**Mount Nansen August 2016**

**Groundwater Monitoring and Sampling**

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**Government of Yukon**

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# Introduction

This Work was performed in accordance with Contract C00033455 between Hemmera Envirochem Inc. (“Hemmera”) and Government of Yukon (“Client”), dated May 13, 2016 (“Contract”). In performing this Work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

Hemmera Envirochem Inc. and Ecological Logistics & Research Ltd. (Hemmera/ELR) were retained by the Government of Yukon (GY), Assessment and Abandoned Mines (AAM) to conduct a groundwater monitoring and sampling program at the Mount Nansen Site (the Site) in August, 2016. Hemmera/ELR’s scope of work included the monitoring of groundwater wells and collection of groundwater samples from a series of existing groundwater wells at the Site. This report summarizes the monitoring and sampling activities, a description of methodologies and field conditions encountered, a summary of field *in-situ* and laboratory analytical results including a comparison to applicable guidelines, a description of any observations and/or occurrences that may have influenced program results, and recommendations relating to sample procedures and monitoring well conditions. This report does not provide an interpretation of the results, nor does it provide recommendations relating to groundwater quality at the Site.

## Site Location

The Mount Nansen site is located approximately 45 kilometres (km) west of the Town of Carmacks (70 km by road). This Type II abandoned mine site consists of three (3) primary areas of existing infrastructure: the Brown McDade Pit, a Mill Complex, and a Tailings Facility (**Figure 1-1**). Groundwater monitoring wells exist throughout the Site, a subset of which were sampled during the August 2016 groundwater monitoring and sampling program. The groundwater monitoring locations included in this program are described in **Sections 1.2** and **1.3**.

## Scope of Work

The scope of work for this program included the coordination and execution of the August 2016 groundwater monitoring and sampling, analysis of samples, and the presentation of results in a report.

Groundwater sampling at the Site was conducted over a four (4) day period, between August 29 and September 1, 2016. Sampling was conducted by a team of four (4) qualified field staff from Hemmera/ELR (Norbert Botca, Jeremy Chua, Aaron Nicholson and Michelle McKay). A total of 60 groundwater wells were included in the August 2016 sampling event (**Table 1-1**). It was not possible to sample two (2) of the groundwater wells listed in the scope of work as they appeared to have been destroyed during placer mining operations in the summer of 2015 (GSI-PC-02-B and MP09-02; Hemmera, 2015).

At each well (sampling station) headspace gas concentrations were measured, well and water level parameters were measured (depth to water, depth to bottom, well diameter, and well stick-up height), the well was purged, and then prescribed *in-situ* groundwater quality parameters were measured. Lastly, groundwater samples were collected for laboratory analysis. A detailed description of the sampling methods and measured groundwater quality parameters is provided in **Section 2**.

## Sample Sites

The groundwater wells included in the August 2016 monitoring and sampling event were grouped into six (6) main areas of the Mount Nansen Site (**Table 1-1**). The majority of groundwater wells were located around existing infrastructure including the tailings facility and seepage dam (24 wells), the Brown McDade Pit (11 wells) and the Mill Complex (9 wells). Additional wells (primarily drive-point piezometer installations) were sampled in the vicinity of Dome Creek (9 wells) and Pony Creek (7 wells). **Table 1-1** provides the location, status, and sample recovery details for groundwater wells included in the August 2016 sampling program. The well locations are also illustrated in **Figures 1-2** and **1-3**. Photographs of each sample site visited in August 2016 are included in **Appendix A**.

Figure 1-1 Site Location – Mount Nansen Site

Table 1-1 Summary of Groundwater Well Locations and Samples Collected

| **Area** | **Well Name** | **UTM (Zone 08N)** | | **Status1,2** | **Sample Collected** | **QA/QC Sample Collected** |
| --- | --- | --- | --- | --- | --- | --- |
| **Easting** | **Northing** |
| Dome Creek | GSI-DC-01B | 387675 | 6881124 | Direct Sampled1 | ✓ | - |
| GSI-DC-02B | 387879 | 6881129 | Slow Recharge | ✓ | - |
| GSI-DC-03B | 388107 | 6881079 | Slow Recharge | ✓ | - |
| GSI-DC-05B | 388725 | 6880836 | Slow Recharge | ✓ | - |
| GSI-DC-06B | 389788 | 6880567 | Good | ✓ | - |
| GSI-DC-07B | 390065 | 6880641 | Good | ✓ | - |
| GSI-DC-08-B | 390311 | 6880583 | Direct Sampled1 | ✓ | - |
| GSI-DC-09-B | 390614 | 6880494 | Good | ✓ | - |
| GSI-DC-10-B | 390859 | 6880447 | Good | ✓ | - |
| Mill Complex | GSI-HA-01A | 387842 | 6881132 | Slow Recharge | ✓ | - |
| GSI-HA-02A | 387861 | 6881135 | Slow Recharge | ✓ | - |
| GSI-HA-03A | 387878 | 6881131 | Direct Sampled 1 | ✓ | - |
| GSI-HA-04A | 387916 | 6881130 | Good | ✓ | - |
| GSI-HA-05A | 387898 | 6881125 | Slow Recharge | ✓ | - |
| MW09-16 | 387992 | 6881094 | Good | ✓ | Duplicate, Field Blank |
| MW09-17 | 388075 | 6880970 | Dry | - | - |
| MW09-18 | 388054 | 6880986 | Good | ✓ | - |
| MW09-19 | 388051 | 6881016 | Good | ✓ | - |
| Brown McDade Pit | CH-P-13-01/10 | 388657 | 6881116 | Frozen | - | - |
| CH-P-13-03/50 | 389143 | 6881110 | Direct Sampled 1 | ✓ | - |
| CH-P-13-04/10 | 389138 | 6881472 | Frozen | - | - |
| CH-P-13-04/35 | 389138 | 6881472 | Frozen | - | - |
| CH-P-13-05/50 | 388954 | 6881466 | Not Accessible 2 | - | - |
| GLL07-01 | 388851 | 6881783 | Frozen | - | - |
| GLL07-02 | 389069 | 6881703 | Dry | - | - |
| GLL07-03 | 388959 | 6881477 | Not Accessible 2 | - | - |
| MW09-13 | 389006 | 6881664 | Frozen | - | - |
| MW09-14 | 389008 | 6881669 | Frozen | - | - |
| MW09-15 | 388920 | 6881727 | Frozen | - | - |
| Pony Creek | GSI-PC-02-B | 388907 | 6881786 | Destroyed 3 | - | - |
| GSI-PC-03-B | 389256 | 6881706 | Direct Sampled1 | ✓ | - |
| GSI-PC-04-B | 389586 | 6881656 | Direct Sampled1 | ✓ | - |
| GSI-PC-05-B | 389713 | 6881661 | Dry | - | - |
| MP09-02 | 388867 | 6881816 | Destroyed 3 | - | - |
| MP09-03 | 388956 | 6881739 | Direct Sampled 1 | ✓ | - |
| MP09-08 | 389160 | 6881718 | Good | ✓ | Duplicate, Field Blank |
| Seepage Dam | W14103083BH01 | 389522 | 6880669 | Frozen | - | - |
| W14103083BH02 | 389561 | 6880665 | Frozen | - | - |
| W14103083BH04 | 389544 | 6880666 | Frozen | - | - |
| Tailings Facility | MP09-04 | 389575 | 6880609 | Good | ✓ | - |
| MP09-05 | 389548 | 6880590 | Good | ✓ | - |
| MP09-09 | 389240 | 6880681 | Good | ✓ | Duplicate |
| MP09-10 | 389241 | 6880684 | Frozen | - | - |
| MP09-11 | 389220 | 6880619 | Good | - | - |
| MP09-12 | 389220 | 6880619 | Good | - | Field Blank |
| MP09-14 | 389138 | 6880722 | Direct Sampled 1 | ✓ | - |
| MW09-02 | 389393 | 6880562 | Good | ✓ | - |
| MW09-03 | 389411 | 6880555 | Good | ✓ | - |
| MW09-04 | 389420 | 6880557 | Good | ✓ | - |
| MW09-05 | 389413 | 6880656 | Dry | - | - |
| MW09-06 | 389411 | 6880653 | Good | ✓ | - |
| MW09-07 | 389322 | 6880699 | Dry | - | - |
| MW09-08 | 389620 | 6880576 | Good | ✓ | - |
| MW09-11 | 389037 | 6880711 | Dry | - | - |
| MW09-20 | 389592 | 6880586 | Frozen | - | - |
| MW09-21 | 389536 | 6880577 | Good | ✓ | - |
| MW09-22 | 389495 | 6880549 | Good | ✓ | - |
| MW09-23 | 389459 | 6880553 | Good | ✓ | - |
| MW09-24 | 389561 | 6880624 | Good | ✓ | Duplicate, Field Blank |
| W14103083BH03 | 389132 | 6880730 | Frozen | - | - |

