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Arctic Gold and Silver Tailings Site Monitoring Report TA005 October 2009



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Waste Management Program
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Location

The Arctic Gold and Silver Mill and tailings impoundment is located approximately 4 km south of the village of Carcross on the road to both the Arctic Caribou and Big Thing mines. It lies at an elevation of approximately 1700 m above sea level on Montanna Mountain at the southeast side of Bennett Lake. Coordinates: (60° 80' 00" N, 134° 43' 20" W)

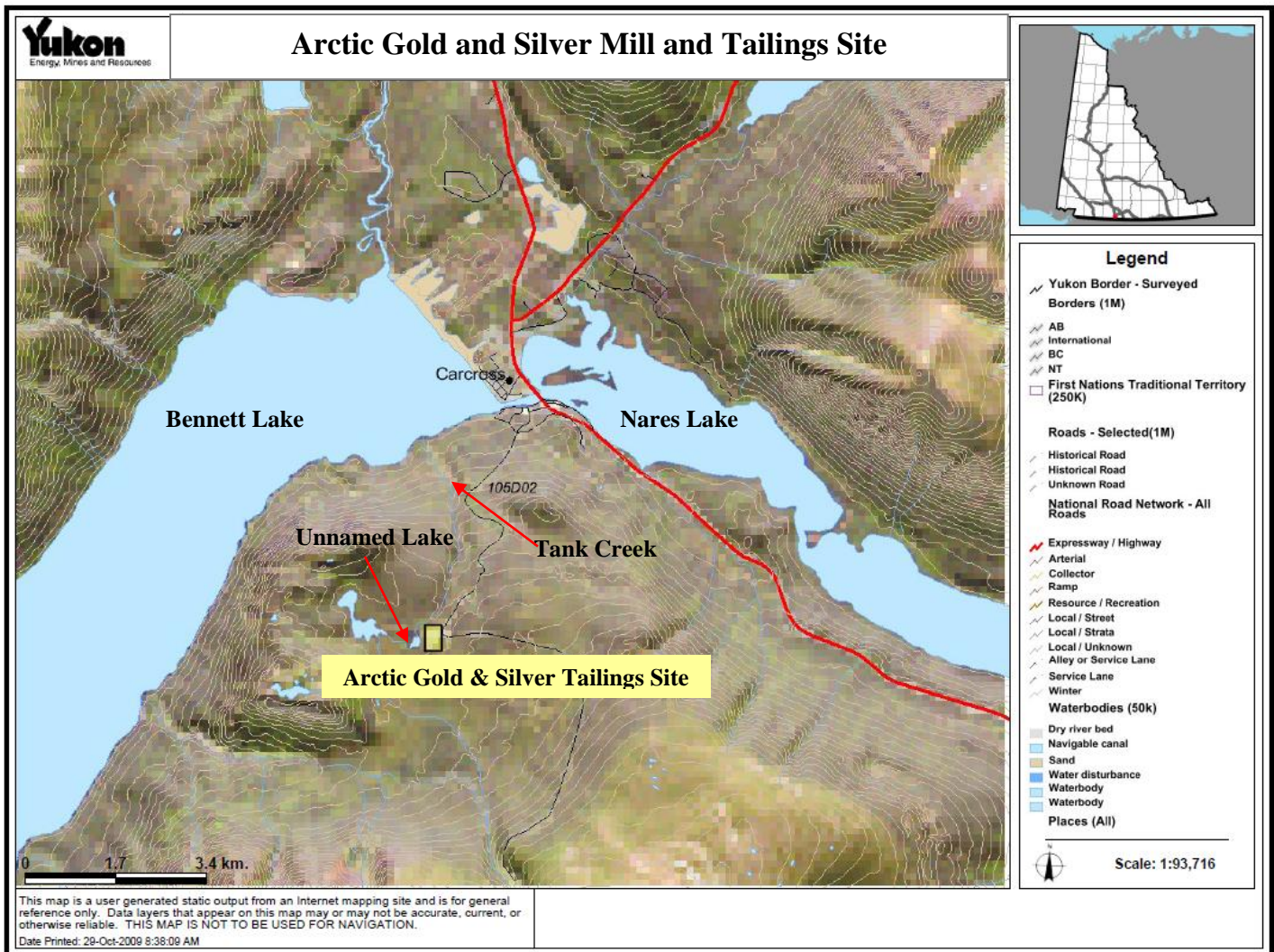


Figure 1: Location of Arctic Gold and Silver Mill and Tailings Site and surrounding area (Yukon Mining and Lands Viewer, 09).

Background

The ore deposit was found in 1905 and was worked on occasionally until the 1920s. Subsequently, in 1964 a mill was constructed and was in production until 1969 (Cunningham & Roach, 2002). It is estimated that about 47,000 tonnes of sulphide ore was processed and collected using a froth floatation process (without cyanide). The ore was then shipped to Sweden for roasting (Cunningham & Roach, 2002). As a result, approximately 27,000 m³ of tailings were discharged into a tailings impoundment (EBA Engineering Consultants LTD. 2001). In August 1997, a phase III environmental assessment was conducted by the Department of Indian Affairs and Northern Development (DIAND), Waste Management. The results indicated that the tailings were acid generating and seepage was entering the Unnamed Lake adjacent to the tailings impoundment (see Fig.1) contained significant concentrations of metals (Public Works and Government Services Canada 1998). Several health and safety concerns and environmental risks were identified. As a result, it was recommended to clean up the site and assess remedial measures for the tailings (Public Works and Government Services Canada 1998).

