE - DETAILED DESIGN	
				TITLE	FEM SEEPAGE MODEL ULTIMATE DAM SECTION A	
				PROJECT NO.	M09234A04	FIGURE NO.





CASE A - HYDRAULIC CONDUCTIVITY OF LINER, $k=1 \times 10^{-8}$ cm/s



CASE B - HYDRAULIC CONDUCTIVITY OF LINER, $k=1 \times 10^{-6}$ cm/s



CASE C - HYDRAULIC CONDUCTIVITY OF LINER, $k=1 \times 10^{-4}$ cm/s

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED		PROJECT			
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORT AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.				WOLVERINE - DETAILED DESIGN	
				RESULTS OF SEEPAGE ANALYSES FOR ULTIMATE DAM SECTION A	
CLIENT		PROJECT NO.		FIGURE NO.	
		M09234A04		I-3.3	

5.3 Seepage Analysis Results

The seepage analyses indicate that the leakage rate out of the impoundment should be on the order of 0.00001 L/s, which is negligible. The sensitivity analysis also indicates that the worst-case condition, considering complete degradation of the liner would result in a seepage rate on the order of 6.8 L/s. Because liner degradation is often a result of UV effects, complete degradation of the Wolverine impoundment liner, which will be covered by tailings, is considered to be highly improbable. As such a more realistic “worst case” evaluation, considering only partial degradation, suggests that seepage under this condition would be less than 0.13 L/s.

There are also a number of mitigating factors, with respect to the potential for long-term degradation of the liner and are summarized as follows:

- Partial degradation of the liner would still result in acceptable seepage rates;
- Degradation of the liner, if it occurs, will be over a long period of time and would result in a very slow change in the groundwater geochemistry. The benefit of adsorption, which will occur, has not been considered in determining the allowable seepage criteria. Assuming a 10% adsorption factor would result in meeting water quality guidelines, even with complete degradation of the liner; and
- Geochemical processes that control dissolved metal concentrations in natural and tailings sediments have not been considered. Experience from other operations indicates that porewater metal concentrations in unoxidized tailings sediments are often very low, resulting from the gradual development of anoxic conditions in sediments and the tendency for metals to precipitate out of solution as metal sulphides.

APPENDIX II

Geochemical Characterization

- Part I – Tailings Geochemistry
(including Tailings Supernatant
Water Chemistry)
- Part II – Dam Construction Materials

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ABBREVIATIONS

Ag – Silver	CNT – Total Cyanate	P – Phosphorous
Al – Aluminium	CN _(T) – Total Cyanide	Pb – Lead
As – Arsenic	Cr – Chromium	S – Sulphur
Au – Gold	Cu – Copper	Se – Selenium
B – Boron	F – Flourine	Si – Silicon
Ba – Barium	F ⁻ – Floride	Sn – Tin
Be – Beryllium	Fe – Iron	SO ₄ – Sulphate
Bi – Bismuth	K – Potassium	S ²⁻ – Sulphide
C – Carbon	Li – Lithium	Sr – Strontium
Ca – Calcium	Mg – Magnesium	Ti – Titanium
Cd – Cadmium	Mn – Manganese	Tl – Thallium
Cl – Chlorine	Mo – Molybdenum	U – Uranium
Cl ⁻ – Chloride	N – Nitrogen	V – Vanadium
Co – Cobalt	Na – Sodium	Zn – Zinc
CO ₃ ²⁻ – Carbonate	NH ₃ – Ammonia	
CNO – Cyanate	Ni – Nickel	
CNS – Thiocyanate	NO ₃ ⁻ – Nitrate	
ABA – Acid Base Accounting	NPR – Neutralization Potential Ratio	
AP – Acid Potential	PAG – Potentially Acid Generating	
DI – Deionised	TDS – Total Dissolved Solids	
ICP-MS – Inductively Coupled Plasma Mass Spectrometry	TIC – Total Inorganic Carbon	
LOI – Loss On Ignition	TSS – Total Suspended Solids	
Non-PAG – Not Potentially Acid Generating	XRD – X-Ray Diffraction	
NNP – Net Neutralization Potential	XRF – X-Ray Fluorescence	
NP – Neutralization Potential	WDXRD – Wavelength Dispersive X-ray Diffraction	

1. TAILINGS GEOCHEMISTRY

1.1 Summary

Environmental characterisation of the Wolverine and Lynx tailings generated from locked cycle flotation testing to date are presented in the following sections. Both static and kinetic testing was employed in the characterisation of samples. The purpose of the testing program was to identify the geochemical, acid rock drainage (ARD) and metal leaching characteristics of tailings materials. To date static testing of tailings has been completed and includes the following:

- Optical petrography;
- X-Ray Diffraction (XRD) with Rietveld Refinement;
- X-Ray Fluorescence (XRF);
- Acid Base Accounting (ABA);
- Inductively Coupled Mass Spectrometry (ICP-MS) 33 element suite; and
- Shake Flask Extractions (SFE).

Kinetic testing continues to date and includes the following analyses:

- Tailings aging testing;
- Acute lethality testing on fresh and aged tailings supernatant;
- Humidity cell testing; and
- Sub-aqueous column leach testing.

A brief summary of results to date are presented in Sections 1.1.1 and 1.1.2, and detailed analyses are presented in the subsequent sections. The summary of the sample counts for each test used to evaluate the metal leaching and ARD potential of the sample tailings is provided in Table II-1.1. The results of these analytical techniques are most useful for interpretation when considered in combination.

Table II-1.1 Number of Tailings Tests by Geochemical Test Method

TEST TYPE	NUMBER OF TESTS
Mineralogy	
Optical Analysis	4
XRD	4
ABA Testing	
Paste pH	12
Total Sulphur	12
Acid Leachable Sulphate	12
Insoluble Sulphate	12
Total Sulphide	12
Organic Sulphide	12
Total Carbon	12
Total Inorganic Carbon	12
Total Organic Carbon	12
Total Carbon as %CO ₃	12
Sobek-NP	12
Solid Phase Metals Analysis	
Solid Phase ICP-MS	13
Kinetic Testing	
Humidity Cells	4
Sub-aqueous Column Leach Tests	2
Environmental Aging Tests	4
Toxicity Testing	
<i>Daphnia magna</i> Acute Lethality	8
Rainbow trout Acute Lethality	4

1.1.1 Static Testing

1.1.1.1 Mineralogy

Optical microscopy of analysed samples indicates a high ratio (by sample weight) of sulphides to carbonates (approximately 3:1 to 6:1). The majority of sulphides occur as large liberated grains that are available for oxidation, while the limited abundance of reactive carbonates (exposed or liberated grains) indicates high potential for acid generation. The presence of As-, Pb-, Zn- and Cu-sulphides suggests these particular metal (loid)s may be released to solution if tailings become acid generating.

1.1.1.2 Solid Phase Elemental Concentrations

Results from XRF and ICP-MS analyses show tailings solids have high concentrations of both major and trace elements including:

- Al (1,200 – 12,000 mg/kg);
- As (760 – 4,800 mg/kg);
- Ca (8,300 – 34,000 mg/kg);
- Cu (630 – 2,100 mg/kg);
- K (500 – 3,300 mg/kg);
- Fe (140,000 – 230,000 mg/kg);
- Mg (1,800 – 19,000 mg/kg);
- Pb (1,900 – 15,000 mg/kg); and
- Zn (2,900 – 20,000 mg/kg).

Moderate to minor concentrations of Cd and Cr as well as minor concentrations of Hg, Mo, Ni and U were also detected in the tailings samples.

1.1.1.3 Modified Acid Base Accounting

Modified ABA test results indicate tailings samples have high concentration of sulphide (10.1% to 39.4%) and negative net neutralization potentials (-196 kg CaCO₃/t to -1038 kg CaCO₃/t). The neutralization potential ratios (NPR) are, therefore, low (0.02 to 0.38) indicating the potential for ARD is likely.

1.1.1.4 Shake Flask Extractions

SFE indicate Zn is above the 1.0 mg/L Metal Mining Effluent Regulations (MMER) only in the Overall Ore Composite (Combine Ro + Cl Sc Tailings) measured at 6.87 mg/L

1.1.2 Kinetic Testing

1.1.2.1 Tailings Aging Testing

Aging testing, scheduled for a total of 120 days, to date are between the 60th (Combined OD, Wolverine D and Lynx D Composite Tailings) and 120th day (Combined Overall Ore Composite Tailings) of testing. Results show Cd, Se and Tl are above CCME guidelines throughout the entire testing period for all tailings samples. Only the Combined Overall Ore Composite Tailings sample shows Zn concentrations exceeding MMER towards the end of the testing period.

1.1.2.2 Acute Lethality Testing

Results from the toxicity tests conducted indicate all the aged decant samples submitted had 100% mortality for *daphnia magna* and rainbow trout at 100% effluent concentrations. Preliminary results indicate the Combined Overall Ore Composite Tailings effluent toxicity for *daphnia magna* increases with effluent aging.

1.1.2.3 Tailings Humidity Cell

Humidity cell testing was done on the Combined OD, Wolverine D and Lynx D Composite Tailings and the Combined Overall Composite Tailings. The initial sulphate in the tailings humidity cells has not been flushed out within this period, therefore, the time to onset of acid generation of the tailings exposed to oxygen and water for a prolonged period cannot be determined at this time. Time to onset of acid generation will certainly be months to years in the field. However, fluctuations in pH over time are observed in some tailings samples nonetheless, likely as a result of incipient thiosalt oxidation in the humidity cell pore-water. Combined Overall Composite, OD, Wolverine D and Lynx D Composite Tailings samples have minimum pH of 6.37, 3.41, 3.36 and 4.27, respectively. Metal(loid)s of concern include Zn, Cd and Se.

1.1.2.4 Sub-aqueous Column Testing

Sub-aqueous column testing has been completed and data is available for 8 weeks on the Combined Overall and OD Composite Tailings samples. Results indicate the Combined Overall

Composite tailings sample initially releases significant Zn and SO_4^{2-} suggesting soluble ZnSO_4 , a reagent added as part of the lead flotation circuit is responsible for elevated dissolved inventories.

1.2 Sample Compilation and Sample Selection

Ore samples for metallurgical testing to generate products for tailings characterization were prepared by collecting separate Lynx and Wolverine zone ore composites from several drill holes.

Drill holes WV04-122, WV04-123, and WV04-129 were identified as being from the Lynx zone, and drill holes WV04-124, WV04-125, WV04-126, and WV04-127 were identified as being from the Wolverine zone. Adjacent intervals of expected mining dilution rock were also composited from each drill hole and combined with the ore samples, where necessary. Table II-1.2 summarizes the drill hole intervals used to prepare the ore and dilution rock samples.

Table II-1.2 Summary of Samples Compiled for Metallurgical and Environmental Testing

ORE ZONE COMPOSITE	DRILL CORE SAMPLED	MATERIAL TYPE	DEPTH RANGE (m)	SAMPLE WEIGHT (kg)
Lynx	WV04-122	Ore Dilution	118.0-120.6, 128.6-130.6, 143.8-149.7 120.6-121.2, 127.2-128.6, 142.6-143.8, 149.7-150.5	51.9 11.3
Lynx	WV04-123	Ore Dilution	175.9-176.7, 179.3-183.0 174.9-175.9, 176.7-179.3, 183.0-183.9	21.4 11.9
Wolverine	WV04-124	Ore Dilution	118.52-119.33, 120.1-123.34 117.38-118.52, 119.33-120.10, 123.34-123.86	22.1 9.5
Wolverine	WV04-125	Ore Dilution	240.0-240.2, 242.5-246.7 239.0-240.0, 240.4-242.5, 246.7-247.0	27.8 10.6
Wolverine	WV04-126	Ore Dilution	151.7-152.5, 154.3-155.6 149.9-151.7, 152.5-154.3, 155.6-156.6	9.8 11.1
Wolverine	WV04-127	Ore Dilution	175.4-180.6 175.0-175.4, 180.6-181.6	23.0 5.8
Lynx	WV04-129	Ore Dilution	331.7-338.8 331.1-331.7, 338.8-339.0	51.9 3.2

The selected drill core intervals were all crushed to minus ½” prior to compositing, while still keeping ore and dilution rock separate for each drill hole. Then, after some material was removed from each drill core composite for other metallurgical test work, the remaining material

was crushed to minus ¼". A sub-sample of each of the Lynx ore only and the Wolverine ore only (no dilution rock) were collected and crushed to minus 10 mesh for undiluted ore flotation. Finally, the ore and dilution rock were combined in the proportions indicated in Table II-1.2 and then separate Lynx and Wolverine diluted ore composites were prepared and screened. Half of each of the Wolverine and Lynx Diluted Ore composites was combined to prepare the Overall Diluted Ore composite.

1.2.1 Laboratory Metallurgical Testing

A total of five locked cycle tests were performed, with the flowsheet used given in Figure II-1.1: two on the Overall composite; and one each on the Diluted Overall Composite; the Diluted Wolverine Composite; and the Diluted Lynx Composite. The tests were run to:

- determine the response of the metallurgy to the recycle of intermediate slurries;
- obtain a projected metallurgical balance for a continuous operation;
- provide final tailing products for environmental evaluation; and
- provide concentrates with detailed analyses for potential buyers.

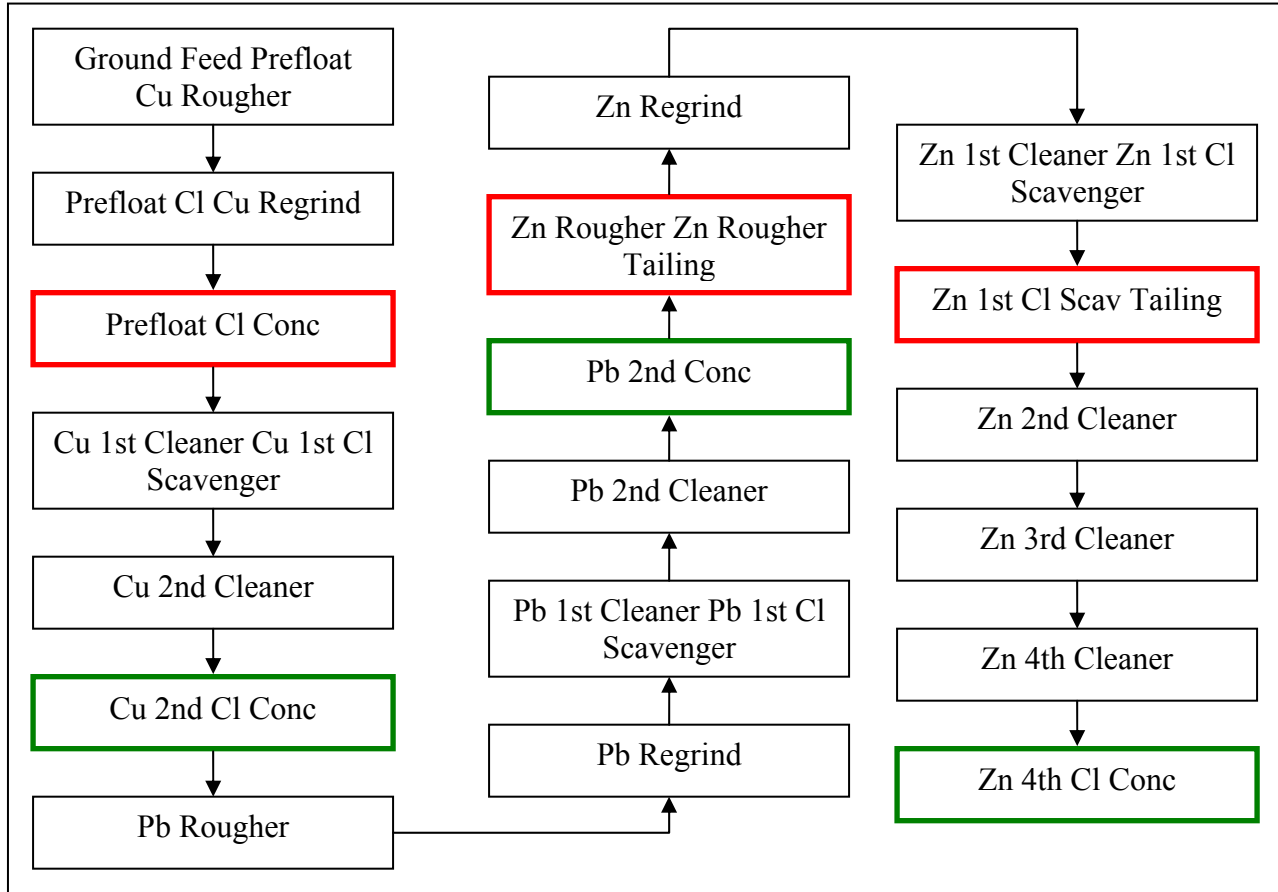


Figure II-1.1 Locked Cycle Test Flowsheet

Note: Items highlighted in green are the concentrates to be dewatered and shipped to market, while the items highlighted in red are the tailings streams to be combined and piped to the tailings impoundment.

The metallurgical test number and the corresponding ore composite are listed in Table II-1.3, and the tests conducted on the resultant ore composites are detailed below.

Table II-1.3 Locked Cycle Tests on Ore Composite Samples

MET TEST	ORE TYPE
LCT1	Overall Ore Composite
LCT2	Overall Ore Composite
LCT3	Overall Dilute Ore Composite
LCT4	Overall Dilute Wolverine Ore Composite
LCT5	Overall Dilute Lynx Ore Composite

In order to generate sufficient liquid sample volumes it was necessary to combine the tailings from the LCT1 and LCT2 metallurgical test runs (which may have been subject to slightly differing process conditions). As seen in the flowsheet, there were three tailings streams

generated from any given locked-cycle test. These were combined at the ratios of solids to liquids expected for a full-scale operation such that the combined final slurry is representative of the ultimate tailings discharge to the pond, for that ore type.

Overall Ore Composite (LCT1)

Samples of rougher (Ro) and first cleaner scavenger (Cl Sc) tailings were received by the SGS Lakefield environmental lab from the SGS Lakefield metallurgical operations on May 6, 2005 from a six-cycle locked cycle test (LCT) on an Overall, undiluted, ore sample. The LCT1 products (pulp) from the last four cycles (C, D, E and F) were combined to generate a single composite tailings sample designated Combined LCT Tails Stages C-F. The combined pulp was mixed for 30 minutes at 200 rpm to ensure all solids had been thoroughly recombined before approximately 12 L of pulp was extracted and filtered through a #1 Watman filter paper. The resultant filtrate was submitted for analysis of pH, conductivity, TSS, TDS, acidity, alkalinity, hardness, Cl^- , F^- , NO_3^- , SO_4^{2-} , $\text{CN}_{(\text{T})}$, CNO, CNS, NH_3 , thiosalts and a suite of dissolved metal(loid)s including Hg. The excess filtrate was reserved in storage. Filter cake solids were submitted for modified ABA, ICP-MS metal(loid) analyses on an *aqua regia* digest, XRF, shake flask testing, humidity cell testing, and mineralogical examination (petrography and Rietveld XRD). No Prefloat cleaner concentrate was received at the time of sample preparation, and therefore it was not included in the combined LCT1 samples; however, analyses were completed on the filtrate samples.

Overall Ore Composite (LCT2)

Tailings slurry and Prefloat cleaner concentrate samples from six cycles of the LCT2 test were received by the SGS Lakefield Environmental Lab from the SGS Lakefield metallurgical lab on May 12, 2005. The six rougher tails and the six first cleaner scavenger tailings were respectively combined to generate composite samples designated Combined LCT2 Ro Tails Stages A-F and Combined LCT2 Cl Sc Tails Stages A-F, respectively. The respective combined pulps were mixed as previously described before approximately 1.5 L of the Combined LCT2 Ro Tails Stages A-F and three litres of the Combined LCT2 Cl Sc Tails Stages A-F were extracted and filtered through #1 Watman filter paper. Respective filter cake solids were submitted for

modified ABA, ICP-MS metal scan on an *aqua regia* digest and whole rock XRF analyses. The respective filtrates were reserved in storage.

The remaining Combined LCT2 Ro Tails Stages A-F, Combined LCT2 Cl Sc Tails Stages A-F and LCT2 Prefloat cleaner concentrate solids were blended with the LCT1 Prefloat cleaner concentrate solids. Blending was based on the proportional ratios of each material component in order to maintain the original ratio of liquids to solids and is referred to as the Combined Ro and Cl Sc Tails sample. The Combined Ro and Cl Sc Tails sample was mixed for 30 minutes at 200 rpm to ensure all solids had been thoroughly recombined before extracting materials for individual aging and toxicity tests. Subsequently, approximately 12 L of pulp was extracted and filtered through a #1 Watman filter paper. The resultant filter cake solids were retained in refrigerated storage and blended manually with the solids retained from the one hour, 24 hour and three day aging samples. The combined filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest, whole rock XRF, shake flask tests, humidity cell testing, and mineralogical examination (petrography and Reitveld XRD). Two litres of the excess filtrate was reserved in storage.

Overall Diluted Ore Composite (LCT3)

Tailings slurry and Prefloat cleaner concentrate samples from 6 cycles of the LCT3 (Overall Dilute) test were received from metallurgical operations on June 29, 2005. The six rougher tails and the six first cleaner scavenger tailings were respectively combined to generate composite samples designated Combined OD Composite Ro Tails and Combined OD Composite Cl Sc Tails. The respective combined pulps were mixed as previously described before approximately three litres of each of the respective pulps were extracted and filtered through a #1 Watman filter paper. Respective filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest and whole rock XRF analyses. Two litres of the respective filtrates were reserved in storage.

The remaining rougher and cleaner scavenger tails pulps were combined with the LCT3 Prefloat cleaner concentrate and blended for 30 minutes at 200 rpm to ensure homogeneity prior to the extraction of materials for individual aging and toxicity tests. Approximately 10 L of the

remaining pulp was extracted and filtered through a #1 Watman filter paper. The resultant filter cake solids were retained and blended manually with the solids retained from the one hour, 24 hour and three day aging samples. The combined filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest, whole rock XRF analyses, shake flask tests, humidity cell testing, and mineralogical examination (petrography and Rietveld XRD). Two litres of the excess filtrate was reserved in storage.

Overall Dilute Wolverine Composite (LCT4)

Combined rougher samples, combined cleaner pulp samples and combined Prefloat cleaner concentrate samples from six cycles of the LCT4 (Dilute Wolverine) test were received from metallurgical operations on June 20, 2005. The Combined Wolverine D Composite Ro Tails and Combined Wolverine D Composite Cl Sc Tails pulps were mixed following the methodology outlined previously. Approximately three litres of each of the respective pulps were extracted and filtered through a #1 Watman filter paper. Respective filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest and whole rock XRF analyses. Two litres of the respective filtrates were reserved in storage.

The remaining rougher and cleaner scavenger tails pulps were combined with the LCT 4 Prefloat cleaner concentrate and mixed as previously outlined before materials extraction for individual aging and toxicity tests. Approximately 10 L of the remaining pulp was extracted and filtered through a #1 Watman filter paper. The resultant filter cake solids were retained and blended manually with the solids retained from the one hour, 24 hour and three day aging samples. The combined filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest, whole rock XRF, shake flask testing, humidity cell testing, and mineralogical examination (petrography and Rietveld XRD). Two litres of the excess filtrate was reserved in storage.

Diluted Lynx Composite (LCT5Overall)

Combined rougher samples, combined cleaner pulp samples and combined Prefloat cleaner concentrate samples from six cycles of the LCT5 (Dilute Lynx) test were received by the

Environmental lab from the Metallurgical lab, on July 5, 2005. The Combined Lynx D Composite Ro Tails and Combined Lynx D Composite Cl Sc Tails pulps were mixed as previously outlined above. Approximately 10 L of the remaining pulp was extracted and filtered through a #1 Watman filter paper. Respective filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest and whole rock XRF analyses. Two litres of the respective filtrates were reserved in storage.

The remaining rougher and cleaner scavenger tails pulps were combined with the LCT5 Prefloat cleaner concentrate and mixed as previously outlined. Approximately 10 L of the remaining pulp was extracted and filtered through a #1 Watman filter paper. The resultant filter cake solids were retained and blended manually with the solids retained from the one hour, 24 hour and three day aging samples. The combined filter cake solids were submitted for modified ABA, ICP-MS metal scan on an *aqua regia* digest, whole rock XRF analyses, shake flask testing, humidity cell testing, and mineralogical examination (petrography and Rietveld XRD). Two litres of the excess filtrated was reserved in storage.

1.2.2 Variation Due to Physical Segregation of Tailings

The proposed grind size for the Wolverine Project ore types is quite fine, with an initial targeted grind of $P_{80} < 68$ microns with the Cleaner Scavenger tailings getting reground in the zinc circuit to a target of $P_{80} < 23$ microns. Therefore, expected quantities of coarser grained tailings will be of little significance. Nevertheless, it should be noted geochemical characterization of the tailings based on grind size has not been undertaken. Sulphides have been known to associate with the fine fraction of mine tailings; however, this has not been addressed in the current assessment. As a result, the geochemical significance of segregation of fine and slightly coarser grained tailings will not be well understood. Even so, the results reported in the following section will apply generally with respect to the range of grain sizes expected to be encountered in the Wolverine tailings. It can be observed that based on qualitative XRD data on flotation circuit feed material from the Wolverine ore zone, that in the “coarse” fraction (>75 microns), pyrite and dolomite are both present at moderate abundance, whereas for all the finer fractions, pyrite is present with major abundance and dolomite is only present at minor to trace abundance. This suggests that at

least for the Wolverine tailings, the coarser material may have a lower acid generation potential (higher Neutralization Potential ratio (NPR), closer to unity). The XRD data for the Lynx ore zone is similar for the >150 micron material (which is only a few percent of the feed) but pyrite is consistently more abundant than dolomite for all the finer grain sizes. Therefore, over the life of the mine it can be expected that there will be little variation in the ARD potential of the tailings due to segregation within the impoundment.

1.3 Mineralogical Assessment

Mineralogical assessment of the Wolverine tailings was undertaken using optical petrography, XRD and whole rock XRF analysis.

1.3.1 Optical Petrography

1.3.1.1 Methodology

Petrographic examination of polished thin sections can provide information on the major and minor mineral phases, grain shapes, grain size, spatial relationship and an estimate of relative proportions. Mineral abundances less than approximately 0.5% will not normally be detected and microscope magnification limits are unable to discern features smaller than approximately 100 µm. Petrographic analyses are most useful for samples that have ABA and trace metals analyses available since the elemental composition of minerals that occur in solid solution is not always precisely distinguishable under the microscope (e.g., differentiating between carbonate minerals). As a result, petrographic analyses are often supplemented with additional mineralogical techniques (Price, 1997), such as XRD and XRF.

One polished thin section and one polished grain mount were prepared for each of the four samples representative of tailings materials. Each polished section was examined optically under incident and transmitted light between 50x and 500x magnification. Mineral assemblage and modal abundance of the sample were determined by point counting 500 mineral particles from polished thin section. The polished thin sections were further analyzed by Scanning Electron

Microscopy (SEM) to identify specific carbonate compositions. The results of the petrographic characterization are discussed below in Section 1.3.1.2.

1.3.1.2 Results

Table II-1.4 lists the minerals identified by optical petrography and their modal abundance.

Table II-1.4 Mineral Assemblages and Modal Abundances by Optical Microscopy (wt.%)

MINERAL	COMB OVERALL ORE COMP	COMB OD COMP	COMB LYNX D COMP	COMB WOLV D COMP
Pyrite	60.1	53.1	60.3	38.3
Quartz	17.1	20.9	16.7	26.7
Carbonate	10.6	10.5	11.6	14.2
Muscovite	5.2	11.9	8.9	14.3
Chlorite	1.1	1.0	0.0	0.9
Sphalerite	1.6	1.1	1.8	1.3
Pyrrhotite	1.6	0.5	0	2.1
Amphibole	0.6	0	0	0.5
Arsenopyrite	0.8	0.3	0.3	0
Pyroxene	0.3	0.2	0.0	1.5
Chalcopyrite	0.4	0.5	0.0	0.2
Galena	0.4	0.0	0.8	0
Biotite	0.2	0	0	0
Magnetite	0.1	0	0	0
Total	100	100	100	100

Overall, microscopic examination of the four tailings samples indicate that they are composed primarily of pyrite (approximately 38 to 60 wt.%) with moderate mineral assemblages that include quartz (approximately 10 to 14 wt.%), carbonates (approximately 10 to 14 wt.%) and muscovite (approximately 5 to 14 wt.%). Minor sulphide mineral assemblages, defined as less than two weight percent, include sphalerite, pyrrhotite, arsenopyrite, chalcopyrite and galena.

Optical microscopy indicates the Combined Overall Ore Composite, Combined Lynx D Composite Tailings and Combined OD Composite Tailings have high sulphide to carbonate ratios (approximately 3:1 to 6:1). Lack of available reactive carbonates, which provide neutralizing potential, may be a problem if sulphide oxidation occurs. Carbonate grains range in size from 20 to 300 µm and occur as liberated grains or attached/ inclusions in/on quartz or muscovite assemblages. The latter two points further reduce available neutralizing potential due to the exclusion of carbonate grains to the surrounding solution. Section 1.3.2.2 expands further

on the type of carbonates available for neutralizing potential. The majority of the sulphides occur as liberated grains, some pyrite and pyrrhotite grains as large as 150 μm and 300 μm respectively, increasing the potential for oxidation based solely on the available surface area for the reaction to occur. If sulphide oxidation is likely, releases of Zn, As, Cu and Pb may follow due to the presence of the minor sulphides in the samples.

1.3.2 X-Ray Powder Diffraction Using the Rietveld Method

1.3.2.1 Methodology

XRD provides the means of determining the type mineral phases while the Rietveld refinement method quantifies the phases relative to one another. This is one of the first steps in identifying potentially reactive waste materials and, unlike petrographic techniques, mineral identification via XRD is not limited to grains larger than 100 μm (Price, 1997). X-ray diffraction is used to distinguish between similar mineral phases, such as the carbonates, or as a final step in determining an unknown mineral phase targeted by optical microscopy. A full explanation of XRD methods using the Rietveld refinement method can be found in Raudsepp and Pani (2002 and 2003).

1.3.2.2 Results

The results of quantitative phase analysis by the Rietveld refinement are given in Table II-1.5.

Table II-1.5 Mineral Abundances Calculated by Rietveld XRD (wt.%)

MINERAL	IDEAL FORMULA	COMB OVERALL ORE COMP	COMB OD COMP	COMB WOLV D COMP	COMB LYNX D COMP
Pyrite	FeS ₂	56.7	48.5	34.1	58.7
Quartz	SiO ₂	20.5	21.4	28.0	17.7
Muscovite	KAl ₂ AlSi ₃ O ₁₀ (OH) ₂	10.7	17.2	19.9	13.5
Dolomite	CaMg(CO ₃) ₂	5.2	5.9	7.4	5.0
Calcite	CaCO ₃	2.9	3.0	2.6	3.6
Clinochlore	(Mg,Fe ²⁺) ₅ Al(Si ₃ Al)O ₁₀ (OH) ₈	1.6	1.7	4.6	nd
Gypsum	CaSO ₄ ·H ₂ O	1.9	1.0	1.0	nd
Pyrrhotite	Fe _(1-x) S	nd	0.9	1.7	0.4
Siderite	Fe ²⁺ CO ₃	0.5	0.4	0.4	0.4
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	nd	nd	nd	0.7
Galena	PbS	nd	nd	0.3	0.1

nd = not detected

These amounts represent the relative amounts of crystalline phases normalized to 100%. Amorphous and nanocrystalline phases are not detected by this method. X-ray diffraction results confirm optical microscopy results. Pyrite is the dominant sulphide phase in all samples with moderate concentrations of quartz and muscovite. Dolomite, calcite and siderite are the three carbonates present in the sample material and indicate the majority of neutralizing potential comes from reactive phases. It is interesting to note some of the minor sulphides (arsenopyrite and sphalerite) were not detected by this method even though optical mineralogy indicates they are present in detectable concentrations. These results suggest the low abundance of reactive carbonates and non-carbonate minerals (less than 10 wt.% total) may not provide enough neutralizing potential so the tailings, with relatively high concentrations of sulphides, are classified as PAG. The neutralizing role of non-carbonate minerals (muscovite and clinochlore), with measured total concentrations ranging from 12.3 wt.% to 24.5 wt.% which also have potential neutralizing capacity, can only be determined through kinetic testing.

1.3.3 Whole Rock XRF Analysis

Whole rock analyses of the four Wolverine tailings samples were performed in May to early July 2005 by SGS Lakefield.

1.3.3.1 Methodology

Samples from each of the rougher, cleaner and combined tailings samples (12 in total) were submitted for determination of major element oxides by XRF. Samples were crushed to 150 mesh and thermally fused with lithium borate forming a glass disk. The disk was then analyzed by WDXRF spectrometry for the oxides. Loss on ignition is determined separately at a temperature of 1000°C.

1.3.3.2 Results

The whole rock analysis results of the tailings samples are presented in Table II-1.6 as oxides and in Table II-1.7 as elemental concentrations.

Table II-1.6 Whole Rock Analysis of Tailings Samples

Oxide (wt.%)	Overall Ro	Overall CI Sc	Overall Comb	OD Ro	OD CI Sc	OD Comb	Wolv D Ro	Wolv D CI Sc	Wolv D Comb	Lynx D Ro	Lynx D CI Sc	Lynx D Comb
SiO ₂	32.0	7.6	24.2	36.6	6.0	26.8	41.9	10.2	35.3	30.4	4.3	20.6
Al ₂ O ₃	5.6	1.8	3.9	6.3	1.4	4.7	8.0	2.3	6.4	5.1	1.0	3.4
Fe ₂ O ₃	30.1	47.9	37.2	26.5	56.1	34.7	19.8	52.0	27.8	32.9	53.7	42.4
MgO	2.5	0.9	1.8	2.9	0.5	2.1	4.2	0.9	3.3	1.7	0.4	1.2
CaO	4.4	1.9	3.3	5.0	1.4	3.8	4.8	1.7	4.2	5.2	1.3	3.6
Na ₂ O	0.3	2.9	0.5	0.3	0.8	0.5	0.2	1.0	0.4	0.3	0.6	0.5
K ₂ O	1.5	0.4	1.0	1.7	0.3	1.2	2.0	0.6	1.6	1.4	0.2	0.9
TiO ₂	0.1	0.0	0.1	0.2	0.0	0.1	0.2	0.1	0.2	0.1	0.0	0.1
P ₂ O ₅	0.1	0.0	0.1	0.1	0.0	0.1	0.2	0.1	0.2	0.1	0.0	0.1
MnO	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1
Cr ₂ O ₃	0.0	0.3	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1
V ₂ O ₅	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	< 0.01	0.0
LOI	19.4	26.4	22.8	16.2	30.3	21.0	13.5	27.4	17.8	18.3	31.0	24.0
Total	96.2	90.1	95.1	95.8	96.9	95.0	94.9	96.4	97.3	95.8	92.8	96.9

Table II-1.7 Elemental Concentrations Calculated from Whole Rock Data

Element (wt.%)	Overall Ro	Overall CI Sc	Overall Comb	OD Ro	OD CI Sc	OD Comb	Wolv D Ro	Wolv D CI Sc	Wolv D Comb	Lynx D Ro	Lynx D CI Sc	Lynx D Comb
Si	14.96	3.55	11.31	17.11	2.79	12.53	19.59	4.77	16.50	14.21	2.03	9.63
Al	2.96	0.94	2.06	3.33	0.72	2.48	4.23	1.23	3.39	2.69	0.53	1.80
Fe	10.53	16.75	13.01	9.27	19.62	12.14	6.92	18.19	9.72	11.51	18.78	14.83
Mg	1.50	0.55	1.09	1.72	0.33	1.27	2.54	0.55	1.98	1.02	0.27	0.69
Ca	3.13	1.34	2.36	3.54	0.98	2.70	3.42	1.23	2.99	3.72	0.94	2.59
Na	0.13	1.06	0.19	0.12	0.28	0.18	0.06	0.36	0.14	0.12	0.24	0.17
K	0.62	0.16	0.40	0.68	0.14	0.50	0.83	0.23	0.68	0.58	0.08	0.38
Ti	0.08	0.02	0.05	0.09	0.02	0.07	0.11	0.04	0.09	0.07	0.02	0.05
P	0.02	0.01	0.02	0.02	0.01	0.02	0.03	0.02	0.03	0.02	0.01	0.01
Mn	0.09	0.05	0.09	0.09	0.03	0.07	0.07	0.03	0.06	0.11	0.03	0.08
Cr	0.01	0.09	0.02	0.01	0.03	0.02	0.01	0.04	0.02	0.01	0.03	0.02
V	0.02	0.02	0.02	0.03	0.01	0.02	0.03	0.02	0.04	0.02	0.00	0.02

Although whole rock data is traditionally presented as oxides, this does not necessarily indicate oxide minerals are present in the sample. For example, the high Fe₂O₃ concentrations reported in all tailings samples is almost certainly influenced to a large degree by the presence of pyrite, confirmed by optical petrography and XRD, and not solely due to hematite (α -Fe₂O₃) and/or maghemite (γ -Fe₂O₃). The conversion of the oxides to total elemental concentrations is therefore more representative of the overall tailings chemistry.

Results show high concentrations of the major cations (Si, Al, Mg, Ca, and K) as well as Fe. Sodium, Ti, P, Mn, Cr and V are present at less than one weight percent. The high LOI and consistently low totals are reflective of the presence of sulphides, carbonates, phyllosilicates and/or hydrated minerals (Price, 1997). X-ray diffraction confirms the presence of all four of these types of mineral phases suggesting the likely volatile components released during thermal glass disc preparation and their respective mineral phases include:

- OH⁻ from muscovite, clinocllore and kaolinite;
- CO₂ from organics, dolomite, calcite and/or siderite;
- H₂O from gypsum; and

- SO_x from sulphides.

1.4 Static Testing

1.4.1 Acid Base Accounting (ABA)

Brief descriptions of the ABA parameters are included in the following sections after Sobek (1978) and Price (1997). Tailings samples were tested at the received particle size (80% passing 68 microns).

1.4.1.1 Methodology

Paste pH

Alone, paste pH does not provide an indication of ARD potential of a sample. It is, however, a principal determinant of both mineral reaction rates and mineral solubility. It can therefore have a large affect on drainage chemistry. For example, paste pH values less than pH 7 can be indicative of a limited availability of NP, whereas higher values suggest that available NP exists in a sample.

The paste pH is determined prior to conducting all other tests included an ABA suite. A small amount of pulverized sample (approximately 25 g) is wetted with distilled water while swirling. Upon saturation, the pH of the paste is measured and recorded.

Sulphur Species

Minerals containing sulphur are the main source of acid and trace metal contaminants in mine waste. Therefore, the determination of sulphur species is a fundamental component in the prediction of mine drainage chemistry. The sulphur species measured include:

- Total sulphur;
- Acid-leachable sulphate sulphur;
- Acid-leachable sulphide sulphur;

- Insoluble sulphate sulphur based on barium determination; and
- Organic sulphur (calculated by difference).

Acid Potential Determination

Total Acid Potential is calculated from the total sulphur determination discussed above. Here, total sulphur (%S) is multiplied by the conversion factor of 31.25 to express the acid potential in kg of CaCO₃ equivalent per tonne of material.

Sulphide Acid Potential (AP) is calculated from the sulphide determination. The sulphide-sulphur (%S) is multiplied by the conversion factor of 31.25 to express the acid potential in kg of CaCO₃ equivalent per tonne of material.

Carbon Content

The following carbon species were analyzed:

- Total carbon;
- Total inorganic carbon;
- Total organic carbon; and
- Carbonate carbon.

Neutralization Potential Determination

In weathering rocks where sulphides are present, ARD will only be produced if there is insufficient release of neutralizing alkalinity. Laboratory Neutralization Potential (NP) measurements such as the bulk NP and carbonate NP measurements provide a first order estimation of the neutralization capacity.

The bulk neutralization potential testing followed the standard Sobek method (Sobek-NP). The Sobek-NP determination yields the NP contributed by all carbonate and non-carbonate neutralizing minerals. This procedure is based upon the results of the fizz test. A fizz test (addition of 25% HCl to a dry, pulverized sample) is used to provide a guide to the strength and

amount of acid to be added to each sample. An initial “fizz test” is conducted on a small portion of the sample and the strength and volume of hydrochloric acid is then added according to Table 7-2 of the MEND Manual (MEND, 2000). The addition of acid must ensure acidification of the neutralizing materials though it must avoid over acidification of the sample. The resulting solution is then titrated back to pH 8.3. The NP of the sample is calculated from the titration data.

Carbonate Neutralization Potential (Carb-NP) is calculated using the Total Inorganic Carbon (TIC) measurement converted back to calcium carbonate equivalent, thus assuming all inorganic carbon is in the form of CaCO_3 . A calculation of the Carb-NP based on TIC provides the NP contributed by carbonate minerals only. This value is the maximum neutralization capacity that could be achieved if all the carbonate in the sample reacted like calcite.

As a result, more Sobek-NP than Carb-NP in a sample indicates there may be significant neutralization from non-carbonate minerals. If the Carb-NP is greater than the Sobek-NP, a measurable portion of the inorganic carbon is not generating alkalinity or is unreactive and suggests the presence of iron and/or manganese carbonates.

Net Neutralization Potential and Neutralization Potential Ratio Calculations

The AP is derived from the total sulphur or sulphide sulphur value as explained above. The NP derived from any one of the above procedures is then used in determining the neutralization potential ratio (NPR), the ratio of the NP:AP or net neutralization potential (NNP), the difference between the NP and the AP. An NPR <1 indicates the material is likely PAG.

Elemental Content - Solid Phase Metals Analysis

Solid phase metals analysis of a sample provides a means of quantifying the elements available in a sample. Samples sent to SGS Lakefield for solid phase metals analyses were examined in-house using a 33 element ICP-MS scan following an *aqua regia* digest.

1.4.1.2 Results

ABA testing of the tailings generated from the four ore composite samples was done by SGS Lakefield. The results of this test work are reported in Table II-1.8.

Table II-1.8 Tailings ABA Results

PARAMETER	UNITS	OVERALL COMP LCT2 RO	OVERALL COMP LCT2 CL SC	OVERALL COMP LCT2 COMB	OD RO	OD CL SC	OD COMB	WOLV RO	WOLV CL SC	WOLV COMB	LYNX RO	LYNX CL SC	LYNX COMB
Paste pH	-	7.79	7.26	7.42	7.85	6.69	7.27	7.68	6.91	7.35	7.67	6.45	7.36
Fizz Rate	-	3	3	3	3	2	2*	3	2	2**	3	2	2
Total S	%S	22.3	39.5	29.2	17.5	43.0	26.6	12.3	39.4	19.7	23.7	48.4	31.2
Acid Leachable SO ₄ ²⁻	%S	1.07	6.98	2.51	0.02	1.18	2.04	0.45	1.63	1.74	0.92	6.45	0.74
Sulphide S	%S	20.2	28.5	25.0	15.7	39.0	22.9	10.1	34.1	15.7	20.4	39.4	27.8
Insoluble SO ₄ ²⁻	%S	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Organic S	%S	1.10	4.00	1.73	1.72	2.83	1.67	1.79	3.64	2.34	2.35	2.61	2.68
AP	kg CaCO ₃ /t	631	891	781	491	1220	715	315	1070	489	638	1230	869
Sobek NP	kg CaCO ₃ /t	103	41.8	72.8	114	21.9	82.5	119	32.1	94.6	111	20.9	49.4
Net NP	kg CaCO ₃ /t	-528	-849	-708	-377	-1198	-632	-196	-1038	-395	-526	-1209	-820
Sobek NP/AP	-	0.16	0.05	0.09	0.23	0.02	0.12	0.38	0.03	0.19	0.17	0.02	0.06
Carb NP	kg CaCO ₃ /t	72.6	23.4	59.4	91.4	20.5	98.3	105	24.6	106	94.4	22.1	52.3
Carb NP/AP	-	0.11	0.56	0.08	0.19	0.02	0.14	0.33	0.02	0.22	0.15	0.02	0.06
TOC	%C	na	na	na	0.54	0.43	0.62	0.69	0.75	0.98	0.49	0.25	0.48
TIC	%C	na	na	na	1.32	0.11	0.94	1.39	0.14	1.2	1.30	0.21	0.79
C(t)	%C	1.72	0.87	1.48	1.86	0.54	1.56	2.07	0.88	2.14	1.79	0.46	1.27

Samples with higher Sobek-NP than Carb-NP (all samples except possibly OD Combined, Wolv Combined and Lynx Cl Sc) indicate the presence of non-carbonate NP. Mineralogical results suggest muscovite, clinocllore and kaolinite are the non-carbonates with NP. In samples having slightly higher Carb-NP compared to Sobek NP indicating some carbonate minerals are not generating alkalinity or are unreactive. Mineralogical results suggest siderite may be the unreactive carbonate, though it is only present at less than 0.5 wt.% in samples analyzed. However, with the two combined samples, it appears that the Fizz Rating, which is highly subjective, may have lead to inadequate acid addition in the Sobek NP determination. Closer inspection of the data indicates that the standard Sobek method may not have been followed precisely, in that acid normality and acid volume do not vary consistently with Fizz Rating in accordance with Table 7-2 in Price (1997).

ABA test work, in particular the information garnered from the NPR, serves as a guide in identifying the likelihood of ARD conditions and distinguishing samples from a deposit as PAG from Non-PAG. Price (1997) provides some criteria for guiding geochemical test work and evaluating the potential for ARD shown in Table II-1.9.

Table II-1.9 ABA Screening Criteria

POTENTIAL FOR ARD	INITIAL SCREENING CRITERIA
Likely	$\text{NPR} \leq 1$
Possible	$1 < \text{NPR} \leq 2$
Low	$\text{NPR} > 2$

The ABA results for the overall composite samples, the two separate deposits and all of the individual tailings streams indicate that the sulphide-rich (10.1-39.4 %) materials are PAG (NPR less than one). However, the samples currently have enough NP (Carb NP of 20-100 kg CaCO_3/t) to remain at a near-neutral pH when initially exposed to oxygen. This is confirmed from the paste pH values, which ranges from pH 6.69 to pH 7.85. Kinetic results addressing the long term temporal performance of the samples are presented in Section 1.5.

1.4.2 Metals Analyses

1.4.2.1 Methodology

ICP-MS analyses were done from May to July of 2005 by SGS Lakefield. Trace element analysis by ICP-MS provides a measure of the solid-phase concentrations of various elements within a sample. Solid samples were subjected to near-total digestion in a mixture of strong oxidizing acids (HNO₃ and HCl), known as *aqua regia*, in order to dissolve most mineral phases. Digests were then quantitatively analyzed for a suite of major, minor and trace elements (33 elements in total).

1.4.2.2 Results

The elemental analyses by ICP-MS are presented in Table II-1.10 for twelve samples. When measured sample concentrations are compared to known crustal abundances, it can be determined which elements may be of environmental concern under neutral or acidic drainage conditions. Anomalous elemental concentrations are defined here as greater than five times normal crustal abundance as listed in Appendix 3 of Price (1997). The measured elemental concentrations which exceeded this criterion in at least 50% of the samples are presented in Table II-1.11.

Table II-1.10 ICP-MS Solid-phase Results

Element	Units	CRUSTAL ¹	O RO	O CS	O COMB	OD RO	OD CI SC	OD COMB	WOLV RO	WOLV CI SC	WOLV COMB	LYNX RO	LYNX CI SC	LYNX COMB
Ag	mg/kg	0.08	39	80	59	42	71	54.8	42	170	82	41	65	54.4
Al	%	8.36	0.67	0.22	0.43	0.99	0.18	0.6	1.2	0.33	1	0.43	0.12	0.28
As	mg/kg	1.8	2100	3800	2700	2200	3800	2700	760	2500	1200	3500	4800	4100
Ba	mg/kg	390	51	25	38	70	30	53	94	29	66	59	28	50
Be	mg/kg	2	0.2	0.1	0.1	0.32	0.05	0.17	0.3	0.1	0.24	0.2	0.04	0.12
Bi	mg/kg	0.0082	7.5	7.5	7.5	8.1	13	11	12	42	19	6	8.8	6.4
B	mg/kg	9	<i>1.5</i>	<i>1.5</i>	<i>1.5</i>	6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Ca	%	4.66	3	1.3	2.3	3.2	0.83	2.5	3.1	1.1	2.7	3.4	0.85	2.4
Cd	mg/kg	0.16	44	500	140	57	160	97	29	180	74	67	160	110
Co	mg/kg	29	29	45	37	27	74	42.7	33	100	47.9	27	56	38.5
Cr	mg/kg	122	70	530	120	120	380	200	94	390	160	130	290	210
Cu	mg/kg	68	750	1800	1100	710	930	820	630	2110	1100	720	860	820
Fe	%	6.22	23	36	28	18	38	23	14	34	18	22	38	27
Hg	mg/kg	0.086	1.5	9.5	3.2	2.4	5.8	3.6	2	8.5	4	2.4	4.9	3.2
K	%	1.84	0.33	0.012	0.21	0.3	0.06	0.17	0.31	0.1	0.25	0.16	0.05	0.11
Li	mg/kg	18	<i>1</i>	<i>1</i>	<i>0.15</i>	<i>1.5</i>	<i>1.5</i>	1.6	10	<i>1.5</i>	5.5	<i>1.5</i>	<i>1.5</i>	0.1
Mg	%	2.764	1.2	0.32	0.75	1.4	0.24	1	1.9	0.41	1.6	0.76	0.18	0.52
Mn	mg/kg	1060	870	550	680	840	320	670	730	310	620	980	350	700
Mo	mg/kg	1.2	21	44	28	37	48	32.3	17	32	24.5	29	58	45.1
Na	%	2.27	0.02	0.008	0.011	0.019	0.005	0.014	0.024	0.008	0.015	0.014	0.005	0.01
Ni	mg/kg	99	51	78	65	60	100	60	46	95	56	55	84	63
P	mg/kg	1120	350	150	290	400	100	320	600	200	520	300	74	190
Pb	mg/kg	13	2600	5800	3500	3000	5200	3900	1900	15000	5100	4300	7400	5600
Sb	mg/kg	0.2	160	340	220	130	220	170	140	820	310	150	220	180
Se	mg/kg	0.05	277	479	361	261	514	364	275	979	464	264	452	336
Sn	mg/kg	2.1	9.8	18	11	12	13	13	8	16	10	34	16	16

1. Source: Crust as a Whole in Abundances of chemical elements in the Earth's Crust and chondrites in Appendix 3 of Price (1997)

Italics indicates measured value less than detection limit and listed as one half of the method detection limit

Bold values exceed normal crustal abundance by a factor of at least 5

Table II-2.10 ICP-MS Solid-phase Results (cont'd)

Element	Units	CRUSTAL ¹	O RO	O CS	O COMB	OD RO	OD CISC	OD COMB	WOLV RO	WOLV CISC	WOLV COMB	LYNX RO	LYNX CISC	LYNX COMB
Sr	mg/kg	384	63	25	49	69	17	53	78	19	59	72	17	48
Ti	mg/kg	6320	71	30	54	99	23	68	95	34	82	75	20	53
Tl	mg/kg	0.72	17	14	16	20	18	19.1	14	13	13.4	25	23	23.7
U	mg/kg	2.3	4.6	3.3	3.9	5.2	3.2	4.7	6.6	4.5	6	4	2.5	3.4
V	mg/kg	136	40	32	29	60	23	37	51	37	49	41	18	33
Zn	mg/kg	76	5000	74000	19000	5500	17000	9800	2900	20000	8000	6500	16000	11000

1. Source: Crust as a Whole in Abundances of chemical elements in the Earth's Crust and chondrites in Appendix 3 of Price (1997)

Italics indicates measured value less than detection limit and listed as one half of the method detection limit

Bold values exceed normal crustal abundance by a factor of at least 5

Table II-1.11 Elemental Concentrations Greater Than 5X Crustal Abundance

ELEMENT	ANOMALOUS SAMPLES (%)	AVG. RATIO ¹
Se	100	9512
As	93	1453
Bi	100	1377
Sb	100	1201
Cd	93	836
Ag	100	763
Pb	93	375
Zn	93	218
Hg	93	52
Mo	93	26
Tl	93	23
Cu	93	14
Sn	71	7

1. Measured Concentration: Crustal Abundance

A total of 13 trace elements, listed in Table II-1.11, show concentrations greater than five times crustal abundance in nearly all samples analyzed. These results suggest the onset of acidic conditions may have the potential to release metal(loid)s from mineral phases, likely from the sulphide phases confirmed by mineralogical characterization (see Section 1.3). Furthermore, any of the elements in this table that are mobile under neutral pH conditions (e.g., Se, Zn, etc.) may have the potential to be released at any time.

1.4.3 Shake Flask Testing

1.4.3.1 Methodology

Shake flask testing of four samples was conducted by SGS Lakefield. This short-term leach test was used to determine the leachate that may flush from the tailings solids when exposed to rain, snowmelt or groundwater flow. A modification of the Special Waste Extraction Procedure, or shake flask test, is outlined in the *British Columbia Waste Management Act*. This procedure is a recommended component of static tests and is used to determine the presence of easily soluble mineral components (Price, 1997). Modifications to the above procedure included using a 20:1 water to solid ratio, rather than 3:1, to ensure measured concentrations were not subject to solubility effects. The test was conducted by adding deionised water to a 50 g dry equivalent tailings sample to create a one litre slurry (liquid:solid = 20:1). The initial pH was measured prior to 24 hr agitation (end over end). After extraction, the final pH was recorded, the sample was filtered through a 0.45 µm filter and a sub-sample of leachate was submitted for analyses of metals by ICP-MS.

1.4.3.2 Results

The results of the shake flask extraction from the four Combined Tailings samples are summarized in Table II-1.12.

Table II-1.12 Shake Flask Extraction Test Results

PARAMETER	UNITS	MMER ¹	10X CCME ²	COMB OVERALL ORE COMP	COMB OD	COMB WOLV D	COMB LYNX D
Moisture	%			1.0	16	16.8	29.9
Sample Weight	g			50	50	50	50
DI Water Volume	mL			990	992	991.6	985
Initial pH	units		6.5-9.0	7.1	9.4	9.2	9.15
Final pH	units		6.5-9.0	7.3	8.2	8.4	8.3
pH	units		6.5-9.0	7.3	7.6	7.6	7.7
Conductivity	uS/cm			813	263	274	242
Tot.Dissolved Solids	mg/L			740	231	220	186
Tot Suspended Solids	mg/L	15.0		3	<i>1.5</i>	<i>1</i>	<i>1.5</i>
Alkalinity	mg CaCO ₃ /L			52	na	na	na
Acidity	mg CaCO ₃ /L			17	na	na	na
F	mg/L			0.06	na	na	na
NH ₃ + NH ₄ ⁺	mg N /L		17.7 (T=15°C and pH 7)	0.3	0.2	1	0.2
Cl	mg/L			1.5	<i>1</i>	<i>1</i>	<i>1</i>
NO ₃ ⁻	mg N/L		130	<i>0.25</i>	<i>0.25</i>	0.79	<i>0.25</i>
SO ₄ ²⁻	mg/L		500†	430	41	41	38.5
CN _(T)	mg/L	1.0		0.02	0.07	<i>0.005</i>	<i>0.005</i>
CNO	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
CNS	mg/L			<i>1</i>	<i>1</i>	<i>1</i>	<i>1</i>
Thiosalts	mg S ₂ O ₃ /L			44	na	na	na
Ag	mg/L		0.0010	<i>0.00005</i>	0.0008	0.0006	0.00075
Al	mg/L			<i>0.002</i>	0.005	0.007	0.007
As	mg/L	0.50		<i>0.0025</i>	0.007	0.007	0.0095
B	mg/L			<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.013</i>
Ba	mg/L			0.070	0.27	0.20	0.32
Be	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>

Table II-2.12 Shake Flask Extraction Test Results (cont'd)

PARAMETER	UNITS	MMER ¹	10X CCME ²	COMB OVERALL ORE COMP	COMB OD	COMB WOLV D	COMB LYNX D
Bi	mg/L			<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>
Ca	mg/L			153	46.8	46.8	42.8
Cd	mg/L		0.00017	0.13	0.0051	0.0025	0.0049
Co	mg/L			0.011	0.0004	<i>0.00015</i>	0.00023
Cr	mg/L		0.010*	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>
Cu	mg/L	0.30		0.0015	0.0014	0.0009	0.0021
Fe	mg/L			<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>
Hg	mg/L		0.00026	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>
K	mg/L			1.9	0.91	1.2	0.55
Li	mg/L			<i>0.002</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			5.7	2.3	2.8	1.8
Mn	mg/L			2.1	0.22	0.078	0.19
Mo	mg/L		0.73	0.0006	0.0033	0.0029	0.0039
Na	mg/L			1.52	2.39	3.21	2.22
Ni	mg/L	0.50		0.024	0.002	0.001	0.002
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Pb	mg/L	0.20		0.17	0.039	0.020	0.061
Sb	mg/L			0.0034	0.016	0.047	0.011
Se	mg/L		0.010	0.20	0.42	0.60	0.53
Si	mg/L			0.36	0.41	0.32	0.33
Sn	mg/L			<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>
Sr	mg/L			0.33	0.064	0.066	0.059
Ti	mg/L			<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>
Tl	mg/L		0.0080	0.022	0.0063	0.0023	0.0087
U	mg/L			<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
V	mg/L			0.0010	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>
Zn	mg/L	0.50		6.87	0.081	0.037	0.064

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. Ten times the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates 10X British Columbia water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME

na = not analyzed

Results show the final pH was near neutral to slightly alkaline and ranged from pH 7.3 to pH 8.4. Only Zn, in the Combined Overall Ore Composite tailings sample, was found to exceed the Metal Mining Effluent Regulations (2002) (MMER). In lieu of MMER guidelines, Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the protection of freshwater aquatic life have been included. Note CCME guidelines are several orders of magnitude more stringent than MMER guidelines. A criteria of 10x the receiving water quality guideline value was selected because, for the parameters where there is an MMER limit because a factor of 10 provides a level of conservatism for protecting downstream aquatic resources similar to or better than the MMER limits. Parameters exceeding 10x CCME guidelines include Cd, Tl and Se in all samples tested.

SFE results suggest the initial exposure of samples to atmospheric conditions will result in minimal trace metal(loid) releases except for the Combined Overall Ore Composite, which shows Cd (0.134 mg/L), Se (0.20), Tl (0.022 mg/L) and Zn (6.87 mg/L) releases. The major ions (Ca^{2+} , Na^+ , Mg^{2+} , Mn^{2+} , Cl^- , SO_4^{2-} and thiosalts) also show releases, likely due to the dissolution of gypsum (CaSO_4) and other salts and sulfosalts present at low abundances. An SFE reassay was conducted to confirm the release of SO_4^{2-} and appears to be related to the drying and oxidation of the Combined Overall Ore prior to analyses. In addition, a ZnSO_4 reagent is added to processing and may also be contributing to the dissolved inventories.

1.5 Kinetic Testing

1.5.1 Tailings Aging Tests

1.5.1.1 Methodology

Aging tests were designed and conducted on combined tailings samples representing possible tailings blends from the Wolverine Project. The procedure is intended to mimic the change in water chemistry in a tailings impoundment over time. In this experiment, a clean polyethylene canister was charged with tailings and water and left to stand in the laboratory for an extended period of time (up to 120 days). Canisters are loosely covered by a plastic lid to facilitate free

exchange with atmospheric CO₂ and O₂. A visible observation was made prior to the collection of each supernatant sample. Supernatant samples were collected at pre-determined time periods (Time 0, Day 1, 4, 7, 15, 29, 60, 90 and 120). It should be noted that Time 0 was approximately 1 hour into the test. Several physical and intermediate parameters including pH, conductivity, hardness, alkalinity, acidity, total suspended solids, nitrogen species, cyanides, sulphate and thiosalts were analyzed for. In addition, total metals analyses by ICP-MS on 33 elements were undertaken. Dissolved metals analysis was not completed since all the samples had very low TSS at the time of sampling. Acute lethality testing was also undertaken at an early (e.g., Day 1) and a late (e.g., Day 120) time period during the aging tests.

1.5.1.2 Results

In the case of the Wolverine deposit, the presence of low pH drainage in the vicinity of the ore body confirms the acid generation potential predictions for the ore, tailings and waste rock. The grain size distribution of the material tested in the laboratory will only be affected by beach segregation within the impoundment, which may result in local differences in permeability and sulphide content. The cooler temperatures at site will increase water viscosity and decrease reaction kinetics, which may combine to reduce tailings aging rates and contaminant mass transfer rates. This is likely to serve to attenuate the severity of water quality changes but will also serve to prolong their duration. The Time 0 characteristics of the tailings supernatant analyzed from the tailings aging tests provides the most reliable concentrations expected as the tailings are first deposited into the impoundment. The results of the aging tests are shown in Table II-1.13 through Table II-1.16. Photos of the testing set-up are shown below in Figure II-1.2.