**Notes: 1**Direct sampling was completed at sample stations where insufficient water volumes had been encountered during the event, which limited standard purging and sampling methodologies.

**2** Monitoring wells CH-P-13-05/50 and GLL07-03 were not visited during the August 2016 field event due to pit wall stability safety concerns.

**3** Destroyed wells are included in the scope of work and are therefore listed above in the summary table.

Figure 1-2 Groundwater Sampling Locations – Dome Creek and Tailings Facility

Figure 1-3 Groundwater Sampling Locations – Mill Complex and Brown McDade Pit

# Methodology

## Protocols

Groundwater purging, monitoring and sampling conducted by Hemmera/ELR were completed in accordance with the Groundwater Sampling Standard Operating Procedures included in the document *Scope of Work: Mount Nansen Groundwater Scope of Work*. These procedures were consistent with Environment Yukon’s *Protocol for the Contaminated Sites Regulation #7 - Sampling and Decommissioning* (Environment Yukon, 2011). Methods used were also consistent with the ASTM D4448-01 *Standard Guide for Sampling Groundwater Monitoring Wells* (ASTM, 2013), and the D6452-99 *Guide for Purging Methods for Wells used for Groundwater Quality Investigations* (ASTM, 2012).

## Well Measurements and Purging

Upon arriving at each sample station, headspace gases were measured prior to any other well measurements. Oxygen (%), carbon dioxide (ppm), and methane (%LEL) were measured using a Rae Systems MultiRAE Four-Gas Monitor with photoionization detector (PID).

The well structure and casing were inspected for damage, closure, and general conditions. Depth to water (DTW; m), depth to bottom (DTB; m), well diameter (cm), and well stick-up height (m) were then recorded at each well.

DTB and DTW were measured using either a Solinst - Model 102 Water Level Meter (for 2.54 cm diameter wells) or a Solinst – Model 122 Interface Meter (for wells with diameter greater than 2.54 cm). DTB and DTW were measured from (in order of preference): 1) a black mark drawn on the top of the well; 2) the bottom of the most significant notch found on the top of the PVC if a mark was not present; or 3) a line that was drawn on the highest point of the well if no distinguishable point of measure was present. Stick-up height was measured from the lowest point on the bottom of the well casing to the highest point (or distinguishing mark) on the well. Water level meters were cleaned between each sample site using Alconox low-foaming phosphate-free detergent solution and deionized water.

Following initial inspection and measurements, groundwater wells were purged and sampled using dedicated equipment. Groundwater wells were purged and sampled using one of three (3) techniques: 1) manual purging using high density polyethylene (HDPE) Waterra tubing and a footvalve, 2) GeoPump peristaltic pump with HDPE tubing, or 3) manual purging using disposable polyethylene bailers. The purging technique chosen for each well was that which would provide the most representative groundwater sample.

Groundwater wells were determined to be sufficiently purged when either three (3) successive field parameter measurements were recorded to be within an allowable tolerance level (as summarized in **Table 2-1**, below) or when a volume of water equivalent to three (3) standing well volumes of water had been purged.

Groundwater turbidity measured in Nephelometric Turbidity Units (NTU) or Attenuation Units (AU[[1]](#footnote-1)) was also measured prior to sampling (described below in **Section 2.4**) and was used as an indication of sample quality. Where possible, samples were not collected until turbidity was less than 50 NTU. Purge volumes and purge rates were measured using a graduated container and stop watch. All well measurements, purging details, and additional field notes were recorded on customized field forms in order to minimize the potential for field errors.

Table 2-1 Groundwater Sampling – Field Parameter Purging Criteria

|  |  |
| --- | --- |
| **Field Parameter** | **Allowable Variance** |
| Temperature (°C) | ± 3% |
| pH | ± 0.1 |
| Conductivity (µS/cm) | ± 3% |
| Specific Conductivity (µS/cm) | ± 3% |

## Direct Sampling

During previous events a select number of groundwater wells had insufficient volume of groundwater to sample using conventional methods, limiting the number of wells that were sampled during the event. An alternate sampling strategy was established in 2014 by AAM’s consultant (AMEC) in order to obtain samples from low producing wells; this continued to be followed during the August 2016 sampling event. At wells identified as regularly having insufficient volume of water or insufficient recharge, Hemmera/ELR direct sampled (analytical samples collected prior to purging or collecting field parameter measurements), after which time field parameter measurements were collected if possible. Additionally, a priority ranking order for analytical sample collection previously established by AAM’s consultant (AMEC) was used when collecting samples at these direct sampled wells (as summarized in **Table 2-2**). This ranking system was established to ensure that samples for the highest priority parameters were collected first at each well if limited recharge or volume was encountered. Where the volume or recharge limited sample collected, Hemmera/ELR also re-visited wells when feasible, to attempt to collect a more thorough or complete sample set.

In addition to the priority ranking order, Hemmera/ELR also adhered to minimum required sample volumes for laboratory procedures (provided to Hemmera/ELR by ALS Laboratories) where well volume was limited. This allowed the maximum number of program parameters to be collected when volumes were limited.

## Field Parameters

Hemmera/ELR measured *in-situ* water quality parameters using YSI Professional Plus multi-parameter field meters, Lamotte 2020we turbidity meters, and Hach DR 890 Portable Colorimeters. Flow-through cells were used with the YSI meters to minimize field parameter variability; flow-through cells improve the precision of field measurements by limiting sample water contact with air, and by continuously moving sample water across the field meter sensors. The *in-situ* groundwater quality parameters recorded at each sample station included water temperature (oC), specific conductivity (μs/cm), conductivity (μs/cm), oxidation/reduction potential (ORP; mv), pH (pH units), sulphide (mg/l), dissolved oxygen (mg/l and percent saturation), and turbidity (NTU or AU).

During purging, field parameters were monitored at 3 minute intervals, or at volume related intervals (e.g., every 500 mL) in the case of wells with slow recharge. *In-situ* measurements for reporting purposes were recorded at the conclusion of purging.

## Groundwater Sampling

Groundwater quality samples were collected and preserved in accordance with laboratory directions, and using techniques consistent with *Standard Methods for the Examination of Water and Wastewater* (Rice et al., 2012). ALS Global was the analytical laboratory chosen for this project, and a summary of the sample bottle set (including parameters analysed and preservation techniques) is provided in **Table 2-2**.

