REPORT NO. 212019/1

NYRSTAR MYRA FALLS

2019 SURFACE WATER AND GROUNDWATER MONITORING REPORT

Submitted to:

Nyrstar

Prepared by:

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List of Acronyms and Abbreviations

AMD	Above Mine Datum
ARD	Acid Rock Drainage
MDMER	Metal and Diamond Mine Effluent Regulations
MEMPR	Ministry of Energy, Mines and Petroleum Resources
ML	Metal Leaching
MCCE	Ministry of Environment and Climate Change
MVA	Myra Valley Aquifer
NMF	Nyrstar Myra Falls
PAG	Potentially Acid Generating
QA/QC	Quality Assurance/Quality Control
RGC	Robertson GeoConsultants Inc.
SIS	Seepage Interception System
TDF	Tailings Disposal Facility
WRD	Waste Rock Dump

NYRSTAR MYRA FALLS

2019 SURFACE WATER AND GROUNDWATER MONITORING REPORT

1 INTRODUCTION

1.1 GENERAL

This is the 2019 Surface Water and Groundwater Monitoring Report for Nyrstar Myra Falls (NMF). This report was prepared by Robertson GeoConsultants Inc. (RGC) with input from Swiftwater Consulting Ltd. and the NMF Environment Department.

1.2 TERMS OF REFERENCE

The Myra Falls mine has been operated since 1966 by several companies under *Mines Act* Permit M-26. Most groundwater within the confines of the site is impacted by Acid Rock Drainage/Metal Leaching (ARD/ML) and/or Neutral Mine drainage (NMD). The key ARD sources are sulphide-bearing waste rock deposited in the historic Waste Rock Dumps (WRDs) and the mill area and the waste rock used to construct the Lynx Tailings Disposal Facility (TDF) embankment berm. Other sources of ARD and/or NMD include gravity flows of underground mine water from the various adits and seepage from low-sulphide materials elsewhere on site (see RGC, 2018a, for further details).

NMF operates a site-wide Seepage Interception System (SIS) to capture seepage and ARD/ML-impacted groundwater that would otherwise discharge to Myra Creek. The site-wide SIS consists of a system of under-drains near or beneath the Old TDF and the Lynx SIS near the Lynx TDF. Groundwater captured by the site-wide SIS and impacted mine water and precipitation runoff is directed to a water treatment system that consists of the Superpond and a series of polishing ponds referred to as the “Myra Ponds”. Treated effluent is discharged to Myra Creek according to stipulations in Effluent Permit PE-6858, which is administered by the B.C. Ministry of Climate Change and Environment (MCCE). Monitoring requirements for this permit (and others) are detailed in the Surface Water and Groundwater Monitoring Plan (see NMF, 2019).

This report reviews the effluent and surface water quality monitoring data that are required for Permit PE-6858 from January 1st, 2019, to December 31st, 2019. Previous monitoring data are provided in earlier reports, e.g. NMF (2018), and are provided in this report where appropriate. This report also reviews groundwater and seepage water quality data collected for Permit M-26 and monitoring data collected voluntarily by NMF. Voluntary routine monitoring is undertaken mainly to assess baseline environmental impacts and assess the performance of the site-wide SIS, including the Phase I Lynx SIS that has been operated since September 2017 and the Interim Phase II Lynx SIS.

1.3 Report Objective

The objectives of this report are to:

- Assess the performance of the Phase I Lynx SIS and Interim Phase II SIS.
- Interpret site-wide groundwater quality trends in 2019.
- Fulfill the annual reporting requirements for Effluent Permit PE-6858.

1.4 Scope of Work

The scope of this report is detailed in the Surface Water and Groundwater Monitoring Plan. Groundwater and surface water quality data required for Permit M-26 are provided in the Reclamation Report and are discussed here (in this report) as part of the site-wide groundwater quality review.

Reporting for Operating Permit AMID-927USG (for drinking water) and Metal and Diamond Mining Effluent Regulations (MDMER) is beyond the scope of this report.

1.5 Document Organization

This report consists of the following sections:

- Section 1. Introduction
- Section 2. Lynx SIS Performance
- Section 3. Site-Wide Groundwater Quality Review
- Section 4. Effluent and Surface Water Quality
- Section 5. Summary

2 LYNX SIS OPERATION

This section describes the operation of the Phase I Lynx SIS and the Interim Phase II Lynx SIS as of December 31st, 2019. The focus is on hydraulic performance and contaminant load removal from groundwater in the MVA. Some discussion of groundwater quality is provided, and further details are provided in Section 3.

2.1 PHASE I LYNX SIS

2.1.1 *System Overview*

The Phase I Lynx SIS consists of a fence of pumping wells: PW14-01, PW14-03, and PW14-04 (**Figure 2-1**). The pumping wells are screened in permeable sediments of the Myra Valley Aquifer (MVA) and were installed in 2014. Each Phase I Lynx SIS pumping well is operated by specifying a water level above the pump intake. A water level sensor installed within the well string monitors the water level in the well near-continuously and a control unit continually adjusts the pump speed via a Variable Frequency Drive (VFD) to maintain the selected water level. This allows maximizing drawdown in the pumping wells during all flow conditions without manual adjustments of the pumping rate.

The average pumping rates observed during the 2017/2018 wet winter season represent about 80% of the maximum well capacities determined from hydraulic testing in 2014 (RGC, 2015). Pumps in pumping wells PW14-03 and PW14-04 were placed approximately 1.5 m above the respective top of the screen and hence are higher than originally specified by about 3 and 2 meters, respectively. The pump at PW14-04 was lowered to the specified depth on April 26th, 2018.

At pumping wells PW14-01 and PW14-03, lowering the pump further was not possible because the outer diameter of the installed pumps does not fit past the K packer. However, the pump controllers were reprogrammed in late April to lower the minimum static water level to 0.3 m (1 ft) above the pumps. This provides an additional 0.15 m (0.5 ft) of available drawdown. Lowering of the pump at PW14-04 increased the pumping rate by about 5 L/s while lowering the set point at pumping wells PW14-01 and PW14-03 increased the pumping rate by less than 1 L/s.


Groundwater Monitoring Network, Lynx Area, Nyrstar Myra Falls
LYNX OFFICES
MILL
LYNX TDF
SUPER POND
SURGE POND
ETA / COOKHOUSE AREA
OLD OUTER DRAIN (DISCONNEC
ARNICA CREEK
MW19-01
MW19-02
MW19-03
MW13-03
MW13-04
MW14-02S/D
MW14-01S/D
MW11-01
PW14-03
MW13-02S/D
MW14-03S/D
MW14-05S/M/D
MW11-02
BK01-13S/D
MW18-06S/D
PW18-05
MW18-07S/D
PW14-01
MW13-05S/D
MW13-06S/D
MW14-04S/D
PW14-04
MW17-01
MW17-02S/D
MW17-03
MW13-07S/D
MW13-08S/D
MW13-09S/D
MW04-01
MW04-02
MW11-04
MW16-02
MW16-03
MW16-01
MW-G
MW16-04
MW16-05
PW18-01
PW18-02
PW18-03
PW18-04
MW13-19
MW18-08S/D
Legend
Monitoring Well
Pumping Well
Scale 1:3,000
Meters
NAD83 UTM Zone10N
Robertson GeoConsultants Inc.
Client: nyrstar
Figure: 2-1
Project: Annual Monitoring Report
Last Update: Mar 26, 2020
Report: RGC 212019/1
Drawn: LR
Original File: Figure2-1_MF_GW-MonitoringNetwork_2.mxd

2.1.2 *Assessment Period*

The Phase I Lynx SIS has been operating since October 1st, 2017. This performance assessment reviews monitoring data collected up to December 31st, 2019, and therefore represents the first 27 months of SIS operation. The Phase I pumping wells were operated for the majority of the 27-month assessment period. Pumping was discontinued for an extended period starting on December 4th, 2018, due to power supply issues. Pumping well PW14-03 did not operate for 17 consecutive days from December 4th to 21st, 2018, and pumping well PW14-04 did not operate for 33 consecutive days from December 4th, 2018, to January 7th, 2019.

Pumping well PW14-01 did not operate for 59 consecutive days from December 4th, 2018, to February 1st, 2019. During this extended shutdown, the set level at PW14-01 was increased from 1 ft to 3 ft above the pump intake in an unsuccessful attempt to prevent the pump from faulting, according to C. Schweitzer (email dated December 15th, 2018).

There were no extended shutdowns during the remainder of 2019.

2.1.3 *Flow Rates and Pumped Volumes*

Daily pumping rates and Zn concentrations in pumped groundwater for the Phase I Lynx SIS pumping wells are shown in **Figures 2-2** to **2-4**. Daily precipitation observed at the site are also shown for reference. **Figure 2-5** shows the combined daily pumping rate and observed Zn concentrations in groundwater from monitoring wells MW17-02D and MW17-03. These wells are screened within the deep MVA downgradient of the Superpond and water quality data from these wells is important to assess capture efficiency of the Phase I. The Phase I Lynx SIS pumping wells were pumped at an average combined pumping rate of 48.7 L/s from October 2017 to the end of December 2019. This average rate does not include the periods in December 2018 and January and February 2019 when the pumps were shut down. Pumping rates increased in response to rainfall and gradually decreased once rainfall had ceased.

Table 2-1 shows average pumping rates and total pumped volumes for the Phase I Lynx SIS as well as total recorded precipitation. Average pumping rates for the individual pumping wells were 24.6 L/s for PW14-01, 12.5 L/s for PW14-03, and 16.1 L/s for PW14-04. Pumping well PW14-01 extracted a total of 1,418,639 m^3 of groundwater during the 27-month assessment period. PW14-03 and PW14-04 extracted 829,458 m^3 and 1,034,462 m3, respectively. Since the resumption of pumping from pumping well PW14-01 in February 2019, pumping rates were about 8 L/s lower than previously observed. Although the pumping or set level was increased by 2 ft, this well had previously been operated at similar set levels and flow conditions while yielding higher pumping rates. This may indicate that well performance has decreased due to, for example, a partially clogged screen. Alternatively, there may be issues with the flow meter or pressure transducer.

Table 2-1.

Phase I Lynx SIS Pumping Rates and Pumped Volumes

Year	Average Pumping Rate [L/s]				Pumped Volume [m^3]			Yearly Precipitation [mm]
	PW14 Combined	PW14-01	PW14-03	PW14-04	PW14-01	PW14-03	PW14-04	
2017*	50.8	30.0	13.9	14.9	150,335	84,055	90,187	2,541
2018	50.6	28.2	12.7	16.8	672,542	367,085	450,132	2,773
2019	46.5	20.6	12.0	15.7	595,762	378,317	494,143	1,967
Average/Total	**48.7**	**24.6**	**12.5**	**16.1**	**1,418,639**	**829,458**	**1,034,462**	**2,427**

* Note that the Phase I Lynx SIS was only operated from October to December in 2017.

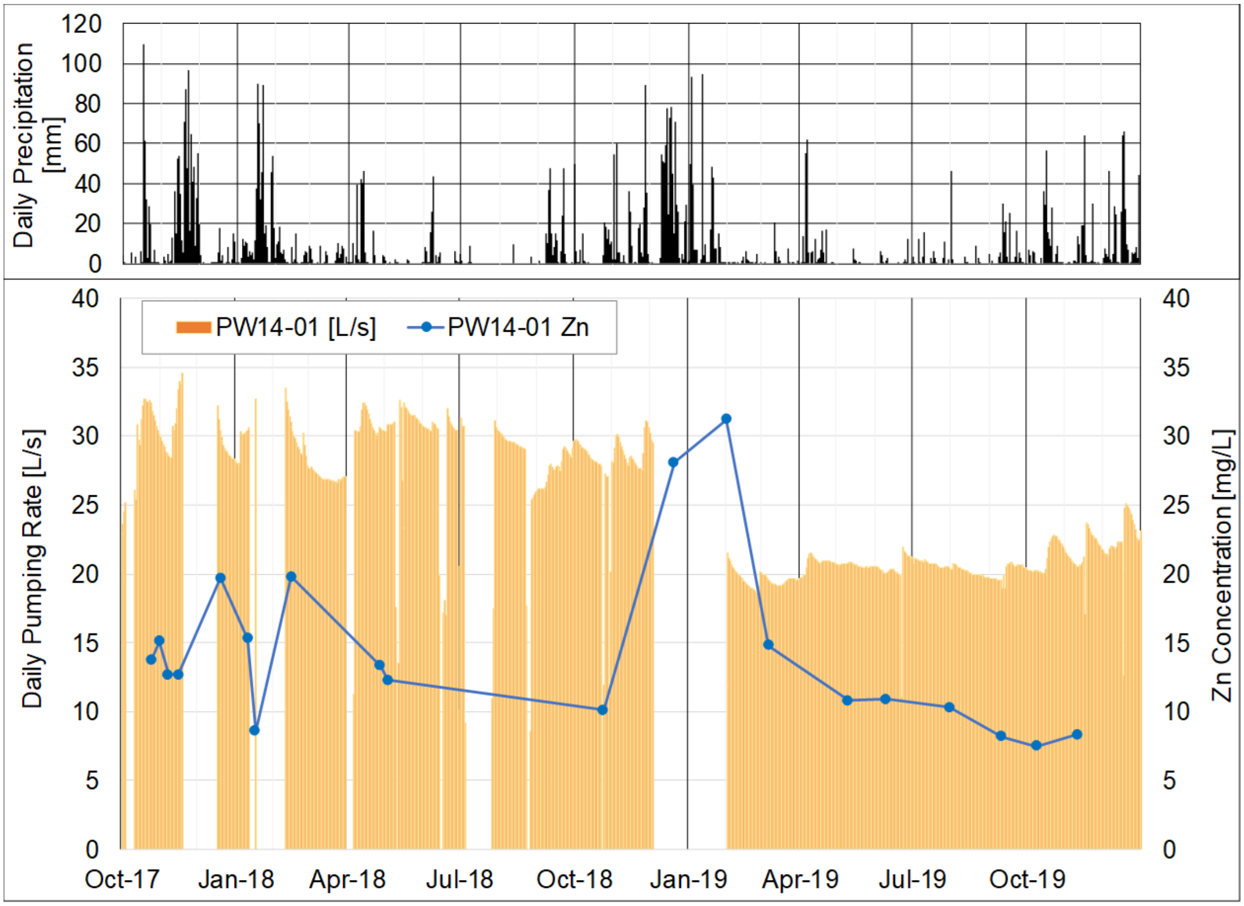


Figure 2-2. Observed Pumping Rate and Zn Concentration at PW14-01

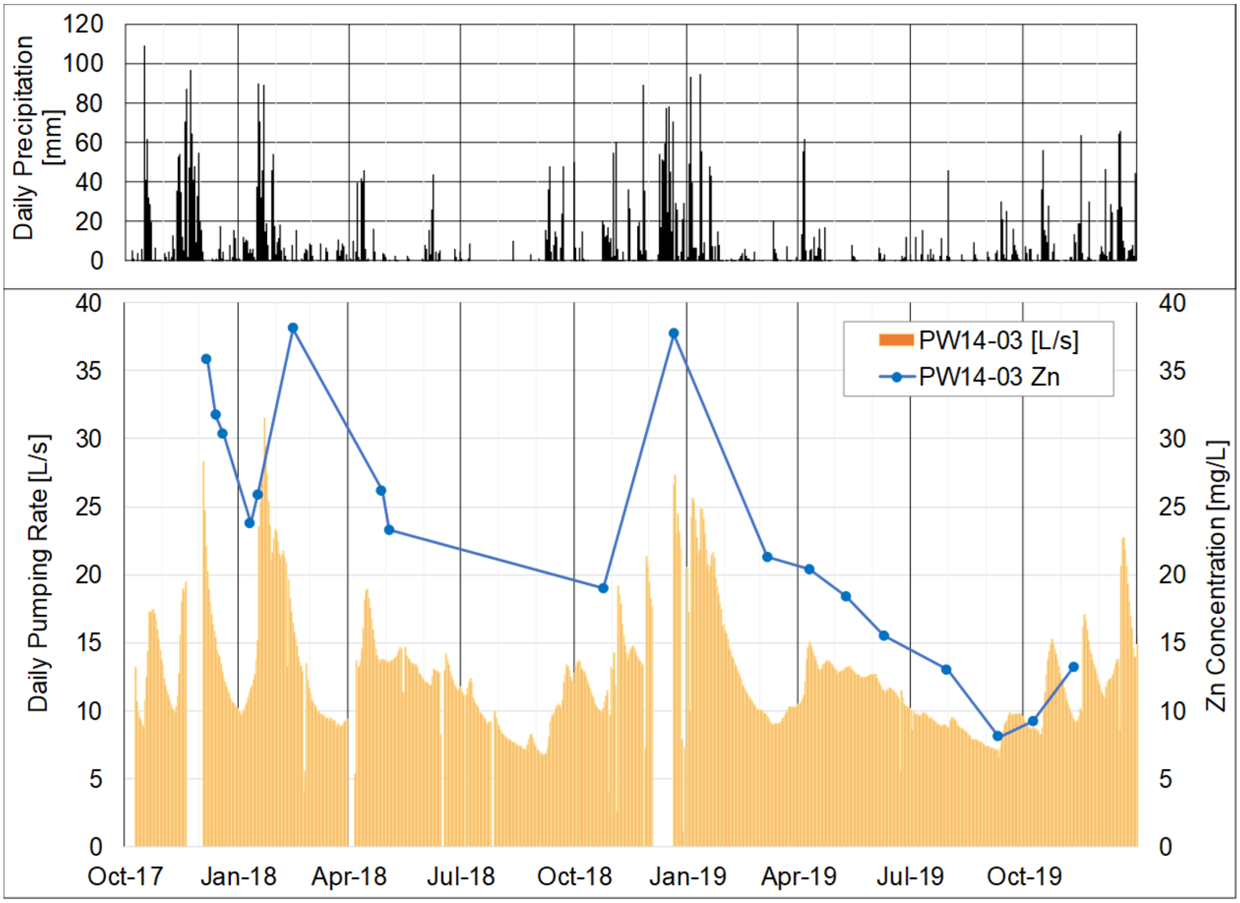


Figure 2-3. Observed Pumping Rate and Zn Concentration at PW14-03

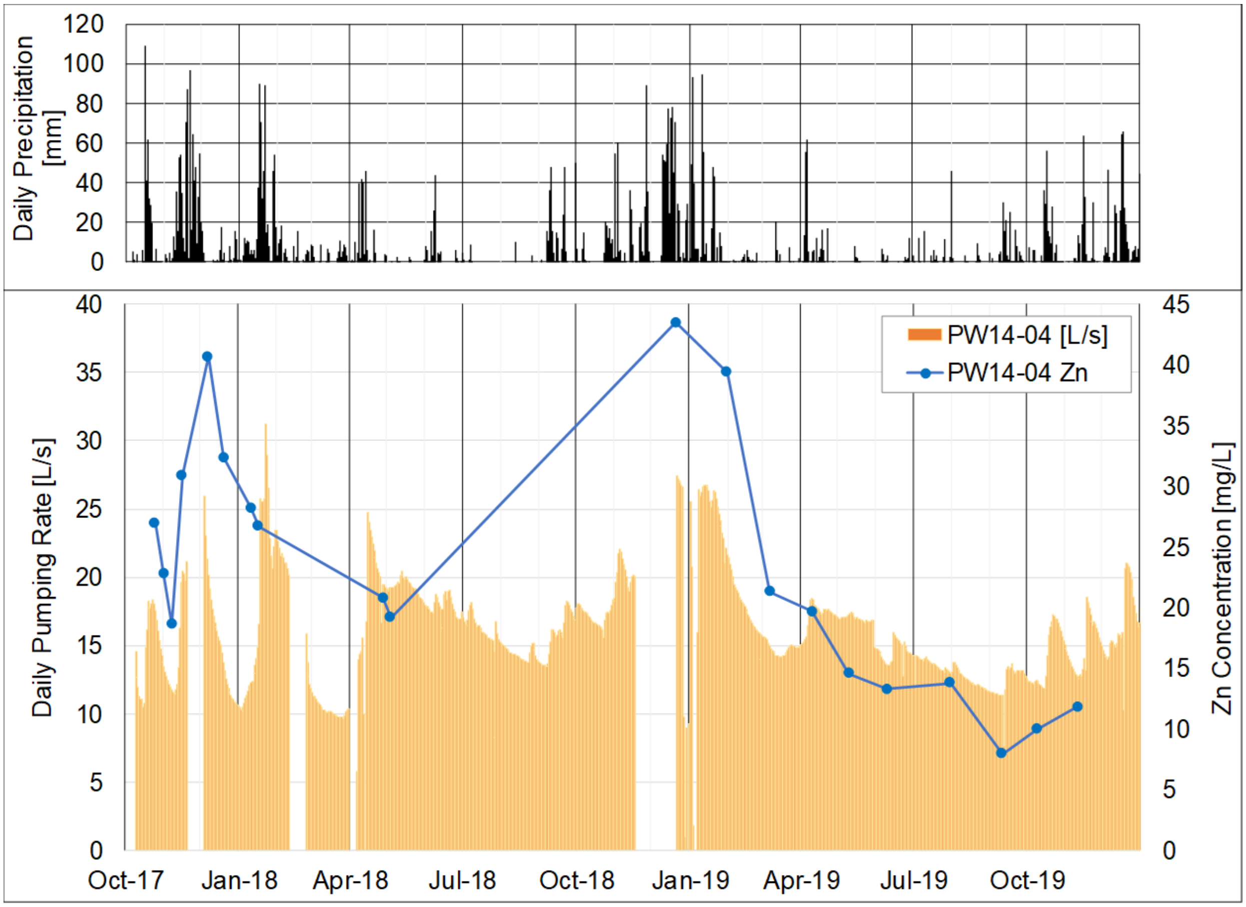


Figure 2-4. Observed Pumping Rate and Zn Concentration at PW14-04

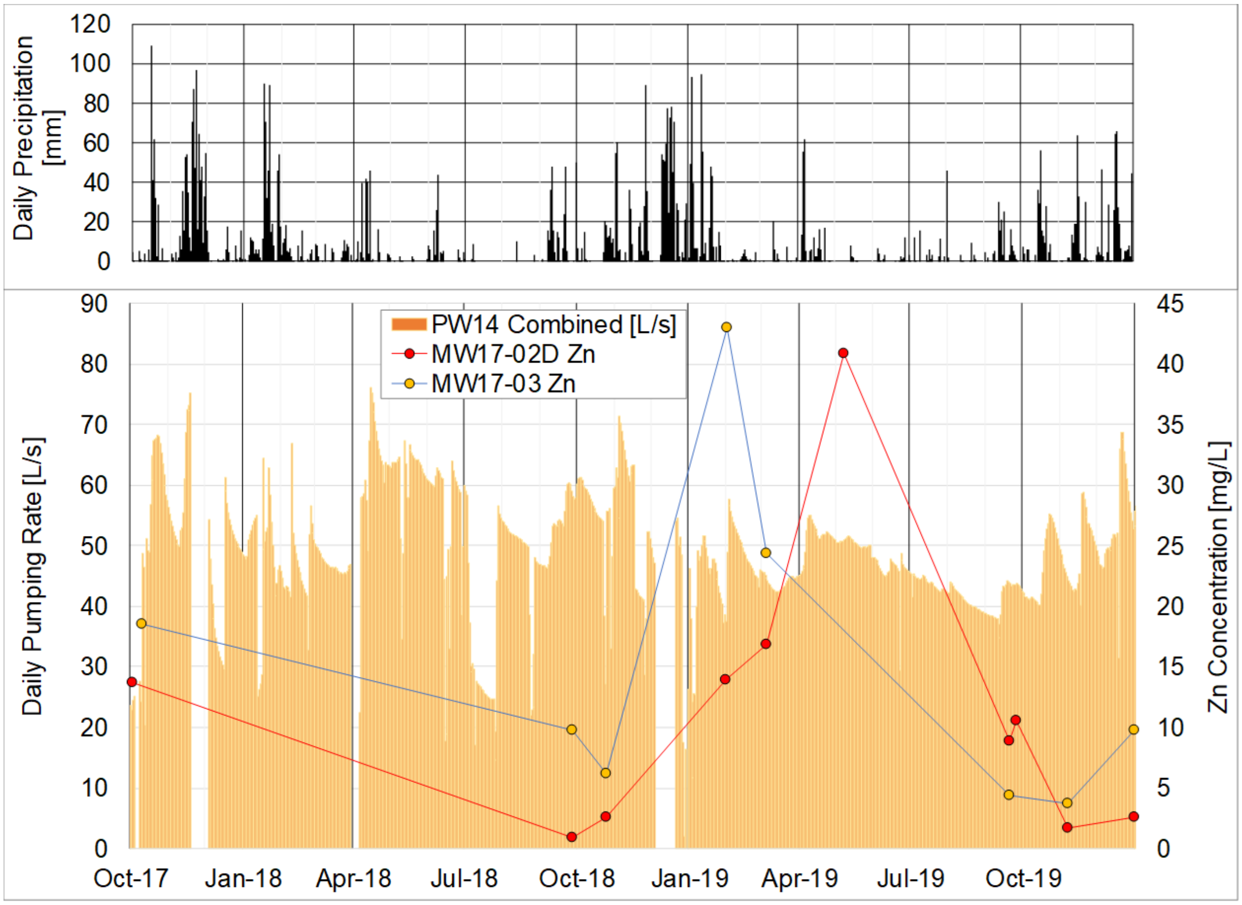


Figure 2-5. Observed Pumping Rate from Phase I Lynx SIS and Downgradient Zn Concentrations

2.1.4 *Inferred Groundwater Flow Field and Capture Zones*

Figure 2-6 shows groundwater levels and the inferred flow field based on a synoptic groundwater level survey completed on June 11th, 2019. Groundwater levels during this survey are characteristic of dry summer conditions and the Phase I Lynx SIS (45.2 L/s combined) and Interim Phase II Lynx SIS (13.6 L/s combined) were operating at the time of the survey. Three days later, on June 14th, a second synoptic groundwater level survey was completed, and the non-pumping (“static”) flow field is shown in **Figure 2-7**.

Groundwater flow in the deep MVA is generally along the valley axis (from WNW to ESE) with lateral inflow from the northern hillside and Lynx TDF. The operation of the fence of pumping wells has resulted in a more pronounced hydraulic gradient towards the valley center or fence of pumping wells compared to earlier observations. The inferred capture zones suggest full capture of impacted groundwater within the Lynx Reach despite the higher set level at PW14-01 following the shutdown in early 2019 (see Section 2.1.3).

The inferred flow field suggests that the removed groundwater is replaced by creek water and/or increased lateral groundwater inflow. Operation of the Phase I Lynx SIS has further shown to reduce the horizontal hydraulic gradient and hence groundwater flow from the Super Pond area towards Myra Creek downstream of the car bridge.

A synoptic water level survey was again completed on January 1st, 2020 and the inferred flow field and capture zones are shown in **Figure 2-8**. At the time of the survey, groundwater levels were elevated but only at ~60% of levels observed during previous high flow events. The Phase I and Phase II Lynx SIS were operating with combined pumping rates of 55.7 L/s and 10.3 L/s, respectively. Note that of the Phase II Lynx SIS only PW18-01 and PW18-03 were operating. The following was observed with respect to performance of the Phase I Lynx SIS:

- Capture zones of the individual pumping wells are consistent with earlier surveys and are as follows:
    - PW14-03 captures groundwater flow from the mill area.
    - PW14-01 continues to capture groundwater flows from the upper half of the Lynx TDF and some flow from the valley center. The inferred capture zone has not changed significantly despite the decreased pumping rate at PW14-01.
    - PW14-04 captures the remaining flows from the Lynx TDF as well as some flow from the valley center.

The inferred capture zones suggest full capture of contaminated groundwater within the Lynx Reach during low flow and high flow conditions. This is further supported by water quality sampling immediately downgradient of the Lynx Reach at monitoring wells MW17-02D and MW17-03 (see **Figure 2-5**). After two years of operation of the Phase I Lynx SIS, metal concentrations downgradient have decreased significantly, for example Zn at MW17-02D and MW17-03 decreased by 88% and 80%, respectively (see Section 4.4 for more details).

2.1.5 *Captured Loads*

Table 2-2 summarizes water quality results for the PW14 pumping wells. **Tables 2-3** to **2-5** summarize calculated loads captured by the Phase I Lynx SIS pumping wells. Detailed monthly loads are provided in Appendix A. Loads were calculated from average monthly flow rates and concentrations in groundwater pumped from each well (see Section 3 for data). Corresponding Zn concentrations are also plotted alongside pumping rates in **Figures 2-2** to **2-4** for pumping wells PW14-01, PW14-03, and PW14-04, respectively.

Calculated loads suggest that the Phase I Lynx SIS continues to capture significantly impacted groundwater from the MVA. SO_4 and metal concentrations in groundwater captured by the pumping wells are generally higher in winter following periods of heavy precipitation and lower during drier summer months suggesting seasonal flushing of contaminants from the nearby ARD sources.

The Phase I SIS pumping wells captured a total Zn load of 58.2 tonnes since October 2017. This represents 59% of the Zn load captured by the Old TDF under-drains (99.1 tonnes[1]). The largest load was extracted by PW14-04 (20.8 t of Zn since October 2017). PW14-03 and PW14-01 extracted 10% and 11% less zinc load, respectively.

[1] assuming an average flow rate of 208 L/s for Pumphouse No. 4 and an average Zn concentration of 6.7 mg/L in groundwater captured by the under-drains

Table 2-2.

Summary of Water Quality Sampling at Phase I Lynx SIS

Sample ID	*Sample Date*	Dissolved Sulphate (SO4) [mg/L]	Conductivity [uS/cm]	pH [pH]	Dissolved Cadmium (Cd) [mg/L]	Dissolved Copper (Cu) [mg/L]	Dissolved Zinc (Zn) [mg/L]
PW14-01	2017-10-25	307	664	6.74	0.0209	0.175	13.7
	2017-11-01	298	665	6.84	0.0224	0.188	15.1
	2017-11-08	256	613	7.18	0.016	0.149	12.7
	2017-11-16	257	600	6.69	0.0192	0.167	12.7
	2017-12-20	410	864	7.03	0.0289	0.327	19.7
	2018-01-11	287	664	6.76	0.021	0.229	15.3
	2018-01-17	200	455	7.17	0.0107	0.0996	8.59
	2018-02-15	410	871	6.71	0.0294	0.329	19.8
	2018-04-28	274	643	6.27	0.0205	0.231	13.3
	2018-05-04	288	616	6.78	0.0195	0.22	12.3
	2018-10-25	246	619	6.79	0.0193	0.166	10.1
	2018-12-21	709	1250	6.42	0.0536	0.755	28.1
	2019-02-01	725	1340	5.08	0.0688	1.26	31.2
	2019-03-07	335	695	6.39	0.0243	0.327	14.8
	2019-05-10	280	536	6.46	0.0174	0.267	10.8
	2019-06-10	232	540*	5.64*	0.016	0.266	10.9
	2019-07-31	208	388.5*	6.89*	0.0154	0.227	10.3
	2019-09-11	183	382	6.48	0.0115	0.189	8.2
	2019-10-09	151	358	6.55	0.0104	0.171	7.48
	2019-11-12	181	437*	6.49*	0.0118	0.197	8.35
PW14-03	2017-12-07	458	977	6.31	0.0484	1.33	35.8
	2017-12-14	402	874	6.33	0.0424	1.28	31.7
	2017-12-20	345	766	6.63	0.036	1.11	30.3
	2018-01-11	282	634	6.54	0.0244	0.86	23.8
	2018-01-17	298	677	6.53	0.0285	0.998	25.9
	2018-02-15	442	934	5.25	0.0545	2.05	38.1
	2018-04-28	328	733	5.71	0.0352	1.49	26.2
	2018-05-04	333	690	6.02	0.0313	1.34	23.3
	2018-10-25	204	550	6.19	0.0256	1.15	19.0
	2018-12-21	577	1040	4.93	0.0638	2.25	37.7
	2019-03-07	390	667	5.84	0.0347	1.42	21.3
	2019-04-10	346	637	5.76	0.0312	1.43	20.4
	2019-05-10	297	577	5.87	0.031	1.33	18.4
	2019-06-10	278	567*	5.2*	0.0263	1.24	15.5
	2019-07-31	213	389.7*	7.47*	0.0204	0.832	13
	2019-09-11	154	358	6.31	0.0116	0.566	8.08
	2019-10-09	154	362	6.41	0.0133	0.569	9.24
	2019-11-12	217	493*	6.59*	0.0198	0.869	13.2
PW14-04	2017-10-25	770	1320	4.48	0.0772	2.26	27
	2017-11-01	640	1170	4.59	0.06	1.76	22.8
	2017-11-08	551	1080	4.63	0.043	1.38	18.6
	2017-11-16	885	1510	4.38	0.0953	2.93	30.9
	2017-12-07	1120	1790	4.19	0.125	4.03	40.7
	2017-12-20	874	1480	4.39	0.0989	2.75	32.4
	2018-01-11	732	1340	4.47	0.0664	2.29	28.2
	2018-01-17	702	1320	4.5	0.0688	2.06	26.7
	2018-04-28	626	1200	4.54	0.0545	1.77	20.8
	2018-05-04	605	1140	4.65	0.0496	1.59	19.2
	2018-12-21	1560	1860	4.24	0.141	4.67	43.5
	2019-01-31	594	-	-	0.0707	2.75	39.4
	2019-03-07	804	1220	4.67	0.0566	1.69	21.3
	2019-04-10	737	1170	4.69	0.0497	1.66	19.7
	2019-05-10	377	853	4.9	0.0317	1.08	14.6
	2019-06-10	668	985*	4.42*	0.0389	1.28	13.3
	2019-07-31	543	830	4.83	0.0347	0.985	13.8
	2019-09-11	384	733*	6.39*	0.0174	0.498	7.95
	2019-10-09	397	758	4.94	0.0273	0.784	10
	2019-11-12	487	874*	6.12*	0.0296	0.936	11.8

*Field Parameters

Table 2-3.

Calculated Contaminant Loads Extracted by PW14-01

Year	Average Pumping Rate [L/s]	Days Operating [days]	Pumped Volume [m^3]	Load [t/yr] SO_4	Cd	Cu	Zn
2017	30.0	58	150,335	48.2	0.003	0.030	2.30
2018	28.2	276	672,542	210.9	0.015	0.182	9.25
2019	20.6	334	595,762	157.1	0.012	0.187	6.99
Total	**24.6**	**668 (82%)**	**1,418,639**	**416.3**	**0.030**	**0.401**	**18.53**

Table 2-4.

Calculated Contaminant Loads Extracted by PW14-03

Year	Average Pumping Rate [L/s]	Days Operating [days]	Pumped Volume [m^3]	Load [t/yr] SO_4	Cd	Cu	Zn
2017	13.9	70	84,055	27.2	0.003	0.110	2.32
2018	12.7	334	367,085	125.7	0.013	0.519	9.67
2019	12.0	365	378,317	114.3	0.011	0.452	6.80
Total	**12.6**	**769 (94%)**	**829,458**	**267.2**	**0.027**	**1.080**	**18.80**

Table 2-5.

Calculated Contaminant Loads Extracted by PW14-04

Year	Average Pumping Rate [L/s]	Days Operating [days]	Pumped Volume [m^3]	Load [t/yr] SO_4	Cd	Cu	Zn
2017	14.9	70	90,187	75.9	0.008	0.240	2.72
2018	16.8	311	450,132	288.1	0.024	0.772	9.13
2019	15.7	362	494,143	276.0	0.020	0.679	8.99
Total	**16.3**	**743 (91%)**	**1,034,462**	**640.0**	**0.052**	**1.691**	**20.83**

2.2 Interim Phase II Lynx SIS

2.2.1 *System Overview*

The Interim Phase II Lynx SIS consists of a fence of shallow pumping wells (PW18 series) downstream of the car bridge (see **Figure 2-1**). These pumping wells and a series of monitoring wells were installed in mid-May 2018 (see RGC, 2018b and Appendix A) and later equipped with submersible pumps. The Interim Phase II Lynx SIS has operated continuously since March 2019. The Phase II Lynx SIS is intended to capture shallow acidic seepage that expresses along the creek bank immediately downgradient of the car bridge following high rainfall periods (RGC, 2018b). An unlined surface runoff storage pond (Duck Pond) and associated channels were identified to be the most likely source of these acidic seeps.

2.2.2 *Flow Rates and Pumped Volumes*

Table 2-6 shows totalizer readings from the Interim Phase II Lynx SIS taken during the initial operating period March to December 2019. Groundwater levels were receding between March and July, and in July had reached levels typical for summer low flow conditions.

Table 2-6.

Totalizer Readings at Interim Phase II Lynx SIS Pumping Wells.

Date	Totalizer Reading [m^3]				
	PW18-01	PW18-02	PW18-03	PW18-04	Total
2019-04-17	15,645	17,910	21,836	10,151	65,542
2019-06-12	25,681	49,152	42,733	18,157	117,567*
2019-06-26	28,380	54,578	47,735	17,713	130,694*
2019-07-02	29,689	57,512	50,433	17,744	137,634*
2019-07-10	31,436	61,397	54,006	17,154	146,839*
2019-07-17	32,973	64,836	57,167	16,869	154,976*
2020-01-02	90,687	98,118	132,424	15,162	321,229*

*Excluding PW18-04.

Note that the well casing at depth in PW18-04 was obstructed and the submersible pump had to be installed about 3 m higher than specified. Groundwater levels at PW18-04 eventually dropped below the pump intake, likely sometime in June, and PW18-04 was shut off. PW18-02 also fell dry at the end of September and was subsequently shut off. It appears that there is some minor reversed flow at both pumping wells as indicated by decreasing volume readings. It was suggested that the check valves are not operating properly allowing backflow (Precision Service Pumps, personal communication). The total pumped volumes reported exclude PW18-04 readings.

November 2019 was unusually dry with precipitation of only 200 mm compared to 944 mm, 830 mm, and 424 mm observed in November 2016, 2017, and 2018, respectively. Precipitation in December 2019 was 421 mm which is more typical. A cold spell at the end of November 2019 caused the PW18 pumping wells to freeze resulting in damage to PW18-02 and PW18-04. During the site visit in late December, PW18-02 was able to be re-started but continued to fault within minutes suggesting damage to some sensor or other electronics. PW18-04 could not be turned on suggesting damage to the submersible pump and/or electronics. Both pumps have not been operating since late November and some minor backflow was observed at both.

Flow rates were periodically determined with a stopwatch and taking totalizer readings (see **Table 2-7**).

Table 2-7.

Interim Phase II Lynx SIS Pumping Rates.

	Pumping Rate [L/s]				
Date	**PW18-01**	**PW18-02**	**PW18-03**	**PW18-04**	**Total**
2019-04-17	4.2	4.1	4.8	2.6	15.8
2019-06-12	2.8	5.7	5.3	-	13.8
2019-06-26	2.6	5.6	5.2	-	13.4
2019-07-02	2.7	5.7	5.2	-	13.6
2019-07-10	2.7	5.7	5.2	-	13.6
2019-07-17	2.5	5.7	5.2	-	13.3
2020-01-01	5.0	-	5.3	-	10.3

Findings are as follows:

- In the first ten months of operation (March to December 2019), the Interim Phase II Lynx SIS removed about 321,230 m^3 of groundwater from the shallow aquifer downgradient of the car bridge.
- The pumping wells in the center, PW18-02 and PW18-03, captured about 98,100 m^3 and 132,400 m^3, respectively while PW18-01 recovered a slightly lower volume (about 90,700 m^3).
- When all four pumping wells were operating, the pumping rate was highest at PW18-03 with 4.8 L/s. Pumping rates at PW18-01 and PW18-02 were slightly less, 4.2 L/s and 4.1 L/s, respectively.
- PW18-01 was initially reported to pump at 4.2 L/s but rates decreased to 2.5 L/s as groundwater levels decreased. A pumping rate of 5 L/s was again observed in the 2019/2020 high flow season.

- PW18-04 only pumped at 2.6 L/s before falling dry, likely sometime in June. The lower observed pumping rate is likely due to the limited available drawdown and cycling of the pump.
- PW18-02 fell dry around September 25, 2019 and was turned off to prevent damage to the pump. Minor backflow was observed.
- On November 15, 2019, PW18-02 and PW18-04 were turned back on with the onset of precipitation and increasing groundwater levels. However, the submersible pumps at both wells were damaged shortly after due to freezing in late November and have not been operating since. A reversal of flow was observed at the damaged pumping wells meaning some minor recharge to the aquifer.
- The average pumping rate over the first ten months of operation was around 13.4 L/s which is lower than the design capacity of 20 L/s to 24 L/s primarily because PW18-02 and PW18-04 were not operating for extended periods.
- Drawdown was greatest in PW18-01 indicating that the aquifer is less permeable at that location and/or a lower well efficiency.

2.2.3 *Water Levels and Inferred Flow Field*

Synoptic water level surveys in the Lynx reach were completed during a site visit on June 11th and 14th, 2019 when groundwater levels were characteristic of dry summer conditions. On June 11th, the Phase I Lynx SIS pumping wells and Interim Phase II pumping wells were operated at 45.2 L/s and 13.6 L/s, respectively and the inferred flow field is shown in **Figure 2-6**.

The following was observed:

- In the proximity of the car bridge, groundwater generally flows in a north-easterly direction towards the actively pumped PW18 wells.
- The width of the inferred capture zone of the Phase II Lynx SIS was estimated to be around 80 m covering the area around the Duck Pond.
- Groundwater levels in the immediate vicinity of the PW18 wells were below the creek bed elevation indicating full hydraulic control. In other words, the hydraulic gradient was reversed, and Myra Creek was losing water to the pumping wells in that reach (rather than groundwater discharging to Myra Creek).

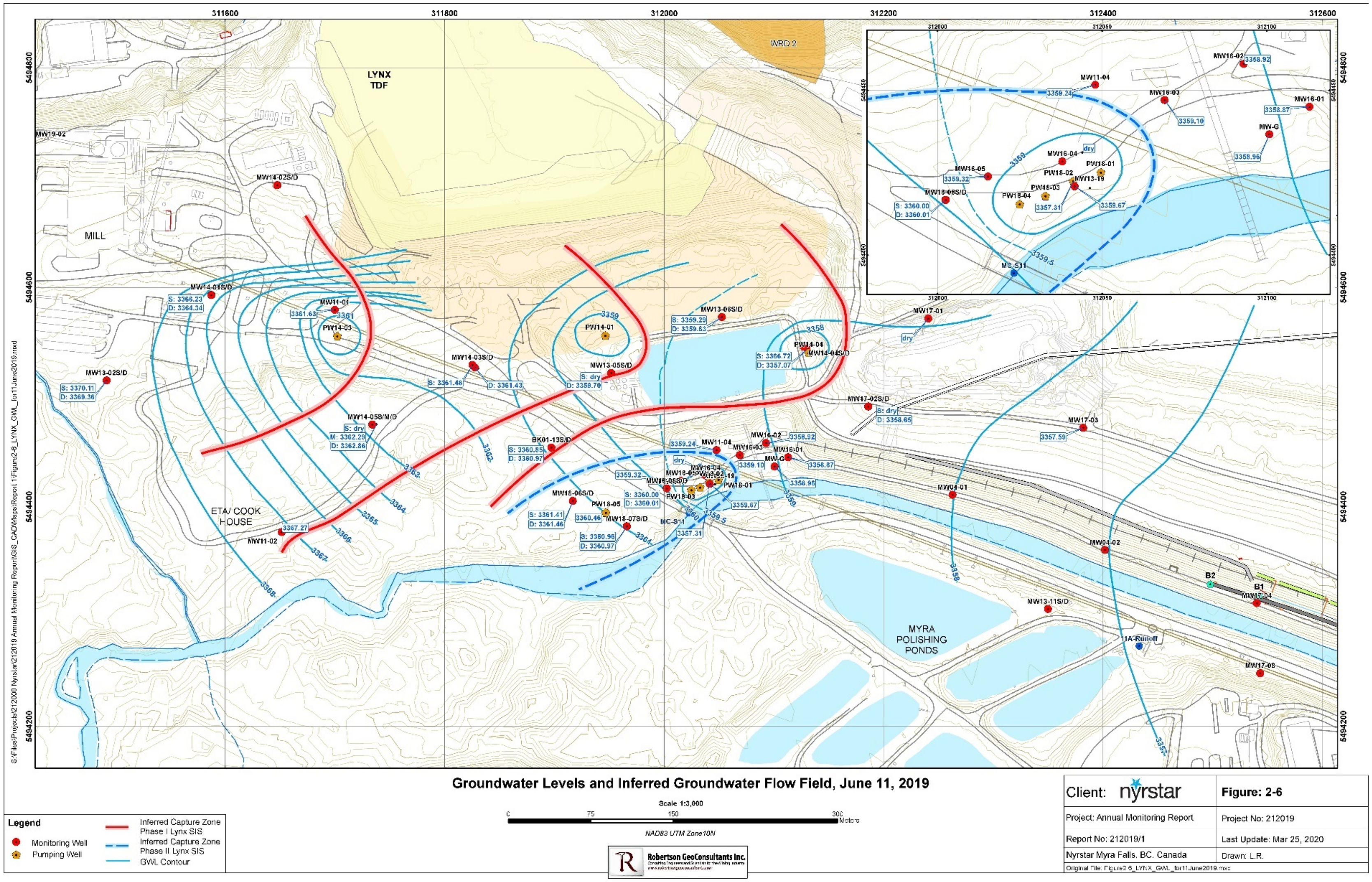
The PW18 pumps (Interim Phase II) were shut off following the initial survey on June 11th, to monitor aquifer recovery. Three days later, on June 14th, a second synoptic groundwater level survey was completed, and the non-pumping ("static") flow field is shown in **Figure 2-7**. Note that the Phase I pumping wells continued to be operated during this period. Key findings are as follows:

- Groundwater levels immediately downgradient of the car bridge recovered, e.g. by 1.0 m at MW16-04 and 0.50 m at MW11-04, in response to shutting off the PW18 pumps.

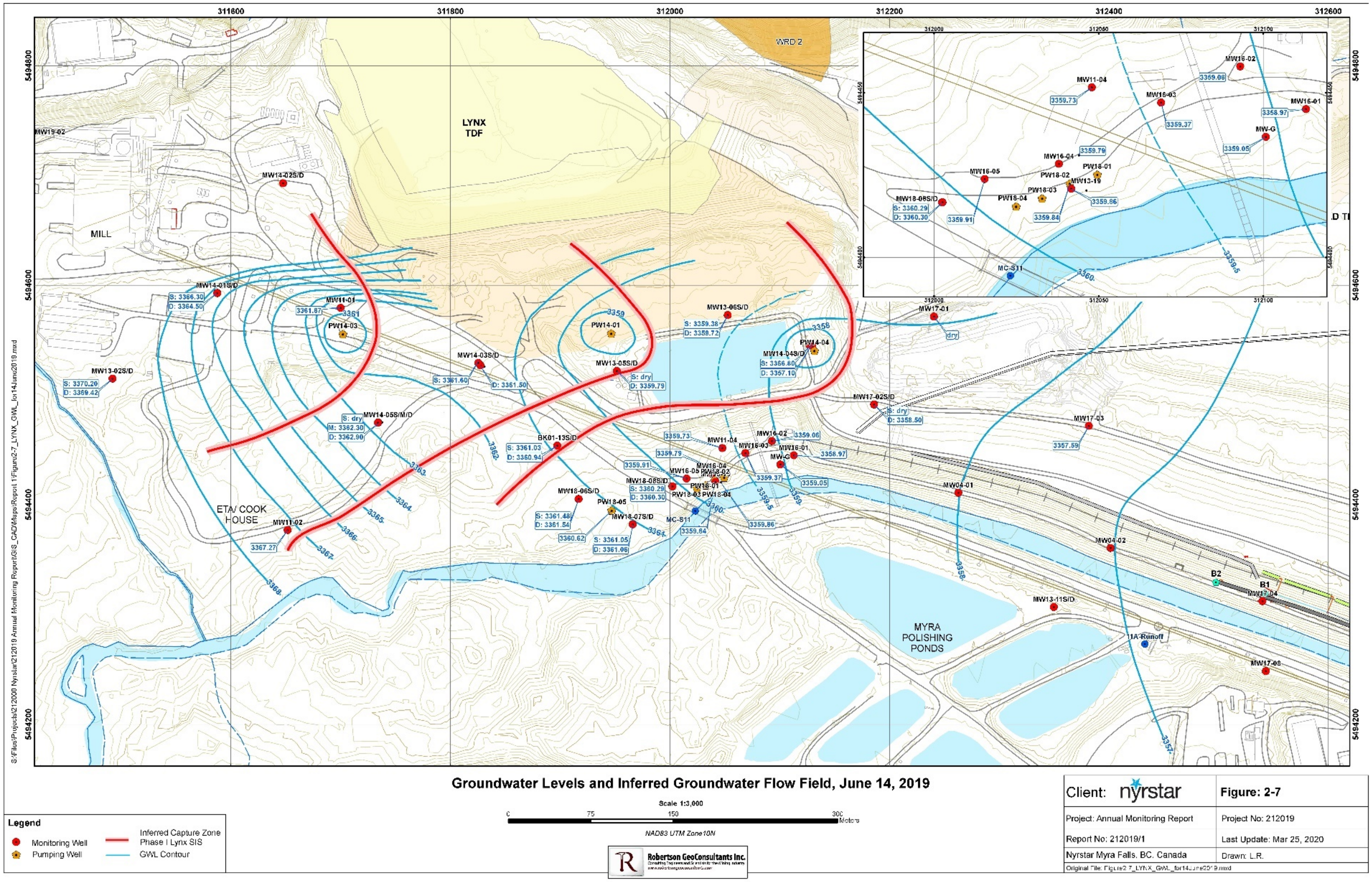
- The Myra Creek stage could only be estimated visually and was inferred to be slightly lower than groundwater levels. Groundwater was likely discharging to Myra Creek at that time, although with a very low horizontal hydraulic gradient.
- No seeps above the water line were visible. Electrical conductivity along the creek bank was not elevated suggesting very minor groundwater discharge and/or discharge of mostly unimpacted groundwater.

