

## H. WATER QUALITY MODEL

**42. Provide the analysis and results of a predictive water quality model for the project.**

Water quality modeling for Go Creek and groundwater in the flooded mine workings has been conducted. Surface water quality modeling in Go Creek was performed as part of establishing discharge limits that are protective of aquatic life and has been described in Section D (38 i).

Details of the underground water quality model, developed to predict groundwater conditions associated with the Wolverine Mine at the cessation of operations and following the flooding of the underground workings, are presented in the following sections.

The foundation for this predictive model is an Acid Rock Drainage and Metal Leaching (ARD/ML) Assessment, conducted by AMEC Earth & Environmental (AMEC) as part of the Environmental Assessment for YZC's Wolverine Project. AMEC has summarized all analytical findings to date on the static and kinetic geochemical testing of mine rock types and developed a prediction of groundwater quality in the flooded workings expected following closure of the mine. The full report is contained in Appendix D and a summary is provided below.

### **Overview of Project Geology**

As discussed in Section C: Geology and Geochemistry, the Wolverine deposit consists of two lenses of massive sulphide mineralization that are sandwiched between phyllite (bottom) and andesite (top). Mining is proposed between the Wolverine and Lynx zone where the thickness of mineralization varies between less than 1 m at the former zone's fringes to over 16 m in the core of the latter zone (Tucker, 1999; Bradshaw, 2003).

Within the Wolverine deposit, six major rock types (99% of total) are distinguished: (1) non-carbonaceous Argillite – 32%; (2) carbonaceous Argillite – 16%; (3) Calcite-Pyrite Exhalite – 5%; (4) Iron Formation and Silica-Pyrite Exhalite – 10%; (5) Interbedded Rhyolite/Argillite – 18%; (6) Rhyolite and Rhyolite Fragmental – 18%.

The massive sulphide mineralization is predominantly composed of pyrite ( $\text{FeS}_2$ ) with major amounts of sphalerite ( $\text{ZnS}$ ), galena ( $\text{PbS}$ ) and chalcopyrite ( $\text{CuFeS}_2$ ). Pyrrhotite ( $\text{Fe}_{1-x}\text{S}$ ), marcasite ( $\text{FeS}_2$ ), arsenopyrite ( $\text{FeAsS}$ ) and sulphosalts (tetrahedrite, meneghinite and boulangrite) occur in minor amounts. Carbonate alteration occurs throughout the Wolverine deposit and involves calcite ( $\text{CaCO}_3$ ), dolomite ( $\text{Ca,Mg}(\text{CO}_3)_2$ ), siderite ( $\text{FeCO}_3$ ) and ankerite ( $\text{Ca}(\text{Fe,Mg})(\text{CO}_3)_2$ ).

### **Underground Water Quality Model Approach**

The water quality prediction model uses the weathering characteristics of the six major rock types, ore materials and paste backfill established in kinetic tests with humidity cells. The weathering characteristics include rates of sulphide oxidation, neutralization potential consumption and metal release. Details of the kinetic tests and the water quality prediction model are discussed below.

#### *Use of ARD/ML Kinetic Test Data*

For each of the six major rock types, two samples were selected for kinetic tests. The selection of the two samples was based on the representation of median characteristics (first sample) and ‘worst case’ characteristics (second sample). Characteristics of interest were neutralization potential (NP) and acid potential (AP) values, NP:AP ratio and metal concentrations. In addition to the samples from the six major rock types, samples of ore (from the Wolverine, Lynx and Pillar or Hump zone), DMS float, NP depleted ore and (simulated) backfill material were used in the humidity cell tests. In total 24 samples were selected for kinetic testing; their characteristics are shown in Table 42.1.