Table 2-2 Groundwater Sampling Parameter Priority, Preservation, and Intended Analysis

| Priority | Bottle Type | Parameters Analyzed | Minimum Volume | Sample Treatment | Preservative Added |
| --- | --- | --- | --- | --- | --- |
| 1a | 120 ml (plastic) | Dissolved Metals | 100 ml | Field Filtered and Preserved | HNO3 |
| 1b | 40 ml (glass) | Dissolved Mercury | 15 mL | Field Filtered and Preserved | HCl |
| 2 | 500 ml (plastic) | General Chemistry | 100 ml | - | - |
| 3 | 145 ml (plastic) | Cyanide (total, free, weak acid dissociable) | 100 ml | Preserved | NaOH |
| 4 | 120 ml (glass amber) | Ammonia (NH3) | 60 ml | Preserved | H2SO4 |
| 5 | 120 ml (plastic) | Thiocyanate (SCN) | 50 ml | Preserved | HNO3 |
| 6 | 120 ml (glass amber) | Total Inorganic Carbon (TIC) | 50 ml | - | - |

## Data Management and Analysis

Groundwater analytical field and laboratory results were tabulated and reviewed using Hemmera/ELR’s EQWin Data Manager water quality database. Data was tabulated for the report and compared to the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FAL; CCME, 2014) standards using the database application. All relevant CCME FAL guidelines are presented alongside data in **Table A**.

## Quality Assurance and Quality Control

### Field QA/QC

Several controls were used by Hemmera/ELR staff while in the field to ensure that sample integrity was maintained and that data were recorded completely and accurately. All equipment used during the sampling process was dedicated to individual wells, including HDPE tubing and Waterra footvalves, laboratory provided pre-cleaned sample bottles, disposable filters, disposable syringes, and disposable polyethylene bailers. Field staff used dedicated disposable nitrile gloves for all measurements, purging, and sampling. Water level meters were cleaned between well locations using Alconox low-foaming phosphate-free detergent and deionized water, and field instruments (YSI field meters, turbidity meters, and portable colorimeters) were checked and calibrated before the site visit to ensure the parameters recorded were as accurate as possible.

Project-specific field data sheets were created for the sampling event to help ensure that all required measurements were taken, and that information was recorded correctly. Field data sheets have been included as **Appendix B** of this report.

### Analytical QA/QC

Analytical QA/QC measures were included in the August 2016 sampling program as outlined in the scope of work and as per standard industry practice. This included the collection of field duplicates and field blanks, and the use of travel blanks. Duplicate samples were collected at a ratio of 10% of the regular samples (1 duplicate was collected for every 10 samples), and one (1) field blank was prepared during each day of sampling (4 field blanks collected). Two travel blanks accompanied the analytical supplies and samples from the laboratory to the field, and back to the laboratory again (one for each two shipments).

The variation between sample and duplicate results was calculated as relative percent difference (RPD). RPD provides a measure of the relative difference between two values in comparison to their mean value, and is calculated as the difference between a sample and its field duplicate over the average of two values. RPD values greater than 20% indicate a greater than expected variation in data that could potentially have affected the precision of sampling or analysis. RPD was calculated according to the following formula:

Where *X1* is the sample result and *X2* is the corresponding duplicate result. RPD is not considered valid and is therefore not calculated if either the sample or the field duplicate concentration is less than five times the detection limit.

The analytical results for field and travel blanks were reviewed to determine whether any of the parameters tested were detected (i.e., result exceeding the detection limit). In such cases, the parameter or element in question and its concentration were reviewed to determine potential sources of contamination or error.

# Results

A summary of laboratory analytical results in the context of CCME FAL guidelines is presented in **Table A** of this report. A summary of the QA/QC sampling results is presented in **Table B**, including analytical data for duplicates, field blanks, and travel blanks. Laboratory analytical reports are presented in **Appendix C**.

## Groundwater Sampling Summary

Groundwater sampling was completed between August 29 and 31, 2016. Weather conditions varied throughout the time of sampling with ambient air temperature ranging from 0 to 10 °C. Periods of light snow and rain, and heavy to light wind occurred throughout the sampling event.

Of the sixty (60) wells specified for the August 2016 sampling event, fifty-six (56) were located and assessed during the program. As noted in **Section 1.2**, two (2) groundwater wells listed in the scope of work had previously been reported as destroyed (GSI-PC-02-B and MP09-02), and two (2) were not accessible due to safety concerns at the Brown McDade Pit (GLL07-03 and CH-P-13-05/50). Further details concerning these wells are provided in **Section 3.2**.

Of the fifty-six (56) wells located, thirty-five (35) wells were sampled; twenty-seven (27) using purging and sample methods as per the program protocols, and eight (8) direct sampled without purging according to the sample priority ranking (**Table 2-2**). In five (5) of the eight (8) direct sampled wells, volumes were insufficient to collect a full sample set. **Table 3-1** provides a summary of limited sample set collection.

Of the remaining twenty-one (21) wells that were assessed but not sampled during the program, fourteen (14) wells were frozen, and seven (7) wells were dry. Despite not collecting water quality samples, these wells were still assessed and water/ice depth, well depth, and headspace gas measurements were collected to the extent possible. A summary of the overall condition (status) and sampling result for groundwater wells is provided in **Table 1-1**, and a summary of all well measurements, purge details, and *in-situ* parameter results is provided in **Table 3-2**.

Table 3-1 Summary of Direct Samples Collected During August 2016 Sampling Program

| Well Name | Dissolved Metals | Dissolved Mercury | Physical Parameters/Anions/ Nutrients | Cyanide | Ammonia | Thiocyanate | Total Inorganic Carbon |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Priority | 1a | 1b | 2 | 3 | 4 | 5 | 6 |
| GSI-DC-01B | ✓ | - | - | - | - | - | - |
| GSI-DC-08B | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSI-HA-03A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CH-P-13-03/50 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSI-PC-03B | ✓ | ✓ | ✓ | - | - | - | - |
| GSI-PC-04B | ✓ | ✓ | ✓ | ✓ | - | - | - |
| MP09-03 | ✓ | ✓ | ✓ | ✓ | - | - | - |
| MP09-14 | ✓ | ✓ | ✓ | - | - | - | - |

**Notes:** Refer to **Section 2.2** for details concerning direct sampling methodologies, including minimum volume collection. Samples were collected based on field priority ranking as specified in **Table 2-2**.

Table 3-2 Groundwater Field Parameters and Well Measurements for August 2016 Sampling Program

