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Memorandum

To:	Emilie Hamm	**From:**	SLR Consulting (Canada) Ltd.
Company:	Government of Yukon Assessment and Abandoned Mines		
cc:		**Date:**	March 31, 2017
Subject:	***FINAL - MOUNT NANSEN MINE*** ***AMP MONTHLY ASSESSMENT – FEBRUARY 2017***		

1.0 INTRODUCTION

The following summarizes the February 2017 assessment of the Adaptive Management Plan (AMP) Events, as outlined in the *Mount Nansen Water Quality and Quantity Adaptive Management Plan* (SLR, September 2015):

- AMP Event 2 - Changes in Water Quality in the Seepage Pond
- AMP Event 3 - Changes in Seepage Pond Inflows/Volume Outside of Historic Norms
- AMP Event 4 - Degraded Water Quality in Dome Creek Downstream of Mine Facilities (station WQ-DC-U in Upper Dome Creek assessed only, as station WQ-DC-R in lower Dome Creek was frozen to substrate).
- AMP Event 5 - Degraded Water Quality in Victoria Creek at Mine Access Road

The following Events are not included in this monthly assessment:

- AMP Event 1 - Degraded Water Quality in Dome Creek Downstream of Mill Area
    - Event 1 was not assessed in February as the creek was frozen to substrate at WQ-DC-D1b, preventing data collection.
- AMP Event 6 - Degraded Water Quality in Pony Creek Downstream of Mine Area
    - Event 6 was not assessed in February as the creek was frozen to substrate at WQ-PC-D, preventing data collection.
- AMP Event 7 - Changes in Pit Water Level Elevation outside of Historic Norms
    - Due to on-going pit-wall stability concerns, data required for the AMP assessment will not be collected and AMP Event 7 will not be assessed on a monthly basis until further notice.
- AMP Event 8 - Changes in Groundwater Quality Downgradient of the Brown-McDade Pit

  - Assessment of this AMP event is carried out on a bi-annual basis in the spring and fall and was last reported on in the June 2016 AMP assessment. The spring assessment was not completed for June 2016 due to lack of sufficient sampling data for trend line development. A sampling event was also conducted in August 2016, however data was also insufficient to carry out the assessment. This assessment will be carried out when sufficient sampling data are available.

- AMP Event 9 - Degraded Water Quality in Brown-McDade Pit

  - For assessment of Event 9, water quality sampling of the Brown-McDade Pit is required, monthly, and this monthly data is then evaluated annually under the AMP. Due to on-going pit-wall stability concerns, data required for the AMP assessment has not been collected since July 2015.

Note that as it has not been possible to conduct an assessment of the three AMP events related to the Brown-McDade Pit in over a year, it is recommended that AAM consider alternate means of assessing the effects of the Brown-McDade pit and drainage on the downgradient environment.

2.0 AMP EVENT 2 – CHANGES IN WATER QUALITY IN THE SEEPAGE POND

2.1 Description

The Seepage Pond at the toe of the tailings impoundment collects shallow groundwater seepage from the tailings area. The seepage collected in the pond is continuously pumped to Dome Creek. The discharge from the Seepage Pond is a primary source of contaminants to Dome Creek including sulphate, arsenic, iron, manganese and cadmium.

The water quality in the Seepage Pond is measured monthly, at the Seepage Pond outlet pipe, WQ-SEEP, with the exception of spring. At this time, an additional sample is collected during freshet. Water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, hardness, total and dissolved metals.

A summary of the specific AMP thresholds for the selected indicators for Event 2 is provided in Table 1.