In 1998, scientific, geotechnical and geochemical services related to the remediation of the mine site was carried out and presented by Steffen Robertson and Kirsten Inc. Delineation of the tailings was initiated and two alternatives were proposed for remediation. Consolidate and cover or chemically amend and reprocess the tailings (Steffen Robertson and Kirsten (Canada) Inc., 1999). It was opted that the environmental and physical risks at the mine site would be most economically addressed by the first of the two alternatives, and thus, completing a “consolidate and cover” operation (EBA Engineering Consultants Ltd., 2001).

Remediation of the site and preparations to secure and cap the tailings was carried out in 1999 as designed by Public Works and Government Services of Canada (PWGSC) (Indian and Northern Affairs Canada (INAC), 2008). The physical site work was contracted out by PWGSC to the Carcross Tagish Development Corporation (CTDC) in

July 1999, when the remediation work began. The consolidation of the tailings was completed by September 2001 (EBA Engineering Consultants Ltd., 2001). Excavation of submerged tailings from the Unnamed Lake took place during the winters of 1999/2000. These tailings were expected to dry during the summer 2000 and be placed in the tailings impoundment; covered with a clayey silt capping material. However, due to a wet and cool summer, the tailings had not dried sufficiently. Therefore, the final work had to be postponed until the summer of 2001 (INAC 2008). The final aspect of the operation consisted of seeding and fertilizing the entire capped tailings impoundment in September 2001, using Russian Wild Rye (EBA Engineering Consultants Ltd., 2001).

Monitoring Program

INAC Waste Management personnel carried out the annual site monitoring for 2009, which included:

- Visual inspection of capped tailings impoundment;
- State of vegetation and signs of erosion on all re-seeded areas;
- Inspection of tailings dam, drainage channels and diversion ditch;
- Inspection of the newly constructed spillway and dam of the Unnamed Lake;
- Sampling of ground water at selected monitoring wells and analysis for dissolved metals; and
- Sampling of surface water at Tank Creek and analysis of dissolved metals.

Observations

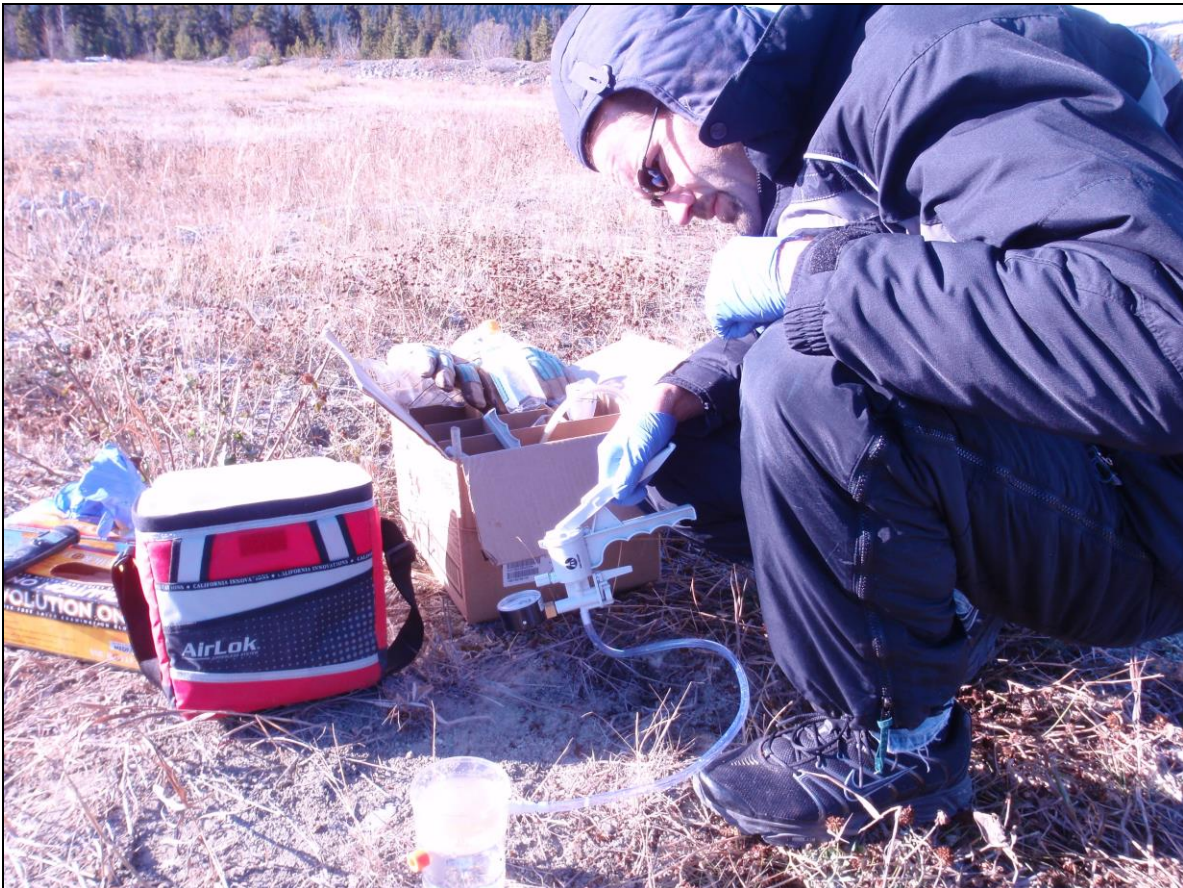
The abandoned mine site was visited by Waste Management Personnel on October 14th, 2009. Weather conditions were sunny, light winds and 8° Celsius. The overall state of the impoundment, tailings dam, drainage channel, diversion ditch, spillway and dam of the Unnamed Lake were satisfactory. The vegetation on the tailings cover was sparse and patchy (see Photo.1 & 2) and not as abundant as the vegetation around it.