| **Area** | **Location ID** | **Sample Date** | **Status** | **Stick up Height (m)** | **Depth To Water (m)** | **Depth to Bottom (m)** | **Standing Water Volume (L)** | **Volume Purged (L)** | **Purge Start Time** | **Purge End Time** | **Elapsed Purge Time** | **Purge Rate (l/min)** | **Criteria1 (3WV/PS/DS)** | **Draw Down (m)** | **pH** | **Temperature (ºC)** | **Conductivity (µS/cm)** | **Specific Conductivity (µS/cm)** | **ORP (mV)** | **Dissolved Oxygen (mg/L)** | **Field Sulphide (mg/L)** | **Methane (%LEL)** | **Oxygen (%)** | **Carbon Dioxide (ppm)** | **Field Turbidity (NTU)** | **Method Used** | **Well Diameter (cm)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dome Creek | GSI-DC-01A | 8/29/2016 | Good | 0.93 | 0.857 | 1.552 | 0.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-DC-01B2 | 8/29/2016 | Direct Sample | 0.96 | 1.247 | 1.702 | 0.2 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-DC-02A | 8/29/2016 | Good | 1.02 | 1.603 | 1.861 | 0.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 500 | - | peristaltic | 2.54 |
| GSI-DC-02B | 8/30/2016 | Slow Recharge | 0.88 | 1.845 | 3.800 | 1.0 | 0.5 | - | - | - | - | PDR | 1.955 | 7.57 | 4.1 | 612 | 1018 | -59.9 | 5.60 | 0.11 | 0 | 20.9 | 500 | 46.5 | peristaltic | 2.54 |
| GSI-DC-03A | 8/29/2016 | Good | 0.99 | 1.248 | 1.855 | 0.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-DC-03B | 8/30/2016 | Slow Recharge | 0.96 | 1.405 | 1.860 | 0.2 | 0.5 | 13:04 | 13:06 | 0:02 | - | PDR | 0.455 | 7.28 | 4.4 | 556 | 916 | 172.9 | 5.63 | 0.25 | 0 | 20.9 | 300 | 58.2 | peristaltic | 2.54 |
| GSI-DC-05A | 8/29/2016 | Good | 1.15 | 1.334 | 1.940 | 0.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-DC-05B | 8/30/2016 | Slow Recharge | 0.65 | 0.930 | 2.865 | 1.0 | 0.5 | 16:35 | 16:38 | 0:03 | - | PDR | 1.935 | 7.23 | 1.9 | 770 | 1380 | 50.9 | 2.39 | 0.80 | 0 | 20.9 | 500 | 9203 | peristaltic | 2.54 |
| GSI-DC-06A | 8/31/2016 | Good | 0.84 | 1.816 | 2.001 | 0.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-DC-06B | 8/31/2016 | Good | 0.49 | 0.720 | 2.910 | 1.2 | 2.9 | 10:43 | 11:05 | 0:22 | 0.1 | PS | - | 7.50 | 2.7 | 570 | 993 | -143.4 | 0.69 | 0.06 | 0 | 20.9 | 300 | 42.7 | peristaltic | 2.54 |
| GSI-DC-07A | 8/31/2016 | Good | 1.06 | 1.845 | 1.853 | 0.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-DC-07B | 8/31/2016 | Good | 1.05 | 1.370 | 3.770 | 1.3 | 4.0 | 11:57 | 12:23 | 0:26 | 0.2 | 3WV | - | 6.96 | 2.9 | 590 | 1022 | -64.3 | 0.96 | 0.05 | 0 | 20.9 | 400 | 8.7 | peristaltic | 2.54 |
| GSI-DC-08A | 8/31/2016 | Good | 1.05 | 1.309 | 2.008 | 0.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 300 | - | peristaltic | 2.54 |
| GSI-DC-08B2 | 8/31/2016 | Direct Sample | 0.46 | 0.796 | 2.902 | 1.2 | - | - | - | - | - | DS | - | 6.60 | 8.9 | 839 | 1212 | -35.7 | 2.48 | 0.80 | 0 | 20.7 | 200 | 15403 | peristaltic | 2.54 |
| GSI-DC-09A | 8/31/2016 | Good | 0.94 | 1.136 | 2.000 | 0.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 300 | - | peristaltic | 2.54 |
| GSI-DC-09B | 8/31/2016 | Good | 0.91 | 1.125 | 3.852 | 1.5 | 3.0 | 13:50 | 14:12 | 0:22 | 0.1 | PS | - | 7.12 | 2.7 | 219 | 382 | -66.0 | - | - | 0 | 20.7 | 300 | 8.4 | peristaltic | 2.54 |
| GSI-DC-10A | 8/31/2016 | Good | 1.29 | 1.060 | 2.009 | 0.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 300 | - | peristaltic | 2.54 |
| GSI-DC-10B | 8/31/2016 | Good | 1.22 | 1.121 | 3.794 | 1.5 | 3.0 | 12:45 | 13:10 | 0:25 | 0.1 | PS | - | 6.65 | 1.8 | 696 | 1251 | -45.7 | 0.26 | 0.02 | 0 | 20.7 | 300 | 6.6 | peristaltic | 2.54 |
| Mill Complex | GSI-HA-01A | 8/30/2016 | Slow Recharge | 1.23 | 2.065 | 3.130 | 0.6 | 0.5 | - | - | - | - | PDR | - | 7.07 | 4.3 | 664 | 1097 | -19.8 | 5.12 | - | 0 | 20.9 | 400 | - | peristaltic | 2.54 |
| GSI-HA-02A | 8/30/2016 | Slow Recharge | 1.54 | 1.828 | 2.785 | 0.6 | 0.5 | - | - | - | - | PDR | - | 6.89 | 6.6 | 680 | 1047 | -44.2 | 2.57 | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-HA-03A2 | 8/29/2016 | Direct Sample | 1.00 | 1.141 | 2.190 | 0.6 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-HA-04A | 8/29/2016 | Good | 0.68 | 1.015 | 2.194 | 0.7 | 2.0 | 10:32 | 10:47 | 0:15 | 0.1 | PS | - | 6.66 | 4.0 | 525 | 877 | -26.6 | 7.70 | 0.06 | 0 | 20.9 | 300 | 2.8 | peristaltic | 2.54 |
| GSI-HA-05A | 8/30/2016 | Slow Recharge | 1.14 | 1.340 | 2.189 | 0.5 | 2.5 | 10:11 | 10:13 | 0:02 |  | PDR | - | 7.15 | 7.1 | 686 | 1042 | -87.9 | 6.53 | 0.15 | 0 | 20.9 | 300 | 42.1 | peristaltic | 2.54 |
| MW09-16 | 8/29/2016 | Good | 1.39 | 1.922 | 2.730 | 1.6 | 4.0 | 11:07 | 11:25 | 0:18 | 0.1 | PS | - | 6.63 | 6.6 | 1086 | 1673 | 170.0 | 2.26 | 0.01 | 0 | 24.7 | 1900 | 0.2 | peristaltic | 5.08 |
| MW09-17 | 8/29/2016 | Dry | 0.98 | - | 5.725 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4.2 | 427 | - | - | 5.08 |
| MW09-18 | 8/29/2016 | Good | 0.88 | 4.460 | 7.794 | 6.6 | 2.0 | 12:29 | 12:42 | 0:13 | 0.5 | PS | - | 6.91 | 1.8 | 1591 | 2862 | 41.5 | 0.18 | 0.01 | 0 | 20.9 | 800 | 7.1 | peristaltic | 5.08 |
| MW09-19 | 8/29/2016 | Good | 0.99 | 2.400 | 5.900 | 7.0 | 3.5 | 13:28 | 13:50 | 0:22 | 0.3 | PS | - | 6.77 | 4.0 | 1360 | 2271 | -28.4 | 0.24 | 0.15 | 0 | 20.9 | 300 | 2.6 | peristaltic | 5.08 |
| Brown McDade Pit | CH-P-13-01/10 | 8/29/2016 | Frozen | 0.48 | 6.800 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 500 | - | - | 3.81 |
| CH-P-13-03/502 | 8/29/2016 | Direct Sample | 0.56 | 46.921 | 50.528 | 1.8 | - | - | - | - | - | DS | - | - | - | - | - | - | - | 0.09 | 0 | 20.9 | 400 | 28.1 | disp. bailer | 3.81 |
| CH-P-13-04/10 | 8/29/2016 | Frozen | 0.68 | 6.100 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 22.3 | 200 | - | - | 3.81 |
| CH-P-13-04/35 | 8/29/2016 | Frozen | 0.61 | 6.500 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 21.6 | 300 | - | - | 3.81 |
| CH-P-13-05/504 | - | Not Accessible | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.08 |
| GLL07-01 | 8/29/2016 | Frozen | 0.75 | 13.824 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 200 | - | - | 5.08 |