**Table 42.1: Humidity Cell Samples used in Kinetic Tests**

Rock Type	Cell No.	Description	MPA	NP	NP/MPA	Cd	Cu	Pb	Se	Zn	
			kg CaCO <sub>3</sub> /tonne	kg CaCO <sub>3</sub> /tonne	-	ppm	ppm	ppm	ppm	ppm	
1		Argillites (n=6)	Median	34	28	0.80	0.23	69.2	15.9	2.4	132
			90 <sup>th</sup> Percentile	83	92	0.75	0.328	79.2	23.96	4.94	211.2
	HC9	A083503		17	15	0.91	0.15	69.2	16.1	1.2	132
	HC10	A083529		30	22	0.74	0.34	62.5	29.2	2.4	192
2		Carbonaceous argillites (n=10)	Median	39	27	0.69	0.25	58.9	19.7	2.7	107
			90 <sup>th</sup> Percentile	58	38	0.45	2.334	71.46	41.12	5.28	420.6
	HC7	Argillite-2		38	18	0.48	2.55	54.8	19.7	6	855
	HC8	Argillite-4		53	32	0.61	0.35	44.2	34.9	2.7	40
3		Calcite-pyrite exhalite (n=9)	Median	138	345	2.49	0.29	45.45	184.25	3.4	164.5
			90 <sup>th</sup> Percentile	203	524	1.50	19.705	75.91	479	4.42	4221
	HC5	EXCP-2		138	227	1.64	0.73	75.4	256	2.8	239
	HC6	EXCP-3		139	350	2.52	0.09	55.1	139	2.3	31
4		Magnetite iron formations and Silica-pyrite exhalite (n=7)	Median	58	80	1.38	0.125	44.9	6.55	1.5	96
			90 <sup>th</sup> Percentile	97	106	0.47	26.033	69.4	176.4	8.8	1786
	HC11	A083504		56	89	1.59	0.04	70.4	18.8	4.3	106
	HC2	EXMT		100	99	0.99	37.1	29	334	13.3	3390
5		Interbedded rhyolite/argillites (n=5)	Median	28	48	1.69	0.07	68	11.15	2.1	103
			90 <sup>th</sup> Percentile	52	131	0.72	0.192	76.01	40.81	3.77	157.2
	HC12	A083505		28	21	0.74	0.08	67.9	10.4	2.3	159
	HC13	A083511		30	67	2.26	0.24	68.1	11.9	4.4	153
6		Rhyolite and Rhyolite Fragmental (n=16)	Median	21	33	1.72	0.19	62.5	7.5	1.4	66
			90 <sup>th</sup> Percentile	121	68	5.33	2.046	629.6	58.08	42.66	254.2
	HC1	Siliceous Siltstone-2		19	22	1.17	0.32	75.2	8.2	1.9	128
	HC3	Footwall Rhyolite-2		238	7	0.03	1.68	165.5	63.4	40.2	202
	HC4	Footwall Rhyolite-3		113	19	0.17	2.52	939	34	44.3	289
<b>Ore Samples</b>											
	HC14	Wolverine Feed Ore		523	58	0.11	>500	6090	6560	760	>10000
	HC15	Hump Feed Ore		413	113	0.27	308	6430	3760	540	>10000
	HC16	Lynx Feed Ore		900	100	0.11	>500	9670	6480	>1000	>10000
<b>DMS Float Samples</b>											
	HC17	Wolverine Float		28.1	84	3.00	13.8	567.8	140.8	37.2	1248
	HC18	Hump Float		55.3	241	4.36	15.3	158	130.1	26.5	1229
	HC19	Lynx Float		50.6	121	2.39	16.4	754.5	198.5	39.6	1577
<b>Ore Samples - NP Depleted</b>											
	HC20	Wolverine Feed Ore		523	8	0.02	>500	6090	6560	760	>10000
	HC21	Hump Feed Ore		413	20	0.05	308	6430	3760	540	>10000
	HC22	Lynx Feed Ore		900	16	0.02	>500	9670	6480	>1000	>10000
<b>Backfill Samples</b>											
	T1	Paste Backfill A		608	131	0.22	73.2	3130	3030	830	7320
	T2	Paste Backfill B		586	131	0.22	76.3	3370	2990	830	7850

MPA: maximum potential acidity

In kinetic tests, weathering rates are often at their maximum and soluble oxidation products that accumulate on the rock surfaces are collected by weekly rinses with distilled water. The weekly-collected leachates are analyzed and (metal) concentrations (mg/L) are converted to (metal) release rates (mg/m<sup>2</sup>/week) using the estimated surface area of the humidity cell sample. Although weathering and metal leaching are initially high and eventually stabilize at a steady rate, the (weekly) metal release rates are estimated from the entire humidity cell monitoring period (i.e. average values).

## **Underground Water Quality Prediction**

### *General Model Description*

At Wolverine, backfilling of completed mining areas will occur throughout the life of the operation. Paste backfill, using cemented tailings, will be the dominant backfill material with lesser quantities of mined waste rock and DMS float. The mine access ramp and ventilation raises will have their surfaces shotcreted to enhance structural stability.