Table 1: Summary of AMP Event 2 Thresholds

Indicators	Location	Thresholds	Frequency
Sulphate Total and Dissolved Arsenic Total Cadmium Total and Dissolved Iron Total and Dissolved Manganese Total Zinc Total and WAD Cyanide	WQ-SEEP	• Monitoring results at WQ-SEEP above the reference EQS for Dissolved Arsenic (0.15 mg/L), Total Iron (1.0 mg/L), Total Cadmium (0.02 mg/L), Total Manganese (0.5 mg/L), Total Zinc (0.3 mg/L), Total Cyanide (0.3 mg/L), WAD Cyanide (0.1 mg/L); or, • Three consecutive monitoring results at WQ-SEEP greater than the upper 95th percentile of the reference period (2008 to 2013); or • A statistically significant increasing trend (0.05) which, when extrapolated forward one year, would result in values greater than the 95th percentile. For the purposes of AMP trend line development, data for station WQ-SEEP from 2008 and on will be used for the trend analysis.	Monthly

2.2 AMP Event 2 – Data Review

Assessment under the AMP of the relevant water quality data from WQ-SEEP was carried out using the February 2017 water quality data. The results of the assessment are summarized in Table 2.

Table 2: Summary of AMP Event 2 Assessment

Indicators	Trigger Activation	Results
Sulphate	No	• February sulphate concentration (687 mg/L) was below the 95th percentile threshold value of 822.6 mg/L. • Statistically significant increasing trend in sulphate concentrations but not estimated to reach the threshold value for another 9 years.
Total Cyanide	No	• February concentration (0.02 mg/L) was below the EQS threshold value of 0.3 mg/L. • Total cyanide concentration in February was below the 95th percentile threshold value of 0.076 mg/L. • Non-statistically significant decreasing trend in concentrations.
WAD Cyanide	No	• February concentration (<0.005 mg/L) was below the EQS threshold value (0.1 mg/L). • WAD Cyanide concentration was below the 95th percentile threshold (0.035 mg/L). • Statistically significant decreasing trend in concentrations.

Total Arsenic	Yes	• The arsenic concentration in February (0.083 mg/L) was above the 95th percentile threshold value of 0.057 mg/L, and was part of three consecutive exceedances. • Statistically significant increasing trend estimated to reach the threshold value (0.057 mg/L) in less than 1 year.
Dissolved Arsenic	Yes	• February concentration (0.031 mg/L) was below the EQS threshold value of 0.15 mg/L. • The dissolved arsenic concentration in February was below the 95th percentile threshold value of 0.035 mg/L. • Statistically significant increasing trend in dissolved arsenic concentrations, estimated to reach the 95th percentile threshold value (0.035 mg/L) in less than 1 year.
Total Cadmium	No	• February concentration (0.00057 mg/L) was below EQS threshold of 0.02 mg/L. • February concentration was below the 95th percentile threshold of 0.00117 mg/L. • Statistically significant decreasing trend in concentrations.
Total Iron	Yes	• February concentration (17.6 mg/L) is above the EQS threshold of 1.0 mg/L and concentrations have been since at least 2008. • February concentration was below the 95th percentile threshold of 20.8 mg/L. • Non-statistically significant increasing trend in concentrations.
Dissolved Iron	Yes	• February concentration (14.5 mg/L) was above the 95th percentile threshold of 9.67 mg/L, and was part of four consecutive exceedances. • Statistically significant increasing trend estimated to reach 95th percentile threshold value in less than 1 year.
Total Manganese	Yes	• February concentration (6.6 mg/L) was above EQS threshold of 0.5 mg/L and has been since 2008. • February concentration was below the 95th percentile threshold value of 9.2 mg/L. • Statistically significant decreasing trend in concentrations.
Dissolved Manganese	No	• February concentration (6.4 mg/L) was below the 95th percentile threshold value of 8.8 mg/L. • Statistically significant decreasing trend in concentrations.
Total Zinc	Yes	• February concentration (0.05 mg/L) was below the EQS threshold of 0.3 mg/L. • February concentration was above the 95th percentile threshold value of 0.028 mg/L for six consecutive months. • Statistically significant increasing trend estimated to reach 95th percentile threshold value in less than 1 year.