| GLL07-02 | 8/29/2016 | Dry | 1.27 | - | 7.257 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 19.5 | 4600 | - | - | 5.08 |
| GLL07-034 | - | Not Accessible | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.08 |
| MW09-13 | 8/29/2016 | Frozen | 0.76 | 8.710 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.3 | 3500 | - | - | 5.08 |
| MW09-14 | 8/29/2016 | Frozen | 0.74 | 6.835 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 500 | - | - | 5.08 |
| MW09-15 | 8/29/2016 | Frozen | 0.88 | 14.161 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 300 | - | - | - |
| Pony Creek | GSI-PC-02B5 | - | Destroyed | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| GSI-PC-03A | 8/31/2016 | Good | 0.97 | 1.016 | 2.002 | 0.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 1.27 |
| GSI-PC-03B2 | 8/31/2016 | Direct Sample | 0.96 | 1.972 | 2.834 | 0.6 | - | - | - | - | - | DS | 0.862 | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 1.27 |
| GSI-PC-04A | 8/31/2016 | Frozen | 0.98 | 1.342 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 1.27 |
| GSI-PC-04B2 | 8/31/2016 | Direct Sample | 1.05 | 1.850 | 2.900 | 0.6 | - | - | - | - | - | DS | 1.050 | - | - | - | - | - | - | - | 0 | 20.9 | 500 | - | peristaltic | 1.27 |
| GSI-PC-05A | 8/31/2016 | Dry | 0.89 | - | 2.000 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 1000 | - | - | 1.27 |
| GSI-PC-05B | 8/31/2016 | Dry | 0.89 | - | 3.715 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 9.0 | 6500 | - | - | - |
| MP09-025 | - | Destroyed | 0.62 | 1.618 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MP09-032 | 8/31/2016 | Direct Sample | 0.62 | 1.058 | 1.980 | 1.1 | - | - | - | - | - | DS | 0.922 | - | - | - | - | - | - | - | 0 | 20.9 | 200 | - | peristaltic | 1.27 |
| MP09-08 | 8/31/2016 | Good | 0.57 | 0.450 | 1.974 | 0.8 | 3.5 | 10:30 | 10:59 | 0:29 | 0.1 | PS | - | 7.14 | 1.1 | 457 | 840 | -16.8 | 0.24 | 0.05 | 0 | 20.3 | 500 | 2.6 | peristaltic | 1.27 |
| Seepage Dam | W14103083BH01 | 8/30/2016 | Frozen | 0.65 | 6.496 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 500 | - | - | 5.08 |
| W14103083BH02 | 8/30/2016 | Frozen | 0.78 | 6.705 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 5.08 |
| W14103083BH04 | 8/30/2016 | Frozen | 0.77 | 6.570 | - | - | - | - | - | - | - | - | - | - | - | - |  |  |  |  | 0 | 20.9 | 320 | - | - | 5.08 |
| Tailings Facility | MP09-04 | 8/30/2016 | Good | 1.20 | 2.070 | 3.080 | 1.1 | 4.6 | 9:40 | 10:01 | 0:21 | 0.2 | PS | - | 6.96 | 2.8 | 659 | 1142 | 86.8 | 1.96 | 0.01 | 0 | 20.9 | 500 | 2.4 | peristaltic | 5.08 |
| MP09-05 | 8/30/2016 | Good | 1.10 | 1.386 | 1.830 | 0.5 | 2.4 | 10:34 | 10:56 | 0:22 | 0.1 | PS | - | 6.69 | 6.4 | 1221 | 1895 | 25.2 | 1.55 | 0.03 | 0 | 20.9 | 1400 | 5.4 | peristaltic | 5.08 |
| MP09-09 | 8/30/2016 | Good | 2.59 | 3.782 | 5.653 | 3.7 | 3.5 | 16:28 | 17:07 | 0:39 | 0.1 |  | - | 9.52 | 6.3 | 344 | 536 | -25.6 | 0.11 | 0.31 | 0 | 20.7 | 300 | 98.2 | peristaltic | 5.08 |
| MP09-10 | 8/30/2016 | Frozen | 2.31 | 3.446 | 3.952 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 200 | - | - | 2.54 |
| MP09-11 | 8/30/2016 | Good | 2.10 | 2.115 | 4.959 | 3.1 | 2.4 | 18:07 | 18:34 | 0:27 | 0.1 | PS | - | 7.79 | 7.4 | 473 | 713 | -130.5 | 0.80 | - | 14 | 19.9 | 3000 | 83.1 | peristaltic | 2.54 |
| MP09-12 | 9/1/2016 | Good | 2.01 | 2.170 | 4.240 | 3.1 | 2.5 | 18:00 | 18:05 | 0:05 | - | PS | - | 8.04 | 8.4 | 460 | 690 | -75.6 | 11.30 | 0.80 | 0 | 20.9 | 400 | 30503 | peristaltic | 2.54 |
| MP09-142 | 8/29/2016 | Direct Sample | 0.73 | 0.752 | 1.610 | 0.4 | - | - | - | - | - | DS | 0.858 | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| MW09-02 | 8/30/2016 | Good | 0.73 | 2.888 | 4.737 | 3.6 | 2.5 | 13:13 | 13:36 | 0:23 | 0.2 | PS | - | 7.16 | 4.2 | 1499 | 2487 | -79.4 | 0.05 | 0.02 | 0 | 20.7 | 500 | 6.5 | peristaltic | 2.54 |
| MW09-03 | 8/30/2016 | Good | 0.38 | 6.356 | 9.962 | 7.2 | 2.0 | 11:12 | 11:33 | 0:21 | 0.3 | PS | - | 8.25 | 3.3 | 1544 | 2634 | -72.4 | 0.07 | 0.00 | 0 | 20.9 | 300 | 10.8 | peristaltic | 2.54 |
| MW09-23 | 8/30/2016 | Good | 0.18 | 12.614 | 15.842 | 6.5 | 6.0 | 10:12 | 10:41 | 0:29 | 0.2 | PS | - | 7.18 | 1.2 | 776 | 1425 | -66.9 | 2.18 | 0.05 | 0 | 20.9 | 300 | 11.7 | Waterra | 5.08 |
| MW09-24 | 8/30/2016 | Good | 0.67 | 9.628 | 11.945 | 4.6 | 70.0 | 9:00 | 9:31 | 0:31 | 2.3 | PS | - | 7.23 | 0.7 | 455 | 850 | 197.0 | 5.07 | 0.09 | 0 | 20.9 | 1400 | 28.4 | Waterra | 5.08 |
| W14103083BH03 | 8/29/2016 | Frozen | 0.80 | 1.865 | 4.560 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 500 | - | - | 5.08 |
| MW09-04 | 8/30/2016 | Good | 0.24 | 3.926 | 7.694 | 7.5 | 3.5 | 11:52 | 12:25 | 0:33 | 0.1 | PS | - | 8.41 | 4.4 | 1602 | 2634 | -64.8 | 0.08 | 0.00 | 0 | 20.7 | 300 | 0.5 | peristaltic | 5.08 |
| MW09-05 | 8/30/2016 | Dry | 1.45 | - | 7.572 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 10.8 | 7900 | - | - | 5.08 |
| MW09-06 | 8/30/2016 | Good | 2.37 | 3.809 | 6.055 | 4.5 | 4.5 | 14:30 | 15:11 | 0:41 | 0.1 | PS | - | 7.39 | 8.5 | 1034 | 1512 | 32.6 | 1.20 | 0.01 | 0 | 20.6 | 300 | 7.1 | peristaltic | 5.08 |
| MW09-07 | 8/29/2016 | Dry | 1.26 | - | 3.399 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 900 | - | - | 5.08 |
| MW09-08 | 8/30/2016 | Good | 1.14 | 1.167 | 3.900 | 5.5 | 6.2 | 8:43 | 9:09 | 0:26 | 0.2 | PS | - | 6.71 | 4.7 | 160 | 262 | -97.3 | 2.00 | 0.04 | 19 | 20.0 | 4900 | 4.2 | peristaltic | 5.08 |
| MW09-11 | 8/29/2016 | Dry | 0.85 | - | 4.930 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 1200 | - | - | 5.08 |
| MW09-20 | 8/29/2016 | Frozen | 0.93 | 3.690 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 1400 | - | - | 5.08 |
| MW09-21 | 8/30/2016 | Good | 0.74 | 1.704 | 3.603 | 3.6 | 4.2 | 11:17 | 11:53 | 0:36 | 0.1 | PS | - | 6.81 | 5.3 | 1135 | 1820 | -27.5 | 1.25 | 0.06 | 0 | 20.7 | 300 | 28.6 | peristaltic | 5.08 |
| MW09-22 | 8/29/2016 | Good | 0.87 | 4.224 | 5.299 | 2.0 | 1.5 | 16:54 | 17:20 | 0:26 | 0.1 | PS | - | 6.44 | 4.5 | 395 | 649 | 9.3 | 0.59 | 0.08 | 0 | 20.9 | 400 | 21.3 | peristaltic | 5.08 |