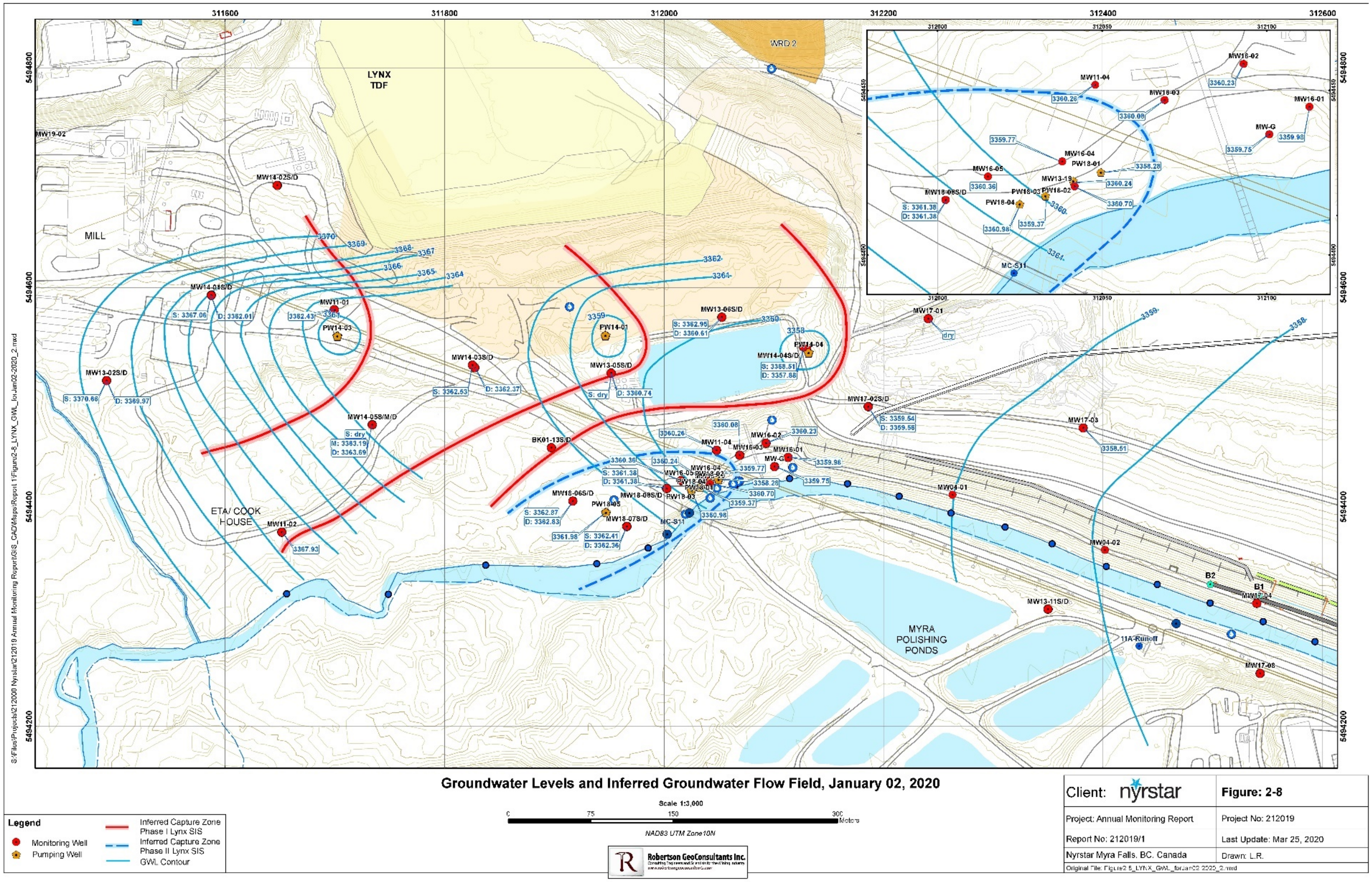
A synoptic water level survey was completed on January 1st, 2020 and the inferred flow field and capture zones are shown in **Figure 2-8**. At the time of the survey, groundwater levels were elevated but only at ~60% of levels observed during previous high flow events. The Phase I and Phase II Lynx SIS were operating with combined pumping rates of 55.7 L/s and 10.3 L/s, respectively. Note that of the Phase II Lynx SIS only PW18-01 and PW18-03 were operating. The following was observed with respect to performance of the Phase II Lynx SIS:

- Myra Creek had reached a stage of 3360.95 m AMD (above mine datum) measured at the car bridge at 8:15 PM the day before the water level survey. At the time of the survey, the stage had receded to 3360.3 m AMD.
- Drawdown in PW18-01, PW18-02, and PW18-03 was sufficient to provide hydraulic control, i.e. drawing down the groundwater level in the shallow aquifer below the creek stage elevation preventing groundwater from discharging to Myra Creek.
- At PW18-04, which was not operating at the time, groundwater levels were above creek levels indicating groundwater discharge to Myra Creek at that location.



Groundwater Levels and Inferred Groundwater Flow Field, June 11, 2019


LYNX TDF
MILL
WRD 2
ETA/ COOK HOUSE
MYRA POLISHING PONDS
Groundwater Levels and Inferred Groundwater Flow Field, June 14, 2019
Scale 1:3,000
NAD83 UTM Zone10N
Legend
Monitoring Well
Pumping Well
Inferred Capture Zone Phase I Lynx SIS
GWL Contour
Client: nyrstar
Figure: 2-7
Project: Annual Monitoring Report
Project No: 212019
Report No: 212019/1
Last Update: Mar 25, 2020
Nyrstar Myra Falls, BC, Canada
Drawn: L.R.
Robertson GeoConsultants Inc.


Groundwater Levels and Inferred Groundwater Flow Field, January 02, 2020
Legend
Monitoring Well
Pumping Well
Inferred Capture Zone Phase I Lynx SIS
Inferred Capture Zone Phase II Lynx SIS
GWL Contour
Scale 1:3,000
NAD83 UTM Zone10N
Robertson GeoConsultants Inc.
Client: nyrstar
Figure: 2-8
Project: Annual Monitoring Report
Project No: 212019
Report No: 212019/1
Last Update: Mar 25, 2020
Nyrstar Myra Falls, BC, Canada
Drawn: L.R.
LYNX TDF
MILL
ETA/ COOK HOUSE
MYRA POLISHING PONDS
WRD 2

2.2.4 *Observed Drawdown (Aquifer Recovery Test)*

Figure 2-9 shows time trends of groundwater levels observed in monitoring wells surrounding the Interim Phase II Lynx SIS during aquifer recovery. The inferred drawdown is shown in **Figure 2-10** and findings are as follows:

- The observed drawdown at PW18-02 is 2.53 m. At MW16-04 (distance ~25 m), the observed drawdown is 1.0 m indicating that the shallow aquifer in this area is hydraulically well connected.
- At PW18-01, a drawdown of ~5.25 m was observed. Note that the water level was fluctuating near the pump intake indicating that the pump was cycling.
- Groundwater levels fully recovered after shutdown of the PW18 wells within 24 hrs.
- The shallow colluvium and underlying shallow glaciofluvial sediments are well connected at MW18-08, immediately upgradient of the PW18 pumping wells as evidenced by identical recovery in both the shallow and deep piezometer.
- The shallow glaciofluvial sediments (in which the PW18 wells are screened) are not well connected to the deeper glaciofluvial aquifer as evidenced by the comparatively small drawdown (0.19 m) at MW13-19 screened in the deep aquifer.

2.2.5 *Captured Loads*

Calculated loads of contaminants of concern captured by the individual PW18 pumping wells are presented in **Table 2-7** and **2-8**. The first totalizer readings were taken in April and it was assumed that the pumping rate remained steady over the initial period from March to April. For months where no totalizer readings were taken and/or water quality samples collected, values were inferred from preceding and/or following months. Key findings are as follows:

- Groundwater captured by the Phase II Lynx SIS is only marginally impacted with SO_4 below 40 mg/L and Zn concentrations of less than 0.7 mg/L.
- The Interim Phase II Lynx SIS extracted a total load of 148 kg of Zn from the shallow MVA between March and June 2019. This represents only about 3% of the total load captured by Phase I Lynx SIS over the same period.
- On average, the Interim Phase II Lynx SIS extracted 0.7 kg of zinc per day between March and May. This represents only 2% of typical zinc loading within Myra Creek during average flow conditions.
- Captured Zn loads decreased by 46% between March and June due to a 39% and 15% decrease in Zn concentrations and pumping rates, respectively. The extracted daily zinc loads represent ~2% of typical zinc loading in Myra Creek during dry summer low flow conditions.
- During winter, the Interim Phase II Lynx SIS extracted around 12.5 kg of zinc per month, representing less than 1% of the zinc load observed at MC-TP4 during high flow conditions.

Note that the groundwater captured by the Phase II Lynx SIS is only marginally impacted and not representative of the acidic seeps observed in early 2018. Concentrations are also much lower than in samples collected from the Duck Pond and, more recently, observed at MW18-06S/D (see Section 3.3.7). This suggests that the improved surface water management may have effectively minimized acidic surface runoff infiltrating into the shallow aquifer in this area.

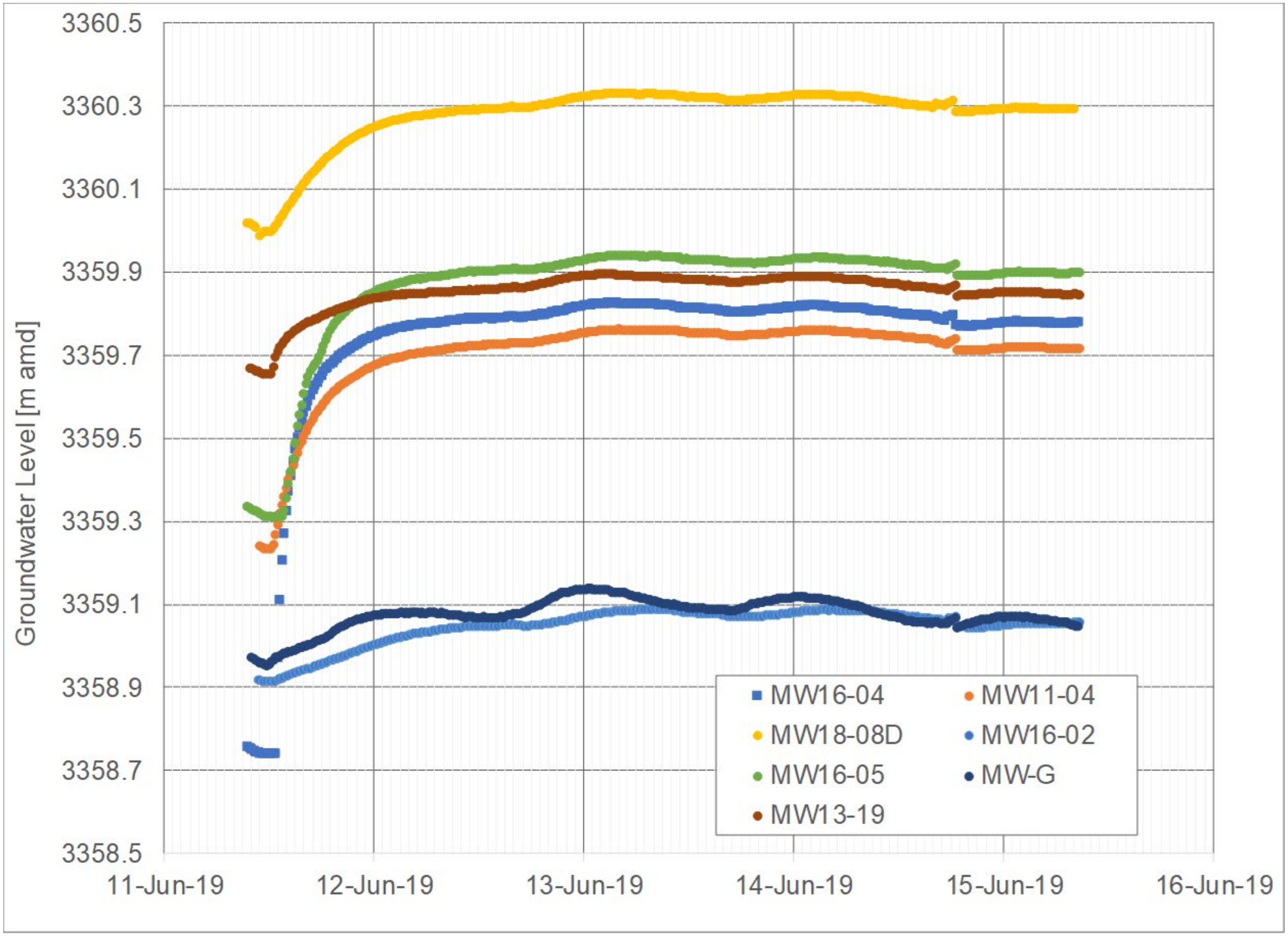


Figure 2-9. Time Trends of Groundwater Levels Near PW18 Pumping Wells

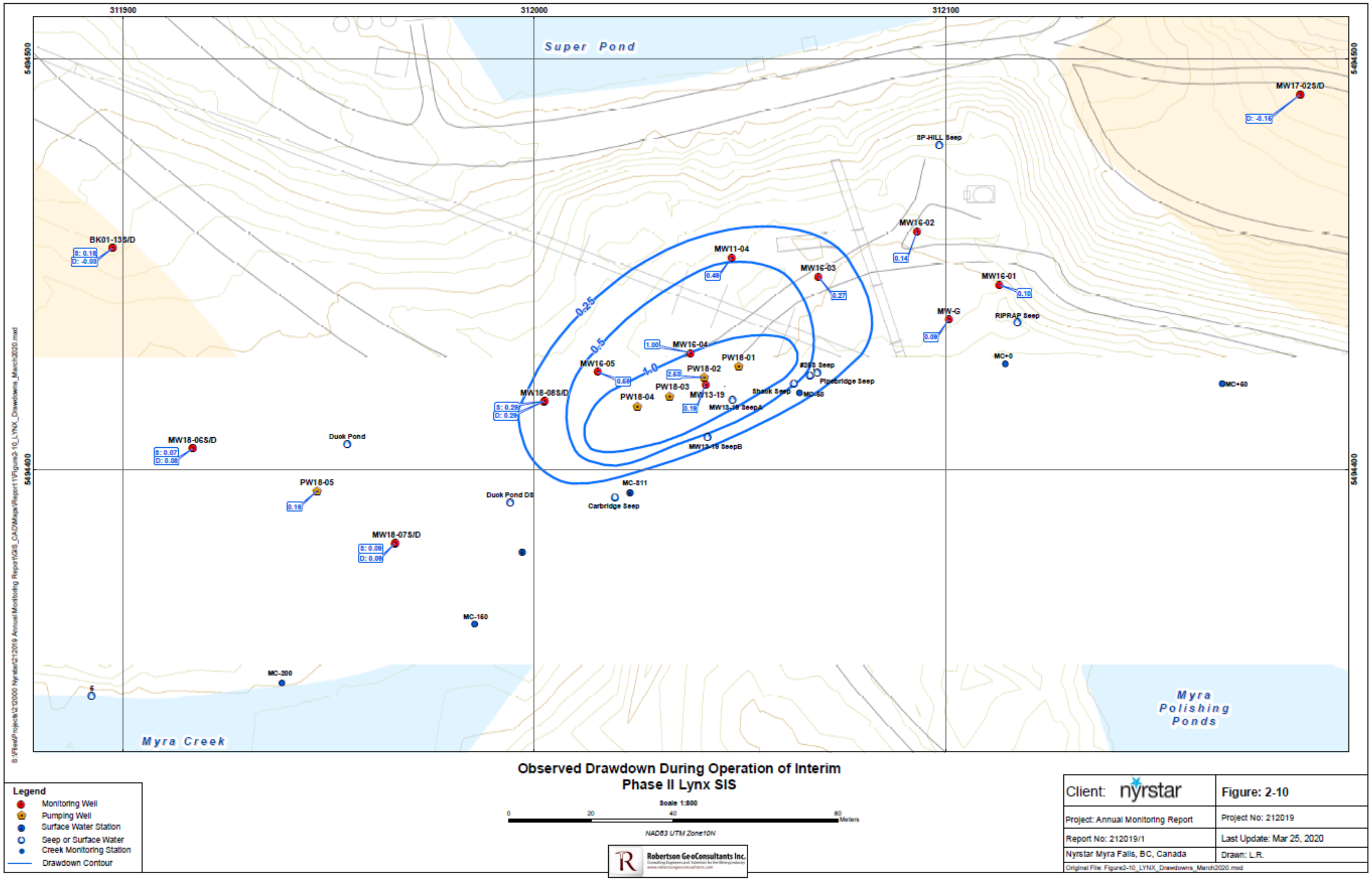

Super Pond
Myra Creek
Myra Polishing Ponds
MW17-02S/D
BK01-13S/D
MW11-04
MW16-02
MW16-03
MW16-01
MW-G
RIPRAP Seep
SP-HILL Seep
MW16-04
MW16-05
PW18-01
PW18-02
PW18-03
PW18-04
PW18-05
MW13-19
MW18-08S/D
MW18-06S/D
MW18-07S/D
Duck Pond
Duck Pond DS
Carbridge Seep
MC-811
MC-150
MC-200
MC+0
MC+60
Legend
Monitoring Well
Pumping Well
Surface Water Station
Seep or Surface Water
Creek Monitoring Station
Drawdown Contour
Observed Drawdown During Operation of Interim Phase II Lynx SIS
Scale 1:800
NAD83 UTM Zone10N
Client: nyrstar
Figure: 2-10
Project: Annual Monitoring Report
Project No: 212019
Report No: 212019/1
Last Update: Mar 25, 2020
Nyrstar Myra Falls, BC, Canada
Drawn: L.R.
Robertson GeoConsultants Inc.

Table 2-7.

Water Quality Results and Calculated Loads Captured at PW18 Series of Pumping Wells

Sample ID	Month	Pumping Rate [L/s]	Dissolved Sulphate (SO_4) [mg/L]	Dissolved Cadmium (Cd) [mg/L]	Dissolved Copper (Cu) [mg/L]	Dissolved Zinc (Zn) [mg/L]	Dissolved Sulphate (SO_4) [kg/month]	Dissolved Cadmium (Cd) [kg/month]	Dissolved Copper (Cu) [kg/month]	Dissolved Zinc (Zn) [kg/month]
PW18-01	March	4.2*	37.9	0.0014	0.028	0.626	427	0.016	0.32	7.0
PW18-02		4.1*	38.2	0.0013	0.024	0.623	423	0.014	0.27	6.9
PW18-03		4.8*	33.4	0.0009	0.011	0.509	428	0.012	0.14	6.5
PW18-04		2.6*	35.4	0.0009	0.005	0.619	250	0.006	0.04	4.4
PW18-01	April	4.2	31.9*	0.0012*	0.023*	0.521*	347	0.013	0.25	5.7
PW18-02		4.1	36.8*	0.0015*	0.033*	0.647*	393	0.016	0.35	6.9
PW18-03		4.8	30.9*	0.0008*	0.011*	0.454*	383	0.010	0.14	5.6
PW18-04		2.6	31.8*	0.0009*	0.005*	0.619*	217	0.006	0.04	4.2
PW18-01	May	3.5	25.9	0.0009	0.018	0.415	243	0.009	0.17	3.9
PW18-02		4.9	35.3	0.0016	0.041	0.670	463	0.021	0.54	8.8
PW18-03		5.0	28.4	0.0007	0.011	0.399	380	0.010	0.14	5.3
PW18-04		2.6	28.1	0.0009	0.005	0.619	196	0.006	0.04	4.3
PW18-01	June	2.6	20.3	0.0005	0.008	0.245	136	0.003	0.06	1.6
PW18-02		5.6	28.1	0.0011	0.024	0.483	409	0.016	0.35	7.0
PW18-03		5.2	25.4	0.0006	0.009	0.357	340	0.008	0.12	4.8
PW18-04		0.0	-	-	-	-	-	-	-	-
PW18-01	July	2.7	17.85*	0.0005*	0.008*	0.229*	130	0.003	0.06	1.7
PW18-02		5.7	24.9*	0.0009*	0.020*	0.405*	378	0.013	0.30	6.1
PW18-03		5.2	23.55*	0.0006*	0.008*	0.342*	327	0.008	0.11	4.7
PW18-04		0.0	-	-	-	-	-	-	-	-
PW18-01	August	2.7*	17.85*	0.0005*	0.008*	0.229*	130	0.003	0.06	1.7
PW18-02		5.7*	24.9*	0.0009*	0.020*	0.405*	378	0.013	0.30	6.1
PW18-03		5.2*	23.55*	0.0006*	0.008*	0.342*	327	0.008	0.11	4.7
PW18-04		0.0	-	-	-	-	-	-	-	-
PW18-01	September	2.7*	15.4	0.00045	0.0082	0.213	109	0.003	0.06	1.5
PW18-02		5.7*	21.7	0.00070	0.0146	0.327	319	0.010	0.21	4.8
PW18-03		5.2*	21.7	0.00051	0.0077	0.326	292	0.007	0.10	4.4
PW18-04		0.0	-	-	-	-	-	-	-	-
PW18-01	October	2.7*	20.5	0.00067	0.0127	0.307	149	0.005	0.09	2.2
PW18-02		0.0	-	-	-	-	-	-	-	-
PW18-03		5.2*	22	0.00068	0.0096	0.344	305	0.009	0.13	4.8
PW18-04		0.0	-	-	-	-	-	-	-	-
PW18-01	November	2.7*	23.8	0.00105	0.0198	0.419	168	0.007	0.14	3.0
PW18-02		0.0	-	-	-	-	-	-	-	-
PW18-03		5.2*	25.1	0.00101	0.0203	0.485	337	0.014	0.27	6.5
PW18-04		0.0*	-	-	-	-	-	-	-	-
PW18-01	December	5.0	23.8*	0.00105*	0.0198*	0.419*	319	0.014	0.27	5.6
PW18-02		0.0	-	-	-	-	-	-	-	-
PW18-03		5.3	25.1*	0.00101*	0.0203*	0.485*	356	0.014	0.29	6.9
PW18-04		0.0	-	-	-	-	-	-	-	-

*Note: Values were inferred from values observed in preceding and/or following months.

Table 2-8.

Summary of Contaminant Loads Captured by Interim Phase Lynx SIS

Month	Pumping Rate Combined [L/s]	Dissolved Sulphate (SO_4) [kg/month]	Dissolved Cadmium (Cd) [kg/month]	Dissolved Copper (Cu) [kg/month]	Dissolved Zinc (Zn) [kg/month]
March	15.8	1528	0.048	0.77	24.8
April	15.8	1342	0.045	0.77	22.5
May	16.0	1282	0.046	0.89	22.3
June	13.4	885	0.027	0.53	13.4
July	13.6	835	0.025	0.47	12.6
August	13.6	835	0.025	0.47	12.6
September	13.6	719	0.020	0.38	10.7
October	7.9	455	0.014	0.23	7.0
November	7.9	505	0.021	0.41	9.5
December	10.3	675	0.028	0.55	12.5
	Total	**9,061**	**0.30**	**5.46**	**148.0**

3 SITE-WIDE GROUNDWATER QUALITY REVIEW

The focus of this section is to review groundwater quality time trends and to assess how groundwater quality in 2019 compares to historic trends. A key emphasis is how groundwater quality has changed since the Phase I Lynx SIS began operating in September 2017. Some information on the MVA and local groundwater flow fields is provided but the information from Section 2 is not repeated, nor are details from previous RGC reports which detail design, installation and operation of the Lynx SIS, e.g. RGC (2018a).

Groundwater monitoring well and pumping well locations are shown in **Figure 3-1**. Groundwater quality in the following reaches is discussed in this section:

- Upstream Reach
- Lynx Reach
- Old TDF Reach
- Downstream Reach

These reaches are defined by water quality impacts to Myra Creek and multiple areas within each reach are discussed. These areas are discussed from upstream to downstream. Construction details and the monitoring status of monitoring wells and pumping wells are provided in the sub-sections below, either in the text or accompanying tables. Borehole logs are not provided but are available in previous RGC reports, including RGC (2015), RGC (2018b), and RGC (2018c).

Most of the wells are screened in the MVA or shallow underlying bedrock. Some wells are screened in waste rock or shallow sediments along the northern hillslope of Myra Valley. These wells are discussed separately, as they pertain to ARD/ML that reports to the MVA or seepage that is now collected by the Diversion Ditch Springs Drain (DDSD) near the Amalgamated Paste Area. None of these wells was sampled in 2019 but previous monitoring data are provided and discussed.

Voluntary and required monitoring data are discussed together in this section. Required monitoring data are also discussed in the 2019 Reclamation Report.

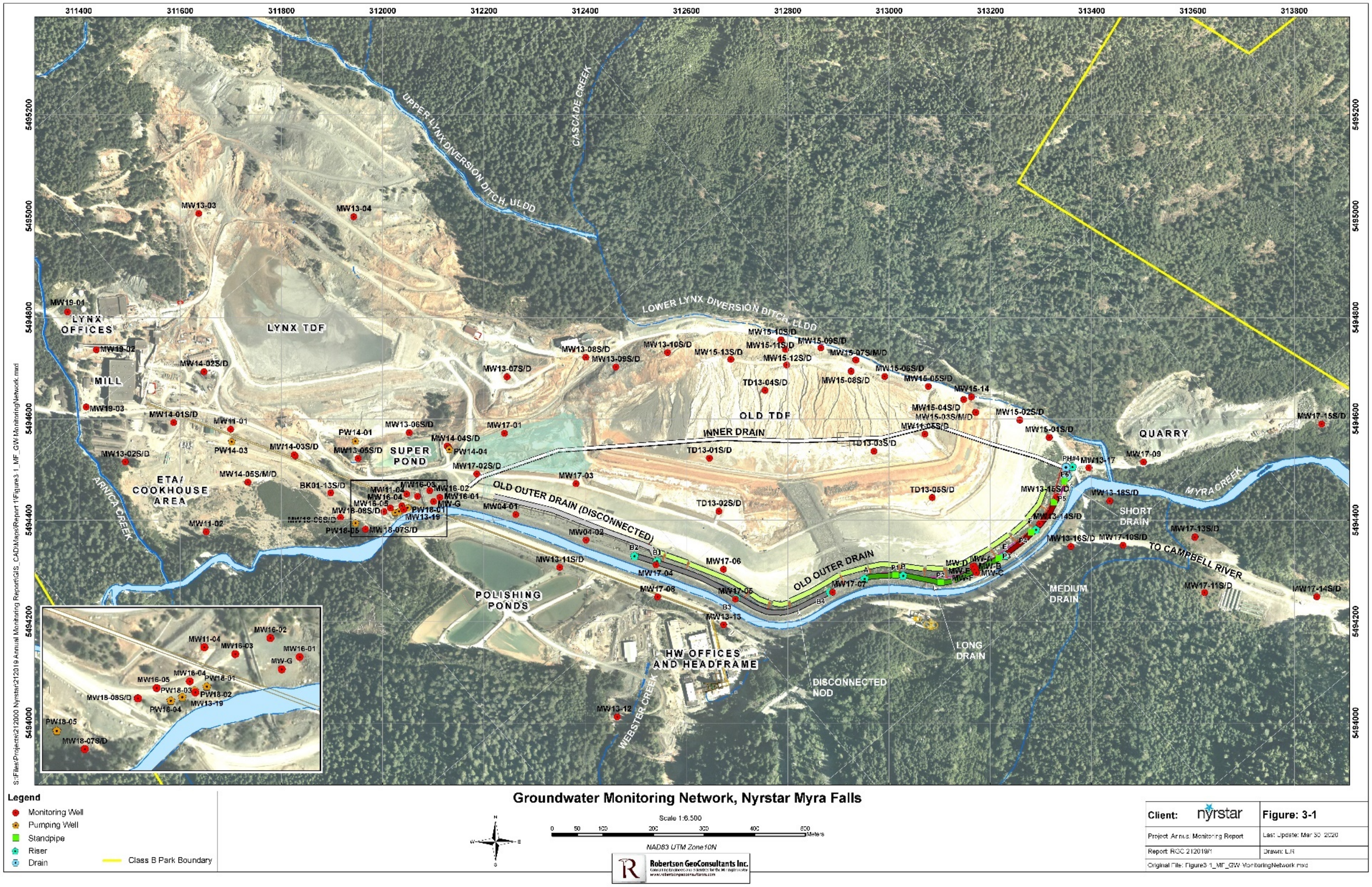


Figure 3-1. Groundwater Monitoring Wells and Pumping Wells

3.1 Data Sources

Groundwater quality results were provided by the NMF Environment Department and incorporated into a Microsoft Access database as part of the preparation of this report. The database contains water quality results since 2007. A Charge Balance Analysis (CBA) was conducted on the data included in the database to identify potential outliers and suspect data. Some data were removed from the database based on results from the CBA and a review of any unusually high or low metal concentrations that are unlikely to be representative.

A CBA and a comparison of duplicates for samples collected in 2019 was also completed as part of a Quality Assurance/Quality Control (QA/QC) check of these data (see Appendix B). None of the samples collected in 2019 were removed from the database, so the data (as received) are included in relevant tables and figures in this section and Section 4.

3.2 Upstream Reach

3.2.1 *Monitoring Well MW13-01*

Monitoring well MW13-01 is screened from 8.2 to 11.2 b bgs in bedrock (dacite) upgradient of the mine site. This well was installed in 2013 as part of a site-wide hydrogeological field investigation completed by RGC (see RGC, 2014). This well is not routinely monitored and was last sampled in 2018. All the data collected since 2013 are provided below.

3.2.2 *Background Water Quality*

Groundwater quality time trends for well MW13-01 are provided in **Figure 3-2**. There are no ARD/ML sources in the Upstream Reach. Groundwater from well MW13-01 is alkaline (pH 8) and characterized by substantial alkalinity, i.e. 100 to 150 mg/L HCO_3, and 20 to 80 mg/L SO_4. Metal concentrations are low, e.g. less than 0.04 mg/L Zn and less than 0.01 mg/L Cu. These concentrations are likely naturally occurring and vary slightly from year-to-year.

The last sample from well MW13-01 was collected in 2018 and was characterized by very low metal concentrations that were near or below reporting limits (see **Table 3-1**). There is some suggestion in RGC (2014) that the slightly elevated SO_4 and metals could be related to bedding material used for the explosive magazine. Groundwater quality in this area is a low priority and the ambiguity regarding a natural and mine-related source to groundwater in bedrock does not warrant further study or investigation.

Table 3-1.

Groundwater Quality Results for Monitoring Well MW13-01, Upstream of Mine Site

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW13-01	16-Sep-13	*7.9*	*161*	80	30	0.027	0.00001	0.00064	0.000	0.002	0.3	0.003	0.00001	0.00013	0.0005
MW13-01	14-Jan-14	7.9	261	97	37	0.007	0.00007	0.00077	0.003	0.001	0.5	0.002	0.00004	0.00009	0.012
MW13-01	04-Mar-14	7.9	292	98	47	0.006	0.00003	0.00048	0.001	0.001	0.5	0.001	0.00002	0.00007	0.030
MW13-01	08-Apr-14	-	-	117	79	0.025	0.00005	0.00024	0.003	0.004	0.7	0.002	0.00001	0.00008	0.001
MW13-01	16-Jun-14	-	-	104	50	0.013	0.00011	0.00044	0.002	0.002	0.6	0.001	0.00001	0.00008	0.007
MW13-01	06-Aug-14	-	-	100	40	0.014	0.00008	0.00023	0.002	0.002	0.5	0.001	0.00001	0.00007	0.002
MW13-01	02-Dec-14	-	-	93	20	0.013	0.00015	0.00004	0.006	0.001	0.01	0.001	0.00010	0.00005	0.034
MW13-01	09-Feb-15	-	-	121	44	0.012	0.00024	0.00006	0.005	0.003	0.3	0.001	0.00001	0.00005	0.037
MW13-01	29-Jun-15	8.0	338	115	52	0.013	0.00019	0.00008	0.009	0.029	0.3	0.001	0.00019	0.00005	0.029
MW13-01	11-Mar-16	-	-	128	63	0.005	0.00006	0.00003	0.003	0.012	0.4	0.001	0.00008	0.00004	0.008
MW13-01	14-Sep-18	7.8	175	81	8	0.005	0.00003	0.00008	0.000	0.004	0.1	0.000	0.00002	0.00008	0.002

Note: Italicized pH and EC values are lab results

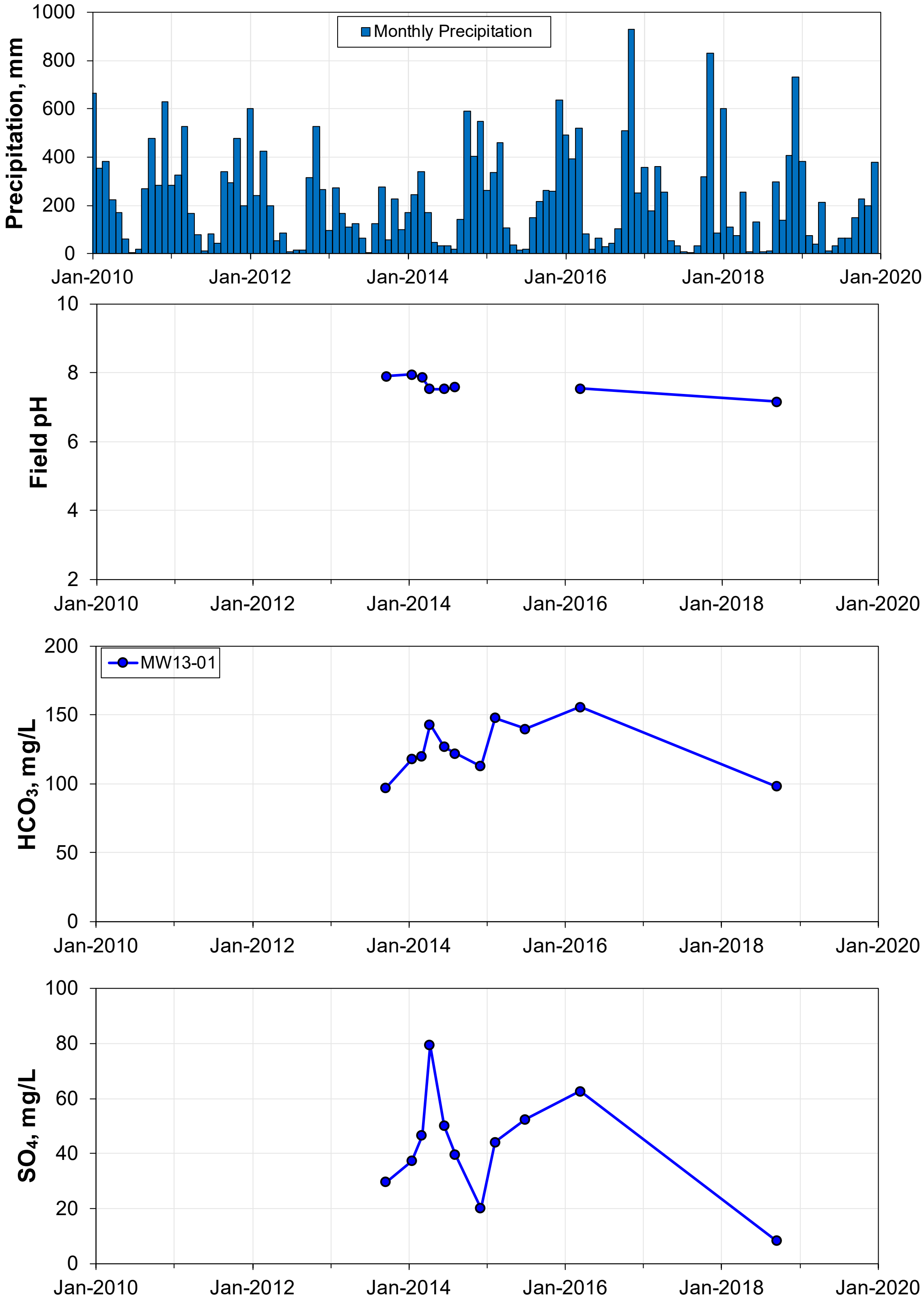


Figure 3-2a. Groundwater Quality Time Trends for Well MW13-01

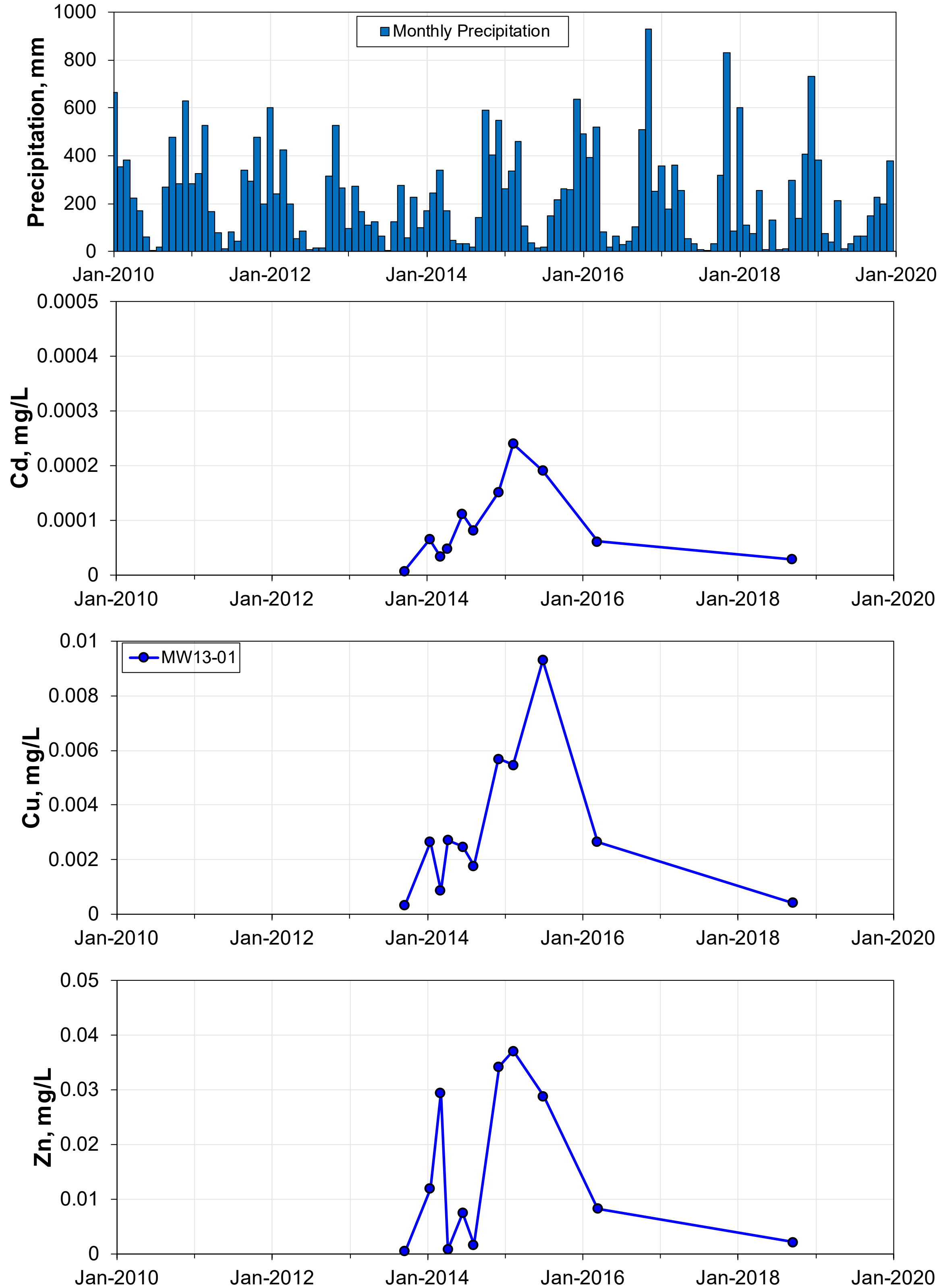


Figure 3-2b. Groundwater Quality Time Trends for Well MW13-01

3.3 NORTHERN HILLSLOPE – NEAR WRDS

3.3.1 *Monitoring Wells*

Table 3-2 summarizes construction details for groundwater monitoring wells screened in waste rock from the historic WRDs or the sediments or bedrock that underlie these WRDs.

Table 3-2.

Groundwater Monitoring Wells in WRD Area (Northern Hillslope)

Well ID	Installation Date	Depth Drilled, m bgs	Screening Interval, m bgs top	Screening Interval, m bgs bottom	Screened Material	Monitoring Status	Obligation
Lynx WRD Area							
MW13-03	26-Jul-13	38.8	35.7	28.7	Waste rock	Not routinely monitored	-
MW13-04	27-Jul-13	17.0	7.7	10.7	Gravel (some waste rock)	Not routinely monitored	-
Near WRD#1 and WRD#6							
MW13-07S	13-Aug-13	59.7	26.5	32.6	Waste rock	Not routinely monitored	-
MW13-07D	13-Aug-13	53.6	53.6	59.7	Gravel with sand	Semiannual	Voluntary
MW13-08S	12-Aug-13	34.1	17.1	20.1	Waste rock	Not routinely monitored	-
MW13-08D	12-Aug-13	31.1	31.4	34.1	Bedrock	Not routinely monitored	-
MW13-09S	8-Aug-13	59.7	29.3	35.4	Waste rock	Not routinely monitored	-
MW13-09D	8-Aug-13	50.3	50.3	54.9	Bedrock	Not routinely monitored	-

Well MW13-03 is screened in waste rock from WRD#3. Well MW13-04 is screened predominantly in natural gravel and sand but some oxidized waste rock in WRD#2 is also screened. WRD#2 is located along the northern hillslope above the Lynx TDF. WRD#3 and portions of WRD#2 were re-located in 2017 and 2018, as waste rock was unstable and therefore considered a risk to the Lynx TDF (see Amec Foster Wheeler, 2017). Well MW13-03 was destroyed in 2018 and MW13-04 was destroyed in 2019 duing re-location of WRD#2. WRD#2, WRD#3, and WRD#4 are collectively referred to as the Lynx WRDs, given their proximity to the former Lynx open pit.

Wells MW13-07S, MW13-08S, and MW13-09S are screened in oxidized waste rock in WRD#1. WRD#1 is the largest of the historic WRDs and has been partially buried by tailings in the Old TDF. A portion of WRD#1 is exposed near the Paste Plant where well MW13-07S is located. Well MW13-09S and MW13-09D are located on top of WRD#6. The deeper ("D") wells near WRD#1 and WRD#6 are screened in natural sediments or underlying bedrock.

Wells MW13-07S, MW13-08S, and MW13-09S are typically dry and therefore have not been sampled. Wells MW13-07S and MW13-07D are within a construction stockpile and can currently not be sampled safely.

3.3.2 *Groundwater Quality Trends – Near WRDs*

Figure 3-3 provides groundwater quality time trends for wells near the WRDs. No water quality data are available for wells MW13-07S, MW13-08S, and MW13-09S (all screened in waste rock) as these wells were dry. Key observations are summarized below:

- *MW13-04 (7.7 to 10.7 m bgs, "Shallow MVA").* Groundwater from well MW13-04 is characterized by circum-neutral to slightly acidic pH values and elevated EC. SO_4 concentrations range from 100 to 200 mg/L SO_4 and metal concentrations are elevated, e.g. up to 5 mg/L Zn. These data are consistent with moderate impacts due to ARD from sulphide-bearing waste rock in WRD#2. Groundwater quality appears to be stable and this well was not sampled in 2019.
- *MW13-07D (53.6 to 59.7 m bgs, "Deep MVA").* Groundwater from well MW13-07D is characterized by elevated SO_4 and very low Zn concentrations. These data suggest some impact by ARD generated by PAG waste rock in WRD#1. Groundwater quality appeared to be stable when it was last sampled in 2015 and this well was later destroyed during construction earthworks.
- *MW13-08D (31.4 to 34.1 m bgs, "Bedrock").* Groundwater from well MW13-08D is acidic (pH 4.5) and characterized by no appreciable alkalinity. Cu concentrations range from 1 to 3 mg/L and Zn concentrations were near 20 mg/L in 2015. These data suggest substantial ARD from WRD#1 reports to groundwater in bedrock in this area. There is 27.5 m of sulphide-bearing waste rock overlying bedrock at this location, so the elevated SO_4 and metal concentrations are expected. Well MW13-08D has not been sampled since 2016 and further characterization of the groundwater quality time trend is a low-priority, given the location of this well and the small magnitude of groundwater flow in bedrock.

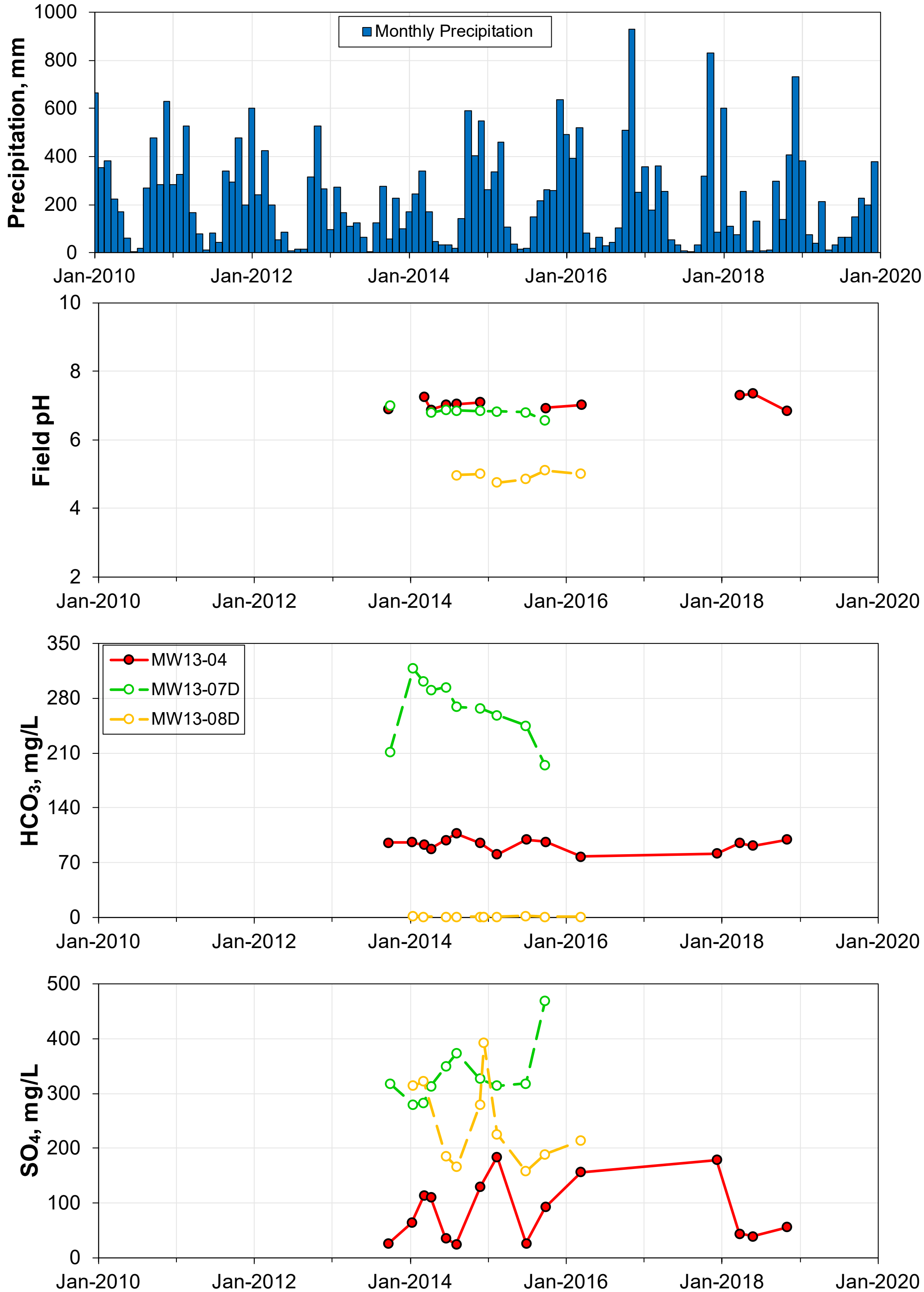


Figure 3-3a. Groundwater Quality Time Trends for Wells Near WRDs (Northern Hillslope)

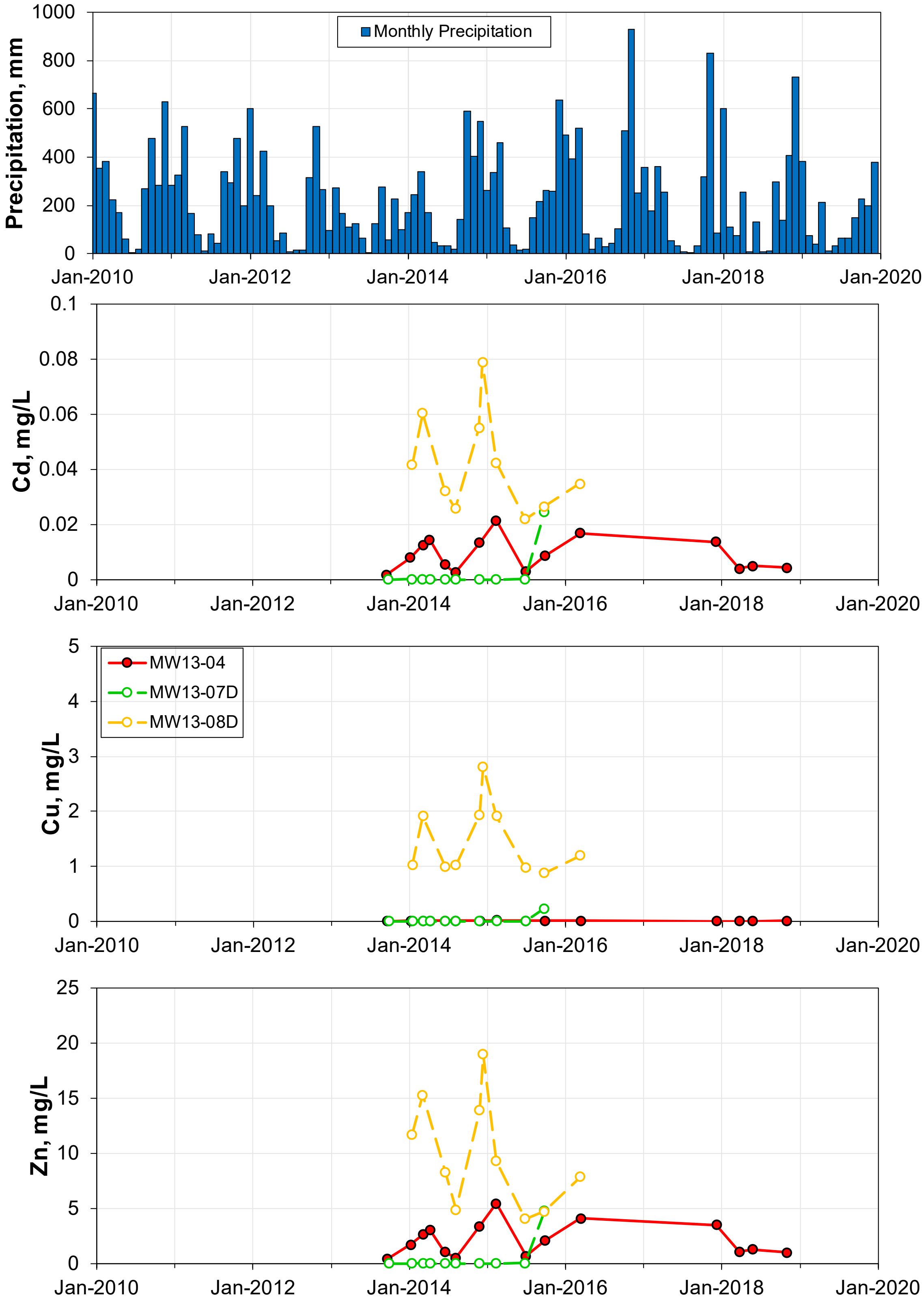


Figure 3-3b. Groundwater Quality Time Trends for Wells Near WRDs (Northern Hillslope)

3.4 LYNX REACH

3.4.1 *Monitoring Wells*

Table 3-3 summarizes construction details for monitoring wells in the Lynx Reach. The Lynx Reach includes the mill area, the ETA/Cookhouse area, and the area downgradient of the Lynx TDF near the Interim Phase II Lynx SIS and Myra Creek (near carbridge). Most of the wells in this reach were installed in 2013 as part of a site-wide hydrogeological field investigation or in 2014 to support the design of the Phase I Lynx SIS. Several wells were also installed in 2011 as part of previous geotechnical investigations of this area.

Three new monitoring wells (MW19-01, MW19-02, and MW19-03) were installed in 2019 to refine the local groundwater flow field near the mill and further characterize stratigraphy and groundwater quality impacts near the mill. The locations and screening intervals for these wells were selected by RGC and drilling and well installation was undertaken by Wood. These wells were first sampled in January 2020 and the initial monitoring results are provided here for reference.

3.4.2 *Local Groundwater Flow Field*

The local groundwater flow field during low flow conditions in groundwater suggests groundwater flows in an easterly direction across the mill area towards the Old TDF and does not discharge to Myra Creek (**Figure 3-4**). Under higher flow conditions (**Figure 3-5**), the local flow field shifts slightly so that groundwater is directed in a more south-easterly direction towards Myra Creek at the carbridge (at MC+50 m). These groundwater flow fields likely prevailed since the mill was constructed in the 1960s and for the 12 years since construction of the Lynx TDF began. This is important because sulphide-bearing waste rock in the mill area and the waste rock used to construct the Lynx TDF embankment berm are major sources of ARD/ML and have contributed to SO_4 and metal plumes that migrate downgradient in the MVA towards the Old TDF Reach.