2.3 Follow-up Action Required

The above noted changes in water quality in the Seepage Pond, as measured at WQ-SEEP, have been previously documented in various reports including *Mount Nansen – Assessment of Zinc Concentrations in the Seepage Pond* (SLR 2015) and *Mount Nansen 2013 Annual Surface Water Quality Review* (SLR 2015). As a result of those reports, additional work is being carried out to investigate the sources of the changing water quality in the Seepage Pond, including sulphate, total zinc, total and dissolved arsenic, and total and dissolved iron. Some of the recommendations for proposed study/investigations included:

- A detailed hydrogeological and geochemical assessment of the water quality trends in seepage water and groundwater to fully assess the changing conditions in the Seepage Pond and upgradient in the tailings area, and evaluate potential impacts to ongoing attenuation processes.
- The development of a contingency plan for the potential treatment of Seepage Pond water should the concentrations reach a point where treatment is required.

3.0 AMP EVENT 3 - CHANGES IN SEEPAGE POND INFLOWS/VOLUME OUTSIDE OF HISTORIC NORMS

3.1 Description

The Seepage Pond at the toe of the tailings impoundment collects shallow groundwater seepage from the tailings area. The seepage collected in the pond is continuously pumped to Dome Creek. The maximum design operating level of the Seepage Pond is 1078.1 masl. The pond water levels are measured daily, during open water, via a staff gauge. The discharge pumping rate is measured daily via an inline flowmeter (H-SEEP) installed in 2012 and routinely checked using timed volumetric measurements.

The environmental consequence of changes in the Seepage Pond inflows/volumes above historic norms is the potential exposure of aquatic and terrestrial resources, and human users to increased levels of contaminants in the downstream receiving environment in Victoria Creek due to increased seepage from the tailings impoundment area. In addition, as a result of seepage inflows above or below historic norms, there are concerns related to the stability of the dam structure including, dam failure or reduction in hydro-static pressure.

Assessment of the water level and water level rate of change triggers occur during the open water season only, while assessment of the pumping rate occurs year round. A summary of the specific indicators and thresholds for AMP Event 3 is provided in Table 3.

Table 3: Summary of AMP Event 3 Thresholds

Indicators	Locations	Thresholds	Frequency
Seepage Pond pumping rate Seepage Pond water level Seepage Pond water level rate of change	H-SEEP	• Four consecutive average weekly results greater than the upper 95th percentile or lower than the lower 5th percentile of the 2012 to 2013 data record on a year round basis for the pumping rate and during open water for the water level and water level rate of change; or • A statistically significant (0.05) increasing or decreasing trend in the monitoring results on a year round basis for the pumping rate, and during open water for the water level and water level rate of change. For the purposes of AMP trend line development, data from 2012 on will be used for the trend analysis.	Daily

3.2 AMP Event 3 – Data Review

Assessment under the AMP of the relevant water level and discharge data from H-SEEP was carried out using the February 2017 data.

The results of the assessment are summarized in Table 4.

Table 4: Summary of AMP Event 3 Assessment – H-SEEP

Indicators	Trigger Activation	Results
Seepage Pond pumping rate	Yes	• Throughout February, the average weekly Seepage Pond pumping rates (129.57 to 135.14 L/min) did not exceed the upper 95th percentile threshold (240.12 L/min). • Throughout February, the average weekly Seepage Pond pumping rates (129.57 to 135.14 L/min) were below the 5th percentile threshold (156 L/min) for eleven consecutive weeks. • Statistically significant decreasing trend in the Seepage Pond pumping rate.
Seepage Pond water level	N/A	• The surface of the Seepage Pond was frozen as of October 1st, 2016. This assessment will not be performed until open water season.
Seepage Pond water level rate of change	N/A	• The surface of the Seepage Pond was frozen as of October 1st, 2016. This assessment will not be performed until open water season.