Photograph 1 & 2: Top and Bottom-Vegetation on tailings cover.

Monitoring Well Sampling Methods

Groundwater samples were taken from two selected monitoring wells (MW-2 and MW-1D) within the tailings impoundment (See Fig.2 Sampling Locations). The well volume was calculated, and each well was purged (3 x well volume) prior to sampling. Water quality data recorded on site is shown in Table 1 and sampling locations in Figure 2. All water quality data was measured using the HANNA waterproof Combo pH & EC multi-checker # H198129. All samples collected were filtered (0.45 µm) using a pressurized hand pump and preserved with nitric acid. Samples were sent to Taiga laboratory in Yellowknife, North West Territories for dissolved metals analysis.



Photograph 3: Waste Management Personnel using a pressurized pump to filter water samples.



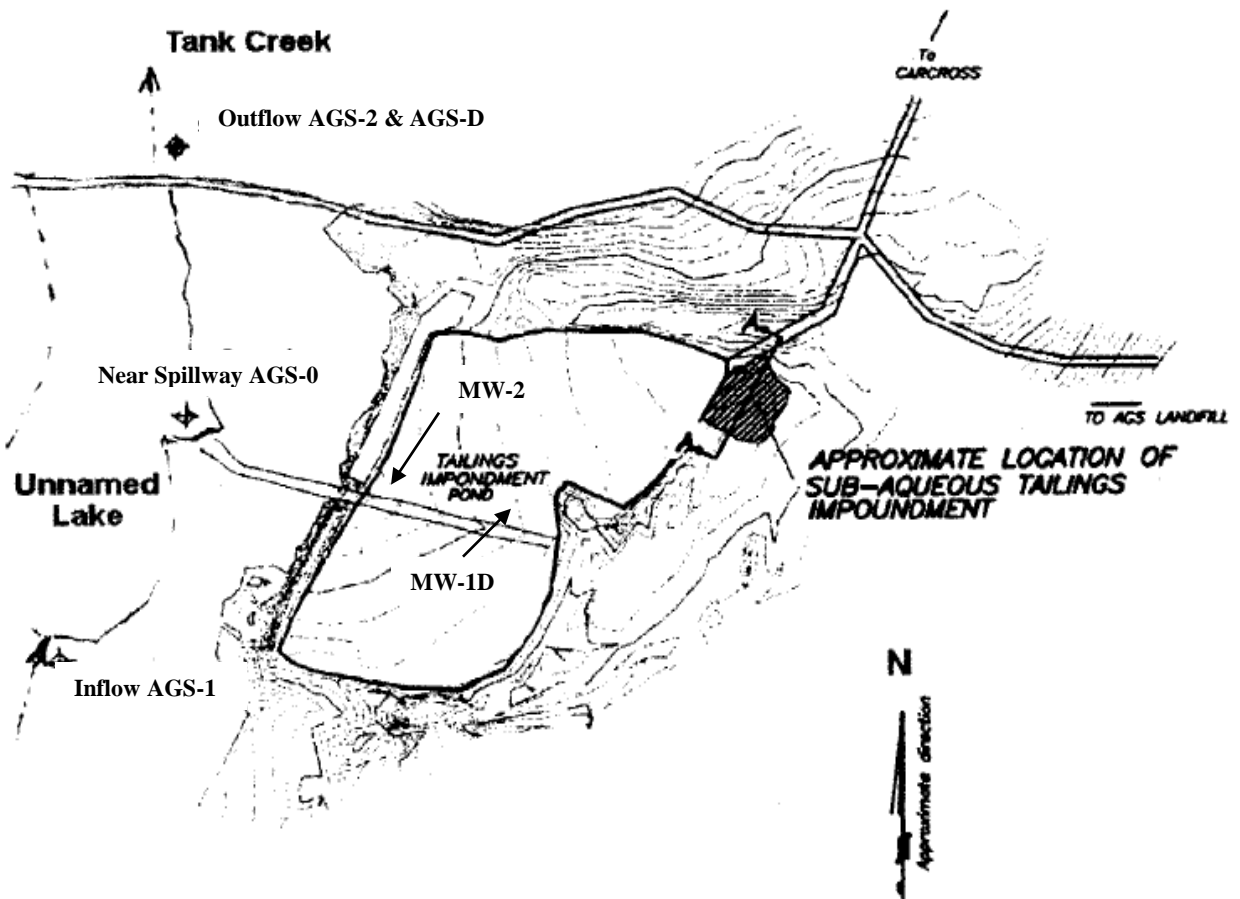
Photograph 4 & 3: Top-Waste Management Personnel removing the top from the monitoring well.
Bottom- Multi-checker taking sample readings from (MW-1D) monitoring well