Since October 2017, the groundwater flow field in the Lynx Reach has been modified by pumping from the Phase I Lynx SIS pumping wells PW14-01, PW14-03, and PW14-04 (see Section 2.1). Pumping has caused a more pronounced horizontal hydraulic gradient towards the pumping wells, indicating groundwater flow from a larger portion of the MVA towards the pumping wells. Gradients are reversed immediately downgradient of the pumping wells during low flow and high flow conditions for groundwater. This change in hydraulic gradients has allowed full hydraulic capture of ARD-impacted groundwater within the Lynx Reach to be achieved by the three PW14 pumping wells (see Section 2) and explains recent groundwater quality improvements in the Lynx Reach and the upper Old TDF Reach near the Surge Pond that are detailed below.

Groundwater quality time trends in the Lynx Reach are discussed in this section in the context of these recent changes in the local groundwater flow regime. Groundwater quality further downgradient of the Lynx Reach (i.e. in the Old TDF Reach) is discussed in Section 3.4.

Table 3-3.

Groundwater Monitoring Wells in Lynx Reach

Well ID	Installation Date	Depth Drilled, m bgs	Screening Interval, m bgs top	Screening Interval, m bgs bottom	Screened Material	Monitoring Status	Obligation
Mill Area							
MW19-01S	6-Dec-19	24.4	6.1	7.6	Gravel	TBD	-
MW19-01D	6-Dec-19	24.4	16.5	19.5	Sand	TBD	-
MW19-02S	4-Dec-19	31.4	5.2	9.8	Gravel	TBD	-
MW19-02D	4-Dec-19	31.4	22.3	26.4	Silty sand	TBD	-
MW19-03S	5-Dec-19	18.8	7.2	5.2	Gravel	TBD	-
MW19-03D	5-Dec-19	18.8	14.9	18.0	Gravel	TBD	-
MW14-01S	3-Sep-14	32.3	23.9	26.9	Sand and Gravel	Semiannual	Voluntary
MW14-01D	3-Sep-14	32.3	29.4	32.4	Bedrock	Semiannual	Voluntary
MW14-02S	4-Sep-13	22.9	6.1	9.1	Gravel	Semiannual	Voluntary
MW14-02D	4-Sep-13	22.9	18.3	22.9	Gravel and Bedrock	Semiannual	Voluntary
MW11-01	22-Jun-11	30.5	28.4	29.9	Gravel with 10% Sand	Semiannual	Voluntary
PW14-03	6-Sep-14	41.5	29.0	32.0	Gravel	Monthly	Voluntary
ETA/Cookhouse Area							
MW13-02S	30-Jul-13	44.8	20.4	23.5	Gravel with sand	Semiannual	Voluntary
MW13-02D	30-Jul-13	29.4	29.2	35.4	Sand with gravel	Semiannual	Voluntary
MW11-02	21-Jun-11	9.1	5.5	8.5	Sand and gravel	Semiannual	Voluntary
MW14-05S	13-Sep-14	26.5	7.3	8.8	Gravel	Not routinely monitored	-
MW14-05M	13-Sep-14	26.5	11.0	14.0	Gravel	Semiannual	Voluntary
MW14-05D	13-Sep-14	26.5	23.2	26.2	Gravel	Semiannual	Voluntary
BK01-13S	-	13.4	10.1	13.1	-	Not routinely monitored	-
BK01-13D	-	22.3	18.6	21.6	-	Not routinely monitored	-
Superpond Area (near PW14-01)							
PW14-01	23-Aug-14	31.6	26.4	29.5	Gravel	Monthly	Voluntary
MW14-03S	9-Jul-14	22.0	18.6	21.6	Sand and Gravel	Semiannual	Voluntary
MW14-03D	8-Jul-14	37.5	32.3	35.4	Gravel	Semiannual	Voluntary
MW13-05S	29-Jul-13	57.0	10.7	13.7	Gravel	Semiannual	Voluntary
MW13-05D	29-Jul-13	20.1	20.2	26.2	Sand with gravel	Semiannual	Voluntary
MW13-06S	13-Aug-13	68.9	12.8	15.9	Gravel with sand	Semiannual	Voluntary
MW13-06D	13-Aug-13	35.4	35.4	41.5	Sand with gravel	Semiannual	Voluntary
Superpond Area (near PW14-04)							
PW14-04	9-Sep-14	23.8	19.5	21.9	Coarse Gravel	Monthly	Voluntary
MW14-04S	28-Aug-14	7.9	3.1	6.1	Gravel	Semiannual	Voluntary
MW14-04D	28-Aug-14	41.1	18.7	21.7	Sandy Gravel	Semiannual	Voluntary
Upgradient of Interim Phase II Lynx SIS							
MW16-01	4-Oct-16	4.5	0.8	3.8	Waste rock	Monthly/quarterly*	-
MW16-02	4-Oct-16	5.6	2.2	5.2	Gravel with sand	Monthly/quarterly*	Voluntary
MW16-03	5-Oct-16	4.5	1.1	4.2	Gravel with sand	Monthly/quarterly*	Voluntary
MW16-04	5-Oct-16	5.0	1.7	4.6	Sandy gravel	Monthly/quarterly*	Voluntary
MW16-05	13-Oct-16	5.0	1.8	4.8	Sandy gravel	Monthly/quarterly*	Voluntary
MW11-04	21-Jun-11	6.4	4.9	6.4	Silt and gravel	Monthly/quarterly*	Voluntary
MW18-06S	11-May-18	18.29	6.7	9.8	Gravel with silt and sand	Monthly/quarterly*	Voluntary
MW18-06D	11-May-18	18.29	15.2	18.3	Sand with silt and gravel	Monthly/quarterly*	Voluntary
MW18-07S	10-May-18	17.07	4.6	7.6	Silty gravel with sand	Monthly/quarterly*	Voluntary
MW18-07D	10-May-18	17.07	13.6	15.1	Silty gravel with sand	Monthly/quarterly*	Voluntary
MW18-08S	10-May-18	18.29	3.0	6.1	Clayed gravel with sand	Monthly/quarterly*	Voluntary
MW18-08D	10-May-18	18.29	7.3	10.4	Gravel with sand	Monthly/quarterly*	Voluntary
Interim Phase II Lynx SIS							
PW18-01	12-May-18	11.28	1.5	10.7	Clayey sand with gravel	Monthly, when pumping	Voluntary
PW18-02	12-May-18	11.28	1.5	10.7	Silty gravel with sand	Monthly, when pumping	Voluntary
PW18-03	13-May-18	11.28	1.5	10.7	Clayey gravel with sand	Monthly, when pumping	Voluntary
PW18-04	13-May-18	11.58	1.5	10.7	Sand with gravel	Monthly, when pumping	Voluntary
PW18-05	14-May-18	11.28	1.5	10.7	Sand, gravel with sand	Not routinely monitored	-
MW13-19	14-Aug-13	20.1	17.1	20.1	Sand with gravel	Annual	Voluntary

* Monthly sampling in Q1 and Q4 and quarterly sampling in Q2 and Q3

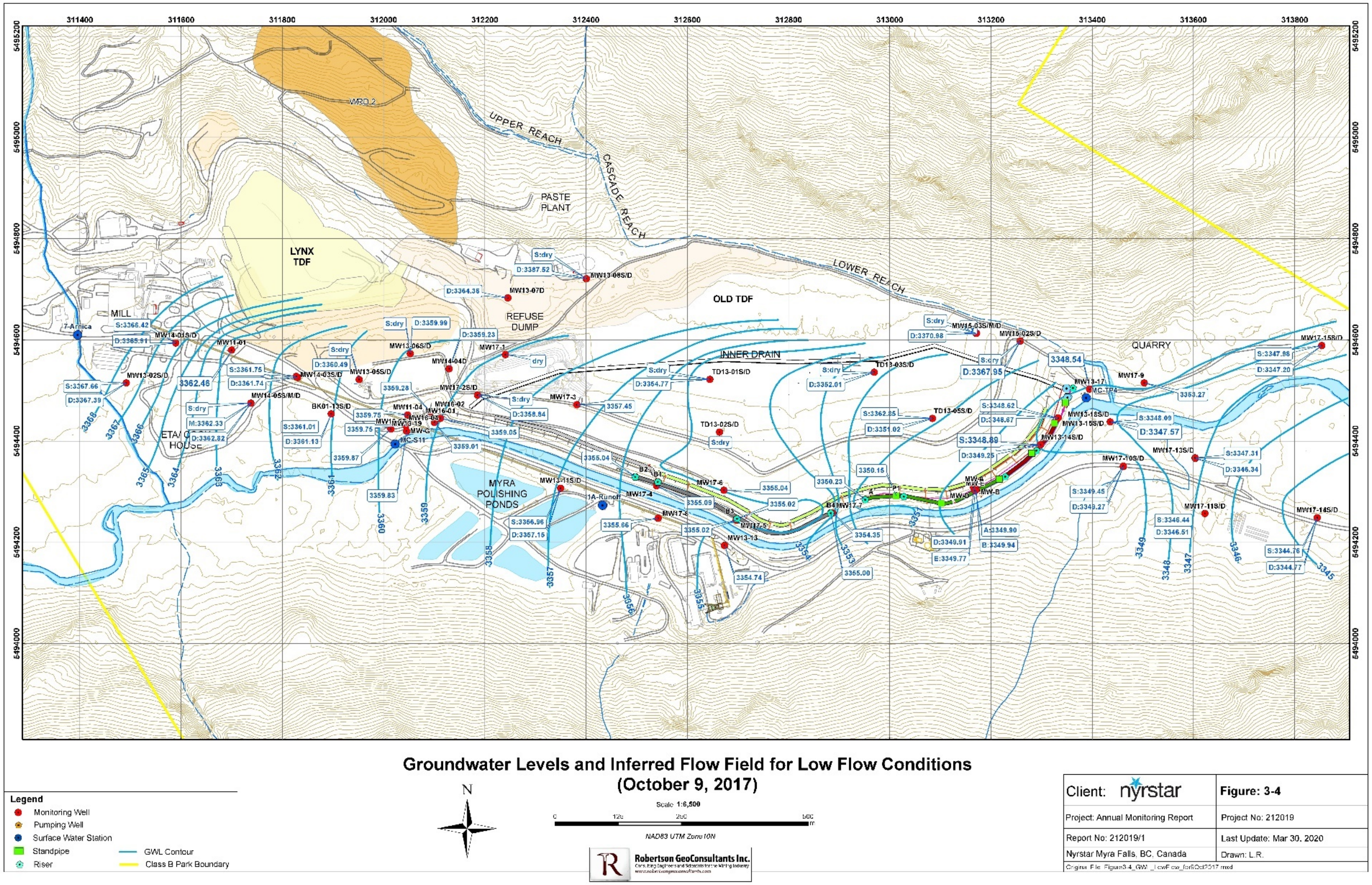


Figure 3-4 Inferred Groundwater Flow Field (Low Flow Conditions) Prior to Lynx SIS Operating

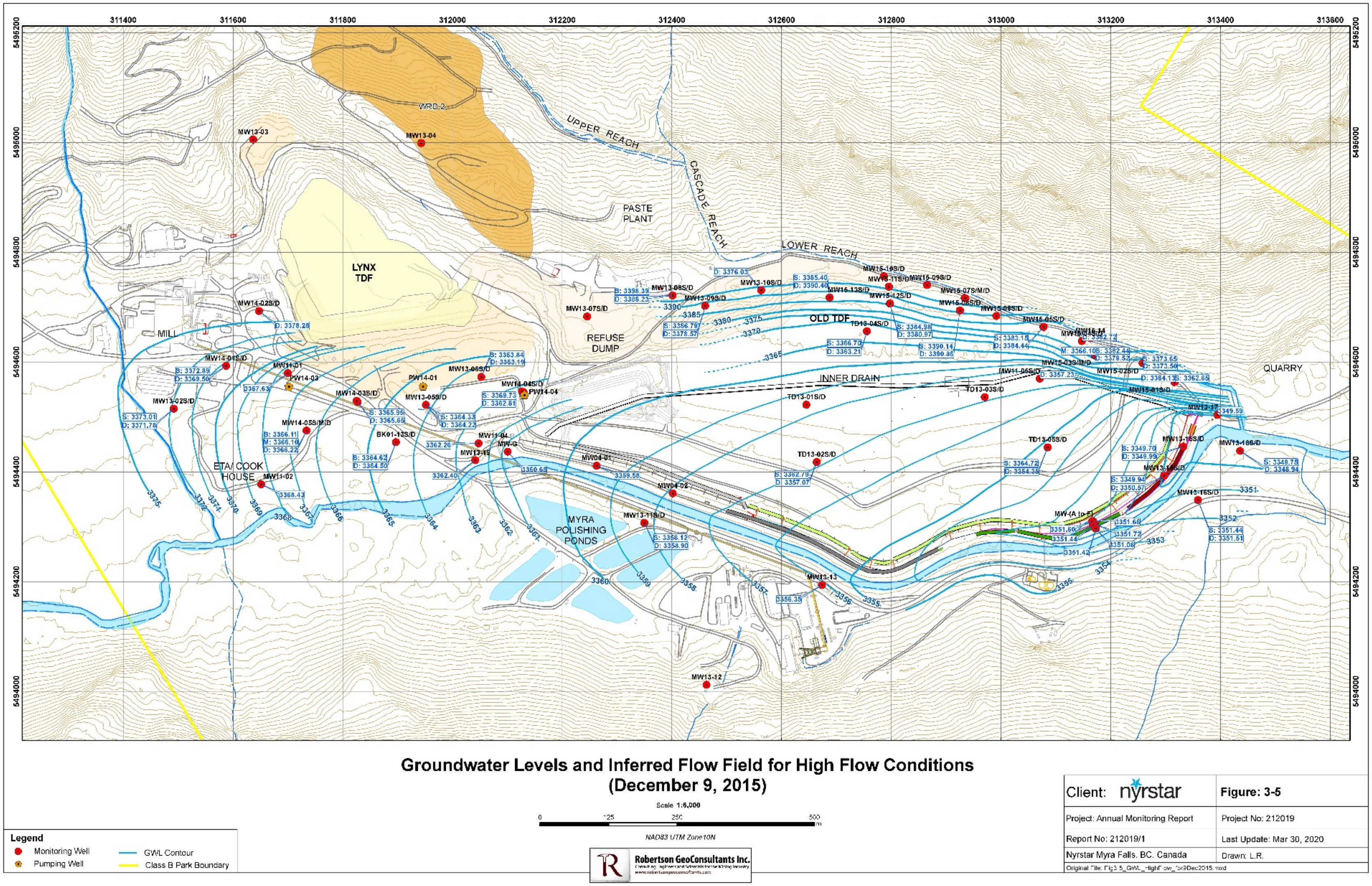


Figure 3-5 Inferred Groundwater Flow Field (High Flow Conditions) Prior to Lynx SIS Operating

3.4.3 *Groundwater Quality – Mill Area*

Groundwater quality time trends for wells in the Lynx WRDs area are provided in **Figure 3-6**. Groundwater quality results for 2019 (and early 2020) are summarized in **Table 3-4**. The key ARD source in this area is likely the sulphidic waste rock behind the mill towards the former Lynx offices or used as foundation material for the mill, which could contribute up to 20% of the annual loads in groundwater in the MVA (see RGC, 2018). Groundwater quality in the Mill area is unlikely to be impacted by ARD generated by the Lynx TDF embankment berm, since the groundwater flow field (see Figures 3-4 and 3-5) shows that most wells are upgradient of the berm.

Table 3-4.

Groundwater Quality Results for Wells in Mill Area, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW19-01	02-Jan-20				12	0.0061	0.0014	0.0037	0.0009	<0.010	0.6	0.0025	<0.00020	<0.00050	0.5
MW19-02S	02-Jan-20				190	0.1	0.0080	0.0158	0.01	0.3	2.8	0.01	0.0006	<0.00050	3.4
MW19-02D	02-Jan-20				22	0.0657	0.0004	0.0002	0.07	<0.010	0.0396	<0.00040	0.0002	0.0005	0.05
MW19-03D	02-Jan-20				8	0.0054	<0.000010	1.20E-04	0.00043	<0.010	0.00974	<0.00040	<0.00020	<0.00050	<0.0040
MW14-01S	07-Mar-19	*6.2*	*433*	11	191	0.11	0.006	0.004	0.2	0.053	0.5	0.007	0.0002	0.0005	5.0
MW14-01S	20-Sep-19	5.5	476	-	212	0.02	0.005	0.003	0.1	0.01	0.4	0.005	0.0002	0.0005	3.4
MW14-01S	07-Nov-19	6.6	462	16	231	0.14	0.004	0.004	0.1	0.116	0.4	0.006	0.0002	0.0005	3.7
MW14-01D	20-Sep-19	6.2	710	112	236	0.01	0.004	0.004	0.04	0.01	1.8	0.005	0.0002	0.0005	2.1
MW14-02D	12-Jun-19	7.2	560	62	227	0.01	0.003	0.003	0.01	0.01	2.0	0.003	0.0002	0.0005	2.4
PW14-03	07-Mar-19	*5.8*	*667*	6	390	1.9	0.035	0.009	1.4	0.018	1.4	0.021	0.0005	0.0005	21.3
PW14-03	10-Apr-19	*5.8*	*637*	5	346	2.1	0.031	0.009	1.4	0.013	1.4	0.020	0.0004	0.0005	20.4
PW14-03	10-May-19	5.2	525	7	297	1.6	0.031	0.008	1.3	0.01	1.4	0.018	0.0048	0.0005	18.4
PW14-03	10-Jun-19	-	-	8	278	1.5	0.026	0.007	1.2	0.02	1.2	0.017	0.0005	0.0005	15.5
PW14-03	31-Jul-19	7.5	390	11	213	0.06	0.020	0.005	0.8	0.01	0.8	0.012	0.0004	0.0005	13.0
PW14-03	11-Sep-19	*6.3*	*358*	15	154	0.59	0.012	0.003	0.6	0.013	0.5	0.008	0.0002	0.0005	8.1
PW14-03	09-Oct-19	*6.4*	*362*	15	154	0.01	0.013	0.003	0.6	0.01	0.6	0.009	0.0002	0.0005	9.2
PW14-03	12-Nov-19	6.6	493	11	217	0.04	0.020	0.005	0.9	0.01	0.8	0.013	0.0003	0.0005	13.2

Note: Italicized pH and EC values are lab results

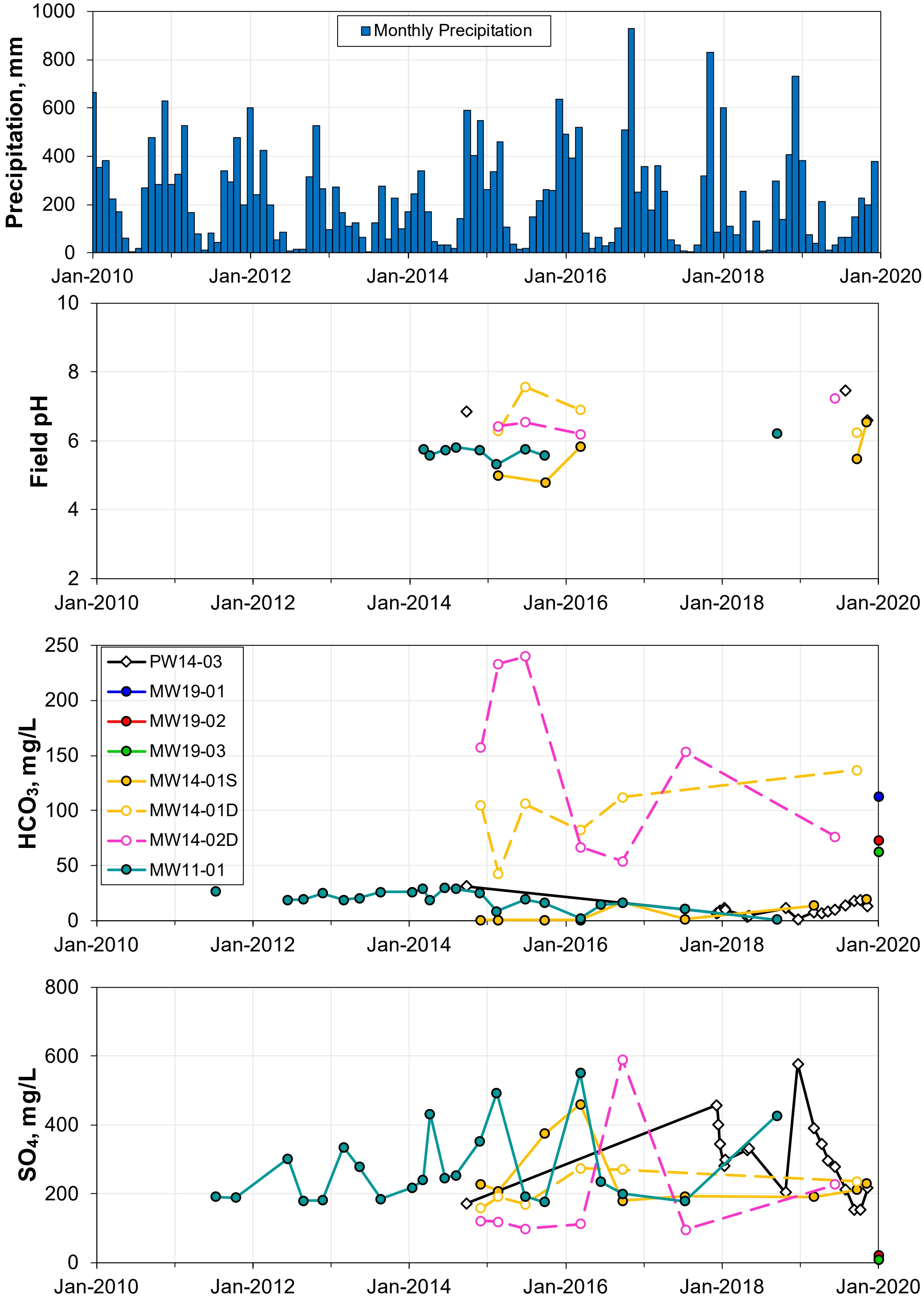


Figure 3-6a. Groundwater Quality Time Trends for Wells in Mill Area

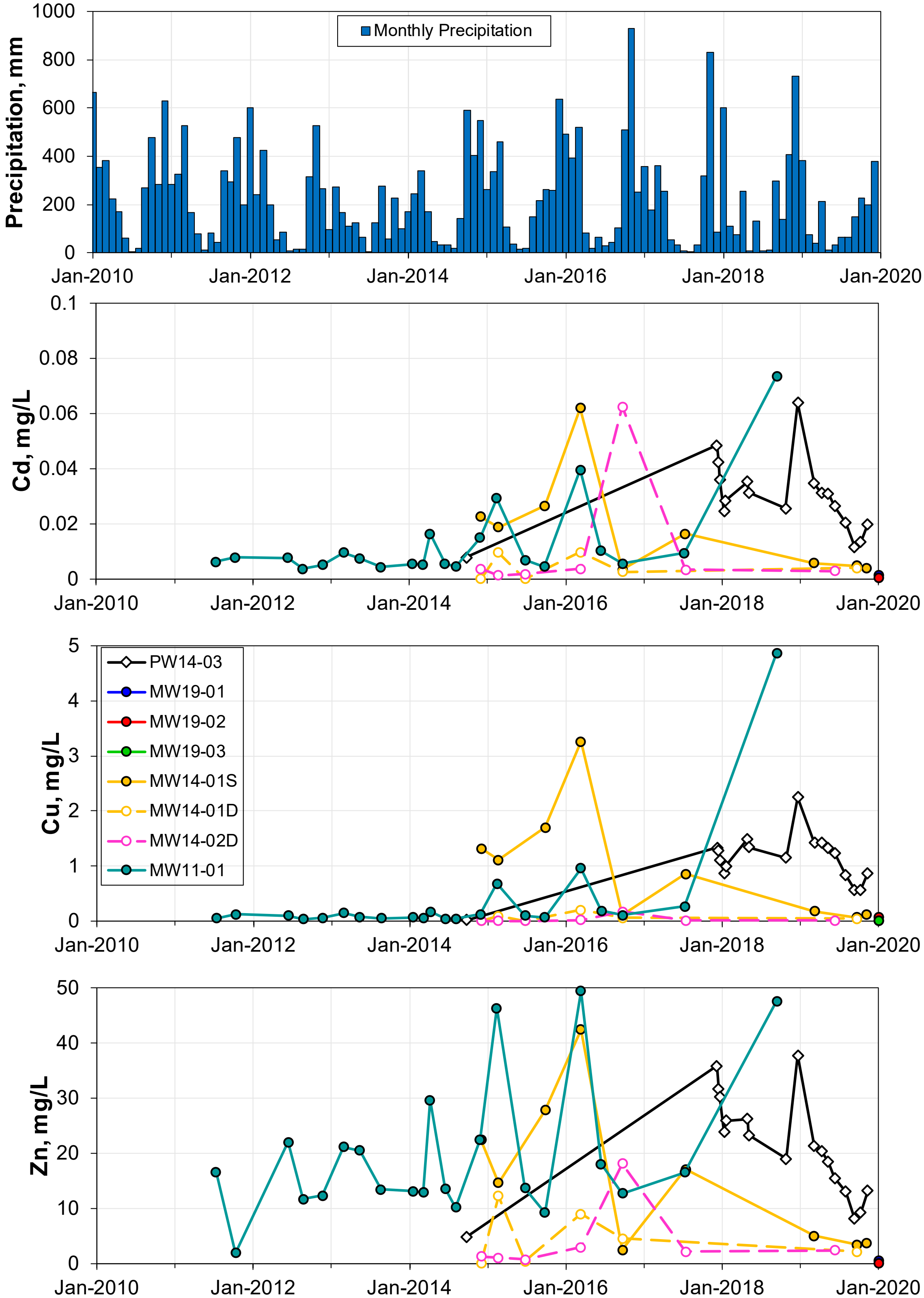


Figure 3-6b. Groundwater Quality Time Trends for Wells in Mill Area

Groundwater quality impacts in the mill area are summarized as follows:

- *MW19-01S (6.1 to 7.6 m bgs, "Deep MVA").* Groundwater from well MW19-01S is characterized by very low SO_4 (6.5 mg/L SO_4) and metal concentrations, e.g. 0.0069 mg/L Zn, which suggests only very minor impacts, if any, due to ARD. Well MW19-01 is north of the Lynx offices where there are no known ARD sources. Flowing Artesian conditions are observed.

- *MW19-01D (16.5 to 19.5 m bgs, "Deep MVA").* Groundwater from well MW19-01D is characterized by low SO_4 (12 mg/L SO4) and metal concentrations, e.g. 0.5 mg/L Zn, which suggests only minor impacts due to ARD.

- *MW19-02S (5.2 to 9.8 m bgs, "Shallow MVA").* Groundwater from well MW19-02S was characterized by elevated concentrations of SO_4 and most metals, e.g. 3.4 mg/L Zn. This well is screened in sand and gravel below approximately 6 m of gravel-sized, oxidized waste rock behind the mill.

- *MW19-02D (22.3 to 26.4 m bgs, "Deep MVA").* Groundwater from well MW19-02D is characterized by SO_4 and metal concentrations that are near background levels observed upgradient of the site at well MW13-01. Well MW19-02D is screened in deeper sediments of the MVA and is separated from MW19-02S by a significant till layer. Groundwater levels within the deeper aquifer are around 7 m higher than levels in the shallow aquifer, suggesting confined conditions in the deeper MVA.

- *MW19-03S (5.2 to 7.2 m bgs, "Shallow MVA").* This well was dry in early January 2019 and has not yet been sampled. Groundwater quality could be affected by interactions with nearby Arnica Creek during high flow periods and sampling in the spring (2020) should be undertaken in conjunction with surface water sampling and a flow survey.

- *MW19-03D (14.9 to 18.0 m bgs, "Deep MVA").* Groundwater from well MW19-03D is characterized by less than 10 mg/L SO_4 and metal concentrations that are below reporting limits, i.e. <0.0004 mg/L Zn. Groundwater temperature was low (2.4 °C) suggesting that Arnica Creek is losing water to the MVA in the vicinity of this well. Further monitoring is needed to better characterize groundwater-surface water interactions in this area and characterize ARD/ML impacts to groundwater and Arnica Creek.

- *MW14-01S (23.9 to 26.9 m, "Deep MVA").* Groundwater from well MW14-01S was characterized by 3 to 5 mg/L Zn in 2019 and approximately 200 mg/L SO_4. These concentrations are about an order-of-magnitude lower than observed in 2016, possibly due to pumping from pumping well PW14-03 since October 2017. However, a downward trend preceded the operation of pumping well PW14-03 and SO_4 concentrations in groundwater from well MW14-01S have not decreased substantially since 2017. This suggests that the decrease may be related to a factor other than pumping, such as higher recharge or the re-location of waste rock from this area. Zn concentrations increased in late 2019, most likely due to high rainfall recharge.

- *MW14-01D (32.3 to 32.4 m bgs, "Bedrock")*. Groundwater from well MW14-01D is characterized by elevated SO_4 and more than 10 mg/L Zn in 2016 and 2017. In 2019, Zn concentrations were less than 5 mg/L Zn. This trend is consistent with the trend observed in the shallow MVA at well MW14-01S (see above) and suggests some effect by pumping at pumping well PW14-03 and/or source removal.

- *MW14-02S (6.1 to 9.1 m bgs, "Shallow MVA").* This well is typically dry and was not sampled initially in 2014, nor since then as part of routine groundwater monitoring. This well is located within the final footprint of the Lynx TDF embankment berm and was destroyed in 2018 to allow future raises of the embankment.

- *MW14-02D (18.3 to 22.9 m bgs, "Deep MVA").* Groundwater from this well is characterized by elevated SO_4 and metals, e.g. 2.4 mg/L Zn in 2019. More than 10 mg/L Zn was observed in groundwater in 2016 and approximately 2 mg/L Zn was observed in 2017. There are too few data available to establish a trend.

- *PW14-03 (29.0 to 32.0 m bgs, "Deep MVA").* Groundwater from pumping well PW14-03 is characterized by elevated SO_4 and metals, i.e. nearly 40 mg/L Zn and 1 to 3 mg/L Cu in early 2018 (within six months of this well first operating). SO_4, Cd, Cu, Mn, and Zn concentrations decreased throughout most of 2019, although there was a slight increase in concentrations in late 2019. The increase could be related to impacted water from the mill flowing nearby in an unlined ditch since May 2019. The overall trend towards lower concentrations suggests this pumping well is capturing less impacted groundwater over time or that concentrations decreased in 2019 due to drier conditions on site and less recharge. This is consistent with increasing HCO_3 concentrations, which suggest groundwater with substantial alkalinity is being recovered by pumping well PW14-03. Future monitoring data are needed to confirm this trend and verify the increase that occurred in late 2019.

- *MW11-01 (28.4 to 29.9 m bgs, "Deep MVA").* Groundwater from well MW11-01 is characterized by elevated concentrations of SO_4 and metals. SO_4 concentrations are quite variable, and peak concentrations appeared to be increasing over time. The last sample collected (in late 2018) was characterized by 400 mg/L SO_4 and nearly 50 mg/L Zn. This well is upgradient of pumping well PW14-03 and the recent deterioration in groundwater quality could be related to a change in the local groundwater flow field and/or construction activities in 2018. Recent trends cannot be established, as this well was not sampled in 2019.

3.4.4 *Groundwater Quality – ETA/Cookhouse Area*

Figure 3-7 provides groundwater quality time trends for wells in the ETA/Cookhouse area. Groundwater quality results for 2019 are summarized in **Table 3-5**. The MVA in the ETA/Cookhouse area is thicker than in the Mill Reach, i.e. approximately ~30 m at MW13-02D, and increases towards the Super Pond. Groundwater quality in the ETA/Cookhouse area is moderately impacted by ARD generated by residual sulphidic tailings and/or waste rock in the ETA. Groundwater from this area tends to flow towards the Duck Pond and/or Myra Creek, although monthly creek profiling suggests loads to the creek from ARD-impacted groundwater in this area are relatively small (see Section 4).

Table 3-5.

Groundwater Quality Results for Wells in ETA/Cookhouse Area, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW13-02S	06-Mar-19	6.4	214	43	48	0.02	0.0001	0.0001	0.01	0.01	0.00203	0.0004	0.0002	0.0005	0.03
MW13-02S	21-Nov-19	5.9	227	45	77	0.01	0.0009	0.0001	0.01	0.01	0.01	0.0007	0.0002	0.0005	0.3
MW13-02D	06-Mar-19	6.7	310	73	78	0.0087	0.00002	0.0001	0.00498	0.01	0.004	0.005	0.0002	0.0005	0.004
MW13-02D	21-Nov-19	6.1	242	71	78	0.0079	0.0001	0.0001	0.00118	0.01	0.002	0.0004	0.0002	0.0005	0.02
MW11-02	09-Aug-19	6.7	230	3	127	0.4	0.02	0.0005	0.3	0.01	0.07	0.010	0.0007	0.001	5.7
MW11-02	21-Nov-19	5.4	685	3	383	1.6	0.06	0.0064	0.9	0.013	0.9	0.04	0.0009	0.0030	20.4
MW14-05M	09-Aug-19	6.1	196	35	106	0.0051	0.0009	0.0001	0.00639	0.01	0.007	0.002	0.0002	0.0005	0.4
MW14-05M	15-Nov-19	*7.0*	*265*	31	88	0.0056	0.0006	0.0001	0.00617	0.01	0.004	0.0011	0.0002	0.0005	0.3
MW14-05D	09-Aug-19	6.1	281	36	103	0.005	0.0001	0.0001	0.00302	0.01	0.001	0.0004	0.0002	0.0005	0.1
MW14-05D	15-Nov-19	6.4	179	33	89	0.005	0.0002	0.0001	0.00216	0.01	0.00097	0.0005	0.0002	0.0005	0.1

Note: Italicized pH and EC values are lab results

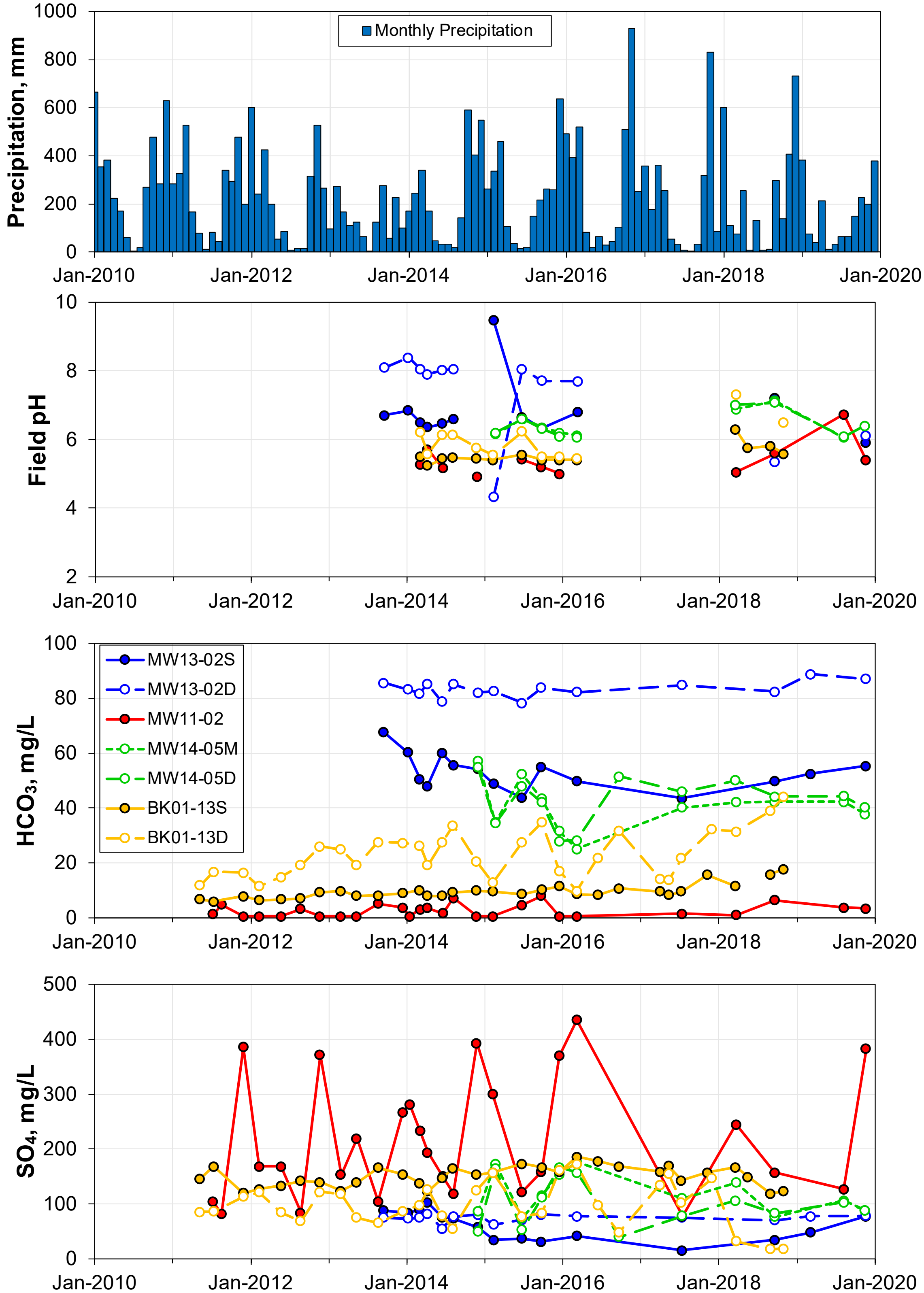


Figure 3-7a. Groundwater Quality Time Trends for Wells in ETA/Cookhouse Area

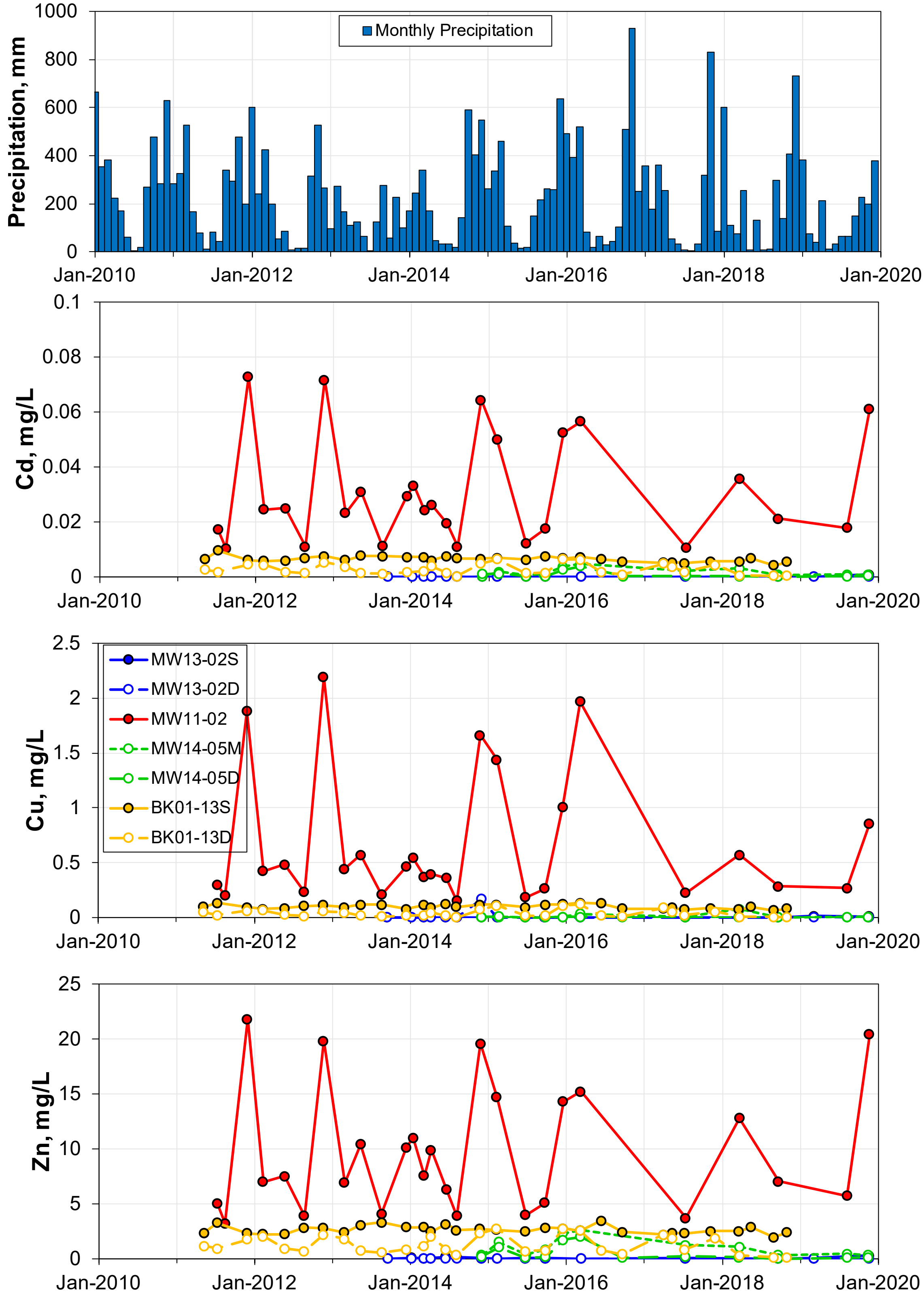


Figure 3-7b. Groundwater Quality Time Trends for Wells in ETA/Cookhouse Area

Key observations from groundwater quality time trends for individual wells in this area are summarized below:

- *MW13-02S (20.4 to 23.5 m, "Deep MVA").* Groundwater from well MW13-02S (near Arnica Creek) is characterized by less than 100 mg/L SO_4 and low concentrations of most metals, e.g. 0.01 mg/L Cu and 0.1 to 0.5 mg/L Zn. There is some indication that metal concentrations in groundwater are increasing and further monitoring is needed to confirm this trend. This is not a high priority given the low concentrations but quarterly monitoring in 2020 could be considered.

- *MW13-02D (29.2 to 35.4 m bgs, "Deep MVA and Bedrock").* Groundwater from well MW13-02D screened in the deeper aquifer (near Arnica Creek) is less impacted than groundwater at MW13-02S, but the trends in water quality are similar and quarterly sampling of this well in 2020 could also be considered.

- *MW11-02 (5.5 to 8.5 m bgs, "Shallow MVA").* Groundwater from well MW11-02 (near Myra Creek) is characterized by elevated SO_4 concentrations (100 to 400 mg/L) and elevated concentrations of most metals, including Al, Cd, Cu, Mn, and Zn. Concentrations are variable, with higher concentrations during winter high flow periods in groundwater. Concentrations are not increasing (or decreasing) over time, however, suggesting stable water quality conditions that reflect ARD impacts from residual sulphide-bearing tailings in the former ETA upgradient.

- *MW14-05S (7.3 to 8.8 m bgs, "Shallow MVA").* This was not sampled in 2019 and there are no historic data available for review (as it is typically dry).

- *MW14-05M (11.0 to 14.0 m bgs, "Shallow MVA").* Groundwater from well MW14-05M is characterized by approximately 100 to 150 mg/L SO_4. There is some indication that SO_4 concentrations may be gradually decreasing over time but too few data are available to establish a definitive trend. Zn concentrations also appear to be decreasing, i.e. from 2 to 3 mg/L Zn in 2016 to 0.5 mg/L Zn in 2019. This decrease could be related to pumping from nearby pumping well PW14-03.

- *MW14-05D (23.2 to 26.2 m bgs, "Deep MVA").* Groundwater from well MW14-05D is slightly acidic and characterized by approximately 100 mg/L SO_4. SO_4 concentrations have not changed since this well was installed in 2014. Zn concentrations in groundwater decreased in 2018 but have since increased to 0.1 mg/L Zn in 2019. Zn concentrations are variable, and more than 1 mg/L Zn was observed in 2015 and 2016. The recent decrease in Zn concentrations could, therefore, be related to pumping from pumping well PW14-03 but could also be related to natural variation. More frequent sampling to resolve this ambiguity is not warranted and semiannual monitoring is to continue in 2020.

- *BK01-13S (10.1 to 13.1 m bgs, "Shallow MVA").* Groundwater from this well is characterized by elevated SO_4 and metal concentrations, e.g. 5 mg/L Zn. SO_4 and metal concentrations are higher than in groundwater from the deeper MVA (at BK01-13D) and are consistent year-round, i.e. do not show seasonal variations. This well was not sampled in 2019.
- *BK01-13D (18.6 to 21.6 m bgs, "Deep MVA").* Groundwater is characterized by elevated concentrations of SO_4 and metals that reflect ARD from residual sulphide-bearing tailings and/or waste rock in the ETA upgradient. A strong seasonal pattern is observed, with higher concentrations during winter high flow periods in groundwater. Metal concentrations, including Cd, Cu, and Zn, decreased in early 2018 due to pumping from nearby pumping well PW14-01. This well has not been sampled since late 2018 when approximately 0.1 mg/L Zn was observed.

3.4.5 *Groundwater Quality – Superpond Area*

Groundwater quality time trends for pumping well PW14-01 and nearby monitoring wells near the Superpond are provided in **Figure 3-8**. See **Table 3-6** for groundwater quality results for 2019. Groundwater quality is moderately impacted by ARD generated by the Lynx TDF embankment berm and local surface waste near the Superpond.

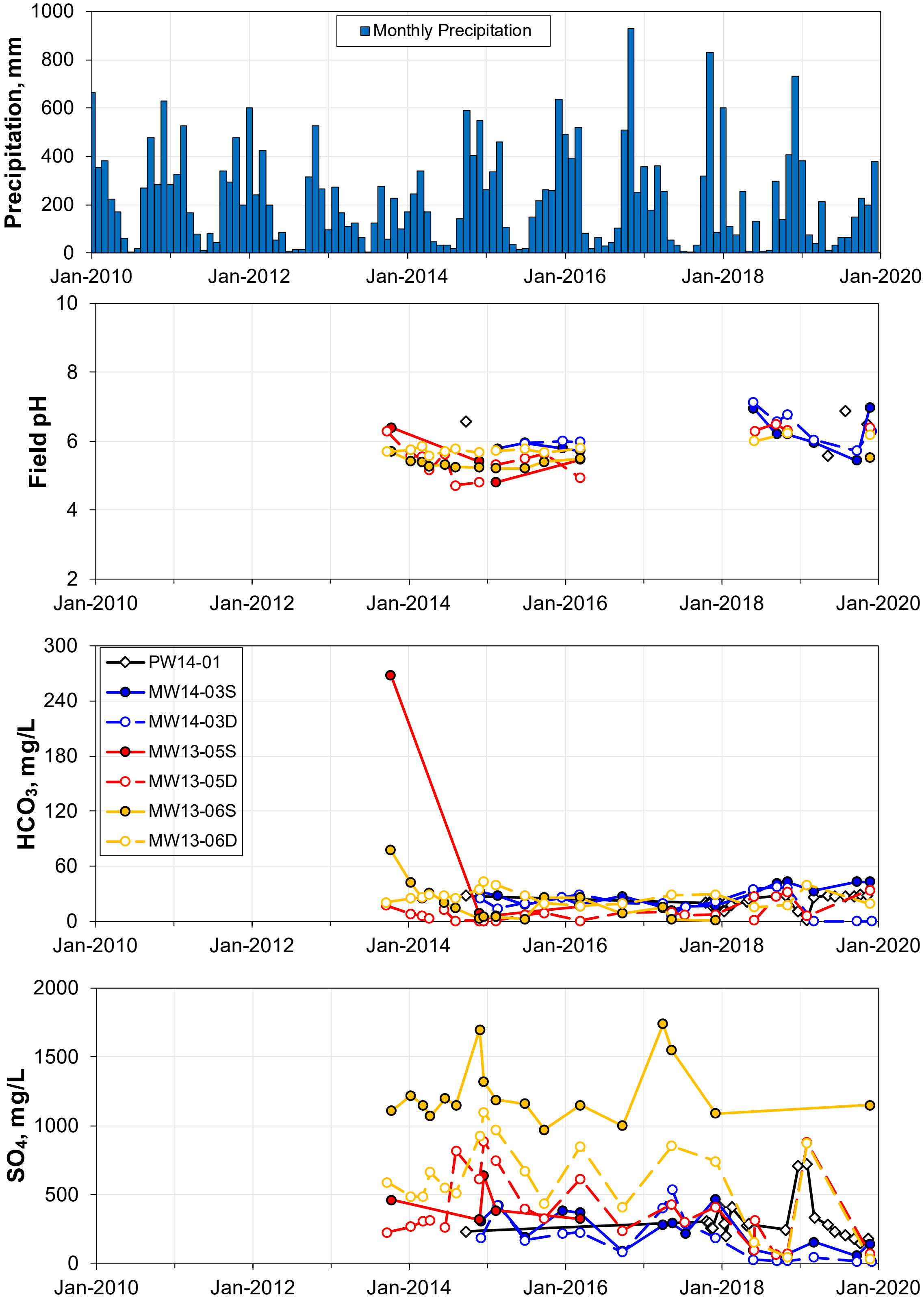


Figure 3-8a. Groundwater Quality Time Trends for Wells in Superpond Area near PW14-01

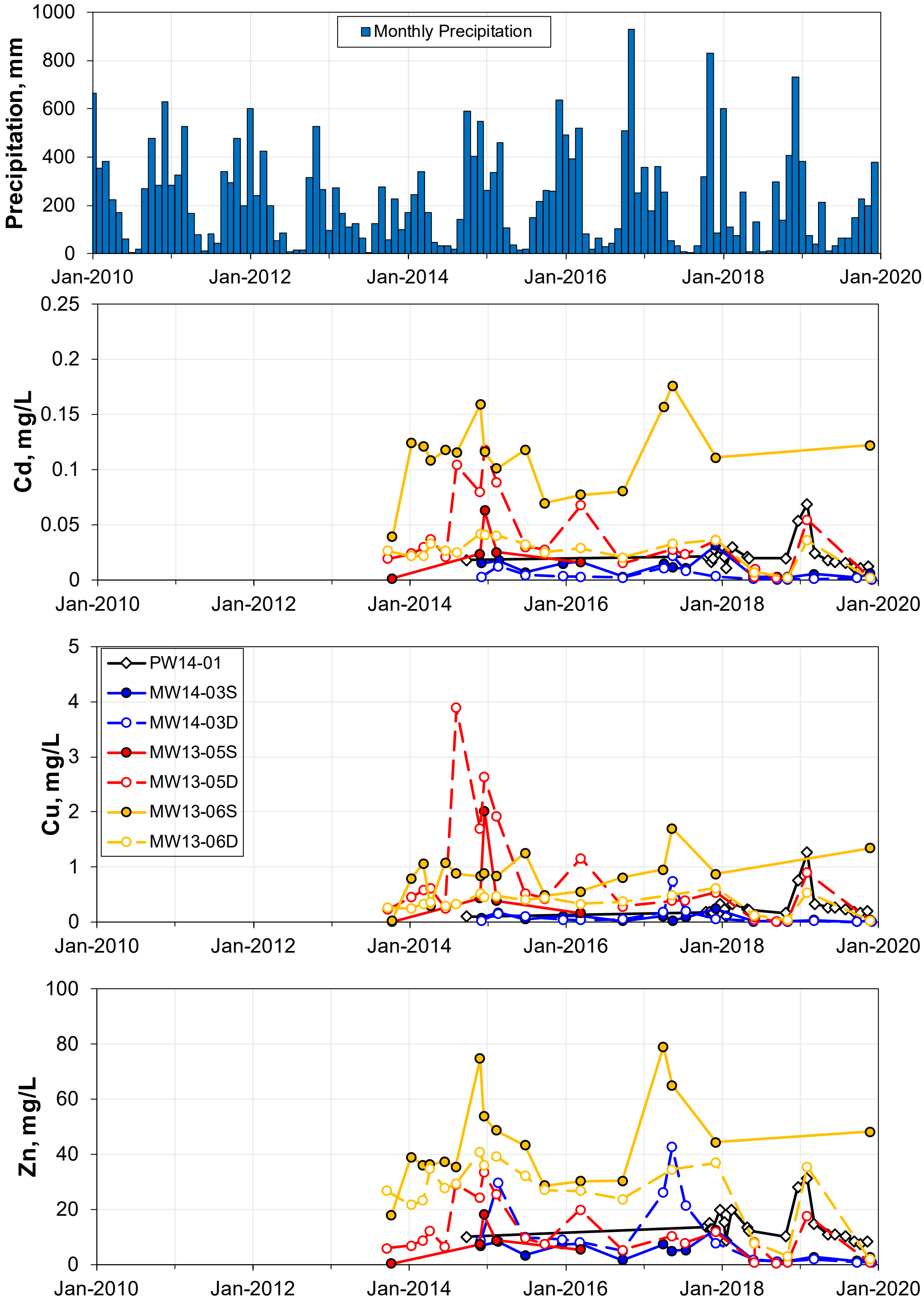


Figure 3-8b. Groundwater Quality Time Trends for Wells in Superpond Area near PW14-01

Table 3-6.