At mine closure, hydraulic plugs will be installed and the backfilled underground workings will be permitted to flood with groundwater. The chemical composition of the flooded mine water will be the result of chemical mass loadings from three different sources:

1. constituents in groundwater;
2. accumulated weathering products on exposed mine rock surfaces; and
3. accumulated weathering products on exposed cemented backfill surfaces

Groundwater that floods the mine will dissolve the soluble weathering products accumulated on the exposed surfaces of mine rock and backfill. Estimates of the accumulated weathering products on the mine surfaces are based on the humidity cell tests with mine rock, ore and paste backfill as well as DMS float (Table 42-1). Measured release rates from humidity cells with the major six rock types are used for non-ore bearing rock surfaces. For exposures of massive sulphides, release rates measured in humidity cells with NP-depleted ore samples are used.

Mass loadings to the total water volume in the flooded mine are estimated by scaling mass loadings (mg/m<sup>2</sup>/wk) derived from humidity cell tests to the estimated surface area exposed in the flooded mine. The weathering products are assumed to accumulate on the mine surfaces throughout the mine operation without losses due to ongoing leaching. Ultimately the water quality of the mine water is estimated by dissolving the total mass (mg) of accumulated weathering products in the total volume of groundwater (L) that has flooded the mine.

### *Model Conditions*

For the prediction of the chemical composition of the mine water the following data sources and assumptions are used:

- estimated mine volumes and surface areas are based on the mine model prepared by YZC in January 2006 and the revised mine plan developed by Snowden Mining Industry Consultants in January 2007 (Snowden 2007); and

- a correction factor to account for 1) uneven surfaces and 2) fractures, thereby observing an effective surface area (Morin and Hutt, 2004);
  - uneven surfaces utilize 30x the actual surface area for most rock types;
  - fracture contribute a 50x factor, to be used for argillite and massive sulphides
- an assumption of 20% backfill surface exposure will account for gaps, joints and spaces subject to weathering,
- current data suggests it will take ~ 13 years to flood the mine; hence, flooded volume is estimated to be 130,000 m<sup>3</sup>

#### *Model Scenarios*

The chemical composition of the mine water is predicted with two different model scenarios. The first model is an unequilibrated or *mass loading model*, which uses a chemical mass balance. The model observes the total chemical loading (mg) to the flooded mine volume (L) to be equal to the sum of the chemical loadings (mg) from the contributing sources (rock surfaces, backfill and groundwater). Water quality predictions from the mass loading model are strictly conservative as no chemical mass contributed by the various sources is lost.

The second scenario is modeled with MINTEQ to determine an equilibrium in a flooded mine, or a *geochemical equilibrium model*. This scenario modifies the chemical composition obtained with the mass loading model by assuming specific geochemical equilibrium conditions and may result in the removal of chemical mass by geochemical processes (e.g. mineral precipitation). The geochemical equilibrium model assumes the following equilibrium conditions:

- pH is either calculated from a H<sup>+</sup> mass balance (no mineral precipitation scenario) or fixed (other scenarios)
- pO<sub>2</sub>(g) is fixed at 10<sup>-35</sup> atm.
- pCO<sub>2</sub>(g) is in equilibrium with atmospheric CO<sub>2</sub>(g) (this allows for the release of alkalinity as CO<sub>2</sub> (10<sup>-3.5</sup>))
- redox couples are specified for Fe<sup>2+</sup>/Fe<sup>3+</sup>, Sb(OH)<sub>3</sub>/Sb(OH)<sub>3</sub><sup>-</sup>, H<sub>3</sub>AsO<sub>3</sub>/AsO<sub>4</sub><sup>-</sup> and SeO<sub>4</sub><sup>2-</sup>/HSeO<sub>3</sub><sup>-</sup>
- initial alkalinity is set at measured value (163 mg/L as CaCO<sub>3</sub>)
- temperature is fixed at 10° C
- the charge balance was maintained by varying the SO<sub>4</sub> concentration
- secondary minerals that are allowed to precipitate if the solution is supersaturated are (based on positive saturation indices): gypsum, calcite, barite, amorphous Al-hydroxide, otavite, malachite, goethite, ferrihydrite, hydrocerussite, rhodochrosite, K-jarosite, imogolite, hydroxyapatite and hydrozincite

Given the above assumptions for the geochemical equilibrium model, four distinct scenarios have been investigated as possible outcomes of mine water. The four scenarios considered are as follows:

1. no mineral precipitation
2. base case (pH~8)
3. pH 6.0
4. pH 4.0 (acidic drainage)

The base case simulation represents a mine flooded by local groundwater with a pH equivalent to mine groundwater seepage measured in 2005 (Appendix D). Simulations using pH values of 6.0 and 4.0 were completed to model flooding by waters of increasing acidity. The concentrations of beryllium, bismuth, chromium, cobalt, lithium, mercury, strontium, thallium, and vanadium are not included in the modelling simulations.