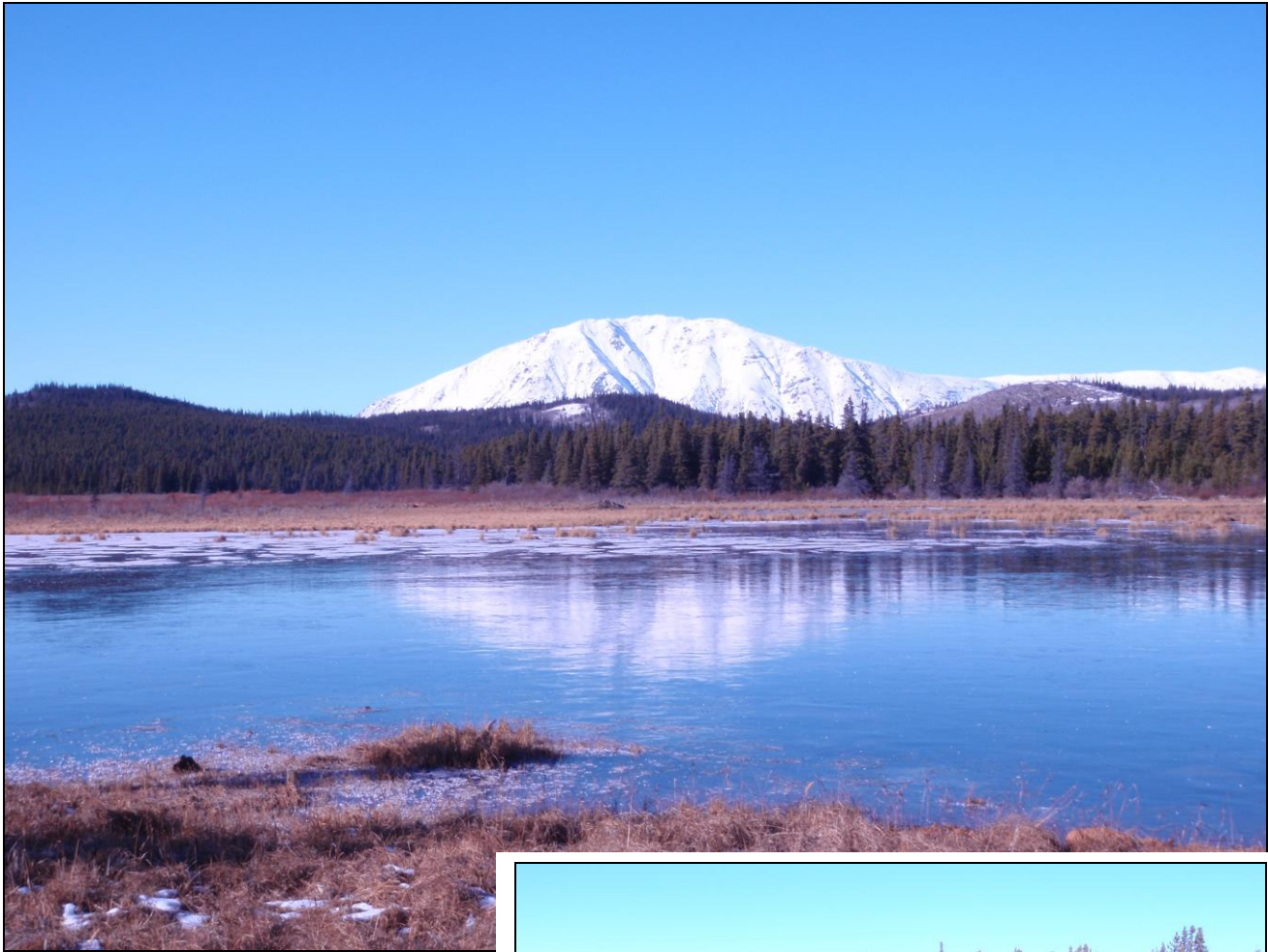


Surface Water Sampling Methods

Surface water samples were taken from Tank Creek (See Fig.2) at the inflow (AGS-1) and outflow (AGS-2) of the Unnamed Lake and also at the point of seepage from the tailings pile (AGS-0). Water quality data recorded on site is shown in Table 1 and sampling locations on Figure 2. For quality assurance purposes, a second sample was collected from the outflow of the Unnamed Lake (AGS-D). All water quality data was measured using the HANNA waterproof Combo pH & EC multi-checker # H198129. All samples collected were filtered (0.45 μm) using a pressurized hand pump and preserved with nitric acid. Samples were sent to Taiga laboratory in Yellowknife, North West Territories for dissolved metals analysis.

Figure 2: Water Sampling Locations modified from PWGS base drawing (EBA, 2001).





Photograph 6 & 7: Top-
Looking out onto the Unnamed
Lake at spillway. Bottom-
Waste Management Personnel
taking surface water readings
from the unnamed lake at the
tailings spillway area (AGS-0).



Analytical Results & Discussion

The analysis of the groundwater samples for dissolved metals show elevated levels of several metals in monitoring well MW-2; located in the lowest lying area of the tailings impoundment. The water quality measurements taken from monitoring well MW-2 (low pH and high conductivity – see Table 1) suggested that metals would be present in a dissolved state. The 2009 results received from the Taiga laboratory (see Appendix II) confirm that dissolved metals are present. Moreover, the sample readings taken from MW-2 (see Table 2) since 1998 indicate an increasing trend in the concentration of some dissolved metals. For example, the level of iron in 1998 was 664 mg/L and has since increased to 2240 mg/L in 2009. Remediation of the site was completed on September 2001, and the tailings are covered with a low permeable layer of clay capping material. Therefore, acid generation should be strongly reduced or not occurring. However, the high dissolved metal concentrations are apparent with little to no variation in this trend (see Table 2). In addition, the arsenic, zinc, copper and iron concentrations recorded since 2001 are higher than the Yukon Contaminated Sites Regulations and Canadian Council of Ministers of the Environment (CCME) total metal guidelines for the protection of aquatic life. These findings also correspond with the average water quality field measurements (see Table 3), in which the conductivity readings have been continually high and the pH continually acidic. It should be noted that the conductivity readings are not readily comparable since different instruments were used to take the sample readings each year.