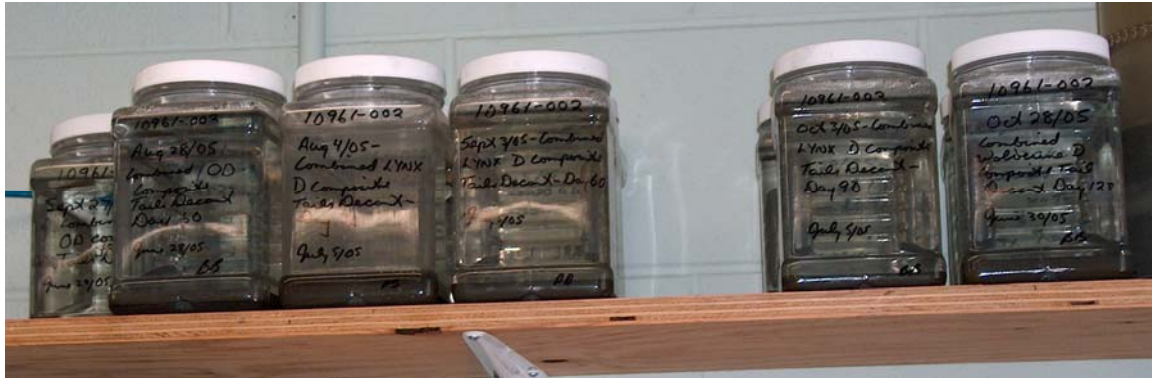


Figure II-1.2 Aging Test Setup

Table II-1.13 Combined Overall Ore Composite Tailings Aging Test Results

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	4	7	15	29	60	90	120
pH	units		6.5-9.0	7.47	7.2	7.04	7.42	7.08	7.91	7.67	7.72	7.39
Conductivity	µS/cm			1570	1570	1570	1660	1650	1780	2010	2010	2140
TDS	mg/L			1290	1290	1290	1290	1420	1520	1690	1950	1840
Acidity	mg CaCO ₃ /L			432	423	434	378	336	253	1	72	< 2
Alkalinity	mg CaCO ₃ /L			36	29	29	28	34	59	44	81	54
F	mg/L			0.27	0.26	0.27	0.29	0.26	0.35	0.38	0.39	0.38
TSS	mg/L	15.0		100	66	2	2	2	4	3	4	3
Cl	mg/L			19	19	19	20	19	20	18	20	20
NO ₃ ⁻	mg N /L			0.43	0.42	0.42	0.43	0.38	0.25	0.025	0.025	0.025
SO ₄ ²⁻	mg/L		500†	520	550	550	570	590	740	1100	1000	1200
NH ₃ ⁺ NH ₄ ⁺	mg N/L		17.7 (T=15°C and pH 7)	1.1	1	1.2	1	1	0.8	1.4	0.8	0.2
Thiosalts	mg S ₂ O ₃ /L			397	395	426	427	393	307	5	248	5
CN _(T)	mg/L	1.0		0.03	0.03	0.01	0.01	0.01	0.005	0.005	0.02	0.01
CNO	mg/L			2.1	2.1	2	1.3	1.7	0.05	0.4	0.05	0.05
CNS	mg/L			4.1	4.9	5.3	5	5	5	0.01	5.9	4.5
Hg	mg/L		0.00026	0.00005	0.00005	0.00005	0.00005	0.0002	0.0001	0.00005	0.00005	0.00005
Hardness	mg CaCO ₃ /L			435	433	443	427	434	591	811	851	860
Ag	mg/L		0.0010	0.022	0.0074	0.0077	0.0072	0.0054	0.0048	0.00005	0.0025	0.00005
Al	mg/L			0.031	0.014	0.012	0.009	0.002	0.002	0.002	0.005	0.002
As	mg/L	0.50		0.01	0.005	0.026	0.02	0.014	0.03	0.011	0.023	0.021
Ba	mg/L			0.114	0.079	0.078	0.071	0.065	0.048	0.039	0.035	0.039
B	mg/L			0.02	0.017	0.016	0.018	0.02	0.02	0.017	0.03	0.030
Bi	mg/L			0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Be	mg/L			0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Ca	mg/L			165	165	166	160	159	217	302	317	319
Cd	mg/L		0.00017	0.0045	0.0123	0.013	0.0109	0.02	0.0136	0.0062	0.0227	0.0169

Table II-2.13 Combined Overall Ore Composite Tailings Aging Test Results (cont'd)

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	4	7	15	29	60	90	120
Co	mg/L			<i>0.0011</i>	<i>0.0011</i>	<i>0.0012</i>	<i>0.0009</i>	<i>0.0011</i>	<i>0.0016</i>	<i>0.0009</i>	<i>0.0021</i>	<i>0.0021</i>
Cr	mg/L		0.010*	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	0.004
Cu	mg/L	0.30		0.0454	0.0191	0.0189	0.0037	0.0096	0.0115	0.004	0.0046	0.0024
Fe	mg/L		3.0	0.04	0.03	<i>0.01</i>	0.05	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>
K	mg/L			8.05	7.69	10	5.82	8.32	10.5	12	10.2	11.4
Li	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			5.46	5.28	6.73	6.65	8.89	11.7	14	14.4	15.1
Mn	mg/L			0.0872	0.117	0.116	0.117	0.205	0.545	1.64	1.65	2.44
Mo	mg/L		0.73	0.0503	0.0419	0.0419	0.0192	0.0028	0.0078	0.0115	0.0050	0.0018
Na	mg/L			198	205	204	149	175	177	180	176	169
Ni	mg/L	0.50		0.004	0.005	0.005	0.004	0.007	0.01	0.01	0.012	0.028
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.0005</i>
Pb	mg/L	0.20		0.0255	0.109	0.108	0.125	0.179	0.102	0.0151	0.0266	0.0760
Sb	mg/L			0.0645	0.0506	0.0505	0.0412	0.0172	0.0249	0.0222	<i>0.025</i>	0.0142
Se	mg/L		0.010	1.89	1.74	3.72	1.93	1.22	0.777	0.237	0.21	0.994
Si	mg/L			0.42	0.43	0.58	0.6	0.91	1.87	2.05	3.11	2.80
Sn	mg/L			0.006	0.006	0.006	0.006	0.008	0.007	0.005	0.004	0.001
Sr	mg/L			0.304	0.318	0.325	0.325	0.311	0.37	0.495	0.490	0.539
Ti	mg/L			<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0025</i>	<i>0.0015</i>
Tl	mg/L		0.0080	0.0067	0.0084	0.0084	0.0076	0.0093	0.0064	0.006	0.0106	0.0089
U	mg/L			0.0006	0.0004	0.0004	0.0004	0.0008	0.0015	0.0011	0.0021	0.0015
V	mg/L			<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	0.0011	0.003	0.0011
Zn	mg/L	0.50		0.076	0.749	0.764	0.833	1.68	1.98	1.78	2.76	5.57

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. 10X the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates BC 10X water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME guidelines

Table II-1.14 Combined OD Composite Tailings Aging Test Results

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	4	7	15	30	61	90	120
pH	units		6.5-9.0	8.13	7.20	6.99	6.76	7.02	7.56	7.16	7.37	7.38
Conductivity	uS/cm			1850	1910	1930	1870	1720	1630	1930	3310	2200
TDS	mg/L			1640	1500	1540	1540	1700	1590	1580	1680	1840
Acidity	mg CaCO ₃ /L			175	<i>1</i>	282	178	91	211	64	5	<i>1</i>
Alkalinity	mg CaCO ₃ /L			26	21	9	8	16	33	34	44	44
F	mg/L			0.22	0.32	0.30	0.29	0.34	0.38	0.44	0.03	0.49
TSS	mg/L	15.0		36	23	<i>1</i>	<i>1</i>	<i>1</i>	<i>1</i>	2	<i>1</i>	2
Cl	mg/L			19	23	19	20	19	20	20	19	21
NO ₃ ⁻	mg N/L			0.18	0.19	0.18	0.18	0.17	0.10	0.09	0.13	0.06
SO ₄ ²⁻	mg/L		500†	630	610	670	640	680	780	920	1100	1300
NH ₃ ⁺ NH ₄	mg N/L		17.7 (T=15°C and pH 7)	1.3	1.4	1.2	1.3	7.4	1.2	1.2	1.1	1.2
Thiosalts	mg S ₂ O ₃ /L			465	458	482	151	330	257	133	85	20
CN _(T)	mg/L	1.0		0.02	0.02	0.01	0.001	0.001	0.005	0.005	0.01	0.005
CNO	mg/L			1.6	1.7	1.3	0.6	1	0.6	0.4	0.05	0.5
CNS	mg/L			3.2	3.1	3.2	3.3	3.4	20	3.4	**	na
Hg	mg/L		0.00026	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0003	0.00005
Hardness	mg CaCO ₃ /L			510	498	512	499	552	562	560	710	904
Ag	mg/L		0.0010	0.0047	0.0057	0.0047	0.0095	0.0082	0.0038	0.0013	0.0008	0.0003
Al	mg/L			0.06	0.045	0.013	0.018	0.007	0.018	0.002	0.011	0.002
As	mg/L	0.50		0.036	0.0025	0.0025	0.006	0.01	0.007	0.013	0.014	0.006
Ba	mg/L			0.366	0.306	0.079	0.135	0.085	0.056	0.032	0.029	0.025
B	mg/L			0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Be	mg/L			0.011	0.08	0.02	0.014	0.016	0.017	0.023	0.025	0.020
Bi	mg/L			0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Ca	mg/L			194	190	193	186	204	206	203	257	328
Cd	mg/L		0.00017	0.0017	0.0021	0.0017	0.0053	0.0074	0.0096	0.0059	0.0131	0.0257

Table II-2.14 Combined OD Composite Tailings Aging Test Results (cont'd)

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	4	7	15	30	61	90	120
Co	mg/L			0.0007	0.0009	0.0004	0.0008	0.0009	0.0018	0.0017	0.0027	0.0035
Cr	mg/L		0.010*	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	0.001
Cu	mg/L	0.30		0.0051	0.0029	0.0016	0.002	0.0031	0.0066	0.0075	0.0065	0.0038
Fe	mg/L			<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	0.02	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>
K	mg/L			10.6	12.1	10.4	10.7	11.5	12.4	14.2	12.6	12.3
Li	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			6	5.93	7.46	8.28	10.5	11.5	12.8	17.0	20.6
Mn	mg/L			0.0169	0.0163	0.0233	0.0608	0.185	0.194	0.373	0.715	1.52
Mo	mg/L		0.73	0.0106	0.0102	0.0090	0.0158	0.0187	0.0207	0.0297	0.0188	0.0096
Na	mg/L			203	196	199	192	213	216	192	205	209
Ni	mg/L	0.50		0.012	0.021	0.010	0.02	0.005	0.020	0.015	0.009	0.032
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Pb	mg/L	0.20		0.0114	0.0718	0.0206	0.0491	0.0153	0.0047	0.0015	0.0013	0.0053
Sb	mg/L			0.027	0.0183	0.0066	0.0197	0.0284	0.0330	0.0146	0.0146	0.0094
Se	mg/L		0.010	1.76	0.854	0.450	1.73	0.67	0.836	1.09	0.889	0.388
Si	mg/L			0.39	0.38	0.43	0.45	0.68	0.82	1.03	1.30	1.40
Sn	mg/L			0.008	<i>0.0005</i>	0.002	0.004	0.003	0.008	0.005	0.001	0.001
Sr	mg/L			0.272	0.230	0.150	0.334	0.358	0.320	0.354	0.398	0.520
Ti	mg/L			<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	0.011	<i>0.0015</i>
Tl	mg/L		0.0080	0.0044	0.0033	0.0021	0.0061	0.004	0.0028	0.0056	0.0063	0.0029
U	mg/L			0.0003	<i>0.0001</i>	<i>0.0001</i>	0.0002	0.0004	0.0007	0.0007	0.0009	0.0009
V	mg/L			<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>
Zn	mg/L	0.50		0.021	0.038	0.050	0.12	0.198	0.162	0.454	1.04	1.68

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. 10X the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates 10X British Columbia water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME guidelines

** = could not be determined due to sample matrix

na = not analyzed

Table II-1.15 Combined Wolverine D Composite Aging Test Results

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	4	7	15	29	60	90	120
pH	units		6.5-9.0	8.59	7.68	7.58	7.00	6.93	6.88	7.11	7.32	7.65
Conductivity	uS/cm			2000	2010	2040	2040	2030	1770	2080	2240	2360
TDS	mg/L			1590	1600	1610	1780	1790	1700	1720	1900	2030
Acidity	mg CaCO ₃ /L			398	437	437	397	375	306	235	124	179
Alkalinity	mg CaCO ₃ /L			47	29	37	14	9	12	28	32	59
F	mg/L			0.42	0.37	0.38	0.34	0.47	0.44	0.50	0.47	0.50
TSS	mg/L	15.0		25	2	32	<i>I</i>	<i>I</i>	4	4	2	3
Cl	mg/L			19	19	19	19	20	20	21	21	21
NO ₃ ⁻	mg N /L			0.25	0.16	0.20	0.17	0.16	0.16	0.15	0.16	0.16
SO ₄ ²⁻	mg/L		500†	590	550	630	590	630	740	890	1200	1200
NH ₃ + NH ₄	mg N/L		17.7 (T=15°C and pH 7)	1.3	1.1	0.4	1.1	1.2	1.2	1.1	1.0	1.0
Thiosalts	mg S ₂ O ₃ /L			553	446	5	525	362	386	243	211	260
CN _(T)	mg/L	1.0		0.02	0.02	0.01	0.005	0.005	0.005	0.005	0.01	0.001
CNO	mg/L			1.2	1.1	1.0	0.8	1.2	0.5	0.2	0.5	0.5
CNS	mg/L			2.2	2.8	2.4	2.5	3.1	11	6.7	**	na
Hg	mg/L		0.00026	0.00005	0.00005	0.00005	0.00005	0.00005	0.0001	0.0002	0.0002	0.0002
Hardness	mg CaCO ₃ /L			442	449	467	463	507	511	544	682	762
Ag	mg/L		0.0010	0.0039	0.0017	0.0044	0.0040	0.0072	0.0038	0.0060	0.0042	0.0039
Al	mg/L			0.190	0.118	0.112	0.057	0.022	0.018	0.006	0.002	0.007
As	mg/L	0.50		0.013	0.006	0.007	0.017	0.022	0.010	0.030	0.012	0.016
Ba	mg/L			0.331	0.227	0.375	0.324	0.123	0.056	0.033	0.024	0.024
Be	mg/L			0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
B	mg/L			0.04	0.02	0.02	0.014	0.016	0.017	0.026	0.015	0.025
Bi	mg/L			0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Ca	mg/L			171	174	181	178	191	189	197	244	272
Cd	mg/L		0.00017	0.0005	0.0010	0.0046	0.0049	0.0060	0.0096	0.0048	0.0046	0.0040
Co	mg/L			0.0008	0.0005	0.0008	0.0008	0.0008	0.0018	0.0010	0.0016	0.0024
Cr	mg/L		0.010*	0.002	0.002	0.0005	0.001	0.0005	0.0005	0.0005	0.0005	0.0005

Table II-2.15 Combined Wolverine D Composite Aging Test Results (cont'd)

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	4	7	15	29	60	90	120
Cu	mg/L	0.30		0.0080	0.0027	0.0174	0.0048	0.0060	0.0064	0.0046	0.0024	0.0048
Fe	mg/L			<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	0.03	<i>0.01</i>	<i>0.01</i>	0.05
K	mg/L			11.1	11.2	11.6	11.9	13.3	13.9	15.7	13.4	13.3
Li	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			3.31	3.45	3.87	4.75	7.36	9.80	12.9	17.6	20.1
Mn	mg/L			0.0013	0.0020	0.0065	0.0190	0.0483	0.190	0.114	0.269	0.288
Mo	mg/L		0.73	0.0497	0.0373	0.0374	0.0402	0.0426	0.0205	0.0262	0.0196	0.0108
Na	mg/L			235	234	237	233	253	259	232	238	227
Ni	mg/L	0.50		0.016	0.013	0.023	0.004	0.003	0.018	0.012	0.005	0.028
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Pb	mg/L	0.20		0.0089	0.0320	0.112	0.0782	0.0396	0.0046	0.0047	0.0024	0.0031
Sb	mg/L			0.0162	0.0095	0.0313	0.0573	0.119	0.0334	0.0704	0.0413	0.0297
Se	mg/L		0.010	1.66	1.06	1.38	1.93	0.91	0.823	1.65	1.19	1.26
Si	mg/L			0.31	0.33	0.32	0.37	0.51	0.54	0.84	0.99	1.18
Sn	mg/L			0.007	0.002	0.007	0.006	0.004	0.008	0.005	0.002	0.004
Sr	mg/L			0.282	0.213	0.298	0.318	0.312	0.312	0.346	0.470	0.527
Ti	mg/L			<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	0.163	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>
Tl	mg/L		0.0080	0.0021	0.0011	0.0021	0.0020	0.0028	0.0028	0.0036	0.0043	0.0034
U	mg/L			<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	0.0007	0.0008	0.0011	0.0018
V	mg/L			<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>
Zn	mg/L	0.50		0.010	0.018	0.097	0.125	0.113	0.160	0.226	0.354	0.514

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. 10X the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates 10X British Columbia water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME guidelines

** = could not be determined due to sample matrix

na = not analyzed

Table II-1.16 Combined Lynx D Composite aging test results

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	3	7	15	30	59	90	120
pH	units		6.5-9.0	8.36	7.87	7.12	7.26	7.32	6.90	7.63	7.72	7.53
Conductivity	uS/cm			1870	1830	1880	1890	1890	2110	2140	2250	2480
TDS	mg/L			1430	1540	1510	1510	1530	1680	1890	2000	2010
Acidity	CaCO ₃ mg/L			332	342	334	324	164	9.2	<i>I</i>	<i>I</i>	<i>I</i>
Alkalinity	CaCO ₃ mg/L			37	29	22	24	40	4	41	53	51
F	mg/L			0.22	0.22	0.23	0.21	0.20	0.21	0.32	0.29	0.25
TSS	mg/L	15.0		23	<i>I</i>	4	14	<i>I</i>	3	8	<i>I</i>	<i>I</i>
Cl	mg/L			19	20	20	19	19	19	20	21	21
NO ₃ ⁻	N mg/L			0.15	0.15	0.15	0.16	0.14	<i>0.025</i>	<i>0.025</i>	<i>0.025</i>	<i>0.025</i>
SO ₄ ²⁻	mg/L		500†	620	600	660	660	840	1000	1200	1400	1500
NH ₃ +NH ₄	N mg/L		0.19	1.3	1.4	1.2	1.0	1.0	5.3	0.9	1.4	1.6
Thiosalts	S ₂ O ₃ mg/L			439	414	421	381	260	23	5	5	5
CN _(T)	mg/L	1.0		0.01	0.01	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.001</i>
CNO	mg/L			2.1	2.1	2.3	2.0	1.1	<i>0.05</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>
CNS	mg/L			16	2.3	3.5	2.3	2.3	4.0	2.0	<i>0.1</i>	
Hg	mg/L		0.00026	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	0.0002	<i>0.00005</i>
Hardness	CaCO ₃ mg/L			462	473	526	547	558	663	813	910	946
Ag	mg/L		0.0010	0.0178	0.0145	0.0131	0.0099	0.0068	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>
Al	mg/L			0.080	0.073	0.056	0.015	0.011	0.007	<i>0.002</i>	<i>0.002</i>	0.012
As	mg/L	0.50		0.008	0.007	0.023	0.043	0.008	0.019	0.010	<i>0.0025</i>	0.005
Ba	mg/L			0.407	0.468	0.355	0.190	0.072	0.054	0.028	0.025	0.023
Be	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
B	mg/L			0.018	0.016	0.013	0.01	0.02	0.019	0.017	0.013	0.016
Bi	mg/L			<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>	<i>0.00015</i>
Ca	mg/L			178	182	201	207	209	249	303	337	348
Cd	mg/L		0.00017	0.0022	0.0030	0.0040	0.0069	0.0086	0.0028	0.0073	0.0031	0.0027
Co	mg/L			0.0008	0.0008	0.0004	0.0004	0.0009	0.0005	0.0007	0.0009	0.0018
Cr	mg/L		0.010*	0.002	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>	0.004

Table II-2.16 Combined Lynx D Composite aging test results (cont'd)

PARAMETER	UNITS	MMER ¹	10X CCME ²	ELAPSED NUMBER OF DAYS								
				0	1	3	7	15	30	59	90	120
Cu	mg/L	0.30		0.0499	0.0027	0.0063	0.0445	0.0224	0.0182	0.0023	0.0064	0.0050
Fe	mg/L			<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	0.03	0.04	0.03	0.05
K	mg/L			9.49	9.62	10.5	10.8	11.5	11.8	11.2	11.4	11.9
Li	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			4.47	4.64	5.91	7.40	9.09	10.3	13.5	16.7	18.5
Mn	mg/L			0.0160	0.0196	0.0412	0.160	0.358	1.05	0.836	1.43	0.860
Mo	mg/L		0.73	0.0042	0.0050	0.0083	0.0396	0.0296	0.0203	0.0180	0.0097	0.0059
Na	mg/L			193	196	218	218	215	215	206	204	206
Ni	mg/L	0.50		0.018	0.019	0.005	0.008	0.005	0.005	0.006	0.004	0.038
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Pb	mg/L	0.20		0.0218	0.0396	0.0614	0.208	0.0470	0.0512	0.0081	0.0064	0.0047
Sb	mg/L			0.0129	0.0167	0.0161	0.0423	0.0334	0.0375	0.0123	0.0073	0.0072
Se	mg/L		0.010	1.95	1.81	0.705	1.68	1.21	0.39	0.27	0.11	0.12
Si	mg/L			0.27	0.28	0.34	0.52	0.86	1.25	1.30	1.23	1.32
Sn	mg/L			0.006	0.008	0.006	0.005	0.005	0.005	0.006	0.001	0.002
Sr	mg/L			0.308	0.318	0.317	0.297	0.313	0.415	0.480	0.515	0.607
Ti	mg/L			<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	0.009	<i>0.0015</i>	<i>0.0015</i>
Tl	mg/L		0.0080	0.0100	0.0092	0.0079	0.0074	0.0051	0.0016	0.0016	0.0011	0.0020
U	mg/L			0.0003	0.0004	0.0003	0.0004	0.0007	<i>0.0001</i>	0.0004	0.0003	0.0004
V	mg/L			0.0011	0.0010	<i>1</i>	0.0011	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	0.0013
Zn	mg/L	0.50		0.027	0.039	0.115	0.28	0.36	0.55	0.33	0.48	0.54

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. 10X the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates 10X British Columbia water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME guidelines

Figure II-1.3 through Figure II-1.5 shows the concentrations of TSS, thiosalts, pH and alkalinity, respectively, changing over time during the aging tests.

Figure II-1.6 indicates tested tailings materials produce significant suspended particulates during the first few days of testing except for the combined Lynx D composite. However, TSS concentrations drop below the MMER limit (15 mg/L) between Day 4 and Day 7 suggesting tailings materials may only exceed guidelines initially before they equilibrate.

The thiosalts (partly oxidized linear polysulphide chains) are a potential concern because further oxidation results in the production of sulphuric acid leading to the potential solubilization of additional metal(loid)s. Aging tests (Figure II-1.3) show thiosalt concentrations are elevated during the initial stages of the test but decrease over time, suggesting thiosalt release to the aqueous phase is short-lived (0-20 days). During operations, thiosalts can be expected to oxidize in the tailings pond during operations but the sulphuric acid that is generated from the oxidation of thiosalts to sulphate is expected to be neutralized by the alkalinity in the tailings slurry water. On closure, there will be a short lag time until the remaining thiosalts are oxidized and water quality stabilizes. The production of sulphuric acid from thiosalt oxidation appears to be minimal and confined to the time immediately after sample submergence.

Figure II-1.5 shows an initial decrease in pH, most likely a result of thiosalt oxidation, followed by a rise and stabilization after 30 days. The upward trend and stabilization of pH after 20 days is likely a result of lime or carbonate dissolution inferred from the alkalinity production in Figure II-1.6.

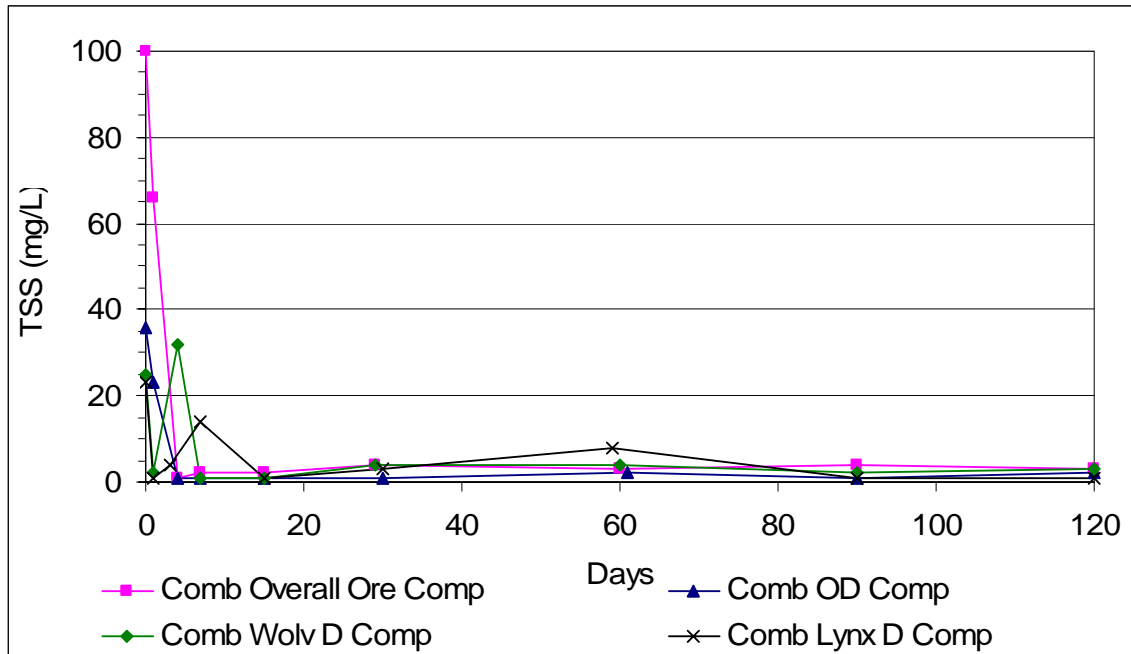


Figure II-1.3 TSS in Supernatant During Aging Tests

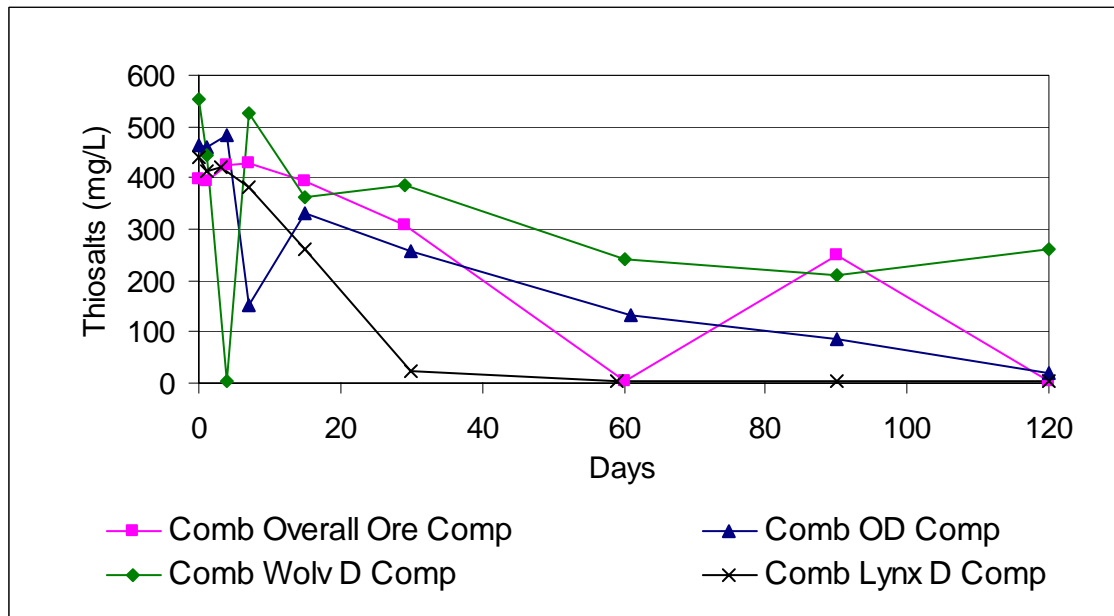


Figure II-1.4 Thiosalt in Supernatant During Aging Tests

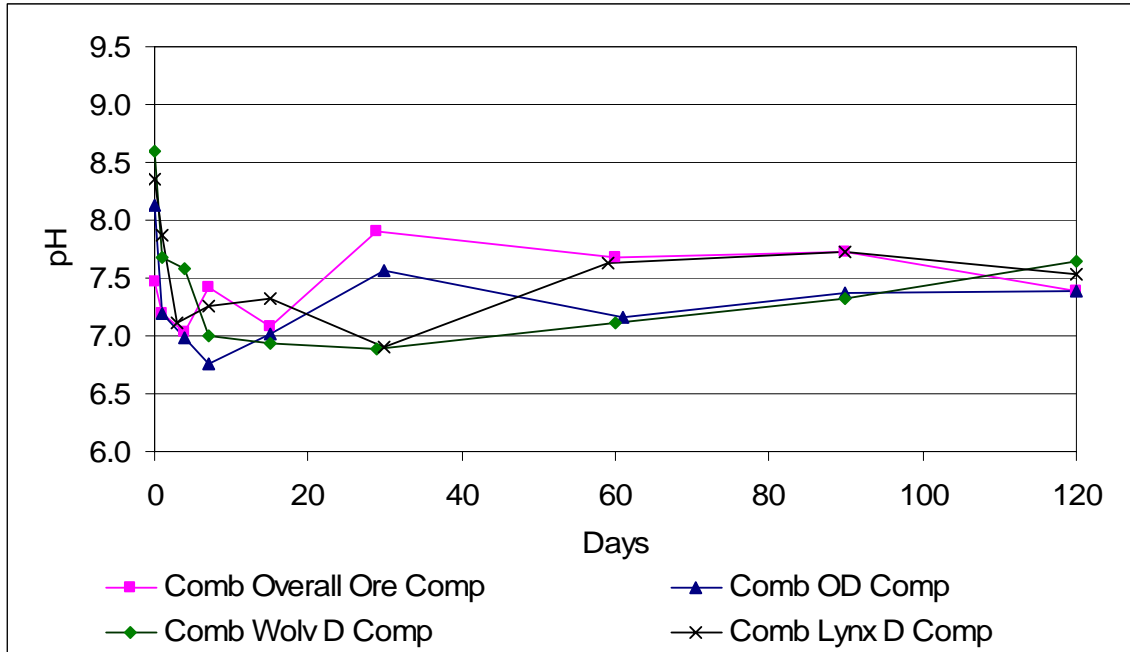


Figure II-1.5 pH in Supernatant During Aging Tests

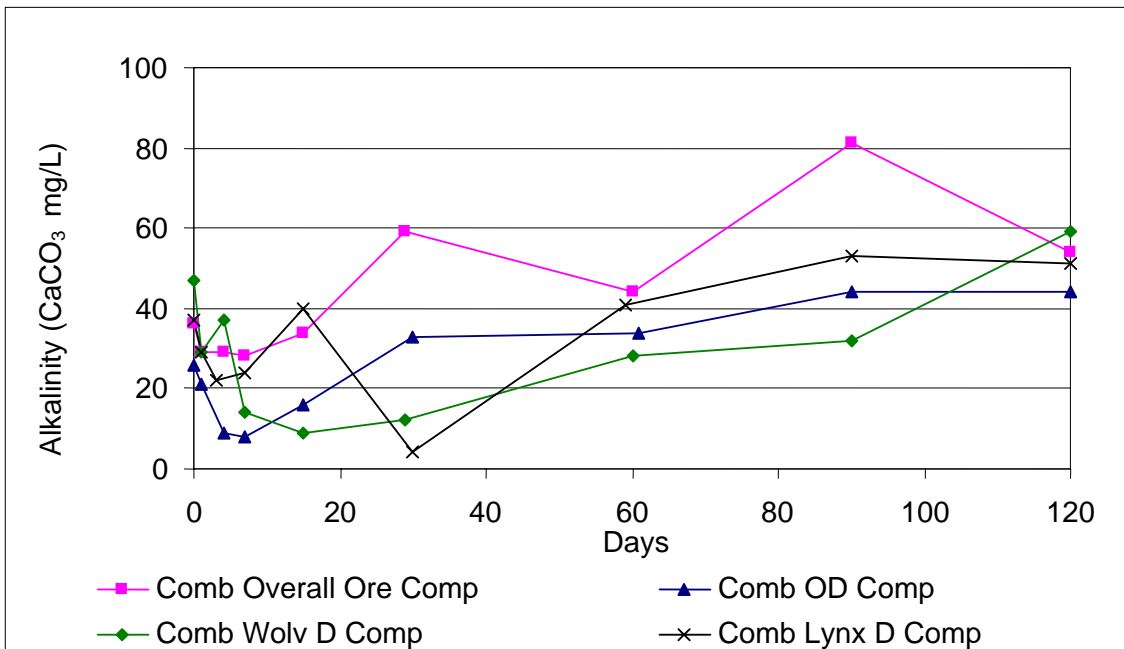


Figure II-1.6 Alkalinity in Supernatant During Aging Tests

Day 0 of the aging tests provides an approximation of total metal concentrations flushed from the tailings as they are first submerged in the Wolverine Tailings impoundment. Due to the abundance of Pb-, Cu-, Zn-, As-, sulphides, initial sulphuric acid production via thiosalt oxidation may result in the solubilization of these elements. Figure II-1.7 and Figure II-1.8 shown Se and Cd may also be released to the surrounding aqueous phase in excess of 10X CCME water quality guidelines (0.01 mg/L and 0.00017 mg/L for Se and Cd, respectively). Se substitution for S in the galena and Cd abundance in sphalerite, reported by Gartner Lee (2004), are likely not the sources of elemental releases due to the lack of concomitant release of dissolved Pb and correlation with dissolved Zn. The origin of the Zn (Figure II-1.9) may be due to several scenarios:

- The dissolution of zinc-bearing carbonates, which is inferred from the concomitant increases in both dissolved Ca and alkalinity with time;
- The dissolution of accumulated oxidation products (zinc sulphate);
- Zn and Cd may be organically complexed, however contributions to dissolved inventories are likely minor due to the small amount of organic C present in these sample (< 1 wt.%); and
- Reagents added to processing streams ($ZnSO_4$).

In addition, Figure II-1.7 through Figure II-1.9 suggests that “aging” may not have reached steady state as concentrations continue to increase at Day 120.

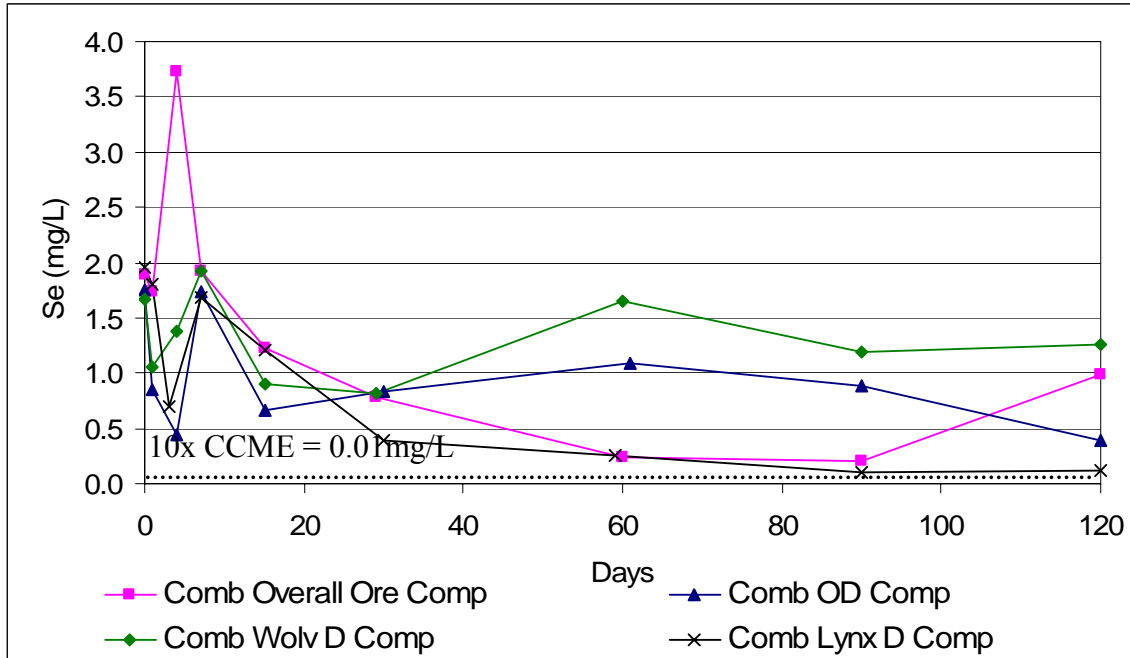


Figure II-1.7 Se in Supernatant During Aging Tests

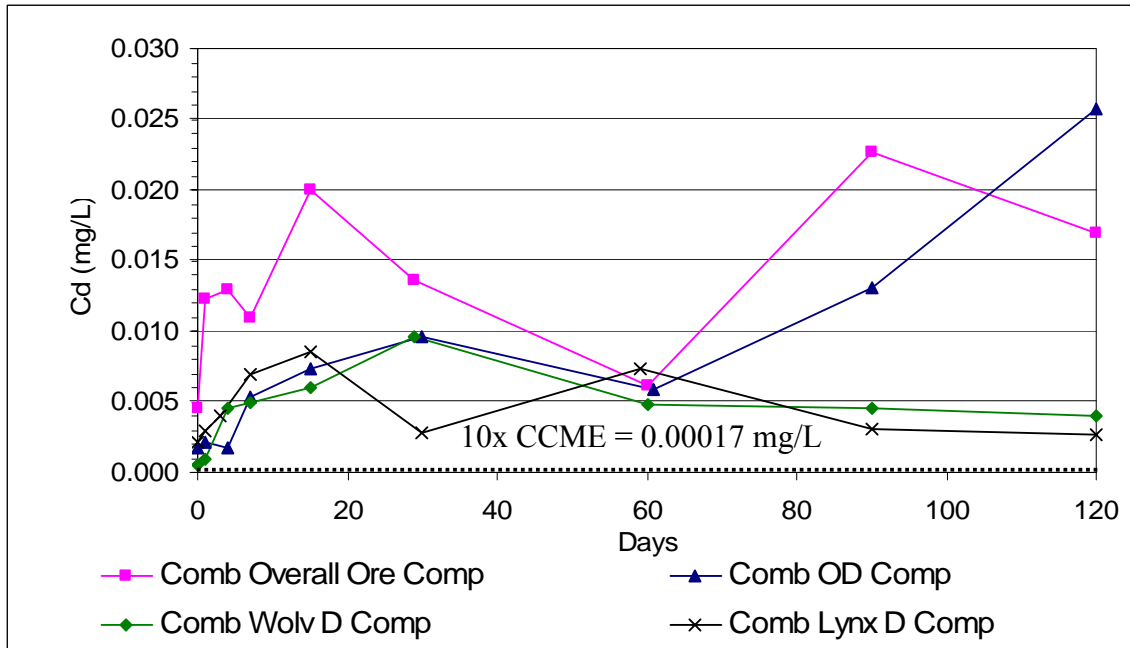


Figure II-1.8 Cd in Supernatant During Aging Tests

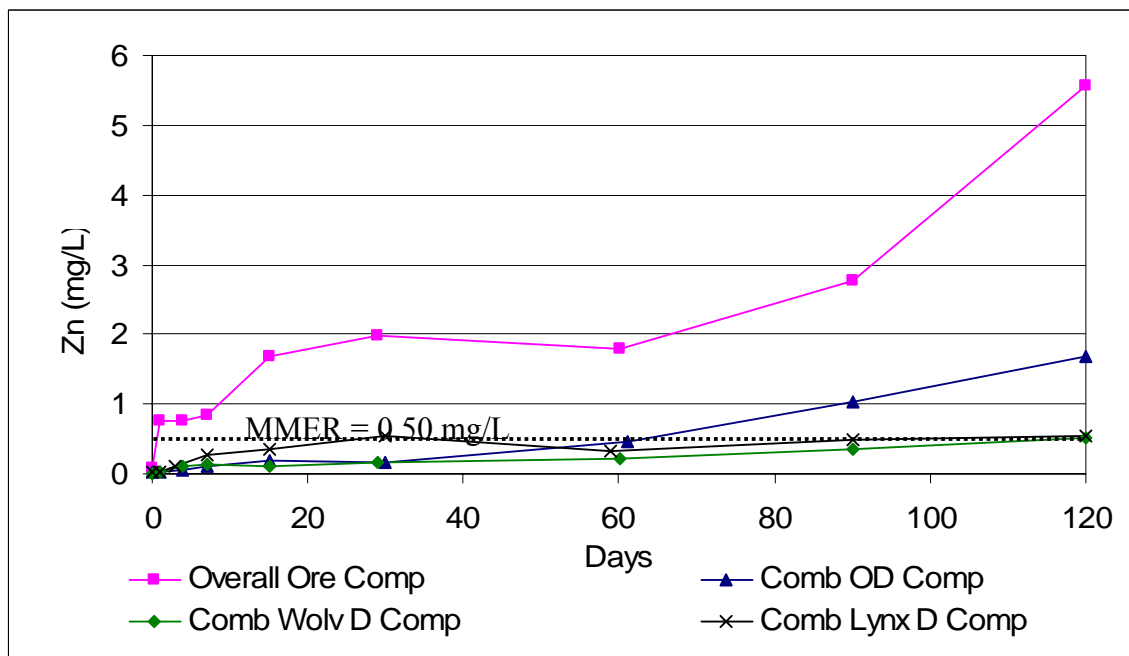


Figure II-1.9 Zn in supernatant during aging tests

1.5.2 Acute Lethality Testing

1.5.2.1 Methodology

The 36 hour decant from the aged Combined Overall Ore Tailings and the 24 hour decant from the aged Combined OD Composite, Combined Wolverine D Composite and Combined Lynx D Composite Tailings were subjected to LC₅₀ acute lethality testing of *Daphnia magna* (i.e., the lethal concentration required to kill 50% of the tested population). LC₅₀ acute lethality of rainbow trout and *Daphnia magna* was completed on the 120 Day decant from the aged Combined Overall Ore Tailings, the OD Combined tailings, the Wolverine D tailings and the Lynx D tailings. The test measured the percent mortality of *Daphnia magna* and rainbow trout in varying concentrations of effluent using standardized test procedures following the *Daphnia magna* Acute Lethality Toxicity Test Protocol EPS 1/RM/14 and Acute Lethality of Liquid Effluents to Fish EPS 1/RM/13 protocols from Environment Canada.

1.5.2.2 Results

Tailings supernatant from acute lethality aging tests results on *Daphnia magna* at day 1 and Day 120 are presented in Table II-1.17. Results indicate that all of the aged decant samples submitted had 100% mortality at 100% effluent concentration. The LC₅₀ values indicate that significant dilution of the sample solutions would be required to render the samples non-toxic. Water treatment testing is recommended to evaluate the effective treatment strategies. Similar results are seen for testing results on rainbow trout, presented in Table II-1.18. Comparing the results for Day 1 and Day 120 for both species shows the effect of the increasing Zn concentration on the Combined Overall Ore Tailings. Cd is the element that actually increases and the table below shows the percentage 48-hr LC₅₀ decreases from day 1.5 to 120.

Table II-1.17 Tailings Supernatant Acute Lethality Results for *daphnia magna*

TAILINGS SAMPLE	DAY OF TESTING	TOXICITY TEST SPECIES	% MORTALITY AT 100% EFFLUENT CONCENTRATION	48 h LC ₅₀
Comb Overall Ore Comp	1.5	<i>Daphnia magna</i>	100	37.7 %
Comb OD Comp	1	<i>Daphnia magna</i>	100	15.5 %
Comb Wolv D Comp	1	<i>Daphnia magna</i>	100	9.7 %
Comb Lynx D Comp	1	<i>Daphnia magna</i>	100	19.2%
Comb Overall Ore Comp	120	<i>Daphnia magna</i>	100	19.1%

Table II-1.18 Tailings Supernatant Acute Lethality Results for Rainbow Trout

TAILINGS SAMPLE	DAY OF TESTING	TOXICITY TEST SPECIES	% MORTALITY AT 100% EFFLUENT CONCENTRATION	96 h LC ₅₀
Comb Overall Ore Comp	120	Rainbow Trout	100	10.9 %
Comb OD Comp	120	Rainbow Trout	100*	< 6 %
Comb Wolv D Comp	120	Rainbow Trout	100**	< 3.1 %
Comb Lynx D Comp	120	Rainbow Trout	100**	> 50 %

* tested in 6 % effluent

** tested in 50 % effluent

The minimum LC₅₀ observed, at 100% effluent concentrations, was approximately 10%. This suggests that with at least 10-fold dilution within the tailings pond and downstream of the impoundment, the tailings supernatant would no longer be considered a deleterious substance under the Fisheries Act.

1.5.3 Tailings Humidity Cells

Kinetic testing in the form of flood leach humidity cells of the four combined tailings samples was initiated in June and July of 2005 by SGS Lakefield. The following provides a summary of the Wolverine tailings humidity cells to August 26, 2008, provided by Marsland Environmental Associates. The Overall Ore Composite (OC) and Overall Diluted ore composite (OD) tailings humidity cells have reached weeks 168 and 162, respectively.

1.5.3.1 Results

The humidity cell test data from inception to August 2008 is provided in The pH of all cells has remained relatively constant generally between pH 6.4 and pH 7.0 (see Figure II-1.10). All the Diluted Ore tailings cells experienced a temporary pH depression within the first 20 weeks, before rebounding. The Overall Ore Composite tailings did not experience this. It is surmised that the amount of thiosalt in solution (400 mg/L) did not exceed the rapid neutralization capacity of the tailings for the OC sample, whereas higher amounts of thiosalt (600-1200 mg/L) in the other cells clearly did. Once the initial flush of thiosalts was over (i.e., thiosalts dropped below 400 mg/L), the pH has been unaffected by these comparatively low concentrations.

There have been a few other instances when the pH dropped below pH 6.0 with the lowest pH in Cell OC at pH 4.7 at week 124. It should be noted that coincident with the low pH value at week 124, the sulphate production was measured at 28 mg/kg/wk well below the 5-week average. The low sulphate value is reflected in the lower conductivity. The lower pH is also reflected in the lower alkalinity and higher acidity values than previous and following cycles. In general, there appears to be some additional variability in the data fluctuations since week 109. These fluctuations do not appear to be occurring simultaneously in both Cell OD and OC, which suggests that the fluctuations are related to variability in reaction rates within the humidity cell and not artifacts of the laboratory testing. However, no trend in median pH is notable.

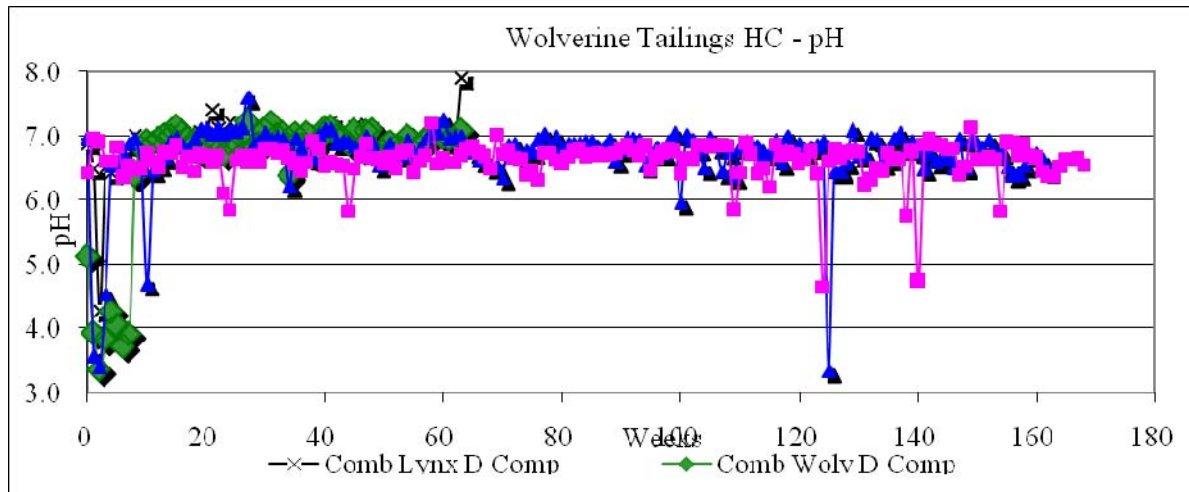


Figure II-1.10 Wolverine Tailings Humidity Cells - pH

Acidity and alkalinity production rates remain low in both cells, consistent with the near-neutral pH and limited by calcite solubility.

The Sulphate production rate for Cell OD has shown a slight decline over the entire testing period (Figure II-1.11). However, this decline has become more evident since week 113 dropping from 232 mg/kg/wk to 116 mg/kg/wk at week 162. Cell OC shows sulphate production remaining relatively constant (fluctuating around 100 mg/kg/wk) from week 70 through week 141. Since week 142 and through to the final measurement taken for this reporting period at week 168, the sulphate production rate has remained consistently above 100 mg/kg/wk and reaching as high as 142 mg/kg/wk at week 150. Both cells now have virtually identical sulphate production rates.

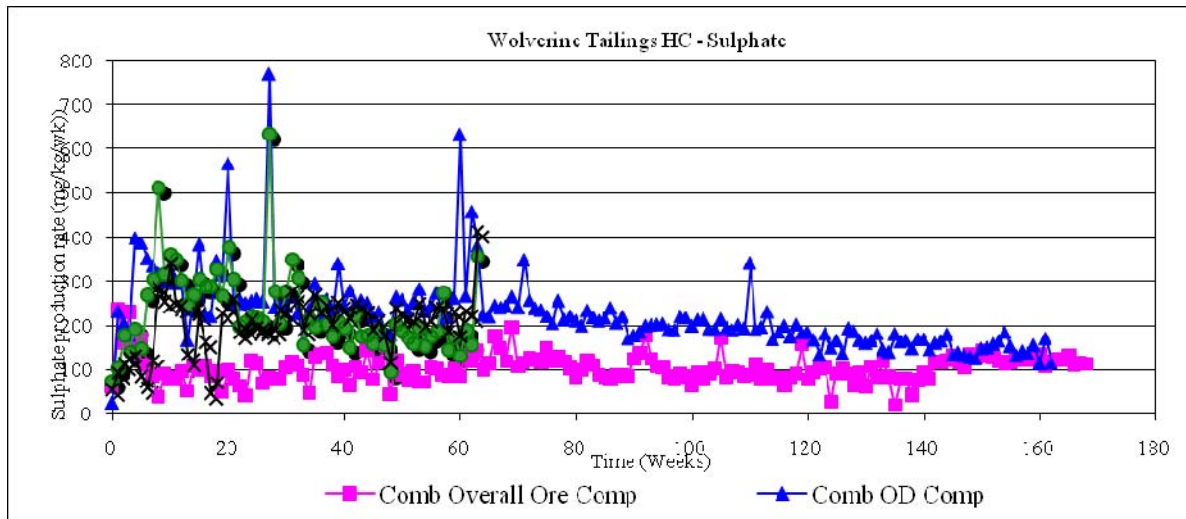


Figure II-1.11 Wolverine Tailings Humidity Cells - Sulphate

Both cells show an abundance of total sulphur (mostly as sulphide) remaining (98.0% and 95.4% for cells OC and OD, respectively) with sulphate sulphur contents of 76.7% and 39.8% for cells OC and OD, respectively.

Table II-1.19 summarizes the range in loading rates for Se and Zn from recent weeks until the current sampling on August 26, 2008.

Table II-1.19 Range in Leachate Elemental Loading Rate over past 20 weeks

ELEMENT	CELL OC LOADING RATE (mg/kg/wk)	CELL OD LOADING RATE (mg/kg/wk)
Se	0.052 – 0.059	0.047 – 0.081
Zn	3.1 – 4.1 ¹	0.91 – 1.3

¹ Zinc loading rates in the 20 weeks prior to the previous reporting period ranged from 1.4 to 1.9 mg/kg/wk

Current Zn loadings in both Cell OC and OD are well below the initial flush values. However, since the last reporting period (week 129 for the OC cell), the range in zinc loadings has approximately doubled and appears from Figure II-1.12 to be rising. The increase in Zn loading rates occurred after week 135 and is approximately coincident with the increase in the sulphate production rate noted above.

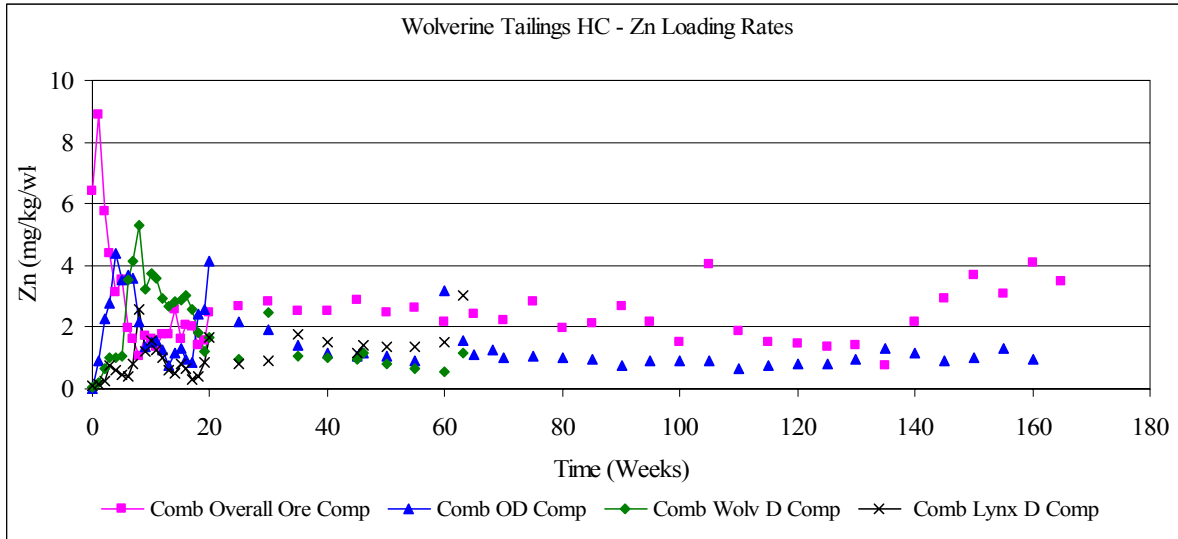


Figure II-1.12 Wolverine Tailings Humidity Cells - Zn Loading Rates

Se loadings have remained relatively constant over the testing period for both cells since the initial flush (see Figure II-1.13). This is likely due to the relatively constant and neutral pH, but shows that soluble minerals still remain even after 3 years of leaching.

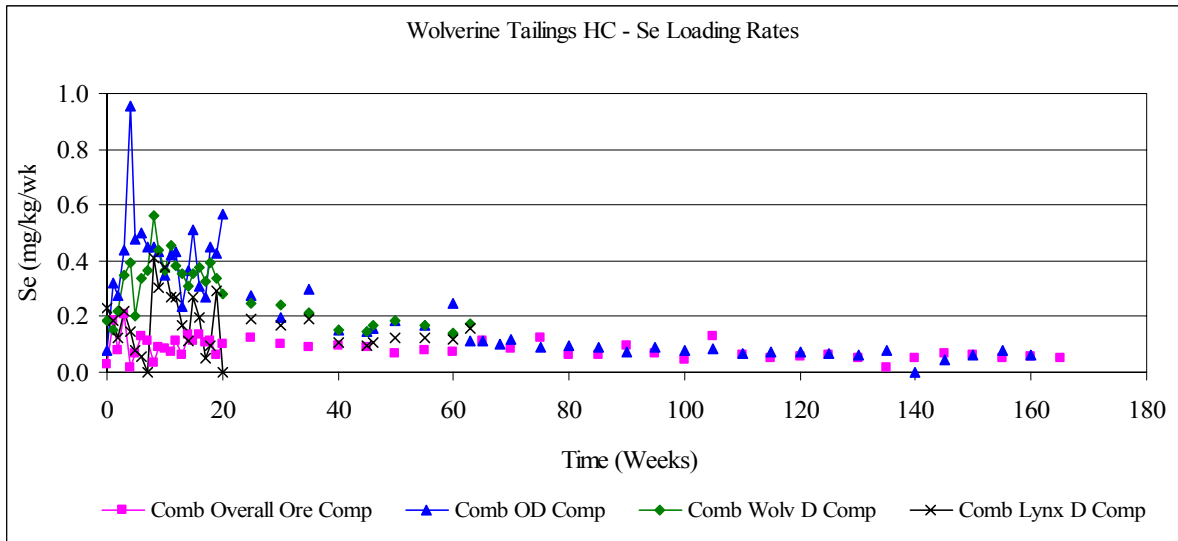


Figure II-1.13 Wolverine Tailings Humidity Cells - Se Loading Rates

Table II-1.20 shows that in the OC cell, of the original Se and Zn contained within the sample used to charge the humidity cell, 5% and 3%, respectively have been flushed out. While, for the OD cell, 14% and 4% of the Se and Zn, respectively have been removed through weekly cell flushing. These low percentages at this stage in the program suggest that Se and Zn leaching will continue for an extended period.

Table II-1.20 Percent Removal of Original Se and Zn

CELL	HEAD ICP Se (mg/kg)	TOTAL Se RELEASED OVER HUMIDITY CELL PERIOD (mg/kg)	% Se REMOVED	HEAD ICP Zn (mg/kg)	TOTAL Zn RELEASED OVER HUMIDITY CELL PERIOD (mg/kg)	% Zn REMOVED
OC	364	17	5	19,000	547	3
OD	261	36	14	5,500	212	4

1.5.3.2 Time to Onset of ARD

In humidity cell testing, it is commonly assumed that sulphide oxidation is not taking place at a substantial rate until flushing of all of the original sulphate measured during the pre-test ABA characterization is complete. Cells OC and OD are showing measurable sulphate in the leachate collected weekly. It is likely that a majority of the sulphate measured is due to flushing of the original sulphate within the sample with some sulphate produced due to sulphide oxidation, particularly in the past few cycles for the OC cell. It is difficult to assess, however, what portion of the sulphate produced is due to sulphide oxidation. Therefore the assumption is made that all sulphate is from flushing as explained above.

The time to sulphate sulphur depletion has been estimated to be 12 and 3 years for Cells OC and OD, respectively. Approximately 60% of the initial sulphate has been removed from the OD cell, however, only 23% has been removed from the OC cell. As mentioned, this assumes that all the sulphate measured in the solution is due to flushing of the original sulphate. It is expected that eventually the sulphide oxidation rate would begin to increase with NP depletion and the onset of acidic conditions.

The time to NP depletion is required to estimate the time to onset of ARD within a laboratory humidity cell. However, the initial sulphate is still flushing from the cells, so it is not possible to ascertain what portion of the sulphate released is from sulphide oxidation. This renders the Carbonate Molar Ratio calculations invalid and precludes an accurate calculation of the time for NP depletion. Once the initial sulphate is believed to have flushed, NP depletion rates can be defined more explicitly. Even if all the current sulphate production from the past 26 weeks in cell OC (the beginning of the rise in sulphate flushing) were to be from sulphide oxidation, it would still take another 11 years in the laboratory humidity cell for all the Sobek-NP to become depleted.

Based on these estimates, acid generation would not occur in the Wolverine tailings for many years. Nevertheless, elevated concentrations of selenium and zinc can be expected in any water contacting the tailings solids.

1.5.3.3 Test Data

The humidity cell test data from inception to August 2008 is provided in the following pages and includes physical parameter and ICP-MS results for cells:

- Lynx – July 22, 2005 through October 3, 2006 (cells decommissioned October 3, 2006)
- Wolverine - July 22, 2005 through October 3, 2006 (cells decommissioned October 3, 2006)
- Overall Diluted Ore Composite - July 22, 2005 through August 26, 2008
- Overall Ore Composite – June 6, 2005 through August 26, 2008

Lynx

Wolverine

Overall Diluted Ore Composite

Overall Ore Composite

1.5.4 Sub-aqueous Column

1.5.4.1 Methodology

The sub-aqueous column tests were conducted to simulate the leaching effects of water infiltration from material stored under water cover. The columns have similar construction to the humidity cells with some modifications. After charging each 15.3 cm diameter cell equipped with an outflow port with one kilogram of sample, the cell was then covered with one layer of nylon mesh on top of which was placed a length of coiled tubing punctured with holes. This tubing passed through the lid of the column and into a feed bottle containing distilled water. Deionised water was added to the tailings to a level of 60 cm above the cell base. Weekly leachate samples were collected via the outflow port in the base after which the water level in the column was topped up to 60 cm. A total of eight weeks of testing was scheduled for each sample. Figure II-1.14 shows the set-up of the trickle leach columns and the material inside each column.

The leachate of the sub-aqueous columns was collected and analyzed for pH, conductivity, acidity, alkalinity, thiosalts, anions (F^- , Cl^- , SO_4^{2-} and NO_3^-), cyanide (CN), thiocyanate (CNS), cyanate (CNO), ammonia + ammonium ($NH_3 + NH_4^+$) and a suite of dissolved metal(loid)s via ICP-MS including Hg by SGS Lakefield.



Figure II-1.14 Set-up of Sub-aqueous Columns

1.5.4.2 Results

Table II-1.21 and Table II-1.22 list the results of the sub-aqueous column tests for the Combined Overall Ore Composite and Combined Overall Dilute Composite Tailings samples.