### Model Results

The water quality predictions for the mine water obtained with the mass loading model and the various geochemical equilibrium models are summarized in Table 42.2. Only key parameters and elements of concern are shown.

**Table 42.2: Underground Mine Water Quality Predictions**

Parameter	Species	Initial Concentration (mg/L)	MINTEQA2 Simulation			
			No Precip (mg/L)	Base Case (mg/L)	pH = 6.0 (mg/L)	pH = 4.0 (mg/L)
Temperature			10°C	10°C	10°C	10°C
Final pH	H <sup>+</sup>		10.24	8.71	6.00	4.00
Final Eh	e <sup>-</sup>		-233 mV	-147 mV	+5.5 mV	+118 mV
Ionic Strength (M)			0.0116	0.0095	0.0136	0.0138
Sulphate	SO <sub>4</sub> <sup>-2</sup>	282	266	266	393	421
Alkalinity	CaCO <sub>3</sub>	157	157	23	157	157
Aluminum	Al <sup>-3</sup>	0.50	0.486	0.006	0.003	0.486
Arsenic	As(V)	0.058	0.055	0.040	5.74E-06	5.15E-08
	As(III)		0.0001	0.0156	0.0554	0.0554
Cadmium	Cd <sup>-2</sup>	0.237	0.225	0.055	0.225	0.225
Calcium	Ca <sup>-2</sup>	137	136.6	85.2	136.6	136.6
Copper	Cu <sup>-2</sup>	0.035	0.064	0.007	0.064	0.064
Iron	Fe(II)	0.136	0.4535	9.64E-05	4.75E-01	4.75E-01
	Fe(III)		0.021	1.46E-09	9.99E-09	3.08E-10
Lead	Pb <sup>-2</sup>	0.136	0.145	0.020	0.145	0.145
Molybdenum	MoO <sub>4</sub> <sup>-2</sup>	0.009	0.010	0.010	0.010	0.010
Nickel	Ni <sup>-2</sup>	0.016	0.018	0.018	0.018	0.018
Selenium	Se(IV)	0.502	0.458	0.458	0.458	0.458
	Se(VI)		1.47E-18	1.04E-18	7.54E-21	7.36E-23
Silver	Ag <sup>+1</sup>	0.0022	0.002	0.002	0.002	0.002
Zinc	Zn <sup>-2</sup>	8.03	8.04	0.30	8.04	8.04

### *Mass Loading*

The results obtained with the mass loading model are the most conservative as no geochemical reactions are considered. Due to the exposure of massive sulphides in the mine the concentrations of zinc, selenium, cadmium, nickel and copper, predicted with the mass loading model, are high in the mine water.

### *Geochemical Equilibrium*

The results for the various geochemical equilibrium scenarios differ from those of the mass loading model due to: (1) the use of SO<sub>4</sub> to maintain a charge balance; (2) fixed pH and corresponding redox potentials (E<sub>h</sub>) according to the Nernst equation; (3) mineral precipitation (except ‘no precipitation’ scenario).

The results of the ‘no precipitation’ scenario are probably closest to those of the mass loading model. The reduction in metal concentrations (e.g. Cd, Cu, Ni and Zn) due to mineral precipitation is particularly evident in the results of the Base Case scenario. At lower pH values (pH 6.0 and 4.0) mineral precipitation is strongly reduced and metal concentrations remain at levels similar to those of the ‘no precipitation’ scenario in the mass loading model.

## **Evaluation of Model Results**

In evaluating the various model results it is important to compare the predicted water quality with that of mines with similar mineralization as the Wolverine deposit. In addition, several factors could have an effect on the predicted mine water quality. These issues are discussed below.

### *Comparison to Other Mines*

Results obtained with the mass loading model, the base case (pH 8.3) and acidic drainage (pH 4.0) scenarios of the geochemical equilibrium model are compared with the underground mine water quality at the Wolverine Project (2005 underground seepage) and four other mines. The latter include: (1) Myra Falls Lynx mine (Vancouver Island, B.C.); (2) Britannia mine (B.C.); (3) Holden Mine (Washington State, US); and (4) Mine 12 (N.B.). Among the four mines, Myra Falls Lynx mine is geologically the most similar to Wolverine mine. The Britannia and Holden mines are characterized by higher concentrations of copper mineralization.