Table 1: Arctic Gold & Silver, 2009 Water Quality Field Measurements

Sample ID	Time	Temperature (C°)	pH	Conductivity (µS)
MW-2	14:37	3.39	3.34	3999 “out of range”
	14:40	3.8	3.26	3999 “out of range”
	14:44	3.8	3.29	3999 “out of range”

MW-1D	13:05	4.7	7.28	350
	13:10	4.9	7.13	352
	13:13	4.8	7.12	345
AGS-1	14:15	0.9	7.63	85
AGS-2	15:00	1.6	7.10	87
AGS-0	13:55	1.1	8.09	98

Table 2: Comparison of Dissolved Metal Levels in Groundwater at Monitoring Well -2 from 1998 - 2009

Parameter	MW-2 1998 mg/L	MW-2 2001 mg/L	MW-2 2004 mg/L	MW-2 2005 mg/L	MW-2 2006 mg/L	MW-2 2007 mg/L	MW-2 2008 mg/L	MW-2 2009 mg/L
Arsenic	0.8	1.92	1.04	2.41	1.74	1.59	1.80	0.523
Aluminum	0.37	8.2	24.4	62.4	31.3	13.3	45.9	42.5
Zinc	16.6	55.8	83.5	152	90.2	38.2	74.6	55.2
Copper	0.03	0.41	0.326	0.33	0.137	0.052	0.088	0.0376
Lead	<0.001	<0.05	0.0679	0.014	0.0172	0.0001	0.0006	0.0009
Iron	664	2000	2340	3140	2180	919	2070	2240

Table 3: Comparison of Average Water Quality Field Measurements in Groundwater at Monitoring Well -2.

Parameter	MW-2 Aug. 4, 2004 (one reading recorded)	MW-2 June 16, 2005 (one reading recorded)	MW-2 July 11, 2006	MW-2 Aug. 24, 2007	MW-2 June 26, 2008	MW-2 Oct. 14, 2009
Time	11:19	14:33	13:20	14:38	14:49	14:40
Temperature (C°)	7.6	8.8	5.7	4.34	4.91	3.66
pH	3.32	2.99	3.44	3.65	3.62	3.29
Conductivity (µS)	3999	3999 “out of range”	6699	4475	6406	3999 “out of range”

Water and/or seepage containing dissolved metals from the containment cell is, consequently, evident in the surface water at the spillway area of the Unnamed Lake (AGS-0), shown in Table 4. Fortunately, the levels do not exceed the Yukon Contaminated Sites Regulations and CCME guidelines for the protection of aquatic life. However, in 2005 an event occurred in which high levels of metals from the tailings impoundment was leaching towards the surface water of the Unnamed Lake (see Table 4). Elevated levels are seen in monitoring well MW-2, Tables 2 & 3 (highlighted), and surface water sample AGS-0, Table 4 & 5 (highlighted). On June 2005 the surface water of the Unnamed Lake was not tested as usual. Instead, a seepage pool was tested that was flowing into the Unnamed Lake (see Photo 8). The results showed that arsenic, copper and iron concentrations were higher than the guidelines for total metals in surface water. The conductivity of the sample reading (see Table 5) was 3300 µS and the pH was 3.01. A pH of 3.01 is more acidic than the recommend guidelines for the protection of aquatic life in Canada, which is 6.5 – 9 (CCME, 1999). Acid Rock Drainage occurs when sulphide minerals are exposed to air and moisture, resulting in oxidation. Microbial action also accelerates the process (Environment Canada, 2009). The spike of high metal

concentrations was detected in samples taken on June 16, 2005, prior to a rain event on June 15, 2005. The Carcross station near the site received 14.0 mm of rain (see Figure 3). In addition to this, on June 12, 2005 the Carcross station received 23.4 mm of rain. It may be possible that the high spike in the sample readings on June 16, 2005 may be correlated to the heavy rain event, which occurred on the previous day. However, no other sample readings are known to have been taken days after a major rain event to compare these findings.