Table II-1.21 Combined Overall Ore Composite Tailings Sub-aqueous Column Results

PARAMETER	UNIT	MMER ¹	10X CCME ²	WEEKS							
				1	2	3	4	5	6	7	8
pH	units		6.5-9.0	7.43	7.18	7.66	8.04	7.36	7.24	7.86	na
Conductivity	µS/cm			2520	1670	740	330	167	156	240	na
Acidity	mg CaCO ₃ /L			1	1	1	1	1	1	1	na
Alkalinity	mg CaCO ₃ /L			137	93	82	73	29	27	59	na
F	mg/L			0.31	0.46	0.49	0.35	0.06	0.10	0.46	0.38
Cl	mg/L			0.1	0.1	0.3	0.2	0.1	0.1	0.1	na
NO ₃ ⁻	mg N /L		130	0.025	0.05	0.13	0.025	0.025	0.16	0.025	na
SO ₄	mg/L		500†	3100	1100	370	95	50	47	52	na
NH ₃ + NH ₄ ⁺	mg N /L		17.7 (T=15°C and pH 7)	0.4	0.1	0.2	0.05	0.05	0.05	0.1	0.1
Thiosalts	mg S ₂ O ₃ /L			35	5	5	5	5	5	5	na
CN _(T)	mg/L	1.0		0.005	0.005	0.005	0.005	0.005	0.001	0.005	0.005
CNO	mg/L			0.05	0.05	0.05	0.05	0.05	0.05	0.05	na
CNS	mg/L			0.1	0.6	0.1	0.1	0.1	0.3	0.1	0.1
Ag	mg/L		0.001	0.0006	0.0001	0.00005	0.00005	0.00005	0.0025	0.00005	0.00005
Al	mg/L			0.012	0.006	0.002	0.002	0.002	0.005	0.002	0.002
As	mg/L	0.5		0.018	0.006	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Ba	mg/L			0.039	0.032	0.041	0.060	0.045	0.040	0.088	0.081
Be	mg/L			0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
B	mg/L			0.03	0.03	0.02	0.005	0.005	0.005	0.005	0.005
Bi	mg/L			0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
Ca	mg/L			555	441	166	64.4	26.8	27.1	42.3	36.5
Cd	mg/L		0.00017	0.0057	0.0002	0.0002	0.00005	0.0017	0.0024	0.00005	0.00005
Co	mg/L			0.0013	0.0004	0.00015	0.00015	0.0003	0.0003	0.00015	0.00015
Cr	mg/L		0.01*	0.0005	0.001	0.0005	0.003	0.0005	0.0005	0.0005	0.0005
Cu	mg/L	0.30		0.0109	0.0034	0.0010	0.0004	0.0004	0.0004	0.0004	0.0004
Fe	mg/L		3.0	1.01	4.06	0.49	0.05	0.01	0.01	0.04	0.03
Hg	mg/L		0.00026	0.0002	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005

PARAMETER	UNIT	MMER ¹	10X CCME ²	WEEKS							
				1	2	3	4	5	6	7	8
K	mg/L			11.9	5.36	2.32	1.43	0.63	0.58	1.31	1.11
Li	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			34.2	6.69	2.13	1.15	1.47	1.50	1.50	1.42
Mn	mg/L			3.86	2.10	0.569	0.173	0.167	0.166	0.105	0.0900
Mo	mg/L		0.73	0.0055	0.0070	0.0083	0.0112	0.0030	0.0031	0.0195	0.0224
Na	mg/L			51.2	3.46	1.68	1.53	1.33	1.27	1.34	1.16
Ni	mg/L	0.5		0.019	0.002	0.005	<i>0.0005</i>	<i>0.0005</i>	<i>0.001</i>	<i>0.0005</i>	<i>0.0005</i>
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Pb	mg/L	0.2		0.0107	0.0003	0.0003	<i>0.0001</i>	0.0136	0.0089	0.0004	0.0005
Sb	mg/L			0.0140	0.0113	0.0111	0.0091	0.0046	<i>0.025</i>	0.0099	0.0092
Se	mg/L		0.010	0.199	0.015	0.0025	0.0025	0.017	0.016	0.008	0.008
Si	mg/L			4.48	4.37	2.88	2.25	0.58	0.51	2.10	1.96
Sn	mg/L			0.003	0.002	<i>0.0005</i>	<i>0.0005</i>	0.001	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>
Sr	mg/L			0.917	0.455	0.197	0.106	0.0602	0.0540	0.0959	0.101
Ti	mg/L			0.0015	0.0015	<i>0.0015</i>	<i>0.0015</i>	<i>0.0015</i>	<i>0.0025</i>	<i>0.0015</i>	<i>0.0015</i>
Tl	mg/L		0.008	0.0046	0.0021	0.0007	0.0002	0.0008	0.0008	<i>0.0001</i>	<i>0.0001</i>
U	mg/L			0.0060	0.0011	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
V	mg/L			<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.00045</i>	<i>0.001</i>	<i>0.00045</i>	<i>0.00045</i>
Zn	mg/L	0.5		1.86	0.635	0.055	0.004	0.129	0.17	0.006	0.005

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. 10X the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates 10X British Columbia water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME guidelines

na = not analyzed

Table II-1.22 Combined OD Composite Tailings Sub-aqueous Column Results

PARAMETER	UNITS	MMER ¹	10X CCME ²	WEEKS								
				0	1	2	3	4	5	6	7	8
pH	units		6.5-9.0	7.58	7.87	7.97	na	8.06	8.11	7.85	7.77	7.65
Conductivity	µS/cm			360	270	260	na	206	190	173	167	160
Acidity	mg CaCO ₃ /L			18	1	1	na	1	1	1	1	1
Alkalinity	mg CaCO ₃ /L			67	87	94	na	73	66	53	51	40
F	mg/L			0.16	0.27	0.20	0.15	0.09	0.11	0.07	0.07	0.07
Cl	mg/L			6.1	1.1	0.7	na	0.7	0.5	0.6	0.5	0.4
NO ₃	mg N /L		130	3.85	0.33	0.25	na	0.22	0.25	0.20	0.14	0.05
SO ₄	mg/L		500†	41	18	13	na	29	28	31	33	38
NH ₃ + NH ₄ ⁺	mg N /L		17.7 (T=15°C and pH 7)	0.1	0.1	0.2	0.05	0.2	0.2	0.2	0.2	0.7
Thiosalts	mg S ₂ O ₃ /L			69	30	18	na	5	5	5	5	5
CN _(T)	mg/L	1.0		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
CNO	mg/L			0.05	0.05	0.05	na	0.05	0.05	0.05	0.05	0.05
CNS	mg/L			0.8	0.5	0.2	6.2	na	na	na	na	na
Ag	mg/L		0.001	0.0017	0.0003	0.00005	0.00005	0.0001	0.00005	0.00005	0.00005	0.00005
Al	mg/L			0.002	0.002	0.002	0.002	0.00005	0.00005	0.00005	0.00005	0.00005
As	mg/L	0.5		0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.004	0.007	0.002
Ba	mg/L			0.526	0.377	0.398	0.324	0.0025	0.0025	0.0025	0.0025	0.0025
Be	mg/L			0.0025	0.0025	0.0025	0.0025	0.262	0.265	0.195	0.166	0.171
B	mg/L			0.005	0.005	0.005	0.005	0.0025	0.0025	0.0025	0.0025	0.0025
Bi	mg/L			0.00015	0.00015	0.00015	0.00015	0.005	0.005	0.005	0.005	0.005
Ca	mg/L			58.6	53.8	49.8	42.0	39.6	31.6	31.4	28.7	25.9
Cd	mg/L		0.00017	0.0124	0.0032	0.0009	0.0003	0.00015	0.00015	0.00015	0.00015	0.00015
Co	mg/L			0.0014	0.0003	0.00015	0.00015	0.00005	0.00005	0.00005	0.00005	0.0002
Cr	mg/L		0.01*	0.0005	0.0005	0.0005	0.0005	0.00015	0.00015	0.00015	0.00015	0.00015
Cu	mg/L	0.30		0.0044	0.0004	0.0004	0.0015	0.0005	0.0005	0.0005	0.0005	0.0005
Hg	mg/L		3.0	0.00005	0.00005	0.00005	0.00005	0.0004	0.0004	0.0012	0.0027	0.0014
Fe	mg/L		0.00026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

PARAMETER	UNITS	MMER ¹	10X CCME ²	WEEKS								
				0	1	2	3	4	5	6	7	8
K	mg/L			1.48	1.23	1.10	1.07	1.11	1.06	0.81	0.65	0.58
Li	mg/L			<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>	<i>0.0025</i>
Mg	mg/L			5.87	2.90	2.55	2.18	1.96	1.56	1.64	1.48	1.53
Mn	mg/L			0.786	0.443	0.362	0.325	0.273	0.168	0.167	0.148	0.129
Mo	mg/L		0.73	0.0012	0.0014	0.0018	0.0022	0.0021	0.0025	0.0045	0.0060	0.0095
Na	mg/L			0.43	0.22	0.25	0.28	0.29	0.21	0.19	0.15	0.11
Ni	mg/L	0.5		0.008	0.005	0.003	0.002	0.001	0.001	<i>0.0005</i>	<i>0.0005</i>	<i>0.0005</i>
P	mg/L			<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Pb	mg/L	0.2		0.0410	0.0461	0.0404	0.0104	0.0014	0.0009	0.0008	0.0005	0.0003
Sb	mg/L			0.0097	0.0111	0.0139	0.0153	0.0168	0.0234	0.0216	0.0221	0.0228
Se	mg/L		0.010	0.081	0.038	0.032	0.053	0.015	0.012	0.012	0.009	0.010
Si	mg/L			1.30	1.51	1.48	1.41	1.31	1.35	1.29	1.08	1.09
Sn	mg/L			0.056	0.039	0.028	0.018	0.013	0.012	0.010	0.009	0.008
Sr	mg/L			0.119	0.0891	0.0843	0.0901	0.0801	0.0717	0.0681	0.0679	0.0589
Ti	mg/L			<i>0.015</i>	<i>0.015</i>	<i>0.015</i>	<i>0.015</i>	<i>0.015</i>	<i>0.015</i>	<i>0.015</i>	<i>0.015</i>	<i>0.015</i>
Tl	mg/L		0.008	0.0076	0.0049	0.0055	0.0050	0.0051	0.0054	0.0035	0.0024	0.0021
U	mg/L			<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
V	mg/L			0.0009	<i>0.00045</i>	<i>0.00045</i>	0.0014	<i>0.00045</i>	<i>0.00045</i>	0.0010	<i>0.00045</i>	<i>0.00045</i>
Zn	mg/L	0.5		0.327	0.214	0.167	0.130	0.076	0.044	0.025	0.015	0.009

1. Metal Mining Effluent Regulations (2002) for maximum monthly mean concentrations.

2. 10X the Canadian Council of Ministers of the Environment Canadian Water Quality Guidelines for the protection of freshwater aquatic life

† indicates 10X British Columbia water quality guidelines for the protection of freshwater aquatic life.

*Hexavalent chromium

Italics indicates measured value less than detection limit and listed as one half of the detection limit

Bold indicates measured values in excess of MMER and/or 10x CCME guidelines

na = not analyzed

Figure II-1.15 and Figure II-1.16 show dissolved sulphate and thiosalt fluctuations during the sub-aqueous column test. Large concentrations of sulphate are released only from the Combined Overall Ore Composite Tailings samples. The sulphate source is unlikely to originate from thiosalts since both samples have comparable concentrations of thiosalts being released in similar laboratory conditions. The source of the sulphate from the Combined Overall Ore Composite can not be assigned to a single source but may in fact be a combination of sources (e.g., flotation circuit reagents ($ZnSO_4$), gypsum dissolution and Na, K and Mg salt dissolution).

Figures II-2.2.5, II-2.2.6 & II-2.2.7 show Cd, Se and Zn releases, respectively, during the initial testing period exceed MMER regulations and water quality guidelines before reaching a steady state suggesting water cover treatment for these particular elements will be required.

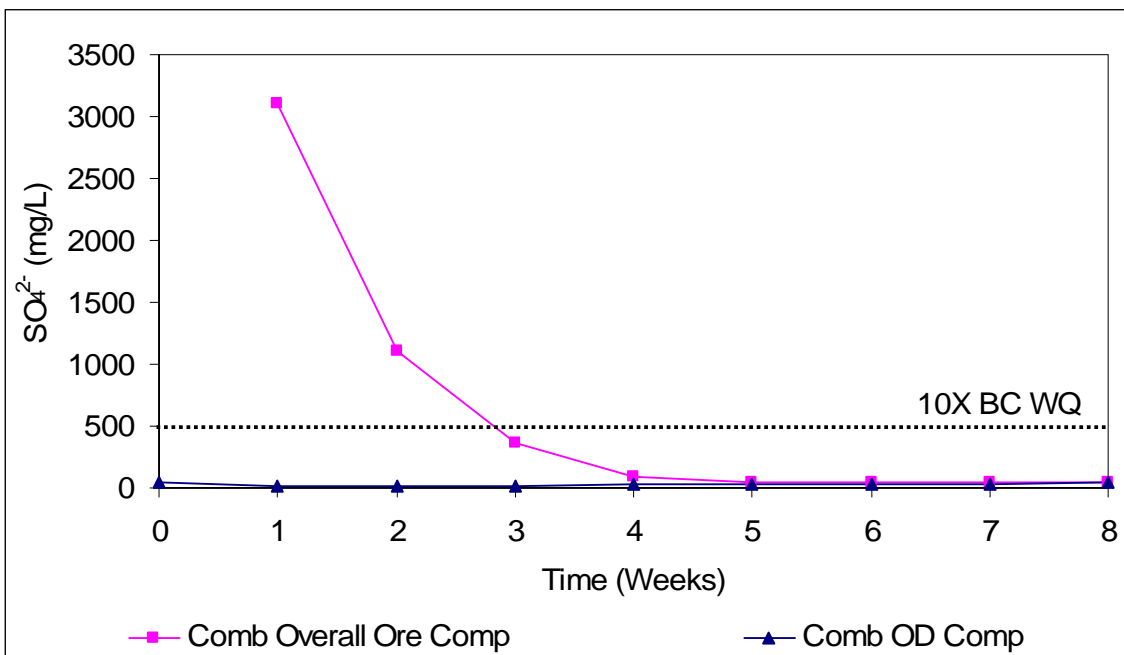


Figure II-1.15 Sulphate Fluctuations During Sub-aqueous Column Tests

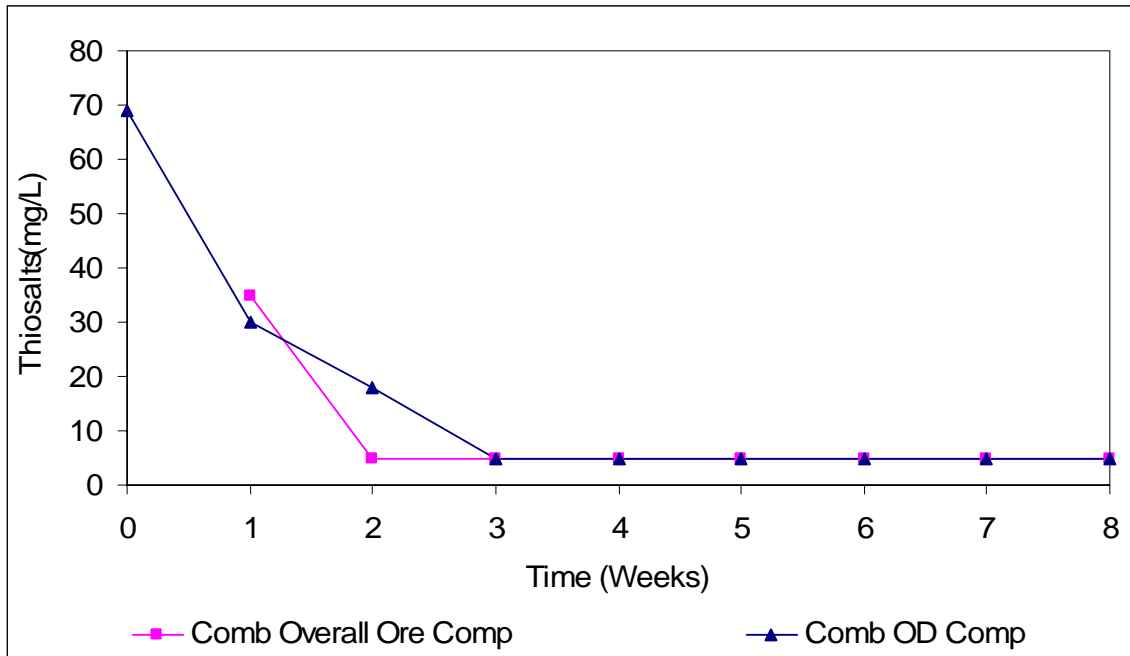


Figure II-1.16 Thiosalt Fluctuations During Sub-aqueous Column Tests

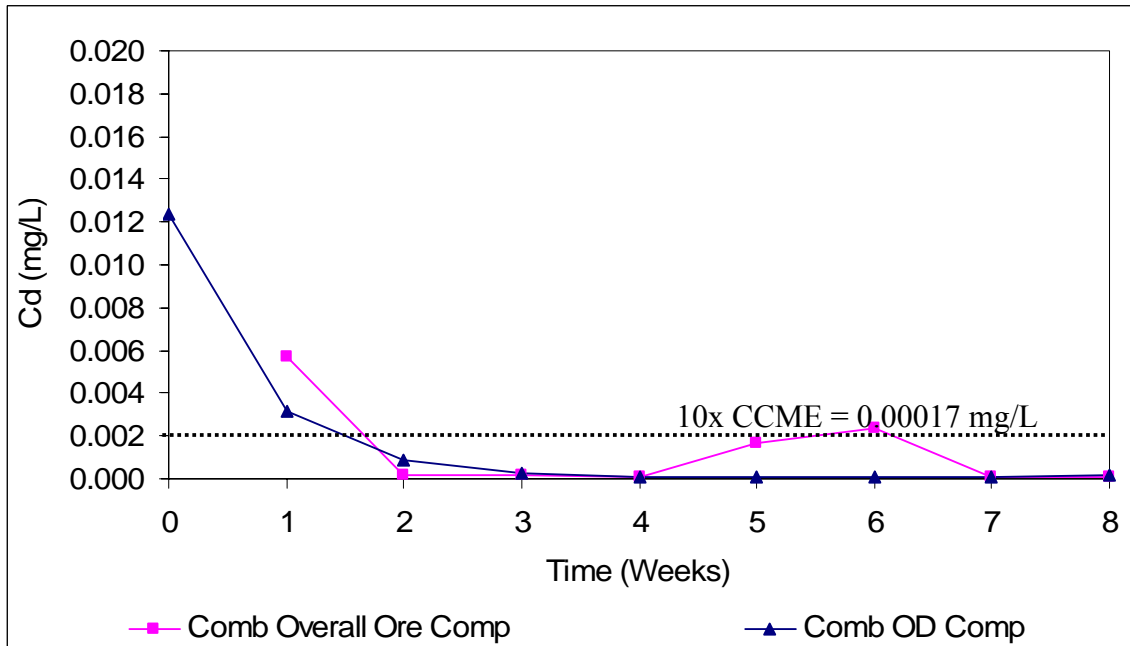


Figure II-1.17 Cd Fluctuations During Sub-aqueous Column Tests

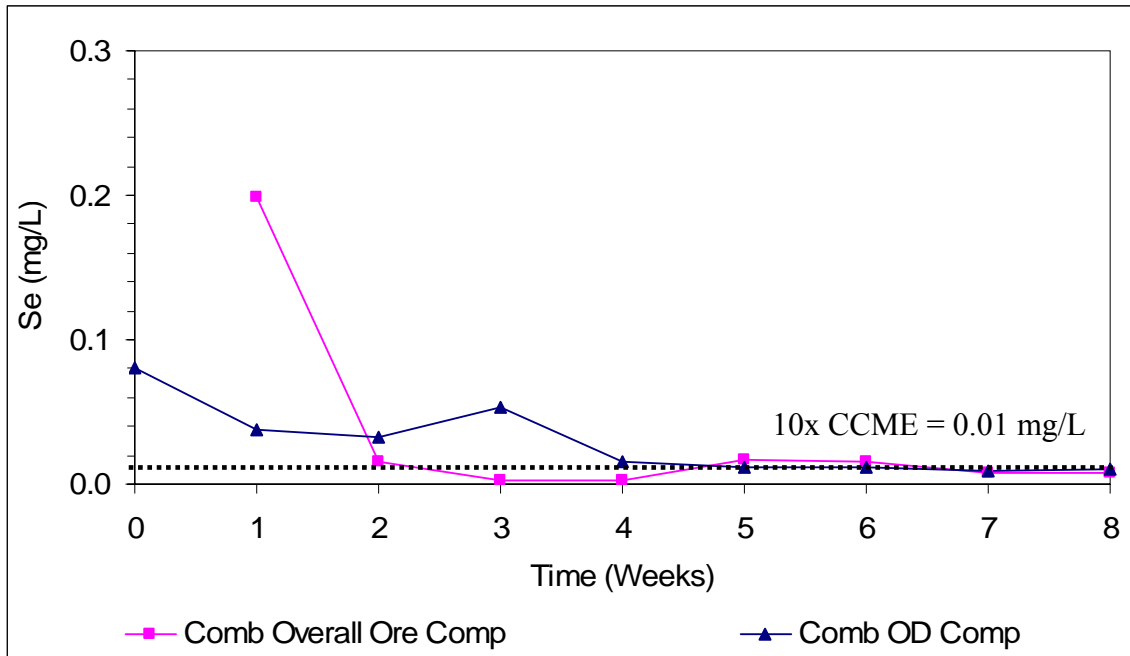


Figure II-1.18 Se Fluctuations During Sub-aqueous Column Tests

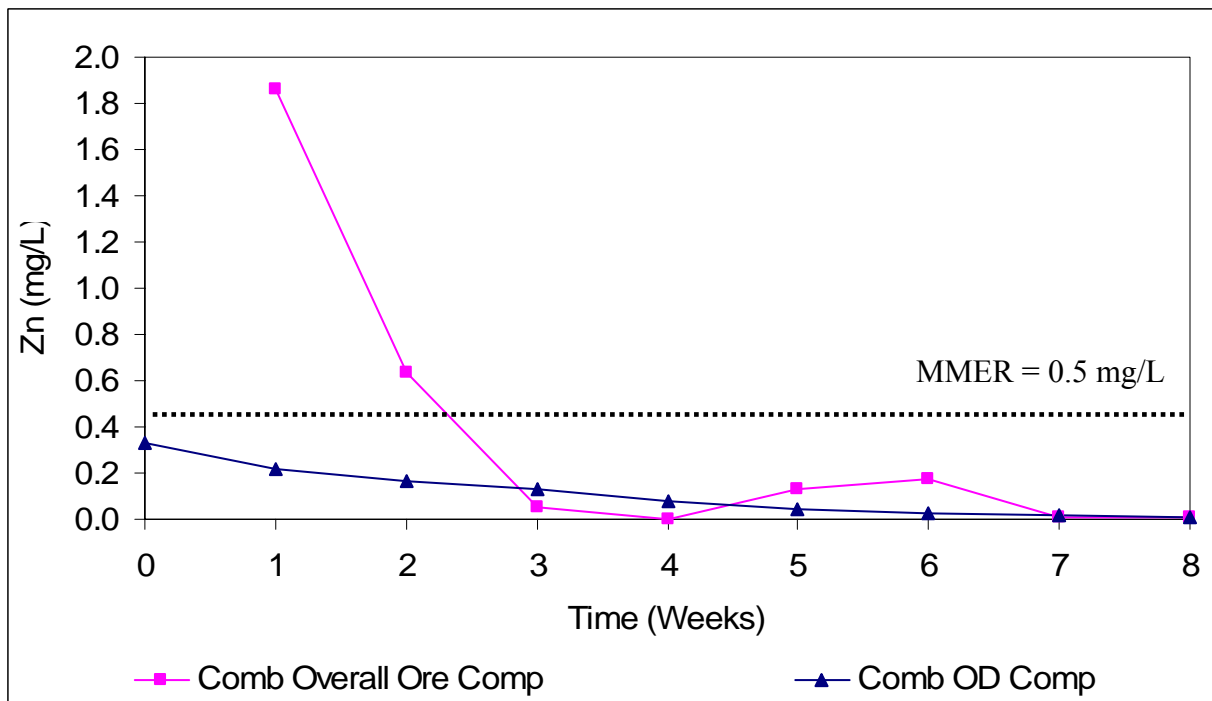


Figure II-1.19 Zn Fluctuations During Sub-aqueous Column Tests

1.6 Examples of Sub-aqueous Disposal of Tailings and Waste Rock Involving the Mobilization of Metal(loid)s Towards the Sediment Water Interface

1.6.1 General

The reviews of literature presented below represent cases that have been studied in detail to determine if sediments composed of tailings either consume metals from the overlying water or release metals into the overlying water. In most cases, extensive scientific work has been completed including sampling of the water column above the sediments, sampling of the sediments, and associated pore waters.

Table II-1.23 provides a summary of the literature review on sub-aqueous disposal of tailings and waste rock and indicates whether metal(loid)s are released by tailings impacted sediment, consumed by sediments from bottom waters and/or whether the sediment are oxic or anoxic. Oxic sediments are sediments in which dissolved oxygen is available and oxidation of sulphide minerals can take place. These conditions could potentially result in the release of metals to bottom waters. Anoxic sediments are sediments in which dissolved oxygen is not available, thus preventing the oxidation of sulphide minerals. These conditions would prevent the release of metals into bottom waters. Studies show lakes used for tailings disposal, and tailings impoundments themselves, have a very thin (maximum thickness of several centimetres) layer of oxic sediments at the sediment-water interface provided the tailings remain permanently submerged. The presence of this oxic sediment-water interface can lead to a slight efflux of metals into the bottom waters of the water body. This slight efflux is however very small resulting in a minimal effect on the water quality within the water body. Often the metals released to the bottom waters are re-precipitated by iron or manganese hydroxides. Alternatively some water bodies cycle between oxic conditions in summer and anoxic conditions in winter resulting in the cycling of metals within the system. Metals are released to the bottom waters during summer and are consumed by the sediment during winter. Below this thin oxic layer, anoxic conditions prevail where sulphidic materials are stable and metal(loid) remobilization is limited.

Table II-1.23 Sub-aqueous Tailings Disposal Summary

SITE	METALS RELEASED BY SEDIMENT	METALS CONSUMED BY SEDIMENT	OXIC OR ANOXIC SEDIMENT
Mandy Lake	Copper and Lead (slight efflux from deep water site).	Zinc, Copper and Lead.	Top 5mm of sediment oxic, anoxic at depths greater than 5mm, with 1 m of water cover.
Anderson Lake	Arsenic and Copper (seasonal cycling).	Copper, Lead, Cadmium, Arsenic, Mercury and Zinc.	Anoxic at very shallow sub bottom depths with an average water depth of 2.1 m (1.5 m to 4 m).
Buttle Lake	Cadmium, Copper, Lead and Zinc Arsenic (seasonal cycling).	Re-precipitation of Cadmium, Copper, Lead and Zinc. Arsenic (seasonal cycling).	Several centimetres of oxic natural sediments overlying anoxic sediments.
Benson Lake	None Reported.	Copper, Zinc, Lead and Cadmium.	Sub oxic or anoxic at very shallow sub bottom depths.
Equity Silver Tailings Pond	Arsenic.	Antimony.	Anoxic at very shallow sub bottom depths with 1.2 m of water cover.
Louvicourt Test Cells	Cadmium and Zinc (very small efflux, minimal effect on water quality).	None reported. Copper neither released nor consumed.	Top 7mm of sediment oxic, anoxic at depths greater than 7mm oxidation rate much reduced (2000 fold) in comparison to tailings exposed to atmosphere with 0.3 m of water cover.
Falconbridge New Tailings Area	Not reported.	Not reported.	Oxic sediment-water interface, oxidation rates much reduced (200 fold) in comparison to tailings exposed to atmosphere.
Lake Junin	None reported for permanently submerged sediment.	Copper and Zinc at permanently submerged sampling site.	Anoxic within several millimetres of the sediment-water interface with 8.5 m water cover. Seasonal exposure to atmospheric oxygen needs to be avoided.

1.6.2 MEND Project 2.11.1b-c Geochemical Assessment of Subaqueous Tailings Disposal in Mandy Lake, Flin Flon Area, Manitoba (Rescan, 1990)

Mandy Lake is located in central Manitoba near the Saskatchewan-Manitoba border. Between 1943 and 1944 the Mandy Mine discharged 75,000 tonnes of tailings from a single launder into Mandy Lake resulting in a fan shaped tailings deposit. The deposited tailings slowly slope away from the east shore to 1 m depth then drop off quickly to a water depth of approximately 5 m. The tailings consisted of primarily pyrite with appreciable quantities of zinc and copper.

Analysis of the submerged tailings in 1976 indicated that little oxidation had occurred. During 1990 two cores were collected from the lake, one from the deepest portion of the lake and one from the original tailings discharge location. Water quality and sediment sampling was also undertaken in 1990.

Oxygen concentrations were high in the upper 4 m of the water column but bottom waters of the lake were severely depleted. This was attributed to high benthic oxygen demand associated with the organic-rich sediments at the bottom of the lake. The results of the study indicated that tailings bearing deposits with the central portion of the lake are suboxic or anoxic at very shallow below the sediment water interface. Nearer to the shore, where the water cover is approximately 1 m, sediment and pore water results indicated oxic conditions in at least the upper 5 mm of the sediment.

Concentrations of zinc, copper and lead in the pore waters at both locations were very low. The report states that there is clearly no efflux of these metals from the mixed tailings and natural organic-rich sediments collected near the former discharge point, despite the presence of high concentrations of metals in the solid phase with indications of oxic conditions in the top 5 mm of the submerged deposit. In fact, pore water profiles at this location indicated that dissolved metals were diffusing into the deposits from the overlying lake water. At the deeper water site within the central basin a very slight efflux of copper and lead to the overlying water column was interpreted, however an influx of zinc to the deposits was also observed. The contribution of metals from the benthic effusion at the deeper water site was considered negligible.

1.6.3 MEND Project 2.11.3abc Geochemical Assessment of Subaqueous Tailings Disposal in Anderson Lake, Manitoba, 1993 to 1995 Study Program (Rescan, 1996a)

Anderson Lake is a small, shallow (average depth 2.1 m) Precambrian Shield lake located in northwest Manitoba. Between 1979 and 1994, over 8 million tonnes of tailings were deposited

into the lake via a floating, moveable pipe. The tailings were rich in sulphide and silicate gangue minerals¹.

Summer and winter surveys were undertaken at Anderson Lake. Both surveys included water column testing, sampling of sediments and associated pore waters using core extrusion and centrifugation. Diffusion-based dialysis array pore-water sampling was employed in the summer survey to better address fluxes of trace metals across the sediment-water interface.

From the winter survey results, it was concluded anoxia was widespread in the water column under ice during the survey and anoxia may be a common wintertime phenomenon. There was no evidence that oxidation of sulphide particles and resultant release of metals and/or acid was occurring in the tailings deposit on the floor of the lake. Not only would oxidation be prevented by the anoxia that existed in the bottom water but all sulphide grains observed under microscopic analyses were fresh and unaltered regardless of the sample depth within sample cores. In addition, the pH increased in the water column with depth.

Pore water profiles indicated that there was no measurable release of dissolved copper, lead, cadmium, arsenic or mercury from the tailings near the outfall even though the deposits were enriched in each of these metals. Similarly there was no measurable release of dissolved zinc, cadmium or lead from the “natural” tailings-contaminated sediments cored at the natural sediments sampling site. It was not clear from the results of the study if there was an influx or efflux of zinc from the tailings site. Pore water profiles in the ‘natural sediments’ implied that copper and arsenic were being released to pore solution at very shallow depths. Arsenic and copper undergo active seasonal cycling in the sediments and water cover of Anderson Lake.

From the summer survey, it was concluded that the water column was well mixed and oxygenated, a result of the shallow depth and absence of an ice cover. As with the winter survey, there was no evidence to suggest oxidation of sulphide particles and resultant release of metals and/or acid was occurring in the tailings deposit on the floor of the lake. All sulphide grains observed microscopically were fresh and unaltered.

¹ Gangue – The valueless rock or mineral assemblages in an ore; that part of an ore that is not economically desirable, but cannot be avoided in mining.

Sampling of pore water from the sediments of Anderson Lake indicated that at sampling sites, cadmium, copper, lead and zinc were diffusing from the overlying lake water into the sediments.

The study concludes by stating there is no evidence (chemical or visual) to suggest that the sulphide component of the tailings submerged in Anderson Lake is oxidizing on the lake floor and this applies for all seasons under a shallow (1.5 m to 4 m) water cover. This result suggests that oxidation of tailings stored permanently underwater is strongly inhibited even where tailings are reworked under shallow oxygenated water columns.

1.6.4 MEND 2.11.4a Geochemical Assessment of Subaqueous Tailings Disposal in Buttle Lake, British Columbia, 1993 Study Program (Rescan, 1995)

Buttle Lake is large (35 km long, 1 km wide and 80 m deep) occupying a U-shaped valley near the Myra Falls Mine on Vancouver Island, British Columbia. Approximately 5.5 million tonnes of sulphidic tailings were discharged to the South Basin (7 km long) of Buttle Lake via a submerged outfall between 1984 and 1996. Deposited tailings were effectively confined in the south basin by a shallow sill separating it from the remainder of the lake. Copper, lead, zinc, gold, silver and cadmium have been recovered from sulphidic ore deposits in the Myra Falls area.

As part of the study, water column testing, diffusion-based dialysis array pore-water sampling, and coring methods were used at two stations within the south basin (tailings sites) and a control station within the central basin (natural site) to sample the water column, sediments and intestinal waters.

The dissolved metal concentrations within the water column of Buttle Lake were among the lowest observed in the last twenty years of observations despite the continued inputs of several trace elements from acid rock drainage in the Myra Creek watershed. A layer of oxic natural sediments, several centimetres thick admixed with a small component of tailings bioturbated upward from below, was observed in the south basin. At the natural site diffuse influxes of dissolved cadmium and zinc into the sediments was observed while copper and lead showed no indication of reactivity. At both of the tailings sites, near surface pore water sampling results

indicated remobilization of cadmium, copper, lead and zinc resulting from oxide dissolution. However, it was noted that the impact of the upward flux toward the water column was likely attenuated by re-precipitation of manganese and iron oxides, which scavenge trace metals. Arsenic distributions followed manganese and iron cycling but no evidence of efflux was shown.

Flux-based diffusion calculations suggested that effluxes of copper, lead, and zinc to the bottom waters are small and have little impact on water quality. The report concluded that very little, if any, oxidation of sulphide particles can be accommodated by the near-surface pore water data.

1.6.5 MEND Project 2.11.1c-b Chemical Diagenesis of Submerged Mine Tailings in Benson Lake and Natural Sediments in Keogh Lake, Vancouver Island, British Columbia (Rescan, 1992)

Benson Lake consists of a single 2.2 km long basin, with a maximum depth of 54 m. The lake, located in northern Vancouver Island, is fed from the eastern end by the Benson and Raging Rivers. The nearby Keogh Lake is similar to Benson Lake in size, shape and depth.

Pyrite rich tailings from the Coast Copper Mine were discharged into Benson Lake from 1962 to 1973. Keogh Lake is within a watershed never used for mine waste disposal and is used in the study as a control site un-impacted by tailings.

Sediment cores were collected and analyzed from the central portion of both lakes. In the central sampling station within Benson Lake, a 300 mm deep natural sediment layer was covering the tailings. A thin veneer (approximately 5 mm thickness) of manganese and iron oxyhydroxide-rich material was present at the sediment water interface at both lakes. High dissolved iron concentrations (relative to bottom waters) at 15 mm depth in the Keogh Lake sediment and below 15 mm in the Benson Lake sediments indicate that the natural sediments are suboxic or anoxic at very shallow depths below the sediment water interface.

Sulphide and dissolved metal concentrations were low in the bottom waters of both lakes. Pore water profiles of dissolved zinc, lead, and cadmium collected from both lakes showed that concentrations of these metals decreased across the sediment water interface and are invariably

lower than measured in the bottom waters. This data confirmed that there was no efflux of these metals to the overlying water in either lake.

Pore water profiles for dissolved copper suggested that some copper may be cycled just below the sediment water interface in both the Keogh and Benson Lake sediments. There was however no evidence of a benthic efflux of dissolved copper from the sediments to bottom waters of either lake.

1.6.6 MEND Project 2.11.5c Geochemical Assessment of the Equity Silver Tailings Pond (Rescan 1996b)

The Equity Silver Mine is located in central British Columbia. The mine operated from 1980 to 1994 extracting copper, silver, iron, and zinc from a sulphidic ore body. Tailings were deposited into a man made tailings impoundment via a mobile floating platform, which was periodically moved to distribute tailings around the impoundment. The impoundment has an area of 1.2 km² and a maximum depth of 5 m in the central area. Neutralised sludge from an ARD treatment plant (lime addition) was co-disposed with the tailings in a portion of the tailings impoundment.

Water quality sampling, pore water sampling and sediment sampling was undertaken at two stations within the tailings impoundment. The first sampling station was from shallow tailings (1.2 m water cover) while the second sampling station was from the deepest (5 m water cover) central portion of the lake. Dissolved oxygen micro-gradients across the sediment-water interface were measured and used to directly infer tailings oxidation rates.

The distribution of most elements studied was seen to reflect small scale lateral in-homogeneity. Dissolved copper was observed to be neither released nor consumed by the tailings with the exception of one well defined zone possibly arising from dissolution of manganese oxides.

Arsenic and antimony were observed to display opposing behaviour. Arsenic was released universally within the tailings pond sediments via the dissolution of an unidentified solid. Antimony is consumed rapidly within the surface sediments.

Dissolved oxygen micro-gradients across the diffusive sub-layer infer oxidation rates lower than are typical of natural lake sediments.

1.6.7 MEND Project 2.12.1c Subaqueous Disposal of Reactive Mine Tailings Louvicourt Mine Test Cells Geochemical Sampling and Analysis (INRS-Eau, 2001)

Fresh tailings from the Louvicourt Mine were submerged under a 0.3 m water cover in experimental field cells. From 1996 to 1998 the chemistry of the interstitial water near the tailings-water interface was monitored using in situ dialysis. The pH and dissolved oxygen profiles across the tailings-water interface were measured using micro-electrodes.

Dissolved oxygen profiles indicated that penetration of dissolved oxygen into the tailings was limited to less than 7 mm. Anoxia of the tailings was further demonstrated by the reduced chemical species detected at depths of approximately 15 mm below the sediment-water interface.

There was clear evidence of oxidation of the mine tailings from the surface layer of the tailings. Mobilization of cadmium and zinc from this surface layer was indicated. There was no evidence of mobilization of copper from the tailings. The observed releases of cadmium and zinc were very small and the report concluded that the cadmium and zinc fluxes from the tailings to the overlying water would have only minimal impacts on the overlying water quality.

1.6.8 Rates of Oxygen Consumption by Sulphidic Tailings Under Shallow Water Covers – Field Measurements and Modelling, (Li *et al.*, 2000)

This paper described some dissolved oxygen profiles measured across the tailings/water interface at submerged tailings sites and oxygen fluxes derived from these profiles. The Falconbridge New Tailings Area (Falconbridge), situated near the town of Falconbridge, Ontario and the Louvicourt Tailings Field Experimental Cells (Louvicourt), located near Val d'Or, Quebec, were the focus of the study. The Falconbridge tailings were rich in pyrrhotite averaging 7% sulphur while the Louvicourt tailings contained 30% to 50% pyrite.

The paper outlines the significant differences between subaqueous disposal of mine waste in lake environments and shallow water covers typical of tailings impoundments. The comparison shows that tailings under shallow water covers are more prone to oxidation than those in lake environments (at least in the first several years after deposition).

Comparison was drawn between the oxygen fluxes into sulphidic tailings submerged under shallow water covers to the same tailings exposed to the atmosphere. Based on the assumption that the total calculated oxygen flux was used for sulphide oxidation, shallow water covers reduced the tailings oxidation rate by about 200 fold at the Falconbridge site and by about 2000 fold at the Louvicourt site. The results of the study were limited due to no reliable techniques available for distinguishing the proportion of the total oxygen flux consumed by tailings oxidation from that consumed by organic matter oxidation.

1.6.9 Management of Water Quality in a Flooded Tailings Impoundment (DeVos *et al.*, 2000)

This paper describes the closure planning and water quality prediction, using oxidation and diffusion modeling, undertaken for the Falconbridge New Tailings Area, Falconbridge, Ontario. The impoundment covers an area of approximately 60 ha and is divided into two terraces (Upper and Lower). Results of water quality monitoring undertaken since flooding of the tailings is compared to predicted values.

It was concluded that it was still too early to truly evaluate the effectiveness of the water quality prediction modeling completed. While the general downward trend in concentrations predicted was observed, peak values were higher than the average values predicted. The model was not sophisticated enough to take into account additional mechanisms now known to be at work at the site. Lime addition to the tailings impoundment to control nickel concentrations in the water column was required and it is thought that incomplete dissolution of lime could be responsible for some of the peaks. Co-precipitation of solutes and the mass transfer mechanism used in the model were also sighted as being responsible for the observed variation between predicted and measured values. The model does however provide a practical insight into the expected water quality both from an oxidation perspective and from a metal diffusion and mixing perspective.

1.6.10 The Reactivity of Sulphur-Rich Sediments in Lake Junin, Peru: The Importance of Permanent Submergence (Martin *et al.*, 2000)

Lake Junin occupies a large shallow basin at an elevation of 4200 m above mean sea level in the Peruvian altiplano approximately 300 km northeast of Lima. The lake is approximately 25 km long, 9 km wide with a maximum depth of 12 m. The lake has been receiving acid rock drainage, tailings and tailings pond overflow from several copper, lead, and zinc mining operations 10 km to 20 km upstream of the lake. There has been continual and widespread accumulation of sulphur and metal rich sediments in Lake Junin. The drainage system has a relatively high alkalinity stemming from abundant carbonate rocks in the drainage system. The lake is well mixed throughout the year and bottom waters are perennially well-oxygenated.

Sampling, which involved collection of water column samples, sediments and pore waters (high resolution dialysis array sampling), was undertaken at two sampling locations. The deep water station was situated in the centre of the main basin at a depth of 8.5 m with permanently submerged organic-rich sediments containing 2.5 wt % sulphur. The shallow water station was situated in a shallow basin with a water depth of 0.8 m and contained less organics and 2 wt % sulphur. Due to seasonal variation in the water level of the lake, the shallow site remains unsaturated for a significant portion of each year.

For the permanently saturated deep water site, high resolution profiles of dissolved iron, manganese, sulphate, and hydrogen sulphide across the sediment-water interface illustrate the sediments at this location become anoxic at very shallow sub-bottom depths (within several millimetres). Furthermore, it was observed that the permanently submerged deposits consume dissolved copper and zinc from the bottom waters of the lake.

The periodically unsaturated sediments were observed to be oxic to a depth 20 cm, suboxic to a depth of 30 cm at which point the sediments were fully anoxic. Copper and zinc were diffusing upward towards the sediment water interface and subsequently being released to the bottom waters of the lake at this location. This study emphasized the importance of maintaining a permanent water cover for the storage of sulphide bearing mine waste.

2. DAM BORROW MATERIAL CHARACTERIZATION

On-site material is scheduled for the construction of the tailings dam. Exposing large amounts of material to atmospheric conditions may result in the destabilization of minerals and lead to metal(loid) releases. Therefore, geochemical assessment of dam borrow material was conducted, specifically to establish the potential for acid generation and metal(loid) leaching.

Samples of different dam borrow materials were geochemically examined to determine the potential for ARD and metal leaching. Results indicate sampled materials have a low potential for both ARD and metal leaching. However, during construction, additional tests should be conducted to confirm that there is no metal leaching concerns for the actual borrow materials used in construction.

2.1 Acid Base Accounting (ABA)

ABA samples were selected from test pits within the tailings impoundment and main Project Borrow areas. Oversize material (>3" diameter), where present, was avoided in sample collection. Sample analyses were performed only on the <2 mm size fraction, as this size range has a high specific area and is generally seen as the reactive fraction (Price 1997). Brief descriptions of the ABA parameters and methodology are included below.

2.1.1 Methodology

Dry sieving was done to separate the > 100 µm particle size fraction. Stones (>12 mm), gravel (2-12 mm), soil (<2 mm), and sand (2 mm – 50 µm) sized particles were separated with standard sieve screens in a Ro-Tap Sieve shaker for 5 to 20 minutes. Wet sieving was done to separate <50 µm sized particles, such as silt and clay, from larger >50 µm particles. The sample was placed on top of the screen and deionised water was used to wet the sample to wash the minus fraction through the screen for collection. Both fractions were then filtered, dried and weighed.

To determine whether acid generation had occurred in the material prior to analysis, the pH of a paste of the finely ground sample with water was measured. Approximately 10 g of sample at minus 60 mesh was placed in a beaker with 5 mL of distilled water without stirring. The sample

was allowed to wet by capillary action, however, more water or sample was added to saturate sample (no puddling of water or dry appearance of solid). The sample was stirred with a spatula to form a thin paste, adding more water or sample to keep sample at the saturation point and measured for pH. The rinse pH was measured in the same manner as paste pH except that it was done directly on the -2 mm fraction with a solids to water ratio of 1:1.

Samples were crushed and pulverized to a target size of 80 percent minus 200 mesh (Tyler) for sulphur species determination. Total sulphur was determined by Laboratory Equipment Corporation (LECO) methods. Sulphate and sulphide were determined by the procedure described by Sobek, *et. al.* (1978). In this procedure total sulphur was measured by LECO methods. A portion of sample was treated with 25% HCl to remove sulphate sulphur. The sample was then re-run by LECO methods to determine, by difference, the quantity of sulphate removed. Sulphide sulphur was determined by taking a portion of sample that has been treated to remove sulphate and further treated with 1:7 mixture of HNO₃ to deionised water to remove the sulphide. The sample was then re-run by LECO methods to determine the quantity of sulphur remaining after sulphate and sulphide have been removed. Sulphide was then determined by difference. The sulphur remaining was considered to be acid insoluble sulphur (e.g. barite, alunite etc.).

Approximately 2.0 g of the pulverized sample was agitated for 24 hours at 150 rpm in HCl to a final pH range between 1.5 and 2.0. The sample was then titrated with NaOH (corresponding to the normality of HCl) to pH 8.3 until a constant pH reading of 8.3 remains for at least 30 seconds. The above procedure yielded data for calculating NP, AP, Net NP and Sobek NPR.

Total Carbon was measured by Leco methods. Inorganic carbon was determined by difference (i.e. a known weight of sample was treated with 25% HCl to remove inorganic carbon (IC) and was then re-analysed for total carbon).

2.1.2 Results

Results for the ABA analyses of the borrow materials are reported in Table II-2.1. Tested materials have low potential for acid generation due to the very low sulphide sulphur content

(0.005 %). The low sulphide sulphur concentrations suggest that oxidation reactions, and subsequent acidic conditions, will not be a major contributor to the liberation of elements within the borrow material. Due to the low sulphide sulphur content the AP within the samples is also low. A negative value of modified Sobek NP indicates that the sample has already accumulated net acidity. This can be noted in the slightly depressed paste and rinse pH values. Paste pH values range from slightly acidic (pH 5.74) to slightly alkaline (pH 8.80).

Table II-2.1 ABA Results for Dam Borrow Materials

Sample ID	Unit	Go Greek Dam Borrow	Project Borrow Sample #1 East	Project Borrow Sample #2 central	Project Borrow Sample #3 West	MW05-6 Borrow	TP05-72 2.5m	TP05-75 1.5m	TP05-78 1.5m	TP05-81 1.5m	TP05-87 3.3m	TP05-89 1.5m
Paste pH	-	7.66	5.74	6.00	6.53	6.54	8.45	8.80	7.89	7.62	8.06	8.11
Rinse pH	-	6.42	4.87	5.01	4.99	5.63	5.88	7.54	6.12	5.7	6.34	6.2
Total Sulphur	%S	<i>0.005</i>	0.04	0.07	0.09	0.05	0.06	0.08	0.09	0.02	0.03	<i>0.005</i>
Sulphate Sulphur	%S	0.01	0.01	0.02	0.01	0.01	0.005	0.005	0.005	0.005	0.005	0.005
Sulphide Sulphur	%S	0.005	0.005	0.05	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Insoluble Sulphur	%S	0.01	0.03	0.05	0.08	0.04	0.06	0.08	0.09	0.02	0.03	0.005
AP	kg CaCO ₃ /t	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Modified Sobek NP	kg CaCO ₃ /t	3	-4.4	-3.1	-2.4	-1.2	3.1	5.1	2.6	0.2	3.3	2.9
Total Carbon	% C	0.51	1.74	1.52	1.13	0.31	0.14	0.21	0.43	0.25	0.18	0.16
Total Inorganic Carbon	% C	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>
Carb NP	kg CaCO ₃ /t	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>
Net Sobek NP	kg CaCO ₃ /t	3	-4.4	-3.1	-2.4	-1.2	3.1	5.1	2.6	0.2	3.3	2.9
Sobek NPR	-	20.00	-29.33	-20.67	-16.00	-8.00	20.67	34.00	17.33	1.33	22.00	19.33
Carb NPR	-	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67

Values in *italics* were reported by the laboratory as less than their detection limit and are shown here at one-half the detection limit.

ABA test work, in particular the information garnered from the NPR, serves as a guide in identifying the likelihood of ARD conditions and distinguishing samples from a deposit as PAG from Non-PAG. Price (1997) provides some criteria for guiding geochemical test work and evaluating the potential for ARD shown in Table 1.9. Table II-2.2 combined with the Sobek NPR and Carbonate NPR from Table II-2.1 confirm the potential for ARD in sample borrow materials is low except for sample TP05-81, where the possibility of ARD may exist, but is still unlikely given the low sulphide content.

Table II-2.2 ABA screening criteria

POTENTIAL FOR ARD	INITIAL SCREENING CRITERIA
Likely	$\text{NPR} \leq 1$
Possible	$1 < \text{NPR} \leq 2$
Low	$\text{NPR} > 2$

2.2 Shake Flask Extraction

SFE short-term leachate test was used to determine the leachate that may flush from the dam borrow solids when exposed to rain, snowmelt or groundwater flow. This procedure is a recommended component of static tests and is used to determine the presence of easily soluble mineral components (Price, 1997). The procedure is a modification of the Special Waste Extraction Procedure, or shake flask test, outlined in the *British Columbia Waste Management Act*. Descriptions of the SFE parameters and methodology are included below.

2.2.1 Methodology

SFE were conducted at a 1:20 solids to liquid ratio to avoid solubility limitations and placed in two litre flasks on a gyratory shaker for 24 hr. The gentle 24 hr agitation is to ensure continuous exposure of all surfaces and mixing of the rinse solution. After agitation, the final pH was recorded, the supernatant sample was filtered through a 0.45 µm filter and a sub-sample of the supernatant was submitted for analyses of metal(loid)s by ICP-MS. In addition pH, conductivity, alkalinity, acidity, hardness and sulphate were determined.

2.2.2 Results

Results from the SFE analyses of the borrow materials are reported in Table II-2.3. Metal(loid) leaching concerns are not anticipated from the borrow materials analyzed. It can be noted that Samples #1 East and #3 West from the main Project Borrow area showed a slight degree of pH depression below that of the deionised water used in the test, consistent with the low rinse pH observed for these samples. Nevertheless, very few parameters showed detectable quantities, and all were well within a factor of ten of any applicable guidelines. However, as borrow pits expand and materials outside the current sampling program locales are considered for construction purposes, additional leachate testing may be appropriate to further address potential metal(loid) leaching.

Table II-2.3 Shake flask extractions results for dam borrow materials

Parameter	Units	Go Greek Dam Borrow	Project Borrow Sample #1 East	Project Borrow Sample #3 West	TP05-78 1.5m
pH	-	6.42	5.27	5.35	6.29
Conductivity	µS/cm	6	5	3	3
Alkalinity	mg CaCO ₃ /L	3.5	2.5	2	3
Acidity (pH 8.3)	mg CaCO ₃ /L	1.5	4	3.5	2.5
Sulphate	mg/L	0.5	0.5	0.5	0.5
Total Hardness	mg CaCO ₃ /L	3.2	1.1	0.6	1.3
Total Metal(loid)s					
Ag	mg/L	<i>0.000025</i>	<i>0.000025</i>	<i>0.000025</i>	<i>0.000025</i>
Al	mg/L	0.059	0.25	0.13	0.066
Sb	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
As	mg/L	0.0005	0.0002	<i>0.0001</i>	0.0005
Ba	mg/L	0.018	0.016	0.0091	0.017
Be	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
Bi	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
B	mg/L	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>
Ca	mg/L	1.07	0.38	0.18	0.36
Cd	µg/L	<i>0.02</i>	<i>0.02</i>	<i>0.02</i>	<i>0.02</i>
Co	mg/L	<i>0.0001</i>	0.0004	<i>0.0001</i>	<i>0.0001</i>
Cr	mg/L	<i>0.0001</i>	0.0004	<i>0.0001</i>	<i>0.0001</i>
Cu	mg/L	0.0073	0.0053	0.0027	0.0049
Fe	mg/L	0.04	0.13	0.01	0.08
Hg	µg/L	<i>0.01</i>	<i>0.01</i>	0.03	<i>0.01</i>
K	mg/L	0.3	0.43	0.16	0.23
Li	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
Mg	mg/L	0.13	0.04	0.03	0.11
Mn	mg/L	0.0067	0.01	0.013	0.0039
Mo	mg/L	0.0003	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>
Na	mg/L	0.09	0.16	0.08	0.2
Ni	mg/L	0.0005	0.0003	0.0002	0.0004
P (as PO ₄)	mg/L	0.07	0.07	0.04	0.05
Pb	mg/L	<i>0.0001</i>	0.0002	<i>0.0001</i>	<i>0.0001</i>
Se	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
Si (as SiO ₂)	mg/L	0.87	1.18	0.83	2.57
Sn	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
Sr	mg/L	0.0017	0.0029	0.0012	0.0008
Te	mg/L	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>	<i>0.0001</i>
Tl	mg/L	<i>0.00001</i>	<i>0.00001</i>	<i>0.00001</i>	<i>0.00001</i>
Th	mg/L	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>
Ti	mg/L	0.0019	0.0075	0.0035	0.0029
U	mg/L	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>	<i>0.00005</i>
V	mg/L	0.0006	0.0004	<i>0.0001</i>	0.0007
Zn	mg/L	0.002	0.004	0.003	0.002
Zr	mg/L	<i>0.001</i>	<i>0.001</i>	<i>0.001</i>	<i>0.001</i>

Italics indicates measured value less than detection limit and listed as one half of the detection limit

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APPENDIX III

Hydrology, Baseline Water Quality and Water Balance

- Part I – Hydrology Data
- Part II – Surface and Groundwater Data
- Part III – Water Balance Tables

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1. HYDROLOGY DATA

1.1 Annual Precipitation, Evaporation and Snowpack

The estimated mean annual precipitation, estimated mean annual evaporation rate and average snowpack presented in Section 2.2 of the main text were derived from local and regional climate data, as provided below from Type A Licence Application (January 2007).

Regional climate data is available from three Environment Canada stations located within the Liard Basin. Watson Lake is located 175 km south-southeast of the project, at an elevation of 687 masl. Climate data is available for the period 1938-2005. Tuchitua is located 80 km southeast of the project, at an elevation of 724 masl. Climate data is available for the period 1971-2004. Hour Lake is located 60 km east-southeast of the project at an elevation of 890 masl. Climate data is available for the period 1982-2004.

These three stations are sited in valley bottoms and range from 500 m to 900 m lower in elevation than the project site. They are not fully representative of the climate at the project site, which is located in the upland region of the Pelly Mountains. Therefore, interpretation of regional climatic data to characterize conditions in the project area was tempered by the data collected on site. Wherever possible, regional data was corrected for the effects of location and elevation to generate expected conditions at the project.

Baseline data collection began at the project site in 1996 and has continued intermittently to the present. In 1996 and 1997, and again for portions of 2000 and 2001, some automated data was collected at a location near the exploration camp site on Wolverine Lake. In October 2004, an automated HOBO® Weather Station, model H21-001 (Onset Computer Corporation) was installed immediately to the north of the airstrip. The station measured rainfall, atmospheric pressure, solar radiation, wind speed, wind direction, air temperature, and relative humidity at 30 minute increments. This station was upgraded and replaced by a new HOBO Onset weather station, installed on the south end of the airstrip on May 10th, 2006 (Figure III-1.1). The weather station on a 3m tripod tower was outfitted with the following data collection features:

- Temperature;
- Relative Humidity;
- Tripod Mounted Rain Gauge;
- Solar Radiation IN and OUT;

- Wind Speed and Direction; and
- Barometric Pressure.

Climate station data has been logged continuously from this station on an hourly basis since May 20th, 2006.

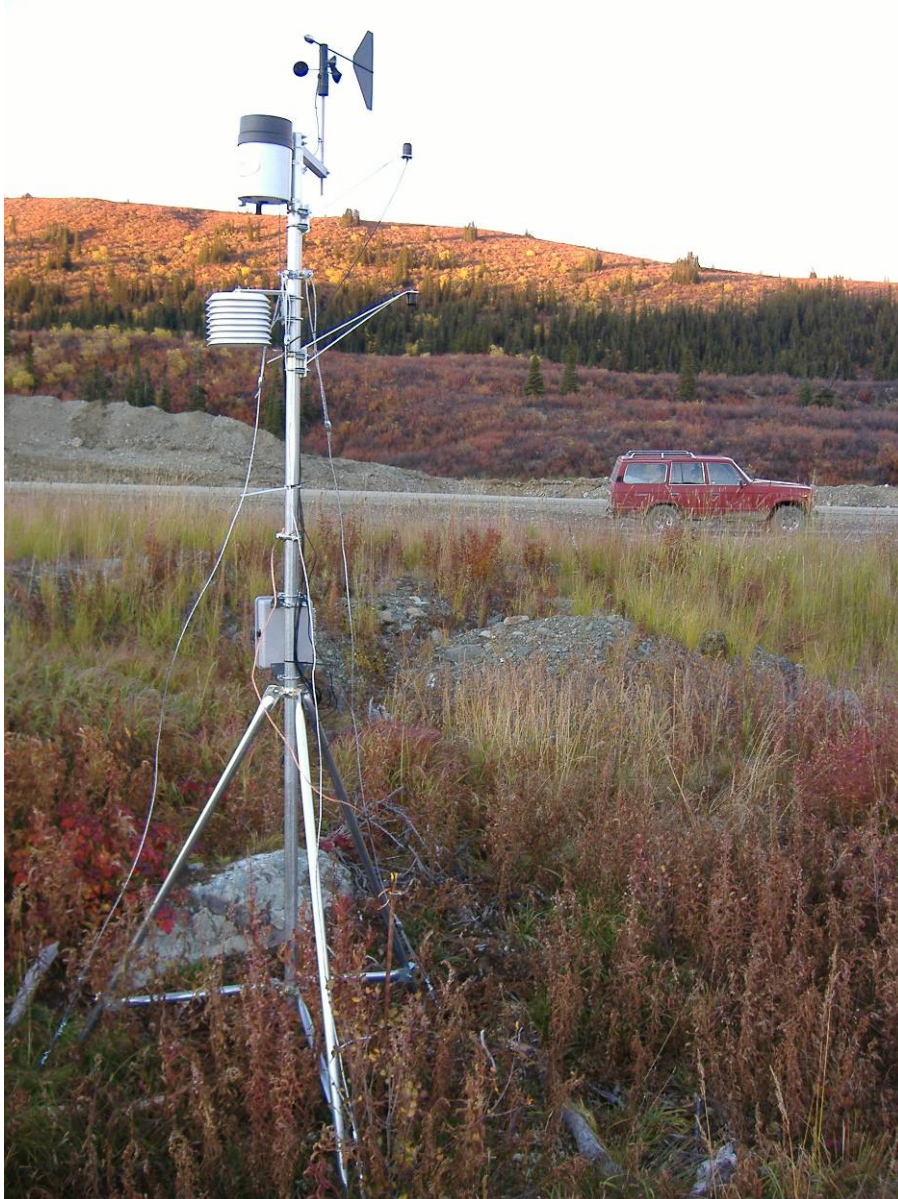


Figure III-1.1 Automated Weather Station Located Near Airstrip

1.1.1 Temperature

Temperatures at the project site have been characterized from the field data recorded in 1996-1997, 2000-2001, and 2004-2005, and more recently during 2006. The data collected in 1996-1997 and 2000-2001 at the exploration camp site (elevation 1150 m asl) was corrected for elevation using an environmental lapse rate (Kushnir 2000) of 1°C/100 m for winter conditions and 0.6°C/100 m for summer conditions. The mean annual temperature at project site is -3.5°C and there is a strong seasonal temperature variation. Mean monthly temperatures are below freezing between October and April, and above freezing from May through September (Figure III-1.2). The minimum recorded winter temperature is -36°C and the maximum recorded summer temperature is 31°C. Generally, the temperatures recorded at the project site are comparable to the temperatures recorded at the regional stations, if the regional stations are corrected for the elevation difference.