A comparison between predicted and measured underground mine water quality is shown in Table 42.3. Although the concentrations observed at other mine sites vary greatly, the predicted concentrations at Wolverine fall within the range observed at other mines. All four mines are characterized by extensive workings, a long mining history and produce poor water quality. The water quality observed at Myra Falls mine appears to be closest to that predicted for Wolverine with various scenarios, whereas Mine 12, Britannia, and Holden are less similar. The similarity supports the results/outcomes of equilibrated models shown in this section.

**Table 42.3: Comparison between Predicted and Measured Underground Mine Water Quality**

	Units	Wolverine Project					Lynx Mine	Britannia Mine	Holden Mine	Mine 12				
		2005 Underground Water		Unequilibrated 'Mass-Loading' Model Estimate	Equilibrated 'Base Case' Model Estimate	Acidic Drainage Model Estimate	Portal 10E Discharge (1997-2001)		4100 Portal (2001-2002)		Portal Discharge (1995-1996)		Mine Dewatering (1989-1997)	
		Mean	90 <sup>th</sup> Percentile				Mean	90 <sup>th</sup> Percentile	Mean	90 <sup>th</sup> Percentile	Mean	90 <sup>th</sup> Percentile	Mean	90 <sup>th</sup> Percentile
pH		8.0	8.2		8.7	4.0	6.9	7.5	3.6	4.0	5.1	5.7	3.0	3.2
Sulphate	mg/L	69.6	72.6	282	266	421	262	466	1359	1454	335	404	6793	8422
<b>Dissolved Metals</b>														
Aluminum	mg/L	0.0737	0.20	0.495	0.006	0.003	0.06	0.05	30.9	32.7	4.34	7.28		
Arsenic	mg/L	0.05759	0.20	0.058	0.055	0.0554			0.001	0.001	0.000813	0.001700		
Cadmium	mg/L	0.003	0.010	0.237	0.055	0.225	0.05	0.09	0.113	0.119	0.031	0.053		
Copper	mg/L	0.004	0.010	0.035	0.007	0.064	0.21	0.23	23.1	24.0	1.50	3.04	7.26	11.07
Iron	mg/L	0.240	0.635	0.490	0.0001	0.4747	0.04	0.07	4.20	6.54	0.742	1.20	856	1531
Lead	mg/L	0.0147	0.050	0.136	0.020	0.475	0.01	0.01	0.04	0.04	0.03	0.06	2.68	4.40
Molybdenum	mg/L	0.0094	0.0300	0.009	0.010	0.010			0.005	0.005	0.027	0.064		
Nickel	mg/L	0.0152	0.0500	0.016	0.018	0.018			0.05	0.05	0.01	0.02		
Selenium	mg/L	0.058	0.200	0.502	0.458	0.458			0.002	0.002				
Silver	mg/L	0.0029	0.010	0.0022	0.0022	0.4580			0.0001	0.0001	0.0001	0.0001		
Zinc	mg/L	0.0094	0.0201	8.03	0.30	8.04	12.9	22.0	23.2	24.3	6.39	9.34	1483	2240

### **Factors Affecting Mine Water Quality**

Several factors may affect the accuracy of the predicted underground mine water quality. These factors are associated with assumptions that are not likely, or did not account for physical/chemical changes to the mass loading. The major factors affecting accuracy are listed and described in detail below:

- scaling of mass loadings from humidity cells to actual mine surfaces assumes:
  - weathering and flushing rates are similar under field and laboratory conditions;
  - the given estimation of exposed mine surface areas is correct.
- ARD released during weathering of sulphides may decrease or even deplete the available neutralizing potential of the underground mine walls.
- alkalinity produced during leaching of cemented backfill may enhance the solubility and mobility of metals that form oxyanions (*e.g.* As, Mo and Se).
- prolonged flooding of the mine may create strongly reducing conditions that could result in enhanced metal release by reductive dissolution of metal hydroxides.

#### *Scaling of Mass Loadings*

Humidity cell data represent rock samples that are fully flushed of oxidation products on a weekly basis, which differs considerably from incomplete flushing in natural environments. Oxidation products accumulate in natural environments and inhibit further oxidation and leaching processes. The difference in temperature between laboratory and natural environments, coupled with “flush” differences results in significantly lower metal release rates in natural scenarios and the potential of geochemical models to exaggerate proposed metal leachate concentrations.