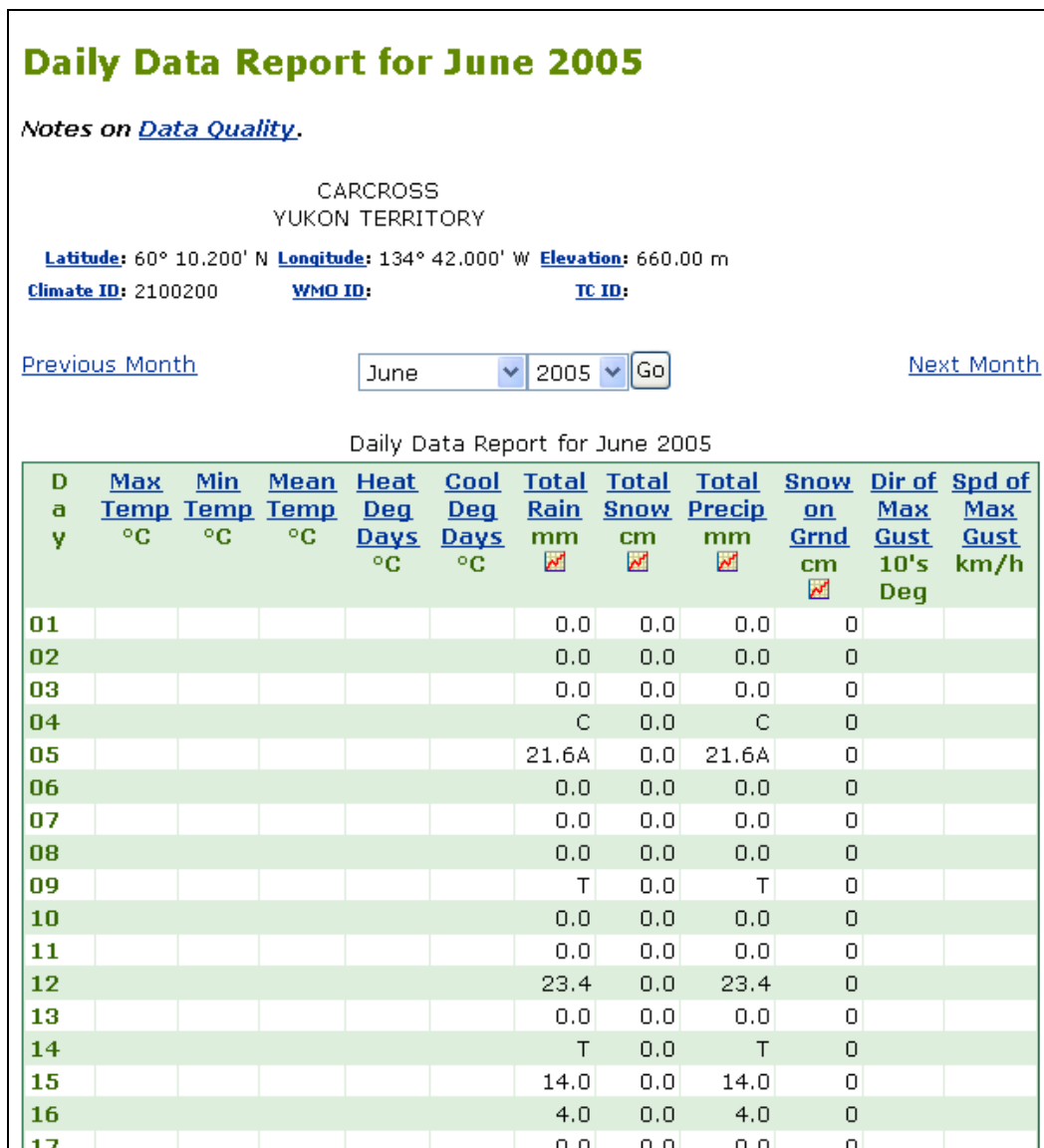


Figure 3: Daily Data Report for June 2005, Carcross, Yukon (Environment Canada, 2009). *T = Trace Amounts of Rain recorded*



Photograph 8 & 9: Top-
Seepage pool tested on
June 2005 (AGS-0).
Bottom- Evidence of
seepage pools near the
Unnamed Lake, Oct.
2009.

Table 4: Comparison of Dissolved Metal Levels in Surface Water at Unnamed Lake near the Tailings Spillway (AGS -0) from 1998 – 2009

Parameter	AGS-0 1998 mg/L	AGS-0 2001 mg/L	AGS-0 2002 mg/L	AGS-0 2005 mg/L	AGS-0 2006 mg/L	AGS-0 2007 mg/L	AGS-0 2008 mg/L	AGS-0 2009 mg/L	CCME (a) Guidelines mg/L Total Metals	CCME (b) Guidelines mg/L Total Metals
Arsenic	0.07	0.005	0.0029	0.014	0.0022	0.0019	0.0008	0.001	0.005	0.050
Aluminum	0.367	0.11	0.066	22.4	0.028	0.043	0.044	0.0153	5 – 100	n/a
Zinc	0.162	<0.05	0.030	6.13	0.015	0.024	0.134	0.0082	30	0.075 – 2.4*
Copper	0.0132	0.003	0.003	0.10	0.002	0.004	0.003	0.0008	0.002 – 0.004	0.02 – 0.09*
Lead	0.0025	<0.001	<0.0001	0.011	0.0002	<0.0001	<0.0001	0.0028	0.3	0.04 – 0.16
Iron	3.10	0.36	0.2	105	0.2	0.18	0.98	0.144	0.3	n/a

AGS-0 sample June 2005, was taken from a seepage pool rather than the Unnamed Lake

* Depending on water hardness

Table 5: Comparison of Water Quality Field Measurements in Surface Water at Unnamed Lake near the Tailings Spillway (AGS -0)

Parameter	AGS-0 Sept. 1998	AGS-0 Aug. 4, 2004	AGS-0 June 16, 2005	AGS-0 July 11, 2006	AGS-0 Aug. 24, 2007	AGS-0 June 26, 2008	AGS-0 Oct. 14, 2009
Time	n/a	12:43	15:51	14:43	14:03	14:10	13:55
Temperature (C°)	9.1	7.5	21.6	15.49	11.51	11.69	1.1
pH	7.10	6.82	3.01*	6.66	7.55	7.86	8.09
Conductivity (µS)	71.1	43	3300	107	100	157	98

AGS-0 sample June 2005, was taken from a seepage pool rather than the Unnamed Lake

* CCME pH guidelines: 6.5 – 9

The dissolved metal concentrations are slightly higher at the outflow (AGS-2) of Tank Creek compared to the inflow (AGS-1). The analysis and comparison of the readings indicate only a small, insignificant increase in the levels (see Appendix I, Table 9 & 11). Both samples tested were well below the Yukon Contaminated Sites Regulations and CCME guidelines for the protection of aquatic life.

The analysis of the average water quality data of monitoring well MW-1D (see Appendix I, Table 6) show that the conductivity in the groundwater is slightly increasing. The conductivity of the well has increased from 270 μS in 2004 to 349 μS in 2009. Despite this, all of the dissolved metal concentrations, except for iron, are at acceptable levels when compared to the total metals guidelines (see Appendix I, Table 7).