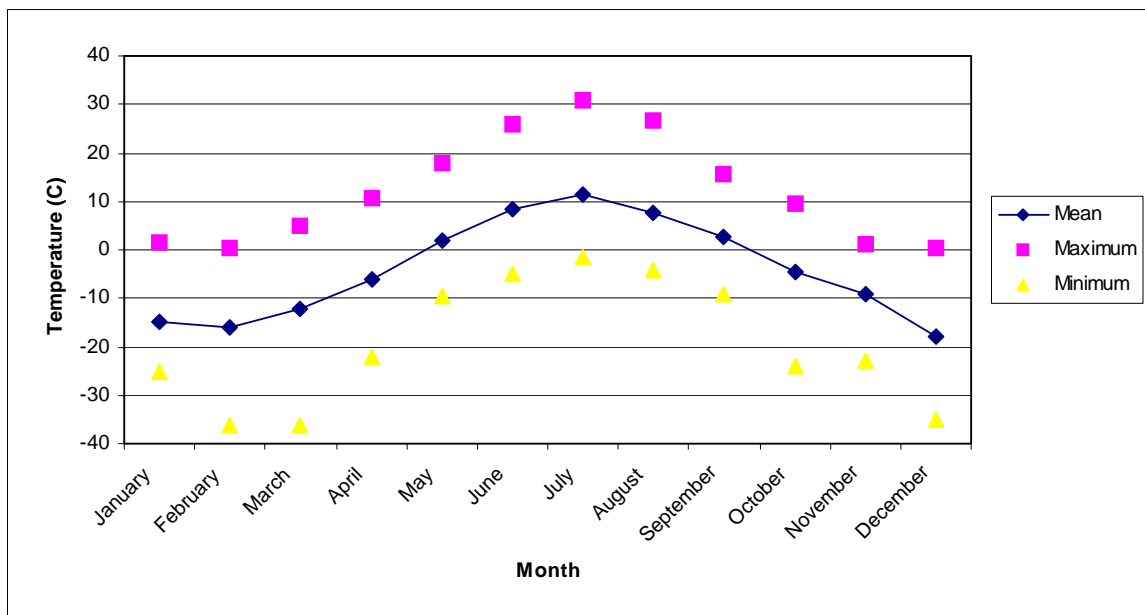


Figure III-1.2 Mean, Maximum and Minimum Temperatures (°C) by Month – Wolverine Project

1.1.2 Precipitation

Like most new mine development projects, site-specific climatic data for the Wolverine Project are of too short a period to be used predominantly in the predictions of site precipitation and the development of project water balances. Accordingly, more regional data were utilized to

estimate annual and monthly precipitation. Two approaches were used in this effort and are described below.

1.1.2.1 Annual Precipitation Estimate from Regional and Wolverine Climate Stations

The three climate stations within the regional study area, for which climate data is available, include Watson Lake, Tuchitua and Hour Lake. Climate measurements at the Wolverine site were collected during the summer of 1996 and 1997, and from October 2004 to September 2005 and May 2006 to October 2006 during the ice-free periods as the automated precipitation sensor does not measure snowfall. Climate measurements were not made during 2005 at Tuchitua and Hour Lake, so the only station for which there is continuous overlap of measured monthly precipitation with the Wolverine site is Watson Lake.

A comparison of the monthly precipitation values measured at Wolverine to the measured monthly precipitation for the same months at Watson Lake indicates that observed monthly precipitation at Wolverine ranges from 59% (June 1997) to 203% (July 2006) of observed monthly precipitation at Watson Lake (Table III-1.1). The average of the monthly Wolverine values are 121% of Watson Lake values, whereas the total precipitation over the observed interval at Wolverine is 112% of Watson Lake. However, if the precipitation at Wolverine is plotted against the precipitation at Watson Lake, the resultant regression equation has a low r-squared value, indicating the relationship is not statistically significant (Figure III-1.3).

Table III-1.1 Ratio of Measured Monthly Precipitation at Wolverine Climate Station and at Watson Lake

	Precip Measured Wolverine (mm)	–Precip Measured Watson Lake (mm)	–Ratio Wolverine to Watson Lake
1996			
Jul	59.8	35.4	1.689
Aug	73.1	56.2	1.301
1997			
May	19.1	24.6	0.776
Jun	51.2	86.9	0.589
Jul	96.2	73.1	1.316
Aug	49.2	67.8	0.726
2005			
March	15.8	10.5	1.505
April	16.2	10.6	1.528
May	51	66.5	0.767
Jun	62.8	61.8	1.016
Jul	83.6	61.8	1.353
Sep	53.2	38.4	1.385
2006			
June	51.0	32.2	1.584
July	67.0	32.9	2.036
Aug	73.4	53.3	1.377
Sept	18.6	37.4	0.497
Mean			1.215
Total	841.2	749.4	1.122

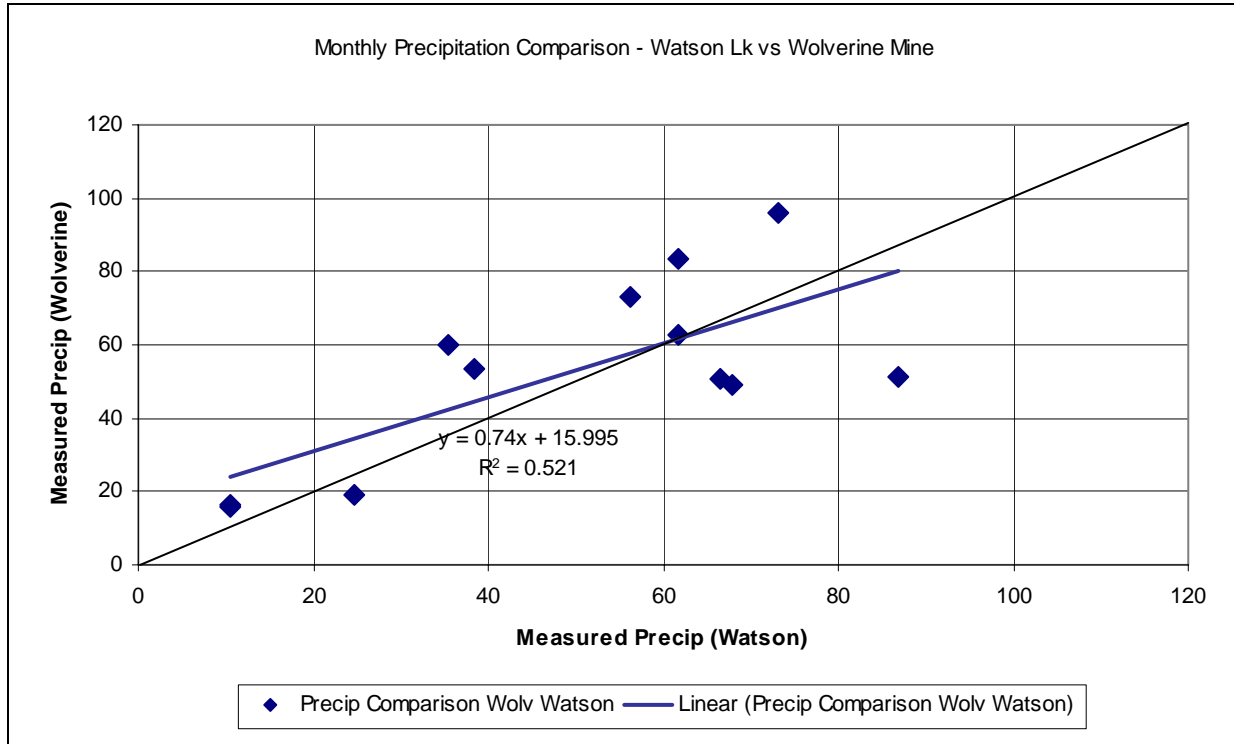


Figure III-1.3 Monthly Precipitation at Watson Lake (mm) vs. Monthly Precipitation at Wolverine (mm)

Although the other two climate stations, Tuchitua and Hour Lake, cannot be compared directly to Wolverine data, they can be compared to Watson Lake. They are both at higher elevation than Watson Lake and receive more precipitation. It would be desirable to extend the regional analysis to include a greater number of climate stations and derive a relation between elevation and precipitation. However, because of the sparseness of the climate station networks within the regional area, it is difficult to compare stations in the same climatic zone at differing elevations. The nearest climate station at an elevation comparable to the Wolverine is at Cassiar, approximately 250 km south; annual precipitation at Cassiar is 750 mm, significantly higher than in the Wolverine region.

The three regional stations and the predicted Wolverine site value plus an estimate of the error are plotted in Figure III-1.4. The predicted value of 556 mm annual precipitation for Wolverine project area was estimated by increasing the average precipitation for Tuchitua and Hour Lake by 111% (the average of the 116% and 106% increases estimated when comparing Wolverine to Watson Lake). The lower error bar represents the regional average precipitation for the three stations (481 mm) increased by 106%; the upper error bar represents the precipitation for Hour Lake (524 mm), the highest of the three stations, increased by 116%.

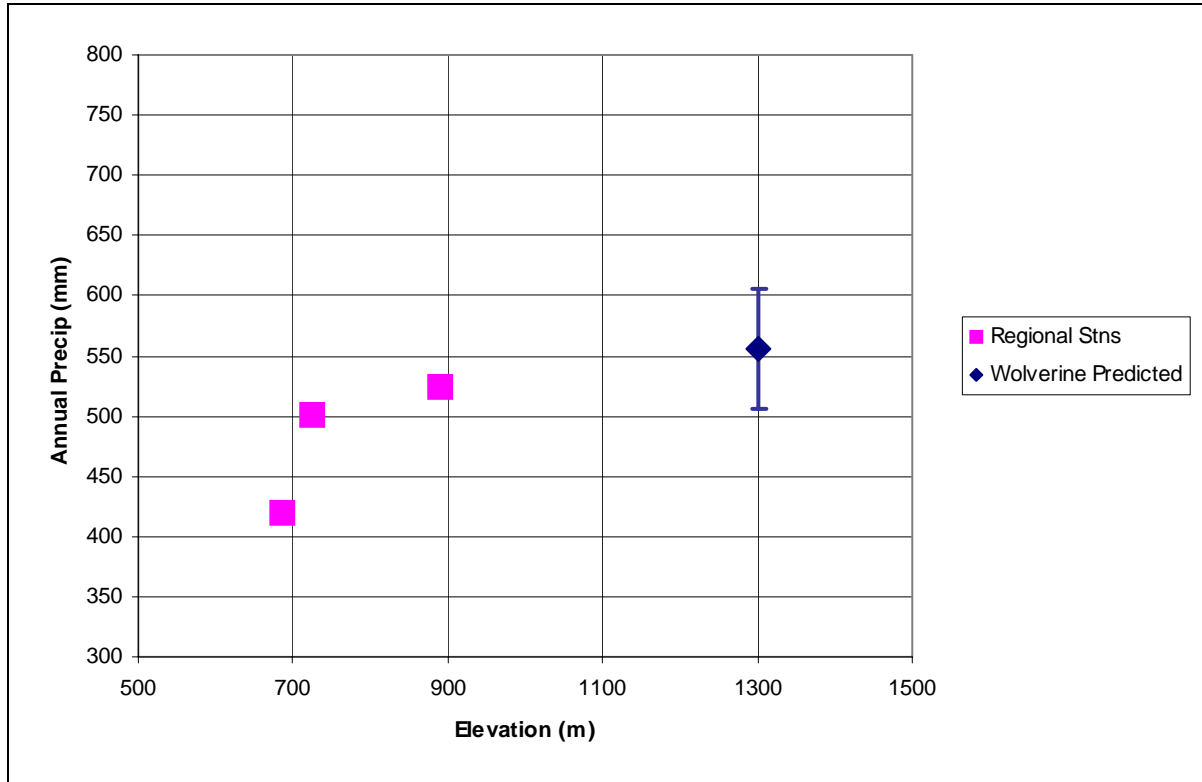


Figure III-1.4 Observed Annual Precipitation at Regional Stations Plotted by Elevation

1.1.2.2 Annual Precipitation Estimate from Precipitation Isoline Maps

As a separate check on the regional estimates described, mean annual precipitation was also estimated from published isolines. Mean annual precipitation of a region is commonly mapped using isolines corresponding to a specified precipitation interval. Because of the spatial variability of precipitation, areas within the precipitation contours will have an intermediate value. Utilizing the Rainfall Atlas of Canada (Bruce, 1968) and an American source for the State of Alaska (Oregon State, 2006), estimates for annual precipitation in the Wolverine Project area are within the range of 500 to 600 mm.

1.1.2.3 Annual Precipitation Estimate from Water Balance

The mean annual precipitation can also be estimated from the water balance. The water balance equation is:

$$\text{Precipitation} = \text{Evaporation} + \text{Runoff} + \text{Change in Storage}$$

Therefore, if runoff and evaporation are reasonably known and long-term change in storage is assumed to be zero, and then precipitation can be estimated. In theory, this is simple. In practice,

it is complicated. For instance, change in storage is usually not zero at all scales. Small watersheds usually have a positive change in storage (water infiltrates into the ground) and thus runoff estimated for small watersheds will underestimate actual runoff. Likewise, for larger watersheds, there is a net negative change in storage (net recharge from groundwater to surface water flow) that will result in the runoff term being overestimated. The scale change in the net change in storage term varies with climate and permeability. For the purposes of this calculation, a figure of 100 km² was assumed to represent no net change in storage. Then the mean annual stream flow (in m³/s/km²) for a 100 km² watershed was calculated and the resultant figure converted to a figure of mm annual runoff/m² unit area.

The calculation for mean annual flow is:

$$\text{Mean Annual Flow} = 0.0041 * (\text{watershed area})^{1.1041}$$

For a 100 km² watershed, this gives a mean annual flow of 0.0062 m³/s/km².

Then 0.0062 m³/s/km * 31557600 s/yr * 0.000001 m²/km² = 0.196 m or 196 mm of runoff. This is close to the regional value of 200 mm predicted for the 1300 m elevation for the Cassiar Mountains by Obedkoff (2000).

Mean annual evaporation has been estimated at approximately 400 mm (discussed below). Therefore, annual precipitation should be approximately 196 + 400 = 596 mm. This is close to both the 556 mm value estimated previously and within (but close to the upper boundary of) the 500-600 mm range estimated from regional precipitation maps. The error in the estimates of evaporation is approximately +/- 30 mm. This would give a range of 566-626 mm.

Averaging the three estimates of precipitation (550 mm, 556 mm, and 596 mm) derived above gives a value of 567 mm for total annual precipitation. For the purposes of calculating monthly precipitation values and for design criteria, a value of 570 mm will be used. The overlap in the three error estimates gives the range of 566 to 600 mm.

1.1.2.4 Monthly Precipitation Estimates from Annual Precipitation

To estimate the monthly precipitation distribution at Wolverine, the monthly fraction of annual precipitation has been determined by simply averaging the three regional station values (Table III-1.2). In general, the proportion of mean monthly precipitation as a function of annual precipitation does not vary significantly between regional stations. The summer precipitation at

Tuchitua and Hour Lake shows more of an increase compared to Watson Lake than does the winter precipitation; however, as there is no winter precipitation data from the Wolverine site, this trend cannot be verified against observed site data.

Table III-1.2 Mean Monthly Precipitation at Wolverine Estimated from Regional Monthly Proportion of Annual Rainfall

Regional Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Watson Lake (mm)	30.9	23.3	19.2	15.6	31.2	52	56.6	45.2	42.5	34.8	32.6	34.6	418.6
Tuchitua (mm)	41.2	32.6	22.1	18.4	37.5	53.6	70.2	50.8	49.2	39.1	42.1	44.0	500.8
Hour Lake (mm)	36.2	28.0	25.8	16.6	38.5	59.7	70.0	62.0	53.1	49.7	43.4	41.5	524.4
Mean (mm)	36.1	28.0	22.4	16.9	35.7	55.1	65.6	52.6	48.2	41.2	39.4	40.0	481.3
% Monthly Precipitation	0.08	0.06	0.05	0.04	0.07	0.11	0.14	0.11	0.10	0.09	0.08	0.08	1.00
Site Data Precipitation (mm)	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	570.0

1.1.3 Snowpack

There are limited winter precipitation records available from Wolverine for the winter months (snowfall), and it is therefore difficult to determine whether there is a seasonal variation in precipitation trend with elevation. Broadly speaking, there are three possibilities with respect to seasonal trends:

- Snowfall at Wolverine in the winter will be greater than the snowfall estimated from the monthly precipitation of the regional stations and scaled for elevation (the effect of elevation on precipitation observed for rain will be intensified for snow).
- Snowfall at Wolverine in the winter will follow the same trend with elevation as observed rainfall. The effect of elevation on precipitation observed for rain can be extended to snowfall. This is the default assumption.
- Snowfall at Wolverine in the winter will be less than the snowfall estimated from the regional stations and scaled for elevation. The effect of elevation on precipitation will be less for snow than is observed for rain.

Examining the monthly differences in precipitation observed at Watson Lake, Tuchitua and Hour Lake, there is no consistent seasonal trend in increased precipitation in winter at the higher elevation Tuchitua and Hour Lake stations when compared to the Watson Lake station in the summer months. This supports the default assumption that the scaling observed for Wolverine in summer will also apply in winter.

If all the snow that fell as snow persisted and accumulated, total snowpack water equivalent (SWE) in the spring would be simply the sum of the winter precipitation values. For the

Wolverine Project area, assuming that all precipitation falling between October and March falls as snow, this total would be 245 mm.

In early March 1997, the snow water equivalent at site was measured to be 128 mm. A depth was not recorded. Anecdotal reports at that time suggested that observed snow depths at the industrial complex and camp sites do not exceed 1 m. A snowpack survey was conducted in late March 2006 in the vicinity of the airstrip. A total of 10 stations along a transect were surveyed with snow depths ranging from 0.95 m to 1.04 m, with an average depth of 0.99 m. These measurements are consistent with anecdotal observations.

The snowpack at maximum depth is not the snowpack at maximum density. Maximum density occurs late in the season when the snow has been partially melted and condensed. At maximum depth, snowpack density will be higher than the 0.1 mm water/1.0 mm snow value for new fallen snow, but most likely lower than 0.2. Maximum density values of 0.2 to 0.25 are usually reached late in the season when the snowpack has begun to melt. The maximum SWE occurs at some point between maximum depth and maximum density.

Assuming only snow accumulation and applying sublimation estimated from the Hamon equation (Figure III-1.5), if the snowpack begins to accumulate on October 1, then on April 1 the net SWE would be 245 mm of precipitation less 42 mm of sublimation, for a total SWE of 203 mm. With an assumed 0.2 snowpack density, this would equate to a snowpack depth of 1 m, similar to the maximum observed depth. However, it is likely that the actual mean SWE on April 1 will be lower than 200 mm, because some of the precipitation in both October and March can fall as rain and is not stored as snow¹. It has therefore been assumed that mean annual SWE at Wolverine is approximately 175 mm.

Mean SWE for the Liard Basin is 150-175 mm. Mean annual precipitation in the Liard Basin likewise varies between 300 mm and 1000 mm. Since the mean annual precipitation at Wolverine has been estimated to be approximately 570 mm, and is in the midpoint of the range for the Liard Basin, it is assumed that the mean SWE at Wolverine would be relatively close to the mean SWE for the Liard Basin.

¹ The automated climate station has recorded small amounts of rainfall in October and March.

Hamon Equation (1961)

$$ET_t = 2.1D_t^2 p_{swt} / (T_t + 273)$$

in which D_t is the number of daylight hours during day t and T_t here refers to the mean air temperature during day t ($^{\circ}\text{C}$). The daylight hours variable can be determined by:

$$D_t = 24\omega_s / \pi$$

where ω_s is the sunset hour angle (radians), calculated from:

$$\omega_s = \arccos[-\tan(\phi)\tan(\delta)]$$

with ϕ equal to latitude (radians), and δ is the declination (radians) given by:

$$\delta = 0.4093 \sin[2\pi(284 + \text{DOY})/365]$$

and DOY is the day of the year (1–365). p_{swt} is the saturation vapour pressure in kilopascals on day t .

Hamon Equation (1963)

$$ET_t = (715.5 \cdot \Delta \cdot p_{swt}) / (T_t + 273)$$

where Δ is day length as fraction of day (length of daylight hours/24 hours).

Figure III-1.5 Hamon Equations**1.1.4 Evaporation**

Evaporation figures were estimated from the Hamon equations and compared to measured evaporation at Carmacks (Figure III-1.6). The average of the two annual totals from the two equations was approximately 400 mm.

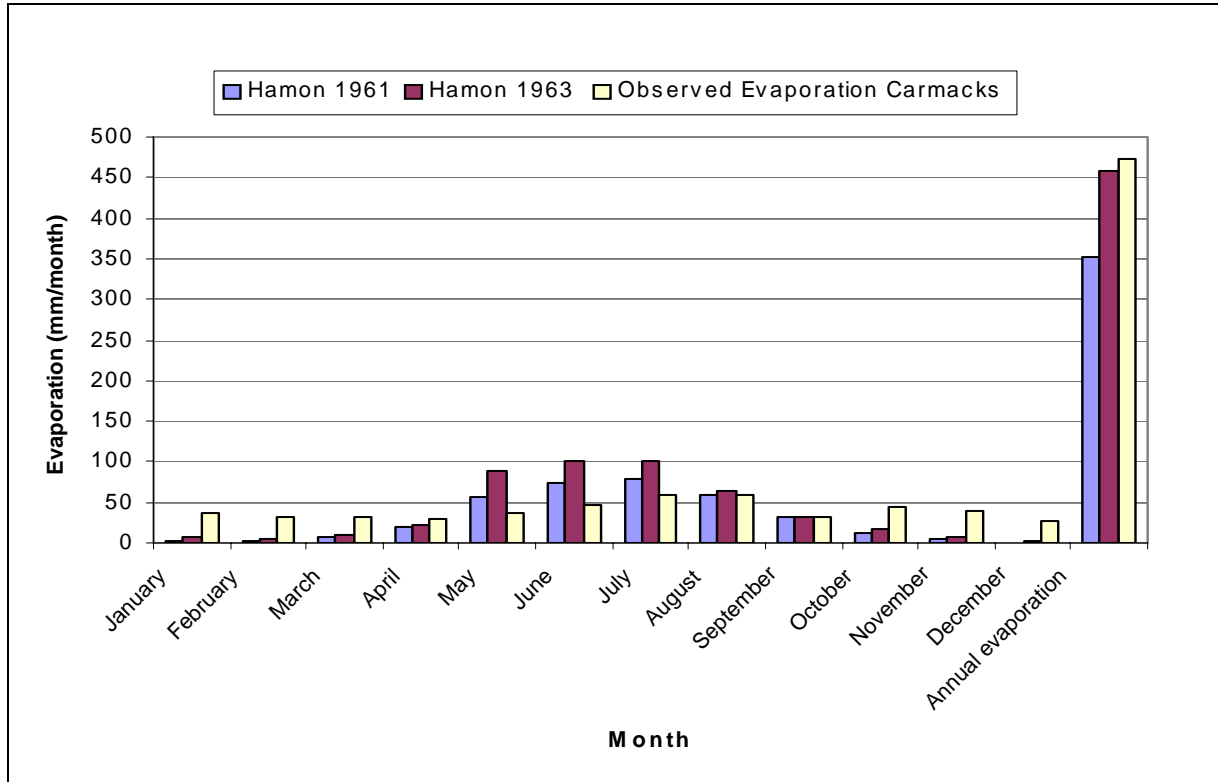


Figure III-1.6 Monthly and Annual Evaporation Estimates

Lake evaporation (free water) has been estimated from both regional data and, more recently employing the Modified Penman Equation and utilizing site specific data collected at the Wolverine project during May through September 2006. Regional lake evaporation figures have been obtained for the period 1951-1980 (the last period for which such statistics were calculated) for four stations in the NWT, three stations in the Yukon and one station in northern BC. The observed values are presented in Table III-1.3.

Table III-1.3 Mean and Standard Deviation of Observed Lake Evaporation (mm) Northwestern Canada, 1951-1980

Station	Elev. (m)	May Mean	SD	June Mean	SD	July Mean	SD	Aug Mean	SD	Sept Mean	SD	Annual
Fort Selkirk	500	107.6	±13	120.3	±12.4	108.0	±16.1	79.8	±13.7	37.2	±5.3	453
Haines Junction	599	99.8	±38.2	139.1	±32.5	128.6	±23.4	88.8	±14.6	37.5	±11.3	494
Whitehorse	706	104.3	±1.6	124.8	±19.8	109.9	±8.1	96.0	±14.6	47.7	±9.4	483
Fort Smith	205	123.4	±20.5	129.3	±9.4	126.3	±15.4	100	±14.3	45.2	±12.9	524
Norman Wells	74	110.4	±29.8	139.9	±15.4	123.0	±15.3	81.4	±15.4	42.3	±4.3	497
Resolute	67	-	-	-	-	100.2	±29.3	52.0	±14.7	-	-	152
Yellowknife	206	-	-	164.1	±10.2	157.9	±12.6	109.6	±14.9	49.9	±8.5	482
Hudson Hope BC	498	102.4	±13.9	121.0	±15.1	111.1	±11.5	98.0	±16.2	48.4	±12.1	481

Annual evaporation figures range from 152 mm for Resolute to 524 mm for Fort Smith. Evaporation is a complex process, being a function of air temperature, wind speed and relative humidity; temperature is a function of elevation as well as latitude. It is therefore reasonable to assume that the evaporation occurring in the Wolverine project area will be lower than these observed values because Wolverine is higher in elevation. However, the stations above vary too widely in latitude and not widely enough with elevation (elevations of the AES stations are between 0 and 700 m) to accurately determine a trend with elevation from the observed data for the latitude of Wolverine. The predicted evaporation values for Wolverine of approximately 400 mm annually seem reasonable given the lower mean temperatures and 1300 m elevation of Wolverine.

With respect to the annual water balance for the site, lake evaporation is largely but not entirely appropriate. Lake evaporation only occurs during the open water season, and drops to zero when the lake is frozen over. However, evaporation from snow-covered ground can occur, particularly when dry air overlies wet snow (sublimation), and is enhanced under windy conditions.

Therefore, the non-zero values estimated from the Hamon equation for winter conditions seen in Figure III-1.6 may have some physical basis.

1.1.4.1 Site Specific Estimation of Free Water Evaporation (ET₀) at Wolverine

Free water evaporation for the Wolverine project was recently re-evaluated using site specific radiation, temperature, wind speed and relative humidity data for the period of May 20 to October 2006. Using the hourly data for the open ice period of 2006, and synthesizing an annual record for certain parameters, an annual estimate of free water evaporation was developed.

1.1.4.1.1 Synthesizing Solar Radiation

Solar radiation incident outside the earth's atmosphere is called extraterrestrial radiation. On average the extraterrestrial irradiance is 1367 Watts/meter² (W/m²). This value varies by +/-3% as the earth orbits the sun. The earth's closest approach to the sun occurs around January 4th and it is furthest from the sun around July 5th. The extraterrestrial radiation is

$$I_0 = 1367 * (R_{av} / R)^2 I \quad (\text{W/m}^2)$$

where R_{av} is the mean sun-earth distance and R is the actual sun-earth distance depending on the day of the year. An approximate equation for the effect of the earth-sun distance is

$$(R_{av} / R)^2 = 1.00011 + 0.034221 * \cos \beta + 0.001280 * \sin \beta + 0.000719 * \cos 2\beta + 0.000077 * \sin 2\beta$$

where $\beta = 2\pi n / 365$ radians and n is the day of the year.

The earth's axis is tilted approximately 23.45 degrees with respect to the earth's orbit around the sun. To describe the sun's path across the sky one needs to know the angle of the sun relative to a line perpendicular to the earth's surface – this is called the zenith angle – and the sun's position relative to the north-south axis, the azimuthal angle. The hour angle is easier to use than the azimuthal angle because the hour angle is measured in the plane of the “apparent” orbit of the sun as it moves across the sky. Since the earth rotates approximately once every 24 hours, the hour angle changes by 15 degrees per hour and moves through 360 degrees over the day. Typically, the hour angle is defined to be zero at solar noon, when the sun is highest in the sky.

To describe the position of the sun in local standard time, one needs to know the relationship between solar time and local standard time. Local time is the same in the entire time zone whereas solar time relates to the position of the sun with respect to the observer, and that is

different depending on the exact longitude where solar time is calculated. To adjust solar time for longitude one must subtract $(Long_{local} - Long_{sm})/15$ (units are hours) from the local time. $Long_{local}$ is the longitude for the observer in degrees and $Long_{sm}$ is the longitude for the standard meridian for the observer's time zone.

As the earth moves around the sun, solar time changes slightly with respect to local standard time. This is important when determining the position of the sun for solar energy calculations. An approximate formula for the equation of time (E_{qt}) in minutes is

$$E_{qt} = -14.2 \sin\{\pi(n + 7)/111\}$$

for Julian day n between 1 and 106

$$E_{qt} = 4.0 \sin\{\pi(n - 106)/59\}$$

for n between 107 and 166

$$E_{qt} = -6.5 \sin\{\pi(n - 166)/80\}$$

for n between 167 and 246

$$E_{qt} = 16.4 \sin\{\pi(n - 247)/113\}$$

for n between 247 and 365.

Using longitude correction and the equation of time, the relationship between the solar time and local standard time is

$$T_{solar} = T_{local} + \frac{E_{qt}}{60} + \frac{Long_{sm} - Long_{local}}{15}$$

Values are in hours. Since equations use sine and cosine functions, it is conceptually easier to calculate using the hour angle instead of time. The relationship between hour angle and time is:

$$\omega = \pi(12 - T_{solar})/12$$

The hour angle is in units of radians. With the above information, one can now calculate the cosine of the zenith angle:

$$\cos Z = \sin \lambda \sin \delta + \cos \lambda \cos \delta \cos \omega$$

where λ is the latitude of the location of interest.

Sunrise and sunset occur when the sun is at the horizon and hence the cosine of the zenith angle is zero. Setting the cosine of the zenith angle to zero in the above equation results in the following equation:

$$\omega_{sr,ss} = \arccos(-\tan \lambda \tan \delta)$$

Near noon on a day without clouds, about 25% of the solar radiation is scattered and absorbed as it passes through the atmosphere. Therefore about 1000 W/m² of incident solar radiation reaches the earth's surface without being significantly scattered. This radiation, coming from the direction of the sun, is called direct normal irradiance, or beam irradiance. Some of the scattered sunlight is scattered back into space and some of it also reaches the surface of the earth. The scattered radiation reaching the earth's surface is called diffuse radiation. Some radiation is also scattered off the earth's surface and then re-scattered by the atmosphere to the observer. This is also part of the diffuse radiation the observer sees. This amount can be significant in areas where the ground is covered with snow or consists largely of exposed rocks. This is one of the major reasons why it was decided not to include the effects of solar zenith and shadow casting to the Wolverine mine site. It is extremely difficult to evaluate the diffuse radiation effects properly.

The total solar radiation on a horizontal surface is called global irradiance and is the sum of incident diffuse radiation plus the direct normal irradiance projected onto the horizontal surface. If the surface under study is tilted with respect to the horizontal, the total irradiance is the incident diffuse radiation plus the direct normal irradiance projected onto the tilted surface plus ground reflected irradiance that is incident on the tilted surface. In the present calculation, for simplification purposes, it was assumed the horizontal surface as the surface of interest (free water surface). The calculation also neglected the effects of dust, moisture, and some other elements which may prevent incidental radiation.

Figure III-1.7 graphically presents the calculation results of irradiation for the Wolverine mine site (for one day May 21, 2006, as an example). These values match well with the observed data for this site in sunny days and therefore a longer-term synthesized radiation record will be used for estimating the evapotranspiration values ET₀, which should be similar to the actual free water surface evapotranspiration.

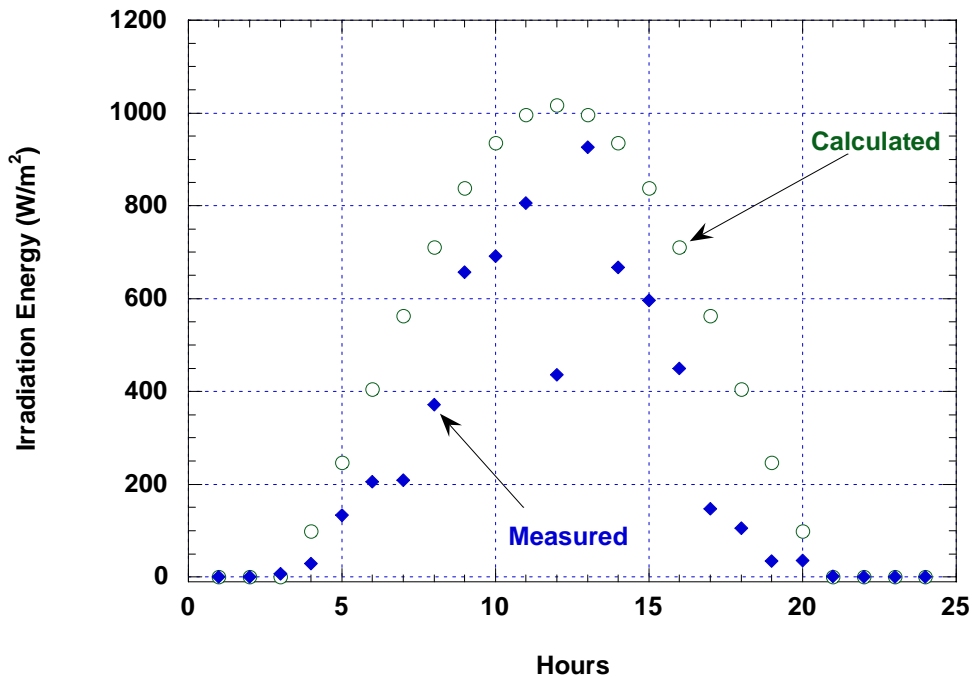


Figure III-1.7 Comparison of Calculated Solar Radiation to Measured Solar Radiation from Site Weather Station (May 21, 2006)

1.1.4.1.2 Estimate of ET_0 value for the Wolverine Mine Site

The evaporation estimate was performed by using the Modified Penman Equation by Pruitt and Doorenbos (Proceedings of the international round table conference on “Evapotranspiration”, Budapest, Hungary. 1977). In 1948, Penman combined the energy balance with the mass transfer method and derived an equation to compute the evaporation from an open water surface from standard climatological records of sunshine, temperature, humidity and wind speed. This so-called combination method was further developed by many researchers and extended to cropped surface by introducing resistance factors.

The resistance nomenclature distinguishes between aerodynamic resistance and surface resistance factors. The surface resistance parameters are often combined into one parameter, the ‘bulk’ surface resistance parameter which operates in series with the aerodynamic resistance. The surface resistance, r_s , describes the resistance of vapour flow through stomata openings, total leaf area and soil surface. The aerodynamic resistance, r_a , describes the resistance from the vegetation upward and involves friction from air flowing over vegetative surfaces. Although the exchange process in a vegetation layer is too complex to be fully described by the two resistance

factors, good correlations can be obtained between measured and calculated evapotranspiration rates, especially for a uniform grass reference surface.

Simplified representation of the (bulk) surface and aerodynamic resistances for water vapour flow can be described as following:

The Penman-Monteith form of the combination equation is,

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a C_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a}\right)}$$

where R_n is the net radiation, G is the soil heat flux, $(e_s - e_a)$ represents the vapour pressure deficit of the air, r_a is the mean air density at constant pressure, C_p is the specific heat of the air, Δ represents the slope of the saturation vapour pressure temperature relationship, γ is the psychrometric constant, and r_s and r_a are the (bulk) surface and aerodynamic resistances. The parameters of the equation will be defined later in this report.

The Penman-Monteith approach as formulated above includes all parameters that govern energy exchange and corresponding latent heat flux (evapotranspiration) from uniform expanses of vegetation. Most of the parameters are measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration as the surface and aerodynamic resistances are crop specific.

Aerodynamic resistance (r_a)

The transfer of heat and water vapour from the evaporating surface into the air above the canopy is determined by the aerodynamic resistance:

$$r_a = \frac{\ln\left[\frac{Z_m - d}{Z_{0m}}\right] \ln\left[\frac{Z_h - d}{Z_{0h}}\right]}{k^2 u_z}$$

where

r_a aerodynamic resistance ($s\ m^{-1}$)

Z_m height of wind measurements (m)

Z_h	height of humidity measurements (m)
d	zero plane displacement height (m)
Z_{0m}	roughness length governing momentum transfer (m)
Z_{0h}	roughness length governing transfer of heat and vapour (m)
k	von Karman's constant, 0.41 (non-dim)
u_z	wind speed at height z (m s^{-1})

The equation is restricted for neutral stability conditions, i.e. where temperature, atmospheric pressure, and wind velocity distributions follow nearly adiabatic conditions (no heat exchange). The application of the equation for short time period (hourly or less) may require the inclusion of corrections for stability. However, when predicting ET_0 in the well-watered reference surface, heat exchange is small, and therefore stability correction is normally not required.

Many studies have explored the nature of the wind regime in plant canopies. Zero displacement heights and roughness lengths have to be considered when the surface is covered by vegetation. The factors depend upon the crop height and architecture. Several empirical equations for the estimate of d , z_{0m} , and z_{0h} have been developed. The aerodynamics resistance term and wind function are also adopted from method developed at the University of California, Davis.

Calculation of ET_0 requires the following variables for the site:

ea	mean hourly vapor pressure (kPa)
RH	mean hourly relative humidity (%)
Rn	mean hourly net radiation (Wm^{-2})
T	mean hourly air temperature ($^{\circ}\text{C}$)
U	mean hourly wind speed at 2 m (m s^{-1})
Z	Elevation of the station above mean sea level (m)

Usually these values can be obtained from meteorological observation data, however, for Wolverine, only a limited period of record exists, which are insufficient to calculate annual values of evapotranspiration. As outlined above, radiation (Rn) can be mathematically synthesized to produce a longer period of record, while the other remaining variables need to be either synthesized or assumed. The present approach was to use averaged values of these

parameters over the period of 20 May – 2 September, 2006 (the period of full meteorological data collection at site), except for the hourly air temperature. Hourly air temperature was then synthesized from monthly average values available from the site. Simple linear regression was used to create these data. Although these assumptions are rather crude and overly simple, the ET_0 values calculated appear to be fairly reasonable.

Using the synthesized radiation data in concert with the meteorological (wind speed, temperature, RH) data and the Penman equation, calculated hourly ET_0 values for Wolverine (assuming year-round availability of free water) are presented in Figure III-1.8 below.

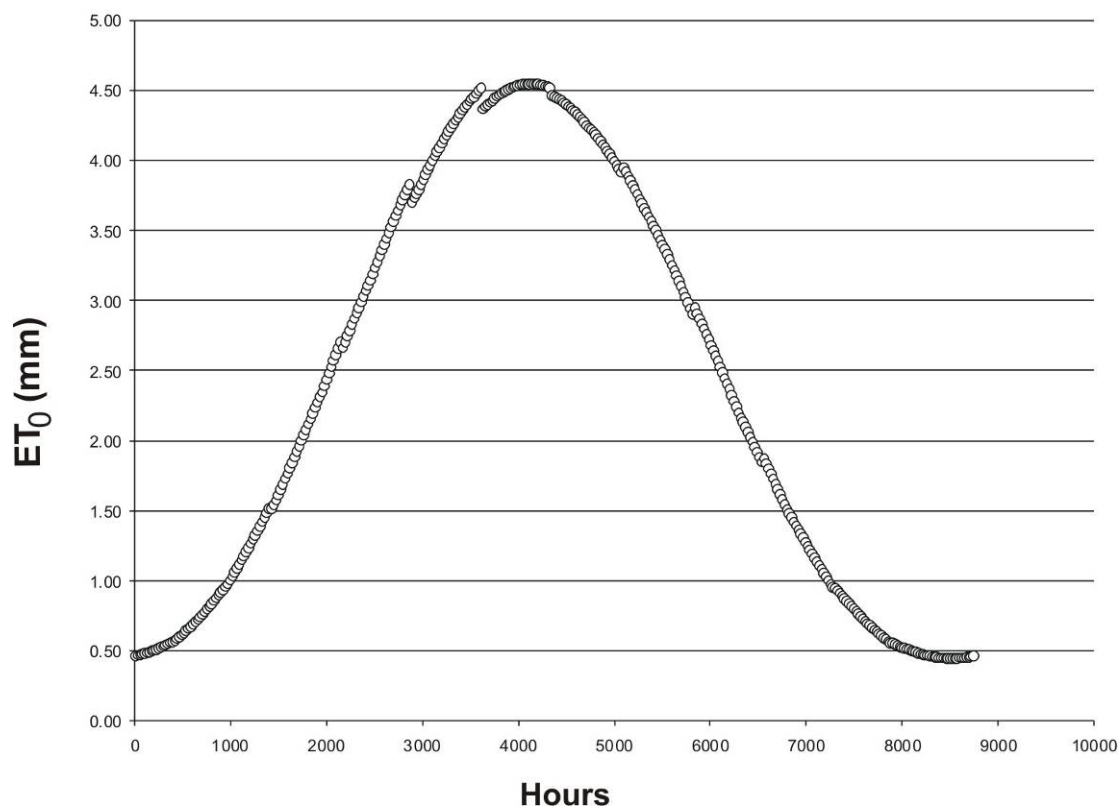


Figure III-1.8 Daily Distribution of ET_0 at Wolverine Assuming Continuous Free Water Availability

Assuming no ice formation, total annual ET_0 is estimated at roughly 865 mm. Clearly, this is inappropriate for the Wolverine site, but nonetheless serves to provide an upper boundary on evaporation potential.

The effects of ice on free water evaporation were included by assigning zero ET_0 values once daily average air temperature becomes below zero °C. Total annual ET_0 for Wolverine,

assuming no evaporation during ice covered periods is approximately 542 mm with an annual distribution as represented in Figure III-1.9.

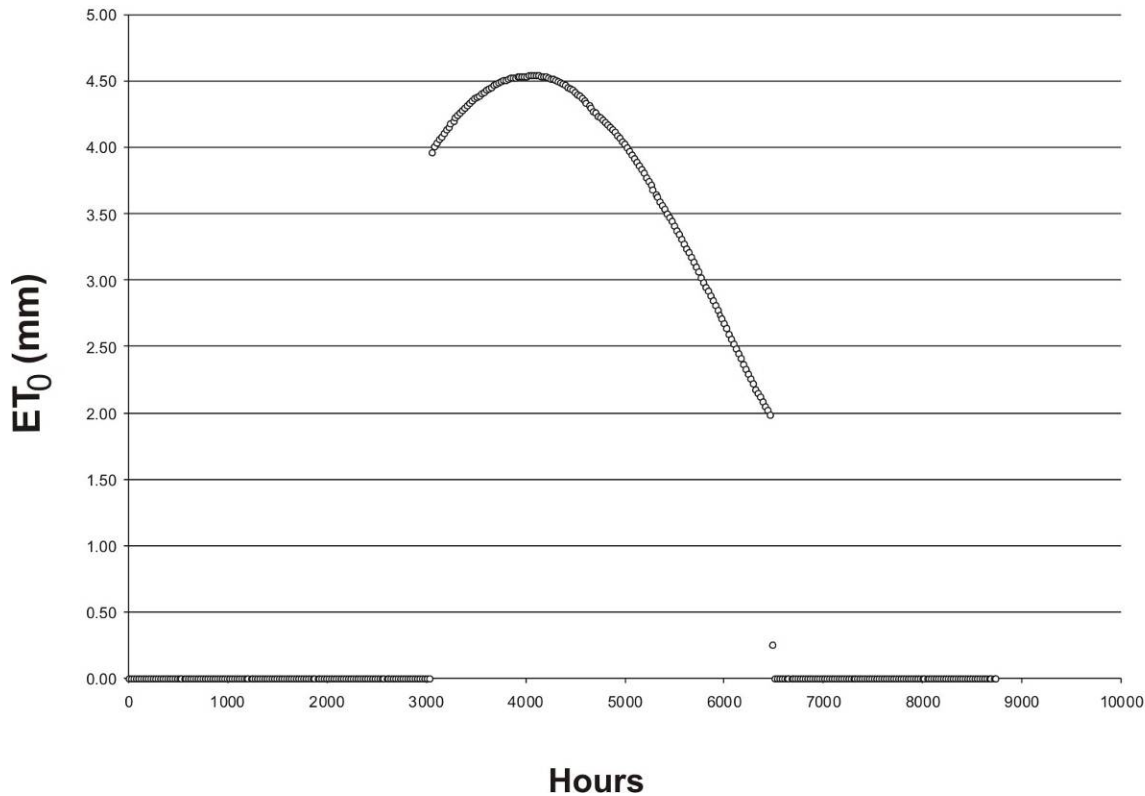


Figure III-1.9 Daily Distribution of ET_0 at Wolverine Considering No Evaporation During Ice Covered Periods

The calculated ET_0 values utilizing synthesized radiation data and averaged wind speed, RH and synthesized hourly temperature data agree reasonably well with ET_0 calculated from site specific meteorological data from the airstrip site for the period of May 21-24, 2006 (Figure III-1.10). These specific dates were chosen randomly to test the comparison. The analysis of site specific data and utilization of calculated radiation data suggest that free water evaporation rates at Wolverine may be somewhat higher than that estimated from pan evaporation and other regional data. Continuation of meteorological data collection will allow this analysis to be further evaluated throughout operations.

In summary, while for water balance purposes described in Section G an annual evaporation rate of 400 mm will be conservatively employed, it is evident from the above analysis that free water evaporation rates could be higher at site. Accordingly, a sensitivity analysis using evaporation rates on the order of 540 mm/y was performed in the water balance analysis (see Section G).

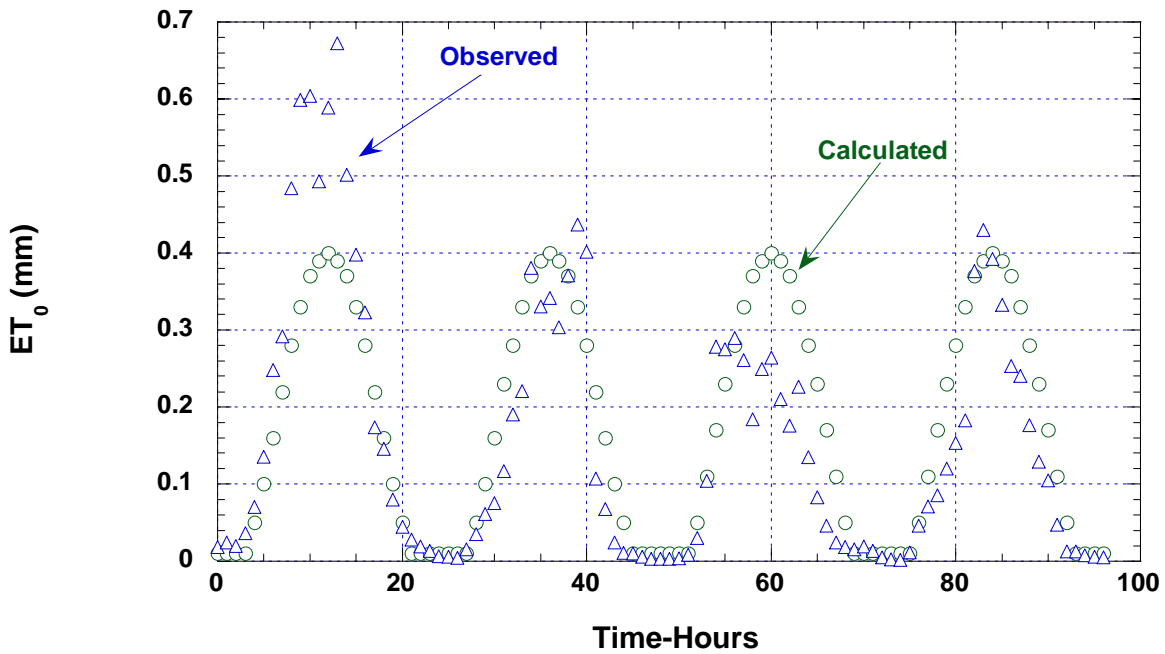


Figure III-1.10 Comparison of Calculated Hourly ET₀ (from Synthesized Data) and Observed ET₀ Generated from Meteorological Station Data for May 21-24, 2006

1.2 Monthly Precipitation

Estimated monthly precipitation by return period and estimated rainfall/duration/intensity are provided in Table X and Table X, respectively, from Madronne Environmental Services Ltd.

Table III-1.4 Estimated Monthly Precipitation (mm) for Wolverine Mine by Return Period

Month	Mean	Return Period (years)																			
		1.001	1.002	1.005	1.01	1.02	1.042	1.053	1.111	1.25	2	5	10	20	25	50	100	200	500	1,000	10,000
Jan	42.8	11.8	13.6	16.2	18.3	20.6	23.0	23.8	26.6	30.0	42.8	42.1	45.2	47.9	48.4	50.4	52.2	54.0	56.0	57.4	63.0
Feb	33.2	9.2	10.6	12.6	14.3	16.0	17.9	18.5	20.7	23.4	33.2	32.7	35.1	37.3	37.6	39.2	40.6	42.0	43.5	44.7	49.0
Mar	26.5	6.9	8.0	9.5	10.7	12.0	13.4	13.9	15.5	17.5	26.5	24.5	26.4	28.0	28.2	29.4	30.5	31.5	32.7	33.5	36.8
April	20.0	6.5	7.6	9.0	10.2	11.4	12.8	13.2	14.8	16.7	20.0	23.4	25.1	26.6	26.9	28.0	29.0	30.0	31.1	31.9	35.0
May	42.3	15.7	18.2	21.6	24.4	27.5	30.7	31.7	35.5	40.0	42.3	56.1	60.2	63.9	64.5	67.2	69.6	72.0	74.6	76.6	84.0
Jun	65.3	22.6	26.2	31.1	35.1	39.5	44.1	45.6	51.1	57.5	65.3	80.7	86.6	91.8	92.7	96.6	100.1	103.4	107.3	110.1	120.8
July	77.7	26.8	31.1	37.0	41.7	46.9	52.4	54.2	60.7	68.4	77.7	95.9	102.9	109.1	110.2	114.8	119.0	122.9	127.5	130.8	143.5
Aug	62.3	20.3	23.5	28.0	31.6	35.5	39.6	41.0	45.9	51.7	62.3	72.5	77.8	82.5	83.3	86.8	90.0	92.9	96.4	98.9	108.5
Sept	57.0	18.6	21.6	25.7	29.0	32.6	36.4	37.7	42.2	47.5	57.0	66.6	71.5	75.9	76.6	79.8	82.7	85.4	88.6	90.9	99.8
Oct	48.8	14.7	17.1	20.3	22.9	25.7	28.8	29.7	33.3	37.5	48.8	52.6	56.5	59.9	60.5	63.0	65.3	67.5	70.0	71.8	78.8
Nov	46.7	13.1	15.2	18.0	20.4	22.9	25.6	26.4	29.6	33.4	46.7	46.8	50.2	53.2	53.8	56.0	58.0	60.0	62.2	63.8	70.0
Dec	47.4	13.1	15.2	18.0	20.4	22.9	25.6	26.4	29.6	33.4	47.4	46.8	50.2	53.2	53.8	56.0	58.0	60.0	62.2	63.8	70.0
TOTAL	570.0	179.2	207.7	247.1	278.9	313.5	350.2	362.2	405.5	457.0	570.0	640.6	687.7	729.4	736.5	767.2	795.1	821.5	852.1	874.1	959.0

Table III-1.5 Estimated Rainfall/Duration/Intensity for Wolverine Mine

Duration	Rainfall (mm)			
	50 year	100 year	200 year	10,000 year
10 min.	7.2	7.9	8.5	-
15 min.	8.6	9.4	10.2	-
20 min.	9.7	10.6	11.5	-
25 min.	10.7	11.7	12.7	-
30 min.	11.6	12.7	13.8	16.3
60 min.	14.5	15.8	17.2	20.4
5 hour	-	-	32.0	38.0
10 hour	-	-	41.0	50.0
15 hour	-	-	48.0	60.0
20 hour	-	-	53.0	66.0
24 hour	-	-	56.0	72.0

2. SURFACE AND GROUNDWATER QUALITY

2.1 Surface Water in Tailings Impoundment Area

Baseline surface water quality samples were collected from 2005 to 2007 from Station W44 (location shown in Figure III-2.1) located on a small stream that drains through the proposed tailings impoundment area. The baseline data is summarized in Table III-2.1, and the full data comprising the averages and ranges in Table III-2.1 are provided in Table III-2.2.

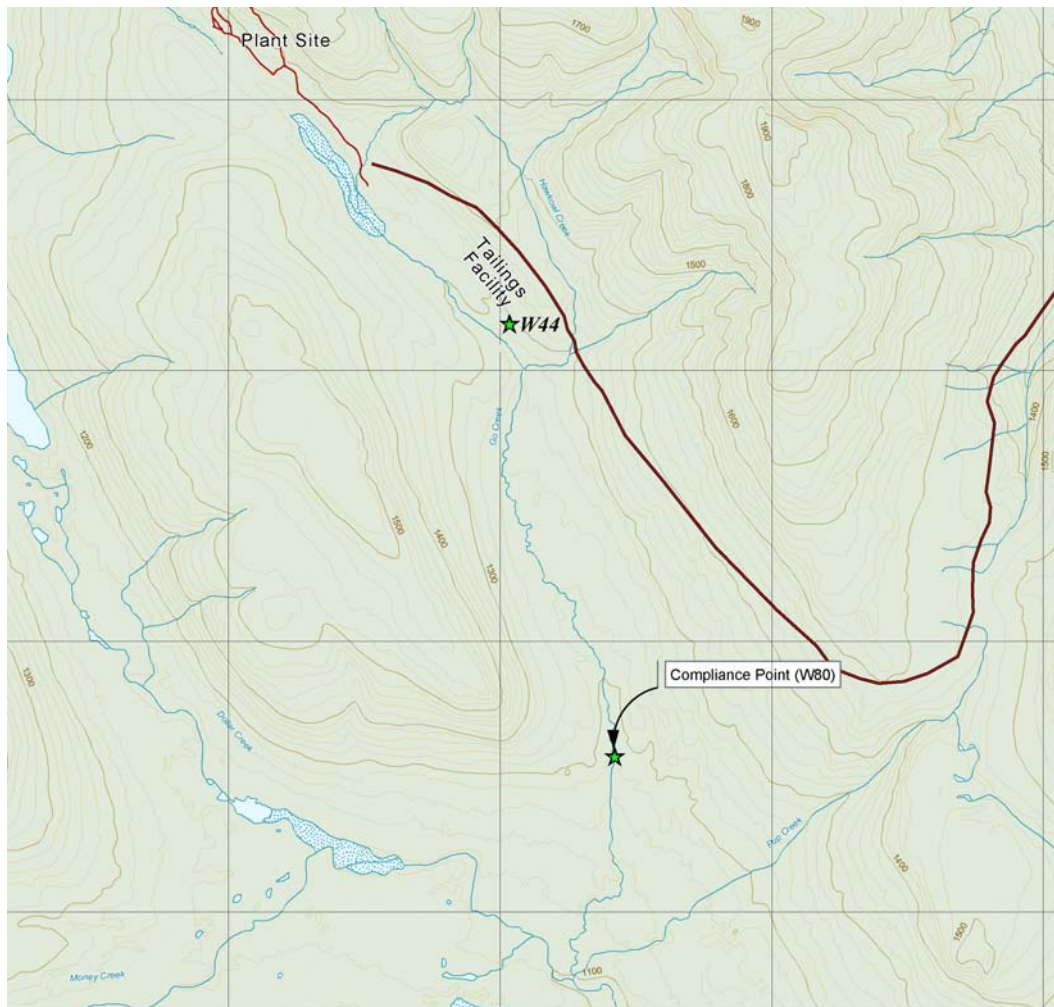


Figure III-2.1 Location Map of Surface Water Sampling Location W44 and Compliance Monitoring Station

The data indicate that water quality in this small stream is dominated by meteoric waters being of low hardness, low alkalinity and circum-neutral pH. The water is low in sulphate, nutrients and metal content is generally low, with slightly higher concentrations observed during peak snow melt periods when TSS levels are elevated.