Groundwater Quality Results for Wells in Superpond Area near PW14-01, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
PW14-01	07-Mar-19	*6.4*	*695*	21	335	0.0	0.024	0.0119	0.3	0.010	2.3	0.016	0.0002	0.0005	14.8
PW14-01	10-May-19	5.6	476	23	280	0.2	0.017	0.0088	0.3	0.1	2.0	0.012	0.0023	0.0005	10.8
PW14-01	10-Jun-19	-	-	22	232	0.1	0.016	0.0089	0.3	0.010	1.8	0.012	0.0002	0.0005	10.9
PW14-01	31-Jul-19	6.9	389	23	208	0.01	0.015	0.0074	0.2	0.016	1.6	0.010	0.0002	0.0005	10.3
PW14-01	11-Sep-19	*6.5*	*382*	22	183	0.08	0.012	0.0062	0.2	0.010	1.3	0.008	0.0002	0.0005	8.2
PW14-01	09-Oct-19	*6.6*	*358*	24	151	0.008	0.010	0.0057	0.2	0.010	1.2	0.008	0.0002	0.0005	7.5
PW14-01	12-Nov-19	6.5	437	23	181	0.008	0.012	0.0064	0.2	0.010	1.3	0.009	0.0002	0.0005	8.4
MW14-03S	05-Mar-19	6.0	395	27	156	0.03	0.005	0.0001	0.04	0.011	0.011	0.005	0.0002	0.0005	2.8
MW14-03S	20-Sep-19	5.5	187	35	60	0.01	0.002	0.0001	0.007	0.010	0.004	0.002	0.0002	0.0005	1.3
MW14-03S	21-Nov-19	7.0	484	35	145	0.05	0.006	0.0002	0.04	0.059	0.075	0.006	0.0002	0.0005	2.5
MW14-03D	05-Mar-19	6.0	181	32	45	0.03	0.001	0.0001	0.02	0.010	0.001	0.001	0.0002	0.0005	1.9
MW14-03D	20-Sep-19	5.7	95	35	17	0.007	0.001	0.0001	0.003	0.010	0.003	0.001	0.0002	0.0005	0.8
MW14-03D	29-Nov-19	6.3	180	78	18	0.02	0.001	0.0001	0.009	0.010	0.003	0.000	0.0004	0.0005	0.9
MW13-05D	01-Feb-19	4.9	977	5	881	1.7	0.055	0.0136	0.9	0.070	2.8	0.041	0.0004	0.0005	17.6
MW13-05D	21-Nov-19	6.4	179	28	75	0.02	0.002	0.0002	0.03	0.010	0.024	0.002	0.0002	0.0005	0.7
MW13-06S	21-Nov-19	5.5	1655	2	1150	2.5	0.122	0.0539	1.3	0.047	17.2	0.108	0.0002	0.0005	48.1
MW13-06D	01-Feb-19	5.2	1225	33	873	0.1	0.036	0.0134	0.5	0.018	7.7	0.032	0.0002	0.0005	35.4
MW13-06D	21-Nov-19	6.2	93	16	32	0.02	0.002	0.0001	0.03	0.010	0.029	0.002	0.0002	0.0005	1.9

Note: Italicized pH and EC values are lab results

Key observations from the time trends for individual monitoring wells and pumping well PW14-01 are summarized below:

- *PW14-01 (26.4 to 29.5 m bgs, "Deep MVA").* Groundwater pumped from pumping well PW14-01 is slightly acidic and characterized by elevated concentrations of SO_4, i.e. up to 750 mg/L in early 2019. SO_4 concentrations decreased throughout 2019, which is consistent with the recent trends in Cd, Cu, and Zn. More than 30 mg/L Zn was observed in early 2019 and Zn concentrations had decreased to less than 10 mg/L by late 2019. The elevated SO_4 and metal concentrations in early 2019 were observed when the pumping wells were turned off[2]. High concentrations observed in early 2019 are therefore likely representative of "high flow" conditions without operation of the Phase 1 wells.
- *MW14-03S (18.6 to 21.6 m bgs, "Deep MVA").* This well is upgradient of pumping well PW14-01 and downgradient of pumping well PW14-03 (towards the mill). Groundwater from well MW14-03S was slightly acidic in 2016 (pH 6) and pH values had been decreasing in recent years. Metal concentrations, e.g. Cu, Zn, have further decreased since late 2017. This decrease is due to pumping from pumping well PW14-03.

[2] The wells were only turned on briefly to collect a water sample

- *MW14-03D (23.2 to 26.2 m bgs, "Deep MVA").* Groundwater quality from well MW14-03D is comparable to water quality at well MW14-03S and water quality trends at these two wells mimic each other. Some seasonality is evident and the overall decrease in concentration is likely related to dilution in the deeper MVA due to pumping from PW14-03.
- *MW13-05S (10.7 to 13.7 m bgs, "Shallow MVA").* Groundwater from well MW13-05S was last sampled in 2016. Groundwater was acidic (pH <5) and up to 600 mg/L SO_4 and 28 mg/L Zn were observed. Too few data are available to establish a trend or characterize current groundwater quality.
- *MW13-05D (20.2 to 26.2 m bgs, "Deep MVA").* Initially, groundwater from well MW13-05D was slightly acidic (pH 6) and characterized by elevated SO_4 and metal concentrations, i.e. 5 mg/L Zn. Groundwater quality subsequently deteriorated in 2014 and early 2015 before improving in 2016 and 2017. The long-term trend towards improved groundwater quality continued in 2018. In 2019, nearly 20 mg/L Zn was observed in January when the Phase I Lynx SIS was shut down. In the last sample collected in 2019, less than 1 mg/L Zn was observed, suggesting much lower concentrations occur when the Phase I Lynx SIS is operating.
- *MW13-06S (6.7 to 8.9 m bgs, "Shallow MVA").* Groundwater in well MW13-06S (screened in the shallow MVA) is highly impacted with elevated SO_4 (1150 mg/L SO_4 in late 2019 and metal concentrations (e.g. 48 mg/L Zn in late 2019). This well is located downgradient of pumping well PW14-01. However, this well has not seen a clear improvement in groundwater quality due to operation of the Phase 1 Lynx SIS since late 2017 suggesting that is beyond the immediate capture zone of pumping well PW14-01 (see Section 2).
- *MW13-06D (35.4 to 41.5 m bgs, "Deep MVA").* Groundwater from well MW13-06D (screened in the deep MVA) is acidic (pH 6) and characterized by elevated SO_4 and metal concentrations Groundwater quality trends in this deep well have generally mimicked the trends observed in the upgradient pumping well PW14-01. SO_4 and metal concentrations in MW13-06D increased sharply in early 2019. This abrupt increase in concentrations in 2019 is likely related to cessation of pumping at PW14-01 during this period. However, heavy rainfall and associated flushing of contaminants from the Lynx berm and local mine waste likely also contributed to this increase.

3.4.6 *Groundwater Quality – Superpond Area near PW14-04*

Figure 3-9 provides groundwater quality time trends for pumping well PW14-04 and nearby monitoring wells MW14-04S and MW14-04D near the east side of Superpond. These wells are near the boundary between the Lynx Reach the Old TDF Reach. Groundwater quality results for 2019 are provided in **Table 3-7**. Groundwater in the MVA in this area is impacted by ARD generated by sulphide-bearing waste rock in the Lynx TDF embankment berm. There is also perched seepage in this area, which is related to seepage from local surface waste and/or seepage from the Lynx TDF embankment berm.

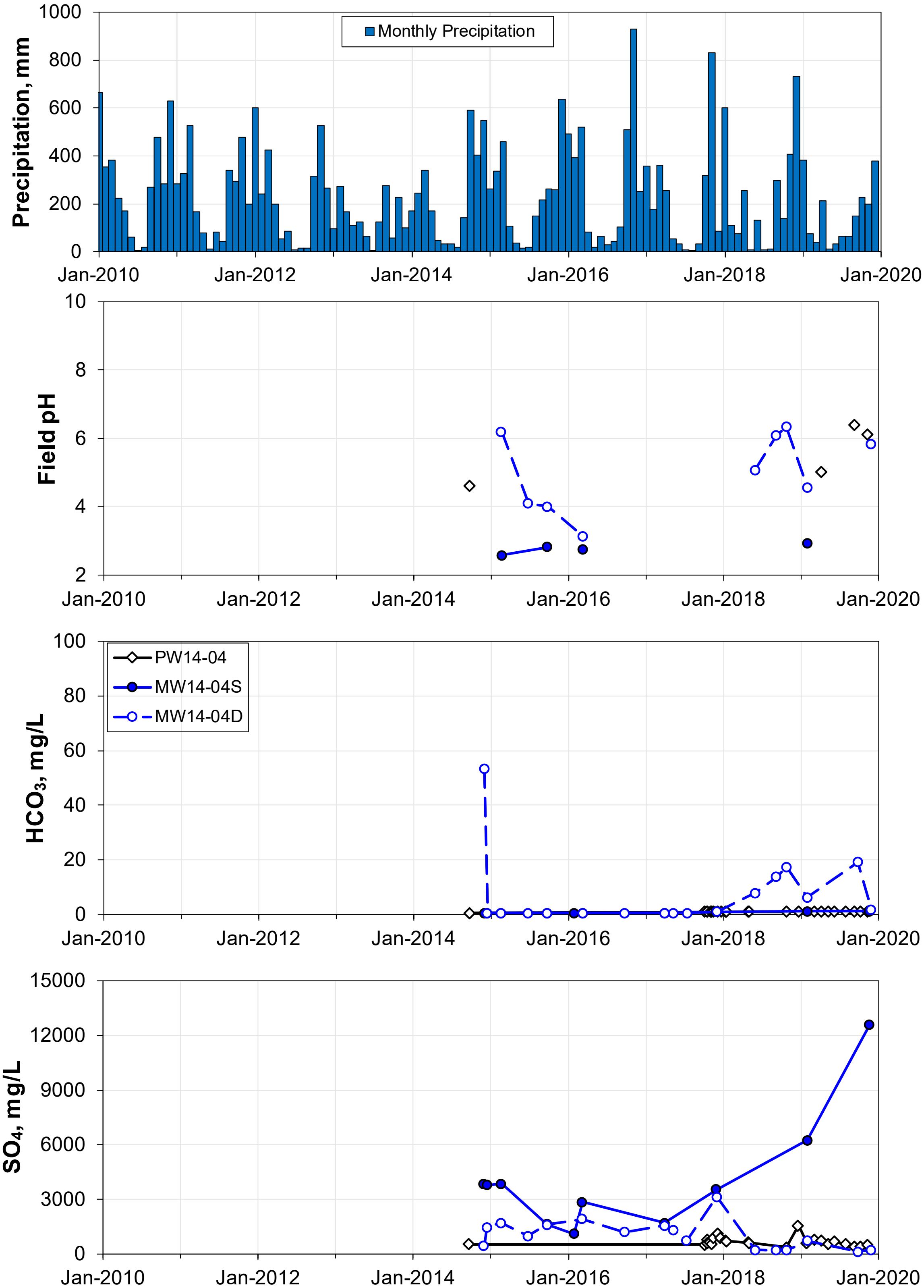


Figure 3-9a. Groundwater Quality Time Trends for Wells in Superpond Area near PW14-04

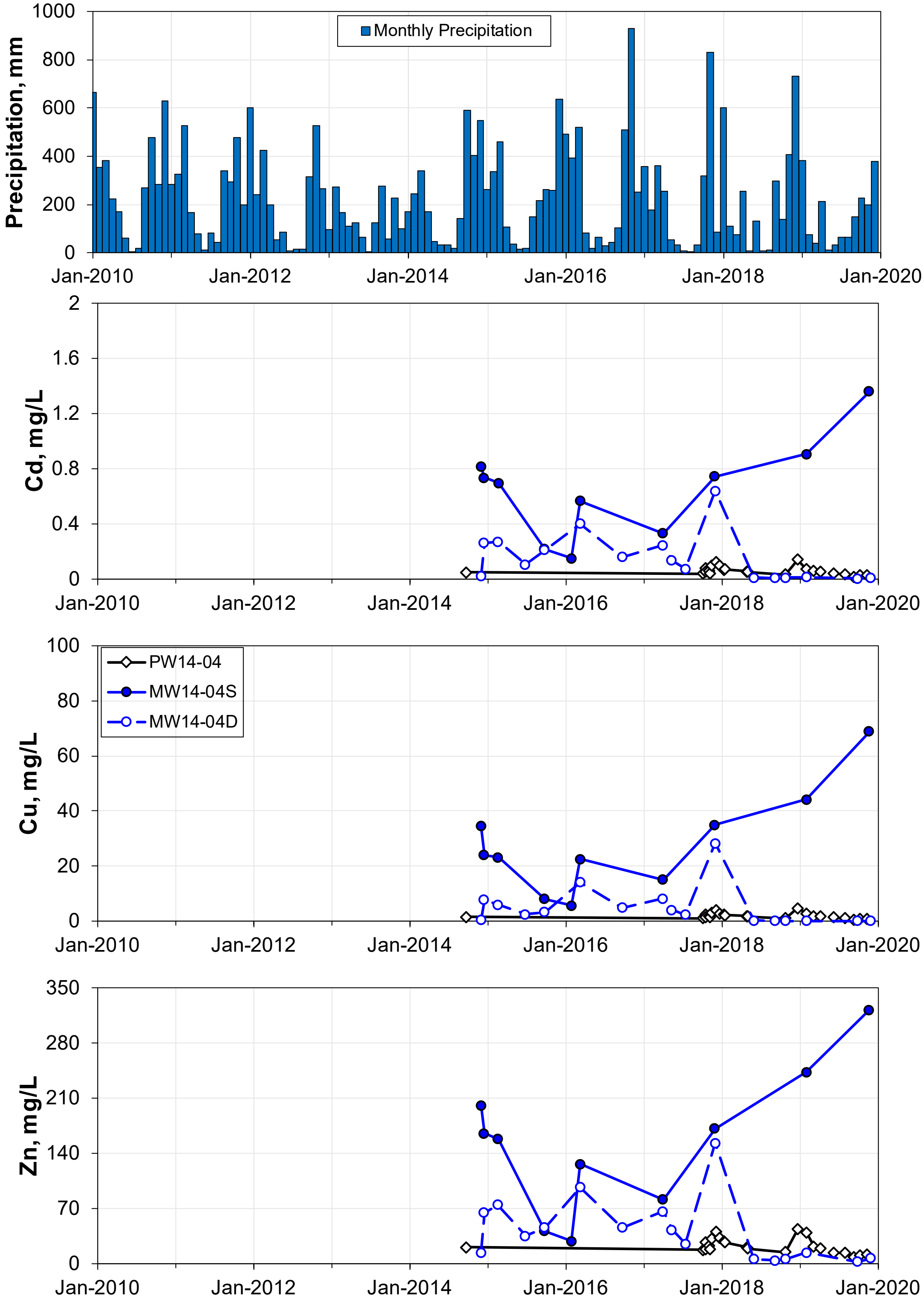


Figure 3-9b . Groundwater Quality Time Trends for Wells in Superpond Area near PW14-04

Table 3-7.

Groundwater Quality Results for Wells in Superpond Area near PW14-04, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
PW14-04	31-Jan-19	-	-	-	594	2.1	0.07	0.02	2.8	0.02	2.9	0.04	0.0007	0.0005	39.4
PW14-04	07-Mar-19	*4.7*	*1220*	1	804	8.6	0.06	0.03	1.7	0.02	5.6	0.05	0.0002	0.0005	21.3
PW14-04	10-Apr-19	5.0	903	1	737	8.7	0.05	0.03	1.7	0.03	5.7	0.04	0.0002	0.0005	19.7
PW14-04	10-May-19	*4.7*	*1010*	1	538	-	-	-	-	-	-	-	-	-	-
PW14-04	10-Jun-19	-	-	1	668	5.7	0.04	0.02	1.3	0.01	4.7	0.03	0.0002	0.0005	13.3
PW14-04	31-Jul-19	*4.8*	*830*	1	543	3.1	0.03	0.02	1.0	0.01	3.9	0.03	0.0002	0.0005	13.8
PW14-04	11-Sep-19	6.4	733	1	384	1.9	0.02	0.0078	0.5	0.03	2.6	0.01	0.0002	0.0005	8.0
PW14-04	09-Oct-19	*4.9*	*758*	1	397	2.0	0.03	0.01	0.8	0.01	3.1	0.02	0.0002	0.0005	10.0
PW14-04	12-Nov-19	6.1	874	1	487	2.9	0.03	0.02	0.9	0.01	3.6	0.03	0.0002	0.0005	11.8
MW14-04S	01-Feb-19	2.9	458	1	6,240	221	0.9	0.5	44	199	42	0.5	0.06	0.002	243
MW14-04S	21-Nov-19	2.6	6314	1	12,600	300	1.4	0.9	69	479	63	0.7	0.09	0.003	322
MW14-04D	01-Feb-19	4.6	952	5	733	1.3	0.01	0.007	0.1	1.4	4.7	0.02	0.0006	0.0005	13.7
MW14-04D	26-Sep-19	*6.7*	*332*	16	135	0.02	0.003	0.001	0.02	0.2	0.5	0.004	0.0002	0.002	2.1
MW14-04D	29-Nov-19	5.8	542	1	231	1.1	0.006	0.01	0.03	2.9	1.2	0.01	0.0002	0.0005	6.6

Note: Italicized pH and EC values are lab results

Key observations for pumping well PW14-04 and monitoring wells MW14-04S/D are summarized below:

- *PW14-04 (19.5 to 21.9 m bgs, "Deep MVA").* Groundwater pumped from pumping well PW14-04 is characterized by elevated SO_4 (up to 1500 mg/L SO_4) and elevated concentrations of Al, Cd, Cu, Mn, and Zn. Concentrations of SO_4 and metals have increased abruptly on several occasions. SO_4 and metal concentrations decreased for most of 2019, i.e. from nearly 40 mg/L Zn in January to 11.8 mg/L Zn in November. This decrease is consistent with less impacted groundwater migrating towards this well from the surrounding MVA, most likely due to a combination of drier conditions and continued interception of loads by the pumping wells further upgradient (PW14-03 and PW14-01).
- *MW14-04S (3.1 to 6.1 m bgs, "Shallow MVA").* This well is screened in shallow sediments where perched seepage occurs above the MVA. Water samples from well MW14-04S represent perched (potentially isolated) seepage that is not captured by the pumping well PW14-04. Concentrations of SO_4 and metals in groundwater from well MW14-04S have progressively increased since 2017. Perched seepage from this well is characterized by more than 1 mg/L Cd, 70 mg/L Cu, and more than 300 mg/L Zn. These are the highest concentrations observed in seepage or groundwater on site and suggest concentrated ARD is generated by local surface waste and/or the Lynx TDF embankment berm. This perched seepage only develops in response to heavy precipitation (typically in fall/winter) and this shallow typically falls dry during low flow periods and therefore cannot be consistently sampled. The increasing trend in this perched seepage should be monitored as it could represent a source of contaminant loading to Myra Creek during high flow periods that is not controlled by the Phase I Lynx SIS.

- *MW14-04D (18.7 to 21.7 m bgs, "Deep MVA").* Groundwater from well MW14-04D is characterized by much lower concentrations of SO_4 and metals than in samples from well MW14-04S. Concentrations of Zn and other metals appear to have decreased in this well due to operation of the Phase I Lynx SIS. In 2019, 2.1 mg/L Zn was observed in September and 6.6 mg/L Zn was observed in November. Other metals showed a similar increase in November, most likely due to flushing of oxidation products at the beginning of the rainfall season and increased loads to groundwater during these periods. Multiple wet seasons of monitoring data are needed to discern the influence of the Phase I Lynx SIS from variability due to seasonal flushing.

3.4.7 *Groundwater Quality – Upgradient of Interim Phase II Lynx SIS*

Figure 3-10 and **Figure 3-11** provides groundwater quality time trends for monitoring wells upgradient of the Interim Phase II Lynx SIS. **Table 3-8** provides groundwater quality results for 2019. Three nested monitoring wells (MW18-06S/D, MW18-07S/D, and MW18-08S/D) were installed in 2018 to better characterize the local hydrogeology of this area as part of designing the Interim Phase II Lynx SIS.

Table 3-8.

Groundwater Quality Results for Wells Upgradient of Interim Phase II Lynx SIS, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW16-01	23-Jan-19	6.6	386	51	194	0.02	0.005	0.0002	0.02	0.013	0.07	0.005	0.0002	0.0005	2.9
MW16-01	01-Mar-19	*7.9*	*517*	119	149	0.02	0.002	0.0001	0.11	0.015	0.02	0.001	0.0002	0.0005	0.5
MW16-01	23-Oct-19	*7.2*	*501*	48	205	0.01	0.001	0.0001	0.00	0.010	0.003	0.001	0.0002	0.0005	0.4
MW16-01	18-Dec-19	6.4	263	14	149	0.9	0.006	0.0023	0.2	0.026	0.1	0.007	0.0004	0.0005	1.5
MW16-02	23-Oct-19	3.8	760	1	591	5.7	0.035	0.0128	1.6	0.011	0.9	0.047	0.0016	0.0005	9.2
MW16-02	18-Dec-19	*3.3*	*857*	1	685	3.9	0.011	0.0044	0.6	6.6	0.5	0.013	0.0342	0.0005	2.5
MW16-03	23-Jan-19	5.2	549	54	304	0.07	0.010	0.0004	0.07	0.010	0.2	0.012	0.0003	0.0005	4.1
MW16-03	18-Dec-19	5.7	625	77	475	0.02	0.008	0.0042	0.01	0.088	3.6	0.010	0.0003	0.0005	3.8
MW16-05	23-Jan-19	5.9	310	39	152	0.03	0.006	0.0001	0.03	0.010	0.04	0.004	0.0002	0.0005	1.9
MW16-05	18-Dec-19	*6.9*	*511*	62	182	0.01	0.004	0.0004	0.01	0.131	0.5	0.002	0.0002	0.0005	1.5
MW11-04	29-Jan-19	4.9	572	1	649	10.2	0.064	0.0237	2.7	0.010	2.6	0.043	0.0004	0.0005	23.7
MW11-04	01-Mar-19	*5.5*	*348*	3	173	0.6	0.011	0.0019	0.4	0.010	0.5	0.009	0.0002	0.0005	5.1
MW11-04	10-May-19	4.8	469	1	297	1.2	0.020	0.0053	0.6	0.082	1.6	0.017	0.0013	0.0005	9.1
MW11-04	02-Jul-19	*5.2*	*490*	1	255	0.8	0.015	0.0028	0.6	0.010	1.0	0.015	0.0002	0.0005	7.5
MW11-04	23-Oct-19	*5.3*	*541*	1	255	0.7	0.018	0.0025	0.6	0.010	1.2	0.016	0.0002	0.0005	9.3
MW11-04	31-Oct-19	5.8	603	1	267	1.1	0.019	0.0032	0.6	0.2	1.3	0.016	0.0023	0.0005	9.4
MW18-08S	29-Jan-19	6.6	28	12	109	0.02	0.006	0.0005	0.11	0.010	0.1	0.006	0.0002	0.0005	2.8
MW18-08S	01-Mar-19	*6.6*	*213*	27	92	0.09	0.005	0.0004	0.09	0.011	0.1	0.005	0.0002	0.0005	2.5
MW18-08S	10-May-19	5.6	223	32	77	0.05	0.003	0.0003	0.04	0.010	0.04	0.004	0.0002	0.0005	1.5
MW18-08S	02-Jul-19	5.7	182	26	67	0.05	0.003	0.0002	0.04	0.010	0.03	0.003	0.0002	0.0005	1.4
MW18-08S	23-Oct-19	*6.6*	*132*	16	68	0.04	0.004	0.0003	0.06	0.010	0.2	0.004	0.0002	0.0005	1.8
MW18-08S	31-Oct-19	6.5	220	18	67	0.2	0.003	0.0002	0.05	0.2	0.05	0.003	0.0019	0.0005	1.6
MW18-08D	29-Jan-19	6.5	233	27	77	0.02	0.003	0.0001	0.04	0.010	0.05	0.004	0.0002	0.0005	1.8
MW18-08D	01-Mar-19	*6.6*	*213*	26	76	0.04	0.004	0.0001	0.06	0.010	0.04	0.004	0.0002	0.0005	1.9
MW18-08D	10-May-19	5.6	143	23	57	0.06	0.003	0.0002	0.06	0.011	0.05	0.003	0.0002	0.0005	1.2
MW18-08D	02-Jul-19	5.4	131	16	53	0.03	0.002	0.0001	0.03	0.010	0.01	0.002	0.0002	0.0005	1.0
MW18-08D	23-Oct-19	6.7	155	17	42	0.01	0.002	0.0001	0.03	0.010	0.04	0.002	0.0002	0.0005	0.9
MW18-08D	31-Oct-19	*6.6*	*132*	18	42	0.6	0.002	0.0006	0.1	0.6	0.09	0.002	0.0082	0.0005	1.0
MW18-06S	29-Jan-19	5.5	347	11	110	0.04	0.007	0.006	0.2	0.01	0.8	0.008	0.0002	0.0005	2.0
MW18-06S	07-Mar-19	*5.9*	*314*	9	138	0.2	0.008	0.007	0.2	0.01	0.8	0.009	0.0002	0.0005	2.5
MW18-06S	09-May-19	5.3	554	5	132	0.3	0.007	0.005	0.2	0.03	0.7	0.008	0.0008	0.0005	2.2
MW18-06S	16-Oct-19	*5.6*	*246*	3	98	0.3	0.007	0.004	0.2	0.02	0.6	0.008	0.0002	0.0005	2.0
MW18-06S	31-Oct-19	5.3	285	2	105	0.3	0.007	0.005	0.2	0.01	0.6	0.007	0.0002	0.0005	2.2
MW18-06S	18-Dec-19	*4.3*	*789*	1	895	20.2	0.1	0.06	3.9	0.261	4.8	0.09	0.003	0.0005	26.8
MW18-06D	29-Jan-19	*6.6*	*204*	25	73	0.01	0.002	0.0001	0.02	0.01	0.01	0.003	0.0002	0.0006	0.6
MW18-06D	07-Mar-19	5.5	310	15	105	0.09	0.005	0.0004	0.09	0.01	0.08	0.006	0.0002	0.0006	1.7
MW18-06D	09-May-19	5.9	199	13	95	0.08	0.003	0.0003	0.05	0.04	0.06	0.004	0.0005	0.0005	1.1
MW18-06D	16-Oct-19	5.0	178	6	77	0.1	0.004	0.0003	0.08	0.02	0.06	0.006	0.0002	0.0005	1.4
MW18-06D	31-Oct-19	5.7	216	9	72	0.08	0.003	0.0002	0.06	0.01	0.05	0.00	0.0002	0.0005	1.1
MW18-06D	18-Dec-19	*4.3*	*408*	1	564	12.5	0.069	0.03	1.6	0.02	2.4	0.05	0.002	0.0005	14.1
MW18-07S	29-Jan-19	*7.4*	*220*	47	62	0.01	0.005	0.003	0.009	0.01	0.4	0.003	0.0002	0.0005	1.0
MW18-07S	18-Dec-19	*5.4*	*271*	4	140	0.4	0.007	0.004	0.2	0.01	0.5	0.007	0.0005	0.0005	2.2
MW18-07D	29-Jan-19	5.4	218	46	12	0.01	0.0003	0.0001	0.00402	0.01	0.00434	0.000	0.0002	0.0005	0.1
MW18-07D	07-Mar-19	5.9	117	29	36	0.1	0.004	0.002	0.1	0.01	0.1	0.003	0.0002	0.0005	1.2
MW18-07D	08-May-19	5.5	120	23	31	0.6	0.006	0.002	0.2	0.01	0.2	0.005	0.0041	0.0005	1.7
MW18-07D	02-Jul-19	*6.1*	*219*	8	85	0.1	0.004	0.0003	0.08	0.01	0.06	0.005	0.0002	0.0005	1.3
MW18-07D	04-Jul-19	*6.8*	*120*	21	34	0.3	0.003	0.001	0.1	0.01	0.1	0.003	0.0003	0.0005	1.0
MW18-07D	16-Oct-19	*6.8*	*102*	20	26	0.1	0.003	0.002	0.05	0.02	0.2	0.002	0.0002	0.0005	0.7
MW18-07D	15-Nov-19	8.1	92	11	25	0.1	0.002	0.0006	0.05	0.01	0.0614	0.002	0.002	0.0005	0.5
MW18-07D	18-Dec-19	*6.0*	*236*	13	101	0.1	0.004	0.0003	0.08	0.01	0.0667	0.005	0.0002	0.0005	1.6

Note: Italicized pH and EC values are lab results

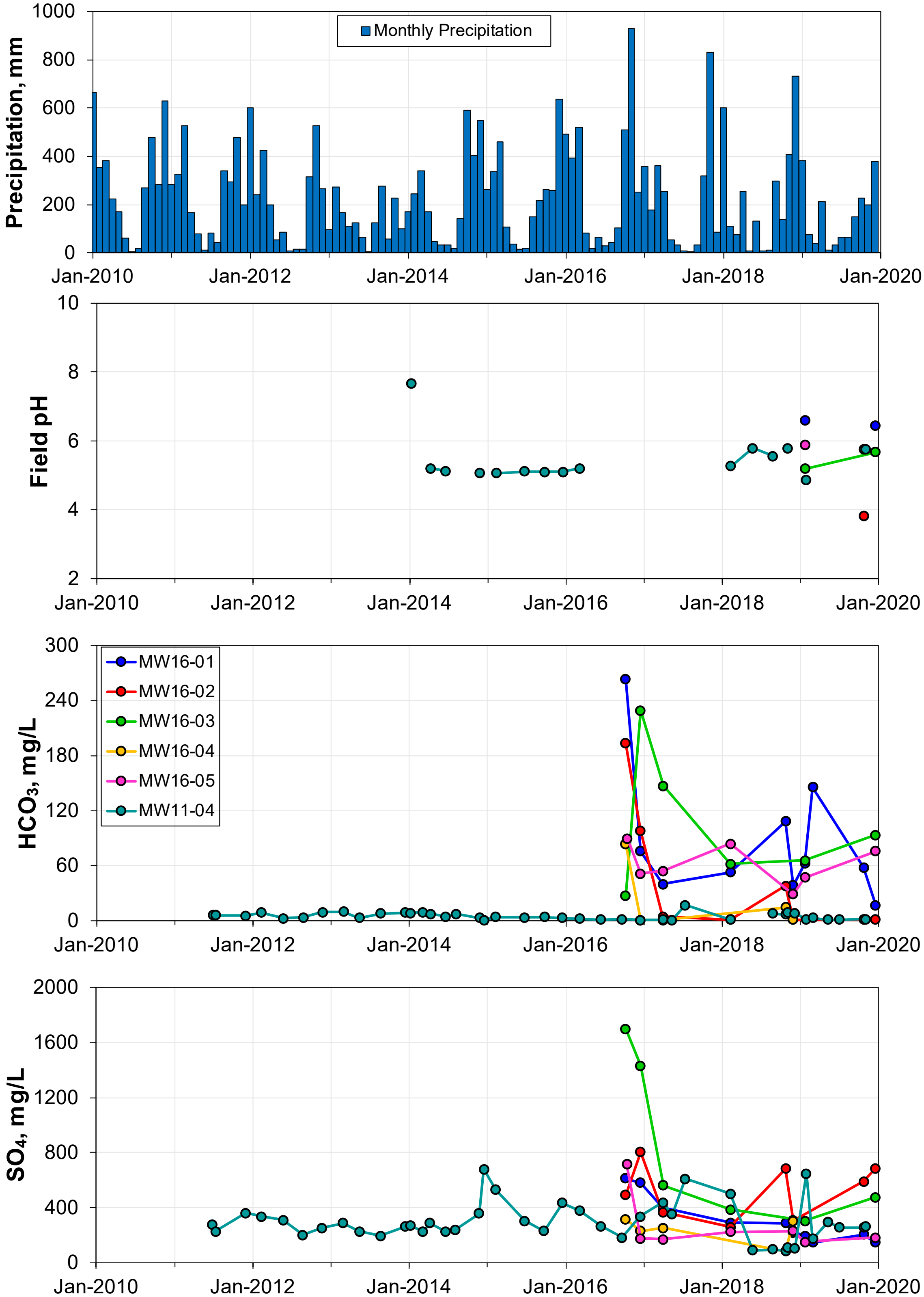


Figure 3-10a. Groundwater Quality Time Trends for Wells Upgradient of Phase II Lynx SIS, 2019

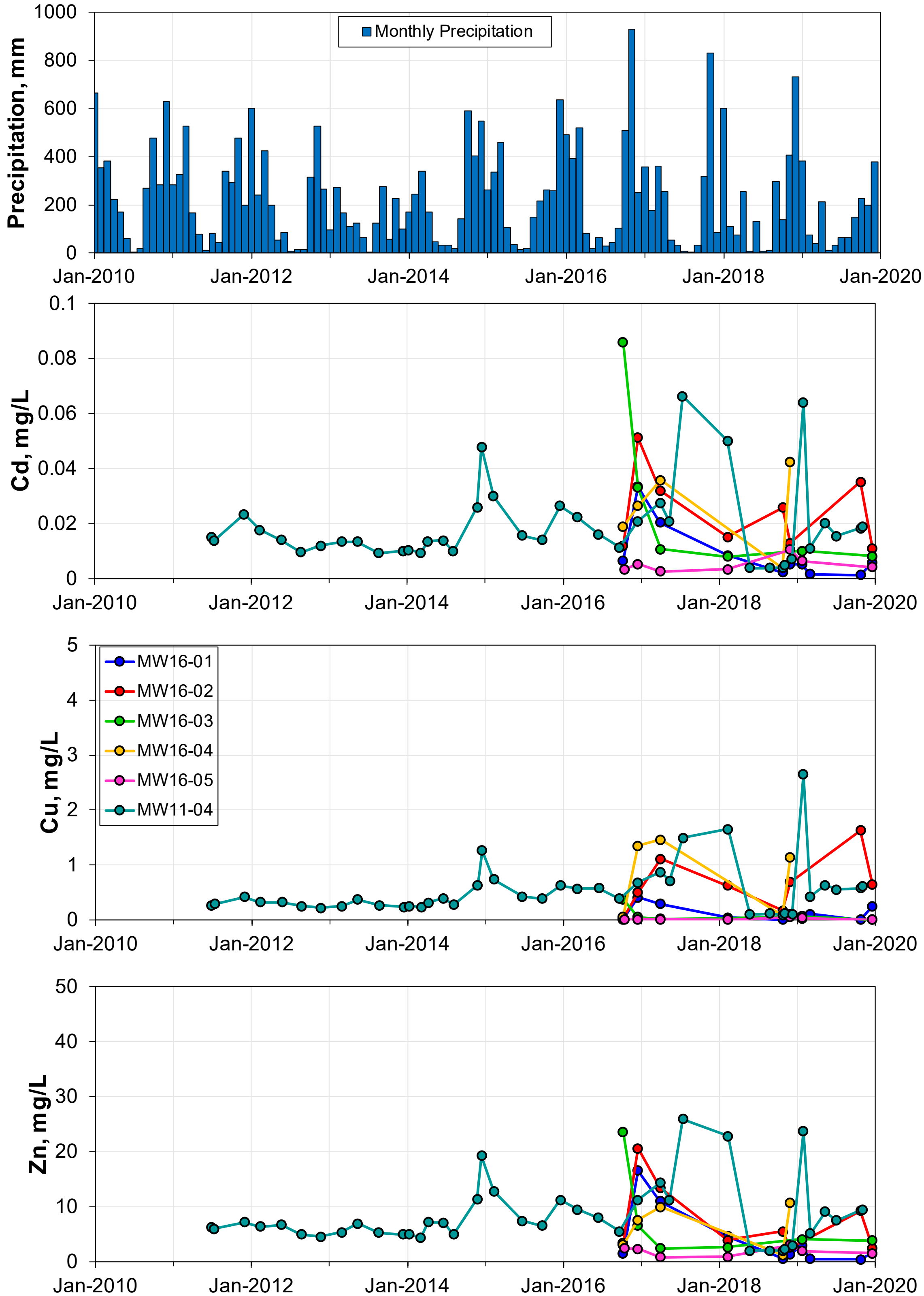


Figure 3-10b. Groundwater Quality Time Trends for Wells Upgradient of Phase II Lynx SIS, 2019

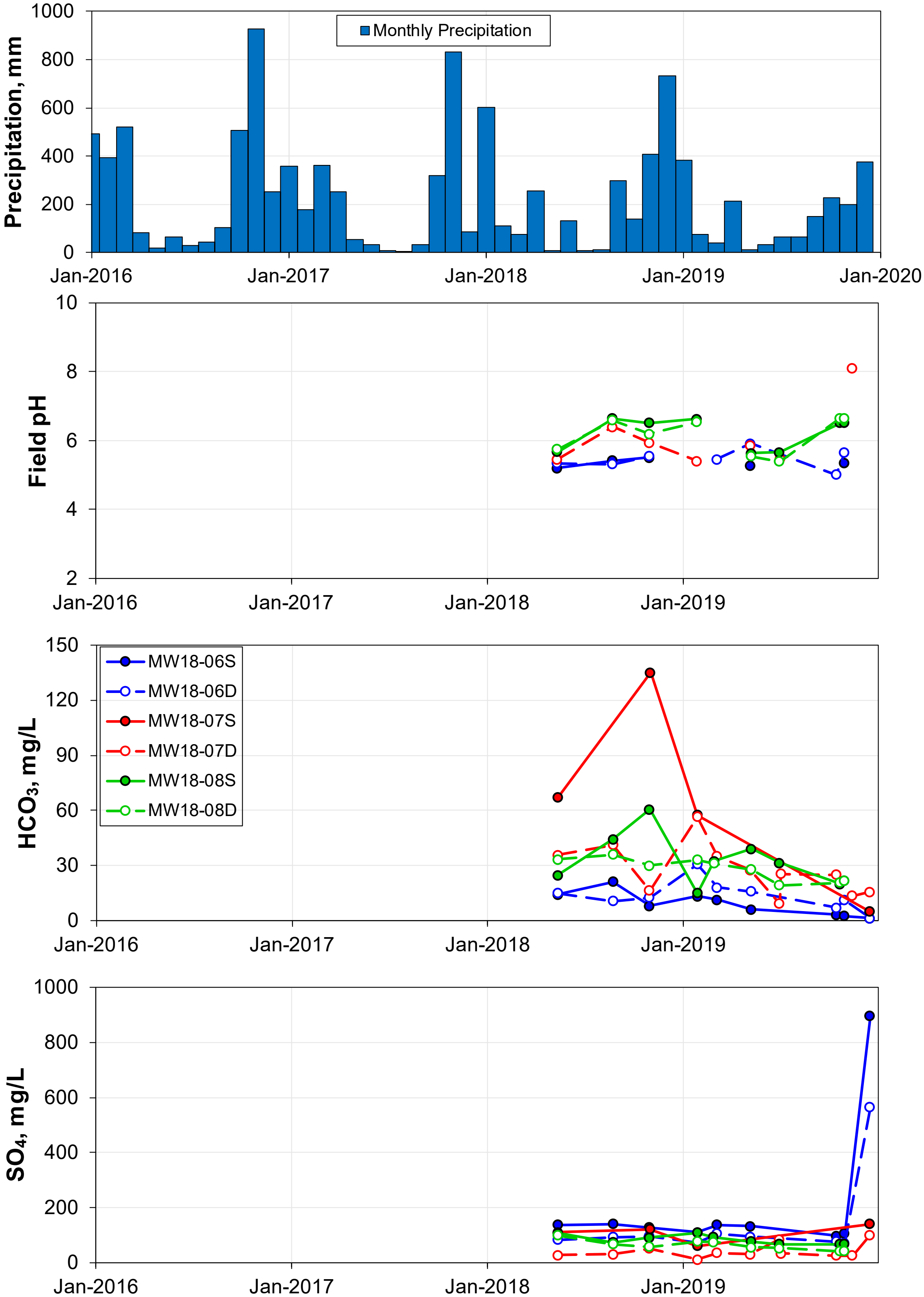


Figure 3-11a. Groundwater Quality Time Trends for MW18 Wells Upgradient of Interim Phase II Lynx SIS, 2019

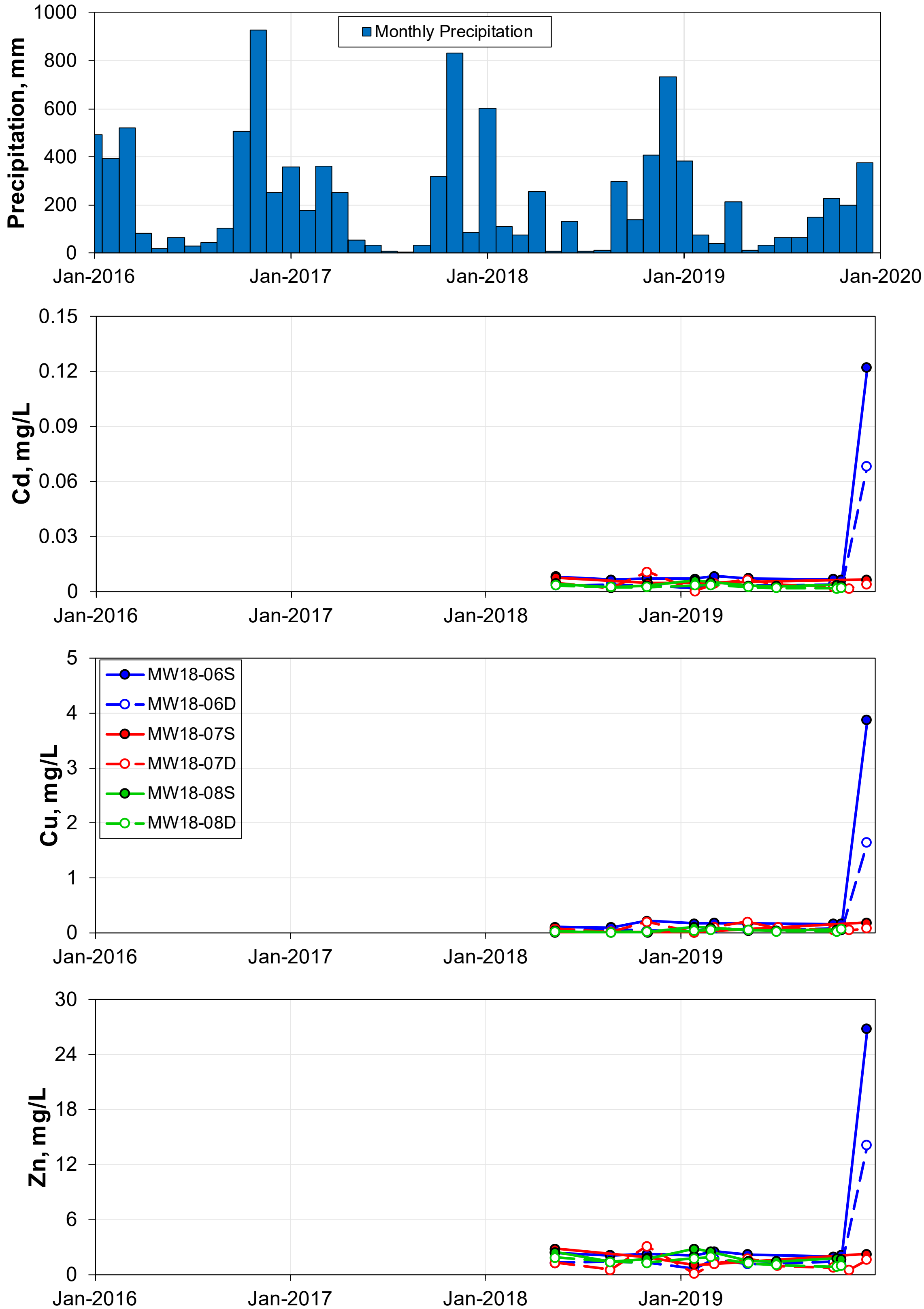


Figure 3-11b. Groundwater Quality Time Trends for MW18 Wells Upgradient of Phase II SIS, 2019

Key observations are summarized below:

- *MW16 Wells (0.8 to 5.5 m bgs, "Shallow MVA").* Zn concentrations in these shallow piezometers are generally higher than in deeper piezometers suggesting a surface source such as recharge from local PAG waste rock and/or leakage from the Duck Pond and associated channels. Monitoring well MW16-04 has previously been an indicator of acidic seepage to Myra Creek. However, the groundwater table decreased below the base of this well, due to low recharge and/or operating the Interim Phase II Lynx SIS, so no samples from well MW16-04 were collected in 2019.
- *MW11-04 (4.9 to 6.4 m bgs, "Shallow MVA").* Groundwater from well MW11-04 is impacted by shallow seepage (ARD) from surface waste near the Superpond. Zn concentrations at well MW11-04 are highly variable and appear to increase following very high rainfall events. Sources likely include acidic runoff conveyed in the adjacent channel and recharge from acidic shallow (perched) seepage residing beneath the Superpond. The acidic seeps observed along Myra Creek (e.g. MW13-19 Seep) in February 2018 likely originated from the same sources (see RGC 2018b for more details). While the Interim Phase II Lynx SIS has operated, observed Zn at MW11-04 varied between 5 and 9 mg/L Zn. Before the SIS was operating, a Zn concentration of 23.7 mg/L was observed. This suggests that the Interim Phase II Lynx SIS could be improving local groundwater quality. However, further monitoring data are needed to evaluate natural variability over several wet seasons during which the system is operating.
- *MW18-06S (6.7 to 9.8 m bgs, "Shallow MVA").* Groundwater from this well is slightly acidic and characterized by approximately 2 mg/L Zn. This well is adjacent to the Duck Pond, which conveys acidic runoff to the 25 Sump. However, in December 2019, this well was acidic with elevated Zn of 26.8 mg/L suggesting leakage of acidic surface runoff to the underlying aquifer. Quarterly monitoring of this well could be considered to confirm.
- *MW18-06D (15.2 to 18.3 m bgs, "Shallow MVA").* Groundwater from this well is characterized by Zn concentrations around 1 mg/L which is slightly lower than what is observed in the shallow piezometer. The sample collected in December 2019 was also elevated in Zn, although to a lesser degree (14.1 mg/L). This further suggests that acidic runoff infiltrates into the aquifer following rainfall events.
- *MW18-07S (4.6 to 7.6 m bgs, "Shallow MVA").* Groundwater from this well is slightly acidic and characterized by 1 to 3 mg/L Zn. This well is upgradient of the car bridge and cross-gradient to the Duck Pond.
- *MW18-07D (13.6 to 15.1 m bgs, "Shallow MVA").* Groundwater from this well is characterized by Zn concentrations of 0.5 mg/L to 3 mg/L. Concentrations are lower compared to the shallow well suggesting a surface source recharging to the deeper portion of the shallow aquifer.

- *MW18-08S (3.0 to 6.1 m bgs, "Shallow MVA").* Groundwater from this well is slightly acidic and characterized by 1 to 3 mg/L Zn. This well is immediately downgradient of the Duck Pond suggesting that the Duck Pond is not a significant source of ARD to shallow groundwater.
- *MW18-08D (7.3 to 10.4 m bgs, "Shallow MVA").* Groundwater from this well is also slightly acidic and characterized by Zn concentrations of ~1 mg/L, lower than what is observed in the shallow piezometer. Again, this suggests a surface source, as at well MW18-07D.

3.4.8 *Groundwater Quality – Interim Phase II Lynx SIS Pumping Wells*

Figure 3-12 provides groundwater quality time trends for the Interim Phase II Lynx SIS pumping wells. The Interim Phase II Lynx SIS consists of a fence of four pumping wells, specifically PW18-01 to PW18-04. These wells were installed between the Duck Pond and the Superpond to intercept acidic seepage (ARD) that was observed discharging to Myra Creek in 2018. **Table 3-9** provides groundwater quality results for the PW18 pumping wells in 2019. Key observations from these wells are summarized below:

- *PW18 Pumping Wells (1.5 to 10.7 m bgs, "Shallow MVA").* The PW18 pumping wells are characterized by low concentrations of SO_4 and metals, e.g. 0.3 to 0.6 mg/L Zn and slight acidity (pH of 5.6 to 7.0). Concentrations also appear to have decreased over the time of operation. Some seasonality is observed, with higher concentrations during winter high flow conditions, although additional monitoring would be needed to confirm this trend. The latest samples (from November 2019) show slightly higher concentrations than observed at the end of the summer low flow period. None of the samples collected from the PW18 wells showed the elevated metal concentrations observed in the strongly acidic seepage that was observed discharging to Myra Creek in 2018 (RGC, 2018d).

Table 3-9.