Fracture factor estimates are based on studies by Morin and Hutt (2004) who estimated the minimum-maximum available surface area of mine rock to range from 27 to 161 times the observed surface area. Morin and Hutt (2004) conducted their studies at three open pit mines, whereas the Wolverine model is an underground operation. As such, the Wolverine model assumed the fracturing of rock of underground mines to be lower than open pits and hence, assigned fracture factors of 30 and 50 for various rock types. To date, no studies similar to Morin and Hutt (2004) have been completed for underground mining operations. This being said, the assignment of fracture factors should be used with caution.

#### *Depletion of Mine Wall NP*

Exposed mine rock surfaces experience ongoing sulphide oxidation and produce weakly acidic to acidic leachates. The production of acidic conditions within the underground mine workings will deplete the available NP of underground mine walls. However, results from kinetic testing of conventional ore samples suggested that the period of NP depletion in ore materials may take upwards of 10 years to occur. Therefore, the

development of acidic conditions within the mine is not expected to occur during the operations phase. Moreover, given that essentially all of the underground workings (stopes, ventilation raises and access ramp) will be paste backfilled, the potential for acidic conditions to manifest in groundwater is considered unlikely. Continued monitoring of humidity cells and waters from the mine will be conducted during operations to further assess the potential for acidification within the mine.

#### *Cemented Backfill Effects on Alkalinity*

Cemented backfill may contribute to increased alkalinity and the solubility of metals that form oxyanions (e.g., Se, As, and Mo). Similar mine scenarios suggest that leachates with elevated pHs commonly seep from the cemented backfill during the operation and mine flood stages. The result is the formation of high pH zones adjacent to backfill, which may increase Se, As, and Mo load concentrations within mine waters. Ongoing kinetic testing will be used to determine the alkalinity and metal leach rates of backfill material and will be used to refine predictions and of mine water quality at closure.

#### *Effect of Reductive Dissolution*

The development of reducing conditions following mine flooding could result in the dissolution of redox sensitive mineral phases (e.g., iron and manganese-oxyhydroxides) that are soluble in their reduced form. The geochemical model has conservatively assumed that mine flooding will cause the accumulated oxidation products to enter into solution instantaneously, which is improbable due to a wide range of mineral solubilities.

Any changes in the assumptions listed and explained above will affect the predicted underground mine water quality at Wolverine.

### **Conclusions**

Based on the water quality predictions, metal concentrations may be elevated in the underground mine water. Two scenarios were investigated with respect to mine water quality; the mass loading model and base case scenario (geochemical equilibrium model). Together these scenarios represent the range in predicted metal concentrations in groundwater. The water quality prediction is based on ‘worst-case’ assumptions regarding weathering rates and mine surface areas under natural field conditions. As such, predictions made are therefore considered to be conservative.

The overall prediction of water quality is affected largely by three factors; ARD which depletes neutralizing potential of bedrock; alkalinity generated by weathering of cemented backfill; and reducing conditions during prolonged flooding of mine. It was found that the predicted underground mine water quality is similar to that observed at existing mines with similar geology and mineralogy. Neutral pH conditions were found to be the only situation to reduce dissolved metal concentrations (*i.e.*, Al, Cd, Cu, Fe, and Zn) via mineral precipitation.

## References

- AMEC, February 2006. Wolverine Project acid rock drainage and metal leaching assessment of mine rock and predicted water quality of the underground workings at closure.
- AMEC, September 2006. Wolverine Project predicted water quality of the underground workings at closure.
- Bradshaw, G.D., 2003, Geology and Genesis of the Wolverine Polymetallic Volcanic Rock-Hosted Massive Sulphide (VHMS) deposit, Finlayson Lake District, Yukon, Canada: Unpublished M.Sc. thesis, The University of British Columbia, p. 128
- Morin, K.A., and Hutt, N.M. 2004. The Minewall Approach for Estimating the Geochemical Effects of Mine Walls on Pit Lakes. Presented at: Pit Lakes 2004, US EPA; Reno NV, November 16-18, 2004.
- Snowden Mining Industry Consultant Ltd., 2006. Yukon Zinc: Wolverine Project (Project No V504) Mining Portion of Underground Feasibility Study. December 2006. Prepared by Yukon Zinc Corporation.
- Tucker, T.L., 1999, Summary report on the geological, geochemical, geophysical, geotechnical, metallurgical, environmental and diamond drilling surveys on the Wolverine property, Yukon Territory, Canada. Expatriate Resources Ltd. internal report.
- Yukon Zinc Corporation (YZC), February 2006. Wolverine Project EAR Response to Public and Regulatory Reviews.