3.3 Follow-up Action Required

The Seepage Pond pumping rate trigger was activated in February 2017 by a statistically significant decreasing trend in the Seepage Pond pumping rate and pumping rate averages were below the lower 5th percentile for eleven consecutive weeks.

Consultation with a geotechnical engineer in August 2016 concluded that there are no concerns with respect to dam stability caused by low seepage pumping rates (refer to August 2016 monthly AMP assessment report). As the low seepage pumping rates do not present a critical issue at this time, no follow-up is required.

4.0 AMP EVENT 4 – DEGRADED WATER QUALITY IN DOME CREEK DOWNSTREAM OF MINE FACILITIES

4.1 Description

Dome Creek, downstream of the tailing impoundment area, receives inputs from the mine site via direct discharge from the Seepage Pond, inflows from the mill area, and seepage and groundwater inflows from mine site facilities. The water quality in Dome Creek below the mine site facilities is measured at stations WQ-DC-U and WQ-DC-R. Station WQ-DC-U is located downstream of the confluence of Dome Creek and the Seepage Pond discharge and station WQ-DC-R is located in Dome Creek at the mine access road crossing. Water quality samples are collected monthly, with the exception of spring. At this time, an additional sample is collected during freshet. Water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, hardness, total and dissolved metals.

The water quality in Dome Creek, below the mine site facilities, shows a clear mine-related influence with elevated concentrations of key contaminants of concern including sulphate, arsenic, iron, manganese, cadmium, and zinc. Total and WAD cyanide is also present in Dome Creek below the mine facilities, although at concentrations typically well below the CCME guidelines.

A summary of the specific AMP thresholds for the selected indicators for Event 4 is provided in Table 5.

Table 5: Summary of AMP Event 4 Thresholds

Indicators	Locations	Thresholds	Frequency
Sulphate Total and Dissolved Arsenic Total Cadmium Total Zinc Total and Dissolved Iron Total and Dissolved Manganese	WQ-DC-U and WQ-DC-R	• Three consecutive monitoring results at WQ-DC-U or WQ-DC-R greater than the upper 95th percentile of the reference period (2008 to 2013); or, • A statistically significant (0.05) increasing trend in the monitoring results from WQ-DC-U or WQ-DC-R which, when extrapolated forward one year, would result in values greater than the 95th percentile. For the purposes of AMP trend line development, data from 2008 and on is used for the trend analysis.	Monthly

4.2 AMP Event 4 – Data Review

Assessment under the AMP of the relevant water quality data from WQ-DC-U was carried out using the February 2017 water quality data. The results of the assessment are summarized in

Table 6. Water quality was not assessed at WQ-DC-R this month as the creek was frozen to substrate.

Table 6: Summary of AMP Event 4 Assessment – WQ-DC-U

Indicators	Trigger Activation	Results
Sulphate	No	• February concentration (610 mg/L) was below the 95th percentile threshold (785.1 mg/L). • Statistically significant increasing trend in sulphate concentrations but not estimated to reach 95th percentile threshold value for another 6 years.
Total Arsenic	Yes	• February concentration (0.058 mg/L) was above the 95th percentile threshold (0.052 mg/L), and was part of three consecutive exceedances. • Statistically significant increasing trend in total arsenic concentrations but not estimated to reach 95th percentile threshold value for another 6 years.
Dissolved Arsenic	Yes	• February concentration (0.039 mg/L) was above the 95th percentile threshold (0.031 mg/L), and was the fourth consecutive exceedance. • Statistically significant increasing trend in dissolved arsenic concentrations but not estimated to reach threshold value for another one year and 8 months (Sept 2018).
Total Cadmium	No	• February concentration (0.00019 mg/L) was below 95th percentile threshold (0.00066 mg/L). • Statistically significant decreasing trend in concentrations.
Total Iron	No	• February concentration (8.13 mg/L) was below the 95th percentile threshold (10.5 mg/L). • Non-statistically significant increasing trend in concentrations.
Dissolved Iron	No	• February concentration (5.86 mg/L) was above the 95th percentile threshold (5.35 mg/L) but was the second exceedance and not part of three consecutive exceedances. • Statistically significant increasing trend in dissolved iron concentrations but not estimated to reach threshold value for another 7 years.
Total Manganese	No	• February concentration (5.01 mg/L) was below the 95th percentile threshold value of 5.94 mg/L. • Non-statistically significant increasing trend in concentrations.
Dissolved Manganese	No	• February concentration (5.07 mg/L) was below the 95th percentile threshold value of 5.68 mg/L. • Non-statistically significant increasing trend in concentrations.
Total Zinc	No	• February concentration (0.025 mg/L) was below the 95th percentile threshold (0.090 mg/L).