Groundwater Quality Results for Interim Phase II Lynx SIS Pumping Well, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
PW18-01	07-Mar-19	*6.8*	*143*	32	38	0.03	0.001	0.0002	0.028	0.010	0.027	0.0011	0.0002	0.0005	0.6
PW18-01	10-Apr-19	5.6	476	35	28	0.01	0.001	0.0001	0.016	0.010	0.0050	0.0007	0.0002	0.0005	0.4
PW18-01	10-May-19	*6.9*	*109*	30	26	0.03	0.001	0.0001	0.018	0.010	0.022	0.0008	0.0002	0.0005	0.4
PW18-01	10-Jun-19	-	-	30	20	0.009	0.000	0.0001	0.008	0.010	0.0041	0.0005	0.0002	0.0005	0.2
PW18-01	31-Jul-19	6.3	82	29	15	0.005	0.000	0.0001	0.005	0.010	0.0012	0.0004	0.0019	0.0005	0.2
PW18-01	11-Sep-19	*6.8*	*86*	27	15	0.007	0.000	0.0001	0.008	0.010	0.0039	0.0007	0.0002	0.0005	0.2
PW18-01	09-Oct-19	*6.8*	*99*	28	21	0.008	0.001	0.0001	0.013	0.010	0.014	0.0006	0.0002	0.0005	0.3
PW18-01	09-Nov-19	7.5	119	31	24	0.01	0.001	0.0002	0.020	0.010	0.017	0.0011	0.0002	0.0005	0.4
PW18-02	07-Mar-19	*6.8*	*147*	33	38	0.02	0.001	0.0001	0.024	0.010	0.011	0.0011	0.0002	0.0005	0.6
PW18-02	10-Apr-19	*7.0*	*143*	29	40	0.04	0.002	0.0004	0.044	0.010	0.039	0.0017	0.0002	0.0005	0.8
PW18-02	10-May-19	6.2	111	29	35	0.04	0.002	0.0003	0.041	0.010	0.037	0.0014	0.0002	0.0005	0.7
PW18-02	10-Jun-19	-	-	31	28	0.02	0.001	0.0002	0.024	0.010	0.018	0.0010	0.0002	0.0005	0.5
PW18-02	31-Jul-19	6.2	88	30	24	0.007	0.001	0.0001	0.012	0.010	0.0066	0.0006	0.0002	0.0005	0.3
PW18-02	11-Sep-19	*6.8*	*98*	28	22	0.008	0.001	0.0001	0.015	0.010	0.0070	0.0006	0.0002	0.0005	0.3
PW18-03	07-Mar-19	*6.8*	*135*	32	33	0.007	0.001	0.0001	0.011	0.010	0.0063	0.0009	0.0002	0.0005	0.5
PW18-03	10-Apr-19	*7.0*	*138*	29	36	0.019	0.001	0.0002	0.026	0.010	0.021	0.0014	0.0002	0.0005	0.7
PW18-03	10-May-19	6.2	101	30	28	0.008	0.001	0.0002	0.011	0.019	0.0070	0.0010	0.0002	0.0005	0.4
PW18-03	10-Jun-19	-	-	29	25	0.008	0.001	0.0001	0.009	0.010	0.0044	0.0008	0.0002	0.0005	0.4
PW18-03	31-Jul-19	6.2	88	27	23	0.005	0.001	0.0001	0.008	0.010	0.0033	0.0005	0.0002	0.0005	0.3
PW18-03	11-Sep-19	*6.8*	*99*	27	22	0.005	0.001	0.0001	0.008	0.010	0.0012	0.0005	0.0002	0.0005	0.3
PW18-03	09-Oct-19	*6.9*	*100*	28	22	0.006	0.001	0.0001	0.010	0.010	0.0067	0.0006	0.0002	0.0005	0.3
PW18-03	09-Nov-19	7.6	123	27	25	0.015	0.001	0.0001	0.020	0.010	0.014	0.0010	0.0004	0.0005	0.5
PW18-04	07-Mar-19	*6.7*	*135*	28	35	0.005	0.001	0.0001	0.005	0.010	0.0006	0.0013	0.0002	0.0005	0.6
PW18-04	10-Apr-19	6.2	102	30	28	0.005	0.001	0.0001	0.004	0.010	0.0005	0.0007	0.0002	0.0005	0.4
PW18-04	10-May-19	*7.0*	*111*	29	28	-	-	-	-	-	-	-	-	-	-
PW18-04	10-Jun-19	-	-	30	26	0.006	0.001	0.0001	0.011	0.010	0.0043	0.0007	0.0002	0.0005	0.4
PW18-04	31-Jul-19	6.4	89	27	22	0.005	0.001	0.0001	0.007	0.010	0.0037	0.0006	0.0002	0.0005	0.3
PW18-05	not sampled	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: Italicized pH and EC values are lab results

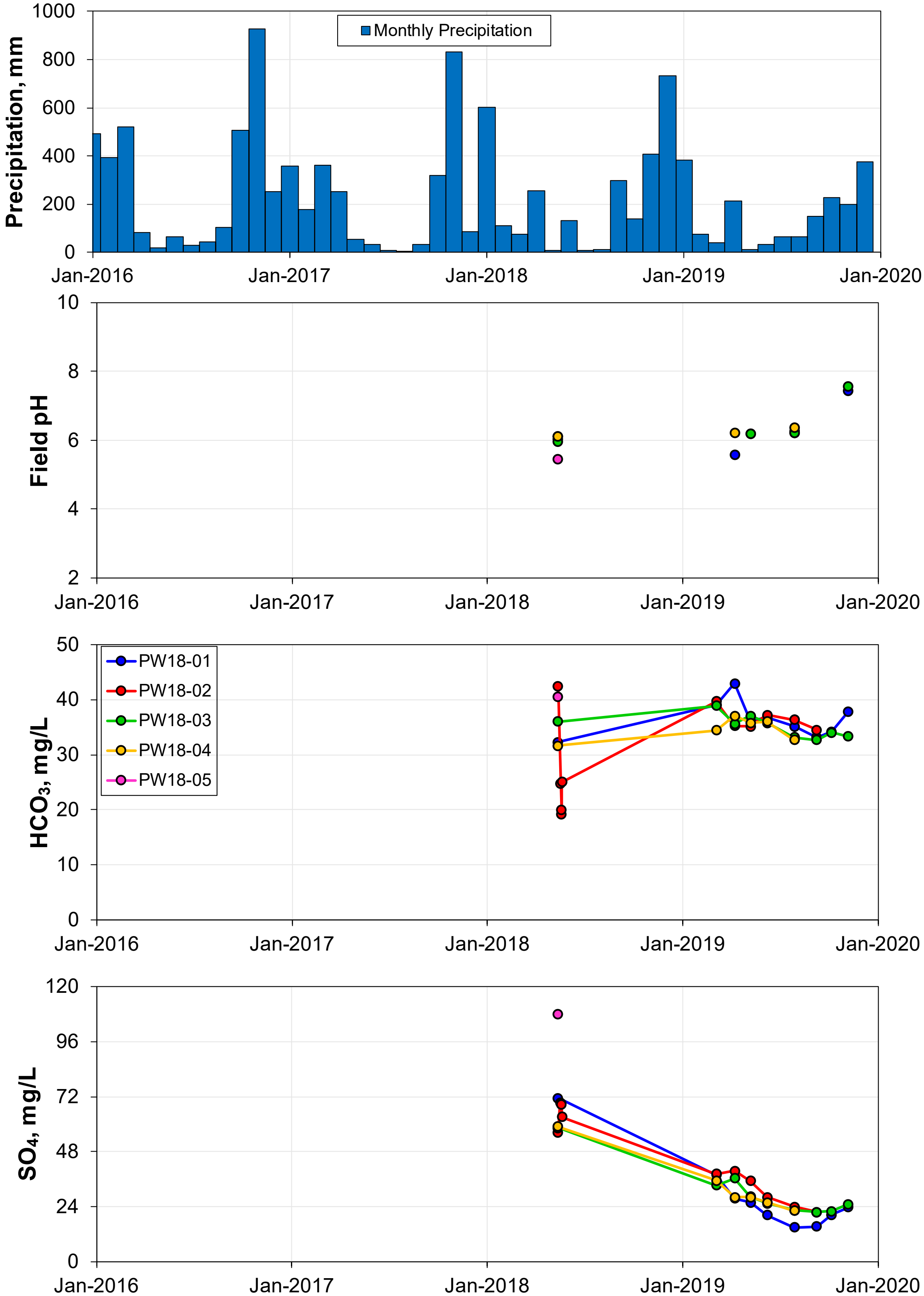


Figure 3-12a. Groundwater Quality Time Trends for Interim Phase II Lynx SIS Pumping Wells, 2019

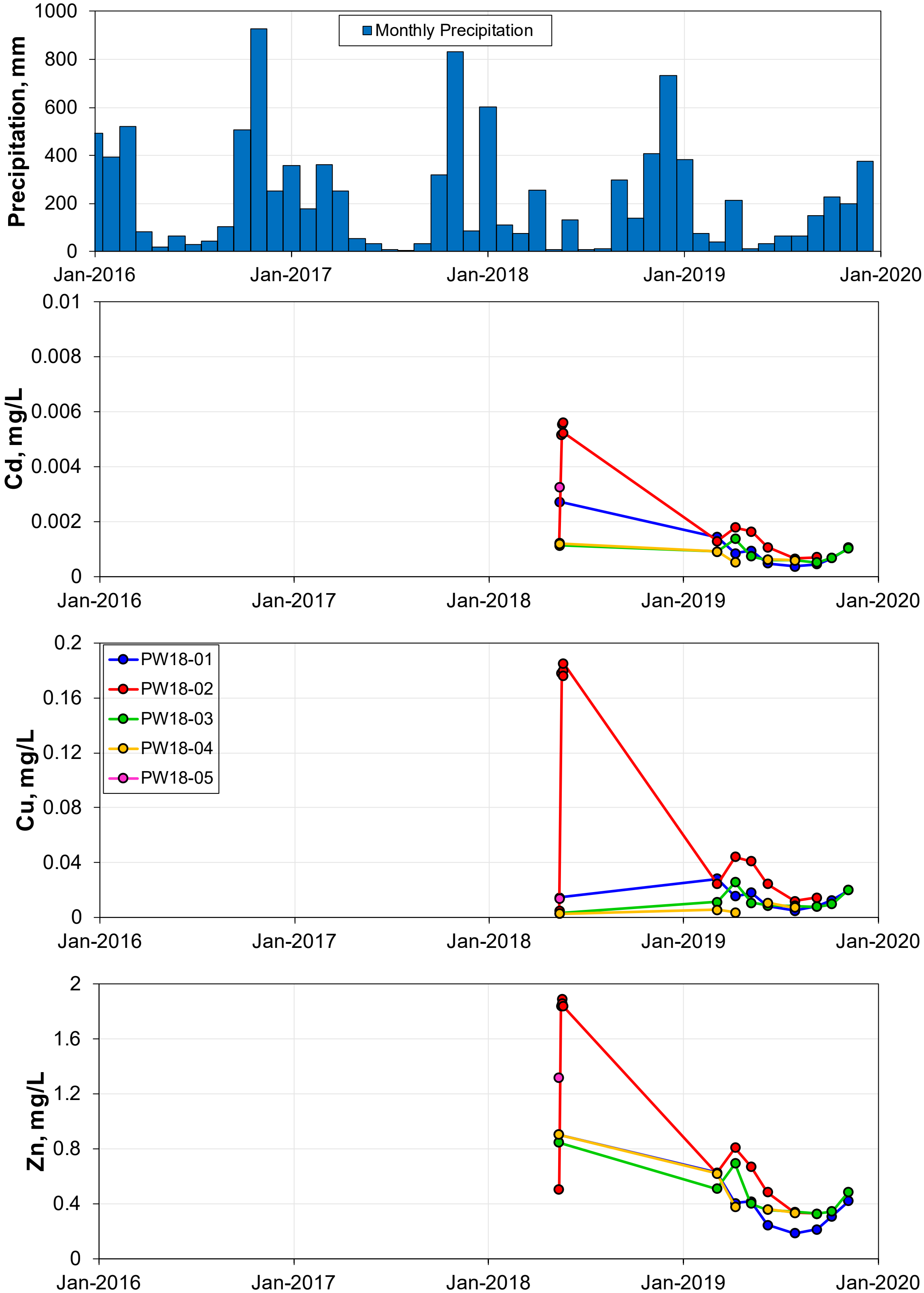


Figure 3-12b. Groundwater Quality Time Trends for Interim Phase II Lynx SIS Pumping Wells, 2019

3.4.9 *Groundwater Quality – Downgradient of Interim Phase II Lynx SIS*

Figure 3-13 provides groundwater quality time trends for monitoring well MW13-19, downgradient of the Interim Phase II Lynx SIS. Well MW13-19 was installed downstream of the carbridge in 2013 as part of the site-wide hydrogeological field investigation. **Table 3-10** provides groundwater quality results for these wells in 2019. Key observations from these wells are summarized below:

- *MW13-19 (17.1 to 20.1 m bgs, "Deep MVA).* Groundwater is characterized by low concentrations of SO_4 and metals that suggest minimal impact by ARD and no change was observed in 2019. Hydraulic testing further suggests that the deep aquifer is not well connected to the shallow sediments intercepted by the Interim Phase II pumping wells.

Table 3-10.

Groundwater Quality Results for Wells Downgradient of Interim Phase II Lynx SIS Pumping Wells, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW13-19	22-Nov-19	6.1	71	40	4	0.03	0.0001	0.0001	0.02	0.01	0.0034	0.0004	0.0002	0.0005	0.03

Note: Italicized pH and EC values are lab results

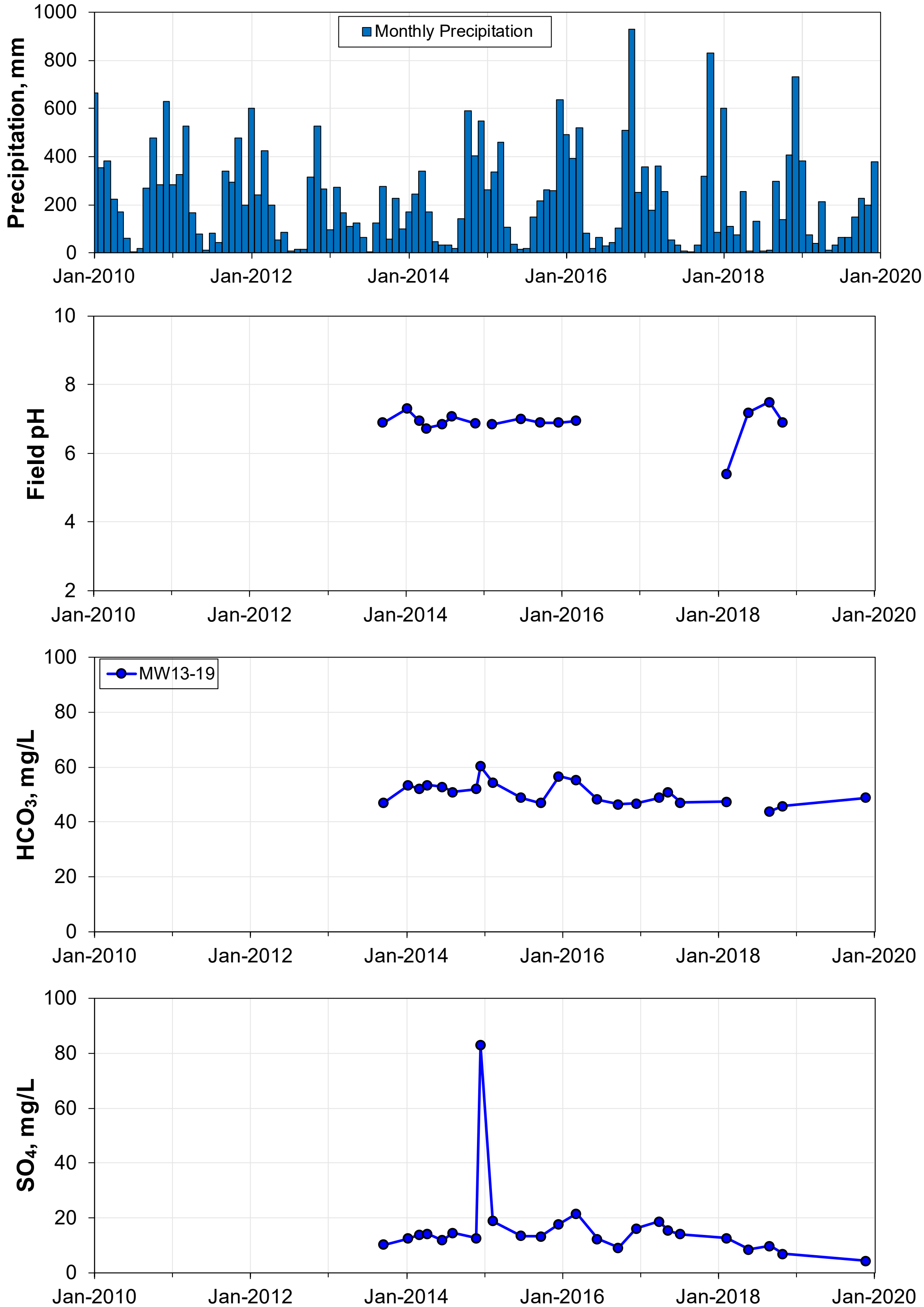


Figure 3-13a. Groundwater Quality Time Trends for Wells Downgradient of Phase II Lynx SIS Pumping Wells, 2019

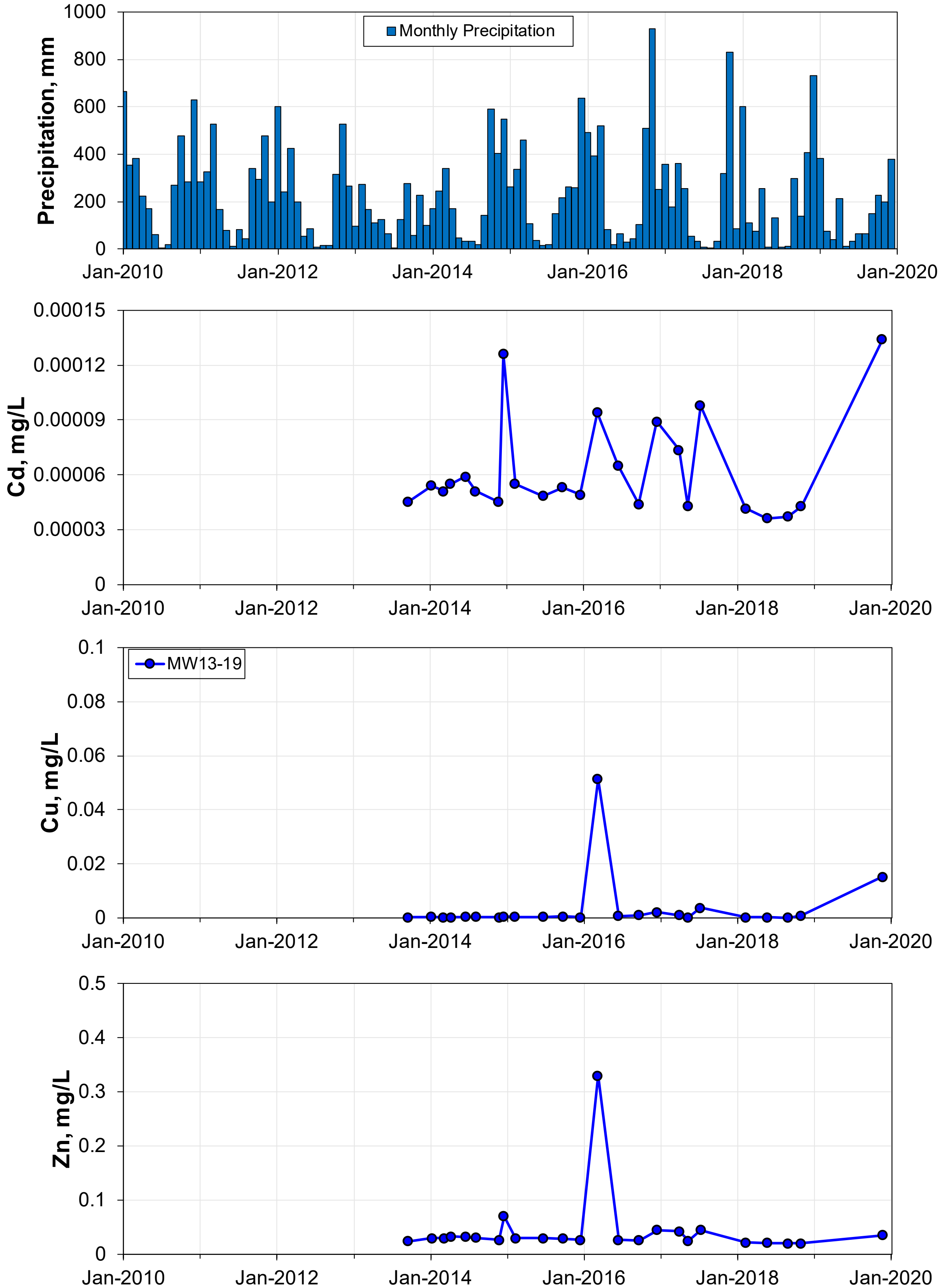


Figure 3-13b. Groundwater Quality Time Trends for Wells Downgradient of Phase II Lynx SIS Pumping Wells, 2019

3.5 GROUNDWATER QUALITY – OLD TDF REACH

3.5.1 *Monitoring Wells*

Construction details for groundwater monitoring wells in the Old TDF Reach are summarized in **Table 3-11.** This reach is subdivided into the Upper Old TDF Reach and the Lower Old TDF Reach based on water quality impacts to Myra Creek. Most of the wells in the Old TDF Reach are screened in the MVA near or beneath the Old TDF and some are screened in tailings in the Old TDF. The MW13 and TD13 wells were installed in 2013 as part of a site-wide hydrogeological field investigation. Other wells, including the MW-A to MW-G, were installed before 2013 as part of previous site investigations. No new wells were installed in the Old TDF Reach in 2019.

Quarterly monitoring of these MW wells and wells MW13-14S/D and MW13-15S/D is required for Permit M-26. Other monitoring wells are sampled quarterly or semi-annually as part of voluntary routine monitoring to support the ongoing assessment of the site-wide SIS and numerical groundwater modeling to support future closure planning.

3.5.2 *Local Groundwater Flow Field*

The overall direction of groundwater flow in the Upper Old TDF Reach follows the main valley axis towards the Lower Old TDF Reach and the Old Outer Drain and New Outer Drain (NOD) near Myra Creek. In the Lower Old TDF, groundwater continues to flow towards Myra Creek and is ultimately captured by the original (old) outer drains and the NOD. Hydraulic gradients are typically directed from Myra Creek towards the NOD, meaning the NOD provides hydraulic control of groundwater levels in the MVA. This is consistent with monthly Zn surveys in Myra Creek that show little groundwater bypass along this reach of Myra Creek (see RGC, 2016).

The groundwater flow field in the Upper Old TDF has been modified, to some extent, by the operation of the Phase I Lynx SIS since October 2017, as the capture zone of pumping well PW14-04 extends slightly into this reach. In the Lower Old TDF Reach, the groundwater flow field is not significantly affected by the Phase I Lynx SIS. The groundwater flow fields during low flow and high flow conditions differ slightly, as they do in the Lynx SIS, but these differences are not critical to the interpretation of groundwater quality time trends in this section.

Table 3-11.

Groundwater Monitoring Wells in the Old TDF Reach

Well ID	Installation Date	Depth Drilled, m bgs	Screening Interval, m bgs top	Screening Interval, m bgs bottom	Screened Material	Monitoring Status	Obligation
Upper Old TDF Reach near Surge Pond							
MW17-01	20-Sep-17	31.39	20.7	23.8	Sand and gravel	Semiannual	Voluntary
MW17-02S	22-Sep-17	42.67	21.7	23.2	Sand	Semiannual	Voluntary
MW17-02D	22-Sep-17	42.67	32.6	34.1	Sand	Monthly	Voluntary
MW17-03	21-Sep-17	42.98	39.3	40.8	Sand with gravel	Monthly	Voluntary
Near Myra Creek and Polishing Ponds							
MW04-01	-	-	-	-	-	Not routinely monitored	-
MW13-11S	27-Jul-13	17.0	4.3	7.3	Gravel with sand	Quarterly	Voluntary
MW13-11D	27-Jul-13	11.5	12.2	15.2	Gravel with sand	Quarterly	Voluntary
MW17-04	28-Sep-17	10.67	8.2	9.8	Sand with gravel	Quarterly	Voluntary
MW17-05	27-Sep-17	12.19	7.0	8.5	Sand with gravel	Quarterly	Voluntary
MW17-06	24-Sep-17	30.48	24.1	25.6	Sand with gravel	Quarterly	Voluntary
MW17-07	28-Sep-17	10.67	7.6	9.1	Cobbles with sand and gravel	Quarterly	Voluntary
MW17-08	24-Sep-17	9.14	5.5	7.0	Gravel with sand	Quarterly	Voluntary
MW13-13	27-Jul-13	14.2	9.2	12.2	Gravel with sand	Quarterly	Voluntary
Near Myra Creek and HW Offices							
MW13-12	31-Jul-13	20.1	11.0	15.5	Gravel with sand	Not routinely monitored	-
Old TDF Footprint							
TD13-01S	11-Aug-13	47.6	20.1	26.2	Tailings (coarse seam)	Not routinely monitored	-
TD13-01D	11-Aug-13	36.6	36.6	44.2	Gravel with sand	Quarterly	Voluntary
TD13-02S	9-Aug-13	41.4	19.6	25.6	Tailings (coarse seam)	Not routinely monitored	-
TD13-02D	9-Aug-13	35.1	35.1	38.1	Sand with gravel	Quarterly	Voluntary
TD13-03S	10-Aug-13	47.6	20.4	26.4	Tailings (coarse seam)	Not routinely monitored	-
TD13-03D	10-Aug-13	44.5	44.5	47.6	Gravel with sand	Quarterly	Voluntary
TD13-04S	11-Aug-13	49.7	26.2	29.2	Gravel with sand	Not routinely monitored	-
TD13-04D	11-Aug-13	41.4	41.4	44.5	Gravel with sand	Quarterly	Voluntary
TD13-05S	9-Aug-13	41.4	20.1	23.2	Tailings	Not routinely monitored	-
TD13-05D	9-Aug-13	35.1	35.1	38.1	Gravel with sand	Quarterly	Voluntary
MW11-05S	24-Jun-11	10.1	5.4	10.1	Tailings	Not routinely monitored	-
MW11-05D	23-Jun-11	42.1	40.2	42.1	Tailings	Not routinely monitored	-
Near NOD and Myra Creek							
MW13-14S	28-Jul-13	17.7	8.0	11.0	Gravel with sand	Quarterly	Required (Permit M-26)
MW13-14D	28-Jul-13	14.7	14.7	17.7	Gravel with sand	Quarterly	Required (Permit M-26)
MW13-15S	29-Jul-13	19.2	9.5	12.5	Gravel with sand	Quarterly	Required (Permit M-26)
MW13-15D	29-Jul-13	16.2	16.2	19.2	Gravel with sand	Quarterly	Required (Permit M-26)
MW-A	-	15.8	11.6	13.1	Gravel and Sand	Quarterly	Required (Permit M-26)
MW-B	-	14.8	11.6	13.1	Gravel and Sand	Not routinely monitored	-
MW-C	-	14.8	11.6	13.1	Gravel and Sand	Quarterly	Required (Permit M-26)
MW-D	-	7.6	6.1	7.6	Coarse Sand	Quarterly	Required (Permit M-26)
MW-E	-	5.8	4.3	5.8	Coarse Sand	Not routinely monitored	-
MW-F	-	5.8	4.3	5.8	Coarse Sand	Quarterly	Required (Permit M-26)
MW-G	-	-	-	-	-	Not routinely monitored	-

3.5.3 *Groundwater Quality – Upper Old TDF Reach near Surge Pond*

Figure 3-14 provides groundwater quality time trends for monitoring wells in the Upper Old TDF Reach near the Surge Pond. **Table 3-12** provides groundwater quality results for these wells in 2019. Key observations from these wells are summarized below:

- *MW17-01 (20.7 to 23.8 m bgs, "Deep MVA").* Groundwater from well MW17-01 is characterized by elevated SO_4 (1,560 mg/L SO_4) and elevated concentrations of most metals, 0.3 mg/L Cu and 45 mg/L Zn. These elevated concentrations are attributed mainly to ARD that reports to the MVA from the buried portion of WRD#1. This well was installed in 2017 to differentiate the contribution of ARD from WRD#1 and ARD from the Lynx TDF embankment berm and to refine the groundwater flow field in the Upper Old TDF Reach. Only one initial sample has been collected in April 2018 using a bailer as there was not sufficient water to use a sampling pump. MW17-01 is usually reported as dry and has not been sampled for water quality since. This well is downgradient of the Phase I Lynx SIS and sampling in 2020 should be attempted (using a bailer if necessary) and prioritized unless the well is dry.

- *MW17-02S (21.7 to 23.2 m bgs, "Shallow MVA").* Groundwater from this well was acidic (pH 3.3) and characterized by 3,000 mg/L SO_4, 3.6 mg/L Cu, and 112 mg/L Zn in January 2018 when it was first sampled. This initial sample was collected during high flow conditions using a bailer. These elevated concentrations were attributed to ARD from the buried portion of WRD#1 (to the north) and/or tailings that were deposited in the nearby Reclaim Sand Area (RSA). This well has not been sampled since 2018 as it is usually dry, so there is no information on how groundwater quality has changed since tailings were removed from the RSA (to construct the Surge Pond) and/or the Phase I Lynx SIS has been operating.
- *MW17-02D (32.6 to 34.1 m bgs, "Deep MVA").* Groundwater from well MW17-02S is acidic (pH 4.5 to 5.5) and is characterized by elevated SO_4 and metal concentrations, including Al, Cu, Fe, and Zn. Groundwater quality has improved substantially since 2017, presumably due to operating the Phase I Lynx SIS upgradient in the Lynx Reach. During the first year of operating the Phase I Lynx SIS, Zn concentrations in groundwater from well MW17-02D decreased by an order-of-magnitude, from 14 mg/L Zn to 1 mg/L Zn. Higher concentrations (> 40 mg/L Zn) observed in early 2019 are attributed to groundwater bypass while the Phase I Lynx SIS pumping wells were turned off (in December 2018 and January 2019, see Section 2). Zn concentrations in groundwater have since decreased again to concentrations that are comparable to concentrations observed in late 2018. In late 2019, a slight increase in Zn concentrations was observed. The cause of this variability is unknown and further monitoring is needed to determine if it is part of a trend or short-term variability.
- *MW17-03 (39.3 to 40.8 m bgs, "Deep MVA").* Groundwater from well MW17-03 is acidic (pH < 5.5) and characterized by elevated SO_4 and metals. Groundwater from this well was initially characterized by elevated SO_4 and dissolved metals, i.e. 18.5 mg/L Zn, that were attributed to groundwater impacted primarily by ARD (seepage) from the Lynx TDF embankment berm and/or tailings in former RSA. SO_4 and metal concentrations decreased by approximately 50% by operating the Phase I Lynx SIS since September 2017. Elevated Zn concentrations were again observed in early 2019 likely due to the shutdown of the Phase I Lynx SIS. A slight increase in Zn concentrations was observed in late 2019, possibly due to increased recharge and associated contaminant flushing. These trends are similar to the trends in groundwater from well MW17-02D, which require further monitoring to assess.

Table 3-12

Groundwater Quality Results for Monitoring Wells in Upper Old TDF Reach near Surge Pond, 2019

Well ID	Sample Date	Field pH	Field EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW17-2D	31-Jan-19	*4.4*	*920*	1	425	2.9	0.02	0.03	0.4	14.3	4.2	0.04	0.0005	0.0005	13.9
MW17-2D	05-Mar-19	4.8	804	1	520	4.2	0.03	0.04	0.6	26.5	5.9	0.05	0.0005	0.0005	16.8
MW17-2D	08-May-19	*4.6*	*2268*	1	880	8.2	0.08	0.09	1.4	31.9	12.4	0.1220	0.0083	0.0005	40.9
MW17-2D	20-Sep-19	*4.7*	*558*	1	276	2.7	0.01	0.02	0.3	10.3	2.6	0.03	0.0003	0.0005	8.9
MW17-2D	26-Sep-19	4.8	656	1	336	1.9	0.01	0.02	0.3	13.6	3.1	0.03	0.0002	0.0008	10.6
MW17-2D	07-Nov-19	*5.4*	*209*	9.5	73	0.5	0.00	0.004	0.1	0.4	0.5	0.0052	0.0008	0.0005	1.7
MW17-2D	31-Dec-19	*6.1*	*199*	5.8	79	0.1	0.00	0.005	0.1	1.1	0.8	0.0068	0.0002	0.0005	2.5
MW17-03	01-Feb-19	*4.2*	*1164*	1	1,670	17.9	0.1	0.07	3.2	9.3	11.1	0.09	0.01	0.0005	43.0
MW17-03	05-Mar-19	4.5	1120	1	770	9.3	0.07	0.05	2.1	13.3	7.5	0.06	0.0041	0.0005	24.4
MW17-03	20-Sep-19	*5.3*	*385*	7.3	170	0.3	0.007	0.008	0.026	0.9	1.5	0.009	0.0002	0.0005	4.4
MW17-03	07-Nov-19	*5.6*	*354*	1	154	1.0	0.01	0.006	0.5	1.0	1.1	0.009	0.002	0.0005	3.7
MW17-03	31-Dec-19	*4.0*	*650*	1	525	4.8	0.03	0.020	1.0	6.8	2.6	0.023	0.009	0.0005	9.7

Note: Italicized pH and EC values are lab results

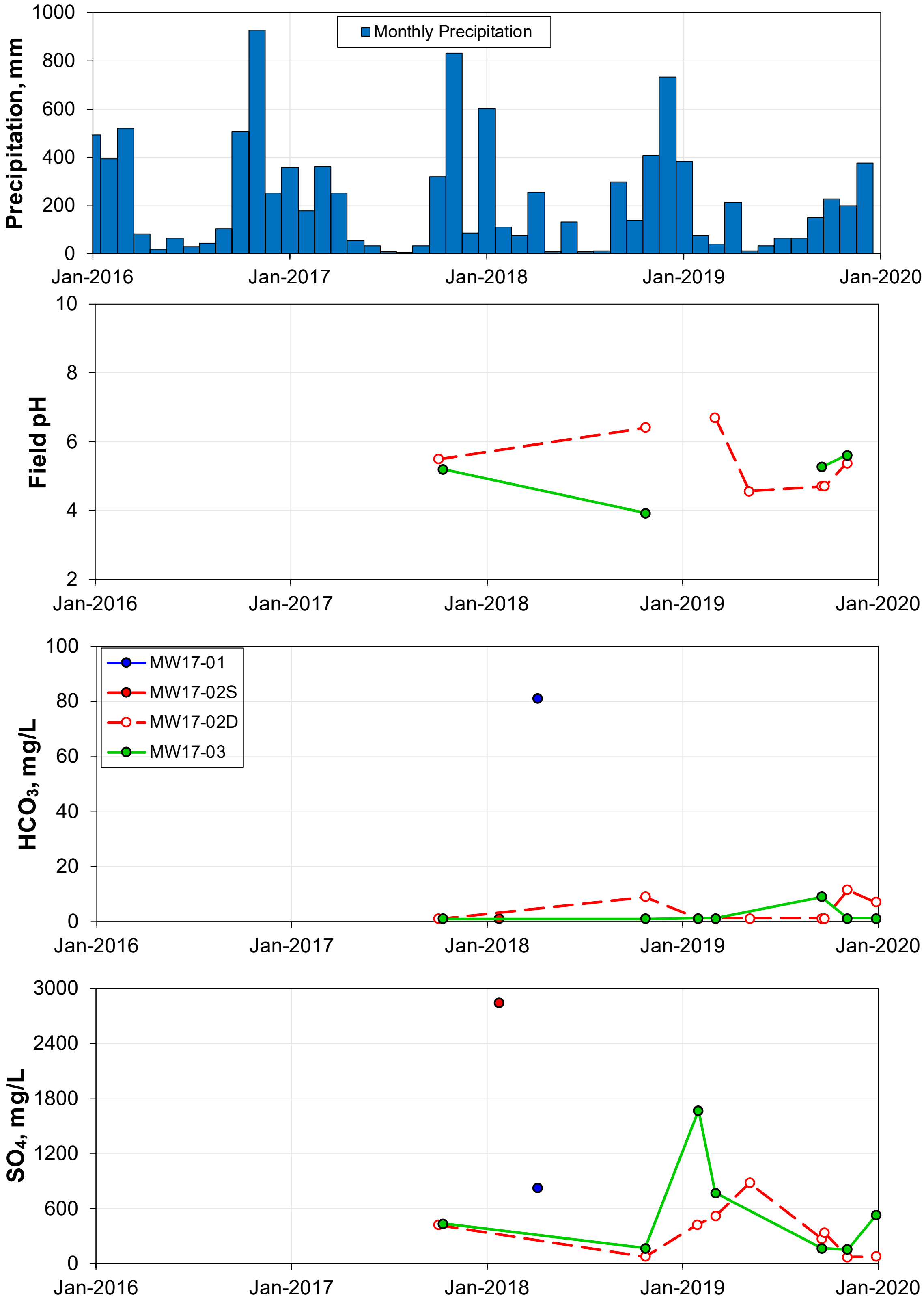


Figure 3-14a. Groundwater quality time trends for Monitoring Wells near Surge Pond

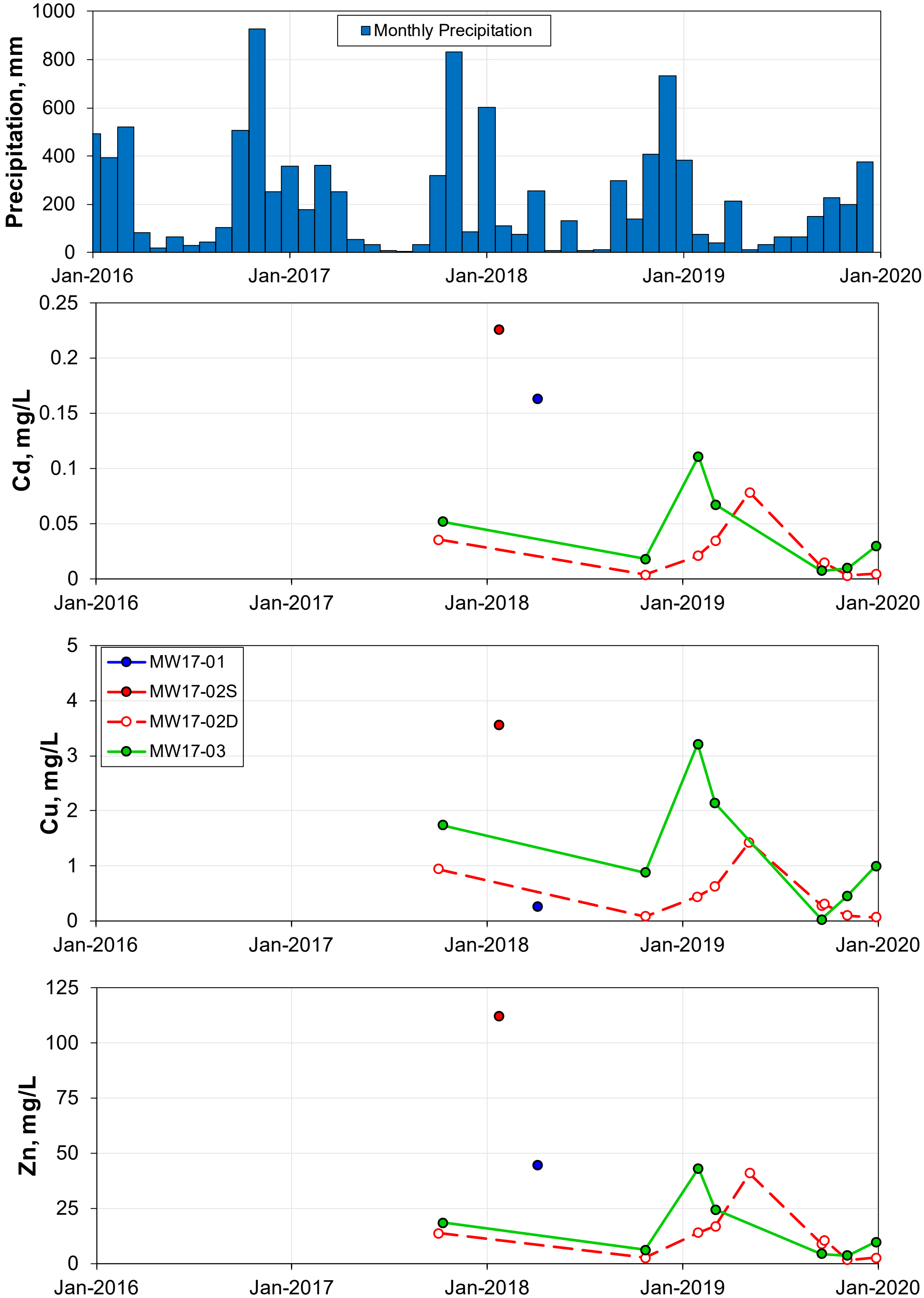


Figure 3-14b. Groundwater quality time trends for Monitoring Wells near Surge Pond

3.5.4 *Groundwater Quality – Near Old Outer Drain & Disconnected Long Drain*

Figure 3-15 provides groundwater quality time trends for wells near the Old Outer Drain and Disconnected Long Drain. Monitoring wells in this area are located on the north side of Myra Creek. **Table 3-13** provides groundwater quality results for 2019. A segment of the original ("Old") Outer Drain in this area is disconnected, up to around Station MC+400. This segment has been disconnected since it was installed due to issues connecting it to conveyance pipes. Myra Creek is, however, inferred to lose water in this section and monitoring wells show low concentrations. Connecting the drain would hence only collect diluted groundwater and likely not improve Myra Creek water quality noticeably. Several wells in this area are downgradient of the disconnected Long Drain segment of the NOD and were installed in 2017 to assess potential groundwater bypass to Myra Creek.

Table 3-13.

Groundwater Quality Results for Monitoring Wells near Old Outer Drain & Disconnected Long Drain, 2019

Well ID	Sample Date	pH	EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW17-04	09-May-19	6.8	124	23	45	0.01	0.0001	0.0001	0.001	0.01	0.002	0.0004	0.0002	0.0005	0.04
MW17-04	09-Aug-19	6.1	168	17	55	0.01	0.0002	0.0001	0.006	0.01	0.001	0.0004	0.0002	0.0005	0.1
MW17-04	22-Nov-19	6.4	61	30	7	0.01	0.0001	0.0001	0.002	0.01	0.002	0.0004	0.0002	0.0005	0.2
MW17-05	09-May-19	6.7	152	57	33	0.04	0.0002	0.0001	0.003	0.07	0.005	0.0004	0.0003	0.0005	0.1
MW17-05	08-Aug-19	6.6	161	37	37	0.01	0.0002	0.0001	0.002	0.01	0.001	0.0004	0.0002	0.0005	0.1
MW17-05	22-Nov-19	*7.1*	*243*	29	83	0.01	0.0004	0.0001	0.004	0.01	0.012	0.0004	0.0002	0.0005	0.2
MW17-06	26-Sep-19	5.3	194	22	45	0.01	0.002	0.0002	0.01	0.01	0.1	0.0020	0.0002	0.0026	0.9
MW17-06	07-Nov-19	5.6	330	28	88	0.02	0.002	0.0003	0.003	0.14	0.023	0.0039	0.0003	0.0005	2.0
MW17-07	09-May-19	6.5	116	34	33	0.01	0.0004	0.0001	0.005	0.01	0.00517	0.0004	0.0002	0.0005	0.2
MW17-07	09-Aug-19	8.0	145	35	40	0.01	0.0003	0.0001	0.003	0.01	0.00027	0.0004	0.0002	0.0005	0.2
MW17-07	22-Nov-19	6.4	130	39	39	0.01	0.0004	0.0001	0.003	0.01	0.006	0.0004	0.0002	0.0005	0.2

Note: Italicized pH and EC values are lab results

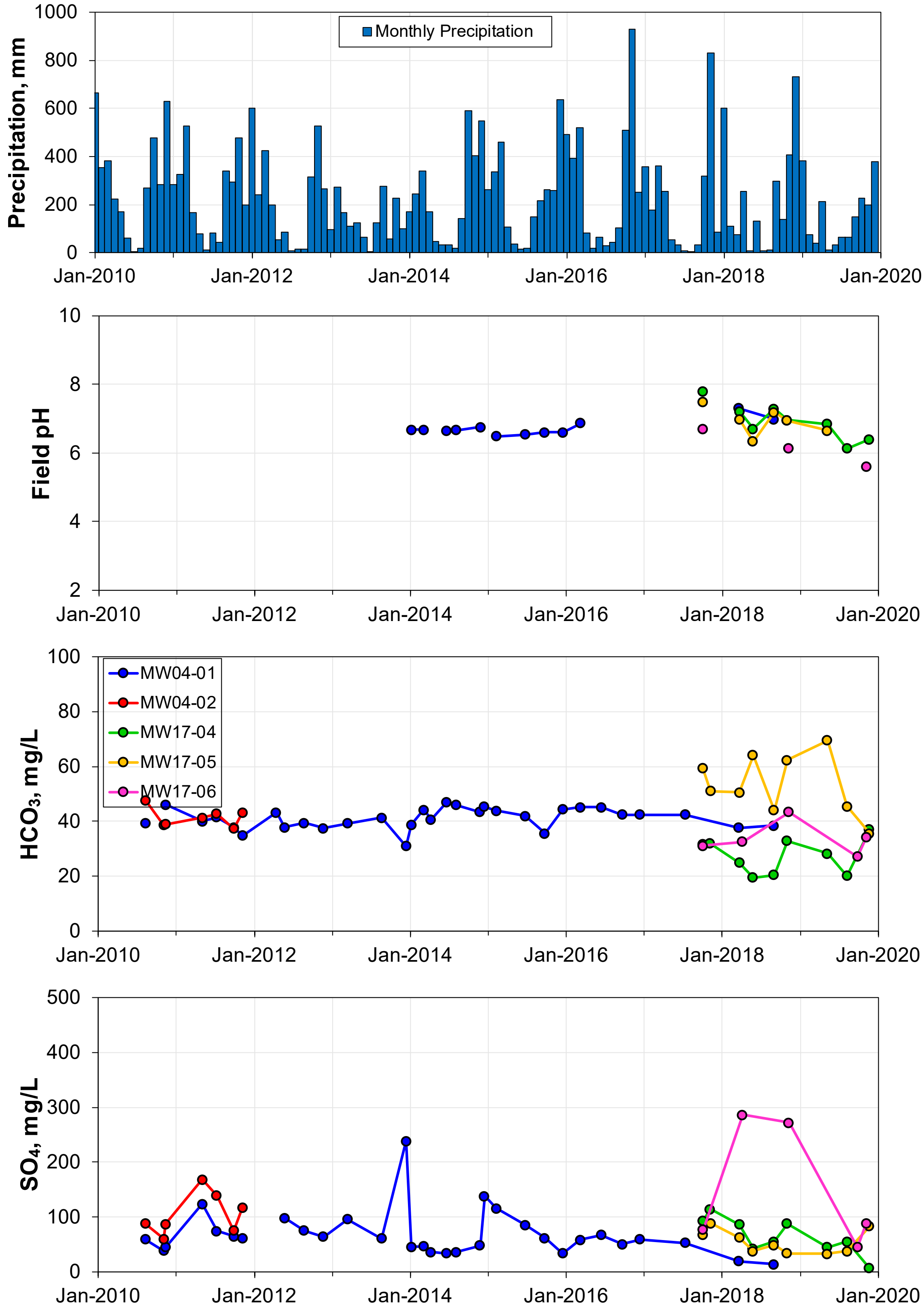


Figure 3-15a. Groundwater Quality Time Trends – Old Outer Drain & Disconnected Long Drain

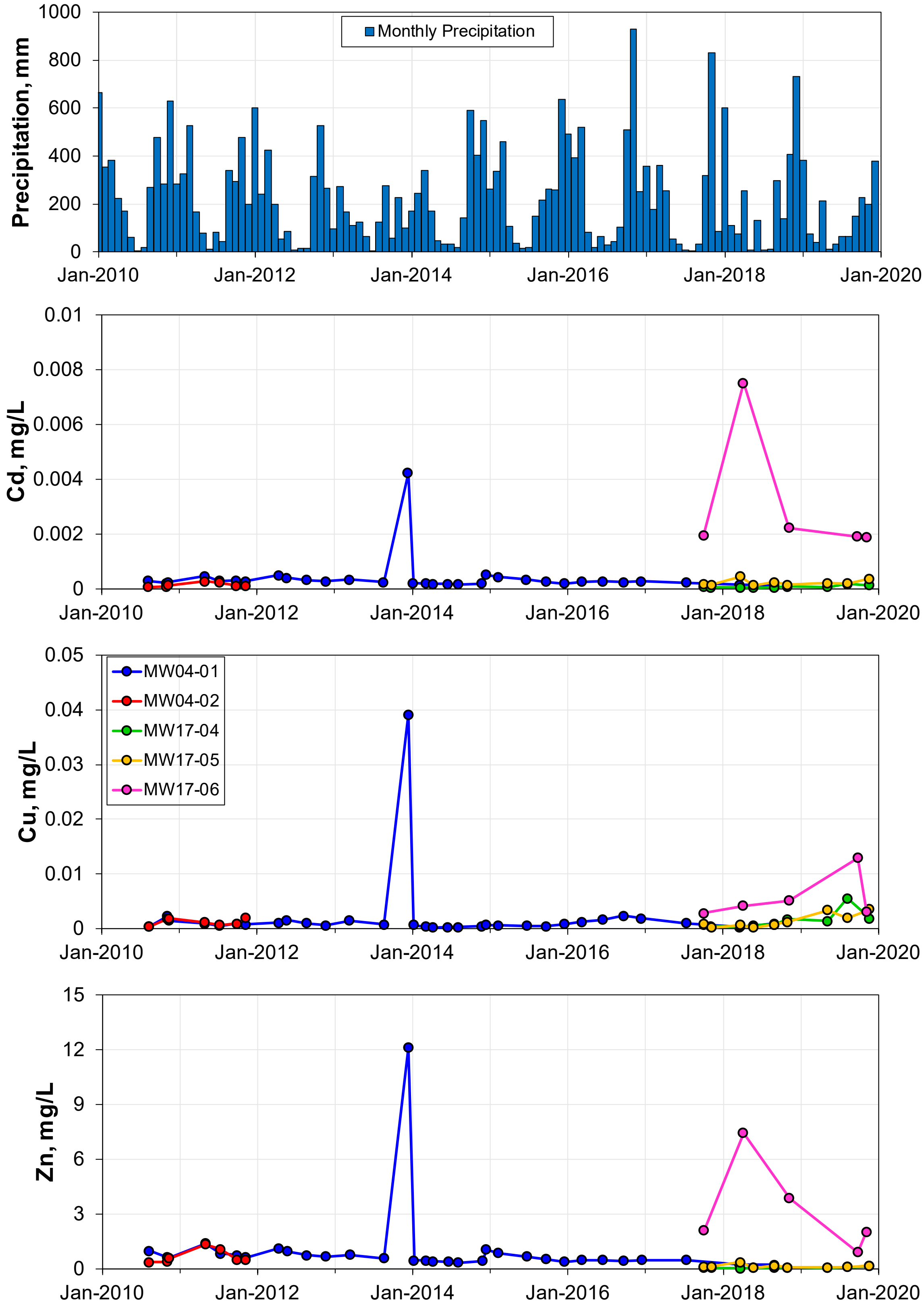


Figure 3-15a. Groundwater Quality Time Trends – Old Outer Drain & Disconnected Long Drain

Key observations for individual monitoring wells are summarized below:

- *MW04-01 (screening interval not known)*. MW-04-01 is between the disconnected portion of the Old Outer Drain and Myra Creek at around Station MC+100. Zn has remained low, usually below 1 mg/L and SO_4 concentrations usually do not exceed 100 mg/L. This suggests that the impacted groundwater observed in the Lynx Reach does not discharge to Myra Creek in this section. Water quality is representative of lateral inflow of cleaner groundwater from the south and/or leakage from Myra Creek mixing with more impacted groundwater to some degree. No samples were collected in 2019.
- *MW04-02 (screening interval not known)*. MW04-02 is downstream of MW04-01 between Myra Creek and the disconnected portion of the Old Outer Drain at around Station MC+350. Water quality conditions are similar to MW04-01 and this well has not been sampled since 2011.
- *MW17-04 (8.2 to 9.5 m bgs, "Shallow MVA").* Groundwater from well MW17-04 is characterized by low concentrations of SO_4 and metals, i.e. 0.2 mg/L Zn. This well is immediately downgradient of the upgradient end of the connected Long Drain segment of the NOD. Water level monitoring suggests that Myra Creek is losing water to the aquifer and diluting groundwater in this area. No change in groundwater quality time trends was observed in 2019.
- *MW17-05 (7.0 to 8.5 m bgs, "Shallow MVA").* Groundwater samples collected at MW17-05 are characterized by low SO_4 (less than 100 mg/L) and low metal concentrations. Myra Creek is inferred to lose water to the aquifer upstream of MW17-05 which is then mixing with more impacted water in the aquifer and discharging to Myra Creek again starting at around MW17-05. The relatively low concentrations suggest only a small amount of mixing with impacted groundwater.
- *MW17-06 (24.1 to 25.6 m bgs, "Shallow MVA").* Groundwater from well MW17-06 is acidic (pH 5.0 to 5.5) and characterized by elevated SO_4 and metal concentrations. These data suggest that groundwater in the shallow MVA upgradient of the disconnected Long Drain segment of the NOD is moderately impacted by ARD. Zn concentrations decreased until fall 2019 but showed a small increase in late 2019.
- *MW17-07 (7.6 to 9.1 m bgs, "Shallow MVA").* MW17-07 is screened between the disconnected NOD and Myra Creek, just upstream of the spillway. A strong hydraulic gradient towards Myra Creek exists at this location indicating groundwater discharge to Myra Creek. Groundwater from well MW17-07, however, is characterized by less than 100 mg/L of SO_4 and low metal concentrations (Zn <0.5 mg/L) likely due to dilution with creek water recharging the aquifer further upstream.