Table III-2.1 Background Surface Water Quality in Tailings Impoundment Area (Station W44) 2005 – 2007 Averages and Ranges

	AVG	Range		AVG	Range		AVG	Range
Parameters (mg/L)	n = 13		Parameters (mg/L)	n = 13		Parameters (mg/L)	n = 13	
			Total Metals			Dissolved Metals		
Physical Parameters			Aluminum (Al)	0.3092	0.012 - 1.59	Aluminum (Al)	0.0286	0.0085 - 0.162
Conductivity	130.67	80 - 150	Antimony (Sb)	0.0001	<0.00005 - 0.00019	Antimony (Sb)	0.00006	<0.00005 - 0.00006
Hardness	68.04	23 - 93	Arsenic (As)	0.0147	0.0001 - 0.144	Arsenic (As)	0.00017	0.0001 - 0.0002
Total Suspended Solids	40.13	<4 - 74	Cadmium (Cd)	0.0002	<0.00001 - 0.0008	Cadmium (Cd)	0.000039	<0.00001 - 0.00011
Total Dissolved Solids	86.23	40 - 106	Calcium (Ca)	24.72	9.5 - 33.2	Calcium (Ca)	24.61	8.25 - 33.3
pH	7.73	6.6 - 8.1	Chromium (Cr)	0.0017	0.0003 - 0.0042	Chromium (Cr)	0.0004	0.0004 - 0.0004
Turbidity	3.145	0.2 - 26.2	Cobalt (Co)	0.0003	0.00002 - 0.00117	Cobalt (Co)	0.00014	<0.00002 - 0.00035
DOC	3.2	1.3 - 6	Copper (Cu)	0.0026	0.0006 - 0.0098	Copper (Cu)	0.0012	0.0006 - 0.0036
			Iron (Fe)	0.3651	0.031 - 1.94	Iron (Fe)	0.0518	0.012 - 0.202
			Lead (Pb)	0.0005	<0.00002 - 0.00157	Lead (Pb)	0.00007	<0.00002 - 0.00014
Major Anions			Magnesium (Mg)	1.87	1.03 - 2.48	Magnesium (Mg)	1.83	0.64 - 2.32
Alkalinity-Total	59.21	25.3 - 73	Manganese (Mn)	0.0525	0.00032 - 0.334	Manganese (Mn)	0.0345	0.00333 - 0.287
Bromide	<0.01	<0.01	Mercury (Hg)	<0.00001	<0.00001	Mercury (Hg)	<0.00001	<0.00001
Chloride	0.6	<0.5 - 0.6	Molybdenum (Mo)	0.00031	0.00022 - 0.00046	Molybdenum (Mo)	0.00026	0.00015 - 0.00034
Fluoride	0.0393	0.029 - 0.05	Nickel (Ni)	0.1969	0.0007 - 0.781	Nickel (Ni)	0.0011	<0.0005 - 0.0011
Sulphate	6.76	1.5 - 9.6	Phosphorus (P)	0.0636	0.005 - 0.2	Phosphorus (P)	<0.1	<0.1
			Potassium (K)	0.9686	0.513 - 2.95	Potassium (K)	0.9328	0.544 - 2.83
			Selenium (Se)	0.0006	<0.0005 - 0.0007	Selenium (Se)	0.0006	<0.0005 - 0.0007
Nutrient Parameters			Silicon (Si)	3.6958	2.05 - 5.26	Silicon (Si)	3.48	0.68 - 4.19
Ammonial Nitrogen	0.027	<0.005 - 0.07	Silver (Ag)	0.00005	<0.00001 - 0.00007	Silver (Ag)	<0.00001	0.00003 - 0.00003
Nitrate Nitrogen	0.032	0.002 - 0.11	Sodium (Na)	0.8991	0.34 - 1.16	Sodium (Na)	0.8882	0.29 - 1.14
Nitrite Nitrogen	0.0044	<0.002 - 0.009	Strontium (Sr)	0.05415	0.0241 - 0.0744	Strontium (Sr)	0.0548	0.0176 - 0.0717
Total Phosphate	0.0056	0.0042 - 0.007	Thallium (Tl)	<0.00005	<0.00005	Thallium (Tl)	<0.00005	<0.00005
Dissolved Ortho-Phosphate	0.0043	0.001 - 0.007	Vanadium (V)	0.0007	0.00011 - 0.0031	Vanadium (V)	0.00016	0.00006 - 0.00044
			Zinc (Zn)	0.0057	0.0008 - 0.0201	Zinc (Zn)	0.0045	0.0016 - 0.0082

Table III-2.2 Background Surface Water Quality in Tailings Impoundment Area (Station W44) 2005 – 2007 Data

Sample name	W-44	W-44	W44	W44	W44	W44	W44	W44	W44	W44	W44	W44	W44
Date	23-Oct-05	13-Sep-05	10-May-06	1-Jun-06	3-Jul-06	31-Jul-06	7-Sep-06	4-Oct-06	18-Nov-06	4-Jun-07	29-Jun-07	29-Jul-07	26-Aug-07
	W6798	W4423	A619028	A623186	A629169	A635289	A642441	A647966	A656333	A724714	A729135	A734931	A740044
Parameters (mg/L)													
Physical Parameters													
Conductivity	143	150								80	124	139	148
Hardness		75.1	23	54	69	86	83	82	93	40.8	64	74.6	72
Total Suspended Solids	5.4	<3.0	74	<4	<4	<4	<4	<4	41	<4	<4	<4	<4
Total Dissolved Solids	90	95	40	78	82	94	94	84	84	86	94	94	106
pH	7.79	7.66	6.6	7.2	8	8	8.1	8	7.8	7.6	7.9	7.9	8
Turbidity		0.44	26.2	0.5	0.5	0.2	0.3	0.2	8.1	0.4	0.4	0.2	0.3
DOC	2.87	3.03	3	6	-	2.4	4.4	1.3	2.8	4.2	2.5	3	2.9
Major Anions													
Alkalinity-Total		66.3	25.3	49.4	61	69.8	72	69	73	37.7	57.5	62.9	66.6
Bromide	<0.050	<0.050								<0.1	<0.1	<0.01	<0.01
Chloride	<0.50	<0.50	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5
Fluoride	0.029	0.037								0.04	0.04	0.04	0.05
Sulphate	9.34	8.83	1.5	4.7	8.4	7.9	7.4	9.2	9.6	1.8	6.2	6.6	6.4
Nutrient Parameters													
Ammonial Nitrogen	<0.020	<0.020	0.07	<0.005	<0.005	<0.005	<0.005	0.012	0.017	<0.005	0.009	<0.005	<0.005
Nitrate Nitrogen	0.037	<0.0050	0.11	<0.02	0.008	<0.002	<0.002	0.016	0.093	0.003	0.012	0.007	0.002
Nitrite Nitrogen	0.0024	<0.0010	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	0.003	0.003	<0.002	<0.002
Total Phosphate	0.0042	<0.0020								0.007	0.006	<0.005	0.005
Dissolved Ortho-Phosphate			<0.005	0.005	0.005	-	<0.001	0.001	0.007	0.006	0.002	0.002	0.006
Total Metals													
Aluminum (Al)	<0.20	0.012	1.57	0.0446	0.0318	0.0152	<0.00005	0.0309	1.59	0.0464	0.0252	0.0192	0.0162
Antimony (Sb)	<0.20	<0.00050	0.00008	0.00011	<0.00005	<0.00005	0.0001	<0.00005	0.00019	<0.00005	<0.00005	<0.00005	<0.00005
Arsenic (As)	<0.20	<0.00050	0.0005	0.0002	0.0001	0.0002	0.144	0.0002	0.0006	0.0002	<0.0001	0.0004	0.0001
Cadmium (Cd)	<0.010	<0.000017	0.00013	<0.00001	<0.00001	<0.00001	0.0008	<0.00001	0.00015	0.00002	0.00002	<0.00001	<0.00001
Calcium (Ca)	27	25.7	9.5	19.5	25.2	33.2	30.9	30.3	29.9	14.6	23.6	25.6	26.3
Chromium (Cr)	<0.010	<0.0010	0.0037	<0.0002	0.0005	<0.0002	<0.0002	0.0008	0.0042	0.0003	0.0005	<0.0002	<0.0002
Cobalt (Co)	<0.010	<0.00030	0.00095	0.00005	0.00002	<0.00002	0.0006	0.00002	0.00117	0.00004	0.00003	0.00002	0.00003
Copper (Cu)	<0.010	<0.0010	0.0077	0.0012	0.0021	0.001	<0.00002	0.0006	0.0098	0.0015	0.0009	0.0009	0.0007
Iron (Fe)	<0.030	<0.030	1.53	0.041	0.031	0.242	0.049	0.036	1.94	0.041	0.042	0.031	0.033
Lead (Pb)	<0.050	<0.00050	0.00096	<0.00002	0.00005	<0.00002	0.0002	0.00003	0.00157	<0.00002	0.00004	<0.00002	<0.00002
Magnesium (Mg)	2.15	2.15	1.03	1.44	1.84	2.24	2.1	2.13	2.48	1.17	1.71	1.9	1.97
Manganese (Mn)	<0.0050	0.00415	0.212	0.00645	0.00968	0.0155	0.00032	0.013	0.334	0.00875	0.01	0.00719	0.00949
Mercury (Hg)		<0.000020								<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Mo)	<0.030	<0.0010	0.00029	0.00031	0.00035	0.00022	<0.0005	0.00033	0.00046	0.00026	0.00029	0.00029	0.00031
Nickel (Ni)	<0.050	<0.0010	0.0028	<0.0005	<0.0005	<0.0005	0.781	<0.0005	0.0031	<0.0005	0.0007	<0.0005	<0.0005
Phosphorus (P)	<0.30	<2.0	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.007	0.006	<0.005	0.005
Potassium (K)	<2.0	<0.0010	1.75	0.573	0.513	0.616	<0.001	0.683	2.95	0.658	0.681	0.606	0.656
Selenium (Se)	<0.20	<0.000020	0.0005	<0.0005	<0.0005	0.0007		<0.0005		<0.0005	<0.0005	<0.0005	<0.0005

Table III-2.2 Background Surface Water Quality in Tailings Impoundment Area (Station W44) 2005 – 2007 Data (con't)

Sample name	W-44	W-44	W44	W44	W44	W44	W44	W44	W44	W44	W44	W44	W44
Date	23-Oct-05	13-Sep-05	10-May-06	1-Jun-06	3-Jul-06	31-Jul-06	7-Sep-06	4-Oct-06	18-Nov-06	4-Jun-07	29-Jun-07	29-Jul-07	26-Aug-07
	W6798	W4423	A619028	A623186	A629169	A635289	A642441	A647966	A656333	A724714	A729135	A734931	A740044
Parameters (mg/L)													
Silicon (Si)	3.59	<2.0	2.05	3.45	3.74	4.22	4.12	3.99	5.26	2.73	3.52	3.75	3.93
Silver (Ag)	<0.010	<0.00020	0.00005	<0.00001	<0.00001	0.00003	<0.00001	<0.00001	0.00007	<0.00001	<0.00001	<0.00001	<0.00001
Sodium (Na)	<2.0	<0.00050	0.34	0.83	1.12	1.16	1.01	1.04	1.02	0.66	0.89	0.86	0.96
Strontium (Sr)	0.0651	<0.010	0.0241	0.0423	0.0573	0.0631	0.0632	0.0616	0.0744	0.0344	0.0507	0.0534	0.0602
Thallium (Tl)	<0.20	<0.00020	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Vanadium (V)	<0.030	<0.030	0.0026	0.00018	0.00016	<0.00005	0.00017	0.00011	0.0031	0.0002	0.00014	0.00016	0.00012
Zinc (Zn)	<0.0050	<0.0050	0.0201	0.0008	0.0037	0.0036	0.0053	0.0063	0.0116	0.0031	0.0053	0.0012	0.0015
Dissolved Metals													
Aluminum (Al)	<0.20	0.0103	0.0226	0.0203	0.0209	0.0135	0.0095	0.0085	0.162	0.0378	0.0141	0.0128	0.0109
Antimony (Sb)	<0.20	<0.00050	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00006	<0.00005	<0.00005	<0.00005	<0.00005
Arsenic (As)	<0.20	<0.00050	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0001	<0.0001	0.0002	<0.0001	0.0001
Cadmium (Cd)	<0.010	0.000034	0.00005	<0.00001	0.00001	<0.00001	<0.00001	<0.00001	0.00011	0.00001	0.00002	<0.00001	<0.00001
Calcium (Ca)	28.6	26.4	8.25	19.2	24.4	31	29.6	29.2	33.3	14.5	23	26.7	25.8
Chromium (Cr)	<0.010	<0.0010	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004
Cobalt (Co)	<0.010	<0.00030	0.00004	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00035	0.00003	<0.00002	<0.00002	<0.00002
Copper (Cu)	<0.010	<0.0010	0.0009	0.0011	0.0036	0.0015	0.0006	0.0007	0.0008	0.0014	0.0007	0.0008	0.0007
Iron (Fe)	<0.030	<0.030	0.036	0.012	0.024	0.156	0.025	0.031	0.202	0.025	0.02	0.021	0.018
Lead (Pb)	<0.050	<0.00050	0.00009	<0.00002	0.00006	0.00005	0.00003	0.00002	0.00014	<0.00002	0.00008	<0.00002	<0.00002
Magnesium (Mg)	2.3	2.23	0.64	1.45	1.88	2.13	2.17	2.16	2.32	1.14	1.62	1.94	1.86
Manganese (Mn)	<0.0050	0.00333	0.0377	0.00433	0.00853	0.0146	0.0142	0.0127	0.287	0.00663	0.00867	0.00794	0.00865
Mercury (Hg)		<0.000020								<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Mo)	<0.030	<0.0010	0.00021	0.00027	0.00034	0.00026	0.00032	0.0003	0.00015	0.00022	0.00029	0.00026	0.00028
Nickel (Ni)	<0.050	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0011	<0.0005	<0.0005	<0.0005	<0.0005
Phosphorus (P)	<0.30	<2.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Potassium (K)	<2.0	<0.0010	1.54	0.544	0.556	0.663	0.893	0.678	2.83	0.66	0.631	0.598	0.668
Selenium (Se)	<0.20	<0.000020	<0.0005	0.0006	0.0007	0.0005	0.0006	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Silicon (Si)	3.88	<2.0	0.68	3.37	3.89	3.91	3.96	4.03	4.19	2.72	3.46	3.98	3.74
Silver (Ag)	<0.010	<0.00020	<0.00001	<0.00001	<0.00001	0.00003	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Sodium (Na)	<2.0	<0.00050	0.29	0.77	1.13	1.11	1.14	1.08	1.11	0.65	0.79	0.91	0.79
Strontium (Sr)	0.0687	<0.010	0.0176	0.0407	0.0549	0.0632	0.0677	0.0717	0.0698	0.0325	0.053	0.0574	0.0604
Thallium (Tl)	<0.20	<0.00020	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Vanadium (V)	<0.030	<0.030	0.0002	0.00013	0.00013	0.00006	0.00008	0.00009	0.00044	0.00015	0.00022	0.00011	0.00012
Zinc (Zn)	<0.0050	<0.0050	0.0082	0.0023	0.004	0.005	0.0075	0.0061	0.0034	0.002	0.0047	<0.0005	0.0016

2.2 Groundwater

Baseline groundwater quality data were collected from 2005 to 2008 at the Wolverine tailings impoundment area monitoring wells MW05-2A, MW05-2B, MW05-6A, MW05-6B, MW05-7B, and MW08-13 as shown in Table III-2.3. MW08-14 was installed upstream of the tailings facility in October 2008, however; it was frozen during the December sampling period, hence results are not presented here. Monitoring well locations are shown on Drawing D-3002 and the complete water quality results for the monitoring wells are provided in Table III-2.4.

The results indicate that the groundwater has a neutral to slightly alkaline pH (7.6 to 9.1) and low conductivity values (84.8 $\mu\text{S}/\text{cm}$ to 410 $\mu\text{S}/\text{cm}$). Based on the Piper Trilinear plot for September 2005 (Figure III-2.2), the groundwater is generally calcium-bicarbonate (Ca-HCO₃) type water, which is associated with glacio-fluvial sediments and ground moraine. These are the main soils underlying the tailings area. MW05-5 is also included on this plot although it is located at the headwaters of the Wolverine Creek watershed.

Table III-2.3 Background Groundwater Quality in Tailings Impoundment Area 2005 – 2008 Averages and Ranges

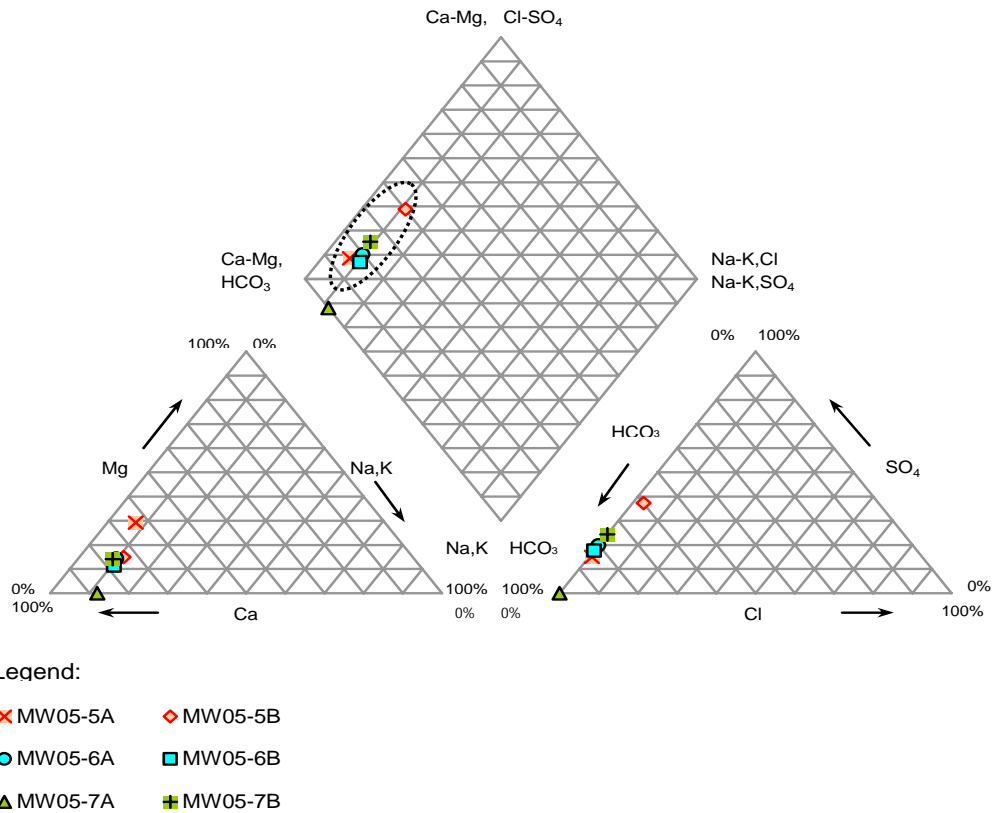
Parameters	Units	MW05-2A (n = 6)		MW05-2B (n = 6)		MW05-6A (n = 5)		MW05-6B (n = 4)		MW05-7B (n = 11)		MW08-13 6-Dec-08
		AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range	
Electrical Conductivity	(µS/cm)	399.5	385 - 410	253	246 - 260	160.76	84.8 - 189	184	172 - 197	160.9	146 - 180	230
pH		8.2	8 - 8.3	7.9	7.6 - 8.2	7.9	7.75 - 7.9	8.4	8 - 9.11	8.3	7.58 - 9	8.0
Total Alkalinity	(mg CaCO3/L)	178.3	170 - 185	126	120 - 131	77	70.3 - 79.1	86	81 - 92.1	66	56.1 - 79	120
Fluoride	(mg/L)	0.28	0.24 - 0.31	0.07	0.06 - 0.08	0.17	0.135 - 0.18	0.05	0.04 - 0.068	0.13	0.09 - 0.166	0.08
Sulphate	(mg/L)	33.3	27.4 - 38	7.5	3.9 - 12	14.6	12.5 - 18.5	10.6	7.3 - 16.6	13.3	6.2 - 22.2	3.1
Aluminum	(mg/L)	0.0108	<0.0002 - 0.0449	0.0165	0.001 - 0.0884	0.0058	0.001 - 0.0219	0.0291	0.0074 - 0.0667	0.0280	0.0003 - 0.112	0.0049
Arsenic	(mg/L)	0.00072	0.00038 - 0.0011	0.0300	0.0136 - 0.0362	0.0048	0.0044 - 0.0061	0.0003	0.0003 - 0.0003	0.0009	0.00047 - 0.0019	0.00148
Cadmium	(mg/L)	0.00001	<0.000005 - 0.00001	0.00003	<0.000005 - 0.00003	0.000043	<0.00001 - 0.000076	<0.00001	<0.00001 - 0.00001	0.00003	<0.000005 - 0.00004	0.000035
Calcium	(mg/L)	59.7	56.9 - 62.2	41.9	40 - 44.6	28.5	25.3 - 29.9	34.4	31.2 - 36.1	27.7	25.1 - 31.3	40.5
Copper	(mg/L)	0.00043	<0.00005 - 0.0007	0.00034	0.00008 - 0.0006	<0.0001	<0.0001 - 0.00094	0.00127	0.0006 - 0.00262	0.00145	<0.0001 - 0.00552	0.00183
Selenium	(mg/L)	<0.00004	<0.00004	<0.00004	<0.00004	0.001075	<0.0010 - 0.0014	0.0009	<0.0010 - 0.0009	<0.0005	<0.00004 - 0.0006	0.00005
Zinc	(mg/L)	0.0011	0.0009 - 0.0012	0.0021	<0.0005 - 0.0047	<0.0005	<0.0005 - 0.0092	<0.0005	<0.0005 - 0.0013	0.0018	<0.0005 - 0.0047	0.003

Table III-2.4 Groundwater Quality in Tailings Impoundment Area 2005 – 2008 Data

Sample name	MW 05-6A	MW 05-6A	MW05-6A	MW 05-6B	MW 05-6B	MW 05-07A	MW 05-7A	MW 05-7A	MW 05-7A	05-7B	05-7B	MW 05-07B	MW 05-7B	MW 05-7B	MW 05-7B	MW05-7B	MW 05-7B	MW 05-7B
Date	2-Sep-07	21-Sep-07	5-Oct-07	1-Sep-07	21-Sep-07	8-Jun-07	12-Jul-07	1-Sep-07	21-Sep-07	27-Apr-07	13-May-07	7-Jun-07	12-Jul-07	1-Sep-07	21-Sep-07	4-Oct-07	21-May-08	3-Sep-08
Job Number	A741295	A745736	A748794	A741295	A745736	A724712	A731839	A741295	A745736	A717990	A719951	A724712	A731839	A741295	A745736	A748794	A825056	A846361
Parameters (mg/L)																		
Physical Parameters																		
Temperature																		5
Conductivity	180	184	189	183	197	3010	695	8120	5710	175		158	146	153	157	153	180	160
Dissolved Hardness	88.1	86.6	84.8	101	101	2420	393	2160	1470	86.5	81.8	75.4	71.5	75.2	78.6	78.1	91	79.3
Total Suspended Solids	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Total Dissolved Solids	118	100	114	102	130	1050	353	1840	1380	120	88	102	96	112	112	93	120	120
pH	7.8	7.9	7.9	8	8.1	12.1	11.5	12.5	12.4	8	8	8.3	8.5	9	8.9	8.1	8.1	8.1
Turbidity	4.8	6.3	4.1	0.2	<0.1	<0.1	<0.1	0.8	0.3	6.1	0.2	<0.1	<0.1	0.2	<0.1	0.3	0.2	0.2
DOC	0.9	1.1	<0.5	1	<0.5	9.5	7.3	1.3	3		0.7	0.5	<0.5	0.8	0.6	<0.5	2.7	0.5
Major Anions																		
Alkalinity-Total	70.3	79.1	78.6	83.4	92.1	811	213	2100	1410	72.5	62.3	56.1	61.3	66.5	67.3	60.6	79	63
Acidity - Total																	<0.5	2
Bromide	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.01	<0.1	0.1
Chloride	<0.5	1	<0.5	<0.5	<0.5	6.5	1.1	2.5	2.1	<0.5	8.1	5	<0.5	<0.5	<0.5	<0.5	<0.5	2.4
Fluoride	0.18	0.17	0.17	0.04	0.04	0.11	0.12	0.07	0.08			0.14	0.14	0.13	0.13	0.14	0.09	0.12
Sulphate	16.3	12.5	12.9	7.3	8	7.2	14	<0.5	4.7	14.1	6.2	14.8	13.7	12.4	14.8	13.9	8	14
Nutrient Parameters																		
Ammonial Nitrogen	0.006	<0.005	<0.005	<0.005	<0.005	0.064	0.048	0.068	0.092	<0.005	0.006	<0.005	0.038	0.007	0.017	0.016	<0.005	<0.005
Nitrate Nitrogen	0.002	<0.002	<0.002	0.209	0.184	0.044	0.03	0.025	0.027	0.032	0.015	0.005	0.01	0.019	0.007	0.008	0.014	0.011
Nitrite Nitrogen	<0.002	<0.002	<0.002	0.004	<0.002	0.005	0.003	<0.002	0.003	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002
Total Phosphate	0.776	0.54	0.56	<0.005	0.006	0.013	0.007	<0.005	<0.005			0.041	0.043	0.047	0.051	0.04	0.03	0.052
Dissolved Ortho-Phosphate	0.56	0.57	0.59	0.017	0.009	0.002	0.003	0.006	0.005	0.014	0.033	0.027	0.041	0.045	0.052	0.05	0.024	0.036

Table III-2.4 Groundwater Quality in Tailings Impoundment Area 2005 – 2008 Data (con't)

Sample name	MW 05-6A	MW 05-6A	MW05-6A	MW 05-6B	MW 05-6B	MW 05-07A	MW 05-7A	MW 05-7A	MW 05-7A	05-7B	05-7B	MW 05-07B	MW 05-7B	MW 05-7B	MW 05-7B	MW05-7B	MW 05-7B	MW 05-7B
Date	2-Sep-07	21-Sep-07	5-Oct-07	1-Sep-07	21-Sep-07	8-Jun-07	12-Jul-07	1-Sep-07	21-Sep-07	27-Apr-07	13-May-07	7-Jun-07	12-Jul-07	1-Sep-07	21-Sep-07	4-Oct-07	21-May-08	3-Sep-08
Job Number	A741295	A745736	A748794	A741295	A745736	A724712	A731839	A741295	A745736	A717990	A719951	A724712	A731839	A741295	A745736	A748794	A825056	A846361
Parameters (mg/L)																		
Dissolved Metals																		
Aluminum (Al)	0.001	0.0026	0.0017	0.0074	0.0133	0.0496	0.134	0.0262	0.0369	0.0997	0.0226	0.0367	0.0066	0.0053	0.0049	0.0061	0.0003	0.0074
Antimony (Sb)	0.00033	0.00047	0.00016	0.00006	<0.00005	0.00012	0.00058	0.00006	0.00019	0.00032	0.00013	0.00013	0.00012	0.00012	0.00009	0.0001	0.00012	0.00011
Arsenic (As)	0.0061	0.0045	0.0044	0.0003	<0.0001	0.0007	0.0007	0.0001	0.0002	0.0019	0.0008	0.0012	0.0012	0.0011	0.0005	0.0009	0.00047	0.00057
Cadmium (Cd)	0.00001	<0.00001	<0.00001	0.00001	<0.00001	0.00002	0.00001	<0.00001	0.00001	0.00004	0.00004	0.00003	0.00002	0.00003	0.00002	0.00003	<0.000005	0.000006
Calcium (Ca)	29.9	29.5	28.8	35.8	36.1	969	157	866	589	29.9	28.7	26.3	25.1	26.6	27.6	27.4	31.3	27.7
Chromium (Cr)	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	0.0077	0.0015	0.0081	0.0043	<0.0002	<0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0001	<0.0001
Cobalt (Co)	0.00049	0.00029	0.00037	0.00039	0.00017	0.00057	<0.00002	0.00024	<0.00002	0.00057	0.00027	0.00022	0.00009	0.00005	0.00006	0.00006	0.000118	0.000067
Copper (Cu)	<0.0001	<0.0001	<0.0001	0.0006	0.0006	0.0073	0.0033	0.0017	0.0051	0.0024	0.0007	0.001	0.0002	<0.0001	<0.0001	<0.0001	0.00018	0.00016
Iron (Fe)	0.947	0.39	0.595	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	0.179	0.028	0.066	<0.005	0.005	0.005	0.011	0.002	0.018
Lead (Pb)	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00412	0.00032	0.00185	0.0009	0.00012	0.00004	0.00007	0.00009	<0.00002	<0.00002	<0.00002	<0.000005	0.000017
Magnesium (Mg)	3.29	3.13	3.15	2.87	2.74	<0.05	<0.05	<0.05	<0.05	2.87	2.46	2.36	2.13	2.15	2.37	2.35	3.13	2.45
Manganese (Mn)	0.295	0.341	0.352	0.171	0.0624	0.00058	0.00025	0.00003	0.00006	0.159	0.151	0.124	0.109	0.0793	0.0964	0.0986	0.27	0.117
Mercury (Hg)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Mo)	0.00392	0.00361	0.00324	0.00115	0.0008	0.00483	0.00683	0.00197	0.00445	0.012	0.0098	0.00907	0.00924	0.00969	0.00985	0.0107	0.00769	0.00909
Nickel (Ni)	0.0014	0.0007	<0.0005	0.0048	0.0037	0.0166	<0.0005	0.0124	0.005	0.0049	0.0028	0.0007	<0.0005	<0.0005	<0.0005	<0.0005	0.00022	0.00014
Phosphorus (P)	0.8	0.6	0.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.031	
Potassium (K)	1.54	1.2	1.31	1.14	0.87	13.6	5.01	3.4	8.12	0.915	0.848	0.845	0.811	0.96	0.882	0.903	0.84	0.87
Selenium (Se)	0.0009	0.0006	0.0014	0.0009	0.0009	0.0017	0.0008	0.0005	0.0007	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.00004	<0.00004
Silicon (Si)	6.76	6.31	6.27	4.16	3.91	0.23	2.96	0.16	0.44	3.82	3.96	3.82	3.97	4.05	4.04	4.06	4.19	4.39
Silver (Ag)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.000005	<0.000005
Sodium (Na)	2.78	3.86	3.5	1.39	1.37	8.47	3.15	3.28	4.71	1.59	1.72	1.81	1.63	1.79	1.76	1.89	1.93	2.06
Strontium (Sr)	0.0288	0.0362	0.0351	0.047	0.0492	2.01	0.377	0.687	1.08	0.0693	0.0534	0.0461	0.0472	0.0445	0.0497	0.0485	0.0587	0.0553
Thallium (Tl)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.000002	<0.000002
Vanadium (V)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00058	0.00282	0.00008	0.00062	0.0021	0.00204	0.00097	0.00137	0.00103	0.00028	0.00066	<0.0002	0.0003
Zinc (Zn)	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	0.269	0.0047	0.0475	0.019	0.0019	0.0008	0.0015	0.0015	<0.0005	<0.0005	<0.0005	0.0003	0.002



notes:

Sample date September 8, 2005.

Sample MW05-7B was affected by the cement grout during well installation. Datapoint should be updated when more results become available.

Figure III-2.2 Piper Trilinear Plot of Background Groundwater Chemistry (2005)

3. WATER BALANCE TABLES

This section comprises the water balance tables for the following scenarios:

- Table III-3.1 - Average climate conditions
- Table III-3.2 - Average annual values, as compared to values presented in the Type A Water Licence Application (January 2007)
- Table III-3.3 - Year 2 (the first year of tailings facility operation) – 100 Year Dry
- Table III-3.4 - Year 2 – 100 Year Wet
- Table III-3.5 - Year 8 (the final year of tailings facility operation) – 100 Year Dry
- Table III-3.6 - Year 8 – 100 Year Wet
- Table III-3.7 - Closure (with Diversions) – 100 Year Dry
- Table III-3.8 - Closure (with Diversions) – 100 Year Wet
- Table III-3.9 - Closure (without Diversions) – Average
- Table III-3.10 - Closure (without Diversions) – 100 Year Dry
- Table III-3.11 - Closure (without Diversions) – 100 Year Wet

Table III-3.1 Water Balance Table – Average Climate Conditions

Mine Year													1	1	1	1	1	1
Calendar Year	2009	2009	2009	2009	2009	2009	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Temperature	11	8	2	-7	-10	-18	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18
Monthly percent of annual precip.	14%	11%	10%	9%	8%	8%	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%
Monthly Precipitation (mm)	77.7	62.3	57.1	48.8	46.7	47.4	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4
Average monthly runoff (% of annual)	17%	9%	9%	6%	3%	1%	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%
Monthly Evaporation (mm)	90	61.5	32	14.5	6	2	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2
Incremental ice thickness on pond (m)	0.0	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4
Tailings to TSF (tpd)													866.8	866.8	866.8	866.8	866.8	866.8
Tailings to paste (tpd)													794.0	794.0	794.0	794.0	794.0	794.0
Water Inputs (m³/hr)																		
Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	154.97	154.97	154.97	154.97	154.97	154.97
Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	130.40	130.40	130.40	130.40	130.40	130.40
Balance of process plant	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	8.72	8.72	8.72	8.72	8.72	8.72
Direct precipitation	10.96	8.79	8.32	6.89	6.80	6.69	6.03	5.18	3.74	2.92	5.97	9.52	10.96	8.79	8.32	6.89	6.80	6.69
Runoff from unlined area	1.27	1.02	0.97	0.12	0.00	0.00	0.00	0.00	0.03	0.05	0.69	1.10	1.27	1.02	0.97	0.12	0.00	0.00
Snowmelt runoff from unlined area	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	1.24	1.28	1.24	0.00	0.00	0.00	0.00	0.00
Seepage from diversion ditch	16.87	8.93	8.96	5.89	3.49	0.99	0.00	0.00	0.00	1.03	18.86	9.57	4.50	2.38	2.39	1.57	0.93	0.26
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	33	21	20	15	12	10	8	7	6	7	29	24	313	307	307	304	303	302
Water Losses (m³/hr)																		
Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.69	12.69	12.69	12.69	12.69	12.69
Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	285.37	285.37	285.37	285.37	285.37	285.37
Pond evapor.	0.00	0.00	0.00	0.00	0.00	0.23	0.56	0.56	1.07	2.45	8.13	10.09	10.16	6.94	3.73	1.64	0.70	0.23
Seepage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	0	0	0	0	0	0	1	1	1	2	8	11	309	306	303	301	300	299
Net water surplus (deficit)	33	21	20	15	12	10	8	7	5	4	21	13	4	1	4	3	3	3
Discharge period water surplus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actual water treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operational pond volume													48,682					
Incremental pond volume	24,220	15,582	14,722	11,230	8,994	7,181	5,706	4,582	3,649	3,004	15,499	9,062	2,864	953	2,863	2,209	2,207	2,050
Seasonal pond volume	-	-	-	-	-	7,181	12,887	17,469	21,118	24,122	39,621	48,682	51,546	52,499	55,362	57,572	59,779	61,828

Table III-3.1 Water Balance Table – Average Climate Conditions (con't)

Mine Year		2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	
Calendar Year		2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2012	2012	2012	2012	
Month		Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31	Feb 28	Mar 31	Apr 30
Mean Monthly Temperature		-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	-15	-16	-12	-8
Monthly percent of annual precip.		8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	8%	6%	5%	4%
Monthly Precipitation (mm)		42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	42.8	33.2	26.5	20.0
Average monthly runoff (% of annual)		0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	0%	0%	0%	1%
Monthly Evaporation (mm)		5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	5	4.5	9.5	21
Incremental ice thickness on pond (m)		0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.1	0.0
Tailings to TSF (tpd)		706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	745.8	745.8	745.8	745.8
Tailings to paste (tpd)		620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	584.7	584.7	584.7	584.7
Water Inputs (m³/hr)																	
Tailings water		126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	133.34	133.34	133.34	133.34
Paste plant overflow		101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	96.03	96.03	96.03	96.03
Balance of process plant		8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Climate																	
Direct precipitation		6.03	5.18	3.74	2.92	5.97	9.52	10.96	8.79	8.32	8.53	8.42	8.28	7.47	6.41	4.64	3.61
Runoff from unlined area		0.00	0.00	0.03	0.05	0.69	1.10	1.27	1.02	0.97	0.08	0.00	0.00	0.00	0.00	0.02	0.03
Snowmelt runoff from unlined area		0.00	0.00	0.00	0.43	1.24	1.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Seepage from diversion ditch		0.00	0.00	0.00	0.27	5.03	9.57	4.50	2.38	2.39	1.57	0.93	0.26	0.00	0.00	0.00	0.27
Seepage reclaim		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs		244	243	242	242	251	259	256	250	250	248	247	246	247	246	244	243
Water Losses (m³/hr)																	
Tailing voids		10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.92	10.92	10.92	10.92
Water reclaim to process plant		228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	229.37	229.37	229.37	229.37
Climate																	
Pond evapor.		0.56	0.56	1.07	2.45	8.13	10.09	10.16	6.94	3.73	2.03	0.87	0.28	0.70	0.70	1.33	3.03
Seepage		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses		240	240	241	242	248	250	250	246	243	242	240	240	242	242	243	244
Net water surplus (deficit)		4	3	1	0	3	10	6	4	6	7	7	7	5	4	1	-1
Discharge period water surplus		0.0	0.0	0.0	0.0	9.4	9.4	9.4	9.4	9.4	9.4	0.0	0.0	0.0	0.0	0.0	0.0
Actual water treatment		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operational pond volume																	
Incremental pond volume		2,860	2,012	803	(291)	2,365	7,028	4,609	2,697	4,551	4,855	4,942	4,938	3,402	2,366	842	(734)
Seasonal pond volume		64,688	66,701	67,504	67,213	69,578	76,606	81,214	83,912	88,463	93,318	98,260	103,198	106,600	108,966	109,808	109,073

Year 3-5 extra water treatment: Min. pond 40,928 m³

Table III-3.1 Water Balance Table – Average Climate Conditions (con’t)

Mine Year	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4		
Calendar Year	2012	2012	2012	2012	2012	2012	2012	2012	2013	2013	2013	2013	2013	2013	2013		
Month	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	
Mean Monthly Temperature	2	9	11	8	2	-7	-10	-18	-15	-16	-12	-8	2	9	11	8	
Monthly percent of annual precip.	7%	11%	14%	11%	10%	9%	8%	8%	8%	6%	5%	4%	7%	11%	14%	11%	
Monthly Precipitation (mm)	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	
Average monthly runoff (% of annual)	19%	35%	17%	9%	9%	6%	3%	1%	0%	0%	0%	1%	19%	35%	17%	9%	
Monthly Evaporation (mm)	72	86.5	90	61.5	32	14.5	6	2	5	4.5	9.5	21	72	86.5	90	61.5	
Incremental ice thickness on pond (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	
Tailings to TSF (tpd)	745.8	745.8	745.8	745.8	745.8	745.8	745.8	745.8	634.8	634.8	634.8	634.8	634.8	634.8	634.8	634.8	
Tailings to paste (tpd)	584.7	584.7	584.7	584.7	584.7	584.7	584.7	584.7	692.1	692.1	692.1	692.1	692.1	692.1	692.1	692.1	
Water Inputs (m³/hr)																	
Tailings water	133.34	133.34	133.34	133.34	133.34	133.34	133.34	133.34	113.49	113.49	113.49	113.49	113.49	113.49	113.49	113.49	
Paste plant overflow	96.03	96.03	96.03	96.03	96.03	96.03	96.03	96.03	113.67	113.67	113.67	113.67	113.67	113.67	113.67	113.67	
Balance of process plant	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	
Climate																	
Direct precipitation	7.39	11.78	13.57	10.88	10.31	8.53	8.42	8.28	7.47	6.41	4.64	3.61	7.39	11.78	13.57	10.88	
Runoff from unlined area	0.47	0.75	0.86	0.69	0.66	0.08	0.00	0.00	0.00	0.00	0.02	0.03	0.47	0.75	0.86	0.69	
Snowmelt runoff from unlined area	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	
Seepage from diversion ditch	5.03	9.57	4.50	2.38	2.39	1.57	0.93	0.26	0.00	0.00	0.00	0.27	5.03	9.57	4.50	2.38	
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Subtotal: All Inputs	253	262	259	253	252	249	248	248	244	243	242	241	251	260	257	251	
Water Losses (m³/hr)																	
Tailing voids	10.92	10.92	10.92	10.92	10.92	10.92	10.92	10.92	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	
Water reclaim to process plant	229.37	229.37	229.37	229.37	229.37	229.37	229.37	229.37	227.16	227.16	227.16	227.16	227.16	227.16	227.16	227.16	
Climate																	
Pond evapor.	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Subtotal: All Losses	251	254	254	250	246	243	242	242	238	238	239	240	248	250	250	246	
Net water surplus (deficit)	1	8	5	3	7	6	6	6	6	5	3	1	3	10	7	5	
Discharge period water surplus	8.4	8.4	8.4	8.4	8.4	8.4	0.0	0.0	0.0	0.0	0.0	0.0	11.6	11.6	11.6	11.6	
Actual water treatment	11.6	11.6	11.6	11.6	11.6	11.6	0.0	0.0	0.0	0.0	0.0	0.0	14.8	14.8	14.8	14.8	
Operational pond volume	Max. pond	109,808	m³	Excess treatment rate				3.2	m³/h								
Incremental pond volume	(7,552)	(2,402)	(4,921)	(6,291)	(3,664)	(4,217)	4,529	4,511	4,611	3,458	2,051	436	(8,742)	(3,553)	(6,111)	(7,480)	
Seasonal pond volume	101,521	99,120	94,198	87,908	84,244	80,027	84,556	89,067	93,679	97,137	99,188	99,624	90,882	87,329	81,218	73,738	

Table III-3.1 Water Balance Table – Average Climate Conditions (con't)

Mine Year	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	6
Calendar Year	2013	2013	2013	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2015
Month	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31
Mean Monthly Temperature	2	-7	-10	-18	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	-15
Monthly percent of annual precip.	10%	9%	8%	8%	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	8%
Monthly Precipitation (mm)	57.1	48.8	46.7	47.4	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	42.8
Average monthly runoff (% of annual)	9%	6%	3%	1%	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	0%
Monthly Evaporation (mm)	32	14.5	6	2	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	5
Incremental ice thickness on pond (m)	0.0	0.0	0.3	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.4
Tailings to TSF (tpd)	634.8	634.8	634.8	634.8	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5
Tailings to paste (tpd)	692.1	692.1	692.1	692.1	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4
Water Inputs (m³/hr)																	
Tailings water	113.49	113.49	113.49	113.49	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37
Paste plant overflow	113.67	113.67	113.67	113.67	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69
Balance of process plant	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	12.72
Climate																	
Direct precipitation	10.31	8.53	8.42	8.28	7.47	6.41	4.64	3.61	7.39	11.78	13.57	10.88	10.31	8.53	8.42	8.28	7.47
Runoff from unlined area	0.66	0.08	0.00	0.00	0.00	0.00	0.02	0.03	0.47	0.75	0.86	0.69	0.66	0.08	0.00	0.00	0.00
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.00
Seepage from diversion ditch	2.39	1.57	0.93	0.26	0.00	0.00	0.00	0.27	5.03	9.57	4.50	2.38	2.39	1.57	0.93	0.26	0.00
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	250	247	246	245	244	243	241	241	251	260	257	251	250	247	246	245	248
Water Losses (m³/hr)																	
Tailing voids	9.29	9.29	9.29	9.29	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
Water reclaim to process plant	227.16	227.16	227.16	227.16	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07
Climate																	
Pond evapor.	4.62	2.03	0.87	0.28	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	0.70
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	242	239	238	238	238	238	239	240	247	250	250	246	242	239	238	238	238
Net water surplus (deficit)	8	8	8	8	6	5	3	1	3	10	7	5	8	8	8	8	10
Discharge period water surplus	11.6	11.6	0.0	0.0	0.0	0.0	0.0	0.0	11.8	11.8	11.8	11.8	11.8	11.8	0.0	0.0	0.0
Actual water treatment	14.8	14.8	0.0	0.0	0.0	0.0	0.0	0.0	15.0	15.0	15.0	15.0	15.0	15.0	0.0	0.0	0.0
Operational pond volume																	
Incremental pond volume	(4,815)	(5,406)	5,699	5,721	4,679	3,519	2,119	502	(8,809)	(3,618)	(6,178)	(7,547)	(4,880)	(5,473)	5,765	5,789	7,655
Seasonal pond volume	68,923	63,516	69,215	74,936	79,615	83,135	85,254	85,756	76,947	73,330	67,152	59,604	54,724	49,251	55,016	60,805	68,460

Table III-3.1 Water Balance Table – Average Climate Conditions (con't)

Mine Year	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7
Calendar Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016
Month	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30
Mean Monthly Temperature	-16	-12	-8	2	9	11	8	2	-7	-10	-18	-15	-16	-12	-8	2	9
Monthly percent of annual precip.	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	8%	6%	5%	4%	7%	11%
Monthly Precipitation (mm)	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	42.8	33.2	26.5	20.0	42.3	65.3
Average monthly runoff (% of annual)	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	0%	0%	0%	1%	19%	35%
Monthly Evaporation (mm)	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	5	4.5	9.5	21	72	86.5
Incremental ice thickness on pond (m)	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.1	0.0	0.0	0.0
Tailings to TSF (tpd)	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	630.2	630.2	630.2	630.2	630.2	630.2
Tailings to paste (tpd)	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	700.3	700.3	700.3	700.3	700.3	700.3
Water Inputs (m³/hr)																	
Tailings water	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.68	112.68	112.68	112.68	112.68	112.68
Paste plant overflow	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	115.01	115.01	115.01	115.01	115.01	115.01
Balance of process plant	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72
Climate	Direct precipitation	6.41	4.64	3.61	7.39	11.78	13.57	10.88	10.31	8.53	8.42	8.28	7.47	6.41	4.64	3.61	7.39
Runoff from unlined area	0.00	0.02	0.03	0.47	0.75	0.86	0.69	0.66	0.08	0.00	0.00	0.00	0.00	0.02	0.03	0.47	0.75
Snowmelt runoff from unlined area	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.84	0.87
Seepage from diversion ditch	0.00	0.00	0.27	5.03	9.57	4.50	2.38	2.39	1.57	0.93	0.26	0.00	0.00	0.00	0.27	5.03	9.57
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	247	245	245	255	264	261	255	254	251	250	249	249	248	246	246	255	264
Water Losses (m³/hr)																	
Tailing voids	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.23	9.23	9.23	9.23	9.23	9.23
Water reclaim to process plant	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.69	227.69	227.69	227.69	227.69	227.69
Climate	Pond evapor.	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	0.70	0.70	1.33	3.03	10.06
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	238	239	240	247	250	250	246	242	239	238	238	239	239	239	241	248	250
Net water surplus (deficit)	9	7	5	7	14	11	9	12	12	12	12	10	9	7	5	7	14
Discharge period water surplus	0.0	0.0	0.0	19.8	19.8	19.8	19.8	19.8	19.8	0.0	0.0	0.0	0.0	0.0	0.0	19.7	19.7
Actual water treatment	0.0	0.0	0.0	19.8	19.8	19.8	19.8	19.8	19.8	0.0	0.0	0.0	0.0	0.0	0.0	19.7	19.7
Operational pond volume																	
Incremental pond volume	6,207	5,095	3,382	(9,355)	(4,147)	(6,725)	(8,094)	(5,409)	(6,020)	8,645	8,765	7,637	6,190	5,077	3,364	(9,337)	(4,129)
Seasonal pond volume	74,668	79,763	83,145	73,789	69,643	62,918	54,824	49,415	43,395	52,040	60,805	68,442	74,632	79,708	83,072	73,735	69,606

Table III-3.1 Water Balance Table – Average Climate Conditions (con't)

Mine Year	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	
Calendar Year	2016	2016	2016	2016	2016	2016	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	
Month	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30
Mean Monthly Temperature	11	8	2	-7	-10	-18	-15	-16	-12	-8	2	9	11	8	2	-7	-10
Monthly percent of annual precip.	14%	11%	10%	9%	8%	8%	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%
Monthly Precipitation (mm)	77.7	62.3	57.1	48.8	46.7	47.4	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7
Average monthly runoff (% of annual)	17%	9%	9%	6%	3%	1%	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%
Monthly Evaporation (mm)	90	61.5	32	14.5	6	2	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6
Incremental ice thickness on pond (m)	0.0	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Tailings to TSF (tpd)	630.2	630.2	630.2	630.2	630.2	630.2	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5
Tailings to paste (tpd)	700.3	700.3	700.3	700.3	700.3	700.3	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4
Water Inputs (m³/hr)																	
Tailings water	112.68	112.68	112.68	112.68	112.68	112.68	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37
Paste plant overflow	115.01	115.01	115.01	115.01	115.01	115.01	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69
Balance of process plant	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72
Climate																	
Direct precipitation	13.57	10.88	10.31	8.53	8.42	8.28	7.47	6.41	4.64	3.61	7.39	11.78	13.57	10.88	10.31	8.53	8.42
Runoff from unlined area	0.86	0.69	0.66	0.08	0.00	0.00	0.00	0.00	0.02	0.03	0.47	0.75	0.86	0.69	0.66	0.08	0.00
Snowmelt runoff from unlined area	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00
Seepage from diversion ditch	4.50	2.38	2.39	1.57	0.93	0.26	0.00	0.00	0.00	0.27	5.03	9.57	4.50	2.38	2.39	1.57	0.93
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	261	255	255	252	251	250	248	247	245	245	255	264	261	255	254	251	250
Water Losses (m³/hr)																	
Tailing voids	9.23	9.23	9.23	9.23	9.23	9.23	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
Water reclaim to process plant	227.69	227.69	227.69	227.69	227.69	227.69	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07
Climate																	
Pond evapor.	12.58	8.60	4.62	2.03	0.87	0.28	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	250	247	243	240	239	238	238	238	239	240	247	250	250	246	242	239	238
Net water surplus (deficit)	11	9	12	12	12	12	10	9	7	5	7	14	11	9	12	12	12
Discharge period water surplus	19.7	19.7	19.7	19.7	0.0	0.0	0.0	0.0	0.0	0.0	19.8	19.8	19.8	19.8	19.8	19.8	0.0
Actual water treatment	19.7	19.7	19.7	19.7	0.0	0.0	0.0	0.0	0.0	0.0	19.8	19.8	19.8	19.8	19.8	19.8	0.0
Operational pond volume																	
Incremental pond volume	(6,706)	(8,075)	(5,391)	(6,001)	8,627	8,746	7,655	6,207	5,095	3,382	(9,355)	(4,147)	(6,725)	(8,094)	(5,409)	(6,020)	8,645
Seasonal pond volume	62,900	54,825	49,434	43,432	52,059	60,805	68,460	74,668	79,763	83,145	73,789	69,643	62,918	54,824	49,415	43,395	52,040

Table III-3.1 Water Balance Table – Average Climate Conditions (con’t)

Mine Year	8	9	9	9	9	9	9	9	9	9	9	9	9	Closure	Closure	Closure	
Calendar Year	2017	2018	2018	2018	2018	2018	2018	2018	2018	2018	2018	2018	2018	2019	2019	2019	
Month	Dec 31	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31	Jan 31	Feb 28	Mar 31	
Mean Monthly Temperature	-18	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	-15	-16	-12	
Monthly percent of annual precip.	8%	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	8%	6%	5%	
Monthly Precipitation (mm)	47.4	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	42.8	33.2	26.5	
Average monthly runoff (% of annual)	1%	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	0%	0%	0%	
Monthly Evaporation (mm)	2	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	5	4.5	9.5	
Incremental ice thickness on pond (m)	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.1	
Tailings to TSF (tpd)	628.5	513.4	513.4	513.4	513.4	513.4	513.4	513.4	513.4	513.4	513.4	513.4	513.4				
Tailings to paste (tpd)	698.4	505.3	505.3	505.3	505.3	505.3	505.3	505.3	505.3	505.3	505.3	505.3	505.3				
Water Inputs (m³/hr)																	
Tailings water	112.37	91.79	91.79	91.79	91.79	91.79	91.79	91.79	91.79	91.79	91.79	91.79	91.79	91.79	0.00	0.00	0.00
Paste plant overflow	114.69	82.98	82.98	82.98	82.98	82.98	82.98	82.98	82.98	82.98	82.98	82.98	82.98	82.98	0.00	0.00	0.00
Balance of process plant	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	3.78	3.78	3.78	
Climate Direct precipitation	8.28	7.47	6.41	4.64	3.61	7.39	11.78	13.57	10.88	10.31	8.53	8.42	8.28	7.47	6.41	4.64	
Runoff from unlined area	0.00	0.00	0.00	0.02	0.03	0.47	0.75	0.86	0.69	0.66	0.08	0.00	0.00	0.00	0.00	0.02	
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage from diversion ditch	0.26	0.00	0.00	0.00	0.27	5.03	9.57	4.50	2.38	2.39	1.57	0.93	0.26	0.00	0.00	0.00	
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Subtotal: All Inputs	249	196	195	193	193	202	211	208	202	202	199	198	197	12	11	9	
Water Losses (m³/hr)																	
Tailing voids	9.20	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	0.00	0.00	0.00
Water reclaim to process plant	227.07	174.77	174.77	174.77	174.77	174.77	174.77	174.77	174.77	174.77	174.77	174.77	174.77	0.00	0.00	0.00	
Climate Pond evapor.	0.28	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	0.70	0.70	1.33	
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Subtotal: All Losses	238	184	184	185	186	193	196	196	192	188	185	184	184	2	2	2	
Net water surplus (deficit)	12	12	11	9	6	9	16	12	11	14	13	14	13	11	9	7	
Discharge period water surplus	0.0	0.0	0.0	0.0	0.0	23.1	23.1	23.1	23.1	23.1	23.1	0.0	0.0	0.0	0.0	0.0	
Actual water treatment	0.0	0.0	0.0	0.0	0.0	23.1	23.1	23.1	23.1	23.1	23.1	0.0	0.0	0.0	0.0	0.0	
Operational pond volume																	
Incremental pond volume	8,765	8,909	7,340	6,349	4,596	(10,589)	(5,341)	(7,958)	(9,327)	(6,603)	(7,254)	9,858	10,019	7,850	6,383	5,290	
Seasonal pond volume	60,805	69,714	77,054	83,404	87,999	77,410	72,070	64,111	54,784	48,181	40,928	50,786	60,805	68,655	75,038	80,327	

Table III-3.1 Water Balance Table – Average Climate Conditions (con't)

Mine Year		Closure	Closure	Closure	Closure	Closure	Closure	Closure	Closure	Closure	
Calendar Year		2020	2020	2020	2020	2020	2020	2020	2020	2020	
Month		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		30	31	30	31	31	30	31	30	31	
	Mean Monthly Temperature	-8	2	9	11	8	2	-7	-10	-18	
	Monthly percent of annual precip.	4%	7%	11%	14%	11%	10%	9%	8%	8%	
	Monthly Precipitation (mm)	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	
	Average monthly runoff (% of annual)	1%	19%	35%	17%	9%	9%	6%	3%	1%	
	Monthly Evaporation (mm)	21	72	86.5	90	61.5	32	14.5	6	2	
	Incremental ice thickness on pond (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	Averages
	Tailings to TSF (tpd)										653
	Tailings to paste (tpd)										658
Water Inputs (m³/hr)											
	Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	116.74
	Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	108.10
	Balance of process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.60
	Direct precipitation	3.61	7.39	11.78	13.57	10.88	10.31	8.53	8.42	8.28	8.28
Climate	Runoff from unlined area	0.03	0.47	0.75	0.86	0.69	0.66	0.08	0.00	0.00	0.33
	Snowmelt runoff from unlined area	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.25
	Seepage from diversion ditch	0.27	5.03	9.57	4.50	2.38	2.39	1.57	0.93	0.26	2.23
	Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Subtotal: All Inputs	5	15	24	21	15	14	11	10	10	247.52
Water Losses (m³/hr)											
	Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.56
	Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	224.83
Climate	Pond evapor.	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.62
	Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Subtotal: All Losses	4	11	13	14	10	6	3	2	1	240.01
Net water surplus (deficit)		1	4	10	7	5	9	8	8	8	7.5
Discharge period water surplus		0.0	12.8	12.8	12.8	12.8	12.8	12.8	0.0	0.0	7.3
Actual water treatment		0.0	12.8	12.8	12.8	12.8	12.8	12.8	0.0	0.0	7.3
Operational pond volume											
Incremental pond volume		849	(6,780)	(1,655)	(4,150)	(5,519)	(2,917)	(3,445)	6,111	6,147	
Seasonal pond volume		73,011	66,231	64,576	60,427	54,908	51,991	48,547	54,658	60,805	72,450

Table III-3.2 Water Balance Table – Average Annual Values (m³/hr)

Wolverine Tailings Facility Water Balance: Average Annual Values (m³/hr)

Green text indicates number copied from Type A Water License Application, January 2007 (shown for comparison)

Year	1	2	3	4	5	6	7	8	9	Closure
Net surplus	6.2	4.7	4.2	5.9	6.0	10.0	9.9	10.0	11.6	10.2
<i>A-License</i>	<i>10.2</i>	<i>8.1</i>	<i>8.1</i>	<i>8.1</i>	<i>8.1</i>	<i>12.4</i>	<i>12.4</i>	<i>12.4</i>	<i>13.0</i>	<i>11.3</i>
Actual water treatment	0.0	0.0	5.9	7.5	7.6	10.0	9.9	10.0	11.6	10.2
INPUTS										
Tailings water	78.1	126.3	133.3	113.5	112.4	112.4	112.7	112.4	91.8	0.0
Paste overflow	65.7	101.9	96.0	113.7	114.7	114.7	115.0	114.7	83.0	0.0
Total	143.9	228.2	229.4	227.2	227.1	227.1	227.7	227.1	174.8	0.0
<i>A-License</i>	<i>43.3</i>	<i>129.7</i>	<i>129.7</i>	<i>129.7</i>	<i>129.7</i>	<i>129.7</i>	<i>129.7</i>	<i>129.7</i>	<i>81.7</i>	<i>21.4</i>
Industrial Plant Balance	5.0	8.7	8.7	8.7	8.7	12.7	12.7	12.7	12.7	3.8
<i>A-License</i>	<i>6.6</i>	<i>7.1</i>	<i>7.1</i>	<i>7.1</i>	<i>7.1</i>	<i>11.1</i>	<i>11.1</i>	<i>11.1</i>	<i>10.3</i>	<i>7.1</i>
Direct Precipitation	6.8	7.2	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
<i>A-License</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>
Runoff from unlined area	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Snowmelt runoff	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
<i>A-License</i>	<i>1.1</i>	<i>1.1</i>	<i>1.1</i>	<i>1.1</i>	<i>1.1</i>	<i>0.7</i>	<i>0.7</i>	<i>0.7</i>	<i>0.7</i>	<i>0.7</i>
Seepage from diversions	3.5	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
<i>A-License</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>
Seepage reclaim	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<i>A-License</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>
All Inputs	161.0	248.2	250.3	248.1	248.0	252.0	252.7	252.0	199.7	16.0
<i>A-License</i>	<i>60.9</i>	<i>148.3</i>	<i>148.3</i>	<i>148.3</i>	<i>148.3</i>	<i>150.8</i>	<i>150.8</i>	<i>150.8</i>	<i>102.8</i>	<i>40.4</i>
LOSSES										
Tailings voids	6.4	10.3	10.9	9.3	9.2	9.2	9.2	9.2	7.5	0.0
<i>A-License</i>	<i>1.1</i>	<i>4.2</i>	<i>4.2</i>	<i>4.2</i>	<i>4.2</i>	<i>4.2</i>	<i>4.2</i>	<i>4.2</i>	<i>2.7</i>	<i>1.3</i>
Reclaim to Process Plant	143.9	228.2	229.4	227.2	227.1	227.1	227.7	227.1	174.8	0.0
<i>A-License</i>	<i>42.6</i>	<i>127.5</i>	<i>127.5</i>	<i>127.5</i>	<i>127.5</i>	<i>127.5</i>	<i>127.5</i>	<i>127.5</i>	<i>80.3</i>	<i>21.0</i>
Pond evaporation	3.9	3.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
<i>A-License</i>	<i>6.1</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>	<i>6.8</i>
Seepage	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<i>A-License</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>
All Losses	154.7	243.5	246.1	242.3	242.1	242.1	242.7	242.1	188.1	5.8
<i>A-License</i>	<i>50.7</i>	<i>140.2</i>	<i>140.2</i>	<i>140.2</i>	<i>140.2</i>	<i>138.4</i>	<i>138.4</i>	<i>138.4</i>	<i>89.8</i>	<i>29.1</i>

Table III-3.3 Water Balance Table – Year 2 100 Year Dry (m³/hr)

Annual Precipitation:		279 mm											--> Stage 2 construction complete		
Red text indicates number that differs from average climate case															
Mine Year	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Calendar Year	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages		
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18			
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%			
Monthly Precipitation (mm)	20.9	16.2	13.0	9.8	20.7	31.9	38.0	30.5	27.9	23.9	22.8	23.2			
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%			
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2			
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4			
Tailings to TSF (tpd)	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	707		
Tailings to paste (tpd)	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620		
Water Inputs (m³/hr)															
Tailings water	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33		
Paste plant overflow	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87		
Balance of process plant	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72		
Climate	Direct precipitation	2.95	2.54	1.83	1.43	2.92	4.66	5.37	4.30	4.07	4.17	4.12	4.05	3.54	
	Runoff from unlined area	0.00	0.00	0.02	0.02	0.34	0.54	0.62	0.50	0.47	0.04	0.00	0.00	0.21	
	Snowmelt runoff from unlined area	0.00	0.00	0.00	0.43	1.24	1.28	1.24	0.00	0.00	0.00	0.00	0.00	0.35	
	Seepage from diversion ditch	0.00	0.00	0.00	0.13	2.46	4.69	2.20	1.17	1.17	0.77	0.46	0.13	1.10	
	Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Subtotal: All Inputs		241	240	240	240	245	249	247	244	244	243	243	242	243.14	
Water Losses (m³/hr)															
Tailing voids	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34		
Water reclaim to process plant	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20		
Climate	Pond evapor.	0.56	0.56	1.07	2.45	8.13	10.09	10.16	6.94	3.73	2.03	0.87	0.28	3.93	
	Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Subtotal: All Losses		240	240	241	242	248	250	250	246	243	242	240	240	243.48	
Net water surplus (deficit)															
		1	0	-1	-2	-3	-1	-2	-3	0	1	2	2	-0.3	
Discharge period water surplus															
		0.0	0.0	0.0	0.0	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	0.0	0.0	-0.3	
Actual water treatment															
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Operational pond volume															
Incremental pond volume															
		569	235	(631)	(1,483)	(2,075)	(394)	(1,749)	(1,934)	258	990	1,503	1,694		
Seasonal pond volume															
		62,397	62,631	62,000	60,518	58,443	58,048	56,300	54,366	54,624	55,614	57,117	58,811	58,380	

Table III-3.4 Water Balance Table – Year 2 100 Year Wet (m³/hr)

Annual Precipitation:		795 mm											--> Stage 2 construction complete
Red text indicates number that differs from average climate case													
Mine Year	2	2	2	2	2	2	2	2	2	2	2	2	2
Calendar Year	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	
Monthly Precipitation (mm)	59.6	46.2	37.0	27.9	59.0	91.0	108.4	86.9	79.6	68.0	65.1	66.1	
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	
Tailings to TSF (tpd)	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	706.6	707
Tailings to paste (tpd)	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620.3	620
Water Inputs (m³/hr)													
Tailings water	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33	126.33
Paste plant overflow	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87	101.87
Balance of process plant	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Climate													
Direct precipitation	8.41	7.23	5.22	4.07	8.32	13.27	15.29	12.26	11.61	11.89	11.75	11.54	10.10
Runoff from unlined area	0.00	0.00	0.05	0.07	0.97	1.54	1.78	1.42	1.35	0.11	0.00	0.00	0.61
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.43	1.24	1.28	1.24	0.00	0.00	0.00	0.00	0.00	0.35
Seepage from diversion ditch	0.00	0.00	0.00	0.38	7.01	13.35	6.28	3.32	3.33	2.19	1.30	0.37	3.14
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	246	245	243	243	255	267	263	255	254	252	251	250	252.12
Water Losses (m³/hr)													
Tailing voids	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34	10.34
Water reclaim to process plant	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20	228.20
Climate													
Pond evapor.	0.56	0.56	1.07	2.45	8.13	10.09	10.16	6.94	3.73	2.03	0.87	0.28	3.93
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	240	240	241	242	248	250	250	246	243	242	240	240	243.48
Net water surplus (deficit)	6	5	3	1	8	18	13	8	11	11	11	10	8.6
Discharge period water surplus	0.0	0.0	0.0	0.0	17.1	17.1	17.1	17.1	17.1	17.1	0.0	0.0	8.6
Actual water treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operational pond volume													
Incremental pond volume	4,632	3,387	1,913	631	5,797	12,767	9,524	6,278	7,871	7,844	7,600	7,447	
Seasonal pond volume	66,460	69,847	71,759	72,390	78,188	90,955	100,478	106,757	114,627	122,471	130,072	137,519	96,958

Table III-3.5 Water Balance Table – Year 8 100 Year Dry (m³/hr)

Annual Precipitation: **279** mm
Red text indicates number that differs from average climate case

Mine Year	8	8	8	8	8	8	8	8	8	8	8	8	8
Calendar Year	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	
Monthly Precipitation (mm)	20.9	16.2	13.0	9.8	20.7	31.9	38.0	30.5	27.9	23.9	22.8	23.2	
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	
Tailings to TSF (tpd)	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	629
Tailings to paste (tpd)	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698
Water Inputs (m³/hr)													
Tailings water	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37
Paste plant overflow	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69
Balance of process plant	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72
Climate													
Direct precipitation	3.66	3.14	2.27	1.77	3.62	5.77	6.64	5.33	5.04	4.17	4.12	4.05	4.14
Runoff from unlined area	0.00	0.00	0.01	0.02	0.23	0.37	0.42	0.34	0.32	0.04	0.00	0.00	0.15
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.24
Seepage from diversion ditch	0.00	0.00	0.00	0.13	2.46	4.69	2.20	1.17	1.17	0.77	0.46	0.13	1.10
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	244	244	243	243	248	252	251	248	247	246	245	245	246.41
Water Losses (m³/hr)													
Tailing voids	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
Water reclaim to process plant	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07
Climate													
Pond evapor.	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.80
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	238	238	239	240	247	250	250	246	242	239	238	238	242.07
Net water surplus (deficit)	6	6	4	3	1	3	1	2	5	6	7	7	4.3
Discharge period water surplus	0.0	0.0	0.0	0.0	8.6	8.6	8.6	8.6	8.6	8.6	0.0	0.0	4.3
Actual water treatment	0.0	0.0	0.0	0.0	8.6	8.6	8.6	8.6	8.6	8.6	0.0	0.0	4.3
Operational pond volume													
Incremental pond volume	4,818	4,007	3,326	1,941	(5,958)	(4,247)	(5,626)	(5,104)	(2,292)	(1,593)	5,206	5,521	
Seasonal pond volume	65,623	69,630	72,956	74,896	68,939	64,692	59,066	53,963	51,671	50,078	55,284	60,805	62,247

Table III-3.6 Water Balance Table – Year 8 100 Year Wet (m³/hr)

Annual Precipitation: **795** mm
Red text indicates number that differs from average climate case