**Notes:**To maximize the sample return for analytical analysis, field parameters were not collected at all direct sampled wells. Shaded rows indicate monitoring stations where analytical samples were collected.

1 3WV = Three standing well volumes purged prior to sample collection, PS = field parameters stabilized prior to sample collection, PDR = purge dry and return, and DS = sample collected directly without purging.

2Due to low well volumes (direct sampling), field parameters were not measured.

3 Turbidity measurement exceed Nephelometric Turbidity Units and was therefore measured in Attenuation Unit (AU).

4 Well was not accessible during the sampling event due to health and safety concerns in the Brown McDade Pit.

5 Well has been destroyed by placer mining activity.

## Analytical Results

Analytical results are summarized below, including a brief summary of CCME FAL guideline exceedances and a description of factors that may have influenced the data. Details regarding well status, including a description of damaged or underperforming wells, are also provided.

In several instances, laboratory reportable detection limits (RDL) for parameters exceeded applicable CCME FAL standards (lightly shaded values in**Table A**). In these cases, samples having elevated levels of certain parameters required laboratory dilution prior to performing the required analyses, thereby resulting in an elevated RDL. For the purpose of this report, samples where the reported RDL is greater than the applicable guideline have not been reported as CCME FAL exceedances.

### Dome Creek

Groundwater wells along Dome Creek were monitored between August 29 and September 1, 2016. All nine (9) drive-point piezometers located in this area were sampled. Of the nine (9) wells sampled, two (2) were direct sampled, four (4) were sampled as per normal groundwater sampling protocol, and three (3) were purged dry on a first site visit then sampled the following day when full or nearly full recharge had occurred. A summary of field measurements, including headspace gases, is provided in **Table 3-2**.

CCME FAL guideline exceedances were observed at all of nine (9) sites sampled in the Mill Complex area, including exceedances of ammonia (one site), dissolved fluoride (three sites), dissolved arsenic (seven sites), dissolved copper (one site), dissolved iron (seven sites) and dissolved selenium (one site). Where measured (seven sites), field dissolved oxygen concentrations were less than the CCME FAL minimum concentration. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Where measured, groundwater turbidity of the samples collected was less than 50 NTU in five (5) of the eight (8) sites. Groundwater turbidity measurements at three (3) sites were greater than 50 NTU; GSI-DC-05B (920 AU), GSI-DC-08B (1549 AU), and GSI-DC-03B (58.2 NTU). Due to limited well volumes, groundwater turbidity was not measured at the sample location (GSI-DC-01B) within the Dome Creek area (**Table 3-2**).

### Mill Complex

Groundwater in the Mill Complex Area was sampled between August 29 and August 30, 2016. Samples were obtained from eight (8) of the nine (9) wells identified in this area. One (1) of the wells identified in this area was found dry at the time of sampling (MW09-17). Hemmera/ELR observed bentonite residue at the bottom of the well, which appears to be from a breakage at approximately 1.3 m down the well. The frozen blockage of bentonite that was encountered at this well in May of 2016 (1.310 m deep) appears to have thawed and dispersed through the summer of 2016. Drive-point GSI-HA-03A was direct sampled without purging, while wells GSI-HA-04A, MW09-16, MW09-18, and MW09-19 were sampled according program protocols. Drive-points GSI-HA-01A, GSI-HA-02A, and GSI-HA-05A were direct sampled, but Hemmera/ELR returned to these wells and found that they had nearly fully recharged, and therefore the original samples were discarded and new more representative samples were collected (thus the purge criteria was classified as purged dry and returned to sample). A summary of the samples collected is provided in **Table 3-1**, and analytical results are provide in **Table A**.

CCME FAL guideline exceedances were observed at all of the eight (8) sites sampled in the Mill Complex area, including exceedances of ammonia (two sites), dissolved fluoride (two sites), dissolved arsenic (seven sites), dissolved copper (one site), dissolved iron (six sites) and dissolved zinc (two sites). Where measured (seven sites), field dissolved oxygen concentrations were less than the CCME FAL minimum concentration. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Where measured, groundwater turbidity of the samples collected was less than 50 NTU. (**Table 3-2**).

### Brown McDade Pit

Groundwater wells in the Brown McDade Pit area were sampled on August 29, 2016. Samples were obtained from only one (1) of the eleven (11) sites identified in this area (CH-P-13-03/50), which was direct sampled without purging. Seven (7) wells were frozen during the site visit (CH-P-13-01/10, CH-P-13-04/10, CH-P-13-04/35, GLL07-01, MW09-13, MW09-14, and MW09-15), and one (1) well was dry (GLL07-02). Two (2) wells (CH-P-13-05/50 and GLL07-03) were not accessible during the time of sampling due to safety concerns due to pit wall instability (access to the Brown McDade Pit was restricted by AAM). A summary of the samples collected is provided in **Table 3-2**, and analytical results are provide in **Table A**.

CCME FAL guideline exceedances were observed in the one (1) site sampled in this area, including dissolved fluoride, dissolved copper, and dissolved selenium. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Groundwater turbidity was less than 50 NTU at the sample site (CH-P-13-03/50) within the Brown McDade Pit area (**Table 3-2**).