3.5.5 *Groundwater Quality – Myra Ponds/HW Area*

Figure 3-16 provides groundwater quality time trends for wells MW13-11S/D, MW17-08, MW13-12, and MW13-13. These wells are south of Myra Creek near the Myra Ponds and HW offices area. The groundwater flow suggests groundwater in this area discharges to Myra Creek, hence these wells are discussed separately from the wells north of Myra Creek. **Table 3-14** provides groundwater quality results for 2019. Note that well MW13-12 located south of the HW yard near the Myra 11L adit was not sampled in 2019.

Key observations from the time trend for this well are summarized below:

- *MW13-11S (4.3 to 7.3 m bgs, "Shallow MVA").* Groundwater from well MW13-11S is characterized by elevated concentrations of SO_4 and some metals, namely Zn. Concentrations of Cd, Cu, Zn, and other metals are variable, with higher concentrations often observed during winter high flow periods. Metal concentrations have been increasing since early 2018 and 8.9 mg/L Zn was observed in October 2019. This is the highest Zn concentration that has been observed in groundwater from well MW13-11S. Note that no increase in the deeper piezometer was observed suggesting a localized source (fill). Alternatively, this could be seepage from the ETA/Cookhouse area further upstream which is migrating downgradient in the shallow aquifer.
- *MW13-11D (12.2 to 15.2 m bgs, "Shallow MVA").* Groundwater from well MW13-11D is characterized by elevated SO_4 concentrations but low metal concentrations. SO_4 concentrations in groundwater are comparable to groundwater in the shallower MVA screened by well MW13-11S. SO_4 concentrations have not increased in recent years and increased concentrations were not observed in 2019.
- *MW17-08 (5.5 to 8.0 m bgs, "Shallow MVA").* Groundwater from well MW17-08 is characterized by elevated SO_4 and some metals, i.e. up to 0.5 mg/L Zn. This well is located south of well MW17-04 on the south side of Myra Creek. Elevated SO_4 and metal concentrations suggest impacted groundwater that is most likely related to a source on the south side of Myra Creek. This groundwater migrates downgradient in the shallow MVA from the Myra Ponds area near well MW13-11S/D or the HW area. Groundwater quality in 2019 was consistent with previous time trends.
- *MW13-12 (11.0 to 15.5 m bgs, Shallow Sediments).* Groundwater from monitoring well MW13-12 is slightly acidic and characterized by low concentrations of SO_4 and metals. Elevated metal concentrations have been observed (due to mine water losses from the nearby adit) but concentrations have declined in recent years and are now relatively stable. This well was not sampled in 2019.
- *MW13-13 (9.2 to 12.2 m bgs, "Shallow MVA).* Groundwater from well MW13-13 is elevated in SO_4 and metal concentrations and shows a strong seasonal pattern with higher concentrations observed in winter (high flow). The source of contamination is likely local as monitoring well MW13-12 which is upgradient on the hillside is unimpacted.

Table 3-14.

Groundwater Quality Results for Monitoring Wells in Myra Ponds/HW Area, 2019

Well ID	Sample Date	pH	EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW13-11S	28-Mar-19	7.2	538	54	278	0.03	0.001	0.0020	0.02	0.11	0.7	0.0027	0.0007	0.0005	4.5
MW13-11S	31-Oct-19	6.7	788	59	320	0.03	0.004	0.0055	0.04	0.12	0.6	0.0063	0.0008	0.0014	8.9
MW13-11D	28-Mar-19	7.2	477	54	242	0.01	0.0001	0.0001	0.001	0.01	0.2	0.0004	0.0002	0.0005	0.01
MW13-11D	01-Aug-19	6.0	488	68	263	0.01	0.0001	0.0001	0.001	0.01	0.4	0.0004	0.0002	0.0005	0.004
MW13-11D	31-Oct-19	7.0	635	36	250	0.01	0.0002	0.0002	0.002	0.01	0.6	0.0004	0.0002	0.0005	0.2
MW13-13	28-Mar-19	6.9	154	27	62	0.01	0.007	0.0001	0.2	0.01	0.006	0.0025	0.0095	0.0005	2.3
MW13-13	08-May-19	5.6	256	23	142	0.15	0.025	0.0032	0.9	0.02	0.4	0.0098	0.0184	0.0005	7.7
MW13-13	31-Oct-19	6.7	190	15	60	0.06	0.008	0.0008	0.4	0.01	0.1	0.0025	0.0373	0.0005	2.2
MW17-08	28-Mar-19	*7.3*	*510*	59	199	0.02	0.0004	0.0026	0.00077	2.66	1.3	0.0005	0.0002	0.0005	0.4
MW17-08	08-May-19	5.6	393	50	240	0.14	0.0004	0.0024	0.0214	2.54	1.1	0.0005	0.0003	0.0005	0.5
MW17-08	02-Aug-19	6.6	345	56	128	0.01	0.0002	0.0014	0.00084	2.24	1.0	0.0004	0.0002	0.0005	0.3

Note: Italicized pH and EC values are lab results

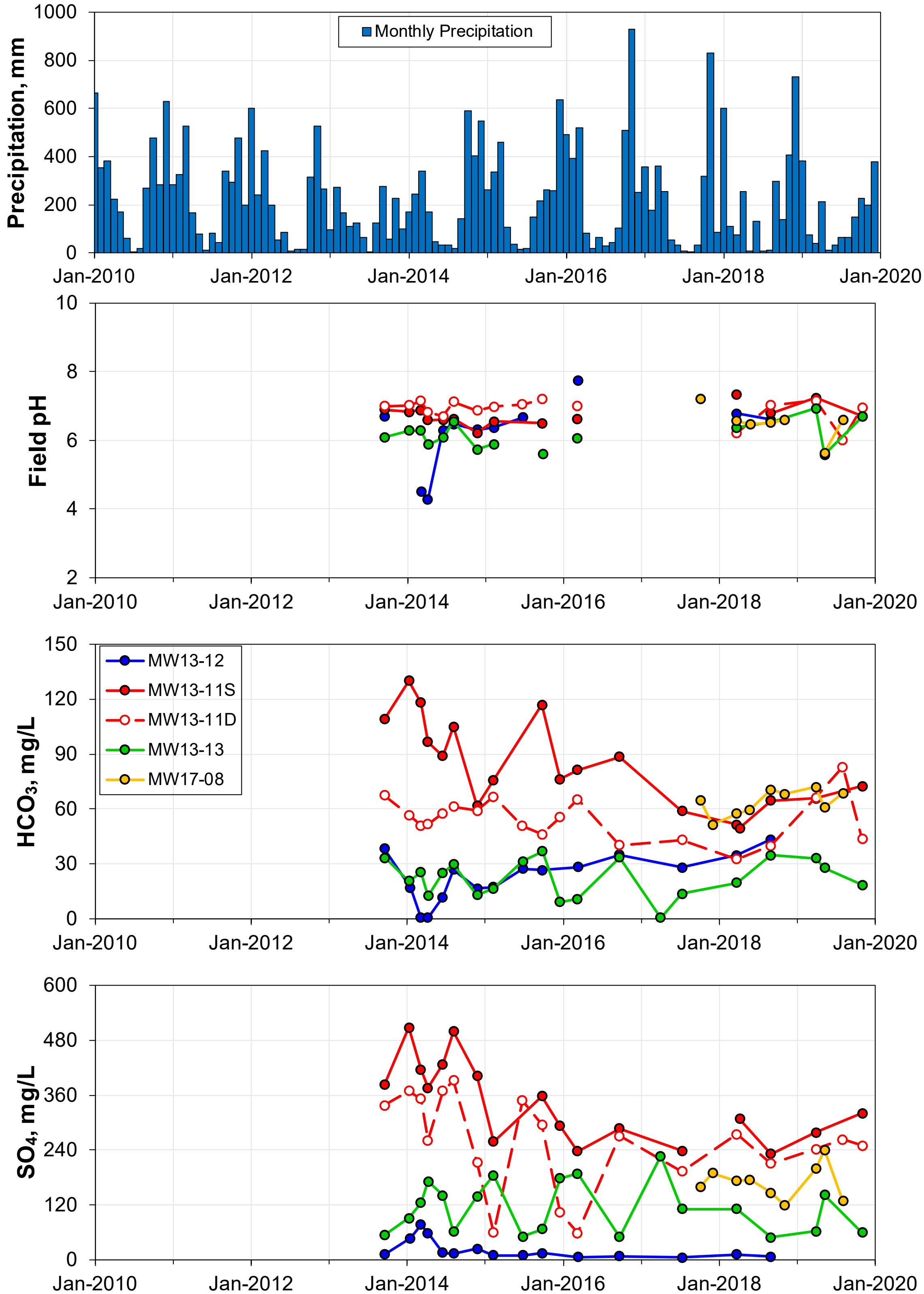


Figure 3-16a. Groundwater Quality Time Trends for Monitoring Wells in Myra Pond/HW Area

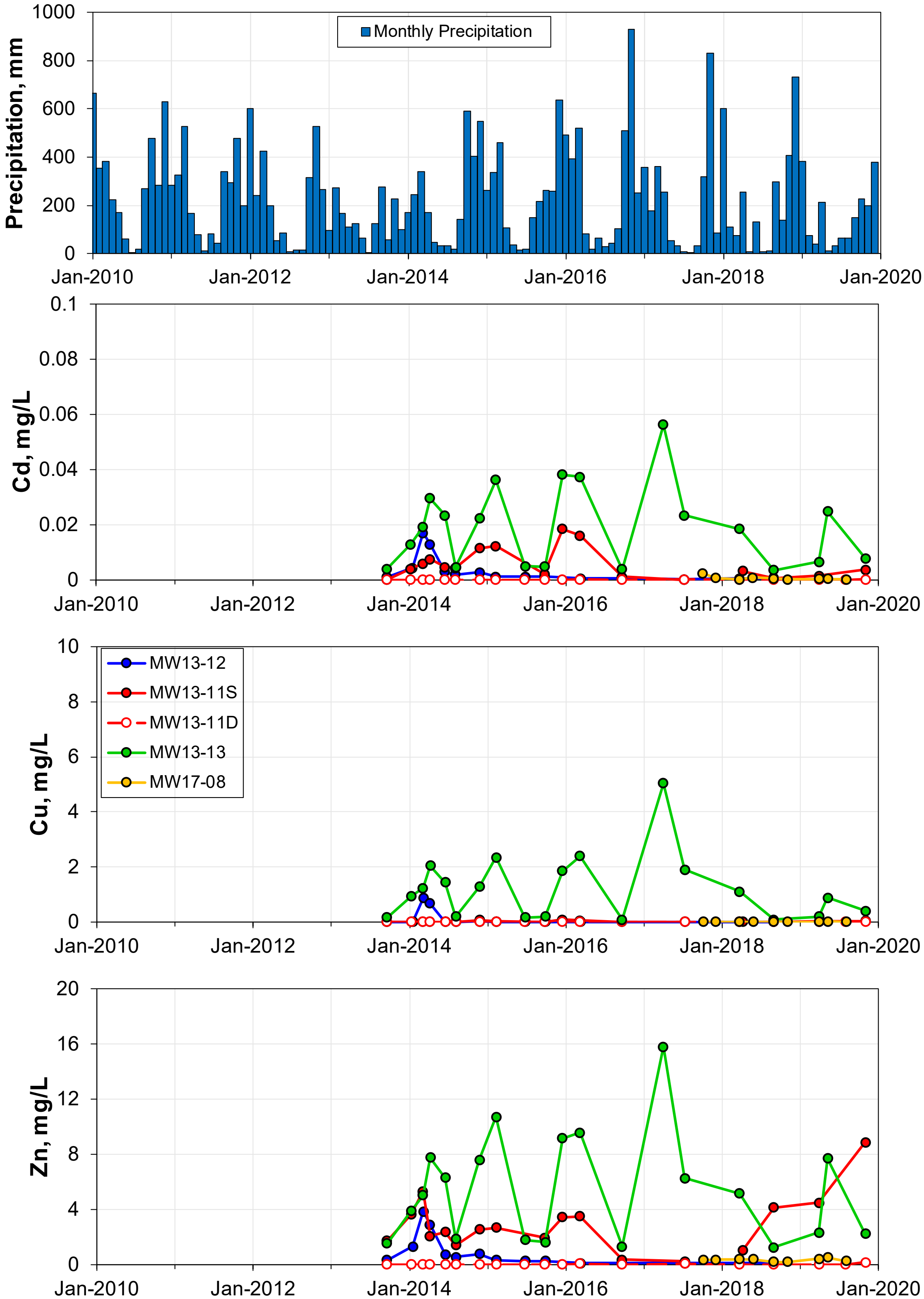


Figure 3-16a. Groundwater Quality Time Trends for Monitoring Wells in Myra Pond/HW Area

3.5.6 *Groundwater Quality – Beneath Old TDF*

Figure 3-17 provides groundwater quality time trends for wells screened in the MVA beneath the Old TDF. Groundwater quality results for 2019 are summarized in **Table 3-15.** Note that several monitoring wells were not sampled in 2019 due to limited lifting capacity of the sampling pump. Key observations are summarized below:

- *TD13-01S (20.1 to 26.2 m bgs, "Tailings – Coarse seam").* Monitoring well TD13-01S is screened in tailings and is dry. Hence no samples have been collected.
- *TD13-01D (36.6 to 44.2 bgs, "Shallow MVA").* Monitoring well TD13-01D screens the MVA beneath the Old TDF, about 50 m south of the Inner Drain. This well is impacted and concentrations vary seasonally in response to metal flushing from the waste rock dumps. Zn, for example, has varied between ~30 mg/L and 60 mg/L. Water quality is expected to improve with ongoing operation of the Phase I Lynx SIS. No samples were collected in 2019.
- *TD13-02S (19.6 to 25.6 m bgs, "Tailings – Coarse seam").* TD13-02S is screened in conventional tailings in the Upper Old TDF Reach. SO_4 is elevated at around 1,400 mg/L but metal concentrations have remained low, e.g. Zn at around 0.04 mg/L. This suggests that tailings are currently not a significant source of ARD/ML to groundwater. No samples were collected in 2019.
- *TD13-02D (35.1 to 38.1 m bgs, "Shallow MVA").* Groundwater from TD13-02D is characterized by elevated SO_4 and metal concentrations. Seasonality is evident with concentrations significantly elevated during winter when loading from the waste rock dumps is increased. This well was not sampled in 2019.
- *TD13-03S (20.4 to 26.4 m bgs, "Tailings – Coarse seam").* TD13-03S is screened in conventional tailings and is dry. This well has not been sampled.
- *TD13-03D (44.5 to 47.6 m bgs, "Shallow MVA").* Monitoring well TD13-03D screens the MVA in the Lower Old TDF Reach. Groundwater at this well is impacted and concentrations vary significantly, for example Zn ranged between 2 mg/L and 37 mg/L. Highest concentrations have been observed in June 2014 and June 2015 suggesting that there may be some dilution with cleaner water from the hillsides during winter when concentrations are lower. No samples were collected in 2019.
- *TD13-04S (26.2 to 29.2 m bgs, "Shallow MVA").* TD13-04S is dry and has not been sampled.
- *TD13-04D (41.4 to 44.5 m bgs, "Shallow MVA").* TD13-04D screens the MVA in the northern part of the Old TDF. Groundwater is highly impacted with elevated SO_4 and Zn up to 110 mg/L. Concentrations appear to be elevated following periods of precipitation resulting in flushing of contaminants from WRD#6 and possibly WRD#1.
- *TD13-05S (20.1 to 23.2 m bgs, "Tailings").* TD13-03S is screened in conventional tailings and is characterized by elevated SO_4 and low metal concentrations. No samples were collected in 2019.

- *TD13-05D (35.1 to 38.1 m bgs, "Shallow MVA").* Monitoring well TD13-05D is at the downstream end of the Old TDF upgradient of the New Outer Drain. Metal concentrations are elevated and vary significantly, with highest concentrations observed in late spring/summer. This is likely a delayed response to seasonal contaminant flushing from the waste rock dumps.
- *MW11-05S (5.4 to 10.1 m bgs, "Tailings").* Groundwater from MW11-05S is characteristic of tailings pore water collected from other monitoring wells screened in tailings within the Old TDF. No samples were collected in 2019.
- *MW11-05D (40.2 to 42.1 m bgs, "MVA").* MW11-05D is screened in the MVA north of TD13-05. Zn concentrations vary significantly, between around 0.3 mg/L and 30 mg/L and a seasonal pattern that is similar to TD13-05D is observed. No samples were collected in 2019.

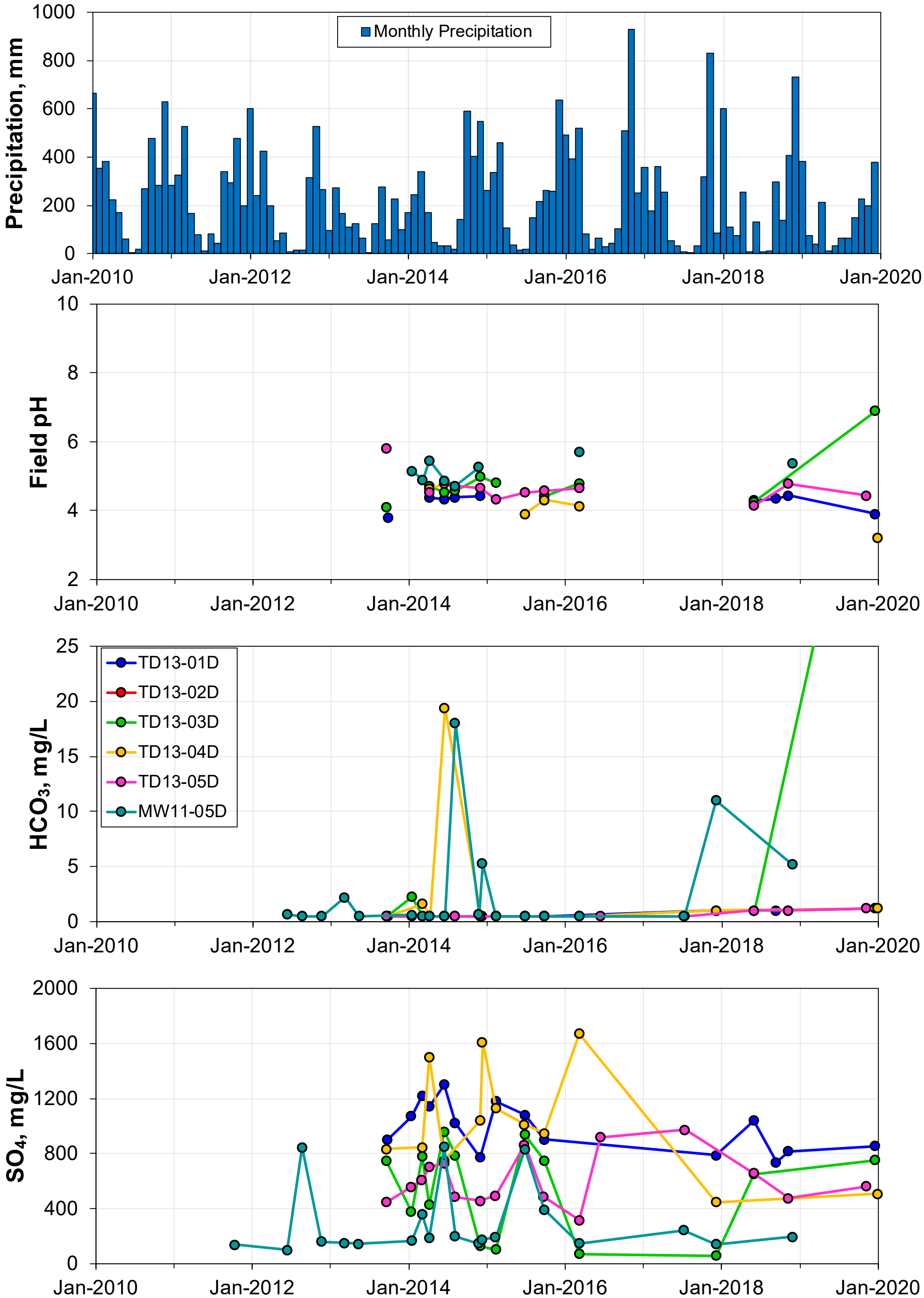


Figure 3-17a. Groundwater Quality Time Trends for Wells Beneath the Old TDF

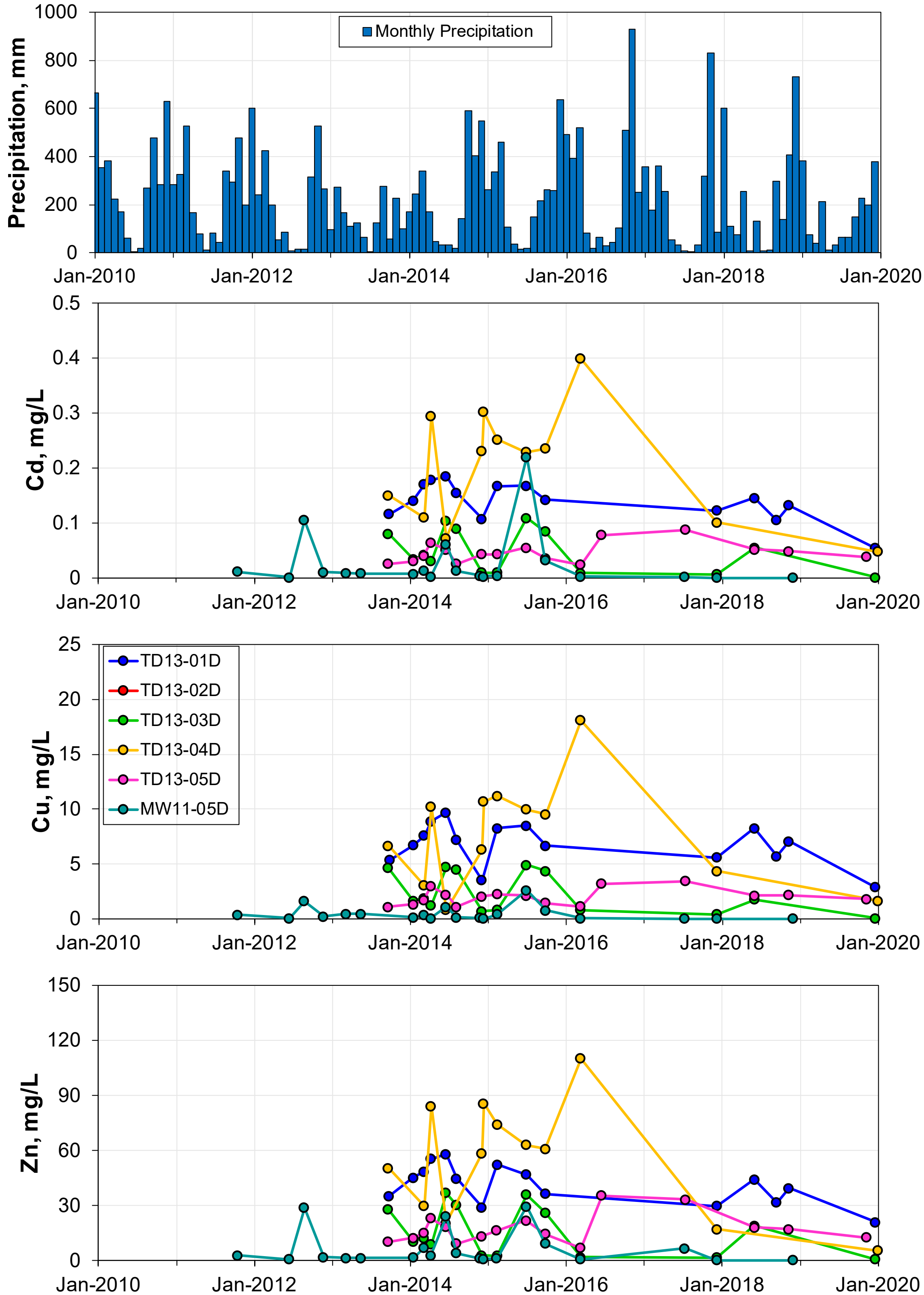


Figure 3-17b. Groundwater Quality Time Trends for Wells Beneath the Old TDF

Table 3-15.

Groundwater Quality Results for Wells Beneath Old TDF, 2019

Well ID	Sample Date	pH	EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
TD13-01D	20-Dec-19	*3.9*	*1210*	1	855	10.3	0.05	0.02	2.9	0.1	3.9	0.04	0.003	0.0005	20.9
TD13-02D	20-Dec-19	*3.6*	*759*	1	600	2.69	0.02	0.01	0.7	1.39	2.2	0.02	0.002	0.0005	8.2
TD13-03D	20-Dec-19	*6.9*	*1400*	41	752	0	0.0006	0.003	0.059	0	1.4	0.00	0.000	0.0005	0.8
TD13-04D	30-Dec-19	*3.2*	*569*	1	507	6.86	0.05	0.015	1.7	3.52	1	0.02	0.001	0.0005	5.6
TD13-05D	07-Nov-19	4.4	856	1	562	7.7	0.04	0.03	1.8	0.07	3.8	0.03	0.001	0.0005	12.6

Note: Italicized pH and EC values are lab results

3.5.7 *Groundwater Quality – Lower Old TDF Reach Near Myra Creek and Outer Drains*

Figure 3-18 provides groundwater quality time trends for well screened in the MVA near the Old Outer Drains and NOD near Myra Creek. Quarterly sampling of most of these wells (all except MW-B, MW-E, and MW-G) is required by Permit M-26 (see **Table 3-11**). Groundwater quality results for 2019 are summarized in **Table 3-16**. Key observations are summarized below:

- *MW13-14S (8.0 to 11.0 m bgs, "Shallow MVA").* This well is between the Medium Drain segment of the NOD and Myra Creek. In 2019, groundwater was characterized by elevated SO_4 of 65 mg/L to 207 mg/L and Zn concentrations of up to 4.6 mg/L. This suggests some impacted groundwater is occasionally bypassing the Medium Drain; however, no trend is apparent in 2019.
- *MW13-14D (14.7 to 17.7 m bgs, "Shallow MVA").* Groundwater from this well is characterized by up to 5.0 mg/L Zn and 274 mg/L SO_4 in 2019. This is comparable to concentrations in the shallower MVA at this location suggesting similar bypass.
- *MW13-15S (9.5 to 12.5 m bgs, "Shallow MVA").* Groundwater from this well (screened between Myra Creek and the downstream end of the Medium Drain) is characterized by Zn concentrations of up to 0.9 mg/L Zn, which suggests the Medium Drain is performing well at this location and/or some dilution from the creek is occurring. There is no noticeable trend in 2019.
- *MW13-15D (16.2 to 19.2 m bgs, "Shallow MVA").* Groundwater is characterized by lower Zn concentrations than in the shallower MVA, suggesting only minor bypass.
- *MW-D (6.1 to 7.6 m bgs, "Shallow MVA").* Monitoring well MW-D is screened upgradient of the NOD and represents highly impacted groundwater discharging to and being captured by the Outer Drain system. Zn concentrations are variable ranging from several mg/L to 25 mg/L with an average of 14.8 mg/L. In 2019, Zn ranged between 8.6 mg/L and 13.0 mg/L and no trend is evident.
- *MW-A (11.6 to 13.1 m bgs, "Shallow MVA").* Monitoring well MW-A is a deeper piezometer next to MW-D (upgradient of the NOD) and samples are also characteristic of the highly impacted

groundwater discharging to the NOD system. Metal and SO_4 concentrations are similar to the shallow piezometer MW-D with no apparent trend in 2019.

- *MW-C (11.6 to 13.1 m bgs, "Shallow MVA").* Monitoring well MW-C is screened downgradient of MW-A and the NOD, between the NOD and Myra Creek. MW-F is the corresponding shallow piezometer (see below) and these wells monitor seepage bypassing the NOD. Zn in the deep piezometer MW-C is generally higher than at MW-F suggesting that seepage is bypassing the NOD at greater depth at this location. Highest concentrations (5.8 mg/L Zn) were observed in March of 2019 but no trend is apparent.
- *MW-F (4.3 to 5.8 m bgs, "Shallow MVA").* Zn concentrations at MW-F have varied between 0.2 mg/L and 3.9 mg/L suggesting occasional bypass. Zn was elevated (3.2 mg/L) in December 2019 indicating some bypass.
- *MW-B (11.6 to 13.1 m bgs, "Shallow MVA").* MW-B is located between MW-A and MW-C, creek-side of the NOD. It is not routinely monitored, and no water quality data are available.
- *MW-E (4.3 to 5.8 m bgs, "Shallow MVA").* MW-E is located between MW-D and MW-F, creek-side of the NOD. It is not routinely monitored, and no water quality data are available.

It should be noted that the system of outer drains in the Lower Old TDF Reach appears to be very effective in preventing discharge of impacted groundwater to Myra Creek despite elevated metals concentrations observed at several creek-side wells. Routine water quality sampling in Myra Creek shows mostly stable concentrations along the NOD suggesting only small loading to Myra Creek in that reach. Hydraulic testing of the NOD (RGC, 2016) has further shown that hydraulic gradients are usually directed towards the drain meaning that creek water is discharging towards the drain rather than groundwater discharging to Myra Creek.

The Phase I Lynx SIS operates upgradient of the Old TDF under-drains so some interference between the two components of the site-wide SIS is expected. **Figure 3-19** compares the combined pumping rate from the Phase I Lynx SIS pumping wells with pumping rates recorded at Pumphouse No. 4. The Phase I Lynx SIS and Pumphouse No. 4 pumping rates show similar seasonal patterns, responding to rainfall with an increase in pumping rates followed by a gradual decrease. Operating the Phase I Lynx SIS has had no noticeable effects on Pumphouse #4 pumping rates. During the extended shutdowns of the Phase I Lynx SIS, pumping rates at Pumphouse No. 4 also remained unaffected. The inferred flow field downgradient of the RSA remains unchanged despite pumping and the observed drawdown is limited. This suggests that the groundwater extracted by Phase I is replaced with recharge from Myra Creek and/or additional groundwater inflow.

Since October 2017, the Phase I Lynx SIS has extracted a zinc load of 85.2 tonnes compared to 99.1 tonnes of zinc captured by the system of underdrains in the Old TDF reach over the same period. The significant load extracted by the Phase I Lynx SIS is expected to eventually reduce loading to the system of outer drains and possibly Myra Creek (see RGC, 2018). Zn concentrations in groundwater reporting to the Old TDF under-drains have so far remained stable since the start of operation of the Phase I Lynx SIS (see **Figure 3-20**). A potential decrease in metal loading at Pumphouse No. 4 is not expected to occur before early 2020 based on travel time estimates and numerical groundwater modeling assuming continuous operation of the Phase I Lynx SIS (RGC, 2018a).

Table 3-16.

Groundwater Quality Results for Wells Near Myra Creek and Outer Drains, 2019

Well ID	Sample Date	pH	EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW13-14S	31-Jan-19	4.7	329	-	207	1.2	0.010	0.012	0.4	0.026	1.3	0.010	0.0002	0.0005	4.6
MW13-14S	06-May-19	6.4	173	9	79	0.05	0.002	0.003	0.05	0.01	0.3	0.004	0.0002	0.0005	1.4
MW13-14S	08-Aug-19	6.1	169	8	65	0.03	0.001	0.001	0.03	0.01	0.1	0.002	0.0002	0.0005	0.6
MW13-14S	31-Oct-19	6.5	348	8	126	0.3	0.006	0.007	0.2	0.01	0.8	0.006	0.0002	0.0005	2.7
MW13-14D	31-Jan-19	6.0	165	-	113	0.6	0.008	0.011	0.3	0.01	1.1	0.008	0.0002	0.0005	3.5
MW13-14D	06-May-19	6.1	266	6	135	0.8	0.009	0.012	0.4	0.01	1.2	0.009	0.0005	0.0005	4.0
MW13-14D	08-Aug-19	5.4	317	7	159	0.7	0.007	0.010	0.3	0.01	1.0	0.008	0.0002	0.0005	2.8
MW13-14D	22-Nov-19	5.6	413	7	274	1.4	0.013	0.019	0.5	0.038	2.0	0.014	0.0003	0.0005	5.0
MW13-15S	16-Aug-19	7.5	150	29	44	0.01	0.0001	0.0001	0.001	0.01	0.00119	0.0004	0.0002	0.0005	0.03
MW13-15S	15-Nov-19	7.8	146	23	50	0.02	0.0002	0.0001	0.004	0.01	0.00271	0.0005	0.0002	0.0005	0.1
MW13-15D	16-Aug-19	7.3	264	96	76	0.005	0.0000	0.0001	0.001	0.01	0.00043	0.0004	0.0002	0.0019	0.004
MW13-15D	15-Nov-19	7.5	250	68	76	0.0072	0.0001	0.0001	0.002	0.01	0.00115	0.0004	0.0002	0.0016	0.028
MW-A	08-Mar-19	4.7	425	1	230	2.2	0.016	0.015	0.8	0.078	1.7	0.014	0.0002	0.0005	7.1
MW-A	26-Jun-19	5.1	646	1	447	4.3	0.027	0.025	1.2	0.015	3.3	0.025	0.0002	0.0005	10.1
MW-A	26-Sep-19	4.5	739	1	458	5.5	0.033	0.032	1.5	0.017	4.1	0.033	0.0009	0.0014	12.2
MW-A	19-Dec-19	*4.4*	*743*	1	669	5.1	0.032	0.030	1.4	0.01	3.8	0.030	0.0002	0.0005	14.0
MW-C	08-Mar-19	*4.8*	*397*	1	250	1.4	0.014	0.010	0.6	0.01	1.2	0.012	0.0004	0.0005	5.8
MW-C	26-Mar-19	7.5	767	31	442	0.1	0.003	0.004	0.07	5.8	4.7	0.004	0.0002	0.0005	1.6
MW-C	09-May-19	6.2	726	29	419	0.2	0.005	0.006	0.1	5.5	5.0	0.006	0.0009	0.0005	2.5
MW-C	08-Aug-19	5.9	826	27	490	0.4	0.007	0.009	0.2	5.3	4.9	0.009	0.0002	0.0005	3.0
MW-C	29-Nov-19	5.7	955	33	474	0.2	0.005	0.007	0.08	5.4	4.9	0.007	0.0002	0.0005	2.7
MW-D	26-Jun-19	4.9	648	1	474	4.7	0.029	0.024	1.3	0.01	3.5	0.027	0.0002	0.0005	10.8
MW-D	26-Sep-19	4.4	738	1	454	5.8	0.035	0.030	1.5	0.014	4.0	0.034	0.0007	0.0011	13.0
MW-D	29-Nov-19	5.2	624	1	346	3.3	0.019	0.014	0.9	0.01	2.0	0.018	0.0002	0.0005	8.6
MW-F	26-Mar-19	8.1	222	8	18	0.04	0.001	0.000	0.007	0.069	0.00888	0.001	0.0006	0.0005	0.2
MW-F	09-May-19	6.3	99	11	17	0.5	0.002	0.001	0.10	1.4	0.8	0.002	0.0054	0.0005	0.5
MW-F	18-Dec-19	5.9	34	18	37	1.2	0.007	0.005	0.3	0.01	0.7	0.007	0.0002	0.0005	3.2

Note: Italicized pH and EC values are lab results

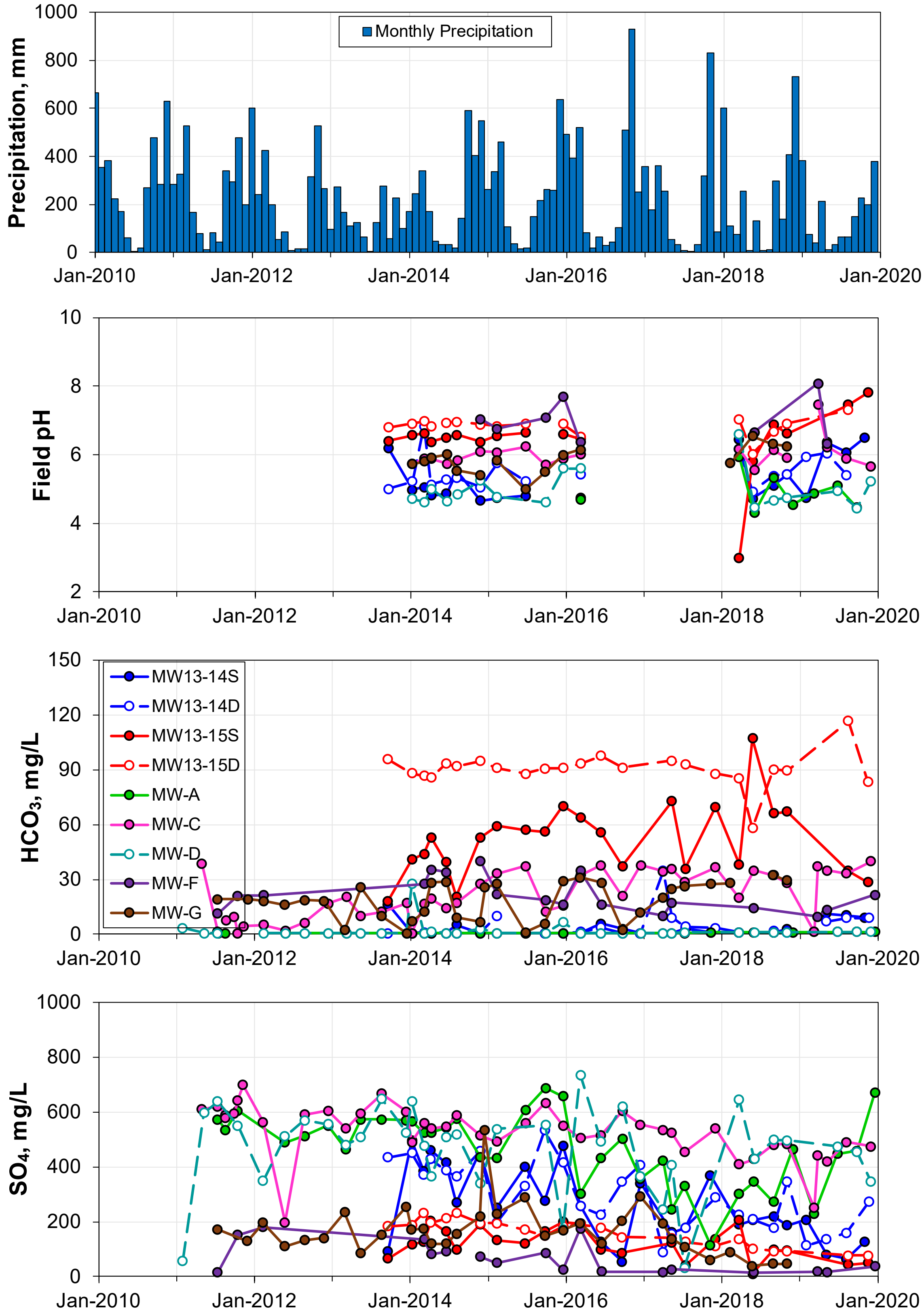


Figure 3-18a. Groundwater Quality Time Trends for Wells near Old Outer Drains and NOD

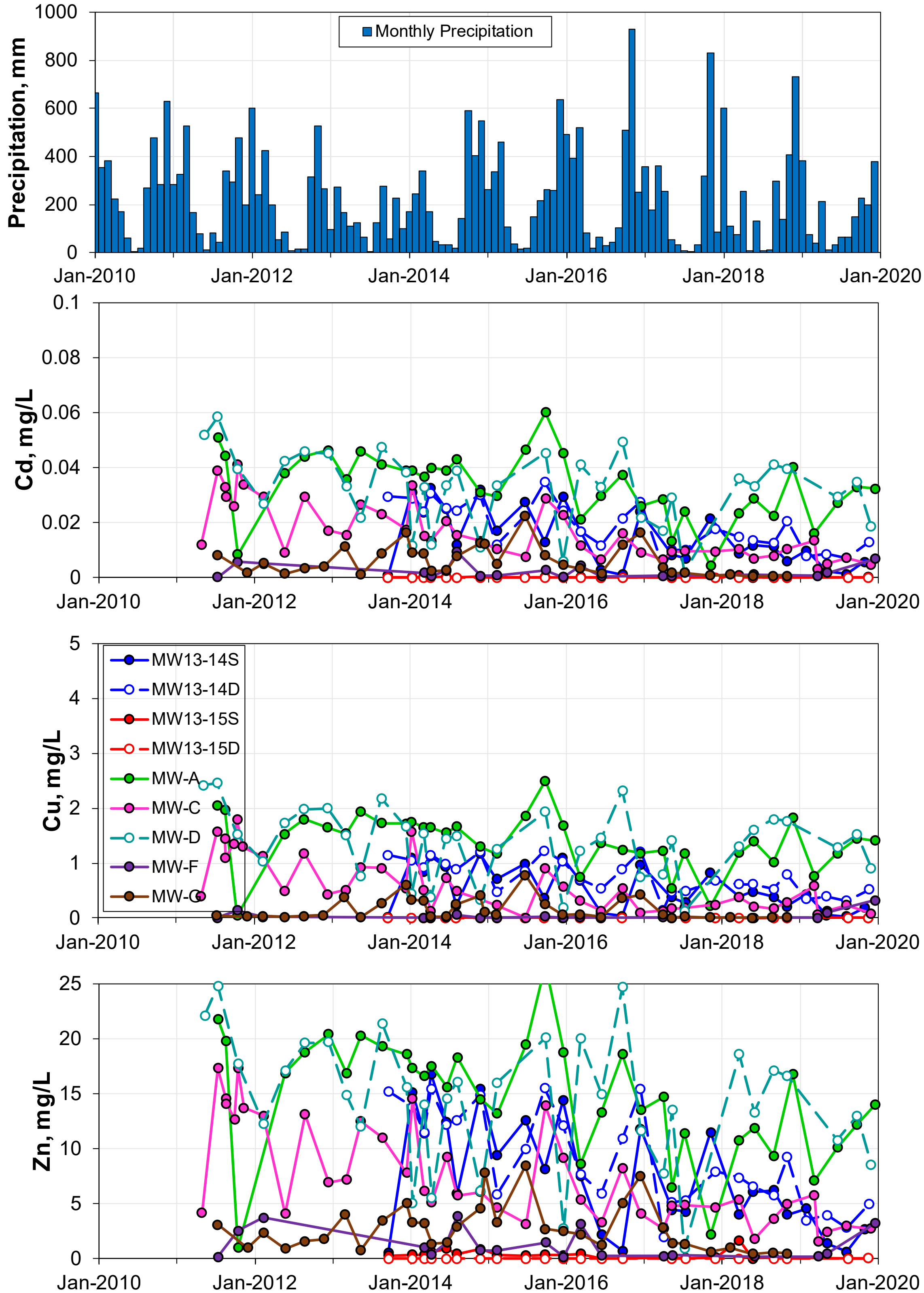


Figure 3-18b. Groundwater Quality Time Trends for Wells near Old Outer Drains and NOD

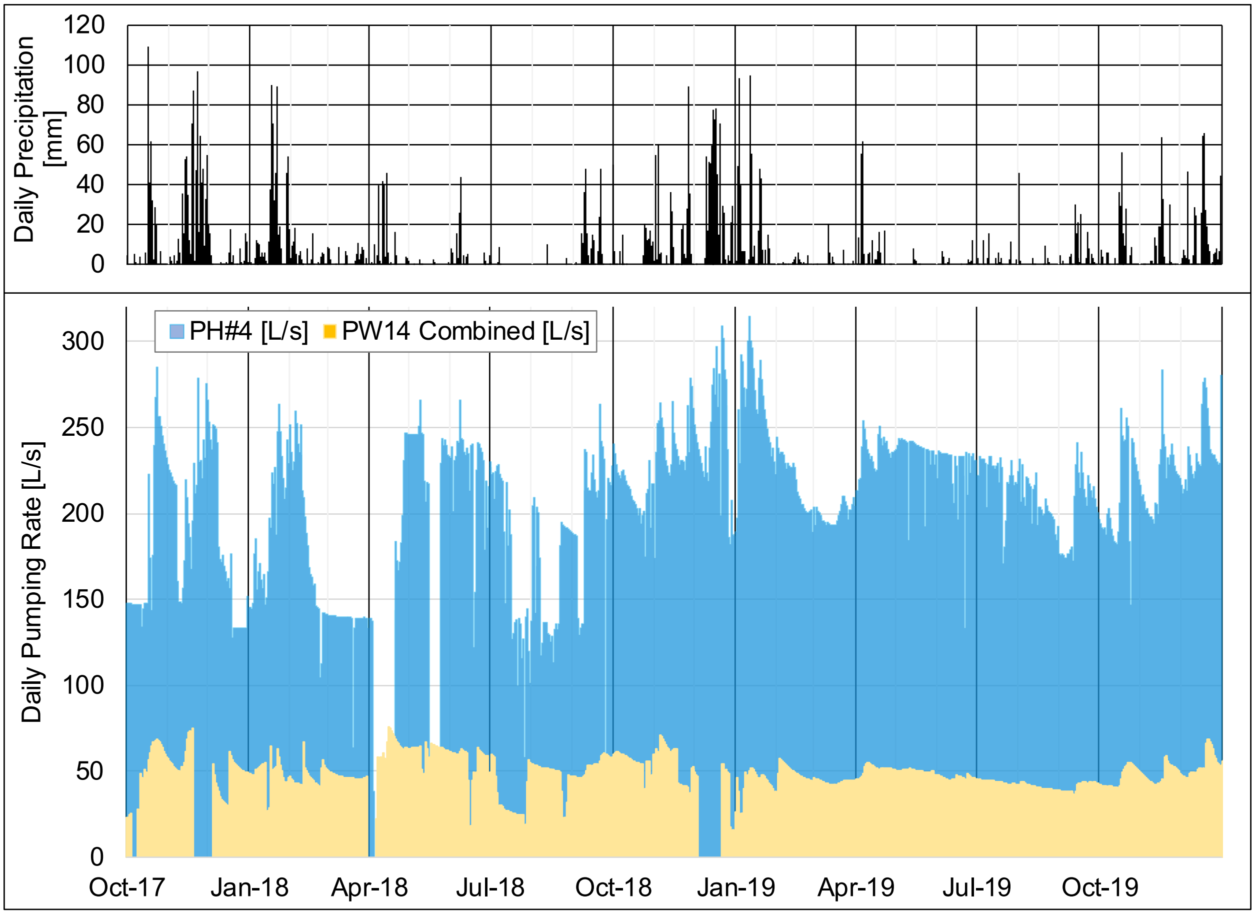


Figure 3-19. Observed Pumping Rate of Phase I Lynx SIS and Pumphouse No.4

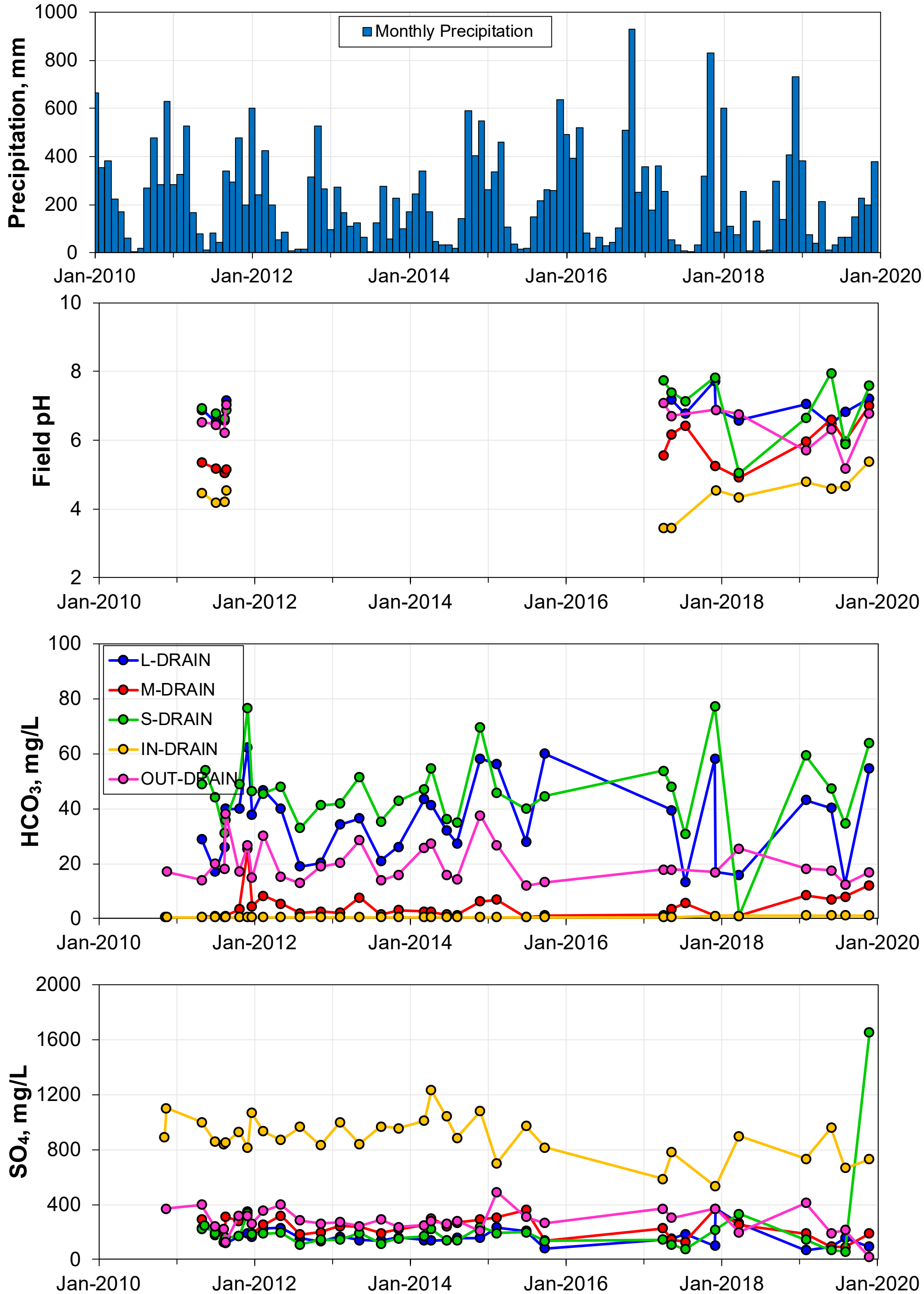


Figure 3-20a. Groundwater Quality Time Trends for Old TDF Under-Drains

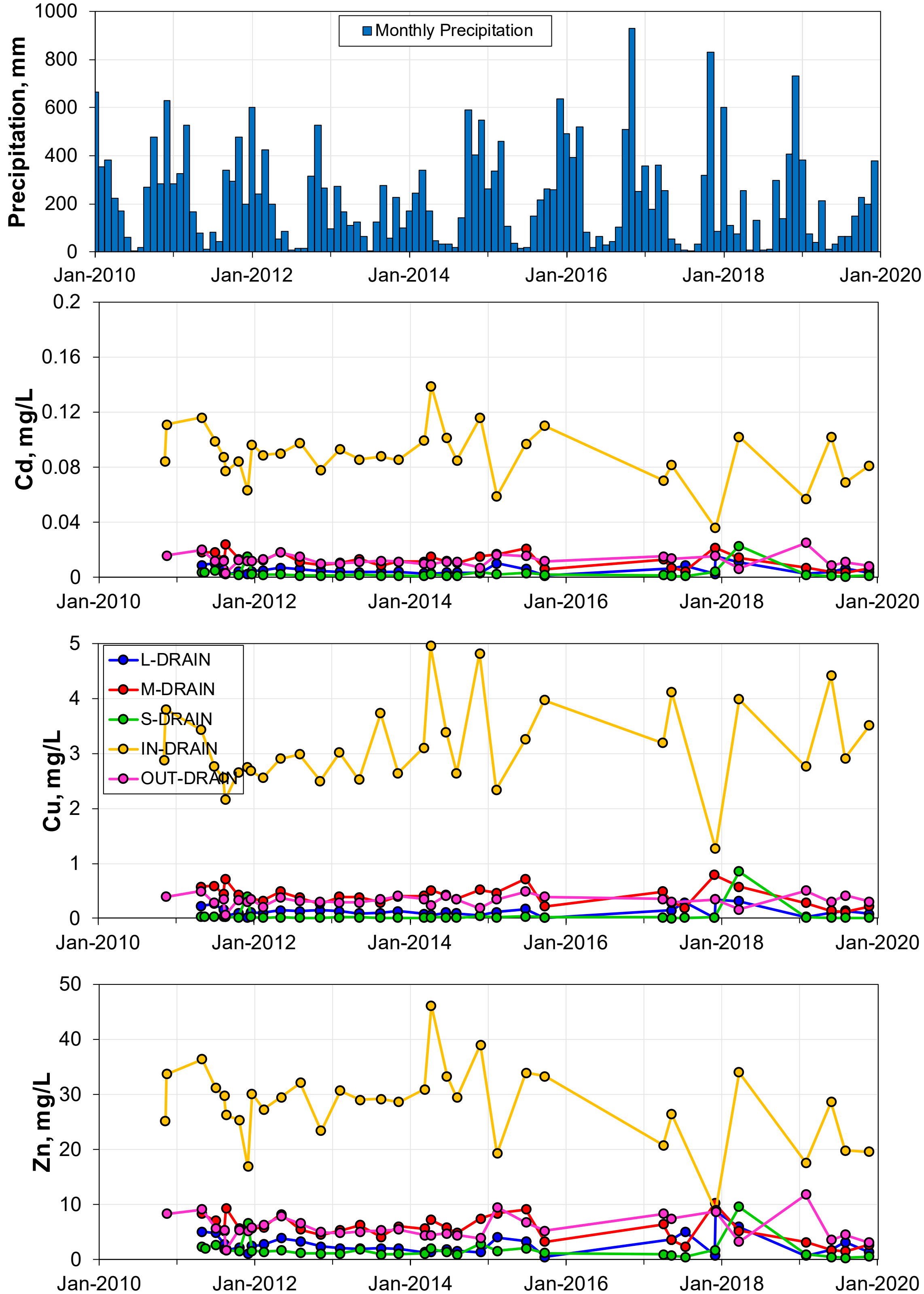


Figure 3-20b. Groundwater Quality Time Trends for Old TDF Under-Drains

3.5.8 *Seepage Conditions near APA and LLDD*

Near the Amalgamated Paste Area (APA), the "APA seeps" and several springs were known to express during the high rainfall periods, including the Main Spring and the Pumphouse Seeps near the northeastern abutment of the Old TDF. A hydrogeological investigation was completed in 2015 to determine seepage patterns and support the upgrade of the LLDD project (RGC, 2016). Most of the monitoring wells installed (MW15 series) were destroyed during the upgrade of the LLDD and have only been sampled between 2015 and 2017. Flows from the Main Spring are currently collected by the DDSD and monitored routinely for Permit PE-6858 (see Section 4).