Indicators	Trigger Activation	Results
		• Non-statistically significant decreasing trend in concentrations.

4.3 Follow-up Action Required

The AMP trigger for dissolved arsenic was activated this month by a third consecutive exceedance (0.051 mg/L) above the 95th percentile threshold (0.031 mg/L) and represents the second time this trigger has been activated. The AMP trigger for dissolved arsenic was also activated in the 2015 – 2016 low flow winter period, for the first time since the reference period (2008 – 2013).

The trigger for total arsenic concentration in Dome Creek at WQ-DC-U (0.058 mg/L) was activated by three consecutive exceedances. This represents the first time that this trigger has been activated since the reference period. There was also an overall statistically significant increasing trend, however the trend assessment trigger was not activated this month.

It is recommended that water quality at WQ-DC-B be monitored, once this station is no longer frozen, to check the arsenic concentration in Dome Creek upstream of drainage from the tailings area seepage.

As noted with Event 2, the triggers for dissolved and total arsenic were also activated at WQ-SEEP (along with the recent trigger for dissolved iron and the on-going trigger for total iron [see Table 2]), upstream of Dome Creek. The dissolved arsenic concentration was 0.031 mg/L and the total arsenic concentration was 0.083 mg/L in February.

Despite the low flow rate from the seep, the seep is a possible source of arsenic loading to Dome Creek. Figures of arsenic concentrations at WQ-SEEP and WQ-DC-U (2008-2016) are shown below:

Figure 4-1: Arsenic (Dissolved) at WQ-SEEP

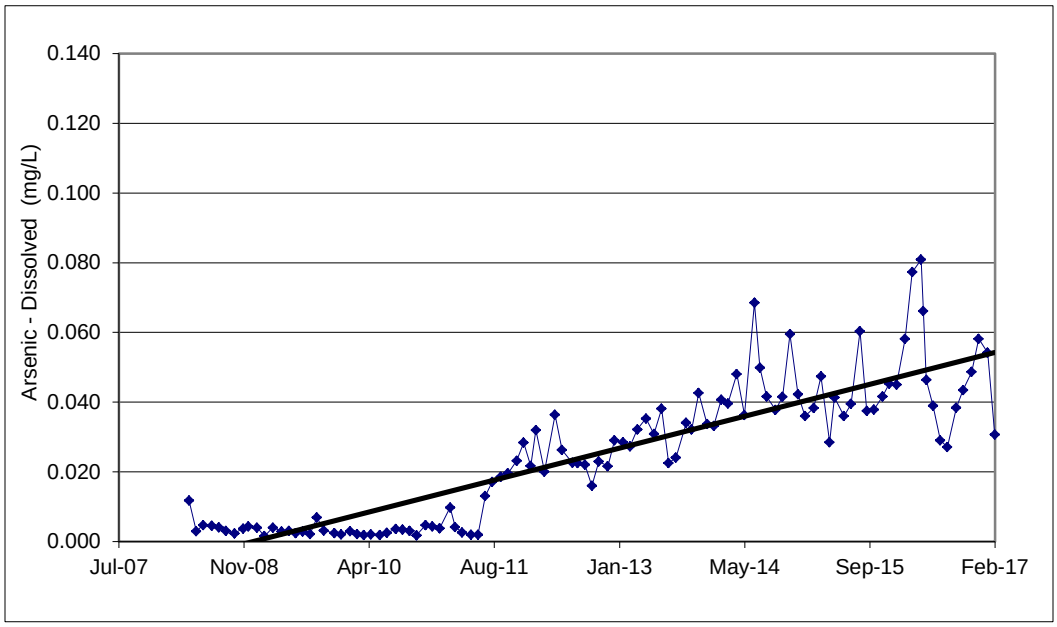


Figure 4-2: Arsenic (Total) at WQ-SEEP

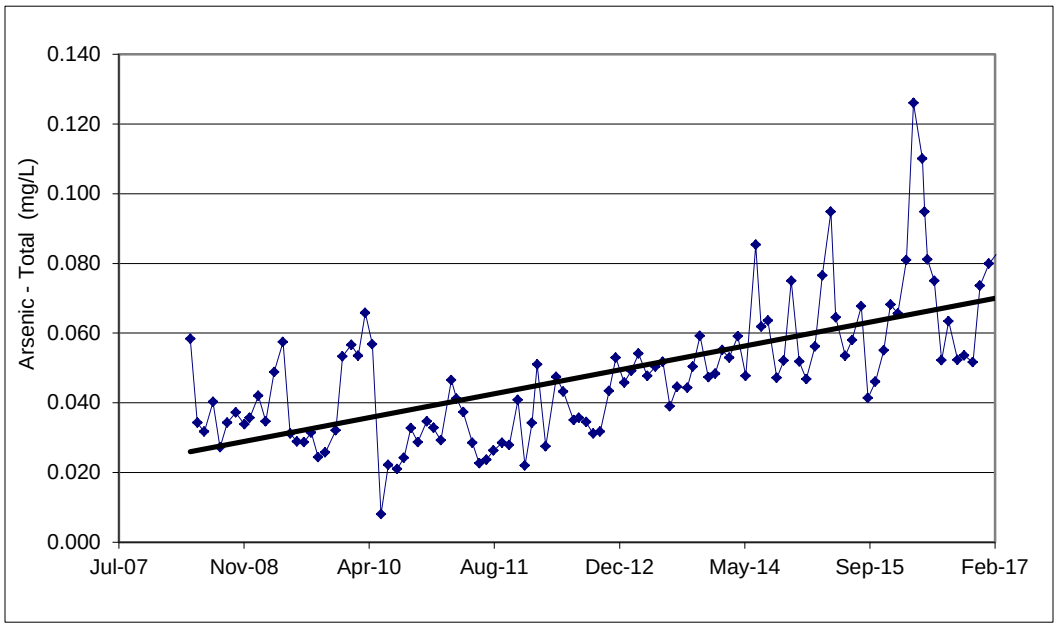


Figure 4-3: Arsenic (Dissolved) at WQ-DC-U

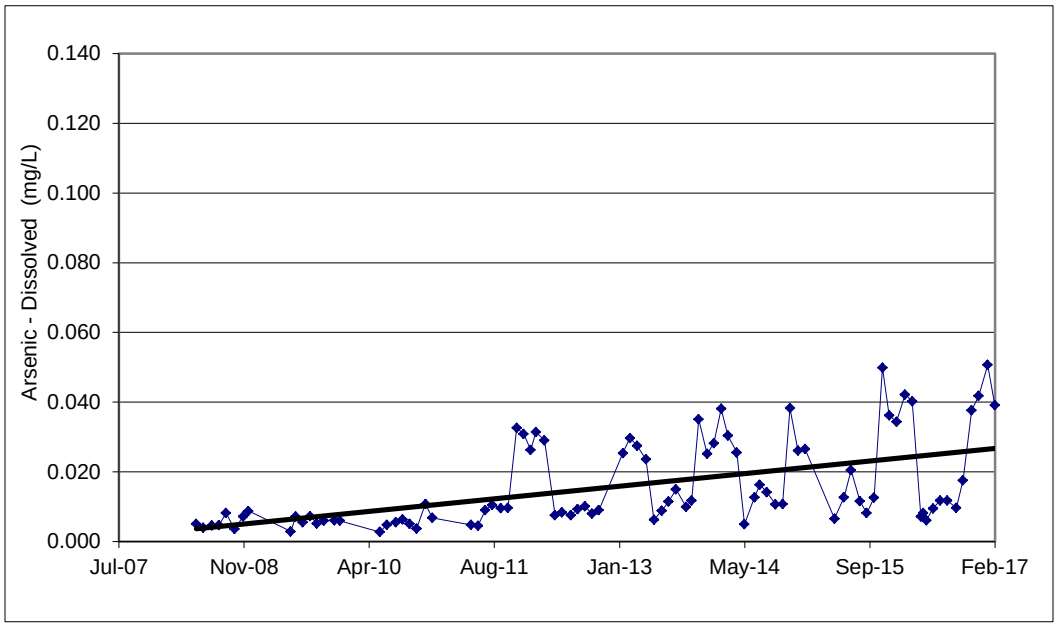
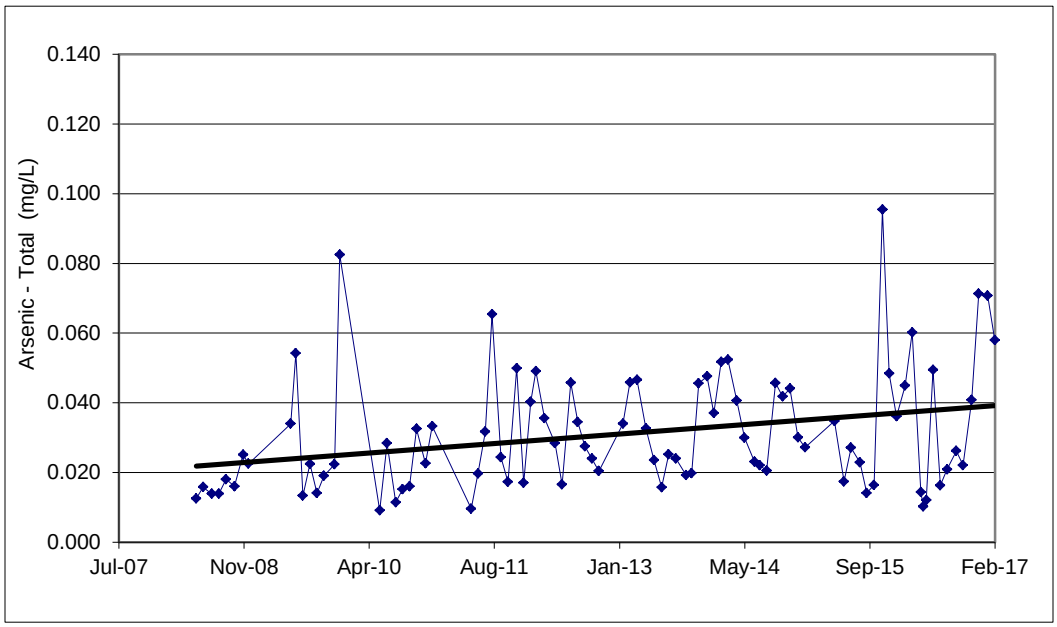


Figure 4-4: Arsenic (Total) at WQ-DC-U



As noted with Event 2, further seepage studies/investigations and the development of a response plan in the event that water treatment is required are underway. Mitigative action to improve the water quality from the tailings seep may improve the water quality in Dome Creek. If the investigations show that the seepage is the likely source of increasing arsenic and iron in Dome Creek, it is recommended that steps to improve water quality from the seep be implemented.