Conclusion

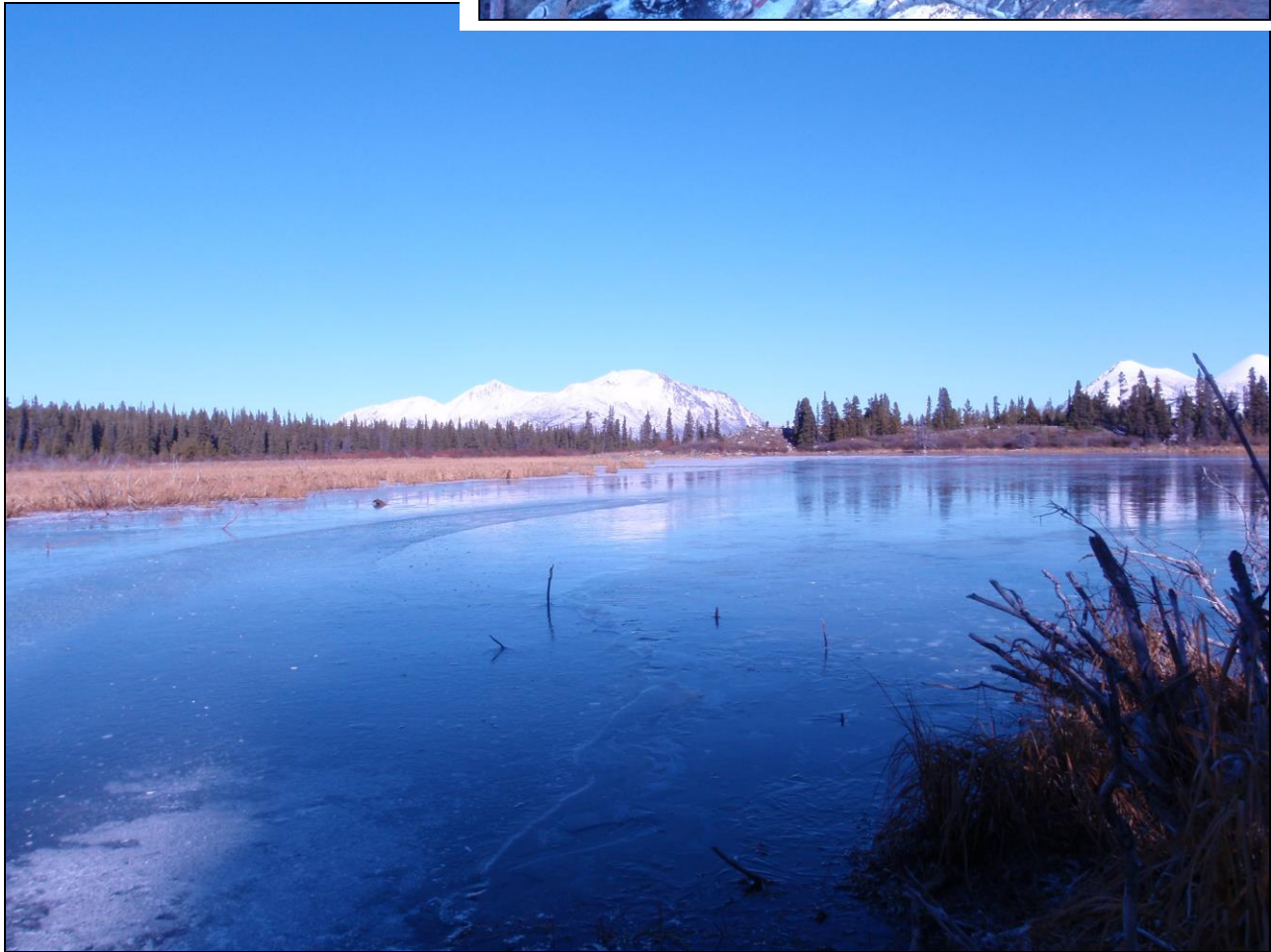
The groundwater samples in monitoring well MW-2 indicate an increasing level of dissolved metals. The tailings were covered with a low permeable layer of clay capping material. Therefore, acid generation should not be as evident as it is. The dissolved metals from the containment cell appear to be leaching gradually into the Unnamed Lake. However, the levels do not exceed the Yukon Contaminated Sites Regulations and CCME guidelines. In one instance, a high concentration of metals appeared in the samples MW-2 and AGS-0 in June 2005. A heavy rain event the previous day may account for the high readings. The dissolved metal concentrations are slightly higher at the outflow of Tank Creek compared to the inflow. Again, the concentrations are below the Yukon Contaminated Sites Regulations and CCME guidelines for the protection of aquatic life.

Annual monitoring will be continued in 2010.



Photograph 10: Waste Management Personnel taking readings from outflow (AGS-2) of the Unnamed Lake

Photograph 11 & 12: Top-
Waste Management Personnel
taking readings from inflow
of the Unnamed Lake (AGS-1)
Bottom- Looking out onto the
Unnamed Lake from the inflow



References

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APPENDIX I

Table 6: Comparison of Average Water Quality Field Measurements in Groundwater at Monitoring Well (MW-1D)

Parameter	MW-1D Aug. 4, 2004 (one reading recorded)	MW-1D June 16, 2005 (one reading recorded)	MW-1D July 11, 2006	MW-1D Aug. 24, 2007	MW-1D June 26, 2008	MW-1D Oct. 14, 2009
Time	12.05	15.01	14:06	13:28	13:19	13:09
Temperature (C°)	7.0	6.0	5.29	5.41	4.73	4.8
pH	6.6	6.64	6.07	7.15	7.93	7.18
Conductivity (µS)	270	309	260	313	319	349