3.6 GROUNDWATER QUALITY – DOWNSTREAM REACH

3.6.1 *Monitoring Wells*

Groundwater monitoring wells in the Downstream Reach were installed in 2013 as part of a site-wide hydrogeological field investigation and in 2017 to augment the existing well network and characterize groundwater conditions further downgradient towards Buttle Lake. Construction details for monitoring wells in the Downstream Reach are summarized in **Table 3-17.**

Table 3-17.

Groundwater Monitoring Wells in Downstream Reach

Well ID	Installation Date	Depth Drilled, m bgs	Screening Interval, m bgs		Screened Material	Monitoring Status (Water Quality)	Obligation
			top	bottom			
Near Myra Creek							
MW13-16S	28-Jul-13	20.0	11.0	14.0	Gravel with sand	Quarterly	Voluntary
MW13-16D	28-Jul-13	17.0	17.1	20.1	Gravel with sand	Quarterly	Voluntary
MW13-17	28-Jul-13	8.6	5.5	8.5	Gravel and sand	Quarterly	Voluntary
MW13-18S	31-Jul-13	23.1	9.1	13.7	Gravel and sand	Quarterly	Voluntary
MW13-18D	31-Jul-13	20.1	20.1	23.2	Gravel and sand	Quarterly	Voluntary
MW17-9	25-Sep-17	14.63	10.7	12.2	Bedrock	Not routinely monitored	-
MW13-10S	7-Aug-13	59.7	35.4	41.4	Gravel with sand	Not routinely monitored	-
MW13-10D	7-Aug-13	55.5	55.5	58.5	Bedrock	Not routinely monitored	-
Towards Buttle Lake							
MW17-10S	1-Oct-17	21.95	9.4	11.0	Gravel with silt	Nor routinely monitored	-
MW17-10D	1-Oct-17	21.95	18.3	21.3	Bedrock	Nor routinely monitored	-
MW17-11S	29-Sep-17	19.20	12.2	13.7	Sand	Not routinely monitored	-
MW17-11D	29-Sep-17	19.20	15.5	18.6	Bedrock	Not routinely monitored	-
MW17-13S	3-Oct-17	35.05	15.8	17.4	Sand	Not routinely monitored	-
MW17-13D	27-Sep-17	18.29	29.0	30.5	Gravel with silt	Not routinely monitored	-
MW17-14S	2-Oct-17	30.48	13.7	15.2	Gravel with silt	Not routinely monitored	-
MW17-14D	2-Oct-17	30.48	23.8	25.3	Sand with gravel	Not routinely monitored	-
MW17-15S	30-Sep-17	18.90	9.1	10.7	Gravel with sand	Not routinely monitored	-
MW17-15D	30-Sep-17	18.90	15.2	18.3	Bedrock	Not routinely monitored	-

3.6.2 *Local Groundwater Flow Field*

The groundwater flow direction immediately downgradient of the Old TDF is generally from west to east towards Buttle Lake. However, further downgradient groundwater levels on the north side (at MW17-15S/D) are about 2.5m higher than on the south side (at MW17-14S/D) indicating a more southerly flow direction, possibly due to the presence of more transmissive sediments on the south side.

3.6.3 *Groundwater Quality – Near Myra Creek*

Figure 3-21 provides groundwater quality time trends for well screened in the MVA or bedrock in the Downstream Reach near Myra Creek. Groundwater quality results for 2019 are provided in **Table 3-18**. Key observations are summarized below:

- *MW13-16S (11.0 to 14.0 m bgs, "Shallow MVA").* Monitoring well MW13-16S screens the sediment aquifer downgradient of the NOD, south of Myra Creek. In 2019, SO_4 has been low (< 40 mg/L) and Zn concentrations have remained below 0.3 mg/L further confirming that the SIS measures effectively prevent contaminated groundwater from migrating off site. There is no apparent trend evident in 2019 for MW13-16S.
- *MW13-16D (17.1 to 20.1 m bgs, "Bedrock").* MW13-16D is screened in bedrock and remains unimpacted with SO4 below 45 mg/L and a maximum Zn of 0.022 mg/L in 2019. There is no apparent trend evident in 2019 for MW13-16D.
- *MW13-17 (5.5 to 8.5 m bgs, "Shallow MVA").* MW13-17 is at the downstream end of the site, near Pumphouse #4. Zn concentrations have remained below 0.1 mg/L and show a seasonal behaviour with higher concentrations in the winter. No longer-term trend is noticeable.
- *MW13-18S (9.1 to 13.7 m bgs, "Shallow MVA").* Monitoring well MW13-18S is located at the downstream end of the site south of Myra Creek. SO_4 and metal concentrations have remained low in 2019 with no seasonal behaviour. This reflects relatively unimpacted conditions.
- *MW13-18D (20.1 to 23.2 m bgs, "Deep MVA").* Lower concentrations are observed at the deep piezometer and this well remains unimpacted with no apparent trend.
- *MW17-09 (10.7 to 12.2 m bgs, "Shallow MVA").* Monitoring well MW17-09 is at the downstream end of the site at the toe of the northern hillside. MW17-09 is characterized by low SO_4 and metals concentrations. This well was not sampled in 2019.
- *MW17-10S (9.4 to 11.0 m bgs, "MVA").* Monitoring well MW17-10S is south of Myra Creek at the downstream end of the site. This well has only been sampled in 2017 with SO_4 of 149 mg/L and Zn of 0.01 mg/L suggesting no offsite migration of impacted groundwater.
- *MW17-10D (18.3 to 21.3 m bgs, "Bedrock").* Monitoring well MW17-10D is screened in bedrock and has not been sampled since 2018.Samples collected in 2017 and 2018 showed average SO_4 concentrations of 210 mg/L and low Zn of ~0.04 mg/L.

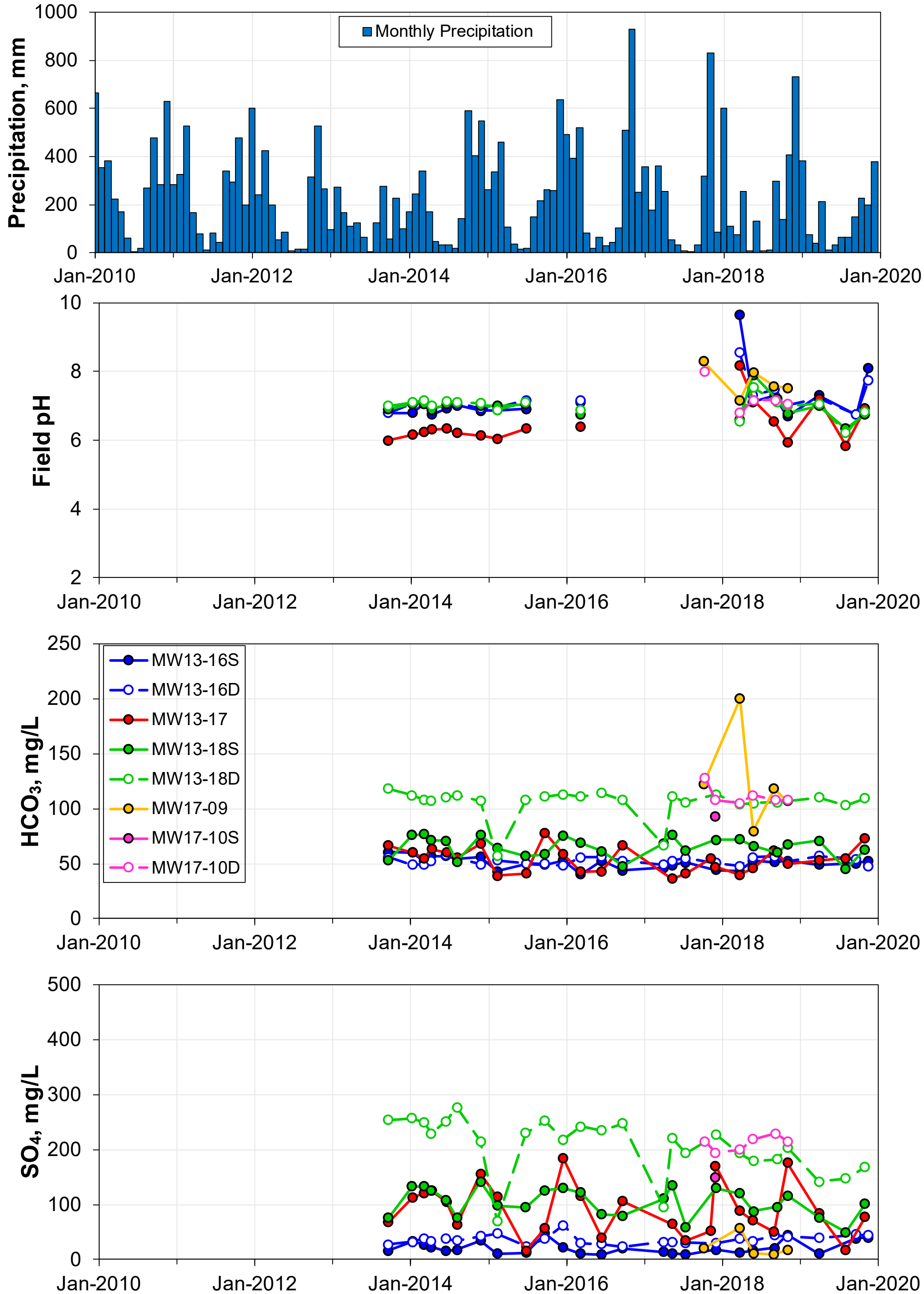


Figure 3-21a. Groundwater Quality Time Trends for Wells in Downstream Reach near Myra Creek

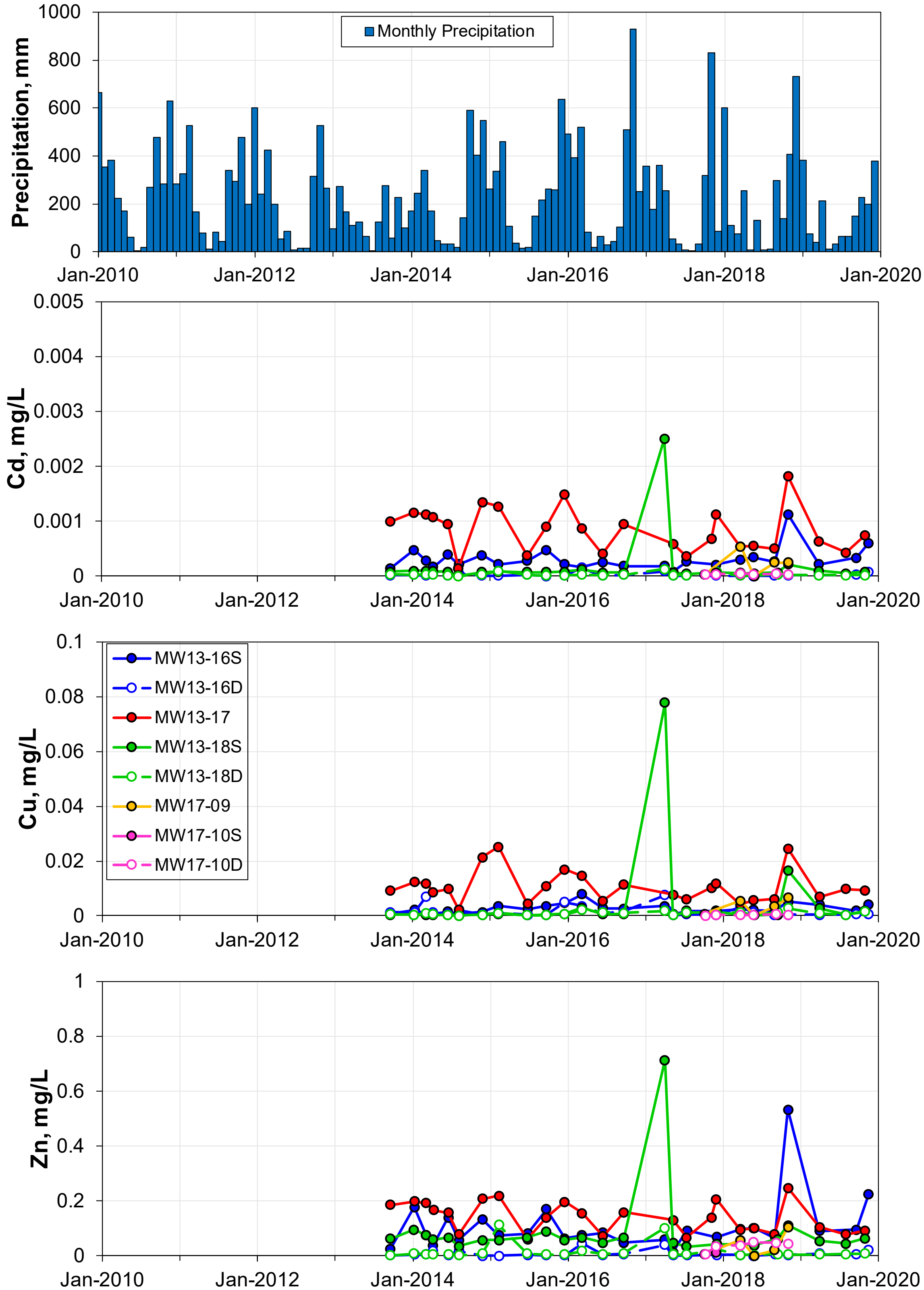


Figure 3-21b. Groundwater Quality Time Trends for Wells in Downstream Reach near Myra Creek

Table 3-18

Groundwater Quality Results for Wells in Downstream Reach, 2019

Station	Sample Date	pH	EC, µS/cm	Alkalinity, mg/L as CaCO3	SO_4, mg/L	Al-d, mg/L	Cd-d, mg/L	Co-d, mg/L	Cu-d, mg/L	Fe-d, mg/L	Mn-d, mg/L	Ni-d, mg/L	Pb-d, mg/L	Se-d, mg/L	Zn-d, mg/L
MW13-16S	28-Mar-19	*7.3*	*110*	40	11	0.112	0.0002	0.0002	0.004	0.166	0.009	0.002	0.0003	0.0005	0.090
MW13-16S	19-Sep-19	*6.7*	*110*	41	39	0.005	0.0003	0.0001	0.002	0.011	0.001	0.001	0.0002	0.0005	0.096
MW13-16S	15-Nov-19	*8.1*	*150*	43	40	0.010	0.0006	0.0001	0.004	0.017	0.003	0.004	0.0003	0.0005	0.2
MW13-16D	28-Mar-19	*7.2*	*142*	47	39	0.005	0.00002	0.0001	0.000	0.01	0.001	0.0004	0.0002	0.0005	0.008
MW13-16D	19-Sep-19	*6.7*	*136*	44	45	0.005	0.00003	0.0001	0.001	0.01	0.000	0.0004	0.0002	0.0005	0.005
MW13-16D	15-Nov-19	*7.8*	*148*	39	44	0.005	0.0001	0.0001	0.001	0.01	0.001	0.001	0.0002	0.0005	0.022
MW13-17	28-Mar-19	*7.2*	*193*	43	84	0.006	0.0006	0.0001	0.007	0.01	0.001	0.0004	0.0002	0.0005	0.1
MW13-17	01-Aug-19	*5.8*	*118*	45	17	0.008	0.0004	0.0001	0.010	0.01	0.010	0.0004	0.0002	0.0005	0.078
MW13-17	31-Oct-19	*6.9*	*281*	60	77	0.007	0.0007	0.0001	0.009	0.01	0.001	0.0004	0.0005	0.0005	0.092
MW13-18S	28-Mar-19	*7.0*	*376*	58	77	0.005	0.0001	0.0001	0.003	0.01	0.0004	0.0004	0.0005	0.0006	0.054
MW13-18S	01-Aug-19	*6.3*	*150*	37	50	0.005	0.00005	0.0001	0.000	0.01	0.0002	0.0004	0.0002	0.0005	0.045
MW13-18S	31-Oct-19	*6.8*	*343*	52	101	0.005	0.0001	0.0001	0.002	0.01	0.0002	0.0004	0.0005	0.0005	0.064
MW13-18D	28-Mar-19	*7.1*	*221*	90	142	0.005	0.00002	0.0001	0.001	0.01	0.0004	0.0004	0.0002	0.0018	0.005
MW13-18D	01-Aug-19	*6.2*	*359*	84	147	0.005	0.00001	0.0001	0.000	0.01	0.0002	0.0004	0.0002	0.0052	0.006
MW13-18D	31-Oct-19	*6.8*	*532*	90	168	0.005	0.00002	0.0001	0.002	0.015	0.001	0.001	0.0005	0.0013	0.008

Note: Italicized pH and EC values are lab results

3.6.4 *Groundwater Quality – Towards Buttle Lake*

Figure 3-22 provides groundwater quality time trends for well screened in the MVA or bedrock in the Downstream Reach towards Buttle Lake. These wells were installed as part of a hydrogeological field investigation of a Cross Valley Dam embankment dam that was proposed as an alternative closure scenario for the site (see RGC, 2014).

Groundwater quality from most of the monitoring wells is unimpacted by ARD and none are routinely monitored. Wells MW17-13S and MW17-13D (both screened in the deep MVA) are the exceptions, as groundwater from both wells was characterized by elevated concentrations of SO_4 and most metals when they were last sampled in 2018. Groundwater was also acidic in the shallow piezometer, i.e. pH < 4. Note that the deep well could not be sampled by Nyrstar staff due to the high sediment content. It was subsequently sampled by RGC staff during a site visit in April 2018 using waterra tubing and a hydrolift. Pumped groundwater was initially high in sediments and field EC was elevated and pH low. The well was developed until parameters had stabilized and pumped water was clear. Zn in MW17-13D was 1.5 mg/L. The elevated metal concentrations might be caused by a very localized source and the well may not have been purging adequately prior to sampling. This well should be sampled at least twice in 2020 to confirm the elevated concentrations observed in 2018. Close attention should be paid to field parameters.

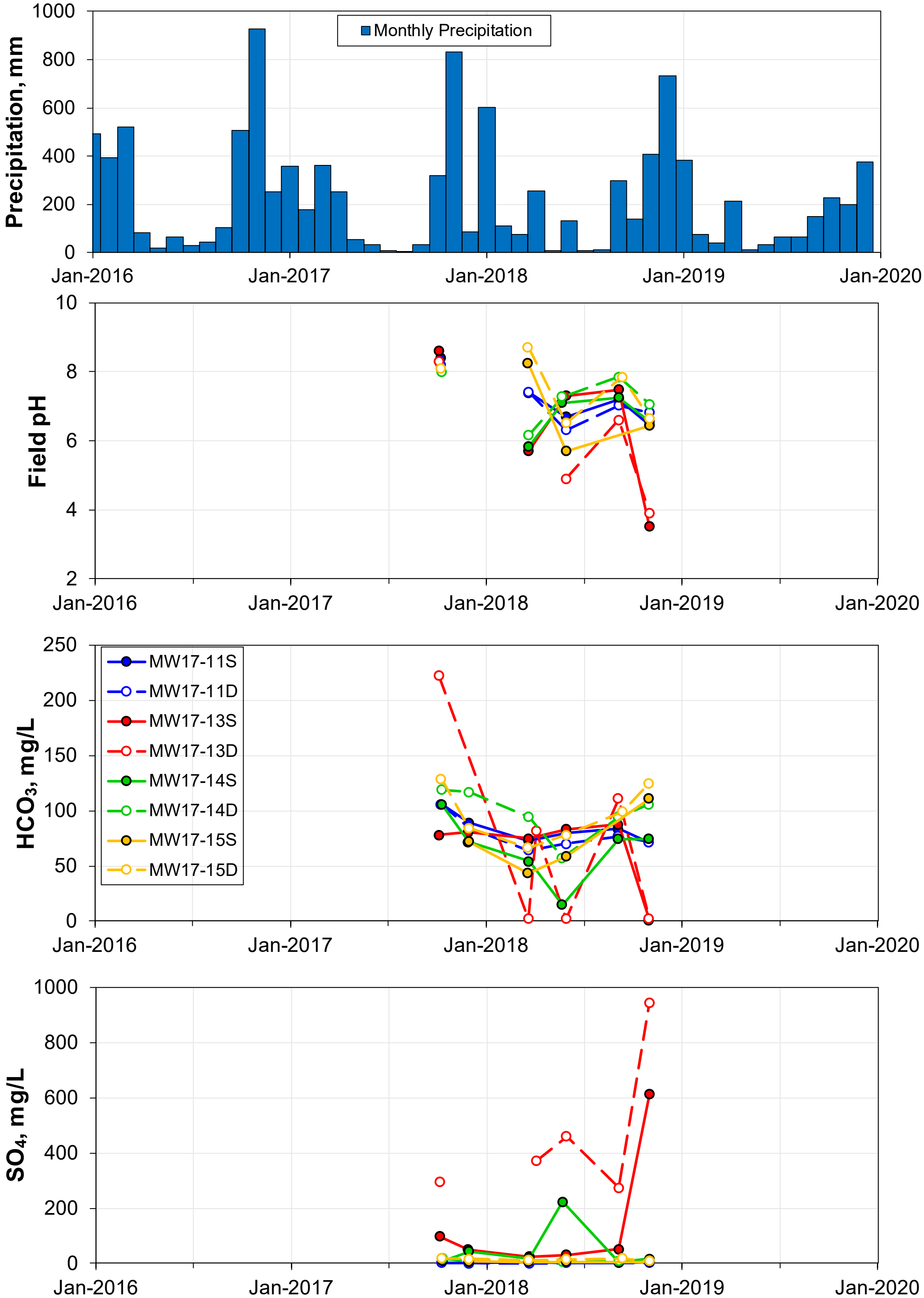


Figure 3-22a. Groundwater Quality Time Trends for Wells in Downstream Reach

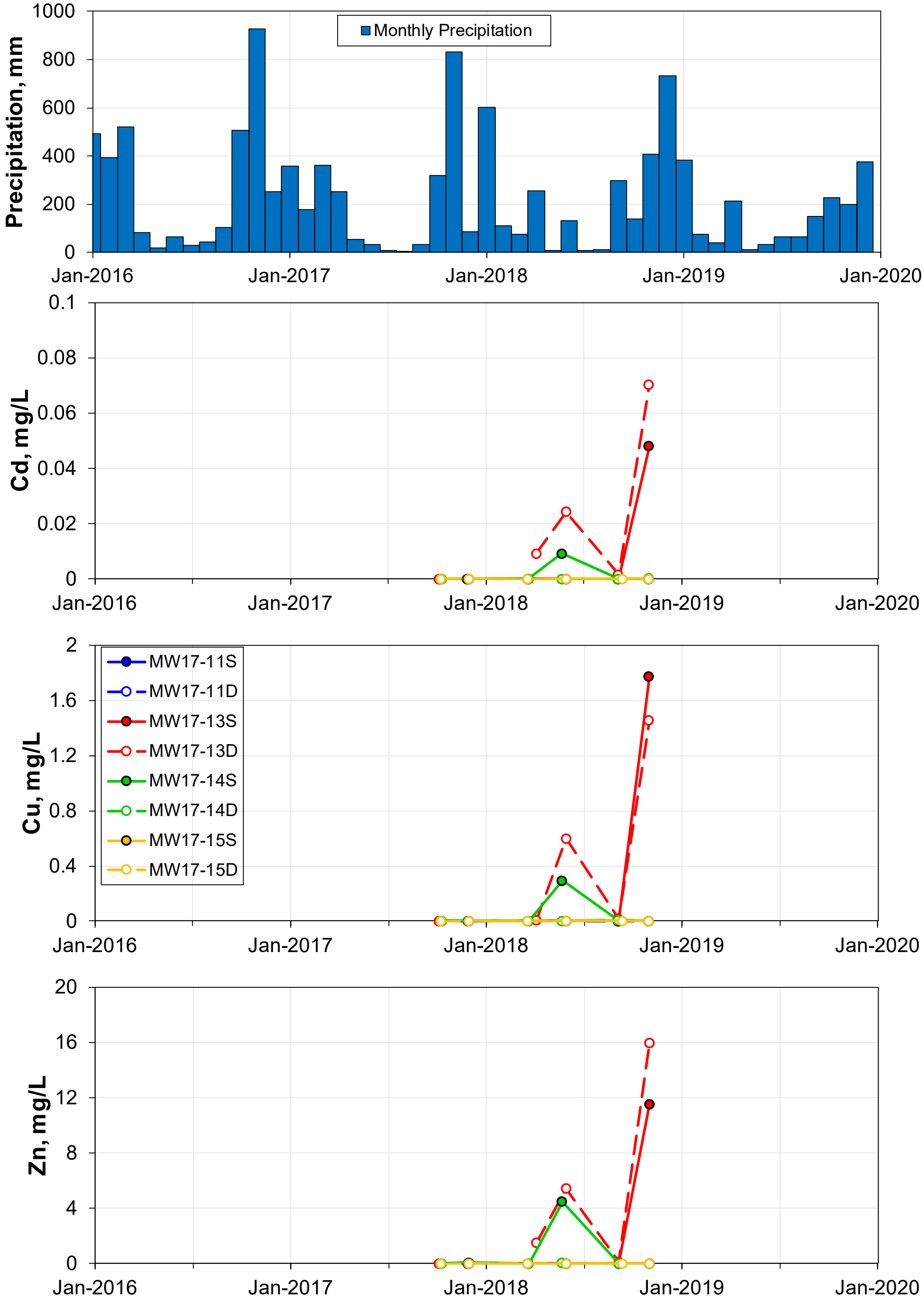


Figure 3-22b. Groundwater Quality Time Trends for Wells in Downstream Reach

4 EFFLUENT AND SURFACE WATER QUALITY

This section provides routine monitoring data required for Permit PE-6858. Voluntary routine monitoring data for Myra Creek are also discussed to identify any recent changes due to operating the Phase I Lynx SIS and the Interim Phase II Lynx SIS.

4.1 PRECIPITATION

Precipitation data for Myra Falls are summarized in **Table 4-1**. These data are recorded at the climate station on site (MYR-CLIMATE) and were compiled by Swiftwater Consulting Ltd. The annual precipitation amount in 2019 was 1882 mm, or about 27% lower than the long-term mean precipitation amount from 1979 to 2019.

Table 4-1

Precipitation Data, 2009 to 2019, with Summary of Long-Term Data (1979 to 2019)

YEAR	Jan mm	Feb mm	Mar mm	Apr mm	May mm	Jun mm	Jul mm	Aug mm	Sept mm	Oct mm	Nov mm	Dec mm	TOTAL
2009	140	139	291	91	171	44	35	17	165	321	882	258	2,553
2010	666	353	381	223	171	60	2	19	269	478	285	629	3,535
2011	284	327	528	166	80	12	82	42	340	295	478	200	2,834
2012	601	241	424	199	55	86	10	14	16	317	525	264	2,752
2013	96	273	168	112	125	66	3	125	277	57	227	100	1,628
2014	170	243	341	170	48	32	32	17	144	589	404	548	2,740
2015	263	338	460	105	35	15	20	149	217	262	259	635	2,759
2016	492	394	521	81	17	63	31	44	104	508	928	250	3,435
2017	358	178	362	254	55	34	9	2	32	319	830	86	2,519
2018	602	111	75	256	8	131	10	13	299	137	407	733	2,782
2019	384	74	41	212	12	32	64	65	150	228	199	421	1,882
1979 to 2019													
n	41	41	41	41	41	41	41	41	41	41	40	40	40
Mean	358	260	247	163	94	66	42	57	115	318	459	370	2,561
Median	333	258	212	166	79	51	32	42	89	317	459	368	2,631
St Dev	193	149	145	81	71	46	34	50	102	178	219	174	529
Max	860	624	528	396	306	184	125	207	384	779	928	733	3,535
Min	50	55	41	21	6	12	1	2	0	34	94	86	1,479

4.2 INFLUENT WATER QUALITY

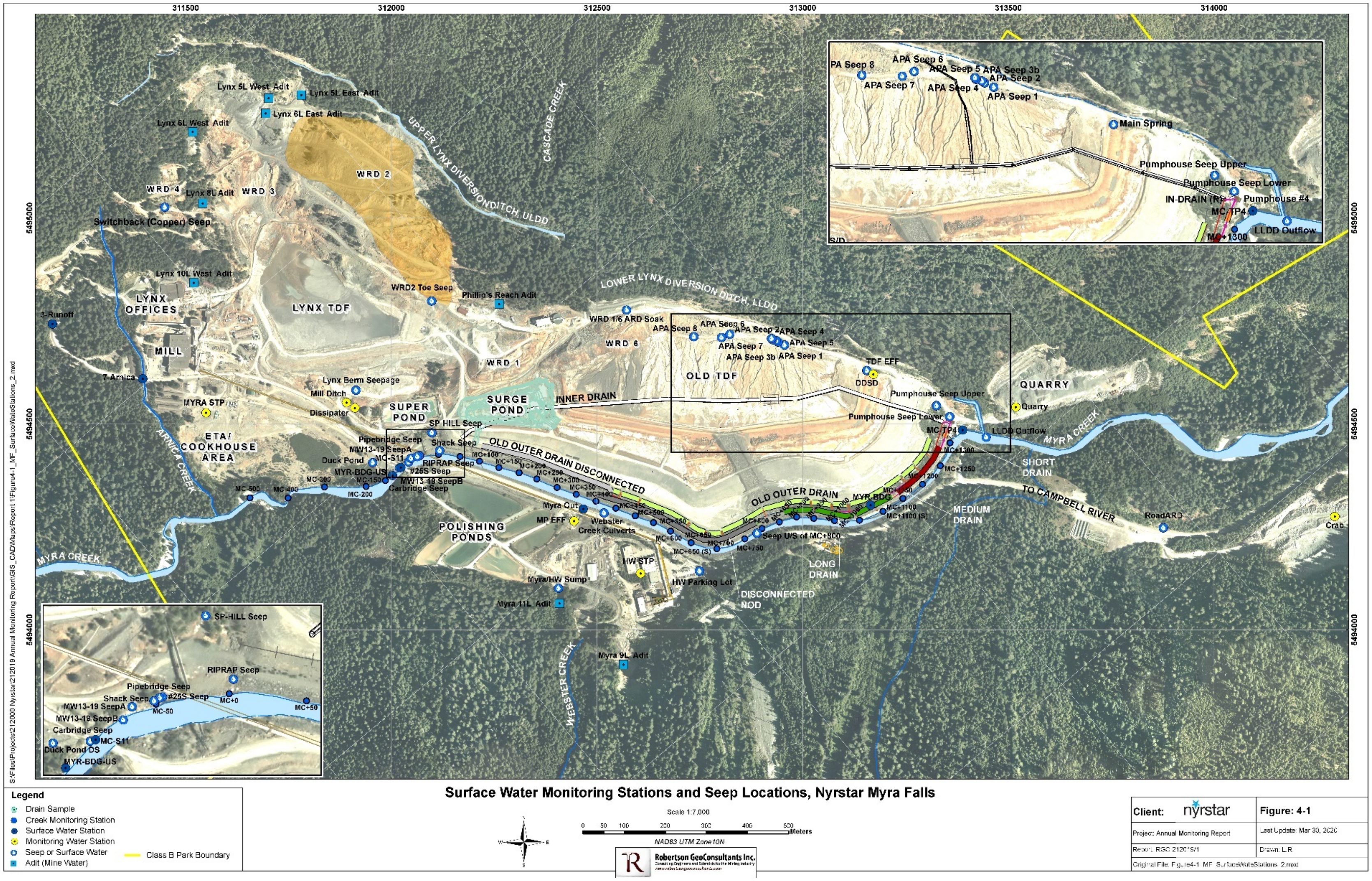
Influent water quality monitoring stations (Mill Ditch and TDF-Dissipater) are shown in **Figure 4-1**. Flows to the water treatment system are not routinely monitored at either station. Further details on influent water quality are provided below. There are no water quality criteria for influent and monitoring is undertaken primarily to assess the quality of water being treated for long-term planning of water management and treatment requirements.

4.2.1 *Mill Runoff*

Precipitation runoff (contact water) from the eastern side of the property, including the mill area, is directed to the water treatment system via a collection ditch. Underground mine water flows from the Lynx 10L East adit and decant flows from the Lynx TDF are also directed to the water treatment system via this ditch. The quality of water in this ditch is routinely monitored at station Mill Runoff (E311028), sometimes referred to as Mill Runoff Collection Ditch.

Water quality samples were collected quarterly in 2019, as required by Permit PE-6858. Samples collected in February, August, and May were characterized by circum-neutral pH values and elevated concentrations of SO_4 and metals, i.e. up to 10.5 mg/L Zn-t (**Table 4-2**). Elevated Zn-d and Zn-t, and some other metals, are related in part to gravity flows of underground mine water from the Lynx 10L East adit, which is characterized by up to 30 mg/L Zn and flows to the Lynx Ditch year-round. Precipitation runoff from the mill area is also characterized by elevated metal concentrations but the contributions of mine water and runoff cannot be differentiated from the data available for this report.

The sample from November 2019 was alkaline (pH 10.1) with very high TSS and high concentrations of total metals, i.e. 51.1 mg/L Cu-t and 560 mg/L Zn-t. The mill was running on the day this sample was collected, which explains the high pH. A sump from the mill was also overflowing to the water treatment system according to site staff. The water collected by this sump appears to have been characterized by elevated metal concentrations, which explains the elevated concentrations at the Mill Runoff station.



Surface Water Monitoring Stations and Seep Locations, Nyrstar Myra Falls

4.2.2 *Flows to TDF-Dissipater*

Influent to the water treatment system is routinely monitored at the station TDF-Dissipater. Flows at this station consist of the following:

i. Groundwater flows from the Old TDF under-drains via Pumphouse No. 4.

ii. Seepage (groundwater) from northern pit wall of the former Lynx Pit via the Springs Drain.

iii. Precipitation runoff from the Old TDF via the Surge Pond.

Groundwater flows from the Old TDF under-drains occur year-round at a rate of approximately 210 L/s. Flows from the Old TDF Surge Pond and the Springs Drain occur during high rainfall periods in the fall, winter and spring. Samples from the dissipater are slightly acidic and characterized by 7 to 14 mg/L TSS (**Table 4-2**). Metal concentrations in samples from the dissipater in 2019 were relatively stable in 2019due to the predominance of groundwater flows from the Old TDF under-drains via Pumphouse No. 4.

The pH of water in the dissipater is slightly lower in the sample from August 2019, possibly due to precipitation runoff from the Old TDF during the summer months. This is consistent with findings from RGC (2018), wherein daily loads to the dissipater (and Superpond) are calculated. Water quality variations in 2019 are, however, difficult to explain without further details on the magnitude of flows from the sources above, particularly precipitation runoff from the Surge Pond.

Table 4-2.

Water Quality Results for Influent to Water Treatment System, 2019

Station	Sampling Date	TSS, mg/L	pH	SO4, mg/L	N-t, mg/L	P-t, mg/L	Cd-d, mg/L	Cu-d, mg/L	Cu-t, mg/L	Pb-d, mg/L	Zn-d, mg/L	Zn-t, mg/L
Discharge limit		-	-				-	-	-	-	-	-
Mill Ditch	6-Feb-19	18	7.3	152	0.3	0.1	0.0231	0.2	0.9	0.00560	9.6	10.5
Mill Ditch	1-May-19	16	7.2	71	0.1	0.1	0.0132	0.1	0.5	0.00833	4.7	5.9
Mill Ditch	8-Aug-19	19	7.0	326	9.3	0.1	0.0026	0.02	0.1	0.00101	0.2	1.4
Mill Ditch	14-Nov-19	18,700	10.1	304	7.4	4.6	0.0001	0.003	51	0.00020	0.01	560
TDF-Dissipater	6-Feb-19	14	5.7	300	0.3	0.1	0.0214	0.8	0.8	0.00470	7.6	7.4
TDF-Dissipater	1-May-19	13	6.2	220	0.2	0.1	0.0148	0.6	0.6	0.00386	5.5	5.9
TDF-Dissipater	7-Aug-19	7	4.6	193	0.2	0.1	0.0142	0.5	0.6	0.00490	4.5	5.0
TDF-Dissipater	14-Nov-19	9	6.5	170	0.3	0.1	0.0120	0.5	0.5	0.00160	4.2	4.3

4.3 TREATED EFFLUENT DISCHARGE

4.3.1 *Effluent Discharge Rates*

Daily effluent discharge rates in 2019 are shown in **Figure 4-2** with daily precipitation. Effluent discharge rates in 2019 ranged from 20,069 m^3/day (on June 22nd) to 124,088 m^3/day (on January 3rd). The average daily discharge rate in 2019 was 40,327 m^3/day. This is 7,673 m^3/d day lower than the 48,000 m^3/day that is authorized by Permit PE-6858.

Monthly and annual inflows to the water treatment system and flows of treated effluent to Myra Creek are summarized in **Table 4-3**. Groundwater flows from the Old TDF under-drains (via Pumphouse No. 4) are continuously recorded with a flow meter and groundwater flows from Lynx SIS are recorded with totalizers (see Section 2). Groundwater flows from the Old TDF under-drains (via Pumphouse No. 4) account for approximately 50% of the volume of treated discharge to Myra Creek. Groundwater flows from the Phase I Lynx SIS represent approximately 10? of the treated discharge.

The “other inflows” in **Table 4-3** are estimated by subtracting groundwater flows from Pumphouse No. 4 and the Lynx SIS from the volume of water discharged to Myra Creek. These flows are predominantly precipitation runoff from the Old TDF and mill area but also include gravity flows of underground mine water from the Lynx 10L East adit (see Section 4.1).

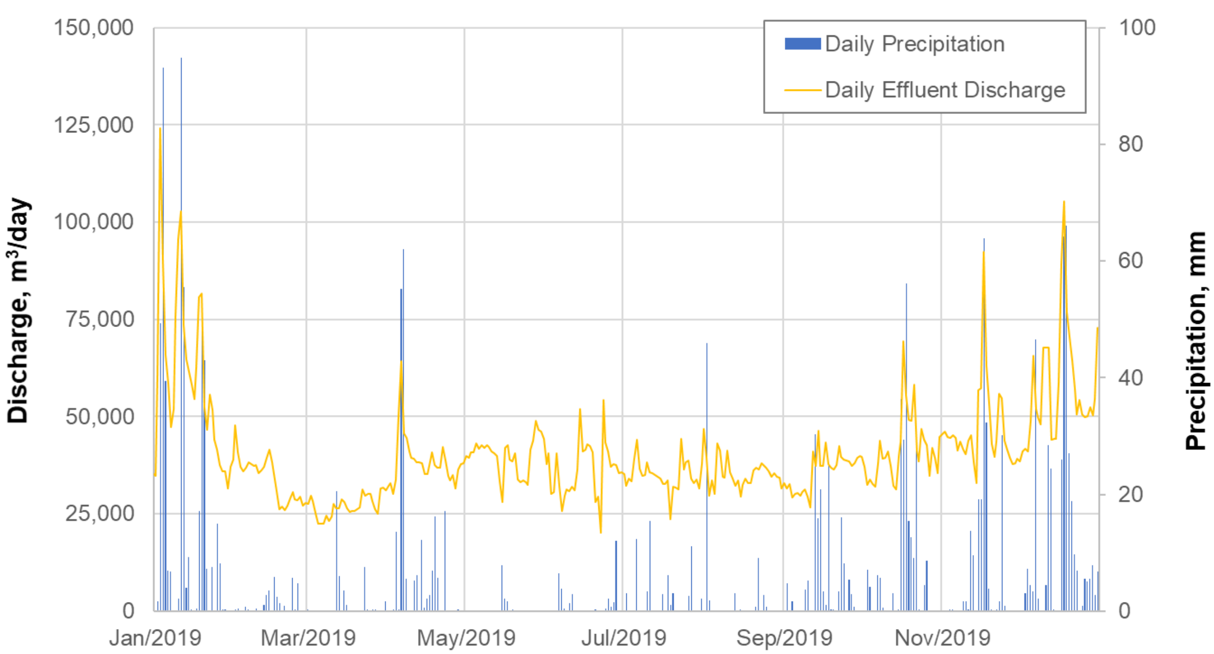


Figure 4-2. Daily Effluent Discharge and Daily Precipitation in 2019

Table 4-3.

Inflows to Water Treatment System and Treated Effluent Flows, 2019

Month	Inflows from Pumphouse No.4,		Inflows from Phase I Lynx SIS,		Other Inflows, e.g. Precipitation Runoff		Treated Effluent Discharge to Myra Creek,	
	m^3	%	m^3	%	m^3	%	m^3	%
January	695,410	10%	113,188	8%	1,045,350	18%	1,853,948	13%
February	579,403	8%	131,731	9%	166,730	3%	877,864	6%
March	533,941	7%	117,790	8%	186,850	3%	838,581	6%
April	629,454	9%	137,209	9%	390,305	7%	1,156,969	8%
May	625,647	9%	134,830	9%	476,669	8%	1,237,147	9%
June	604,281	8%	123,066	8%	139,373	2%	866,720	6%
July	591,234	8%	117,218	8%	374,761	6%	1,083,213	8%
August	551,171	8%	109,870	7%	438,115	8%	1,099,156	8%
September	537,756	8%	110,096	7%	160,650	3%	808,501	6%
October	561,927	8%	124,479	8%	1,037,197	18%	1,723,604	12%
November	585,866	8%	129,894	9%	1,242,949	21%	1,958,709	14%
December	633,525	9%	143,595	10%	133,441	2%	910,560	6%
Total:	**7,129,615**	**100%**	**1,492,967**	**100%**	**5,792,389**	**100%**	**14,414,971**	**100%**

4.3.2 *Effluent Quality*

pH, Cd-d, Cu-d, Cu-t, Pb-d, Zn-d, and Zn-t concentrations in daily composite samples of treated effluent discharge to Myra Creek at station MP-EFF are shown in **Figures 4-3** to **4-7**. None of the Cd-d, Cu-d, Cu-t, Pb-d, Zn-d, or Zn-t concentrations observed in treated effluent exceeded discharge limits in 2019.