Mine Year	8	8	8	8	8	8	8	8	8	8	8	8	8
Calendar Year	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017	2017
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	
Monthly Precipitation (mm)	59.6	46.2	37.0	27.9	59.0	91.0	108.4	86.9	79.6	68.0	65.1	66.1	
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	
Tailings to TSF (tpd)	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	628.5	629
Tailings to paste (tpd)	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698.4	698
Water Inputs (m³/hr)													
Tailings water	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37	112.37
Paste plant overflow	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69	114.69
Balance of process plant	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72	12.72
Climate													
Direct precipitation	10.42	8.95	6.47	5.04	10.30	16.43	18.93	15.18	14.37	11.89	11.75	11.54	11.80
Runoff from unlined area	0.00	0.00	0.03	0.05	0.66	1.05	1.21	0.97	0.92	0.11	0.00	0.00	0.42
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.24
Seepage from diversion ditch	0.00	0.00	0.00	0.38	7.01	13.35	6.28	3.32	3.33	2.19	1.30	0.37	3.14
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	251	250	247	247	260	272	268	260	259	255	254	253	256.38
Water Losses (m³/hr)													
Tailing voids	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
Water reclaim to process plant	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07	227.07
Climate													
Pond evapor.	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.80
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	238	238	239	240	247	250	250	246	242	239	238	238	242.07
Net water surplus (deficit)	13	12	9	6	12	23	18	14	18	16	16	15	14.3
Discharge period water surplus	0.0	0.0	0.0	0.0	28.4	28.4	28.4	28.4	28.4	28.4	0.0	0.0	14.3
Actual water treatment	0.0	0.0	0.0	0.0	28.4	28.4	28.4	28.4	28.4	28.4	0.0	0.0	14.3
Operational pond volume													
Incremental pond volume	9,849	7,909	6,463	4,496	(11,982)	(4,069)	(7,574)	(10,406)	(7,819)	(9,443)	11,303	11,273	
Seasonal pond volume	70,654	78,563	85,026	89,523	77,540	73,471	65,896	55,490	47,671	38,228	49,531	60,805	65,941

Table III-3.7 Water Balance Table – Closure (With Diversions) 100 Year Dry (m³/hr)

Annual Precipitation: **279** mm
Red text indicates number that differs from average climate case

Mine Year Calendar Year	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18		
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%		
Monthly Precipitation (mm)	20.9	16.2	13.0	9.8	20.7	31.9	38.0	30.5	27.9	23.9	22.8	23.2		
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%		
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2		
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4		
Tailings to TSF (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Tailings to paste (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Water Inputs (m³/hr)														
Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balance of process plant	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78
Climate Direct precipitation	3.66	3.14	2.27	1.77	3.62	5.77	6.64	5.33	5.04	4.17	4.12	4.05	4.14	4.14
Runoff from unlined area	0.00	0.00	0.01	0.02	0.23	0.37	0.42	0.34	0.32	0.04	0.00	0.00	0.00	0.15
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.24
Seepage from diversion ditch	0.00	0.00	0.00	0.13	2.46	4.69	2.20	1.17	1.17	0.77	0.46	0.13	0.13	1.10
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	8	8	7	7	12	16	15	12	11	10	9	9	9	10.41
Water Losses (m³/hr)														
Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Climate Pond evapor.	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	0.28	4.80
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	2	2	2	4	11	13	14	10	6	3	2	1	1	5.80
Net water surplus (deficit)	7	6	5	3	1	3	1	2	6	7	7	8	8	4.6
Discharge period water surplus	0.0	0.0	0.0	0.0	9.1	9.1	9.1	9.1	9.1	9.1	0.0	0.0	0.0	4.6
Actual water treatment	0.0	0.0	0.0	0.0	9.1	9.1	9.1	9.1	9.1	9.1	0.0	0.0	0.0	4.6
Operational pond volume														
Incremental pond volume	5,013	4,182	3,521	2,129	(6,149)	(4,432)	(5,817)	(5,295)	(2,477)	(1,784)	5,394	5,715	5,715	
Seasonal pond volume	65,817	70,000	73,520	75,649	69,500	65,068	59,251	53,956	51,480	49,696	55,090	60,805	60,805	62,432

Table III-3.8 Water Balance Table – Closure (With Diversions) 100 Year Wet (m³/hr)

Annual Precipitation: **795** mm

Red text indicates number that differs from average climate case

Mine Year Calendar Year	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	
Monthly Precipitation (mm)	59.6	46.2	37.0	27.9	59.0	91.0	108.4	86.9	79.6	68.0	65.1	66.1	
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	
Tailings to TSF (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Tailings to paste (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Water Inputs (m³/hr)													
Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balance of process plant	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78
Climate													
Direct precipitation	10.42	8.95	6.47	5.04	10.30	16.43	18.93	15.18	14.37	11.89	11.75	11.54	11.80
Runoff from unlined area	0.00	0.00	0.03	0.05	0.66	1.05	1.21	0.97	0.92	0.11	0.00	0.00	0.42
Snowmelt runoff from unlined area	0.00	0.00	0.00	0.29	0.84	0.87	0.84	0.00	0.00	0.00	0.00	0.00	0.24
Seepage from diversion ditch	0.00	0.00	0.00	0.38	7.01	13.35	6.28	3.32	3.33	2.19	1.30	0.37	3.14
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	15	14	11	11	24	36	32	24	23	19	18	17	20.37
Water Losses (m³/hr)													
Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Climate													
Pond evapor.	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.80
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	2	2	2	4	11	13	14	10	6	3	2	1	5.80
Net water surplus (deficit)	13	12	9	7	13	23	18	15	18	16	16	15	14.6
Discharge period water surplus	0.0	0.0	0.0	0.0	28.9	28.9	28.9	28.9	28.9	28.9	0.0	0.0	14.6
Actual water treatment	0.0	0.0	0.0	0.0	28.9	28.9	28.9	28.9	28.9	28.9	0.0	0.0	14.6
Operational pond volume													
Incremental pond volume	10,044	8,085	6,658	4,684	(12,174)	(4,255)	(7,766)	(10,597)	(8,005)	(9,634)	11,492	11,468	
Seasonal pond volume	70,848	78,933	85,591	90,275	78,101	73,847	66,081	55,484	47,479	37,845	49,337	60,805	66,125

Table III-3.9 Water Balance Table – Closure (Without Diversions) Average (m³/hr)

Annual Precipitation: **570** mm

Red text indicates number that differs from average climate case or "with diversions" case

Mine Year Calendar Year	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	
Monthly Precipitation (mm)	42.8	33.2	26.5	20.0	42.3	65.3	77.7	62.3	57.1	48.8	46.7	47.4	
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	
Tailings to TSF (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Tailings to paste (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Water Inputs (m³/hr)													
Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balance of process plant	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78
Climate	7.47	6.41	4.64	3.61	7.39	11.78	13.57	10.88	10.31	8.53	8.42	8.28	8.46
Runoff from unlined area & uphill catchment	0.00	0.00	0.48	0.75	10.29	16.40	18.90	15.15	14.35	1.78	0.00	0.00	6.55
Snowmelt runoff from unlined area & uphill catchment	0.00	0.00	0.00	6.36	18.46	19.08	18.46	0.00	0.00	0.00	0.00	0.00	5.23
Seepage from diversion ditch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	12	11	10	16	41	52	56	31	29	15	13	13	25.01
Water Losses (m³/hr)													
Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Climate	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.80
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	2	2	2	4	11	13	14	10	6	3	2	1	5.80
Net water surplus (deficit)	11	9	8	11	30	39	42	21	24	12	11	12	19.2
Discharge period water surplus	0.0	0.0	0.0	0.0	38.1	38.1	38.1	38.1	38.1	38.1	0.0	0.0	19.2
Actual water treatment	0.0	0.0	0.0	0.0	38.1	38.1	38.1	38.1	38.1	38.1	0.0	0.0	19.2
Operational pond volume													
Incremental pond volume	7,850	6,383	5,633	8,261	(6,141)	319	3,000	(12,562)	(10,290)	(19,379)	8,163	8,762	
Seasonal pond volume	68,655	75,038	80,671	88,932	82,791	83,110	86,111	73,549	63,258	43,879	52,042	60,805	71,539

Table III-3.10 Water Balance Table – Closure (Without Diversions) 100 Year Dry (m³/hr)

Annual Precipitation: **279** mm

Red text indicates number that differs from average climate case or "with diversions" case

Mine Year Calendar Year	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18	
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%	
Monthly Precipitation (mm)	20.9	16.2	13.0	9.8	20.7	31.9	38.0	30.5	27.9	23.9	22.8	23.2	
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%	
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2	
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	
Tailings to TSF (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Tailings to paste (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Water Inputs (m³/hr)													
Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balance of process plant	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78
Climate Direct precipitation	3.66	3.14	2.27	1.77	3.62	5.77	6.64	5.33	5.04	4.17	4.12	4.05	4.14
Runoff from unlined area & uphill catchment	0.00	0.00	0.24	0.37	5.03	8.03	9.25	7.42	7.02	0.87	0.00	0.00	3.21
Snowmelt runoff from unlined area & uphill catchment	0.00	0.00	0.00	3.11	9.04	9.34	9.04	0.00	0.00	0.00	0.00	0.00	2.56
Seepage from diversion ditch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	8	8	7	10	22	28	30	18	17	10	9	9	14.68
Water Losses (m³/hr)													
Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Climate Pond evapor.	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.80
Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	2	2	2	4	11	13	14	10	6	3	2	1	5.80
Net water surplus (deficit)	7	6	5	6	11	14	16	8	11	7	7	8	8.9
Discharge period water surplus	0.0	0.0	0.0	0.0	17.6	17.6	17.6	17.6	17.6	17.6	0.0	0.0	8.9
Actual water treatment	0.0	0.0	0.0	0.0	17.6	17.6	17.6	17.6	17.6	17.6	0.0	0.0	8.9
Operational pond volume													
Incremental pond volume	5,013	4,182	3,689	4,318	(4,623)	(2,302)	(1,104)	(7,208)	(4,601)	(8,049)	5,067	5,619	
Seasonal pond volume	65,817	70,000	73,688	78,006	73,384	71,082	69,978	62,770	58,169	50,120	55,186	60,805	65,717

Table III-3.11 Water Balance Table – Closure (Without Diversions) 100 Year Wet (m³/hr)

Annual Precipitation: **795** mm

Red text indicates number that differs from average climate case or "with diversions" case

Mine Year Calendar Year	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	Closure 2019	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Averages	
Mean Monthly Temperature	-15	-16	-12	-8	2	9	11	8	2	-7	-10	-18		
Monthly percent of annual precip.	8%	6%	5%	4%	7%	11%	14%	11%	10%	9%	8%	8%		
Monthly Precipitation (mm)	59.6	46.2	37.0	27.9	59.0	91.0	108.4	86.9	79.6	68.0	65.1	66.1		
Average monthly runoff (% of annual)	0%	0%	0%	1%	19%	35%	17%	9%	9%	6%	3%	1%		
Monthly Evaporation (mm)	5	4.5	9.5	21	72	86.5	90	61.5	32	14.5	6	2		
Incremental ice thickness on pond (m)	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4		
Tailings to TSF (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
Tailings to paste (tpd)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
Water Inputs (m³/hr)														
Tailings water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paste plant overflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balance of process plant	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78	3.78
Climate Direct precipitation	10.42	8.95	6.47	5.04	10.30	16.43	18.93	15.18	14.37	11.89	11.75	11.54	11.80	11.80
Climate Runoff from unlined area & uphill catchment	0.00	0.00	0.68	1.05	14.35	22.88	26.36	21.14	20.01	2.48	0.00	0.00	0.00	9.13
Climate Snowmelt runoff from unlined area & uphill catchment	0.00	0.00	0.00	8.87	25.75	26.61	25.75	0.00	0.00	0.00	0.00	0.00	0.00	7.29
Climate Seepage from diversion ditch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Climate Seepage reclaim	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Inputs	15	14	12	20	55	71	76	41	39	19	17	16	33.00	33.00
Water Losses (m³/hr)														
Tailing voids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water reclaim to process plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Climate Pond evapor.	0.70	0.70	1.33	3.03	10.06	12.49	12.58	8.60	4.62	2.03	0.87	0.28	4.80	4.80
Climate Seepage	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Subtotal: All Losses	2	2	2	4	11	13	14	10	6	3	2	1	5.80	5.80
Net water surplus (deficit)	13	12	10	16	44	57	62	32	34	16	15	15	27.2	27.2
Discharge period water surplus	0.0	0.0	0.0	0.0	53.9	53.9	53.9	53.9	53.9	53.9	0.0	0.0	27.2	27.2
Actual water treatment	0.0	0.0	0.0	0.0	53.9	53.9	53.9	53.9	53.9	53.9	0.0	0.0	27.2	27.2
Operational pond volume														
Incremental pond volume	10,044	8,085	7,137	11,310	(7,315)	2,345	6,174	(16,701)	(14,689)	(28,139)	10,558	11,193		
Seasonal pond volume	70,848	78,933	86,070	97,380	90,065	92,411	98,584	81,883	67,193	39,054	49,612	60,805	76,040	76,040

APPENDIX IV

Preliminary Emergency Response and Preparedness Plan

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1. INTRODUCTION

The purpose of the Emergency Response Plan (ERP) is to provide a plan that includes mechanisms and processes for addressing potential or actual failures of structures, equipment and material stockpiles, and programs for the training of employees.

This ERP describes the more general aspects of the emergency response for the project site as well as the requirements to respond to a potential or actual failure of the tailings facility. This ERP does not include details of a response to a catastrophic event and all the external agencies and services that will likely be involved. In the event of a major emergency, it is expected that local government, crown corporations and other territorial agencies, the federal and territorial emergency response programs as well as private sector support organizations in the region of the mine will be involved and will respond according to their capabilities and own emergency plans. A coordinated joint emergency response effort is expected in such a situation.

The ERP applies to all site employees: mine personnel, contractor management and supervisors, subcontractor supervisors, as well as employees of contractors transporting, handling & transferring hazardous/toxic materials on site.

2. GENERAL EMERGENCY RESPONSE PLAN

Having an ERP in place enables site personnel to be prepared in the event of an emergency situation. It also provides one component of a comprehensive environmental management system for the site.

This plan briefly defines the responsibilities of key personnel and outlines general procedures to be followed when responding to emergencies in a way that will avoid or reduce health and safety risks, and minimize trauma, safety hazards and environmental damage. It is expected that the ERP will continue to be developed throughout the permitting and associated construction phases, culminating with further refinement during operations. The plan will be reviewed and updated on an annual basis. Furthermore, a documented program of updating, document control, training and testing will be established to ensure the effectiveness of the ERP during an emergency.

The scope of the ERP encompasses the extent of Wolverine Project including:

- the access road,
- the airstrip, the mine, the industrial complex (the mill, maintenance buildings, laboratories, etc.) and camp facilities.

Typical emergencies situations described within this plan include:

- Security Breaches;
- Medical emergencies;
- Missing persons;
- Fires and explosions;
- Natural disasters; and
- Site evacuation.

Spills of hazardous materials may constitute an emergency depending on the circumstances of the spill, and the nature and quantity of the substance spilled and procedures and processes to deal with spills are outlined in the *Spill Contingency Plan*.

The EPR Plan will be widely distributed to personnel within YZC, interested government agencies and members of the local emergency response units that may become involved in case of an emergency.

The goals of the EPR Plan are firstly to *prevent the occurrence of emergencies* and secondly to *reduce the impact of emergencies*, should they arise. In both cases, the ultimate goal is to protect:

- Human life and health;
- Social well-being of the local community and employees;
- Public infrastructure and company facilities; and
- Environment.

The objective of the EPR plan is to ensure timely and appropriate response to emergencies, and compliance with applicable laws, industry standards, and legal codes of practice. Effort has been made to ensure that response guidelines to possible site scenarios are included to better enable

timely and appropriate actions. Emergency preparedness begins with prevention of emergency situations. This is achieved through constructing, operating and maintaining systems to high standards, and by implementing continuous monitoring and surveillance programs to identify potential issues.

2.1 Training

During mining operations, the Site Manager will provide annual training workshops for personnel working at the Wolverine Tailings Facility including: YZC foremen, operators, contractors and site engineers. The workshop will focus on operational procedures, improvements planned for the tailings operation system and an overview of planned construction and maintenance activities. Moreover, a more detailed version of this Emergency Response Plan will be covered. Participants will be required to pass a written examination to demonstrate their understanding of the workshop material.

All personnel will receive training that includes instruction in general emergency response, spill contingency measures and communication procedures. Training for preparedness will be conducted in accordance with both Yukon Workers Compensation Health and Safety Board Regulations and regional legislation. At a minimum, a first responder awareness level training program will be implemented with all key staff and contractors. Emergency Response Team members will undergo more rigorous training and will be appropriately tested and certified in relevant emergency response procedures. Training will include pertinent emergency response topics such as:

- Company Policies and Environmental Protection Plans;
- Responsibilities for updating the ERP and the distribution list;
- Internal/External communication networks;
- Available internal/external resources (equipment, emergency response teams, spill cleanup materials);
- Accessing and the deployment of equipment;
- Dealing with seasonal diversities, adverse weather conditions, terrain, snow/ice;
- Personal protective equipment use;

- Properties of substances transported, handled, stored and used on site (Material Safety Data Sheets; MSDS);
- Individual 'Action Plans' for each material/chemical handled;
- On/off-site transportation;
- Response procedure including initial action, clean-up procedures, storage, disposal, reporting and reclamation;
- Relevant Environmental Legislation;
- Workplace Hazardous Materials Information System (WHMIS);
- Standard First Aid and CPR;
- Transportation of Dangerous Goods (TDG) Regulations;

The level of training required for site personnel will vary depending on their respective roles, for example:

- Emergency Response Teams - Training exercises for the ER teams will be organized by the Environmental/Safety Department and be designed to cover a comprehensive range of emergency situations. The Environmental/Safety Department will also maintain a list of names and training modules and specialized simulations completed.
- Loss Control Officer and any site personnel handling dangerous materials will be appropriately trained with TDG certification, as required.
- New employees and contractors – the training of new employees and contractors will include environmental and cultural awareness, spill cleanup procedures, emergency situations and accident/incident reporting as part of their comprehensive site orientation session.
- Drivers of trucks carrying hazardous materials and concentrate will have additional training including spill response (along roads and into water bodies), emergency driving techniques, emergency communications, hazard avoidance, etc.
- Refresher training for all site personnel will be held at least once per year. Training records will be maintained at both the on-site office by the training coordinator. The trainees will receive a certificate indicating the title of the course, dates attended and the type of simulation training received. These records will be updated regularly and a summary list provided to Site Manager monthly. Based on a predetermined schedule (typically every 2-3 years), a multi-

department emergency response scenario will be organized by the Environmental/Safety Department.

Contractors will be required to be familiar with the most recent version of the Emergency Response Plan and to assist response measures in the following ways:

- Advise all employees of the existence of these procedures;
- Assist with evacuation practice sessions and equipment tests;
- Maintain daily employee lists to be used in the event of employee head counts at assembly areas during an evacuation;
- Assist with notification, first-aid, securing of site, etc., during an emergency;
- Provide manpower and equipment on a priority basis as requested to assist in emergency evacuation or response; and

2.2 Documentation and Updating

2.2.1 Emergency Response Plan

The ERP will be reviewed on a yearly basis and following any emergency, spill, incident or emergency simulation exercise. The reviews will ensure that the EPR is consistent with current best management practices in the field of emergency response and spill management. This review will involve a de-briefing to allow the assessment and documenting of what went right, what went wrong, and what changes should be implemented to improve the performance/outcome. Furthermore, the updating process provides a mechanism that allows for timely adjustments to the ERP (outside of the annual review), if required, as the circumstances at the mine site evolve.

The Environmental/Safety Department will be responsible for updating the ERP annually. The list of personnel on the Emergency Response Teams is the responsibility of the individual department heads (or designates) with updates to be forwarded to the Environmental/Safety Department. The Loss Prevention Department will maintain and update the communication hierarchy and the Contact List of all the appropriate site and company personnel. All changes to the plan are to be accompanied by a revised title page showing the latest revision date as well a revision summary page. Revisions are to be forwarded to all personnel on the primary

distribution list. Outdated copies are to be returned to Environmental/Safety Department for disposal. Each new hardcopy is to include an updated distribution list on its cover. If changes to the Plans are minor or involve only one section, to minimize waste, only those sections relevant to the changes need be distributed with instructions as to the replacement of the out-dated sections. In all cases, whether complete or partial replacement of the hard copy, the revised title page with the latest revision date and the revision summary page are required.

2.2.2 Material Safety Data Sheets (MSDS)

The ER team will be provided with an inventory of chemicals and the Material Safety Data Sheets (MSDS) of all materials transported, stored and used on-site. The MSDS will be made available in all strategic locations on-site and at hazardous substance storage locations and points of use. Each registrar will be organized by location and the specific substances relevant to that location in order to facilitate the rapid finding of pertinent information in the event of a spill or emergency. A copy of the MSDS documents will also be available in Environmental Supervisor's Office, Safety Supervisor's Office, Occupational Health & Safety Committee and First Aid centre. They will be updated regularly as the project develops.

2.2.3 Resource Inventory

A resource inventory will provide information on emergency response personnel (manpower), machinery, equipment, first-aid kits, spill kits and tools for clean-up works available to respond to incidental spills, emergency situations or clean-up situations. The resources will include on-site support as well as external support from other bodies/organizations like the fire department, RCMP, and similar mining establishments or exploration camps in the vicinity. This resource list will be reviewed and updated regularly.

2.2.4 Inspections

Periodic inspections will be carried out to verify that all resources and equipment for emergency response are available and in good working condition. Inspectors will check to ensure that the records of maintenance and repairs for each piece of equipment are current or complete, and that appropriate recommendations are made. Inspections will also be carried out at each of the facilities where hazardous materials or waste streams are handled or stored. An inspection

reporting schedule and checklist for relevant site locations will be provided by the Environmental/Safety Department.

2.3 Emergency Response Procedure

For all situations, the first person on the scene of an emergency is designated the On-Scene Coordinator until such time as the Security Officer, Environmental or Safety Supervisor or Management delegates someone else and releases him/her of this duty. The general emergency response procedure is outlined in Figure 2.1.

Procedures will include steps to be taken during various scenarios and depending on the severity of the emergency.

General Emergency Response Procedure

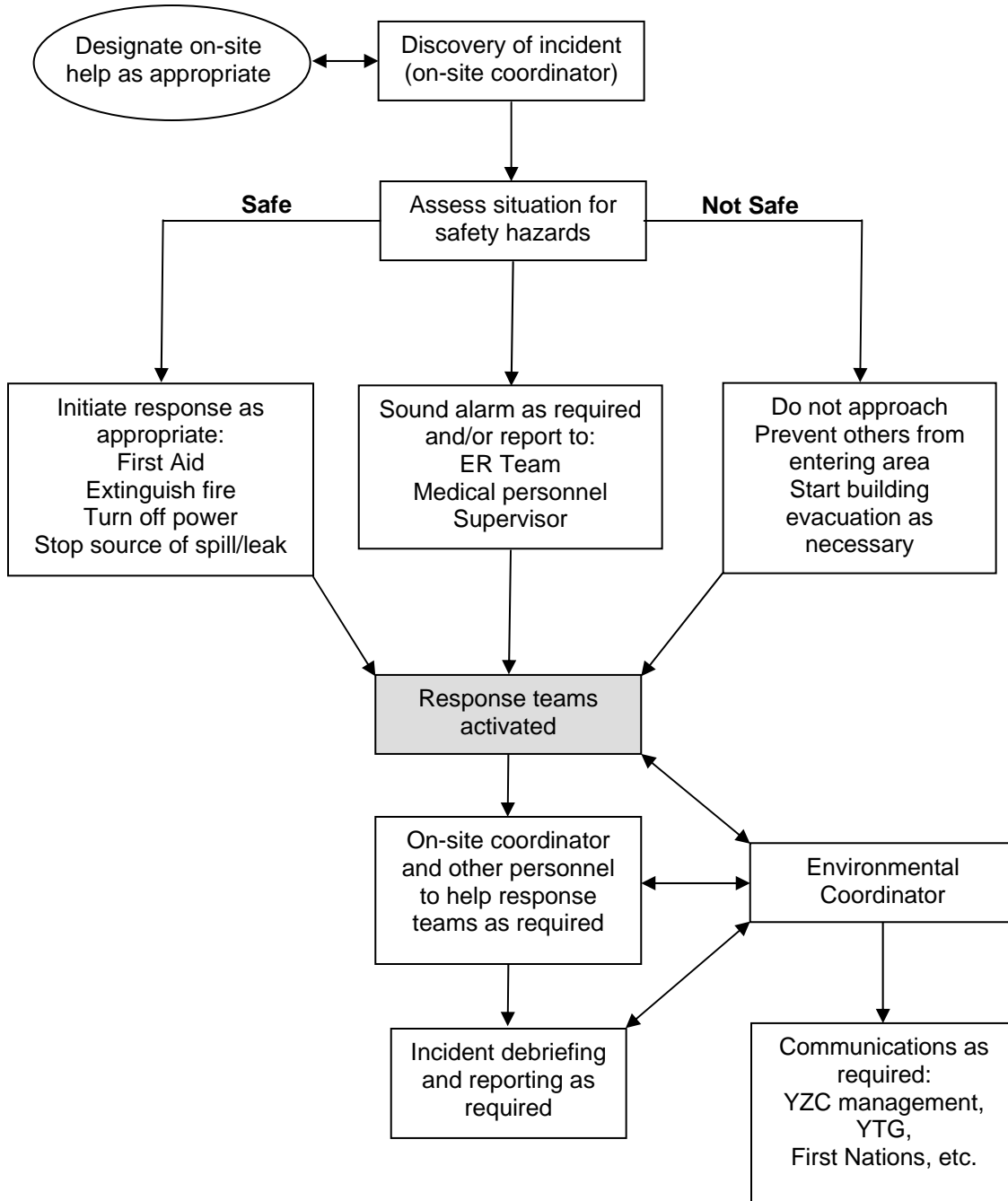


Figure 2.1 General Emergency Response Procedures

2.3.1 Security Breaches

The mine site will be relatively secure due to its remote location and single access road. Use of the road must be authorized and access is controlled with locked gates.

In cases where a security breach is suspected, specific procedures will be developed implemented.

2.3.2 Bomb Threats

A bomb threat cannot be regarded as a meaningless nuisance and is always considered an emergency situation. The project will require storage of large quantities of petroleum products and explosives; therefore a plan, commensurate with the assessed risk, will be developed to specifically deal with potential bomb threats. Any bomb threat will be considered authentic until confirmed otherwise.

2.3.3 Emergency Situations

The emergency response station in the administration building will be equipped for first aid, environmental and mine rescue activities. The first aid room will be separate from the environmental response and mine rescue room where specialized equipment must be stored and maintained. The first aid room will be fully serviced with hot and cold water, toilets and communications. A subsidiary first aid room will be located in the camp. An emergency helipad is located at the northwest corner of the industrial complex area.

2.3.4 Accidents Resulting in Injuries

In the event of a major accident or incident that results in injuries the Safety Supervisor and Medical Personnel should be immediately called to the scene by radio. He or she will then delegate upward depending on the severity of the situation/incident. The following procedures are recommended depending on the seriousness of the injury:

2.3.4.1 Minor Injury - Non-Medical Aid

- The On-Scene Coordinator (until released of his/her duty) is to:

- Ensure the safety of personnel near the site/incident;
- Call ER team and medical personnel;
- Seek assistance or help from others;
- Administer first aid on location at the first aid room;
- Record the first-aid actions taken in the First Aid Log-Book;
- Advise the Supervisor of the incident; and
- Fill out an Incident Report for incident tracking purposes and to implement corrective measures and/or actions, if necessary and to prevent reoccurrence to others.

2.3.4.2 Major Injury - Medical Aid

- The On-Scene Coordinator (until released of his/her duty) is to:
 - Ensure the safety of personnel near the site/incident;
 - Call ER team and medical personnel;
- Seek assistance and medical attention immediately;
- Medical assistants will assess mobility of casualty and administer first aid, as needed;
- Advise the Supervisor, who will:
 - Provide or arrange for further aid;
 - Debrief relevant personnel;
 - Prepare an Incident Report; and
 - Follow Company reporting guidelines and hierarchy as required.

2.3.4.3 Fatalities

In case of an accident/incident leading to a fatality, the following procedures will be carried out:

- The On-Scene Coordinator (until released of his/her duty) is to:
 - Ensure the safety of personnel near the site/incident;

- Call ER team and medical personnel;
- Shut down/turn off any equipment/machinery that may represent an additional safety hazard;
- All material and equipment involved in a fatality are to remain untouched until cleared by the RCMP; and
- Advise immediate Supervisor of the incident, who will advise the Site Manager.
- The Site Manager is to:
 - Call RCMP, ambulance, and fire department as required;
 - Prepare Incident Report; and
 - Follow Company reporting guidelines and hierarchy as required.
- Next of kin to be notified only by RCMP and/or Senior Management;

2.3.4.4 Missing Persons

In the event of a missing person(s), the Site Manager will be notified immediately. A designated supervisor(s) will take charge and initiate the following actions:

- Assess emergency situation;
- Initiate the following, if required;
 - Mobilize search personnel and equipment;
 - Divide areas into quadrants and assign Quadrant Leaders;
 - Distribute communications equipment, as required;
 - Establish routine call-in times;
 - If required, coordinate the search process with RCMP;
 - Prepare necessary reports;
 - Debrief Search Team once emergency search is over; and
 - Notify Senior Management as applicable.

2.3.4.5 Fire or Explosion

In the event of a fire or explosion, the On-Scene Co-coordinator's role will be turned over to the Safety Supervisor, as they arrive on the scene. In the event of a fire or explosion, the On-Scene Coordinator will:

- Assess the situation and determine emergency response needs;
- Activate the fire alarm and call the Emergency Response team;
- Direct and ensure evacuation of personnel, as necessary;
- If evacuation is required, a head-count will be conducted to ensure all personnel have been evacuated;
- Secure area to prevent unauthorized access and to protect equipment, facilities and records;

Employees will be trained and equipped to fight fires in the initial stages only. If a fire is small enough and the risk deemed minimal, extinguish the fire with nearby hand-held or wheeled fire extinguishers;

General Fire Fighting Procedures include:

- Wear SCBA and eye protection when responding to fires;
- Extinguish fires with CO₂, dry chemical, alcohol foam or water fog (note that water or foam may cause frothing); and
- Use water to cool containers exposed to fire.
- Shut off fuel and power supplies.

Firefighting efforts by employees for larger fires will not be encouraged. Notify the Emergency Response Team; providing details of the fire and, if advising of a major fire(s), the requirement for professional fire-fighters to prevent subsequent environmental damage.

2.3.4.6 Natural Disasters

In the event of a natural disaster or severe weather causing damage to a facility and possibly requiring evacuation, the Site Manager assumes the position of On-Scene Coordinator. All site employees must follow the Manager's (or designate's) directions through the emergency broadcast system or other means.

2.4 General Evacuation

Site evacuation will be under the control of the Site Manager, or his designate. A site-wide notification and alarm system will be established. A general evacuation will go into effect upon the sounding of an alarm at any or all of the buildings and facilities on site. The Evacuation Plan may be triggered automatically by fire or gas detectors or manually by an individual or site management upon awareness that an incident requires evacuation.

Muster stations will be established clearly around the project area and site personnel will have been made aware of them during orientation and follow-up training programs.

Primary evacuation from the various project areas will be by road. In the event the road is impassable, evacuation will be conducted by aircraft.

2.4.1 Air Support Operations

Air support will be a very important component of an emergency situation at the site. The airstrip may be used during a major emergency to expedite the movement of emergency resources (manpower and equipment) and to help evacuate site personnel (if required). The responsibility for the operation of the airstrip during an emergency situation will fall under the Site Manager (or designate).

Site-wide evacuation drills will be a part of the regular testing of the emergency response systems. Personnel will receive desktop updates at annual refresher training sessions and major practical drills will occur every two years.

General evacuation guidelines include:

- Keep calm;
- If in a room, take sufficient outdoor clothing (to be kept in rooms at all times) and proceed quickly to the closest muster area; do not congregate in an Office, Control Room or on-site buildings;
- Follow instructions of immediate Supervisor or Environment or Safety Supervisor; and
- When evacuating, leave personal property such as lunch containers, briefcases, etc.

2.5 Communications

Communications during an emergency situation are of utmost importance, and a plan will be prepared that provides direction for how communications are to be undertaken during such a situation. The Communications Plan will provide an organizational structure with specific responsibilities and communications protocols. Generally, in the event of an emergency, only absolutely necessary information should be relayed via the site communication system (e.g., radios and/or cell phones). At all times during an emergency, personnel using the site communication system should only disclose immediately pertinent information to aid the emergency response and should not disclose names or personal details of the casualties.

2.5.1 Public Relations

The Communications Plan will address issues concerning the public, First Nations and affected nearby communities on matters relevant to the situation. The Plan will provide a system to ensure dialogue between YZC and stakeholders of the Wolverine Project. Any reporting to the public or media regarding Emergency Response events or actions will be made directly by, or on authority of, the VP Environment and Community Affairs only, in accordance with the Communications Plan.

3. TAILINGS FACILITY EMERGENCY RESPONSE PLAN

The following section describes the main features of the Tailings Facility Emergency Response Plan, and will be updated with more details regarding the site communication protocols prior to the start up of mine operation.

3.1 Emergency Situations and Response Procedures

Possible emergencies and unusual situations at the Wolverine Tailings Facility may range from a potentially small incident such as a pipeline breakage to the highly unlikely and extreme event of dam instability. All of these situations require site personnel to first be observant and recognize a potential emergency or unusual situation, then follow an established communication procedure and finally, respond appropriately.

This section covers only those emergency situations that could potentially pose a threat to the structural integrity of the tailings dam or result in the release of tailings materials, tailings transportation water, and/or supernatant pond water into the surrounding environment. In the event of an emergency, prompt action will be taken to avoid delays which could have serious consequences.

Emergency situations may include, but are not limited to, the following:

- Failure or suspect impending failure of the tailings dam;
- Slumping, sliding, cracking or bulging of the tailings dam;
- Rapid increase or unexplained cloudy appearance of seepage through the tailings dam and/or its foundation;
- Formation of sinkholes on the tailings beach or dam;
- Breakage of tailings pipelines, which may result in dam erosion and/or release of tailings slurry;
- Large earthquakes;
- Extreme floods; and
- Sabotage and other criminal activities.

Particular attention will be given to inspecting and, where necessary, repairing the tailings facility following unusual or extreme events. All unusual events will be reported to supervisory personnel. In an unlikely event that high seepage flows occur downstream of the tailings dam, and particularly if seepage water is carrying soil particles from the dam or its foundation, which is an early indication of a potential “piping” problem (i.e., internal erosion), it will be reported immediately and the engineering consultant notified.

In the event of an emergency or unusual situation, all instrumentation in the affected area will be monitored during and/or immediately following the event by either the engineering consultant, if on-site, or by YZC personnel. This information will be forwarded to the design engineer(s) immediately so that the situation can be assessed and any required remedial actions taken promptly.

3.1.1 Emergency Response Procedures and Communications

Communication of a potential or actual emergency is essential, in order to get qualified individuals to assess the situation or to assist in response as soon as possible. In virtually all situations the Site Manager must be notified. If there is imminent and substantial danger to people, the environment, or to company property that overwhelms on-site resources, outside assistance must be summoned quickly. Possible examples include: a spill that threatens the environment and cannot be contained, or a catastrophic dam failure that threatens personnel, the public and the environment.

The procedure for response and communication are detailed below. In the event of an emergency or potential emergency:

- Respond to the incident, ensuring safety of yourself and others.
- Notify the supervisor(s), and the Site Manager, as soon as possible.
- In case of an emergency requiring immediate outside assistance, take the following steps:
 - Call the applicable emergency numbers to request for assistance by police and/or other emergency personnel.
 - Be prepared to give the following information:
 - your name and telephone number;
 - the location and time of the incident;
 - (if dam emergency) the dam structure involved;
 - the nature of the emergency situation (e.g., spill, dam incident, etc.);
 - the cause of the emergency (e.g., pipeline break, slope instability, or other unknown causes);
 - actions taken to control the problem and their effect (e.g., close off isolation valves, repair dam slope);
 - the names of the agencies on the scene; and
 - the names of other persons or agencies advised concerning the incident.

3.1.2 Notification Procedures

Notification is done to alert others of an unusual condition that has occurred or is still occurring, that may require action. It is to be done promptly, but there is typically time to first gather more information on a situation, to analyze possible causes, and to perhaps take some initial remedial measures. Notification will occur internally, and externally as deemed necessary by the Site Manager.

Internal notification is given to the supervisor(s) according to the chain of command including the Site Manager, as appropriate. As a general rule, always inform the supervisor(s) of any unusual incident that has occurred on site, any anomalous monitoring results, or any potentially hazardous condition. If in doubt about the significance or importance of something you have observed, err on the side of caution and report it to the supervisor(s). The supervisor(s) will then investigate and determine necessary actions.

Corporate personnel will be notified in the event of significant incidents on site, particularly events where external notifications to government agencies or downstream-affected persons are necessary.

External notification is communication by the Site Manager, or his designate, to persons or agencies outside of the Wolverine Mine site. Contact details (names of key individuals, their agencies and telephone numbers) will be provided prior to the start up of mining operations.

Some key persons or agencies that will be notified of an incident include:

- **Government:** in the event of a significant spill, or dam incident, the Site Manager or Environmental Supervisor will notify the Yukon Department of Energy, Mines and Resources and Department of Environment, and other appropriate agencies.
- **Downstream-Affected Persons:** a dam incident could result in off-site effects, for example a spill, water quality issue, or dam breach. In this case, effort must be made to ensure that all those potentially affected by the situation are notified and given directions to reduce their exposure. Actions must also be taken to prevent the public from unknowingly being affected by the situation (e.g., possibly by restricting access to downstream roads and waterways). The Site Manager will work closely with territorial and appropriate authorities to ensure that notification of downstream-affected persons is timely and comprehensive.

- Dam Consultant: in the unlikely event of potential dam instability or leakage, the dam consultant will be immediately contacted and investigative and mitigate actions will be taken as recommended by the consultant.
- Other: During and after a significant event, it may be necessary to respond to questions and concerns by the media, general public, special interest groups, and other stakeholders. The corporate office is responsible for this communication.

3.2 Actions to Prevent Tailings Dam Breach

In an unlikely event, the Wolverine tailings facility could fail due to the breach of the tailings dam, resulting in flooding to the downstream area. The dam breach could be triggered by “piping” (i.e., internal erosion) or overtopping. It is difficult to predict where a dam breach would be initiated and precisely what corrective actions would be required. Nevertheless, to assist the mine in dealing with emergency situations threatening the tailings dam, this section describes the resources available to the mine and the potential course of actions that could be taken promptly to avert a dam breach. These actions could include: (1) lower tailings pond level; (2) arrest or retard dam internal erosion; and (3) arrest or retard dam external erosion.

During mine operations there will be continual personnel presence around the Wolverine Tailings Facility. If a situation arises that requires immediate attention, YZC has at its disposal the equipment, material, labour and engineering expertise to respond immediately. These resources include those within the mine and those available through outside contractors and consultants.

3.2.1 Lower Tailings Pond Level

In the early stage of either a “piping” or overtopping scenario, the most effective action to reduce the threat of further development of the failure mechanism is to lower the level of water in the tailings pond upstream of the tailings dam, as fast as practical. Actions that can be taken to achieve a lower water level behind the dam include stopping tailings discharge into the tailings impoundment (shut down mill). If this action alone is unable to lower the pond level sufficiently to improve the dam condition, the Site Manager or Environmental Manager will request the Yukon Department of Energy, Mines and Resources and Department of Environment to declare a state of emergency, and to allow YZC to release tailings pond water downstream of the tailings

dam into Go Creek. This request will only be made in the event of imminent dam failure to prevent substantial environmental consequences.

If permission is not granted, YZC could consider pumping tailings pond water to the underground mine, once it has been evacuated.

3.2.2 Arrest or Retard Dam Internal Erosion

Excess and/or murky seepage caused by internal erosion of the tailings dam may indicate a “piping” failure of the dam. If a sinkhole develops, it should be immediately filled with damfill materials compatible with the internal zoning of the dam. If the sinkhole is located upstream of the dam, efforts should be made to prevent pond water from flowing into it. This could be accomplished by placing additional earthfill in the surrounding area to block access, and/or pumping tailings materials to move the tailings beach/water away from the sinkhole.

In the area where excess and/or murky seepage exits from the tailings dam toe a weighted filter buttress berm should be promptly placed along the seepage exit area. The filter berm would allow free exit of seepage water without carrying away existing damfill and/or foundation materials. The filter berm should be constructed of filter and drainage materials with progressively increasing particle size towards the berm outer surface.

3.2.3 Arrest or Retard Dam External Erosion

As the dam freeboard decreases during a major hydrologic event, additional actions can be taken to arrest external erosion of the dam. Concurrent with lowering the tailings pond level, the existing dam crest should be raised by placing additional dam fill on the crest. While raising the crest uniformly across the entire dam, additional dam fill material should be placed in local areas where signs of weakening such as slope slumps, crest deformations and cracks are discovered.

In an event that an open channel begins to form on the dam crest, granular materials should be used to plug the channel. Materials of sufficient size and weight can be dozed into the breach from alternate sides of the channel. As the channel is gradually being closed, the materials used to plug the channel should increase in size and weight to cope with the increasing flow velocity. After the channel is completely closed, additional fill material with sufficient fines should be placed upstream of the granular-fill plug in order to prevent the seepage through the plug.

APPENDIX V

Treatability and Bench-Scale Bioreactor Testing of Waters for Selenium Removal

January 31, 2008

***TREATABILITY AND BENCH-
SCALE BIOREACTOR TESTING
OF WATERS FOR SELENIUM
REMOVAL - FINAL REPORT***

January 31, 2008

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EXECUTIVE SUMMARY

This report summarizes data presented in *Phase 1 and 2 reports* and presents new data gathered for Phases 3 and 4 that addresses bench-scale testing of three potential process waters and provides a cost breakdown for an on-site pilot-scale test. Good microbial growth and selenium reduction was obtained using a defined media and a molasses, yeast, phosphate media (MYP nutrient) at 3.75 gm/L molasses, 1.5 gm/L yeast extract, and 2.0 mg/L phosphate in waters containing ~4.3 mg/L selenium. DGGE profiling of the selected SF036, Z0, SF056, and Lorax-1 (L-1) microbial population and individual isolated microbial constituents was conducted and on-line database sequence comparisons yielded no matches with sequenced microorganisms. These microorganisms are unknowns at the genus and species level. Microbial stock cultures have been made and are available for pilot-scale testing.

Reactor testing was conducted in two new reactor types 1) a biochemical-enhanced material reactor (BEMR) and 2) an electro-biochemical reactor (EBR). Both had void volumes of ~700 mL and used mostly modified pumice as a microbial growth surface. *Phase 3* testing used water spiked with selenium to ~9 mg/L and nine buckets of visibly different waters, received as one process run. Two tests were made with these waters, one at ~4.3 mg/L selenium and one at ~15 mg/L selenium. The first tests used two BEMR in series with feed waters containing ~9 mg/L (spiked) selenium and nutrient addition to only the first bioreactor and produced effluents that averaged ~0.58 mg/L selenium using a total retention time of forty-four hours. In Test 2 the bioreactor configuration was changed to include a pretreatment step and used the feed waters containing ~9 mg/L selenium, with microbes and nutrient, to simulate a holding or equilibration pond, and removed an average of ~2.9 mg/L selenium. Test waters were again supplemented with 100 mL nutrient before entering reactor 1 as described for Test 1; no nutrients were added to the bottom of BEMR-2 during this test except what carried over from BEMR-1. A bioreactor retention time of forty-four hours produced a final effluent averaging ~0.029 mg/L selenium.

In Test 3 the bioreactor configuration was changed to eliminate the pretreatment step and waters containing ~4.3 mg/L selenium were introduced into BEMR-1 and BEMR-2 as in Test 1. In this test 100 mL of 3.75 gm/L MYP nutrient was added to the bottom of both BEMR-1 and BEMR-2 for a total of 200 mL nutrient once daily; the effluent was sampled at the top of BEMR-2. A total retention time of forty-four hours produced a final effluent averaging ~0.031 mg/L selenium. During Test 3, the EBR was started and operated in the same manner as the BEMRs. A retention time of twenty-two hours produced a final effluent averaging ~0.030 mg/L selenium. In Test 4 the bioreactor configuration was again changed to connect the BEMRs and EBR in series using new test waters containing ~15 mg/L selenium and a total retention time of sixty-six hours. Limited data gathered showed an effluent averaging ~0.47 mg/L selenium from the two stage BEMRs and a final effluent from the EBR averaging ~0.072 mg/L selenium. A number of additional metals identified as potential permitting criteria were also removed to a large extent by the bioreactors.

Testing and site conditions indicate that both pre and post treatment steps will be required and sizing is given for both a 1/10 and a 1/50 pilot-scale system. Treatment costing assumptions and items are provided for a 1/10 pilot-scale test running three months with a cost estimate just under \$163,000.00.

TREATABILITY AND BENCH-SCALE BIOREACTOR TESTING OF WATERS FOR SELENIUM REMOVAL - FINAL REPORT

INTRODUCTION

This report summarizes data presented in earlier reports, *Phases 1 and 2*, addressing selenium treatability and initial testing of several different potential process and waste waters for a new mine at the Wolverine Project, YK. *Phases 3 and 4* address bench-scale testing of several different process water samples and provides a cost breakdown for an on-site pilot-scale test. Limiting conditions with respect to treatability at this site are temperature and high selenium concentrations; up to 14 mg/L selenium. It is planned to run the selenium biotreatment system seasonally; six months of the year - spring through fall. Water samples were obtained from tailings pilot plant runs that simulated actual full-scale tailings plant waters; samples were received from *Lorax Environmental Services Ltd.*, 2289 Burrard Street, Vancouver, BC V6J 3H9. The waters received were examined using different methods to assess potential selenium treatability, including two newly developed selenium removal technologies demonstrated to enhance biofilm growth and metal removal.

Data Summary

Phase 1 Goals

- Evaluation of pilot plant process water chemistry for microbial toxicity and required nutrient supplementation
- Qualitative assessment of biotreatability effectiveness at temperatures of 20° C and 4° C using site and repository microbes
- Qualitative assessment of biotreatability effectiveness of several microbial mixtures

Phase 1 testing produced the following conclusions:

- Microbial screening successfully demonstrated that site microbes and two microbial populations were capable of good selenium reduction in site waters at ~20° C and to a lesser degree at 4° C
- Overall, the tests were very positive and provided a strong demonstration that biological selenium reduction was achievable in the waters tested
- If effluents containing higher levels of selenium, e.g., <50 ppb can be considered, they would be possible with considerable less development and capital investment

Phase 1 Recommendations:

- Continue testing the microbial populations and site isolates in *Phase 2*
- Continue investigation of microbial adaptation for lower temperature selenium reduction
- Perform preliminary assessment of selenium removal using selected nutrient combinations

Phase 2 Goals

- Select an optimal microbial population for selenium removal in process test waters received
- Continue to qualitatively assess selenium removal at 20° C and 4° C
- Perform preliminary assessment of selenium removal using selected nutrient combinations
- Evaluate microbial selenium removal characteristics

Phase 2 testing produced the following conclusions:

- Several microbial isolates and microbial populations were capable of selenium reduction in site waters at ~24° C using an economical nutrient and a 72 hour retention time
 - A microbial population – SF036, Z0, SF056, and Lorax-1 (L-1) will be used in bioreactor tests
 - Following mixed culture co-adaptation, site microbes volatilized selenium to a high degree
- pH was not an issue, but the waters provided for the *Phase 2* tests did affect selenium reduction

- Cyanide or another contaminant removed with hydrogen peroxide made a significant difference in the selenium removal obtained
 - Selenium concentration will require at least two treatment stages to remove selenium to <50 ppb
- Nutrient component levels formulated for *Phase 3* tests included sugars, protein (carbon), nitrogen, iron, magnesium, and phosphate
 - Nutrients were provided in test solutions containing molasses/soy (3.75 to 0.75 gm/L), yeast (1.5 to 0.75 gm/L), and phosphate (0.05 to 2 gm/L)
 - The best performing defined media contained 3.75 gm/L molasses/soy, 1.5 gm/L yeast, and .5 to 2.0 gm/L phosphate – MYP media
 - Growth rates in the MYP media were slower than in a rich commercially available trypticase soy microbial media
 - Microbial selenium reduction at ~4° C in the waters provided for the *Phase 2* tests was not acceptable

Phase 2 Recommendations:

- Testing and evaluation should proceed to the next level of bench-scale reactor testing at 24° C
- Testing can be conducted in two new, but tested, biotreatment system designs
 - Electro-biochemical reactor (EBR)
 - Biochemical-enhanced materials reactor (BEMR)
- Profile microbial population using Denaturing Gradient Gel Electrophoresis (DGGE)
- Continue to track selected microbial adaptation and selenium volatilization

BACKGROUND - BIOREACTOR TESTING

Phases 3 and 4

Phases 3 and 4 have not been covered in a formal report and are reported here. This document reports on the bench-scale process tests using three different waters, evaluates bioreactor testing for an on-site pilot-scale test, and provides a rough cost estimate for this test. The objectives include:

- Evaluate the new process waters received for microbial toxicity and required nutrient supplements
- Re-evaluate the selected microbial population in the process waters for relative selenium reduction
- Fingerprint the microbes identified as important for selenium reduction in site waters using DGGE
- Evaluate selenium reduction in two new bioreactor types – a bio-electrochemical (BEC) reactor and a biochemical-enhanced microbial support materials (BEMS) reactor
- Use the developed nutrient containing 3.75 gm/L molasses/soy, 1.5 gm/L yeast, and 1.0 gm/L phosphate – (continued *Phase 2* testing indicated a lower phosphate concentration could be used)
- Target a bioreactor effluent with selenium concentrations below 20 µg/L (ppb)
- Assess technologies for pilot-scale and provide a rough cost estimate for on-site tests

Water Samples

Water Chemistry Analysis

Selenium and other metal concentrations in samples analyzed were obtained by direct ICP MS analysis of the sample or through a dilution of the sample by a factor of 10:1 or 100:1. Samples and sample dilutions were run against calibration curves constructed using response measurements on known calibration standards. For example, for the lower selenium concentrations, the following 0, 40, 80, 120, and 240 ng Se/L calibration standards were used. When required the selenium or other metal concentrations in the calibration standards were revised, for example to 0, 25, 250 and 2500 ng/L. In addition, dilution factors were calculated so that the selenium and other metal concentrations in the resulting dilutions approximated one-half the Se concentration in the new high calibration standard. The new dilutions were then prepared and run on the ICP MS against the calibration standards at the revised concentration levels; detection limits were 2 ppb for selenium. Results presented are corrected for dilution.

Water Samples Received

Phase 3 testing was initiated with five buckets of waters initially received for *Phase 3* that did not contain any significant selenium or other contaminants. These pH ~7 waters did not have any visible precipitates, were initially thought to contain selenium, and be from a process run. Water samples received were re-analyzed three times with the same result, no selenium present. However, analysis of another water sample from the same run, held by *Lorax Environmental Services Ltd.*, was shown to contain selenium, but not enough to conduct the tests required. The five buckets of pH ~7 water were spiked to ~9 mg/L selenium and used to start reactor conditioning and initial reactor tests.

A second water sample received for *Phase 3* tests consisted of nine buckets of water, provided as one process run with the water chemistry listed under the Bulk Tailings analysis in *Attachment 1*. This set of water samples was reported to have a pH of ~10 and a selenium concentration of ~2.5 mg/L. The pH in all buckets was ~10; however, the selenium concentration varied considerably, from ~4.3 mg/L to ~15 mg/L selenium, as did the appearance of the waters, *Figure 1*. The clear solution, five buckets total, containing ~4.3 mg/L selenium was used along with the spiked solution described above for the bulk of the bioreactor testing.

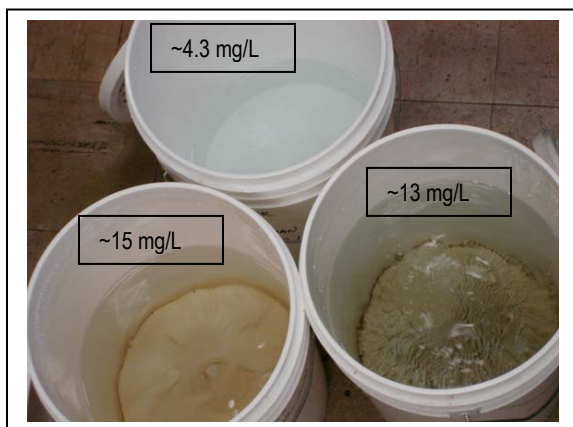


Figure 1. Three different buckets of the nine buckets of test solution received for *Phase 3* testing. These buckets have a selenium concentration of between ~4.3 to 15 mg/L. This photo shows the difference in the solutions received for testing. The clear solution, five buckets total, was assayed at average value of ~4.3 mg/L selenium. The colored solutions contain the higher selenium amounts – there were two buckets each of the red and brown colored solutions. The red colored solutions contained ~15 mg Se/L and the brown colored solutions contain ~13 mg/L selenium; this analysis represents a 0.22 μm filtered sample analysis. Observation: The amount of precipitate in the buckets increased two- to three-fold with time, over approximately two months, and was not a function of settling. Buckets were held at pH ~10, as received, until used in bioreactor or other testing.

METHODS AND RESULTS

Standard and modified methods were used for all microbial analyses conducted. Standard and modified methods were used in all procedural protocols and modified or 'special' analysis methods were used for qualitative microbial selenium evaluations. Data presented represents summary, combined, and average data from individual tests and the screening conducted.

Re-evaluation of test microbes in new waters

In this step, the new process waters received were evaluated for microbial toxicity and nutrient supplements required for good microbial growth and selenium reduction. Evaluation media was made with new test waters containing 4.3 mg/L selenium and various concentrations of nutrient components in a test matrix. Individual microbes were screened in this test procedure for relative growth and selenium reduction. *Figures 2, 3, and 4* depict good microbial growth and selenium reduction using a defined media and a molasses/soy, yeast, phosphate media (MYP nutrient) in waters

containing ~4.3 mg/L selenium. Growth tests were conducted in static test flasks held at ~24° C (Laboratory temperature); absorbance shown in *Figures 3 and 4* is correlated in a direct manner with microbial growth.



Figure 2a and 2b. 2a shows SF036, Z0, SF056, and Lorax-1 (L-1), the individual bioreactor test microbes, with good microbial growth and selenium reduction using a defined media. 2b shows a screen for selenium reduction using three different media containing different amounts of selected media components. The best growth and selenium reduction is on the plate on the right side of *Figure 2b*.

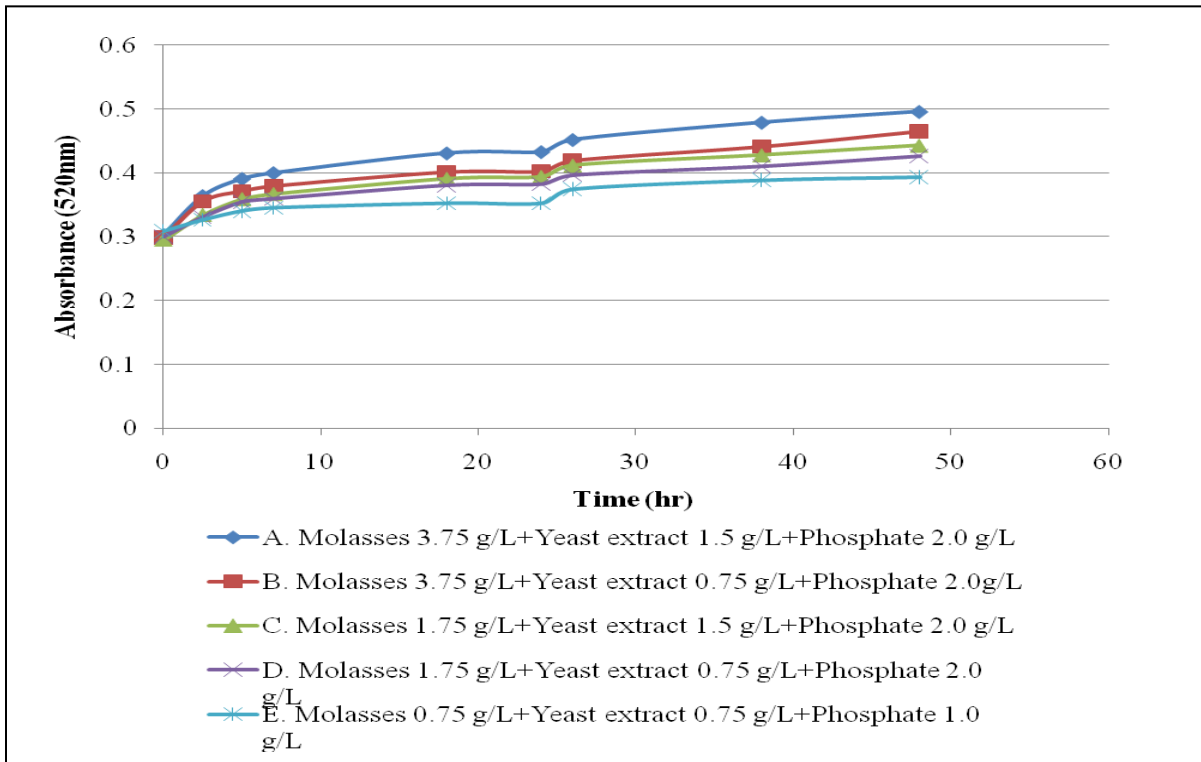


Figure 3. Sample growth curves of the selected microbial population in various media component concentrations.

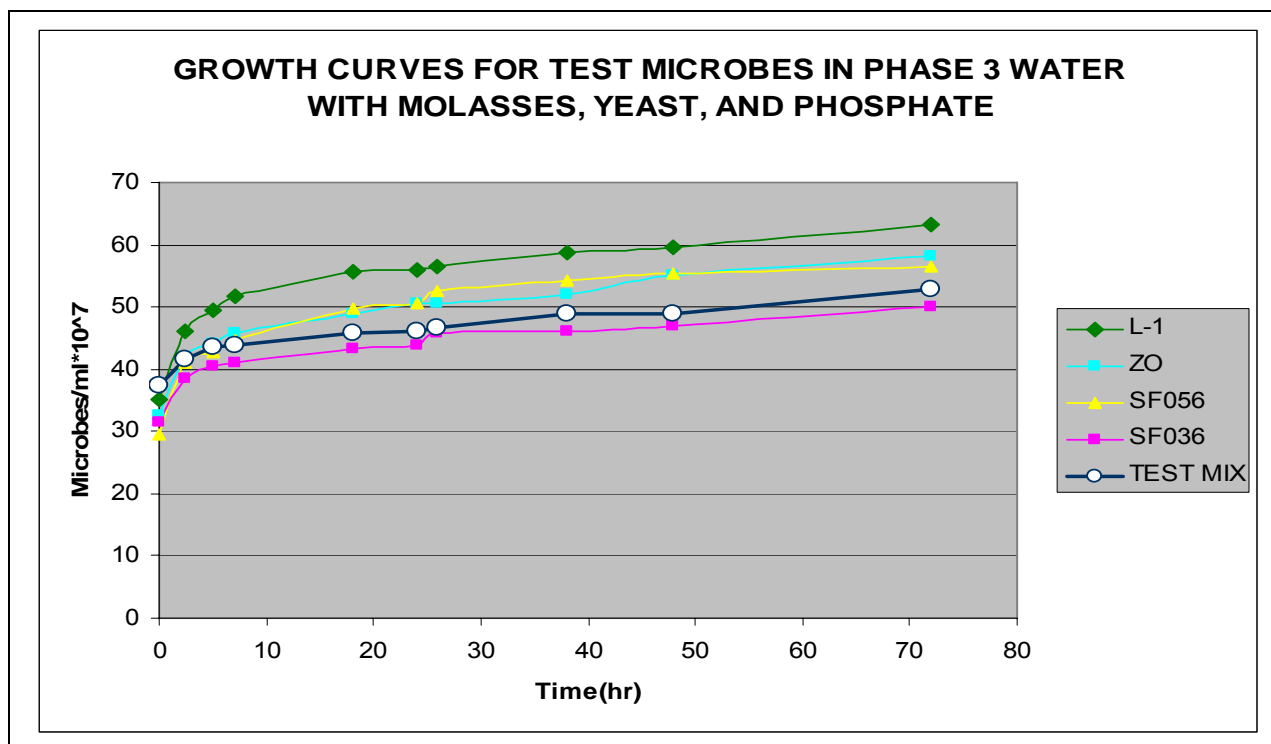


Figure 4. Growth curves of individual test microbes and the test population mix in MYP nutrient over a 72 hour period at 24° C (Laboratory temperature).

Nucleic Acid Profiling

The following discussion is presented because initially these bacteria were sub-cultured together to enhance selenium reduction in the site microbes and in a bioreactor test population that later became defined as containing SF036, ZO, SF056, and Lorax-1 (L-1). It is now accepted that the vast majority of microbes have not yet been isolated, identified or characterized. This is largely due to a lack of knowledge of how these organisms survive and grow in natural habitats. When one also considers that a bacterium is often part of a larger more complex community or ecosystem with possible co-dependence on other members, it is understandable why traditional culturing techniques fail to accurately reflect the large microbial diversity in an environmental sample. Identification and classification of microbes is further confounded by a general absence of morphologically distinct features, thousands of bacterial species are classically categorized by a few different (~17) morphologies.

The advent of culture-independent techniques has transformed the field of microbiology. PCR-based techniques allow the classification of microorganisms based on particular genetic markers and the profiling of complex microbial communities on the basis of nucleic acid sequence diversity (including the uncultured majority). For the past 10 –15 years, microbiologists have relied upon DNA sequence information for microbial identification, based primarily on the genes encoding the small subunit RNA molecule of the ribosome (16S rRNA or SSU rRNA).