Table 3-3 Summary of CCME FAL Guideline Exceedances for August 2016 Sampling Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Area** | **Sample ID** | **Date Sampled** | **ALS Work Number** | **Parameter** | **Field pH** | **Field Dissolved Oxygen** | **Ammonia, Total (as N)** | **Fluoride (F)** | **Nitrite (as N)** | **Cyanide, Free** | **Arsenic (As)** | **Copper (Cu)** | **Iron (Fe)** | **Lead (Pb)** | **Mercury (Hg)** | **Selenium (Se)** | **Silver (Ag)** | **Zinc (Zn)** |
| **Units** | **pH units** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| **CCME-FAL1, 6** | **6.5-9.0** | **9.5** | **Varies** | **0.12** | **0.06** | **0.005** | **0.005** | **Varies** | **0.3** | **Varies** | **0.000026** | **0.001** | **0.0001** | **0.03** |
| Dome Creek | GSI-DC-01B | 8/29/2016 | L1823304 | Direct Sample | - | - | **-** | - | **-** | - | - | 0.0276 | - | **-** | **-** | **-** | **-** | **-** |
| GSI-DC-02B | 8/30/2016 | L1822156 | Slow Recharge | **-** | 5.60 | **-** | - | **-** | **-** | 0.162 | **-** | 42.7 | **-** | **-** | **-** | **-** | **-** |
| GSI-DC-03B | 8/30/2016 | L1822156 | Slow Recharge | **-** | 5.63 | **-** | 0.123 | **-** | **-** | **-** | **-** | - | **-** | **-** | **-** | **-** | **-** |
| GSI-DC-05B | 8/30/2016 | L1822156 | Slow Recharge | **-** | 2.39 | 0.899 | - | **-** | **-** | 0.0385 | **-** | 6.67 | **-** | **-** | - | **-** | **-** |
| GSI-DC-06B | 8/31/2016 | L1823304 | Good | **-** | 0.69 | **-** | 0.35 | **-** | **-** | 0.444 | **-** | 19.5 | **-** | **-** | **-** | **-** | **-** |
| GSI-DC-07B | 8/31/2016 | L1823304 | Good | **-** | 0.96 | **-** | - | **-** | - | 0.140 | **-** | 19.2 | **-** | **-** | **-** | **-** | **-** |
| GSI-DC-08B | 8/31/2016 | L1823304 | Direct Sample | **-** | 2.48 | - | 0.16 | - | - | 0.106 | **-** | 134 | **-** | **-** | 0.00155 | **-** | **-** |
| GSI-DC-09B | 8/31/2016 | L1823304 | Good | **-** | - | **-** | **-** | **-** | **-** | 0.0696 | **-** | 8.75 | **-** | **-** | **-** | **-** | **-** |
| GSI-DC-10B | 8/31/2016 | L1823304 | Good | **-** | 0.26 | **-** | **-** | **-** | **-** | 0.132 | **-** | 67.5 | **-** | **-** | **-** | **-** | **-** |
| Mill Complex | GSI-HA-01A | 8/30/2016 | L1822156 | Slow Recharge | **-** | 5.12 | **-** | 0.137 | **-** | **-** | **-** | **-** | 0.825 | **-** | **-** | **-** | **-** | **-** |
| GSI-HA-02A | 8/30/2016 | L1822156 | Slow Recharge | **-** | 2.57 | **-** | **-** | - | **-** | 0.0283 | **-** | 47.5 | **-** | **-** | **-** | **-** | 0.0362 |
| GSI-HA-03A2 | 8/29/2016 | L1822156 | Direct Sample | **-** | - | **-** | **-** | - | <0.050 | 0.0238 | **-** | 33.5 | **-** | **-** | **-** | **-** | - |
| GSI-HA-04A | 8/29/2016 | L1822156 | Good | **-** | 7.70 | **-** | **-** | - | **-** | 0.0342 | **-** | 8.16 | **-** | **-** | **-** | **-** | - |
| GSI-HA-05A | 8/30/2016 | L1822156 | Slow Recharge | **-** | 6.53 | **-** | **-** | - | **-** | 0.0256 | **-** | 6.60 | **-** | **-** | **-** | **-** | - |
| MW09-16 | 8/29/2016 | L1822156 | Good | **-** | 2.26 | **-** | 0.15 | - | **-** | 0.0113 | 0.00612 | **-** | **-** | **-** | **-** | **-** | 3.54 |
| MW09-18 | 8/29/2016 | L1822156 | Good | **-** | 0.18 | **-** | **-** | - | **-** | 0.0554 | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| MW09-19 | 8/29/2016 | L1822156 | Good | **-** | 0.24 | **-** | **-** | - | **-** | 0.140 | **-** | 15.0 | **-** | **-** | **-** | **-** | **-** |
| Brown McDade Pit | CH-P-13-03/50 | 8/29/2016 | L1822156 | Direct Sample | **-** | - | **-** | 0.16 | - | **-** | **-** | 0.00445 | **-** | **-** | **-** | 0.00639 | **-** | **-** |
| Pony Creek | GSI-PC-03B | 8/31/2016 | L1823304 | Direct Sample | **-** | - | **-** | <0.40 | - | **-** | 0.0458 | **-** | 15.7 | **-** | **-** | **-** | **-** | **-** |
| GSI-PC-04B3 | 8/31/2016 | L1823304 | Direct Sample | **-** | - | **-** | **-** | - | **-** | 0.0115 | **-** | 4.59 | **-** | **-** | **-** | **-** | **-** |
| MP09-034 | 8/31/2016 | L1823304 | Direct Sample | **-** | - | **-** | **-** | - | **-** | 0.0342 | **-** | 2.15 | **-** | **-** | **-** | **-** | **-** |
| MP09-08 | 8/31/2016 | L1823304 | Good | **-** | 0.24 | **-** | **-** | - | **-** | 0.0140 | **-** | 0.862 | **-** | **-** | **-** | **-** | **-** |

Table 3-3 Summary of CCME FAL Guideline Exceedances for August 2016 Sampling Program (Con’t)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Area** | **Sample ID** | **Date Sampled** | **ALS Work Number** | **Parameter** | **Field pH** | **Field Dissolved Oxygen** | **Ammonia, Total (as N)** | **Fluoride (F)** | **Nitrite (as N)** | **Cyanide, Free** | **Arsenic (As)** | **Copper (Cu)** | **Iron (Fe)** | **Lead (Pb)** | **Mercury (Hg)** | **Selenium (Se)** | **Silver (Ag)** | **Zinc (Zn)** |
| **Units** | **pH units** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| **CCME-FAL1, 6** | **6.5-9.0** | **9.5** | **Varies** | **0.12** | **0.06** | **0.005** | **0.005** | **Varies** | **0.3** | **Varies** | **0.000026** | **0.001** | **0.0001** | **0.03** |
|  | MP09-04 | 8/30/2016 | L1822156 | Good | **-** | 1.96 | **-** | 0.42 | - | **-** | 3.52 | **-** | **-** | **-** | **-** | **-** | **-** | 0.554 |
| MP09-05 | 8/30/2016 | L1822156 | Good | **-** | 1.55 | **-** | **-** | - | **-** | 0.0128 | 0.00587 | 3.84 | **-** | **-** | **-** | **-** | **-** |
| MP09-09 | 8/30/2016 | L1822156 | Good | 9.52 | 0.11 | 3.91 | 1.81 | - | 1.15 | 23.4 | 0.214 | **-** | **-** | 0.0000395 | 0.00110 | 0.00151 | **-** |
| MP09-11 | 8/30/2016 | L1822156 | Good | **-** | 0.80 | 15.1 | 0.625 | - | **-** | 4.58 | **-** | 15.0 | 0.0560 | **-** | **-** | **-** | 0.0475 |
| MP09-12 | 9/1/2016 | L1823304 | Good | **-** | - | 5.96 | 0.30 | - | **-** | 7.40 | **-** | 6.32 | **-** | **-** | **-** | **-** | 0.0397 |
| MP09-145 | 8/29/2016 | L1823304 | Direct Sample | **-** | - | **-** | 0.24 | - | **-** | 0.502 | **-** | 0.767 | **-** | **-** | **-** | **-** | **-** |
| MW09-02 | 8/30/2016 | L1822156 | Good | **-** | 0.05 | **-** | 0.55 | - | **-** | 13.8 | **-** | 18.1 | **-** | **-** | **-** | **-** | 0.352 |
| MW09-03 | 8/30/2016 | L1822156 | Good | **-** | 0.07 | 6.59 | 0.32 | - | 0.0085 | 2.26 | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| MW09-04 | 8/30/2016 | L1822156 | Good | **-** | 0.08 | **-** | **-** | - | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| MW09-06 | 8/30/2016 | L1822156 | Good | **-** | 1.20 | **-** | 0.261 | - | **-** | 0.124 | 0.00509 | **-** | **-** | **-** | **-** | **-** | 0.113 |
| MW09-08 | 8/30/2016 | L1822156 | Good | **-** | 2.00 | **-** | 0.147 | - | **-** | 0.110 | **-** | 31.8 | **-** | **-** | **-** | **-** | **-** |
| MW09-21 | 8/30/2016 | L1822156 | Good | **-** | 1.25 | **-** | **-** | - | **-** | 0.0535 | **-** | 15.3 | **-** | **-** | **-** | **-** | **-** |
| MW09-22 | 8/29/2016 | L1822156 | Good | 6.44 | 0.59 | **-** | **-** | 0.0646 | **-** | 0.0111 | **-** | 15.2 | **-** | **-** | **-** | **-** | **-** |
| MW09-23 | 8/30/2016 | L1822156 | Good | **-** | 2.18 | **-** | **-** | **-** | **-** | 0.0353 | **-** | 15.7 | **-** | **-** | **-** | **-** | **-** |
| MW09-24 | 8/30/2016 | L1822156 | Good | - | 5.07 | - | - | - | - | - | 0.00666 | - | - | - | - | - | - |

**Notes:** 1 CCME guideline exceedances shaded with dark grey. Light grey shading denotes reportable detection limit in exceedance of CCME guideline.

2 Due to slow recharge and low well volumes, samples were collected from GSI-HA-03A between August 29 and August 30, 2016. Thiocyanate, total ammonia, and TIC were collected on August 30, 2016. All other parameters were collected on August 29, 2016.