5.0 AMP EVENT 5 – DEGRADED WATER QUALITY IN VICTORIA CREEK AT MINE ACCESS ROAD

5.1 Description

Victoria Creek, downstream of the mine site area, receives inputs from the mine site from surface water inflows and from groundwater inflows from mine site facilities. The receiving environment for the site is represented by sampling location WQ-VC-R. This location is downstream of inputs from both Dome and Back Creeks, and includes all potential mine related inputs to the receiving environment. In contrast to Dome Creek, Victoria Creek is known to support fish and fish habitat. The water quality in Victoria Creek at WQ-VC-R is collected monthly, with the exception of spring. At this time, an additional sample is collected during freshet. During winter, water quality in this area is sampled 150 m downstream at WQ-VC-R+150. Water quality samples are analyzed for a full suite of parameters including total suspended solids, cyanide species, nitrogen species, sulphate, hardness, total and dissolved metals.

The water quality in Victoria Creek, below the mine site facilities, shows a clear mine-related influence with elevated concentrations of key contaminants of concern, compared to background, including sulphate, dissolved arsenic, dissolved iron, dissolved manganese, dissolved cadmium, and dissolved zinc. The water quality at WQ-VC-R is also significantly influenced by elevated levels of suspended solids from both natural and anthropogenic sources (including placer mining in the Back Creek and Pony Creek watersheds). Due to this influence of upstream sediment inputs, the development of the AMP Event for Victoria Creek is based on dissolved metals. Taking this approach enables the isolation of site-related influences and eliminates the interfering effects of elevated suspended solids contributed from upstream, in the Victoria Creek catchment.

A summary of the specific AMP thresholds for the selected indicators for Event 5 is provided in Table 7.

Table 7: Summary of AMP Event 5 Thresholds

Indicators	Locations	Thresholds	Frequency
Sulphate Dissolved Arsenic Dissolved Cadmium Dissolved Iron Dissolved Manganese Dissolved Zinc	WQ-VC-R or WQ-VC-R+150	• Three consecutive monitoring results at WQ-VC-R or WQ-VC-R+150 greater than the upper 95th percentile of the reference period (2008 to 2013); or • A statistically significant (0.05) increasing trend in the monitoring results from WQ-VC-R or WQ-VC-R+150 which, when extrapolated forward one year, would result in values greater than the 95th percentile. For the purposes of AMP trend line development, data from 2008 and on will be used for the trend analysis.	Monthly

5.2 AMP Event 5 – Data Review

Assessment under the AMP of the relevant water quality data from WQ-VC-R+150 was carried out using the February 2017 water quality data. The results of the assessment are summarized in Table 8.

Table 7: Summary of AMP Event 5 Assessment

Indicators	Trigger Activation	Results
Sulphate	No	• February concentration (40.2 mg/L) was below the 95th percentile threshold (45.9 mg/L). • Non-statistically significant increasing trend in concentrations.
Dissolved Arsenic	No	• February concentration (0.001 mg/L) was below the 95th percentile threshold (0.002 mg/L). • Non-statistically significant decreasing trend in concentrations.
Dissolved Cadmium	No	• February concentration (0.00001 mg/L) was below the 95th percentile threshold (0.00009 mg/L). • Non-statistically significant decreasing trend in concentrations.
Dissolved Iron	No	• February concentration (<0.010 mg/L) was below the 95th percentile threshold (0.270 mg/L). • Non-statistically significant decreasing trend in concentrations.
Dissolved Manganese	No	• February concentration (0.004 mg/L) was below the 95th percentile threshold (0.120 mg/L). • Non-statistically significant decreasing trend in concentrations.
Dissolved Zinc	No	• February concentration (0.0061 mg/L) was below the 95th percentile threshold (0.0082 mg/L). • Non-statistically significant decreasing trend in concentrations.

5.3 Follow-up Action Required

No AMP triggers were activated at WQ-VC-R+150 under AMP Event 5 during the February 2017 assessment. Therefore no follow up is required at this time.