Functional constraints on the cellular nucleic acid translational apparatus limit variability in the 16S rRNA molecule, resulting in a high degree of sequence conservation; therefore, a high degree of matching between the same microbes from different sources and different growth conditions. So, even if microbes exchange genes for selenium reduction, the conservation of the rRNA gene sequence permits bacterial characterization and identification based on sequence information obtained from pure cultures or cloned genes from mixed communities. This is possible because rRNA sequence data is used to design phylogenetically conserved probes that target both individual and closely related groups of microorganisms without cultivation.

A principle repository of 16S rRNA sequences, the Ribosomal Database Project (RDP), currently maintains over 17,000 aligned entries representing 850 of 940 formally recognized prokaryotic genera, which are placed into 1,149 phylogenetic groups. Comparative DNA sequencing analysis is widely considered to be the best genotypic method for microbial identification. The most common approach is PCR amplification and sequencing of all or a 500 Base Pair portion of the 16S ribosomal RNA gene. Sequence data is then compared against a sequence database, which ideally contains only validated microbial sequences.

One technique, based on PCR amplification and sequencing of 16S ribosomal RNA, now routinely used is denaturing gradient gel electrophoresis (DGGE). DGGE is a genetic fingerprinting technique that is used to separate individual sequences from a complex mixture. DNA sequences with differing base composition have different melting properties when passed through an acrylamide gel containing an increasing gradient of a chemical denaturant. The melting temperature of a double stranded DNA fragment is influenced by hydrogen bonds formed between complementary base pairs and also by the attraction between neighboring bases on the same strand (known as stacking interactions). The order of bases on a strand determines the degree of stacking. A DNA molecule may therefore have several melting domains with characteristic melting temperatures. DGGE profiles of the selected microbial population and individual isolated microbial constituents were conducted and results are shown in *Figure 5*. As can be seen, all test microbes are quite similar, but slightly different, and the bands found on the individual test microbes are present in the population profile 4M.

DGGE bands were extracted, amplified, and sent for sequence analysis. The DGGE and amplified sequence analysis shows that all microbes tested appear closely related, but their sequences matched no known microbial sequences in the on-line databases; they are unknown at both the genus and species level but closely related. Metabolic tests have shown that these microbes are quite different metabolically. A previous database check of repository microbe SF036 had shown no matching sequences and cultures of all test microbes exhibited the same DGGE profile before and after sub-culturing.

Microbial stock cultures have been made and are available for pilot-scale testing.



Figure 5. DGGE profiles of site microbial RNA from L-1 and ZO, two repository microbes, 4M - a mixture of all bioreactor test microbes, and a *A. ferrooxidans* control.

BIOREACTOR TESTING

Bioreactor Configuration and Operation

Both reactors contained modified pumice materials as the bulk of the microbial support surface. Each bioreactor has a void volume of approximately 700mls and test waters have a twenty-two hour retention time in each bioreactor. Each reactor has three sampling ports used to monitor conditions within the bioreactor at the bottom, middle, and top. Bioreactors were operated at Laboratory temperatures of ~24° C. Bioreactor feed water was added to a clean feed water container on a daily or every other day basis followed by adjustment of the pH between 6.8 and 7.2 using hydrochloric acid. For one test, nutrients, at 3.75 gm/L, were added every other day to a pretreatment container that contained two days of test waters spiked to 9 mg/L selenium. In all other tests shown, nutrients were added to one or each reactor separately at a rate of 3.75 gm/L on a daily basis by mixing the nutrient into a 100mls of pH adjusted test water and pumping it into the reactor over a five minute time period. The flow rate through the bioreactor was then re-adjusted for a twenty-two hour retention time and re-connected to the feed water container.

All reactors were tested with an economical nutrient solution containing 3.75 gm/L MYP nutrient added to test waters. Testing was initially conducted in two new biochemical-enhanced material reactors (BEMR) while a third electro-biochemical reactor (EBR) was being constructed and undergoing preliminary tests. The BEMRs were operated in series for a total retention time of forty-four hours. *Figure 6* depicts the two initial BEMRs tested; no photo of the EBR is provided because patent approval is still in progress. The EBR was constructed and operated in a manner similar to the BEMR; a twenty-two hour retention time was used in this reactor. In one test all three reactors were connected in series, two BEMRs followed by the EBR for a total retention time of sixty-six hours.

Bioreactor effluent samples were collected during nutrient addition into a sterile 50 ml tube. All samples, including paired feed samples were centrifuged for 30 minutes and filtered through a pre-filter followed by a 0.22 micron filter. Samples were preserved by adjusting the pH below 1 with nitric acid and stored at 4° C until analysis. pH and ORP measurements were made before nutrient addition using the three sampling ports; fifteen milliliter samples were collected, centrifuged for 10 minutes, and pH and ORP were measured.

Bioreactor Testing Results and Discussion

BEMR inoculation and start-up was initiated with waters spiked to 9 mg/l selenium at pH ~7. This water was from the first five buckets of waters initially received for *Phase 3* that did not initially contain any significant selenium or other contaminants. Bioreactors were started and operated for one month using these waters. A second water sample was received for *Phase 3* tests that consisted of nine buckets of water; five buckets containing a clear test solution were used for the bulk of the bioreactor testing; these buckets were the ones that closely matched the water chemistry shown in attachment 1. The selenium content of these waters was ~4.3 mg/L. The EBR was started using test waters containing ~4.3 mg/L selenium. The final tests, conducted with three reactors in series, two BEMRs followed by the EBR, with a total retention time of 66 hours used water from a bucket containing a redish precipitate and ~15 mg/L selenium. Testing results are presented in *Figure 7*.



Figure 6. Two BEMR in series using a retention time of twenty-two hour each for a total retention time of forty-four hours.

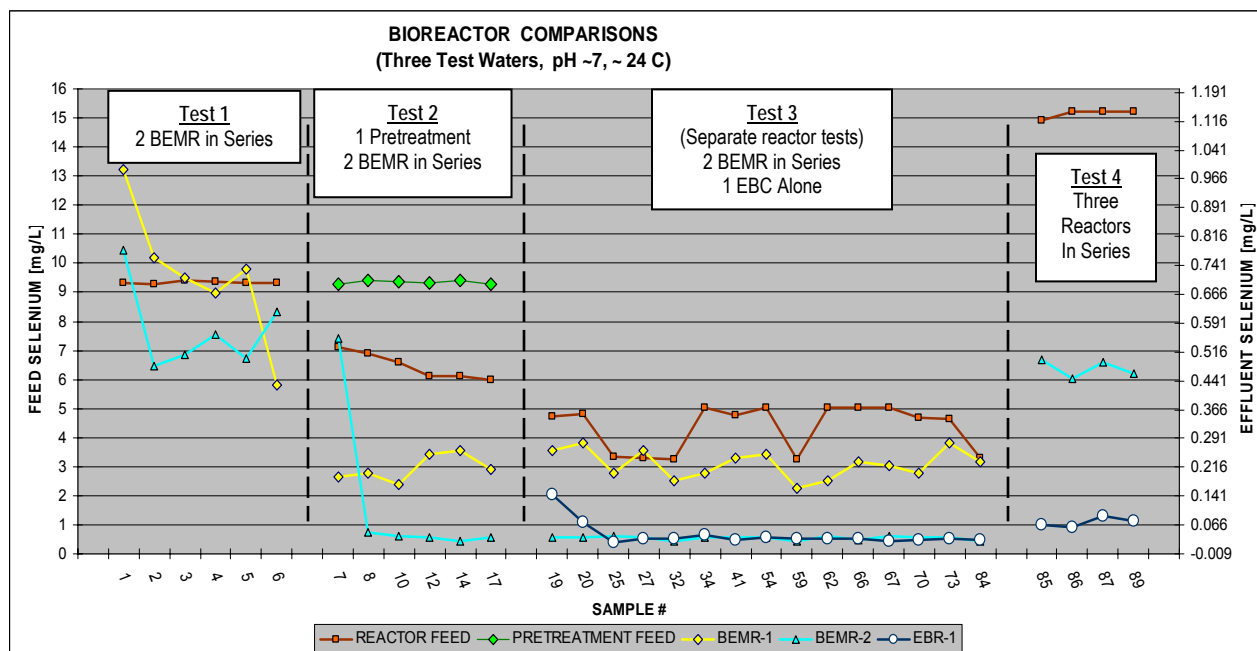


Figure 7. A comparison of a two-stage BEMR and a separate single-stage EBR comparison using a twenty-two hour retention time per stage for a forty-four hour overall retention time in the BEMRs and a twenty-two hour retention time in the EBR. Dashed lines show breaks in reactor testing that included reactor start-up, down time, and re-equilibration of bioreactors for new test solutions or test configurations. The BEMRs and EBR comparisons were made with one test water at ~4.3 mg/L selenium; the BEMRs tests used three different test waters. The BEMRs were used to test three different test water selenium concentrations ~9 mg/L (spiked), ~4.3 mg/L, and ~15 mg/L. The reactor data shown represents operation at one nutrient concentration; 3.75 g/L. Reactors were operated at Laboratory temperature ~24° C.

In Test 1 the bioreactors appear to still be approaching a steady state. In this test, waters containing ~9 mg/L selenium were introduced into the bottom of BEMR-1 and flowed from the bottom to the top of BEMR-1 then into the bottom of BEMR-2; effluents were sampled at the top of BEMR-1 and BEMR-2. Nutrients were added to the feed solution entering the bottom of BEMR-1 using 100 mL of 3.75 gm/L nutrient once daily; no nutrients were added to BEMR-2 during this test except what carried over from BEMR-1. Retention time in each BEMR stage was twenty-two hours for a total retention time of forty-four hours and produced a final effluent averaging ~0.58 mg/L selenium.

In Test 2 the bioreactor configuration was changed to include a pretreatment step in which the feed waters containing ~9 mg/L selenium were held at ~24° C for forty eight hours with microbes and 100 mL of nutrient before entering the bioreactor. This simulated holding pond, with no microbial support materials, removed an average of ~2.9 mg/L selenium. At this point, the test water now containing ~6.5 mg/L selenium was again supplemented with 100 mL of nutrient and continued to flow into BEMR-1 and BEMR-2 as in Test 1; no nutrients were added to BEMR-2 during this test except what carried over from BEMR-1. Retention time in each BEMR stage was twenty-two hours for a total retention time of forty-four hours and produced a final effluent averaging ~0.029 mg/L selenium, if the first data point in this test is not included.

In Test 3 the bioreactor configuration was changed to eliminate the pretreatment step in Test 2. In this test, waters containing ~4.3 mg/L selenium were introduced into BEMR-1 and BEMR-2 as in Test 1, but 100 mL nutrient was added to the bottom of both BEMR-1 and BEMR-2 for a total of 200 mL nutrient once daily; the effluent was sampled at the top of BEMR-2. Retention time in each BEMR stage was twenty-two hours for a total retention time of forty-four hours producing an average final effluent of ~0.031 mg/L selenium.

During Test 3, the EBR was started after a period of preliminary tests and operated independent of the BEMRs; no pretreatment step was included. Separate test waters were introduced into the bottom of the EBR and flowed to the top where the effluent was sampled. One hundred milliliters of 3.75 gm/L nutrient was added to the bottom of the EBR once daily. Retention time in the EBR was twenty-two hours and produced a final effluent of ~0.030 mg/L selenium if the initial data point is discarded.

In Test 4 the bioreactor configuration was again changed to connect the BEMRs and EBR in series using new test waters containing ~15 mg/L selenium and a different water chemistry than in Tests 1, 2, and 3; no pretreatment step was included. In this test, waters were introduced into the bottom of BEMR-1 - to the bottom of BEMR-2 - to the bottom of the EBR; 100 mL of 3.75 gm/L nutrient was added to the bottom all reactors for a total of 300 mL nutrient once daily. Retention time in each reactor stage was twenty-two hours for a total retention time of sixty-six hours and produced an effluent averaging ~0.47 mg/L selenium from the two stage BEMRs and a final effluent from the EBR averaging ~0.072 mg/L selenium.

Evaluation for pilot-scale tests

Several different water chemistries were tested in *Phase 3*, one was close to the provided target process water chemistry with ~4.3 mg/L selenium, and all three were samples were initially thought to be samples of potential water chemistry. A two stage BEMR system of a single stage EBR came close to meeting target discharge criteria of 20 ppb on two of the potential target water chemistries. Addition of another reactor stage or increased retention times should meet these goals, but selenium removal is dependent on the water chemistry, and initial selenium concentration. In assessment of reactor performance, using the five buckets containing ~4.3 gm/L selenium, good selenium reduction and removal was achieved in the BEMRs with a forty-four hour retention time and in the EBR with a twenty-two hour retention time. Oxidation-reduction potential and pH were measured at three points within each reactor and provided for the BEMRs as Attachment 2.

Testing results indicate that a holding pond can be used for slower but significant selenium reduction if treated with nutrients and microbes. The effectiveness of the holding pond could be increased by addition of a microbial support growth surface; however, this would reduce the effective size of the pond. There was no attempt to determine the trade-off between pond size and addition of microbial growth surface which would increase the reaction kinetics.

The single stage EBR, with a twenty-two hour retention time, had the same performance as the two-stage BEMRs with a forty-four hour retention time. The level of selenium removals should be improved in both systems with the addition of a holding pond with microbes and nutrients. *It is likely that target selenium goals of 20 ug/L would have been obtained if a holding pond, with microbial support materials, had been used ahead of the bioreactors in Test 3, Figure 7.*

Selenium removal was good within the BEMRs even as the oxidation-reduction potential dropped into the -200 to -250 mV range between samples 40 and 45. This range is lower than is often considered optimal for the best selenium removal and is due to the amount of nutrients added to the bioreactors. This profile decrease in ORP has been noted in bench- pilot- and full-scale bioreactors and indicates that even though lower nutrient levels exhibited lower growth rates, *Figure 3*, in the long term these lower nutrient concentrations will still develop a substantial biofilm that should function well for selenium removal with significantly lower nutrient concentrations. *In all full-scale biotreatment systems implemented to date, significantly less nutrients were required once biofilm establishment was complete.*

Therefore, it is appropriate to start out a pilot- or full-scale bioreactor with higher nutrient levels to establish a biofilm and then reduce the nutrients significantly once the biofilm is developed. In colder water temperatures the formation of microbial biofilms is slowed considerably and unless the water can be heated, the development of a robust biofilm can take many months. This means the drop in ORP, observed in the bench-scale reactors, may not be observed for a much longer time, but is a good indicator of a mature biofilm and excess nutrients.

The pH increased within the BEMR environment as expected because the concentrated nutrient solution was slightly acidic even when made up with pH adjusted test water; it initially degrades into less acidic byproducts. The bench-scale reactors exhibited pH profiles similar to those observed in full-scale bioreactors. A similar pH profile would be expected during pilot-scale tests.

When nutrient levels in biotreatment systems are not well balanced and in some instances where they are well balanced, post treatment to reduce biological oxygen demand (BOD) is required. In colder climates and instances where the biotreatment systems are shut down for any period a post treatment system is required to reduce BOD.

Additional Water Quality Criteria

As Phase 3 was being completed, a number of additional metals were identified as potential permitting criteria. As indicated in Table 1, the pumice materials used as a microbial growth support were a significant source of several metals of interest. This source of metals could be removed by using gravel or activated carbon, but the gravel would provide significantly less surface area for a microbial biofilm, therefore lower selenium reduction kinetics, and virgin activated carbon would be considerably more expensive. The two different bioreactor types removed different amounts of different metals; however a significant reduction in all metals of interest except copper and nickel was achieved. Copper, at these levels is a component in many nutrients; but the origin of the nickel increase is currently unknown in the BEMRs. Table 1 data is average data from 14 points throughout the experiment.

Table 1. Additional Water Quality Criteria - Bench-Scale Bioreactors

ITEM		ELEMENT	Al	S	Fe	Ni	Cu	Zn	As	Mo	Ag	Cd	Sb	Pb	Hg
			µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	AVERAGE FEED WATERS		998.95	460.67	32.00	6.23	3.00	19.48	2.61	632.52	2.04	1.77	14.93	5.02	2.15
TWO BR IN SERIES	AVERAGE BEMR-1 EFFLUENT	22 HR RETENTION	162.63	421.73	177.37	8.31	3.00	21.77	2.67	57.64	0.30	0.16	6.21	0.77	3.41
	AVERAGE BEMR-2 EFFLUENT	44 HR RETENTION	58.17	339.88	255.68	11.49	4.05	32.51	1.93	12.25	0.21	0.06	3.05	2.61	1.46
	AVERAGE EBR EFFLUENT	22 HR RETENTION	23.21	176.09	339.41	10.41	3.04	31.65	1.40	55.65	0.00	0.18	10.69	5.31	2.74
BR FILL	AVERAGE ELUTED FROM PUMICE*	(gm)	200.07	0.00	175.19	1.22	1.07	7.73	0.00	0.00	0.00	0.00	0.00	0.00	0.08

(BEMR) – Bio-enhanced Materials Reactor

(BER) – Bio-electrochemical reactor

* - Average of two pumice elutions in amount per gram of pumice. Second elution amounts generally decreased by 50% to 75% with the exception of mercury which did not decrease with the 2nd elution. Elutions carried out in a manner to approximate release over the course of the experiments. No new elements showed up in 2nd elution; might expect some elution of these elements to continue over the course of the experiments conducted.

BACKGROUND FOR PILOT-SCALE TESTING

Pre- and Post-Treatments

Considering the range of selenium values and water chemistry differences in the water samples tested in *Phases 1-3*, a pre-treatment stage is strongly recommended. This system should be sized to handle any larger than normal flow events such as those that normally occur in the spring and fall. A recommended system would consist of a holding or equilibration pond either unfilled or partially filled with a microbial growth support. Based on water chemistry and temperature, this pond should have a minimum retention time of seven days to two weeks; or based on a flow rate of 9 L/s, a void volume of ~13,000 m³ for two weeks retention time. A better estimate of pond size, optimal retention time, and an economical trade-off in microbial support surface fill depth can be determined during pilot-scale testing.

Post-treatment is required to reduce treatment system BOD, and will be required at this site due to temperatures and operational requirements; a post-treatment system is also usually required to deal process water chemistry changes. Post-treatment consists of an aerobic stage where the selenium treatment effluents would be aerated in contact with a dense microbial population. Usually this microbial population will be available in site waters and will ultimately consist of a portion of the selenium reducing population; some of the facultative anaerobes. The type of post-treatment system required is dependent on nutrient load and can vary from a conventional trickling filter to an actively aerated system.

Pilot-Scale Treatment Size

The project flow rate for full scale treatment is approximately 9 L/s; therefore, recommended flow rates for a large pilot-scale test would be 0.7, 0.9, and 1.1 L/s or flow rates about one-tenth of the full-scale flow. Smaller pilot-scale tests can be conducted and are often designed around flow rates of 0.02% of the target flow rate or 0.14, 0.18, and 0.22 L/s. Test flow rates are not fixed and should be adjusted to meet site requirements. Based on 50% void volumes and retention times needed, estimated system sizes for the pilot-scale tests are presented in *Table 2* below.

Table 2. Treatment System Component Size – Void Volume 50%.

Flow Rate (L/s)	Total Flow/ Tmt Cycle (L/Day)	Pre-treatment Size (m ³)	Treatment System Size (m ³)	Post-treatment Size (m ³)
0.14	12,096.0	406.4	79.8	14.5
0.18	15,552.0	522.5	102.6	18.7
0.22	19,008.0	638.7	125.5	22.8
0.7	60,480.0	2032.1	399.2	72.6
0.9	77,760.0	2612.7	513.2	93.3
1.1	95,040.0	3193.3	627.3	114.0

Total Flow – Flow Rate L/sec*60 sec/min*60 min/hr*24 hrs/day

Pre-treatment Size – (Flow Rate L/sec*60 sec/min*60 min/hr*24 hrs/day*14 days)/1,000 L/m³*2 vv*1.2 sizing factor

Treatment System – (Flow Rate L/sec*60 sec/min*60 min/hr*66 hrs)/1,000 L/m³*2 vv*1.2 sizing factor

Post-Treatment Size – (Flow Rate L/sec*60 sec/min*60 min/hr*12 hrs)/1,000 L/m³*2 vv*1.2 sizing factor

Treatment Costing Assumptions

The following assumptions are made for the included pilot-scale cost estimate.

- Site lodging and meals will be provided during time at site
- Testing time is June through August – three months
- Labor assistance by on-site personnel
- Weekends or cycle time in Whitehorse, YK (~24 days) - Transportation to Whitehorse
- Power, pumps, tanks/ponds, piping, and water heater at site
- Near-by gravel or pumice supply – provided on site
- Inoculum scale-up tanks – can use treatment system tanks
- Nutrient tank, costs, and transportation to site – ~106 tons OR ~20,000 gal – covered in cost estimate
- 1/10 flow pilot-scale test

Cost Estimate

This is a rough estimate of costs for a 1/10 flow pilot-scale test for a period of three months. Costs will change upon further discussion and refinement of desired test period, test parameters, potential site personnel involvement, and materials that can be provided on site.

Cost Proposal for Pilot-Scale Study at Yukon Mine Site

	Technical Director Consultant	Principal Engineer/ Scientist	Senior Engineer	Associate Engineer/ Scientist	Environmental Scientist Microbiologist	Technician	TOTAL HOURS	TOTAL LABOR \$
Hourly Billing Rate	\$185	\$120	\$80	\$83	\$54	\$36		
TASKS								
1. Project Management								
a. Coordination and Oversight	30			20	40		90	\$9,370.00
b. Client Review Meetings	16				16		32	\$3,824.00
Project Management Hours	46	0	0	20	56	0	122	
Project Management Subtotal Labor Dollars	\$8,510	\$0	\$0	\$1,660	\$3,024	\$0		\$13,194.00
2. Laboratory Optimization								
a. Water Characterization	4			8	16		28	\$2,268.00
b. Culture Screening	4				24		28	\$2,036.00
Laboratory Optimization Subtotal Hours	8	0	0	8	40	0	56	
Laboratory Optimization Subtotal Labor Dollars	\$1,480	\$0	\$0	\$664	\$2,160	\$0	\$4,304	\$4,304.00
3. Pilot-Scale Operations								
a. Bioreactor Preparation	40			16	160		216	\$17,368.00
b. Inoculum Preparation	40				160	40	240	\$17,480.00
c. Pilot-Scale Operation	40			16	160		216	\$17,368.00
d. Microbial Support	8				8	40	56	\$3,352.00
e. Report Preparation	24			16	24		64	\$7,064.00
Pilot-Scale Operations Hours	152	0	0	48	512	80	792	
Total Pilot-Scale Operations Labor Dollars	\$28,120	\$0	\$0	\$3,984	\$27,648	\$2,880		\$62,632.00
Total Project Hours	206	0	0	76	608	80	970	
Total Project Labor Dollars	\$38,110	\$0	\$0	\$6,308	\$32,832	\$2,880	\$80,130	\$80,130.00
							Total Other Direct Charges	\$82,351.50
							Total Estimated Project Fees	\$162,481.50

Other Direct Charges (ODC's)

Air/Mileage	Mileage Cost	Misc. Supplies	Nutrients	Equipment Lease	Lodging & Meals	TOTAL ODC's
	0.45					
2000	900.00					\$900.00
						\$0.00
\$9,600.00					\$2,880.00	\$12,480.00
Project Management Subtotal ODC's						\$13,380.00
400	180.00					\$180.00
	-					\$0.00
Laboratory Optimization Subtotal					Subtotal ODC's	\$180.00
-	\$2,000.00			\$3,700.00		\$5,700.00
-	\$350.00	\$50,000.00				\$50,350.00
-	\$2,000.00					\$2,000.00
-						\$0.00
-						\$0.00
Total Pilot-Scale Operations Subtotal ODC's						\$58,050.00


Subtotal Other Direct Charges	\$71,610.00
Administrative and Handling Fee @ 15%	\$10,741.50
Total Other Direct Charges	\$82,351.50

ATTACHMENT 1. BULK TAILINGS ANALYSIS

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES



Environmental Division

ANALYTICAL REPORT	
LORAX ENVIRONMENTAL SERVICES ATTN: JONATHAN MACKIN 2289 BURRARD STREET VANCOUVER BC V6J 3H9	Reported On: 27-SEP-07 11:13 AM
Lab Work Order #: L550876	Date Received: 06-SEP-07
Project P.O. #: Job Reference: 474-1 YUKON ZINC Legal Site Desc: CofC Numbers: Other Information:	
Comments:	
 Timothy Guy Crowther General Manager, Vancouver	
For any questions about this report please contact your Account Manager: Andre Langlais	

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ALS Canada Ltd.
7471th, **ALS Laboratory Group**
1988 Triumph Street, Vancouver, BC V5L 1K5
Phone: +1 804 263 4188 Fax: +1 804 263 8700 www.alsglobal.com
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ALS LABORATORY GROUP ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L550876-1	L550876-2	L550876-3	L550876-4	L550876-5
		05-SEP-07	05-SEP-07	05-SEP-07	05-SEP-07	05-SEP-07
		BULK TAILINGS 1 (9/10/11)	BULK TAILINGS 2 (12/13/17)	BULK TAILINGS 3 (14/15/16)	PB RO CONC	CU RO CONC
Grouping	Analyte					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	802	834	697	411	463
	Conductivity (uS/cm)	1730	1830	1530	1110	1190
	pH (pH)	10.3	10.7	10.2	7.62	7.91
	Total Dissolved Solids (mg/L)	1550	1560	1330	875	952
	Total Suspended Solids (mg/L)	9.3	<3.0	5.3	<3.0	<3.0
	Turbidity (NTU)	7.36	0.57	3.48	13.9	19.9
Anions and Nutrients	Ammonia as N (mg/L)	0.265	0.389	0.164	0.235	0.197
	Alkalinity, Total (as CaCO3) (mg/L)	106	151	101	7.3	81.3
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	4.44	4.91	5.27	6.07	5.89
	Fluoride (F) (mg/L)	0.167	0.161	0.134	0.114	0.093
	Sulfate (SO4) (mg/L)	597	632	534	393	460
	Nitrate (as N) (mg/L)	0.556	0.550	0.459	0.434	0.473
	Nitrite (as N) (mg/L)	0.0167	0.0085	0.0115	0.0067	0.0059
	Ortho Phosphate as P (mg/L)	0.0042	0.0048	0.0029	0.0035	<0.0010
Total Phosphate as P (mg/L)	0.213	0.142	0.130	0.242	0.0038	
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Cyanide, Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Thiocyanate (SCN) (mg/L)	<0.50	0.58	0.55	<0.50	0.69
Total Metals	Aluminum (Al)-Total (mg/L)	1.19	1.26	1.11	0.0219	0.0117
	Antimony (Sb)-Total (mg/L)	0.0287	0.0294	0.0301	0.0253	0.0598
	Arsenic (As)-Total (mg/L)	0.00789	0.00532	0.00611	0.00379	0.00458
	Barium (Ba)-Total (mg/L)	0.190	0.188	0.174	0.120	0.160
	Beryllium (Be)-Total (mg/L)	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
	Bismuth (Bi)-Total (mg/L)	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
	Boron (B)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Cadmium (Cd)-Total (mg/L)	<0.0020	<0.0020	<0.0020	0.00229	0.00601
	Calcium (Ca)-Total (mg/L)	321	334	279	155	175
	Chromium (Cr)-Total (mg/L)	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
	Cobalt (Co)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00195
	Copper (Cu)-Total (mg/L)	0.00335	0.00095	0.00125	0.0118	0.0652
	Iron (Fe)-Total (mg/L)	0.308	0.039	0.158	0.048	1.02
	Lead (Pb)-Total (mg/L)	0.469	0.748	0.239	0.294	0.622
	Lithium (Li)-Total (mg/L)	<0.025	<0.025	<0.025	<0.025	<0.025
	Magnesium (Mg)-Total (mg/L)	<0.10	<0.10	<0.10	5.81	6.14
	Manganese (Mn)-Total (mg/L)	0.00548	0.00048	0.00208	0.146	2.98
	Molybdenum (Mo)-Total (mg/L)	0.661	0.696	0.562	0.0183	0.00529
	Nickel (Ni)-Total (mg/L)	<0.0025	<0.0025	<0.0025	<0.0025	0.0546
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30

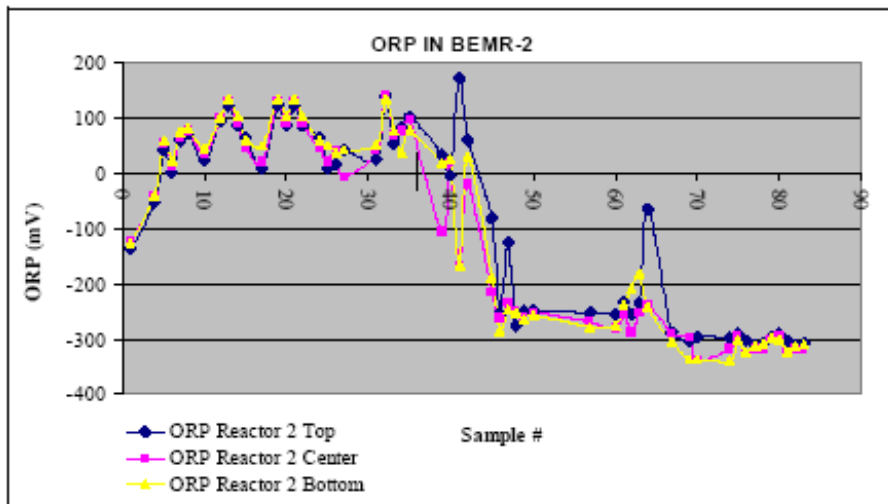
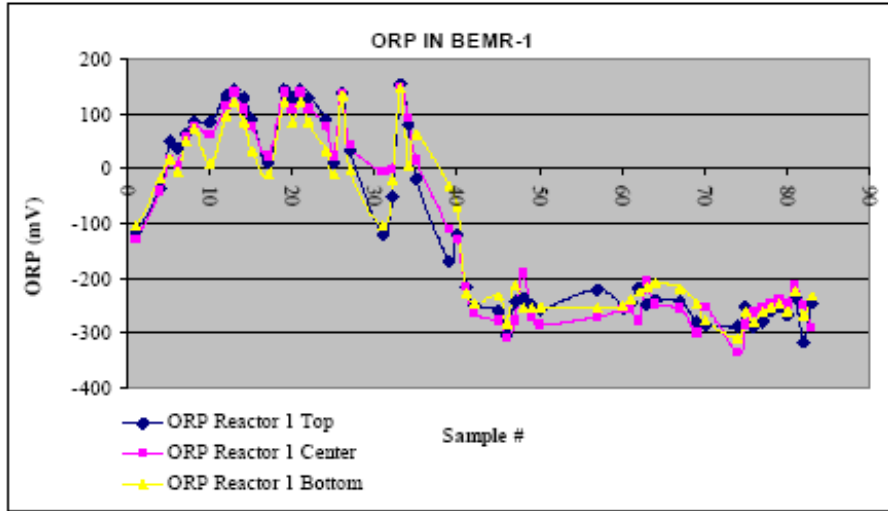
ALS LABORATORY GROUP ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L550876-1	L550876-2	L550876-3	L550876-4	L550876-5
		05-SEP-07	05-SEP-07	05-SEP-07	05-SEP-07	05-SEP-07
		BULK TAILINGS 1 (9/10/11)	BULK TAILINGS 2 (12/13/17)	BULK TAILINGS 3 (14/15/16)	PE RO CONC	CU RO CONC
Grouping	Analyte					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	8.2	7.4	6.4	5.7	5.4
	Selenium (Se)-Total (mg/L)	3.05	3.21	2.54	0.907	0.676
	Silicon (Si)-Total (mg/L)	0.149	0.110	0.148	0.145	1.05
	Silver (Ag)-Total (mg/L)	0.00262	0.00217	0.00122	0.00317	0.00849
	Sodium (Na)-Total (mg/L)	80.8	87.6	70.5	65.8	66.3
	Strontium (Sr)-Total (mg/L)	0.859	0.876	0.747	0.396	0.433
	Thallium (Tl)-Total (mg/L)	0.00152	0.00154	0.00187	0.00721	0.0103
	Tin (Sn)-Total (mg/L)	0.00825	0.00897	0.0165	0.00126	0.00194
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000520
	Vanadium (V)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Zinc (Zn)-Total (mg/L)	0.314	0.486	0.293	0.190	2.44

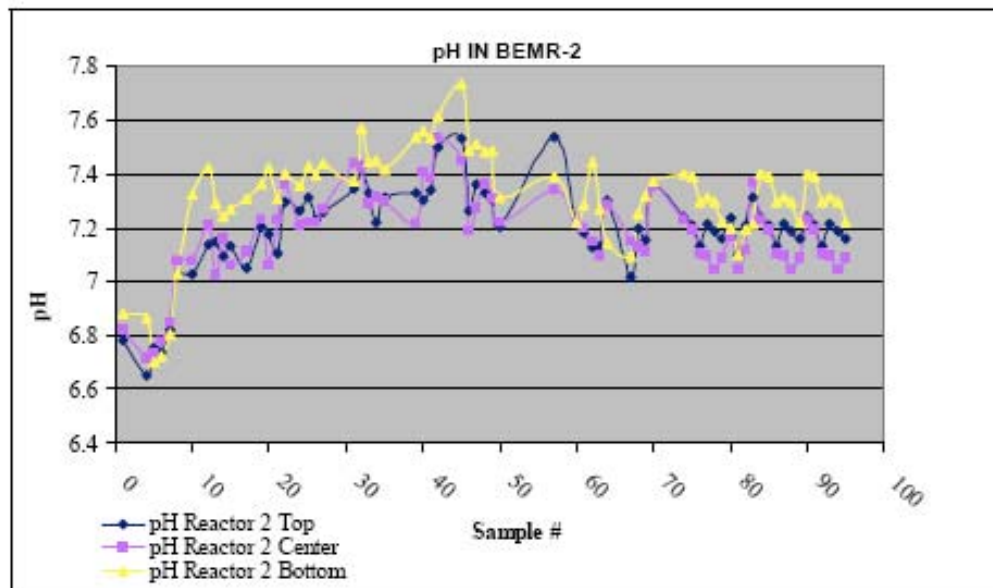
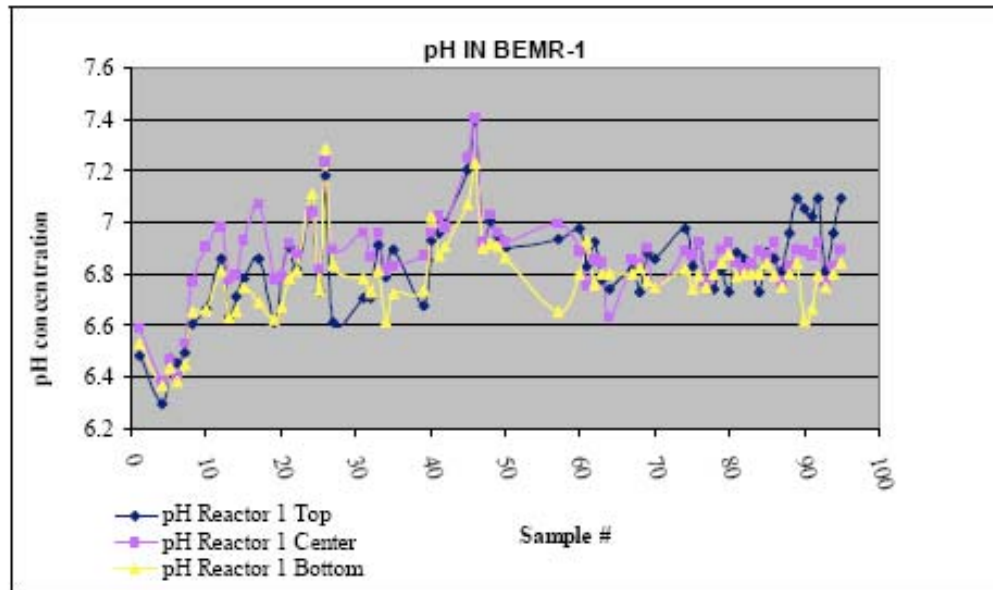
ATTACHMENT 2. BEMR ORP and pH PROFILES

ATTACHMENT 2. OXIDATION REDUCTION POTENTIAL AND pH IN BEMRS

Oxidation Reduction Potential



pH in Bemrs



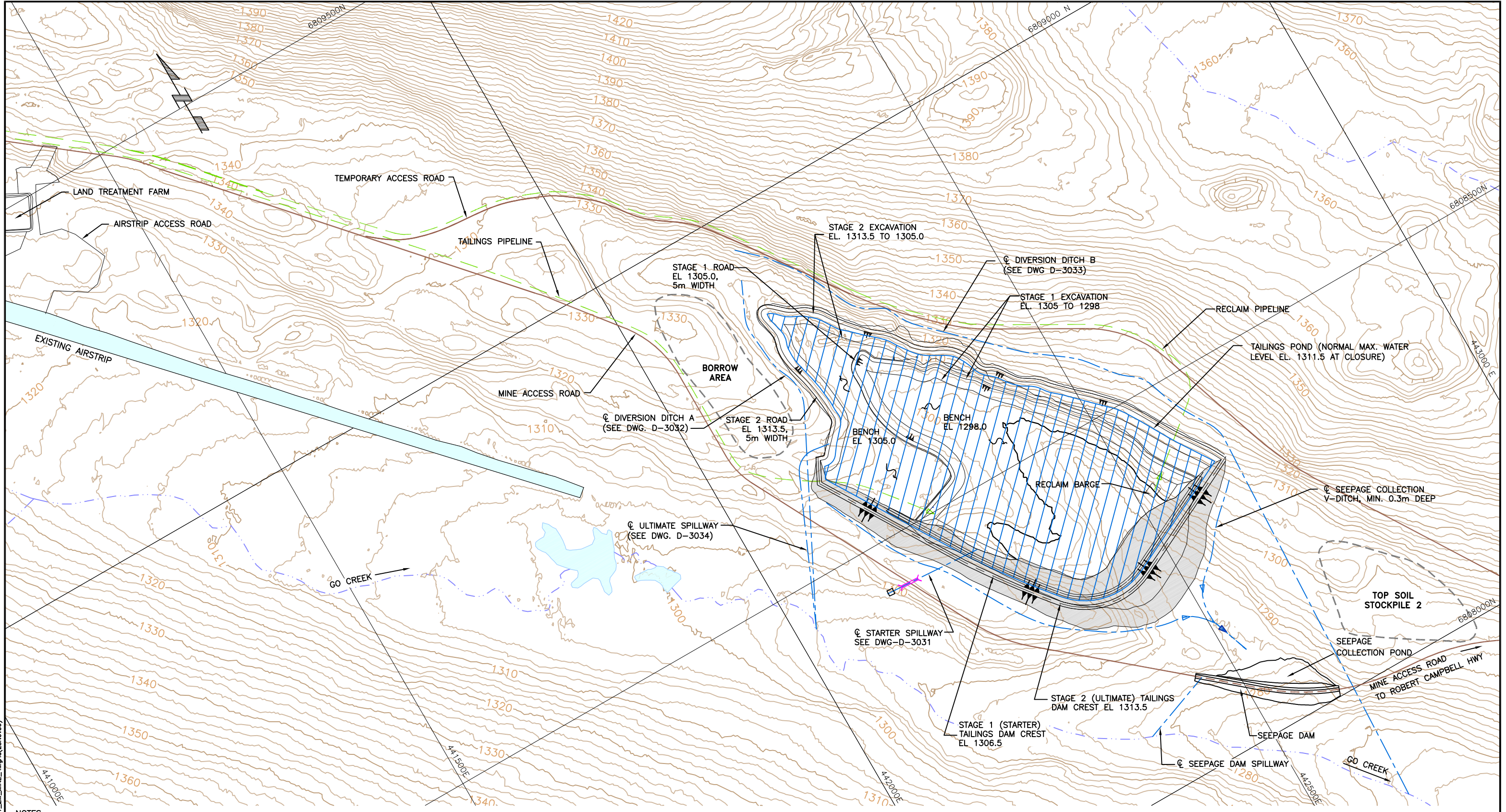
DRAWINGS

Drawing D-3001	General Arrangement
Drawing D-3002	Site Investigation Plan
Drawing D-3003	Subsoil Profiles
Drawing D-3004	Tailings Impoundment Plan and Storage Volumes
Drawing D-3005	Tailings Dam and Seepage Dam – Dam Sections
Drawing D-3006	Starter Impoundment Excavation and Fill – Plan
Drawing D-3007	Starter Impoundment Excavation and Fill – Sections
Drawing D-3008	Ultimate Impoundment Excavation and Fill – Plan
Drawing D-3009	Ultimate Impoundment Excavation and Fill Sections
Drawing D-3010	Starter Impoundment Schematic Sections
Drawing D-3011	Ultimate Impoundment Schematic Sections
Drawing D-3012	Impoundment – Closure Plan
Drawing D-3031	Starter Dam Spillway – Plan, Profile and Sections
Drawing D-3032	Diversion Ditch A – Plan, Profile and Sections
Drawing D-3033	Diversion Ditch B – Plan, Profile and Sections
Drawing D-3034	Closure Spillway – Plan, Profile and Sections

DRAWINGS

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Drawing D-3032	Diversion Ditch A- Plan, Profile and Sections
Drawing D-3033	Diversion Ditch B Plan, Profile and Sections
Drawing D-3034	Closure Spillway – Plan, Profile and Sections

Scale: 1=25(FPS)
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 Xrefs: Utilites(12Dec08), CONT_2M_MINE_MGrid(23Nov06)



NOTES
 1. NOT ALL CULVERTS HAVE BEEN SHOWN.

DRAFT NOT FOR CONSTRUCTION 0 200 m

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

DWG. NO.	REFERENCE DRAWINGS	PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE
												ISSUE/REVISIONS		

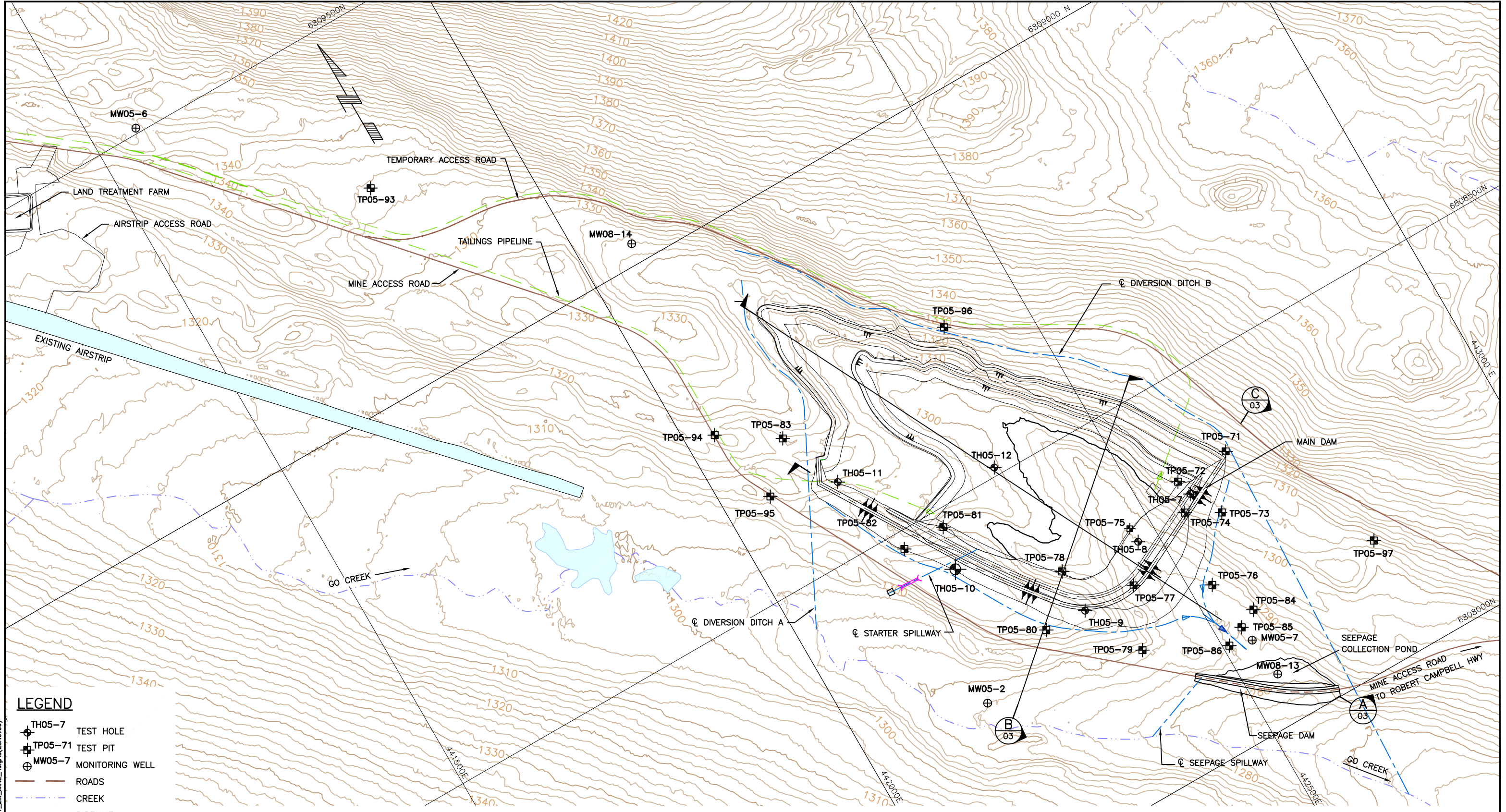
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CHECK BY: HM	
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Yukon Zinc
 CORPORATION
 WOLVERINE PROJECT
TAILINGS STORAGE FACILITY
 GENERAL SITE ARRANGEMENT

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 Xrefs: Utilities(12Dec08), CONT_2M_MINE_A1(23Nov06)



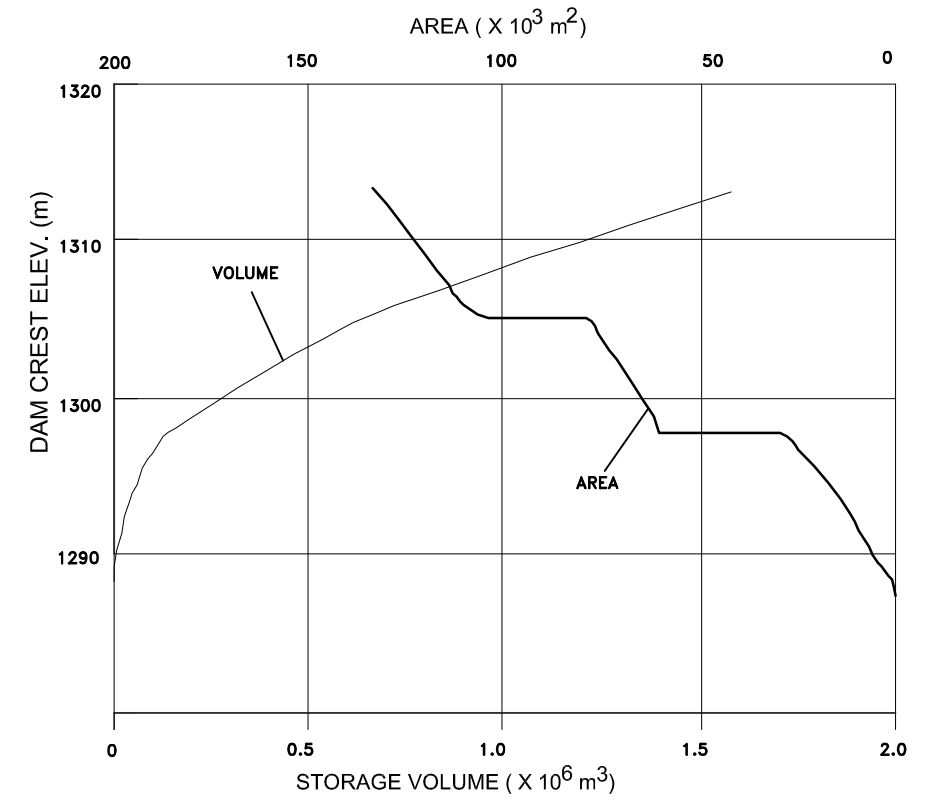
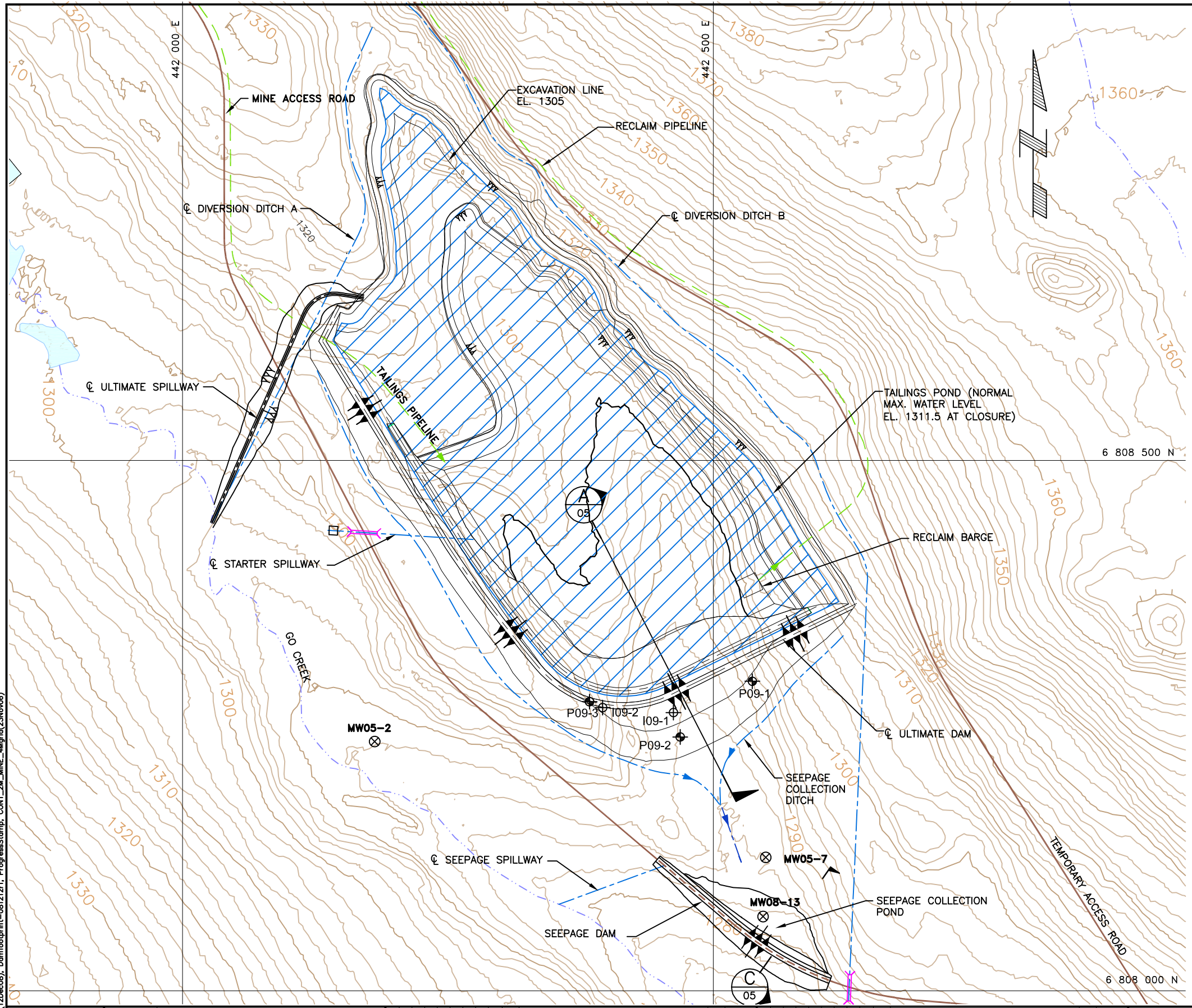
- LEGEND**
- ⊕ TH05-7 TEST HOLE
 - ⊕ TP05-71 TEST PIT
 - ⊕ MW05-7 MONITORING WELL
 - ROADS
 - CREEK
 - PIPELINE
 - - - DIVERSION DITCH

DRAFT
 NOT FOR CONSTRUCTION
 0 200 m

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.		PROJECT NO. _____ DESCRIPTION _____ BY DATE _____		PROJECT NO. _____ DESCRIPTION _____ BY DATE _____		SECTION: _____ SCALE: _____ DATE: _____ DESIGN BY: DK DEC 19/08 DRAWN BY: CYW DEC 19/08 CHECK BY: HM _____ APP BY: HM DEC 19/08		FILENAME: _____ PROJECT NUMBER: M09234A04 DRAWING NUMBER: D-3002 REV: A		 Yukon Zinc CORPORATION WOLVERINE PROJECT TAILINGS STORAGE FACILITY SITE INVESTIGATION PLAN																																																																														
DWG. NO. _____ REFERENCE DRAWINGS _____	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;">PROJECT</th> <th style="width: 5%;">PROCESS</th> <th style="width: 5%;">CIVIL</th> <th style="width: 5%;">MECH.</th> <th style="width: 5%;">STRUCT.</th> <th style="width: 5%;">PIPING</th> <th style="width: 5%;">SERVICES</th> <th style="width: 5%;">ELECT.</th> <th style="width: 5%;">INSTR.</th> <th style="width: 5%;">NO</th> <th style="width: 20%;">DESCRIPTION</th> <th style="width: 5%;">BY</th> <th style="width: 5%;">DATE</th> </tr> </thead> <tbody> <tr> <td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td> </tr> </tbody> </table>				PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE														<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;">PROJECT</th> <th style="width: 5%;">PROCESS</th> <th style="width: 5%;">CIVIL</th> <th style="width: 5%;">MECH.</th> <th style="width: 5%;">STRUCT.</th> <th style="width: 5%;">PIPING</th> <th style="width: 5%;">SERVICES</th> <th style="width: 5%;">ELECT.</th> <th style="width: 5%;">INSTR.</th> <th style="width: 5%;">NO</th> <th style="width: 20%;">DESCRIPTION</th> <th style="width: 5%;">BY</th> <th style="width: 5%;">DATE</th> </tr> </thead> <tbody> <tr> <td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td> </tr> </tbody> </table>				PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE														<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;">PROJECT</th> <th style="width: 5%;">PROCESS</th> <th style="width: 5%;">CIVIL</th> <th style="width: 5%;">MECH.</th> <th style="width: 5%;">STRUCT.</th> <th style="width: 5%;">PIPING</th> <th style="width: 5%;">SERVICES</th> <th style="width: 5%;">ELECT.</th> <th style="width: 5%;">INSTR.</th> <th style="width: 5%;">NO</th> <th style="width: 20%;">DESCRIPTION</th> <th style="width: 5%;">BY</th> <th style="width: 5%;">DATE</th> </tr> </thead> <tbody> <tr> <td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td> </tr> </tbody> </table>		PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE													
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TAILINGS IMPOUNDMENT STORAGE VERSUS DAM CREST ELEVATION

- LEGEND**
- ROADS
 - - - CREEK
 - - - PIPELINE
 - - - DIVERSION OR COLLECTION DITCH, SPILLWAY
 - CULVERT
 - ⊕ P09-1 PROPOSED DAM FOUNDATION PIEZOMETER
 - ⊕ I09-1 PROPOSED DAM FOUNDATION INCLINOMETER
 - ⊗ MW05-7 GROUNDWATER MONITORING WELL

- NOTES**
- SURFACE AREA SHOWN IN PLAN REFLECTS BORROW EXCAVATION WITHIN TAILINGS IMPOUNDMENT.
 - IMPOUNDMENT VOLUME SHOWN IS STORAGE CAPACITY TO THE DAM CREST. FREEBOARD ALLOWANCE IS TO BE DEDUCTED WHEN DETERMINING THE AVAILABLE STORAGE CAPACITY.

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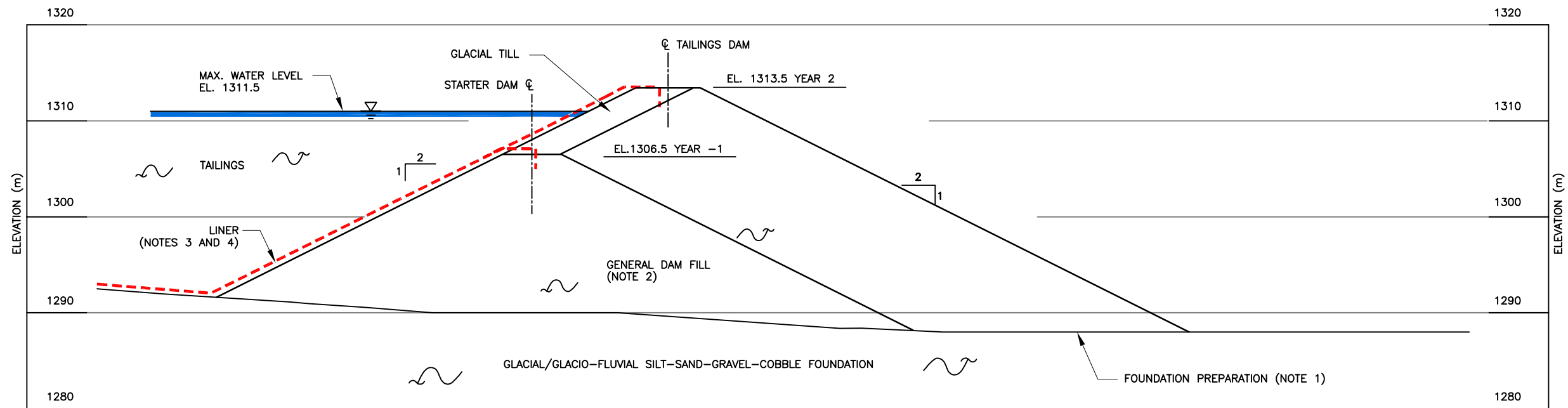
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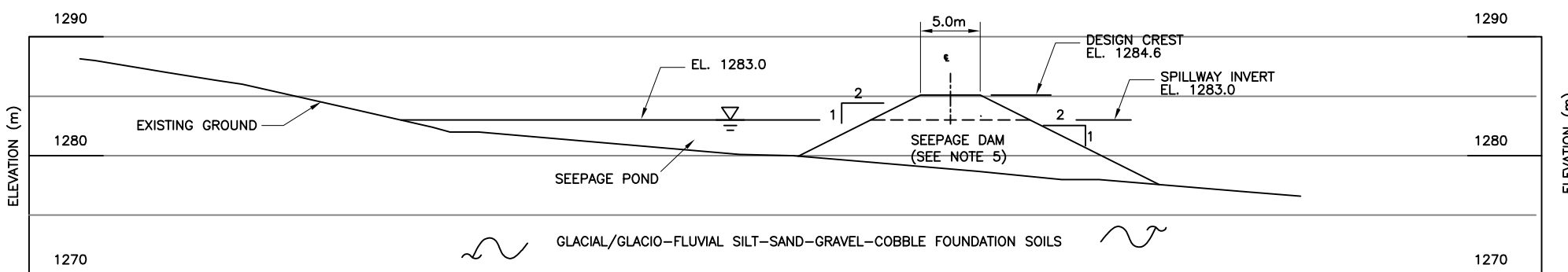
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WOLVERINE PROJECT
TAILINGS STORAGE FACILITY
TAILINGS IMPOUNDMENT - PLAN AND STORAGE VOLUME

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SECTION **A** TAILINGS DAM
SCALE A **04**



SECTION **C** SEEPAGE DAM
SCALE A **04**

NOTES:

1. ALL LOOSE AND ORGANIC MATERIALS SHALL BE REMOVED, AND THE FOUNDATION SHALL BE PROOFROLLED WITH 6 PASSES WITH A 10 TON VIBRATORY ROLLER, AS DIRECTED BY THE ENGINEER. ALL FOUNDATION AREAS SHALL BE DRY AND APPROVED BY THE ENGINEER PRIOR TO PLACEMENT OF GENERAL FILL OR LINER.
2. GENERAL FILL TO CONSIST OF WELL-GRADED SILTY SAND AND GRAVEL BORROWED FROM IMPOUNDMENT EXCAVATION. FINER GENERAL FILL SHALL BE PLACED TOWARDS THE UPSTREAM SLOPE AS WELL AS ADJACENT TO THE GLACIAL TILL ZONE AND COARSER MATERIAL SHALL BE PLACED TOWARDS THE DOWNSTREAM SLOPE. MATERIAL SHALL BE PLACED IN 300 mm THICK LOOSE LIFTS, WATERED AS REQUIRED, AND COMPACTED TO 95% OF STANDARD PROCTOR DENSITY.

GLACIAL TILL TO BE COMPRISED OF LOW PERMEABILITY FILL WITH A FINES CONTENT > 20% PASSING THE 74 MICRON SIEVE SIZE.
3. LINER FOUNDATION AREAS AND SLOPES SHALL BE PROOFROLLED WITH A SMOOTH DRUM COMPACTOR. ALL AREAS WITH COARSE ANGULAR MATERIALS SHALL BE COVERED WITH 150mm THICKNESS OF SCREENED SAND/GRAVEL, AS DIRECTED BY THE ENGINEER.
4. LINER SHALL CONSIST OF A 40 mil ENVIRO-GEOSYNTHETIC LINER OR EQUIVALENT, AS APPROVED BY THE ENGINEER. LINER SHALL BE ANCHORED IN THE DAM CREST IN A 0.6m DEEP TRENCH, BACKFILLED WITH COMPACTED FILL. QA/QC PROGRAM FOR THE LINER TO BE APPROVED BY THE ENGINEER.
5. SEEPAGE DAM WILL BE CONSTRUCTED IN THE SAME MANNER AS THE TAILINGS DAM. THE DAM WILL ALSO BE PART OF THE MINE ACCESS ROAD. THE SEEPAGE DAM SPILLWAY WILL CONSIST OF A 850mm DIAMETER CSP CULVERT TO GO CREEK.