Table 7: Comparison of Dissolved Metal Levels in Groundwater at Monitoring Well (MW-1D) from 1998 - 2009

Parameter	MW-1D 1998 mg/L	MW-1D 2001 mg/L	MW-1D 2004 mg/L	MW-1D 2005 mg/L	MW-1D 2006 mg/L	MW-1D 2007 mg/L	MW-1D 2008 mg/L	MW-1D 2009 mg/L	CCME (a) Guidelines mg/L Total Metals	CCME (b) Guidelines mg/L Total Metals
Arsenic	0.025	0.060	0.0041	0.0016	0.0039	0.0019	0.0020	0.0016	0.005	0.050
Aluminum	0.029	0.73	0.15	0.031	0.063	0.029	0.030	0.0173	5 – 100	n/a
Zinc	<0.005	<0.05	<0.002	0.012	0.082	0.006	0.005	0.0055	30	0.075 – 2.4*
Copper	0.001	0.005	0.0023	<0.001	<0.001	0.001	0.002	0.0011	0.002 – 0.004	0.02 – 0.09*
Lead	<0.001	0.001	0.0002	0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.3	0.04 – 0.16
Iron	0.04	1.20	0.118	0.03	0.09	0.12	0.52	0.044	0.3	n/a

* Depending on water hardness

Table 8: Comparison of Water Quality Field Measurements in Surface Water at the Inflow of the Unnamed Lake (AGS -1)

Parameter	AGS-1 Sept. 1998	AGS-1 June 16, 2005	AGS-1 July 11, 2006	AGS-1 Aug. 24, 2007	AGS-1 June 26, 2008	AGS-1 Oct. 14, 2009
Time	n/a	15:35	14:57	14:21	14:27	14:15
Temperature (C°)	9.0	9.4	7.79	8.08	5.94	0.9
pH	6.83	6.95	5.81	7.35	7.84	7.63
Conductivity (µS)	60.5	47	50	68	46	85

Table 9: Comparison of Dissolved Metal Levels in Surface Water at the Inflow of the Unnamed Lake (AGS -1) from 2002 - 2009

Parameter	AGS-1 2002 mg/L	AGS-1 2003 mg/L	AGS-1 2004 mg/L	AGS-1 2005 mg/L	AGS-1 2006 mg/L	AGS-1 2007 mg/L	AGS-1 2008 mg/L	AGS-1 2009 mg/L	CCME (a) Guidelines mg/L Total Metals	CCME (b) Guidelines mg/L Total Metals
Arsenic	0.0007	0.0006	0.0009	0.0005	0.0015	0.0008	0.0007	0.0009	0.005	0.050
Aluminum	0.007	0.02	0.16	0.045	0.028	0.020	0.018	0.0119	5 – 100	n/a
Zinc	0.001	0.002	0.007	0.014	0.005	0.003	0.010	0.0041	30	0.075 – 2.4*
Copper	<0.001	<0.0006	0.0011	<0.001	<0.001	<0.001	<0.001	0.0009	0.002 – 0.004	0.02 – 0.09*
Lead	<0.0001	<0.0001	<0.0001	0.0001	0.0001	<0.0001	<0.0001	0.0179	0.3	0.04 – 0.16
Iron	<0.1	0.035	0.141	0.03	<0.1	0.08	0.16	0.134	0.3	n/a

* Depending on water hardness

Table 10: Comparison of Water Quality Field Measurements in Surface Water at The Outflow (Tank Creek) of the Unnamed Lake (AGS -2) from 2004 - 2009

Parameter	AGS-2 Sept. 1998	AGS-2 Aug. 4, 2004	AGS-2 June 16, 2005	AGS-2 July 11, 2006	AGS-2 Aug. 24, 2007	AGS-2 June 26, 2008	AGS-2 Oct. 14, 2009
Time	n/a	13:09	16:09	15:22	14:59	15:07	15:00
Temperature (C°)	8.6	11.2	14.2	14.36	10.88	9.43	1.6
pH	7.52	7.01	6.95	6.73	6.39	6.17	7.10
Conductivity (µS)	64.6	56	63	56	69	55	87

Table 11: Comparison of Dissolved Metal Levels in Surface Water at The Outflow (Tank Creek) of the Unnamed Lake (AGS -2) from 2001 - 2009

Parameter	ACS-2 2001 mg/L	ACS-2 2003 mg/L	ACS-2 2004 mg/L	ACS-2 2005 mg/L	ACS-2 2006 mg/L	ACS-2 2007 mg/L	ACS-2 2008 mg/L	ACS-2 2009 mg/L	CCME (a) Guidelines mg/L Total Metals	CCME (b) Guidelines mg/L Total Metals
Arsenic	0.002	0.0007	0.0012	0.0009	0.0013	0.0015	0.0019	0.0008	0.005	0.050
Aluminum	0.07	0.02	0.02	0.036	0.020	0.030	0.021	0.016	5 – 100	n/a
Zinc	<0.05	0.007	0.008	0.018	0.005	0.005	0.011	0.0063	30	0.075 – 2.4*
Copper	0.002	0.0007	0.0012	<0.001	<0.001	0.001	0.001	0.0014	0.002 – 0.004	0.02 – 0.09*
Lead	<0.001	<0.0001	<0.0001	0.0002	0.0001	<0.0001	<0.0001	0.0005	0.3	0.04 – 0.16
Iron	0.36	0.071	0.157	0.08	0.2	0.36	0.12	0.177	0.3	n/a

*Depending on water hardness

APPENDIX II