3 Due to slow recharge and low well volumes, samples were collected from GSI-PC-04B between August 31 and September 1, 2016. Dissolved metals, dissolved mercury, and general chemistry were collected on August 31, 2016. Cyanide was collected on September 1, 2016.

4 Due to slow recharge and low well volumes, samples were collected from MP09-03 between August 31 and September 1, 2016. Dissolved metals, dissolved mercury, and general chemistry were collected on August 31, 2016. Cyanide was collected on September 1, 2016.

5 Due to slow recharge and low well volumes, samples were collected from MP09-14 between August 29 and August 31, 2016. Dissolved metals was collected on August 29, 2016. Dissolved mercury and general chemistry was collected on August 31, 2016.

6 Refer to **Table A** for full analytical report.

“–“ indicates either no exceedance was observed or no analysis was conducted.

### Pony Creek

Groundwater wells along Pony Creek were monitored between August 30 and 31, 2016. One (1) of the seven (7) groundwater wells identified in the Pony Creek area was dry during the time of sampling (GSI-PC-05B). Two (2) of the six (6) remaining wells identified in this area had been previously destroyed by placer mining activity (GSI-PC-02B and MP09-02) and therefore could not be monitored. Of the remaining four (4) wells sampled, three (3) were sampled directly without purging (GSI-PC-03B, GSI-PC-04B, and MP09-03), and one (1) was sampled according to program protocols (MP09-08). A summary of the samples collected is provided in **Table 3-2**, and analytical results are provide in **Table A**.

CCME FAL guideline exceedances were observed at the four (4) sites sampled in the Pony Creek area, including exceedances of dissolved arsenic (four sites) and dissolved iron (four sites). Where measured (one site), field dissolved oxygen concentration was less than the minimum CCME FAL guideline level. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Groundwater turbidity of the one sample measured in this area was less than 50 NTU. Due to limited well volumes, groundwater turbidity was not measured at the other sample locations (GSI-PC-03B, GSI-PC-04B, and MP09-03) within the Pony Creek area (**Table 3-2**).

### Seepage Dam

Groundwater wells in the Seepage Dam area were monitored on August 30, 2016. All three (3) of the groundwater wells in this area were frozen at the time of sampling. A summary of field measurements collected for each site is provided **Table 3-2**.

### Tailings Facility

Groundwater wells in the Tailings Facility area were sampled between August 29 and September 1, 2016. Samples were obtained from fifteen (15) of the twenty-one (21) sample sites located in this area. Three (3) of the twenty-one (21) groundwater wells identified in the Tailings Facility area were frozen at the time of sampling (MP09-10, MW09-20, and W14103083BH03), and another three (3) were dry at the time of sampling (MW09-05, MW09-07, and MW09-11). Of the fifteen (15) wells sampled in the Tailings Facility area, one (1) was direct sampled (MP09-14), while the other fourteen (14) were purged prior to sampling (MP09-04, MP09-05, MP09-09, MP09-11, MP09-12, MW09-02, MW09-03, MW09-04, MW09-06, MW09-08, MW09-21, MW09-22, MW09-23, and MW09-24). A summary of the samples collected is provided in **Table 3-2**, and analytical results are provide in **Table A**.

CCME FAL guideline exceedances were observed at all fifteen (15) sites sampled in the Tailings Facility area, including exceedances of total ammonia (four sites), dissolved fluoride (nine sites), nitrite (one site), free cyanide (two sites), dissolved arsenic (thirteen sites), dissolved copper (four sites), dissolved iron (nine sites), dissolved mercury (one site), dissolved selenium (one site), dissolved silver (one site), and dissolved zinc (five sites). Field dissolved oxygen concentrations, were less than the minimum CCME FAL guideline level at thirteen (13) sites where it was measured. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Groundwater turbidity exceeded 50 NTU at two (2) of the fourteen (14) sites measured, MP09-09 (98.2 NTU), and MP09-12 (3050 AU) (**Table 3-2**).

## Quality Assurance and Quality Control Results

Four (4) duplicate groundwater samples were collected during the August 2016 sampling event. Two (2) travel blanks were provided by the laboratory and accompanied the samples throughout the sampling program, and four (4) field blanks were prepared on site during the sampling program. Detailed results of QA/QC sampling are provided in **Table B**, including RPD values for all duplicate and sample pairs.

### Field and Travel Blanks

All travel blank analytical results were reported as less than the RDL (**Table B**). In three (3) of the four (4) field blanks, analytical results were all reported as less than the RDL (**Table B**). In the other field blank (FB-3) dissolved cadmium was detected at 0.00002 mg/L. Although detected, the observed values were very close to (4 times) the RDL of 0.000005 mg/L. At the sampling location, field crew had observed small amounts of dust, as well as moisture/splashes from the creek that could have potentially accounted for the detected cadmium.

### Field Duplicates

#### MW09-16 and DUP-1

All sample and duplicate pair analytical results for MW09-16 and DUP-1 produced RPD values less than the 20% RPD threshold limit (**Table B**).

#### MW09-24 and DUP-2

All sample and duplicate pair analytical results produced RPD values for samples MW09-24 and DUP-2 less than the 20% RPD threshold limit (**Table B**).

#### MP09-09 and DUP-3

Sample and duplicate pair analytical results produced RPD values for dissolved copper (59.90%), dissolved manganese (41.51%), and dissolved silver (128.18%), which were greater than the acceptable RPD limit. Field notes and measurements show that the source of variability could potentially be due to a high turbidity measurement (98.2 NTU). (**Table 3-2**).

All other sample and duplicate pair analytical results produced RPD values for samples MP09-09 and DUP-3 were less than the 20% RPD threshold limit (**Table B**).

#### MP09-08 and DUP-4

Sample and duplicate pair analytical results produced RPD values for dissolved antimony (35.29%), dissolved molybdenum (31.15%), total organic carbon (20.69%), and Total Kjeldahl Nitrogen (35.13%) greater than the acceptable RPD limit. Field notes and measurements do not identify any potential source of contamination or suggest variability in groundwater quality during the purging process (**Table 3-2**).

All other sample and duplicate pair analytical results produced RPD values for samples MP09-08 and DUP-4 were less than the 20% RPD threshold limit (**Table B**).

### Quality Assurance and Quality Control Summary

Results for the QA/QC analytical program show minimal evidence of sampling variation or contamination during the field collection process and transportation, and that program results are acceptable.

The single detection of low levels (near RDL) of cadmium suggests that slight contamination from the field environment may have occurred, but the level of this detection suggests that this type of contamination would not affect program results. The lack of detections in the other three field blanks also suggests that it is not a systematic occurrence.

Across the results for four (4) sample and duplicate pairs, RPD threshold exceedances were observed at two (2) sites. Field notes for the sample duplicate pair MP09-09 and DUP-3 did not identify any potential sources of contamination, however a high turbidity measurement (98.2 NTU) suggests variability in groundwater quality during the sampling process is due to a high amount of suspended solids (**Table 3-2**). No specific observations were noted for the sample and duplicate pair MP09-08 and DUP-4. Generally, the number of parameters where variations were noted suggest some variability that is most likely attributable to variations in groundwater, and are not likely to represent a larger sampling bias.

# Recommendations

Hemmera/ELR do not have program recommendations based on the observations and results of the August 2016 groundwater sampling program.

# Closure

We have appreciated the opportunity of working with you on this project and trust that this report is satisfactory to your requirements. Please feel free to contact the undersigned regarding any questions or further information that you may require.

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tables

Appendix A

Site Photographs

Appendix B

Field Forms

Appendix C

Laboratory Reports

Appendix D

Response to Client Comments

1. AU stands for Attenuation Units, which is an alternate unit of measure reported by some turbidity meters where turbidity is greater than 500 NTU. AU units are comparable with NTU units, but represent a measure calculated using transmitted rather than scattered light. [↑](#footnote-ref-1)