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 SCALE A 0 25 m

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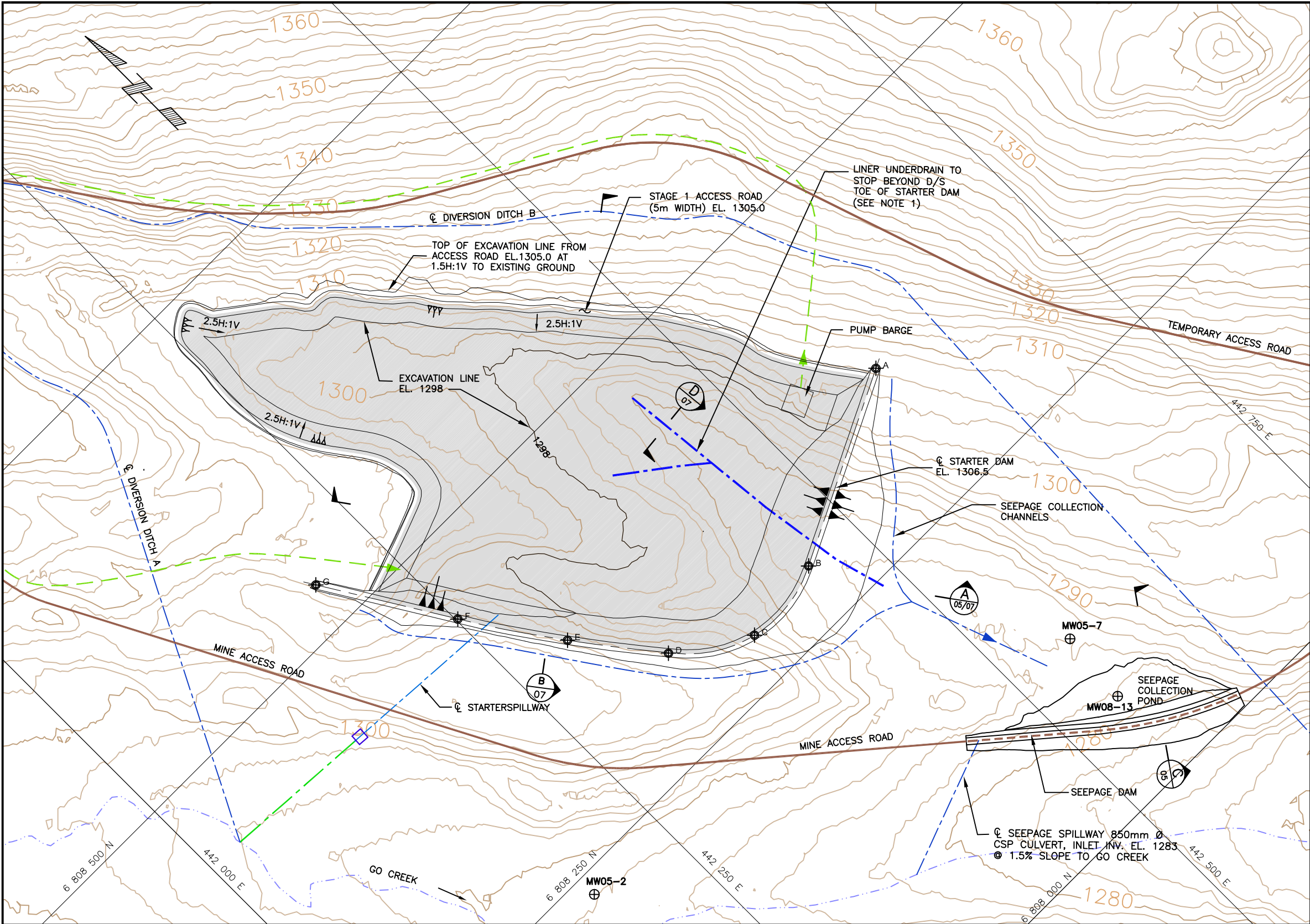
Yukon Zinc
CORPORATION

WOLVERINE PROJECT

TAILINGS STORAGE FACILITY
TAILINGS DAM AND SEEPAGE DAM
DAM SECTIONS



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G	6808533.25	442196.73

LEGEND

- ROADS
- CREEK
- DIVERSION OR COLLECTION DITCH, SPILLWAY
- LINER UNDERDRAIN
- OVERLAND FLOW
- LINER AREA
- MW05-7**
⊕ GROUNDWATER MONITORING WELL
- ⊕ A SURVEY STATION COORDINATES LISTED ABOVE

NOTES

1. LOCATION AND EXTENT OF LINER UNDERDRAIN WILL BE DETERMINED IN THE FIELD BY SITE ENGINEER, FOLLOWING THE LOWEST EXISTING DRAINAGE COURSE. THE UNDERDRAIN SHALL EXIT INTO A SOLID PIPE UNDER THE DAM AND INTO AN OPEN DITCH BEYOND THE DAM TOE.

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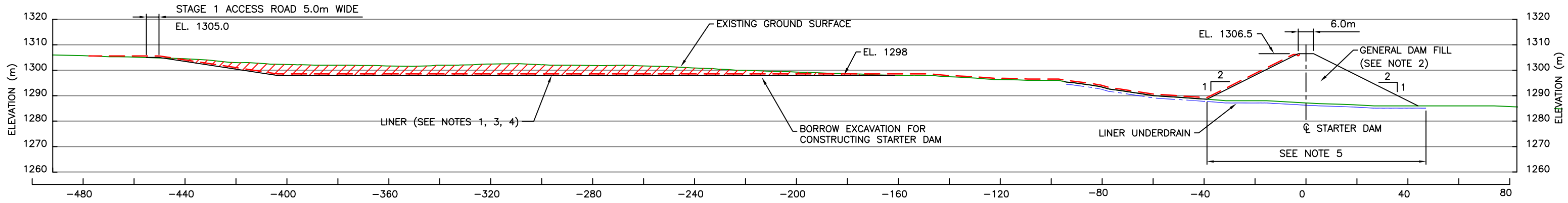
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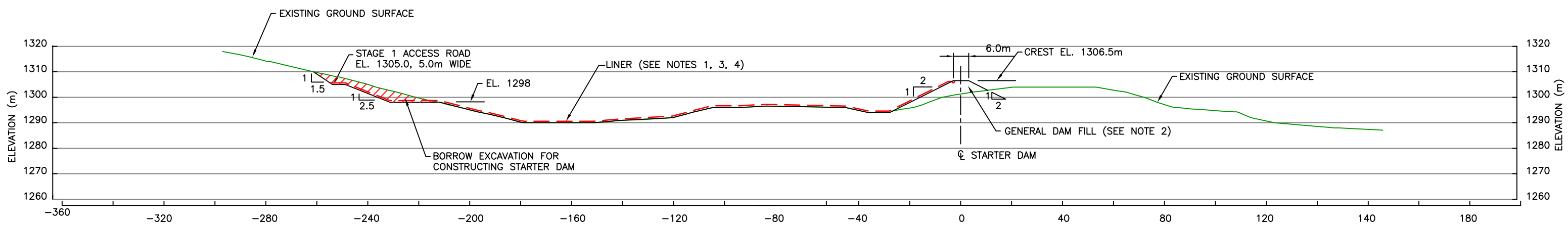
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Yukon Zinc Corporation
WOLVERINE PROJECT
TAILINGS STORAGE FACILITY
STARTER IMPOUNDMENT
EXCAVATION AND FILL PLAN



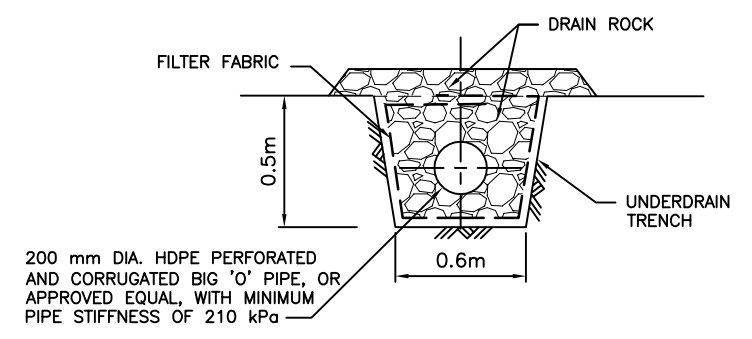
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SCALE A
06
VERTICAL SCALE = HORIZONTAL SCALE



SECTION B (AT RIDGE TOP)
SCALE A
06
VERTICAL SCALE = HORIZONTAL SCALE

NOTES:

1. ALL LOOSE AND ORGANIC MATERIALS SHALL BE REMOVED, AND THE FOUNDATION SHALL BE PROFFROLLED WITH 6 PASSES WITH A 10 TON VIBRATORY ROLLER, AS DIRECTED BY THE ENGINEER. ALL FOUNDATION AREAS SHALL BE DRY AND APPROVED BY THE ENGINEER PRIOR TO PLACEMENT OF GENERAL FILL OR LINER.
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3. LINER FOUNDATION AREAS AND SLOPES SHALL BE PROFFROLLED WITH A SMOOTH DRUM COMPACTOR. ALL AREAS WITH COARSE ANGULAR MATERIALS SHALL BE COVERED WITH 150mm THICKNESS OF SCREENED SAND/GRAVEL, AS DIRECTED BY THE ENGINEER.
4. LINER SHALL CONSIST OF A 40mil ENVIRO-GEOSYNTHETIC LINER OR EQUIVALENT, AS APPROVED BY THE ENGINEER. LINER SHALL BE ANCHORED IN THE DAM CREST AND STAGE 1 ROAD IN A 0.6m DEEP TRENCH, BACKFILLED WITH COMPACTED FILL.
5. SOLID (NOT PERFORATED) UNDERDRAIN PIPE AND APPROVED IMPERVIOUS TRENCH BACKFILL SHALL BE USED BELOW THE DAM EMBANKMENT.



TYPICAL SECTION D LINER UNDERDRAIN
NTS
06

DRAFT NOT FOR CONSTRUCTION



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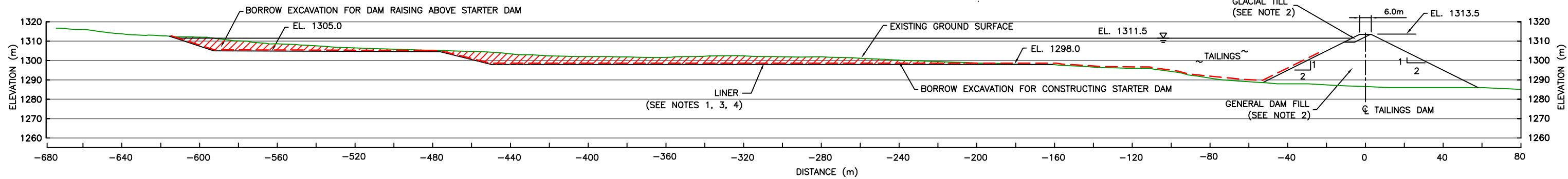
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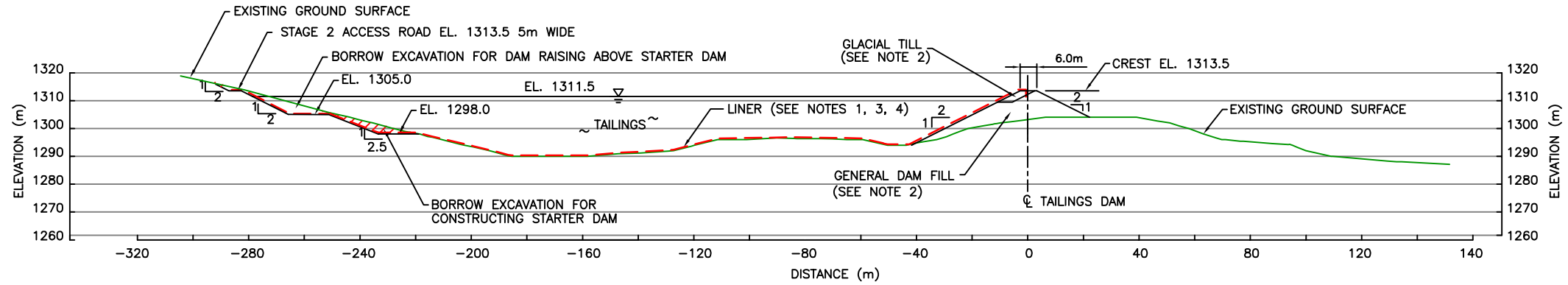
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Yukon Zinc Corporation
WOLVERINE PROJECT
TAILINGS STORAGE FACILITY
STARTER IMPOUNDMENT
EXCAVATION AND FILL TYPICAL SECTIONS



SECTION A (AT MAX VALLEY)
SCALE A
08
VERTICAL SCALE = HORIZONTAL SCALE



SECTION B (AT RIDGE TOP)
SCALE A
08
VERTICAL SCALE = HORIZONTAL SCALE

NOTES:

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DRAFT

NOT FOR CONSTRUCTION



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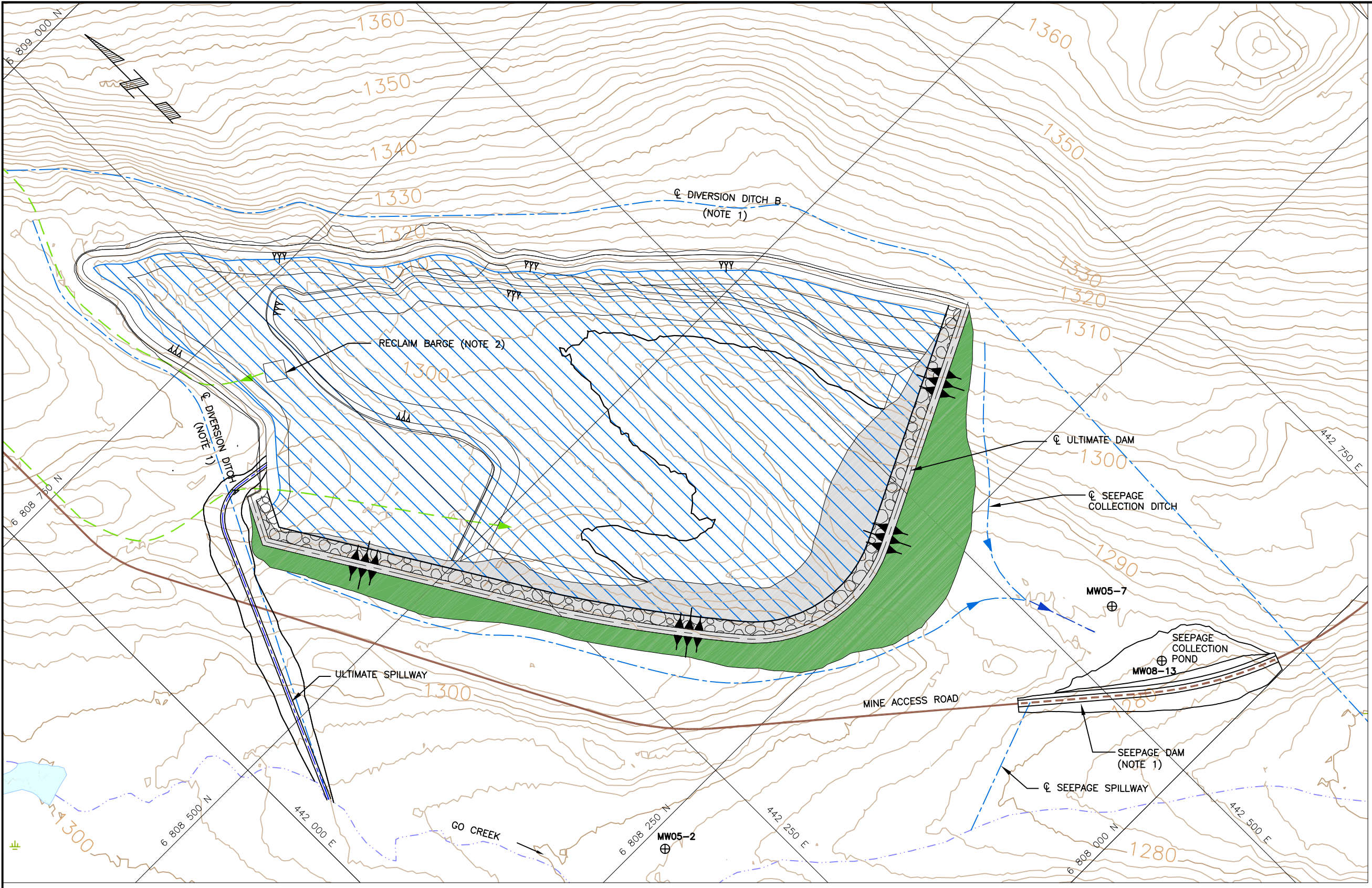
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Yukon Zinc Corporation
WOLVERINE PROJECT
TAILINGS STORAGE FACILITY
ULTIMATE IMPOUNDMENT EXCAVATION AND FILL - TYPICAL SECTIONS



NOTES

1. SEEPAGE DAM AND DIVERSION DITCHES TO BE DECOMMISSIONED AFTER WATER QUALITY OF POND DISCHARGE IS ACCEPTABLE.
2. RECLAIM SYSTEM TO BE USED UNTIL WATER QUALITY IS SUITABLE FOR DISCHARGE. THEN IT WILL BE DECOMMISSIONED.

LEGEND

- ROADS
- CREEK
- DIVERSION DITCH, SPILLWAY
- MW05-7
⊕ EXISTING GROUNDWATER MONITORING WELL
- MW08-2
⊕ ADDITIONAL GROUNDWATER MONITORING WELL
- PIPELINE
- RE-VEGETATION
- ROCKFILL (10m WIDTH)

DRAFT NOT FOR CONSTRUCTION

SCALE A 0 100 m

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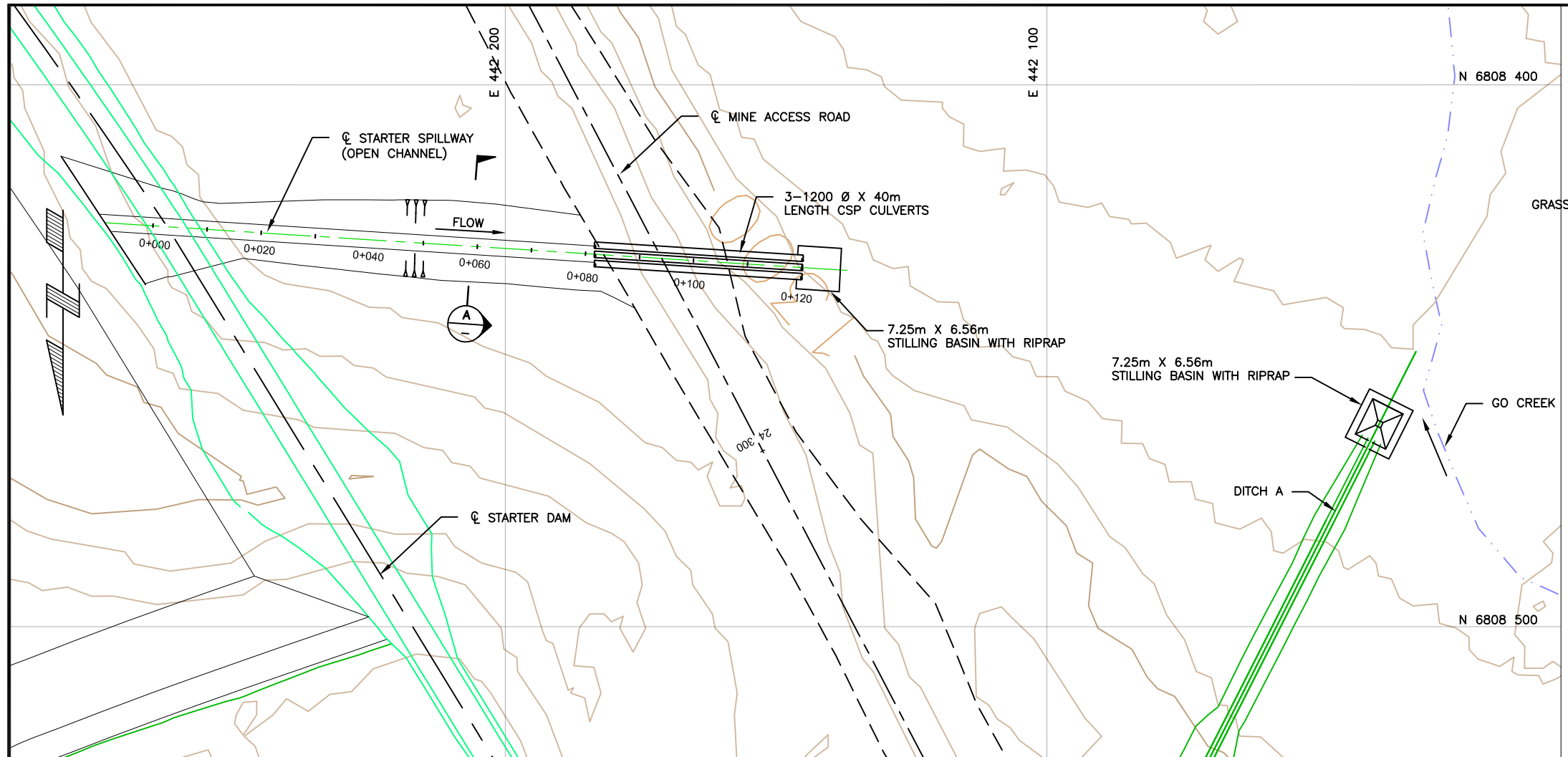
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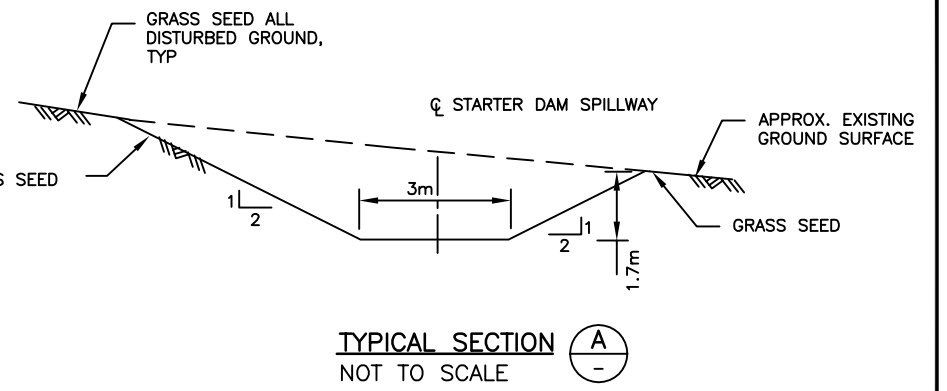


Yukon Zinc Corporation
 WOLVERINE PROJECT
 TAILINGS STORAGE FACILITY
 ULTIMATE IMPOUNDMENT
 CLOSURE PLAN

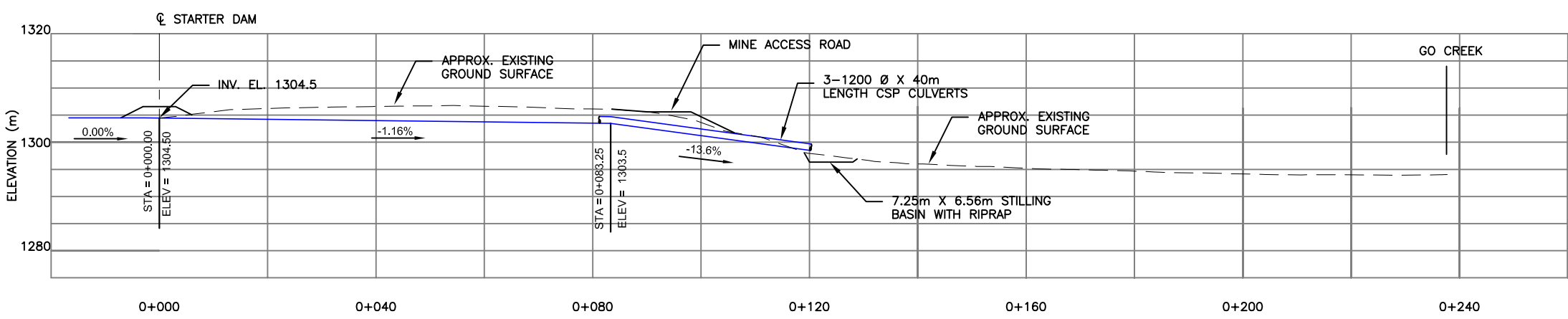
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PLAN
SCALE A



TYPICAL SECTION A-A
NOT TO SCALE



PROFILE - STARTER SPILLWAY
SCALE A

NOTES

1. FOR GENERAL SITE ARRANGEMENT, SEE DWG. D-3001.
2. INVERT ELEVATIONS SHOWN ARE TO FINISHED CHANNEL BOTTOM.
3. FOR RIPRAP AND GRANULAR FILTER GRADATION AND LAYER THICKNESS, SEE TECHNICAL SPECIFICATIONS.

DRAFT NOT FOR CONSTRUCTION



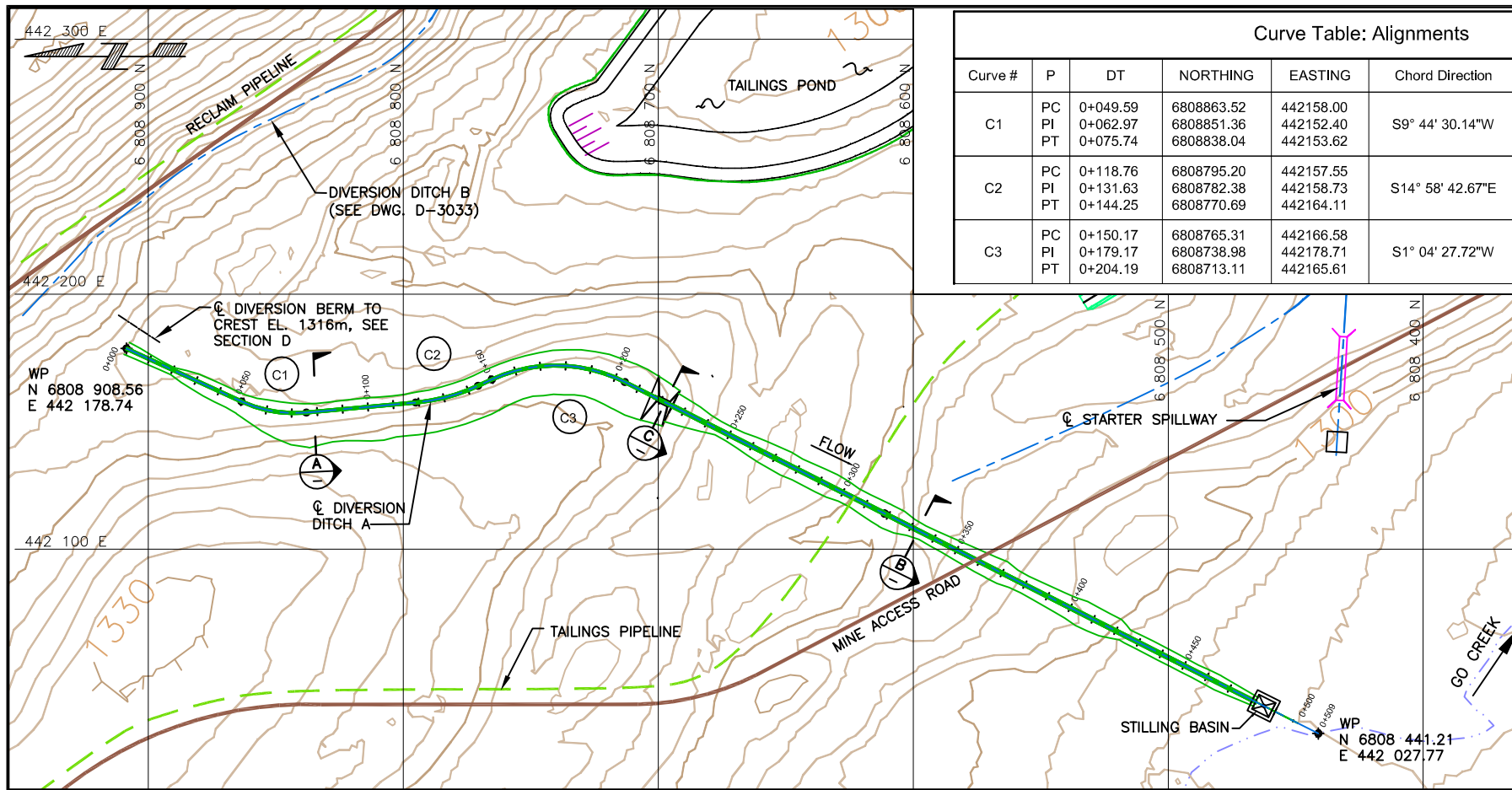
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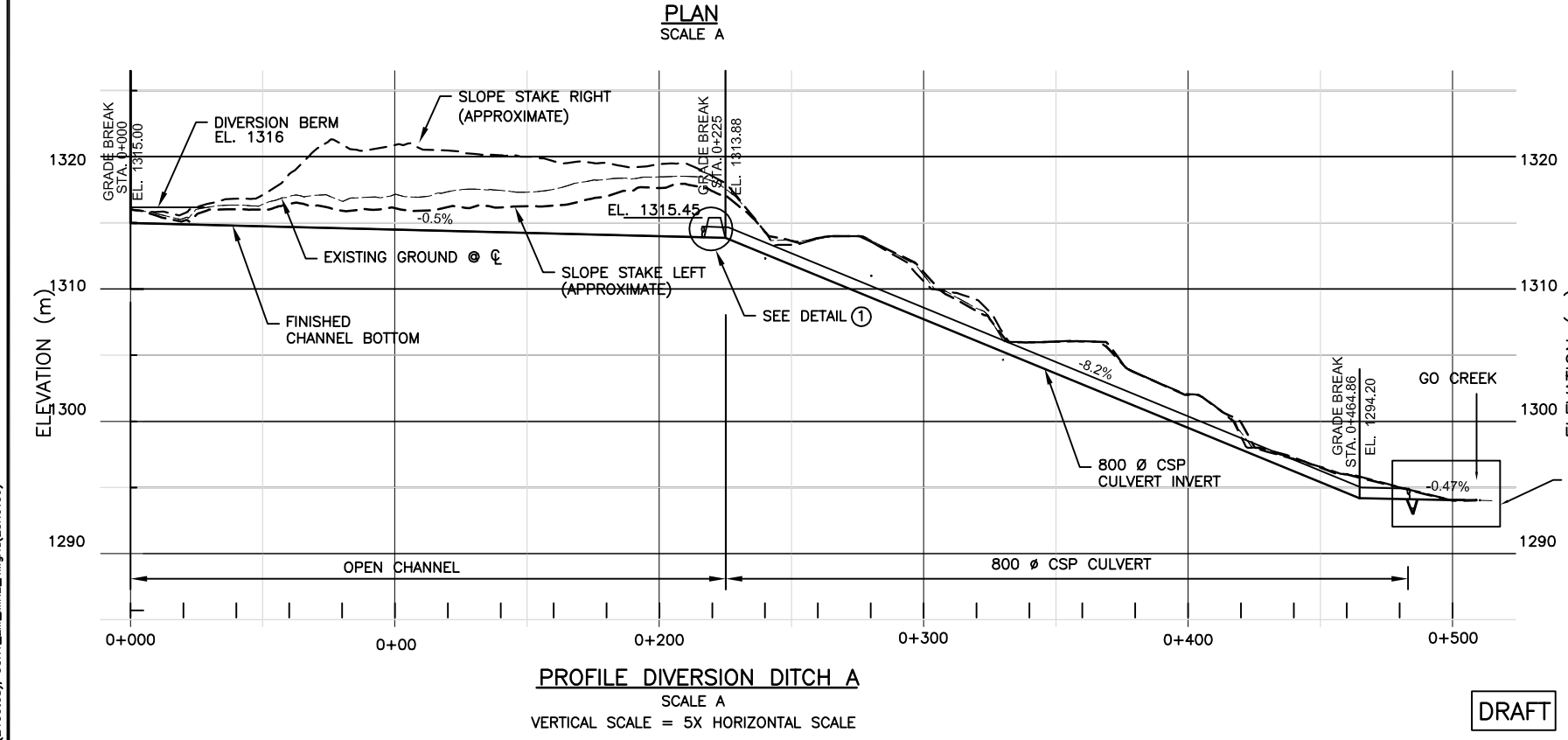
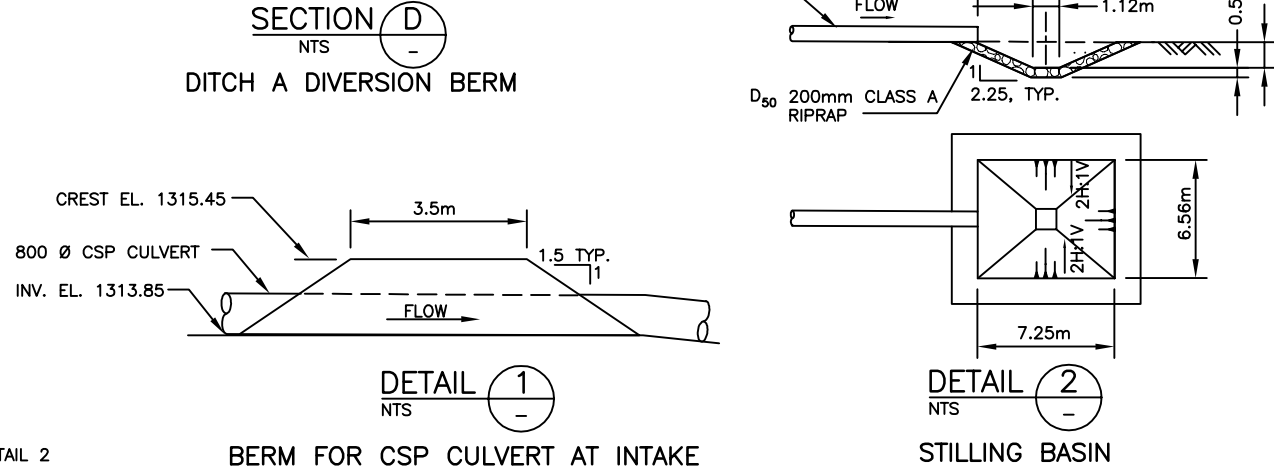
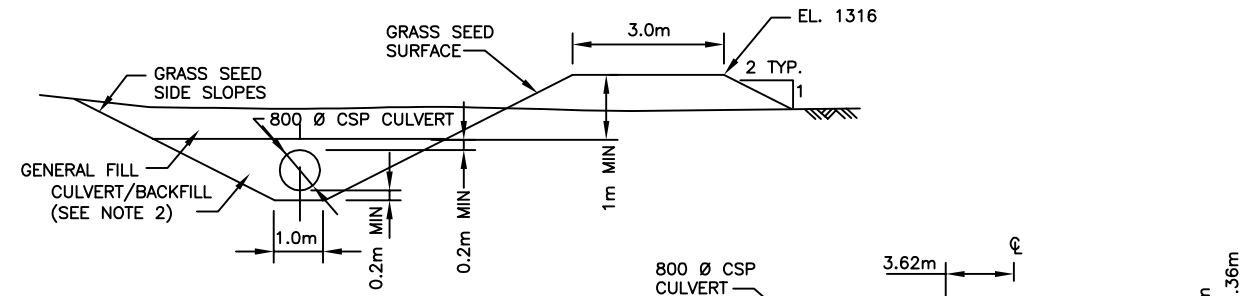
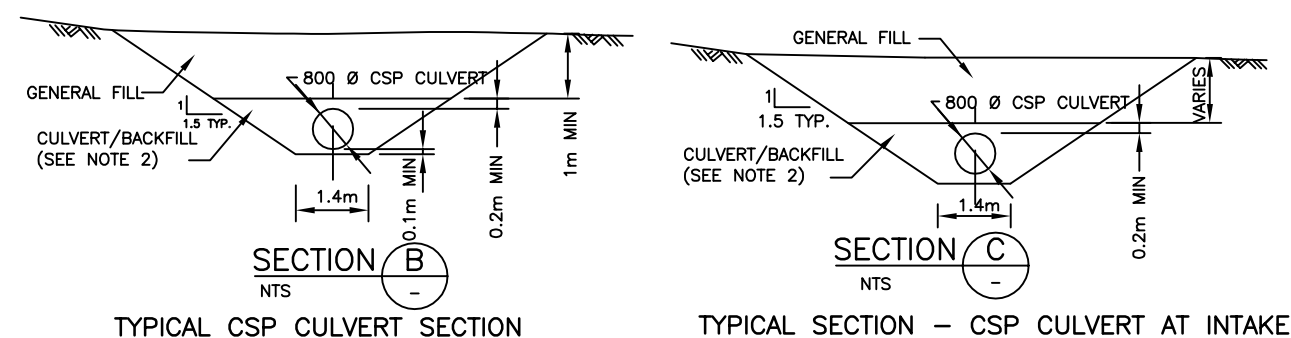
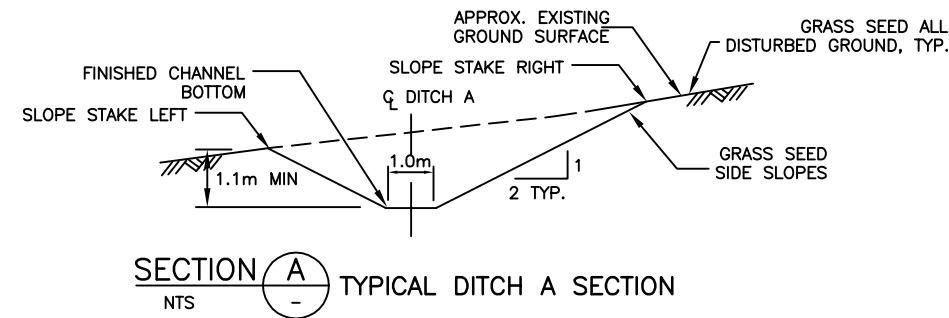
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Yukon Zinc Corporation
WOLVERINE PROJECT
TAILINGS STORAGE FACILITY
STARTER SPILLWAY
PLAN, PROFILE AND SECTION

Klohn Crippen Berger



Curve Table: Alignments								
Curve #	P	DT	NORTHING	EASTING	Chord Direction	Radius	Length	lc
C1	PC	0+049.59	6808863.52	442158.00	S9° 44' 30.14"W	50.00	26.15	150° 01' 52"
	PI	0+062.97	6808851.36	442152.40				
	PT	0+075.74	6808838.04	442153.62				
C2	PC	0+118.76	6808795.20	442157.55	S14° 58' 42.67"E	75.00	25.49	160° 31' 43"
	PI	0+131.63	6808782.38	442158.73				
	PT	0+144.25	6808770.69	442164.11				
C3	PC	0+150.17	6808765.31	442166.58	S1° 04' 27.72"W	60.00	54.01	128° 25' 22"
	PI	0+179.17	6808738.98	442178.71				
	PT	0+204.19	6808713.11	442165.61				

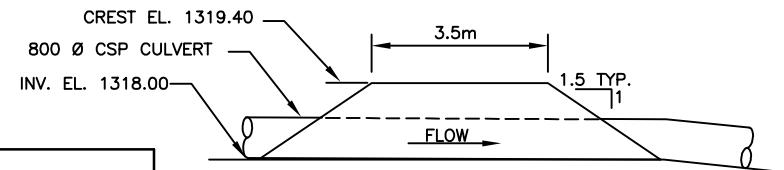
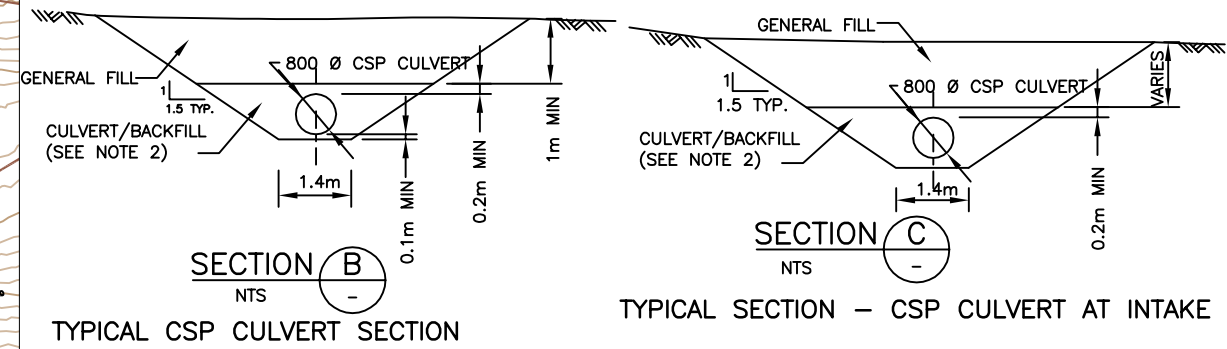
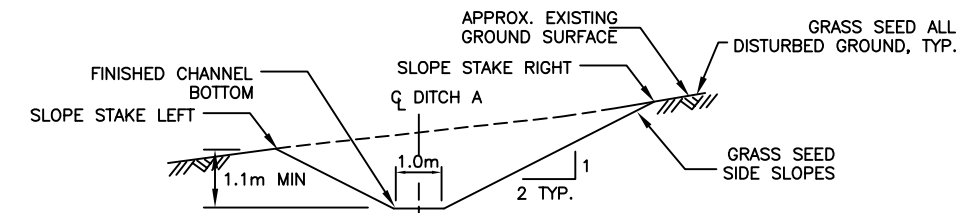
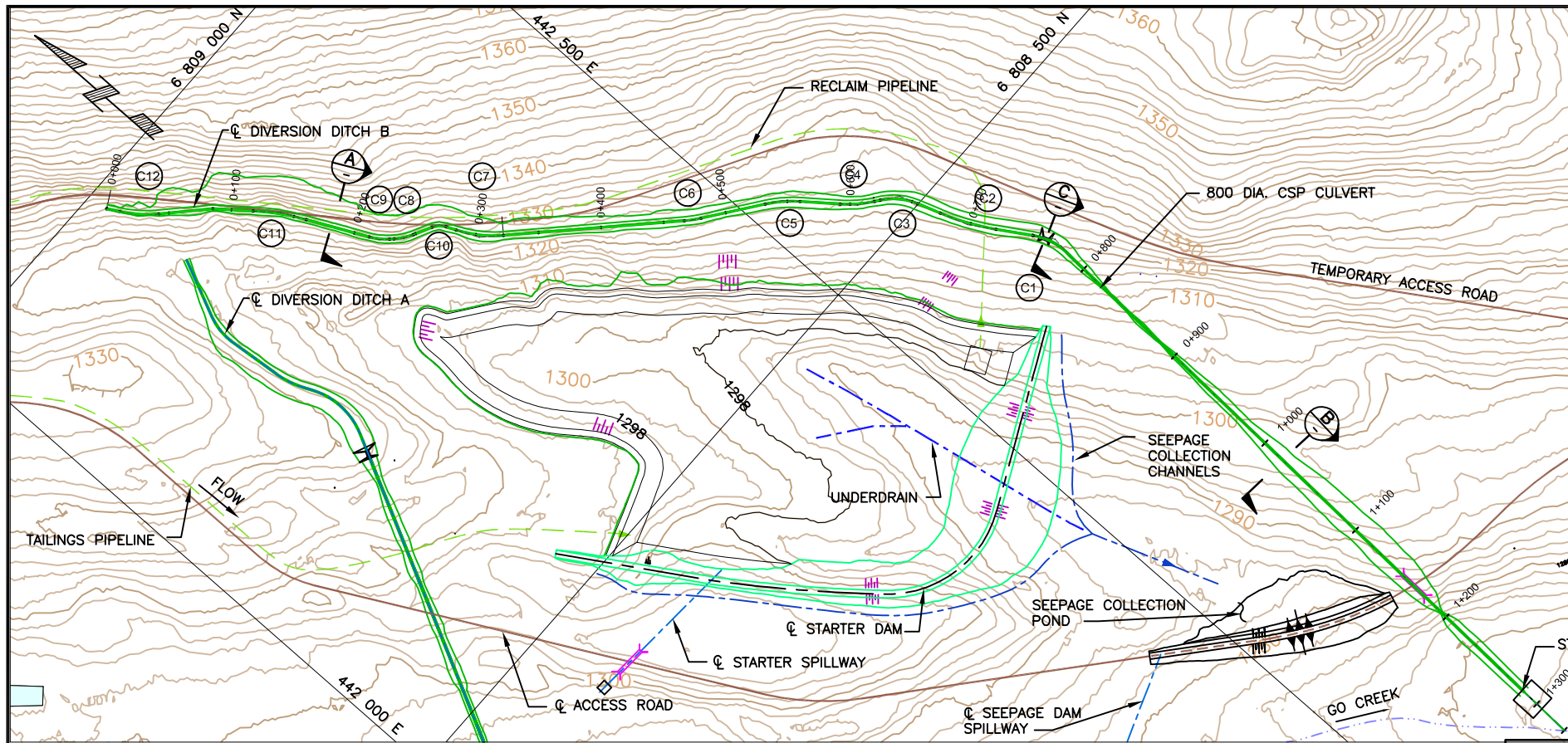


- NOTES**
- FOR GENERAL SITE ARRANGEMENT SEE DWG. D-3001.
 - INVERT ELEVATIONS SHOWN ARE TO FINISHED CHANNEL BOTTOM.
 - CULVERT BEDDING/BACKFILL SHALL BE WELL GRADED 100 mm MINUS MATERIAL WITH LESS THAN 20% PASSING THE #200 SIEVE.

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SCALE A 100 m

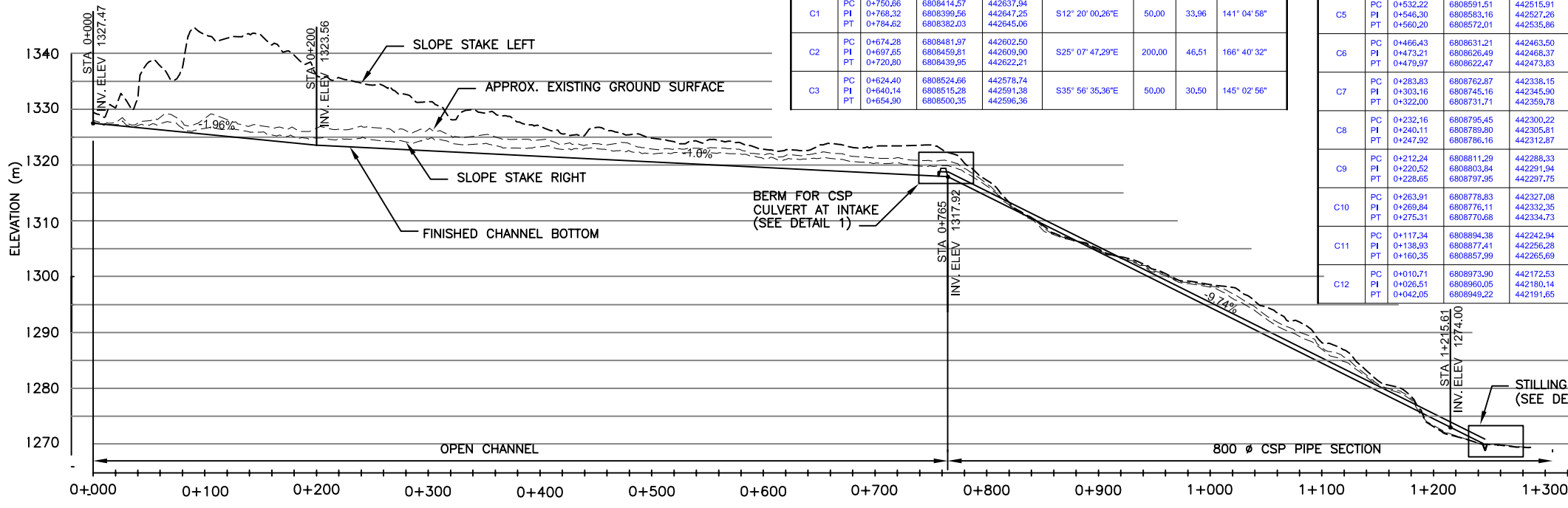
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.		PROJECT: PROCESS: CIVIL: MECH: STRUCT: PIPING: SERVICES: ELECT: INSTR:		NO: DESCRIPTION: ISSUE/REVISIONS:		BY: DATE:		PROJECT: PROCESS: CIVIL: MECH: STRUCT: PIPING: SERVICES: ELECT: INSTR:		NO: DESCRIPTION: ISSUE/REVISIONS:		BY: DATE:		SECTION: SCALE: DATE: DESIGN. BY: MD DEC 19/08 DRAWN BY: CYW DEC 19/08 CHECK. BY: HM APP. BY: HM DEC 19/08		FILENAME: PROJECT NUMBER: M09234A04 DRAWING NUMBER: D-3032 REV: A		 WOLVERINE PROJECT		 TAILINGS STORAGE FACILITY		DIVERSION DITCH A		PLAN AND PROFILE AND SECTIONS	
DWG. NO.		REFERENCE DRAWINGS		PROJECT		NO		PROJECT		NO		SECTION		FILENAME		CORPORATION		PROJECT		FACILITY		SECTION			



PLAN SCALE A

Curve #	P	DT	NORTHING	EASTING	Chord Direction	Radius	Length	lc
C1	PC	+0750.66	6808414.57	442637.34	S12° 20' 00.26"E	50.00	33.96	141° 04' 58"
	PI	+0768.32	6808399.56	442647.25				
	PT	+0784.62	6808382.03	442645.06				
C2	PC	+0674.28	6808481.97	442602.50	S25° 07' 47.29"E	200.00	46.51	166° 40' 32"
	PI	+0697.65	6808459.81	442609.90				
	PT	+0720.80	6808439.95	442622.21				
C3	PC	+0624.40	6808524.66	442578.74	S35° 56' 35.36"E	50.00	30.50	145° 02' 56"
	PI	+0640.14	6808515.28	442591.38				
	PT	+0654.90	6808500.35	442596.36				

Curve #	P	DT	NORTHING	EASTING	Chord Direction	Radius	Length	lc
C4	PC	+0592.14	6808546.71	442555.36	S45° 31' 23.19"E	100.00	27.56	164° 12' 31"
	PI	+0606.01	6808535.73	442563.82				
	PT	+0619.70	6808527.46	442574.96				
C5	PC	+0532.22	6808591.51	442515.91	S45° 38' 36.55"E	100.00	27.98	163° 58' 05"
	PI	+0546.30	6808583.16	442527.26				
	PT	+0560.20	6808572.01	442535.86				
C6	PC	+0466.43	6808631.21	442463.50	S49° 46' 50.48"E	100.00	13.54	172° 14' 32"
	PI	+0473.21	6808626.49	442468.37				
	PT	+0479.97	6808622.47	442473.83				
C7	PC	+0283.83	6808762.67	442338.15	S34° 46' 17.96"E	98.25	38.17	157° 44' 23"
	PI	+0303.16	6808745.16	442345.90				
	PT	+0322.00	6808731.71	442359.78				
C8	PC	+0232.16	6808795.45	442300.22	S53° 40' 58.72"E	50.00	15.76	161° 56' 33"
	PI	+0240.11	6808789.80	442305.81				
	PT	+0247.92	6808786.16	442312.87				
C9	PC	+0212.24	6808811.29	442288.33	S35° 15' 18.59"E	50.00	16.40	161° 12' 07"
	PI	+0220.52	6808803.84	442291.94				
	PT	+0228.65	6808797.95	442297.75				
C10	PC	+0263.91	6808778.83	442327.08	S43° 10' 35.69"E	16.71	11.39	140° 55' 47"
	PI	+0269.84	6808776.11	442332.35				
	PT	+0275.31	6808770.68	442334.73				
C11	PC	+0117.34	6808894.38	442242.94	S32° 00' 57.85"E	200.00	43.00	167° 40' 48"
	PI	+0138.83	6808877.41	442256.28				
	PT	+0160.35	6808857.99	442265.69				
C12	PC	+010.71	6808973.90	442172.53	S37° 45' 55.04"E	100.00	31.35	162° 02' 24"
	PI	+026.51	6808960.05	442180.14				
	PT	+042.85	6808949.22	442191.65				



PROFILE DIVERSION DITCH B SCALE A VERTICAL SCALE = 5X HORIZONTAL SCALE

NOTES

- FOR GENERAL SITE ARRANGEMENT SEE DWG. D-3001.
- INVERT ELEVATIONS SHOWN ARE TO FINISHED CHANNEL BOTTOM.
- CULVERT BEDDING/BACKFILL SHALL BE WELL GRADED 100 mm MINUS MATERIAL WITH LESS THAN 20% PASSING THE #200 SIEVE.

DETAIL 2: STILLING BASIN

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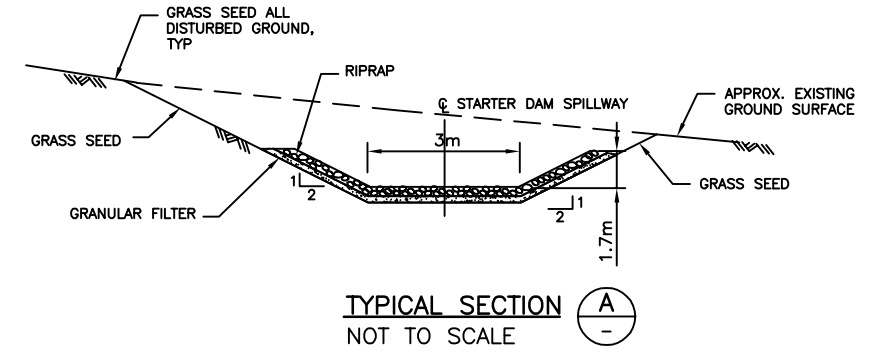
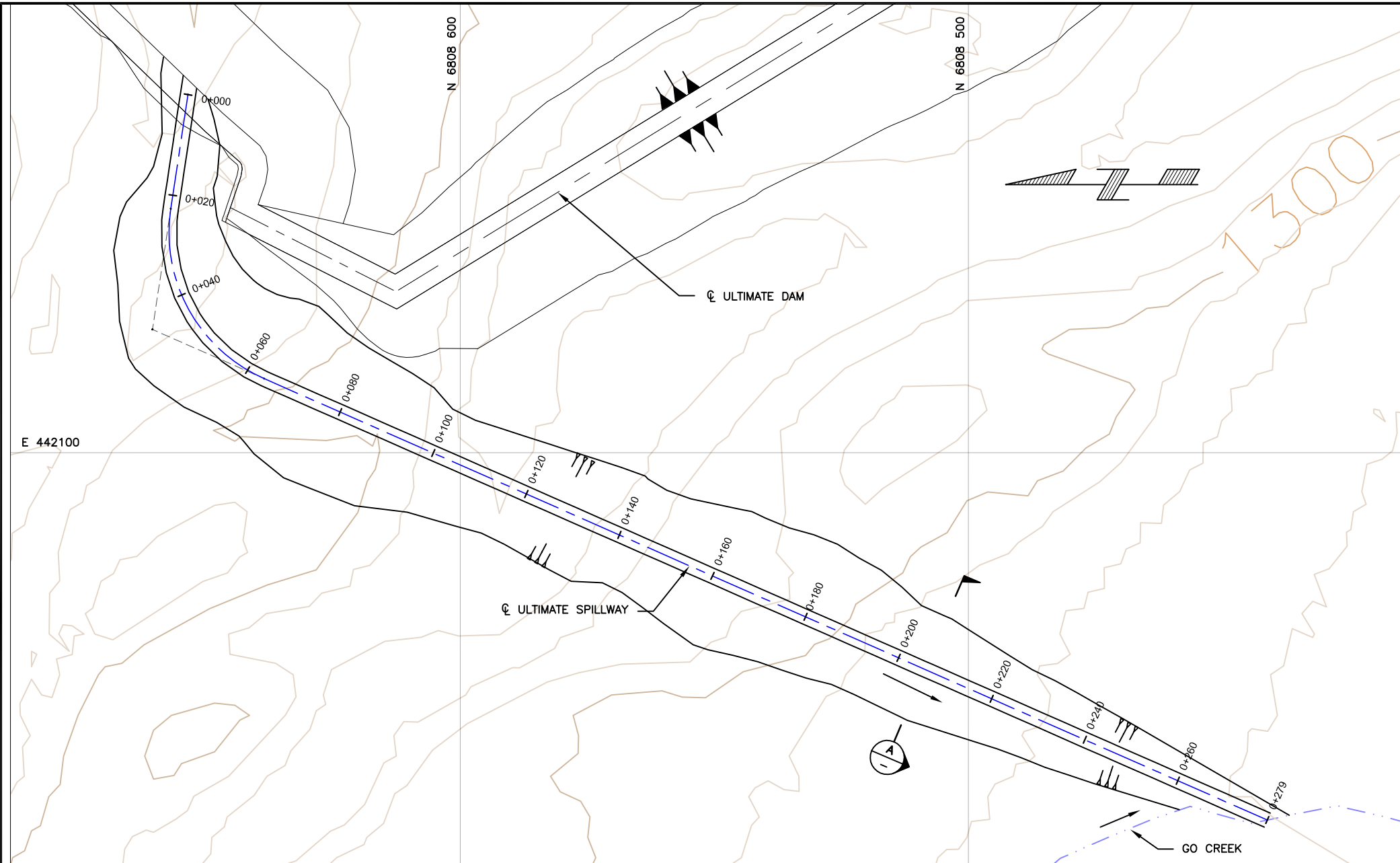


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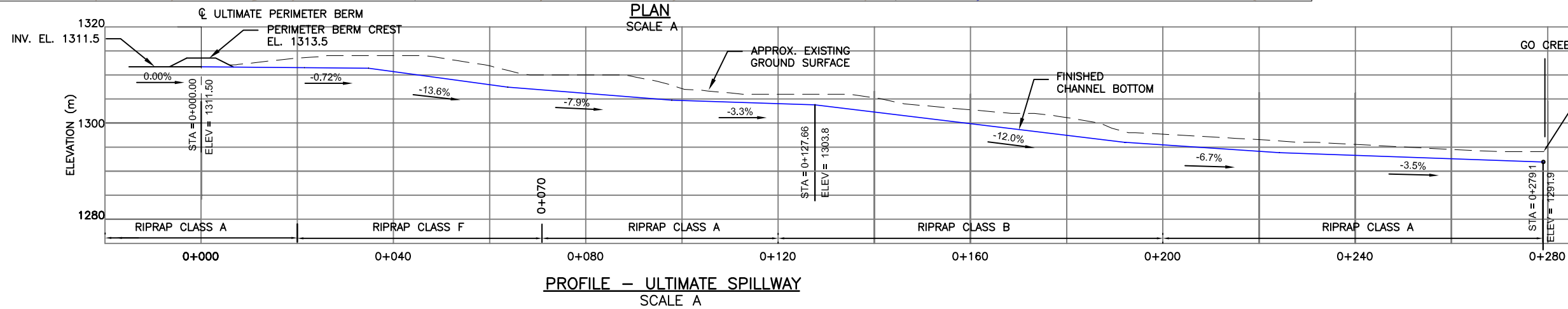
Gradation and Layer Thickness

Material	Particle Size (mm)				Layer Thickness (mm)	
	D ₁₀₀	D ₈₅	D ₅₀	D ₁₅	Riprap	Filter
Riprap A	300	260	200	120	400	200 Filter 1
Riprap B	450	390	300	180	600	200 Filter 1
Riprap C	525	455	350	210	700	300 Filter 1
Riprap D	675	585	450	270	900	300 Filter 1
Riprap E	1200	1040	800	480	1600	300 Filter 1 + 400 Filter 2
Riprap F	1500	1300	1,000	600	2000	400 Filter 1 + 400 Filter 2
Filter 1	75	60 to 70	35 to 50	23 to 28	-	-
Filter 2	300	260	200	120	-	-

- Riprap gradation shall be within -5% to +10% of the specified D₁₅, D₅₀, and D₈₅ sizes.
- Filter 1 shall be well graded between the 75 mm and 19 mm screen sizes.
- Filter 2 shall be the same gradation as Riprap A.
- Filter 1 grading is based on the subsoil being a silty sand and gravel.

NOTES

- FOR GENERAL SITE ARRANGEMENT, SEE DWG. D-3001.
- INVERT ELEVATIONS SHOWN ARE TO FINISHED CHANNEL BOTTOM.
- FOR RIPRAP AND GRANULAR FILTER GRADATION AND LAYER THICKNESS, SEE TECHNICAL SPECIFICATIONS.



FIELD FIT CHANNEL BOTTOM TO EXISTING GO CREEK CHANNEL AS DIRECTED BY THE ENGINEER.

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DWG. NO.	REFERENCE DRAWINGS	PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE					
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												NO		DESCRIPTION		BY		DATE	
												NO		ISSUE/REVISIONS		BY		DATE	

SECTION:	FILENAME:	PROJECT NUMBER:	DRAWING NUMBER:	REV.
SCALE:	-----	M09234A04	D-3034	A
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CHECK. BY: HM	DATE:			
DEC 19/08	---			
APP. BY: HM	DATE:			
DEC 19/08	---			

Yukon Zinc Corporation
WOLVERINE PROJECT
TAILINGS STORAGE FACILITY CLOSURE SPILLWAY
PLAN, PROFILE AND SECTION