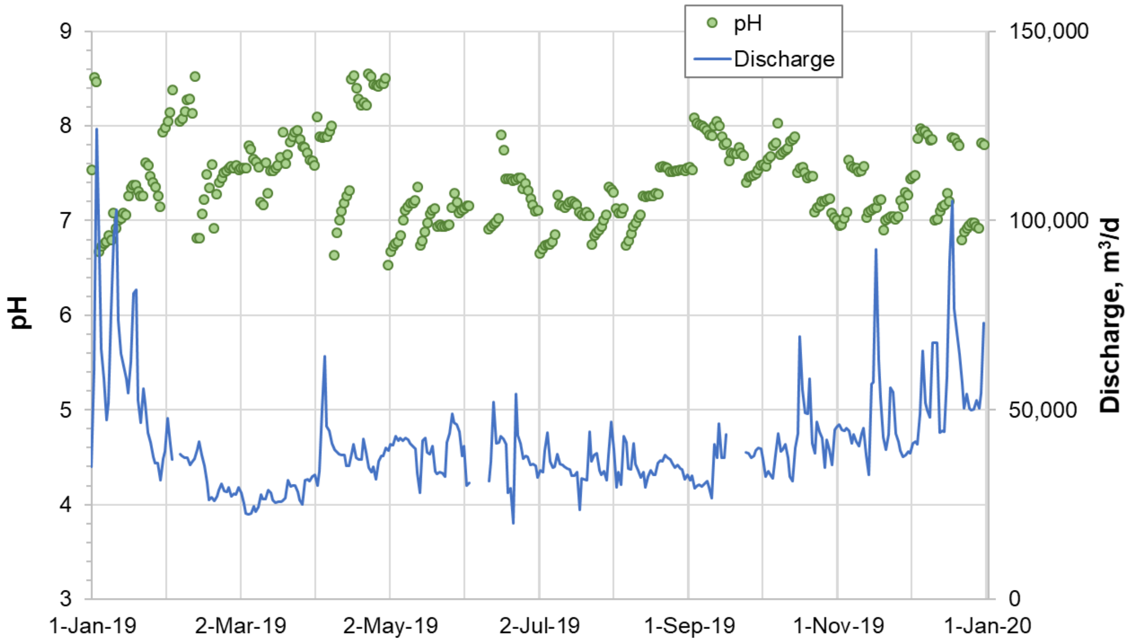


Figure 4-3. pH Measurements for Daily Composite Samples of Treated Effluent (MP-EFF), 2019

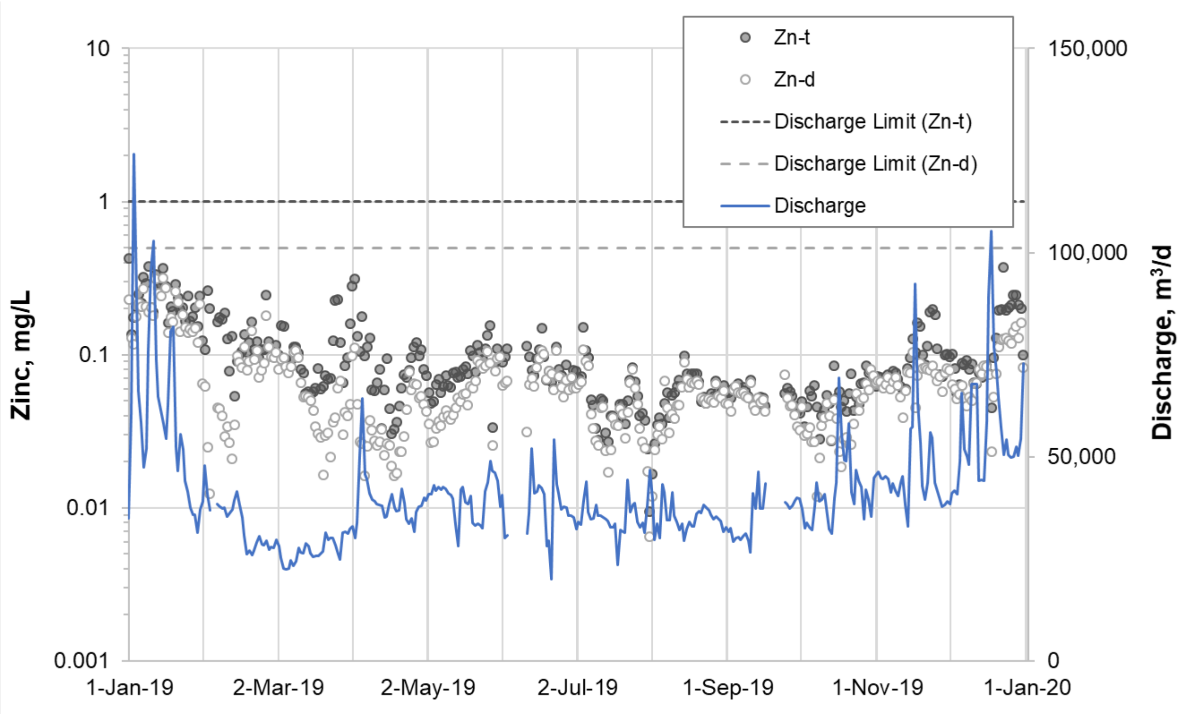


Figure 4-4. Zn Concentrations in Daily Composite Samples of Treated Effluent (MP-EFF), 2019

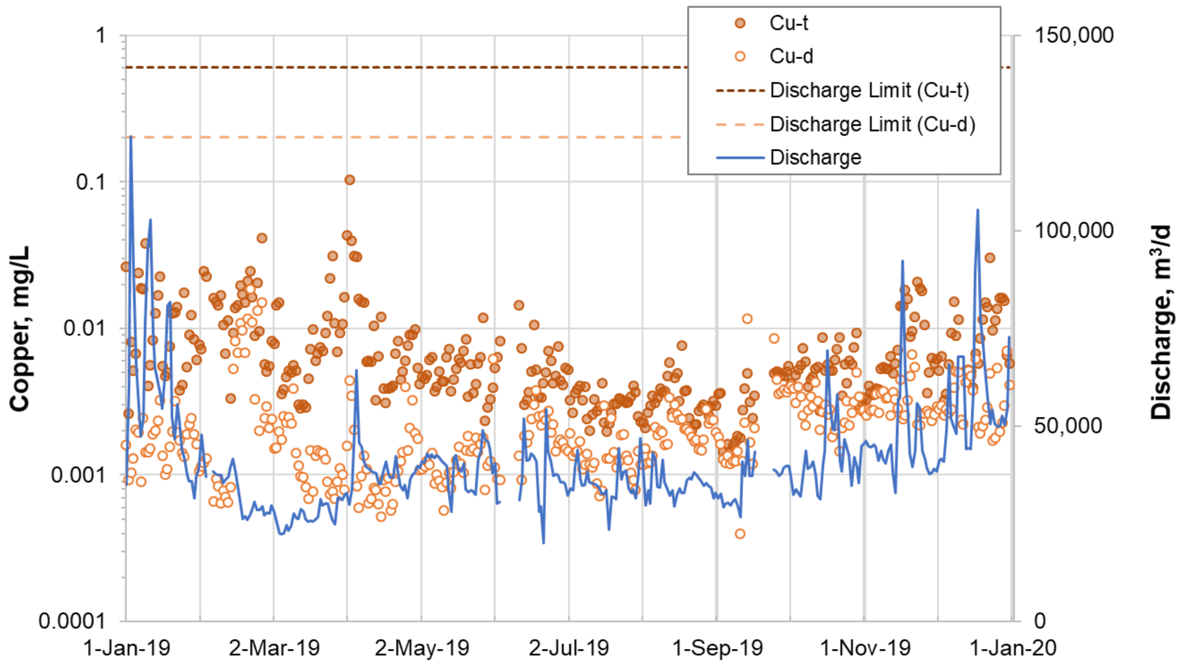


Figure 4-5. Cu Concentrations in Daily Composite Samples of Treated Effluent (MP-EFF), 2019

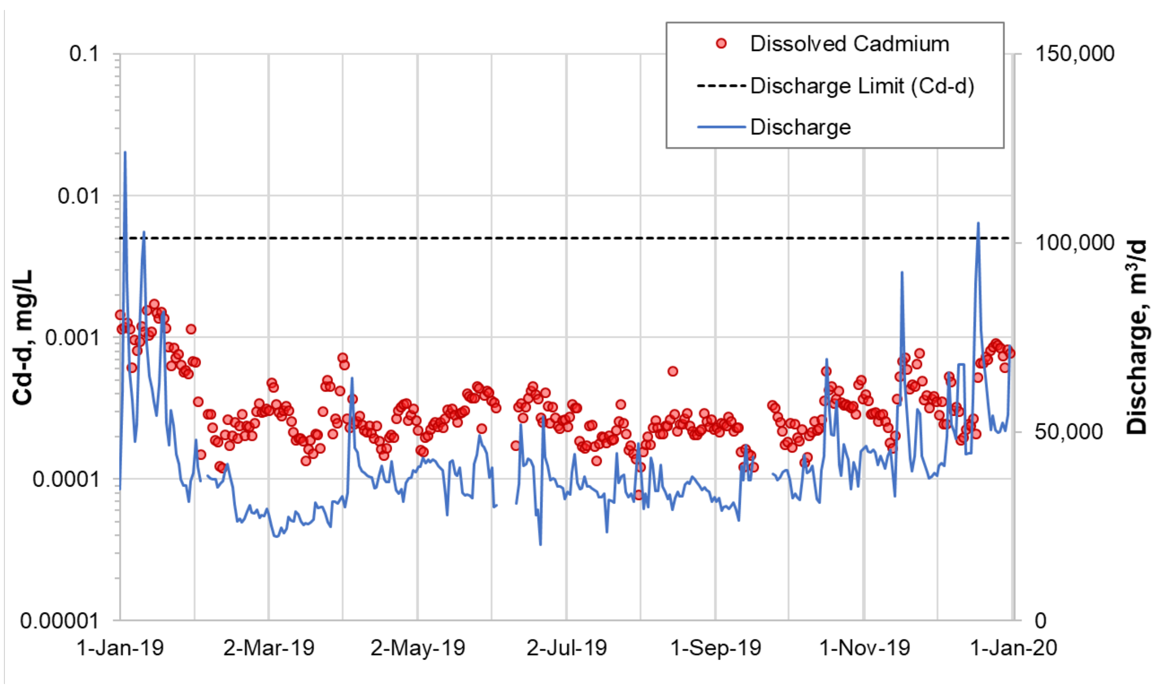


Figure 4-6. Cd-d Concentrations in Daily Composite Samples of Treated Effluent (MP-EFF), 2019

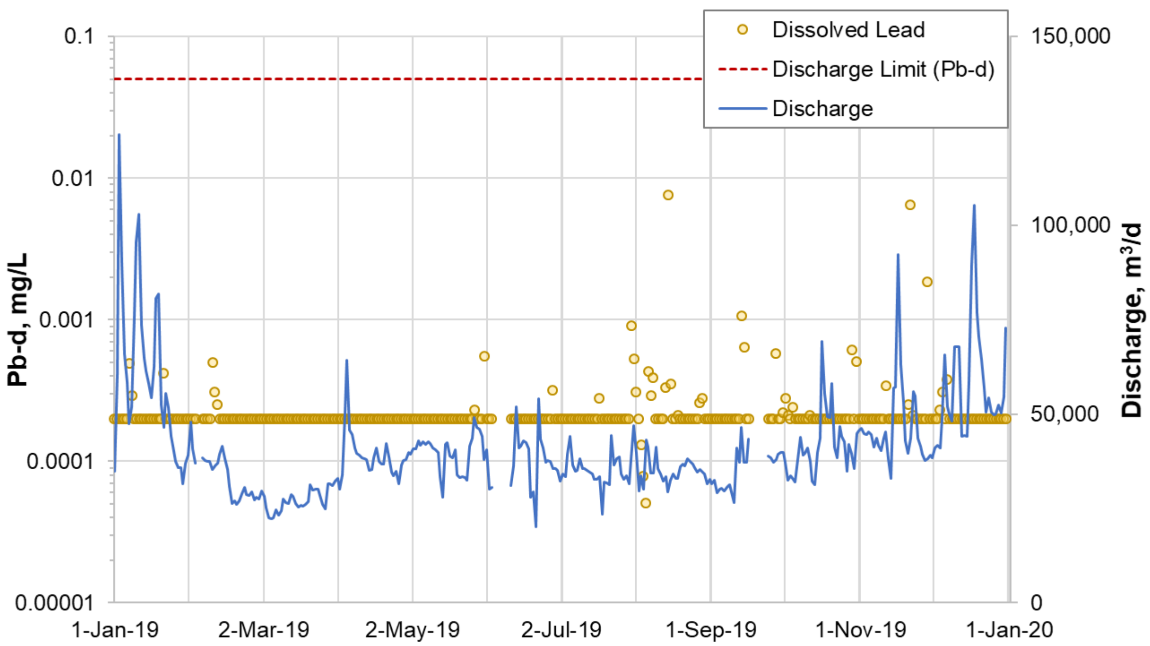


Figure 4-7. Pb-d Concentrations in Daily Composite Samples of Treated Effluent (MP-EFF), 2019

4.3.3 *Toxicity Testing*

Monthly grab samples of treated effluent for acute toxicity testing were collected and analyzed for rainbow trout and *Daphnia magna* to satisfy requirements of Environment Canada Metal and Diamond Mine Effluent Regulations (MDMER). These monthly tests are used to satisfy the quarterly toxicity monitoring requirements of PE-06858. All 2019 96-hour LC50 test results for rainbow trout were >100% vol./vol. survival rate (see Appendix E).

4.4 OLD TDF EFFLUENT DISCHARGE

Water samples from station TDF-EFF represent flows from the Diversion Ditch Springs Drain (DDSD) and the Diversion Ditch Under-Drains (DDUDs). Samples are collected when flows from the DDSD or DDUD are observed by site staff. When multiple DDUDs and/or the DDSD are flowing, a single sample that is representative of the quantity of flow from each source is collected. The water sampled at TDF-EFF typically meets discharge limits without treatment and could, therefore, be released directly to Myra Creek. The infrastructure required to do so, however, has not been constructed so any flows observed here are directed to the water treatment system.

4.4.1 *Water Quality*

Grab samples for water quality testing were collected at station TDF-EFF in January (n =2), February (n=1), April (n=2), May (n=4) and December (n=1). These are the months when flows at station TDF-EFF are observed, although it does not necessarily imply flows from the DDSD. TSS and metal concentrations in samples from January, February, April, and May are typically an order-of-magnitude lower than the discharge limits for station TDF-EFF. Metal concentrations in samples from December 2019 are much higher by comparison, although none of the concentrations exceed discharge limits (**Table 4-4**). These data suggest elevated metal concentrations during an initial flushing period, e.g. in November or December, after which concentrations are much lower than discharge limits for station TDF-EFF. More frequent monitoring is needed to estimate contributions of flows from the DDSD and DDUDs and should be considered in support of any application to do release this water.

Table 4-4.

Inflows to Water Treatment System and Treated Effluent Flows, 2019

Station	SampleDate	pH	SO_4, mg/L	N-t, mg/L	P-t, mg/L	TSS, mg/L	Cd-d, mg/L	Cd-t, mg/L	Cu-t, mg/L	Cu-d, mg/L	Pb-d, mg/L	Pb-t, mg/L	Zn-d, mg/L	Zn-t, mg/L
Discharge limit		**6.5 to 10**				**20**	**0.003**	**-**	**0.3**	**0.1**	**0.03**		**0.3**	**1**
TDF-EFF	19-Jan-2019	7.5			0.05	2	0.0001	0.00016	0.002	0.001	0.0002	0.0002	0.019	0.02
TDF-EFF	20-Jan-2019	7.9			0.094		0.00001	0.00006	0.005	0.0004	0.0002	0.00411	0.004	0.01
TDF-EFF	6-Feb-2019	7.6	1	0.05	0.05	2	0.00001	0.00001	0.001	0.0004	0.0002	0.0002	0.0043	0.004
TDF-EFF	3-Apr-2019	7.8	2	0.05	0.05	2	0.0001	0.00004	0.001	0.001	0.0002	0.0002	0.0097	0.010
TDF-EFF	24-Apr-2019	7.8			0.05	2	0.00001	0.00001	0.0004	0.0004	0.0002	0.0002	0.004	0.004
TDF-EFF	1-May-2019	7.7	1.6	0.05	0.05	2	0.00004	0.00017	0.003	0.001	0.0002	0.00765	0.0074	0.02
TDF-EFF	6-May-2019	7.7			0.05	2	0.00001	0.00004	0.001	0.0004	0.0002	0.0002	0.004	0.007
TDF-EFF	7-May-2019	7.7			0.05		0.00003	0.00004	0.001	0.001	0.0002	0.0002	0.0079	0.007
TDF-EFF	8-May-2019	7.7			0.05		0.00003	0.00004	0.001	0.001	0.0002	0.0002	0.0056	0.007
TDF-EFF	18-Dec-2019	6.9	21.4		0.05		0.0014	0.00140	0.063	0.048	0.0003	0.0028	0.255	0.29
n		10	4	3	10	6	10	10	10	10	10	10	10	10
Minimum		6.9	1.000	0.05000	0.05000	2	0.00001	0.00001	0.0004	0.0004	0.0002	0.000	0.004	0.004
Maximum		7.9	21.4	0.050	0.094	2	0.001	0.001	0.063	0.05	0.0003	0.0	0.3	0.3
Mean		7.6	6.50	0.0500	0.0544	2	0.0002	0.0002	0.008	0.01	0.0002	0.00	0.03	0.04
SD		0.3	9.94	0.0000	0.0139	0	0.0004	0.0004	0.02	0.02	0.00002	0.00	0.08	0.09
Median		7.7	1.80	0.05000	0.05000	2	0.00003	0.00004	0.001	0.001	0.0002	0.00	0.01	0.01

4.4.2 *Toxicity Testing*

Grab samples from TDF-EFF for acute toxicity testing were collected on February 5th and December 18th, 2019 and analyzed for rainbow trout (see Appendix E). The 96-hour LC50 test results for rainbow trout in both tests were >100% vol./vol. survival rate (see Appendix E).

4.5 MYRA CREEK

Routine monitoring locations and streamflow gauges for Myra Creek are shown in **Figure 4-1**.

4.5.1 *Streamflow Discharge*

NMF commissioned the installation of a new streamflow monitoring gauge in 2019. The gauge conforms to RISC (2018) Grade A data quality standards and was installed by Swiftwater Consulting Ltd. ("Swiftwater"). Swiftwater completed four visits in 2019 to install the gauge and obtain surveyed stage and measured discharge. All streamflow records, including field sheet, data files, photographs, and data downloads, are managed using Aquatic Informatics' AQUARIUS software, and continuous discharge data are made available in real-time through Swiftwater's AQUARIUS WebPortal. Further details on hydrometric methods are provided in Swiftwater Consulting Inc. (2020) (see Appendix C).

There are two continuous streamflow monitoring stations.

- MYR-BDG-US, and
- MYR-BDG.

Station MYR-BDG-US is the original monitoring station for Myra Creek and is located beneath the main access road bridge. MYR-BDG is the new, long-term streamflow monitoring station installed in 2019. This station is located on the pipe bridge that crosses Myra Creek approximately 1 km downstream of MYR-BDG-US (Figure 4-1). The new gauge is downstream of the effluent discharge point (MP-EFF) and Webster Creek. The new gauge instrumentation consists of a Campbell Scientific datalogger and radio telemetry system. The stage sensor is a non-contact FTS radar sensor, installed in the center of the pipe bridge overlooking the creek.

Streamflow discharge data for Myra Creek for station MYR-BDG are shown in **Figure 4-8**. The data for MYR-BDG-US consisted of an extended period of unverifiable stage records, spanning several years, and the flows derived from these estimates should be considered estimates of streamflow discharge only (see Appendix C). Data from MYR-BDG are much more reliable and will be the focus of future routine monitoring reports. Data for both gauges are shown with water quality results to illustrate long-term trends and intra-annual variations in water quality (see Section 4.4.2).

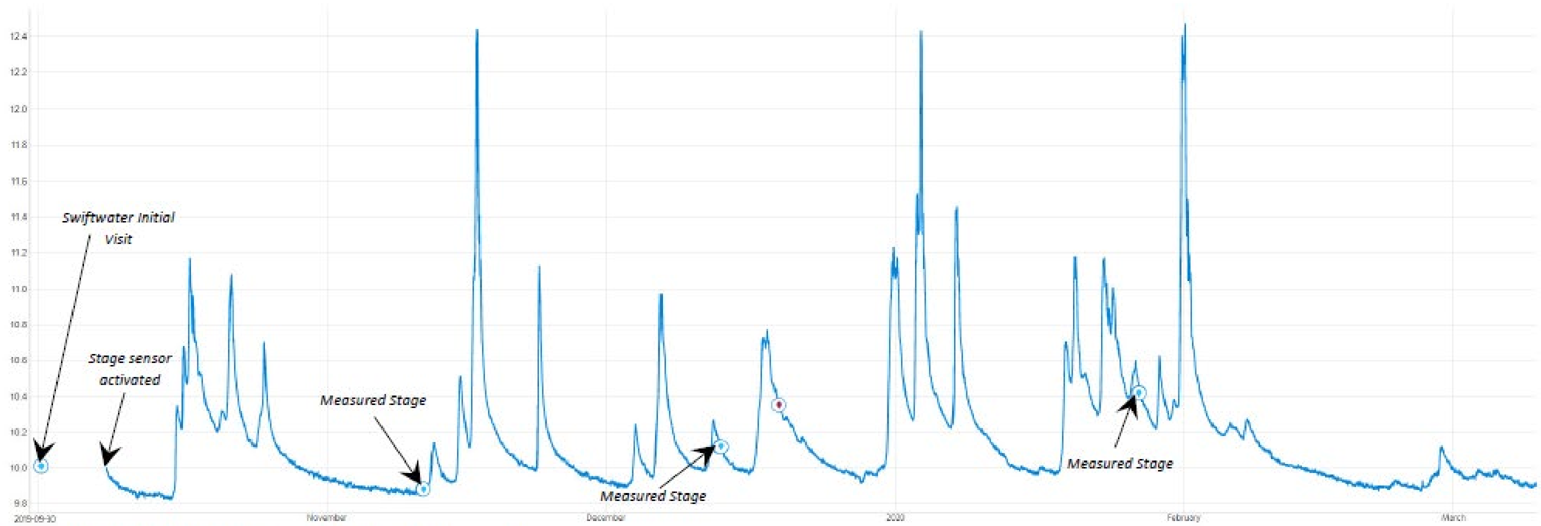


Figure 5. MYR-BDG 2019 Corrected Stage Hydrograph

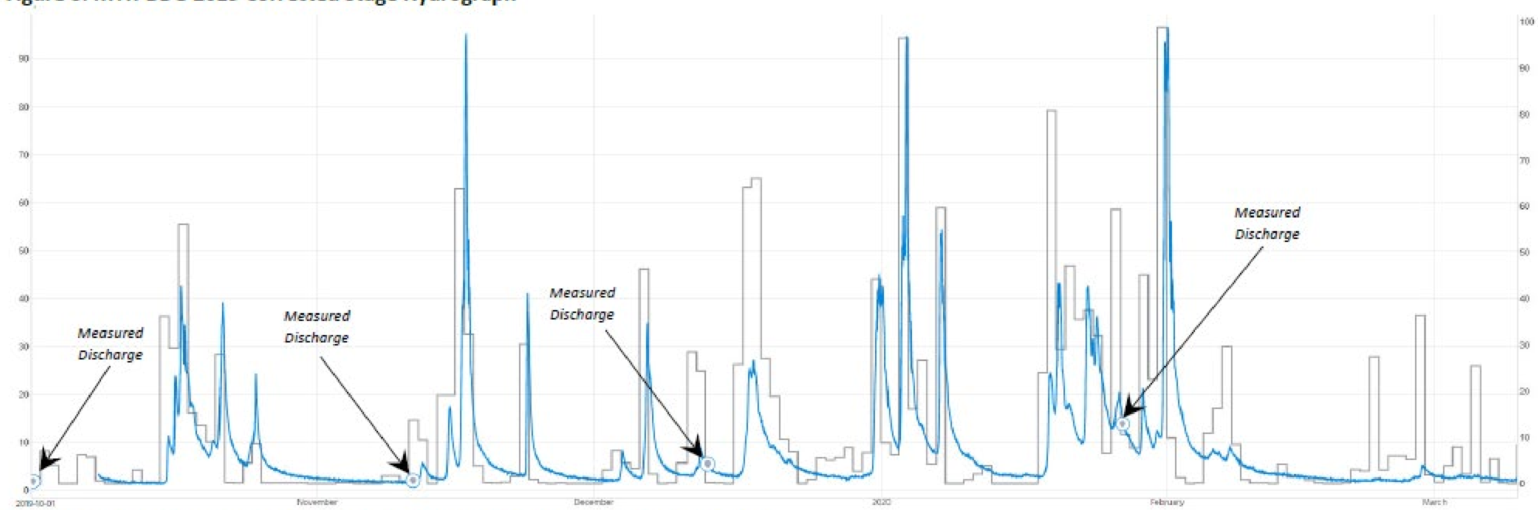


Figure 6. MYR-BDG 2019 Discharge (left axis) and Daily Precipitation (right axis)

Figure 4-8. Streamflow discharge data for Myra Creek from MYR-BDG, 2019

4.5.2 *Water Quality in Myra Creek*

Water quality results for Myra Creek at stations MC-M1, MC-TP4, and MC-M2 are provided in **Table 4-6**. BC WQGs are also shown for ease of reference. For compliance monitoring, all WQGs for the protection of aquatic life were calculated using the average water hardness in Myra Creek (14 mg/L) upstream of the mine site at MC-M1, as per previous monitoring reports (see NMF, 2018).

Concentrations of Zn-t in daily composite samples from Myra Creek at MC-TP4 since April 2017 and in 2019 are shown in **Figure 4-9**. Concentrations since April 2017 are shown in this figure because this is the period that an offsite laboratory has been used for water quality testing. Concentrations of Cu-d and Cu-t in daily composite samples are shown in **Figure 4-10**.

Daily streamflow discharge rates in Myra Creek are shown in these figures for reference. Daily discharge at station MYR-BDG-US (the original gauge) is shown until March 18th, 2019 for reference. Flows in October, November, and December 2019, are from the new gauging station (MYR-BDG-US). There is a gap in the streamflow discharge record in 2019 because the datalogger at the original gauge could not be downloaded by site staff.

Upstream of the mine site (and Arnica Creek), Myra Creek (at MC-M1) is slightly alkaline and characterized by low concentrations of SO_4, nitrate, and total and dissolved metals. The Al-d concentration in Myra Creek at MC-M1 in March 2019 exceeded the long-term (chronic) BC WQG. All other concentrations in Myra Creek at MC-M1 were below long-term BC WQGs. Cu-d, Cu-t, and Zn-t concentrations in Myra Creek at the downgradient stations MC-TP4 and MC-M2, often exceeded long-term (chronic) and short-term (acute) BC WQGs. The highest concentrations were observed in January 2019, when Zn-t concentrations were approximately four times higher than the short-term BC WQG. Concentrations in Myra Creek at MC-TP4 and MC-M2 are comparable because there are no ARD sources to the creek between these stations and dilution from tributary flows is negligible.

Zn-t concentrations in each of the daily composite samples from Myra Creek at MC-TP4 exceeded the long-term (chronic) BC WQG in 2019. Zn-t concentrations in 97% of the daily composite samples exceeded the short-term (acute) BC WQG in 2019. Zn-t concentrations were lowest in the summer months when streamflow discharge in Myra Creek is highest. Cu-d concentrations in each of the daily composite samples from Myra Creek at MC-TP4 exceeded the long-term (chronic) BC WQG and occasionally exceeded the short-term (acute) BC WQG for Myra Creek. Elevated metal concentrations in Myra Creek at MC-TP4 are primarily due to the discharge of ARD-impacted groundwater to the creek upstream of the Old TDF under-drains and treated effluent discharge from the Myra Ponds. Contaminant loads from the catchment upstream of the mine site and loads from Arnica Creek and Webster Creek also contribute, although the magnitudes of these loads is comparatively small (see RGC, 2018a).

Monthly Zn profiles of the creek suggest concentrations of Zn and other metals first increase near the carbridge at station MC-S11 (**Figure 4-11**). Upstream (between MC-S11 and Arnica Creek), the consistency of Zn concentrations in Myra Creek suggests only small loads from ARD-impacted groundwater in the former ETA area (upstream of the Duck Pond). Zn concentrations in Myra Creek at the carbridge are much higher than upstream at chainage marker MC-200. The increased Zn concentrations in Myra Creek at the carbridge is related, in part, to ARD-impacted groundwater that reports to the creek from the Lynx Reach and the Myra Ponds/HW area. Surface seepage and/or perched seepage also appears to contribute but specific source areas (and pathways to the creek) are currently poorly defined. Increased Zn concentrations in Myra Creek can occur at MC+350 during low flow periods due to the discharge of treated effluent from the Myra Ponds. During high flow periods, the load from treated effluent is much smaller than the load in the creek and no increase in metal concentrations can be discerned near the discharge point (Myra Out).

Further downstream, Zn concentrations increase considerably around MC+550 and peak concentrations are observed at MC+800. This increase is due to a well-established seepage area where 100 to 400 µg/L Zn and elevated concentrations of other metals are observed in surface seepage near the creek. Downstream, from MC+800 to MC-TP4, there is no change in Zn concentrations in Myra Creek, suggesting no substantial load to the creek from groundwater. This is due to the effectiveness of the NOD, which allows only a small (<10%) load bypass to the creek.

RGC (2018a) predicted lower Zn concentrations in Myra Creek within one year of the Phase I Lynx SIS being operated continuously. Observed Zn concentrations in Myra Creek at MC-TP4 do not appear to have decreased substantially in 2019 and are therefore not consistent with model predictions. This could indicate that a more substantial proportion of impacted groundwater than simulated in RGC (2018a) is migrating into the Lower Old TDF Reach where it is mostly captured by the Old TDF under-drains. Alternatively, it may take longer than simulated for Zn concentrations in Myra Creek to decrease assuming the Phase I Lynx SIS is operating continuously. Longer-term trends are required to confirm model predictions and determine the degree of improvement in water quality in Myra Creek.

Table 4-6.

Water Quality Results for Myra Creek at MC-M1, MC-TP4, and MC-TP4, 2019

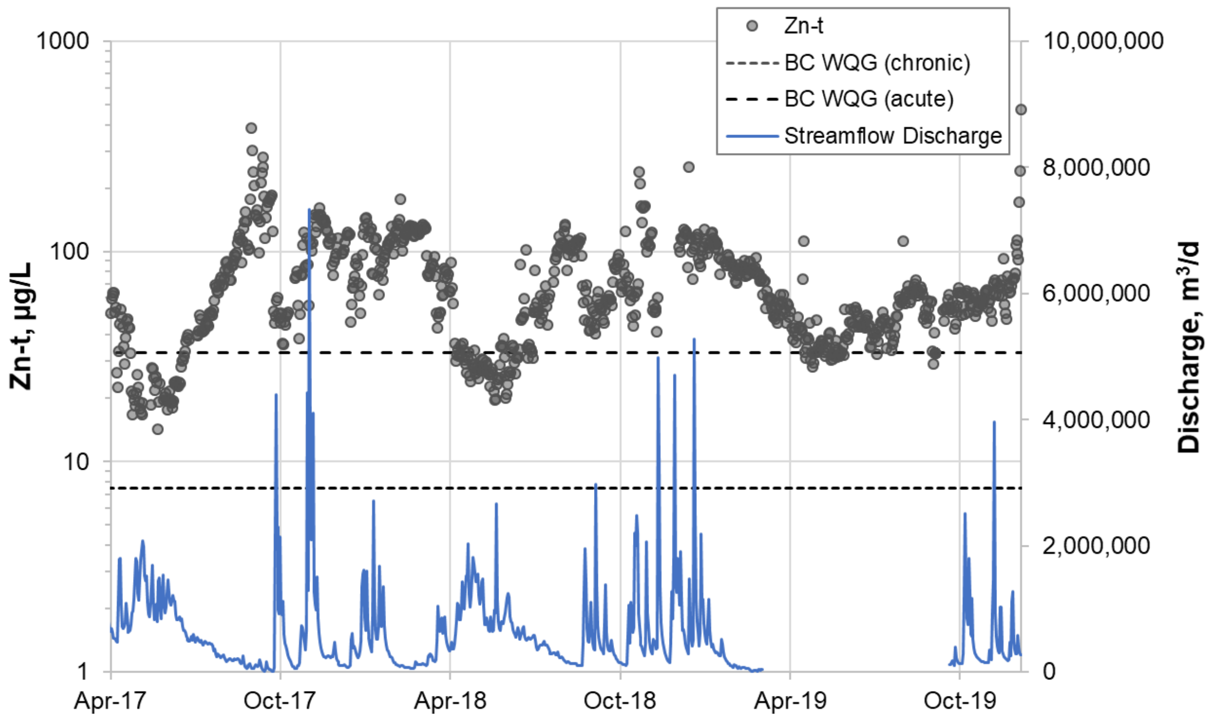
Station	Date	SO_4, mg/L	Nitrate, mg/L	Al-d, ug/L	Al-t, ug/L	Cd-d, ug/L	Cd-t, ug/L	Cu-d, ug/L	Cu-t, ug/L	Fe-d, ug/L	Fe-t, ug/L	P-d, ug/L	P-t, ug/L	Pb-d, ug/L	Pb-t, ug/L	Zn-d, ug/L	Zn-t, ug/L
BC WQG (chronic)		-	-	*50*	-	-	*0.05*	*1*	-	-	-	-	-	-	*3.6*	-	*7.5*
BC WQG (acute)		-	-	*100*	-	-	*0.08*	*7*	-	*350*	*1000*	-	-	-	*6.7*	-	*33*
MC-M1	20-Mar-19	2	0.02	83	45	0.01	0.01	0.4	0.4	10	10	50	2.0	0.2	0.2	4	4
MC-M1	14-May-19	1	0.01	40	46	0.01	0.01	0.4	0.4	10	10	50	5.3	0.2	0.6	4	4
MC-M1	7-Aug-19	1	0.24	21	26	0.01	0.01	0.4	0.4	10	10	50	4.3	0.2	0.2	4	4
MC-M1	14-Aug-19	2	0.03	18	26	0.01	0.01	0.4	0.4	10	15	50	2.1	0.2	0.2	4	4
MC-M1	13-Nov-19	2	0.01	27	36	0.01	0.01	0.4	0.4	10	10	50	2.0	0.2	0.2	4	4
MC-M1	14-Nov-19	1	0.08	28	39	0.01	0.01	0.4	0.4	10	26	50	4.0	0.2	0.2	4	4
	n	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Min:	1.0	0.01	18	26	0.01	0.01	0.4	0.4	10	10	50	2	0.2	0.2	4	4
	Max:	1.8	0.24	83	46	0.01	0.01	0.4	0.4	10	26	50	5	0.2	0.6	4	4
	Mean:	1.4	0.07	36	36	0.01	0.01	0.4	0.4	10	14	50	3	0.2	0.3	4	4
	Standard Deviation:	0.3	0.09	24	9	0.00	0.00	0	0	0	6	0	1	0	0.2	0	0
	Median:	1.5	0.03	28	37	0.01	0.01	0.4	0.4	10	10	50	3	0.2	0.2	4	4
BC WQG (chronic)		-	-	*50*	-	-	*0.05*	*1*	-	-	-	-	-	-	*3.6*	-	*7.5*
BC WQG (acute)		-	-	*100*	-	-	*0.08*	*7*	-	*350*	*1000*	-	-	-	*6.7*	-	*33*
MC-TP4	16-Jan-19	-	-	36	59	0.37	0.46	3.6	6.8	10	18	50	50	0.2	0.2	113	138
MC-TP4	6-Feb-19	-	-	49	74	0.20	0.25	2.0	4.2	10	18	50	50	0.2	0.6	79	98
MC-TP4	13-Mar-19	-	-	50	75	0.15	0.18	8.5	15.6	10	25	50	50	0.2	0.4	52	61
MC-TP4	3-Apr-19	-	-	47	69	0.09	0.12	0.7	1.0	10	22	50	50	0.2	0.7	29	45
MC-TP4	1-May-19	-	-	45	58	0.08	0.09	1.0	1.6	10	15	10	50	0.2	0.5	27	35
MC-TP4	12-Jun-19	-	-	29	34	0.03	0.04	1.7	2.4	10	10	10	10	0.2	0.3	11	10
MC-TP4	3-Jul-19	-	-	43	49	0.10	0.08	4.0	5.6	10	10	50	50	0.2	0.2	22	26
MC-TP4	7-Aug-19	15	0.04	85	102	0.09	0.12	0.5	0.8	10	47	10	50	0.2	0.3	31	37
MC-TP4	11-Sep-19	83	0.27	61	90	0.14	0.17	2.1	7.8	2	38	50	50	0.1	1.9	35	57
MC-TP4	9-Oct-19	33	0.18	31	52	0.08	0.09	1.1	1.8	3	11	10	10	0.2	0.3	22	27
MC-TP4	14-Nov-19	-	-	70	83	0.10	0.12	2.0	2.8	10	14	50	50	0.2	0.4	25	34
MC-TP4	10-Dec-19	-	-	44	55	0.01	0.04	2.5	4.0	10	13	50	50	0.2	0.4	26	41
	n	3	3	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Min:	15	0.04	29	34	0.01	0.04	0.5	0.8	2	10	10	10	0.1	0.2	11	10
	Max:	83	0.27	85	102	0.37	0.46	8.5	15.6	10	47	50	50	0.2	1.9	113	138
	Mean:	44	0.16	49	67	0.12	0.15	2.5	4.5	9	20	37	43	0.2	0.5	39	51
	Median:	33	0.18	46	64	0.09	0.12	2.0	3.4	10	17	50	50	0.2	0.4	28	39
BC WQG (chronic)		-	-	*50*	-	-	*0.05*	*1*	-	-	-	-	-	-	*3.6*	-	*7.5*
BC WQG (acute)		-	-	*100*	-	-	*0.08*	*7*	-	*350*	*1000*	-	-	-	*6.7*	-	*33*
MC-M2	16-Jan-19	38	0.04	32	51	0.37	0.41	3.4	6.1	10	14	21	55	0.2	0.2	108	128
MC-M2	6-Feb-19	55	0.04	40	67	0.20	0.23	2.8	5.0	10	20	4	53	0.2	0.5	78	90
MC-M2	20-Mar-19	34	0.05	42	58	0.08	0.09	1.3	2.5	10	15	2	52	0.2	0.2	30	38
MC-M2	3-Apr-19	17	0.02	46	61	0.10	0.11	7.4	11.6	10	21	6	54	0.2	0.6	31	39
MC-M2	1-May-19	23	0.03	42	55	0.17	0.10	3.8	2.6	10	22	2	52	2.2	0.5	54	37
MC-M2	12-Jun-19	14	0.05	26	31	0.03	0.06	0.7	1.2	10	10	5	52	0.2	0.4	12	11
MC-M2	17-Jul-19	17	0.04	26	33	0.04	0.05	0.8	2.0	5	10	9	19	0.1	0.2	10	16
MC-M2	7-Aug-19	55	0.40	72	88	0.10	0.13	1.9	2.8	10	10	2	52	0.2	0.3	33	40
MC-M2	11-Sep-19	66	0.21	59	74	0.15	0.18	2.4	4.1	10	13	8	57	0.2	0.9	44	56
MC-M2	9-Oct-19	34	0.13	27	43	0.08	0.09	1.5	2.1	2	9	3	12	0.1	0.3	21	27
MC-M2	14-Nov-19	38	0.21	61	75	0.09	0.11	1.9	4.0	10	15	4	52	0.2	1.2	29	49
MC-M2	10-Dec-19	34	0.16	37	48	0.02	0.03	2.2	3.4	10	10	5	52	0.3	0.7	29	40
	n	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Min:	14	0.02	26	31	0.02	0.03	0.7	1.2	2	9	2	12	0.1	0.2	10	11
	Max:	66	0.40	72	88	0.37	0.41	7.4	11.6	10	22	21	57	2.2	1.2	108	128
	Mean:	35	0.12	43	57	0.12	0.13	2.5	3.9	9	14	6	47	0.4	0.5	40	48
	Median:	34	0.05	41	56	0.09	0.10	2.0	3.1	10	14	5	52	0.2	0.4	30	39

Notes:

Shaded values denote a concentration that exceeds the chronic BC WQG

Red numbers denote a concentration that exceeds the acute BC WQG

Green numbers denote a concentration below the indicated reporting limit



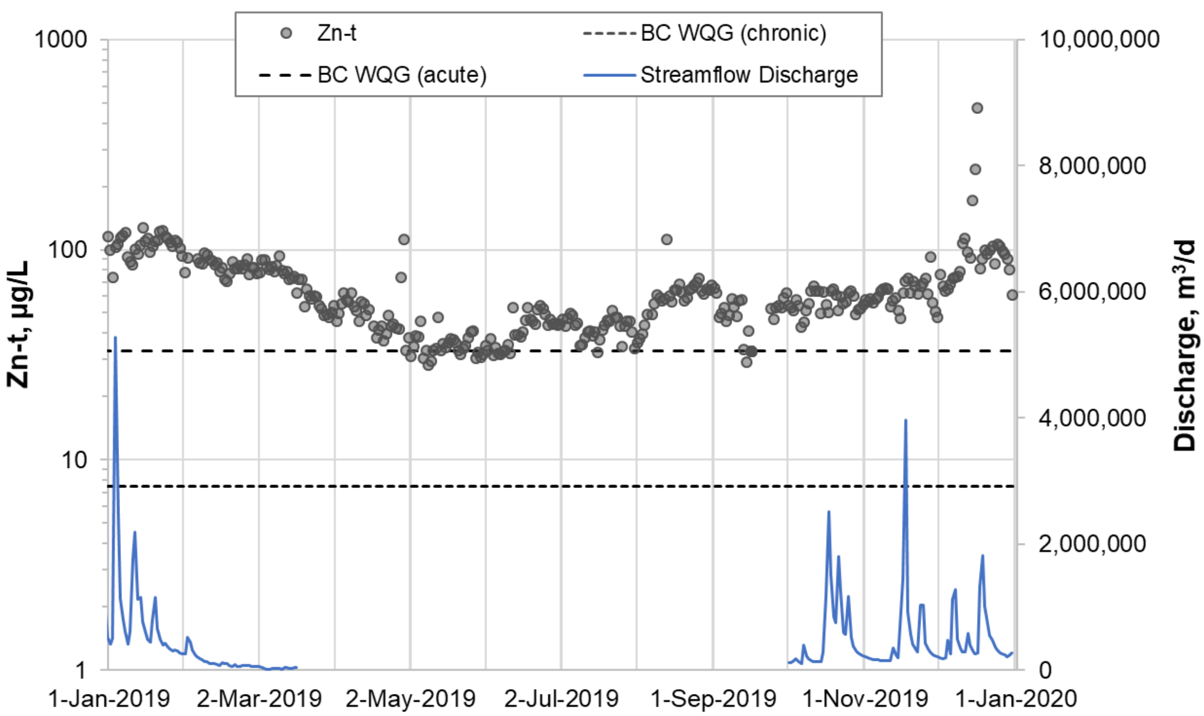
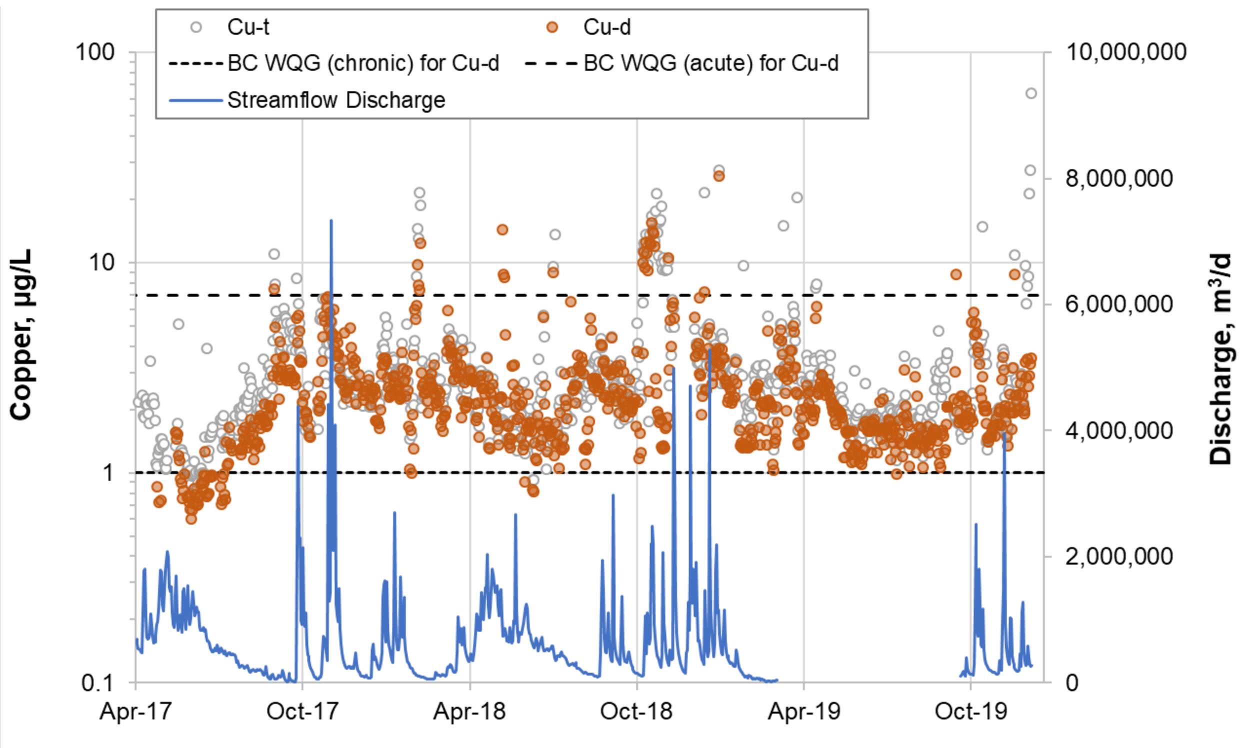


Figure 4-9. Zn-t Concentrations in Daily Composite Samples from Myra Creek at MC-TP4, April 2017 to December 2019 (Top) and 2019 (Bottom)



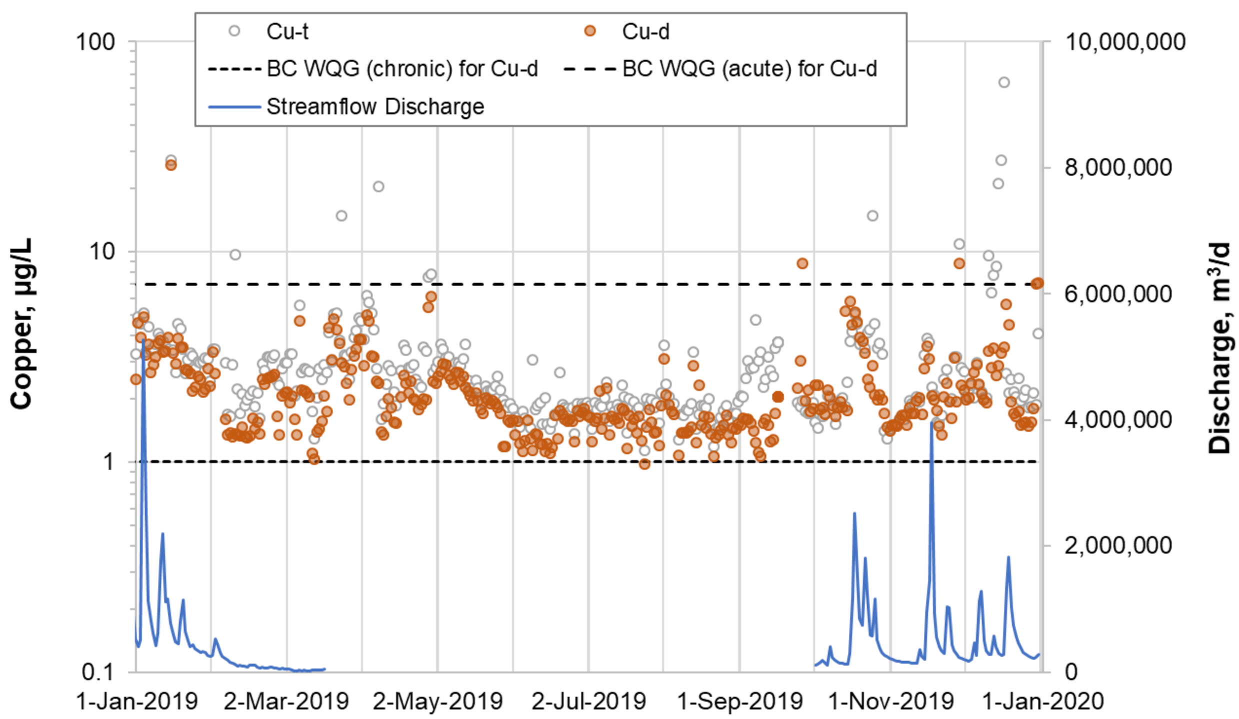
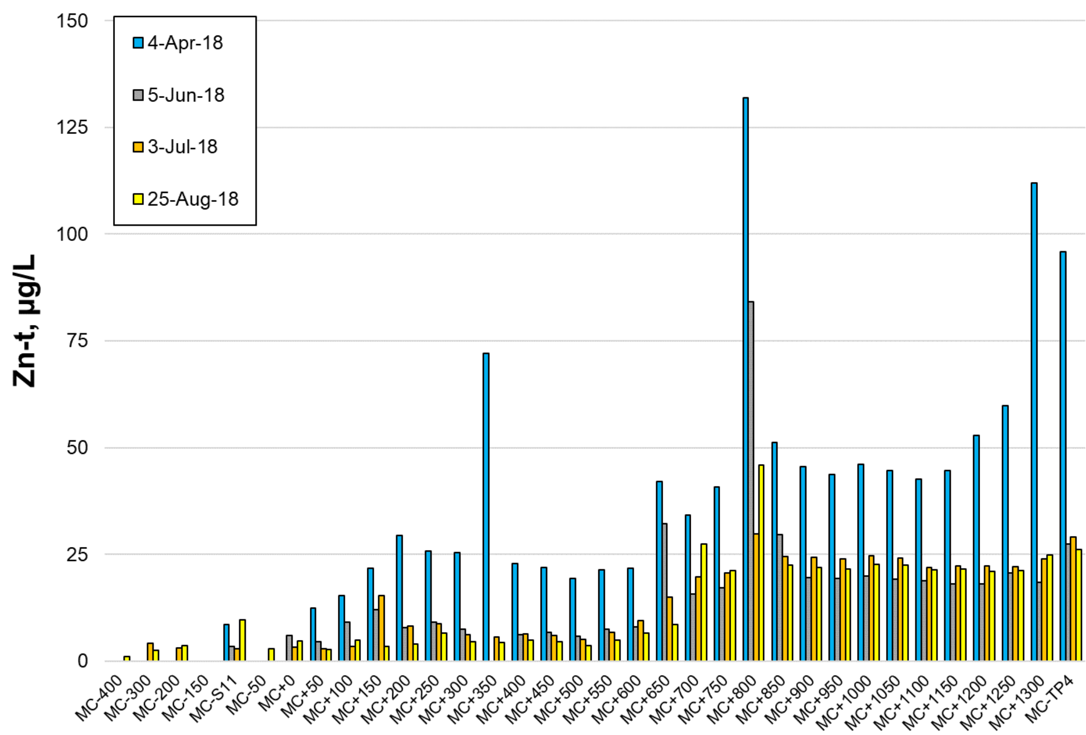


Figure 4-10. Cu-d and Cu-t Concentrations in Daily Composite Samples from Myra Creek at MC-TP4, April 2017 to December 2019 (Top) and 2019 (Bottom)



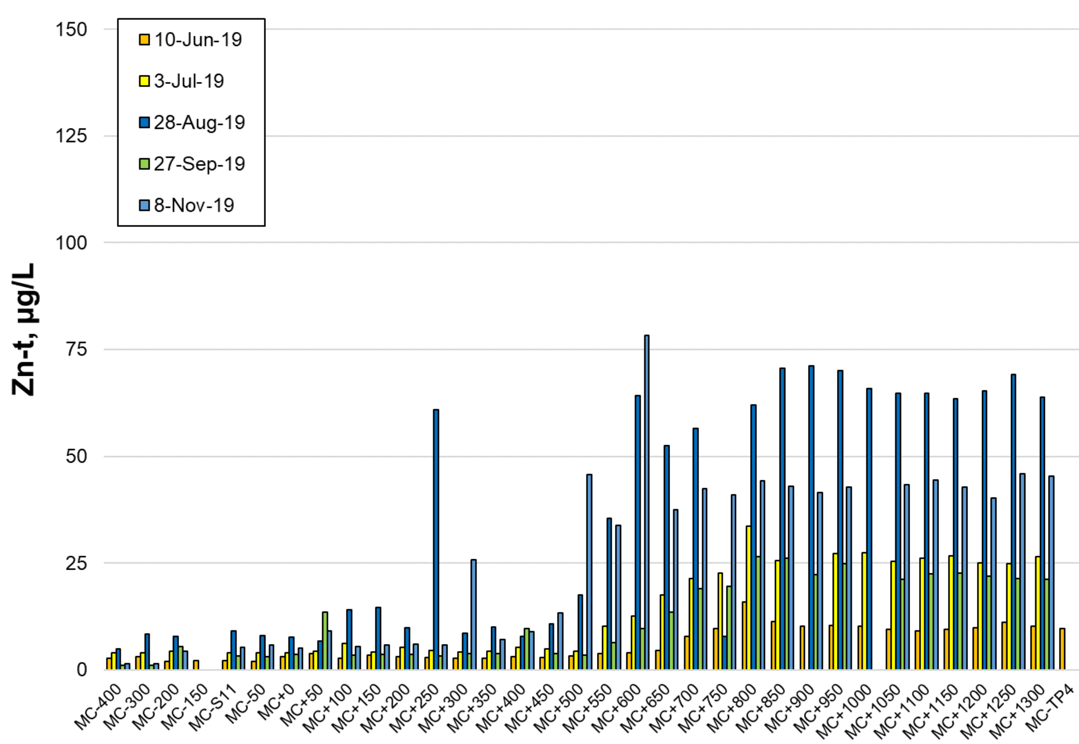


Figure 4-11. Zn-t Concentrations in Myra Creek from Monthly Surveys. 2018 Surveys (Top) and 2019 Surveys (Bottom)

4.6 MINE WATER FLOWS FROM PRICE 13L ADIT

4.6.1 *Flow Rates*

Flow rates are estimated during sampling with a bucket and stopwatch or by visual inspection. This flow is assumed to be the same for each day of the month to estimate the monthly discharge from the Price 13L adit to the Price Pond. In 2019, the annual discharge volume from the Price 13L adit was approximately 149,248 m^3. This is about 14% higher than the volume discharge in 2018, mainly due to higher flows in April and May 2019.

4.6.2 *Mine Water Quality*

Water quality results for mine water flowing from the Price 13L adit are summarized in **Table 4-7**. Mine water is circum-neutral to slightly alkaline (pH 7.3 to 8.5) and characterized by EC values of 130 to 366 μS/cm. Metal concentrations are often one or two orders-of-magnitude lower than discharge limits for Price 13L adit flows. One sample (collected in May 2019) was characterized by a Zn-t concentration (2.4 mg/L Zn-t) that exceeded the discharge limit. This sample was not, however, collected from the Price Pond but from a flow monitoring location upstream. Two duplicate samples confirmed this elevated Zn-t concentration in May 2019 and other metal concentrations that were elevated but did not exceed discharge limits.

Table 4-7.

Water Quality Results for Price 13L Adit, 2019

Station	Date	Flow Rate, m^3/day	Field pH	Field EC, uS/cm	Cu-d, mg/L	Cu-t, mg/L	Cd-d, mg/L	Pb-d, mg/L	Zn-d, mg/L	Zn-t, mg/L
Discharge limit		**3,450**	**6.5 to 8.5**	**-**	**0.2**	**0.6**	**0.005**	**0.05**	**0.5**	**1**
PR-13L	16-Jan-19	319	7.4	167	0.002	0.01	0.001	0.004	0.24	0.3
PR-13L	7-Feb-19	327	7.8	225	0.003	0.005	0.002	0.004	0.44	0.5
PR-13L	27-Mar-19	436	8.0	130	0.002	0.003	0.000	0.002	0.04	0.1
PR-13L	24-Apr-19	751	7.7	180	0.003	0.01	0.002	0.014	0.40	0.5
PR-13L	1-May-19	773	7.6	255	0.002	0.21	0.002	0.014	0.36	2.4
PR-13L	12-Jun-19	315	8.0	258	0.01	0.02	0.0006	0.012	0.16	0.3
PR-13L	17-Jul-19	340	8.2	366	0.004	0.01	0.0005	0.011	0.08	0.1
PR-13L	7-Aug-19	259	8.5	245	0.003	0.01	0.0004	0.007	0.05	0.1
PR-13L	11-Sep-19	288	8.1	246	0.003	0.01	0.0004	0.003	0.07	0.1
PR-13L	9-Oct-19	288	7.3	330	0.003	0.03	0.0005	0.014	0.10	0.5
PR-13L	14-Nov-19	288	7.8	337	0.002	0.01	0.0005	0.046	0.09	0.2
PR-13L	10-Dec-19	514	7.5	316	0.001	0.02	0.0003	0.032	0.07	0.4
PR-13L D	1-May-19	-	-	-	0.002	0.20	0.002	0.013	0.35	2.1
PR-13L D RS	1-May-19	-	-	-	0.002	0.20	0.002	0.014	0.36	2.0
PR-13L RS	1-May-19	-	-	-	0.002	0.23	0.002	0.014	0.36	2.3
PR-13L POND	22-May-19	-	-	-	-	0.01	-	-	-	0.1
PR-13L CULVER'	22-May-19	-	-	-	-	0.25	-	-	-	2.4

4.7 THELWOOD CREEK

4.7.1 *Streamflow Discharge*

Thelwood Creek is un-gauged.

4.7.2 *Water Quality in Thelwood Creek*

The water quality monitoring location for Thelwood Creek is shown in **Figure 4-12**. Quarterly grab samples from Thelwood Creek are collected voluntarily and analyzed for a standard suite of water quality parameters that includes total and dissolved metals (see **Table 4-8**).

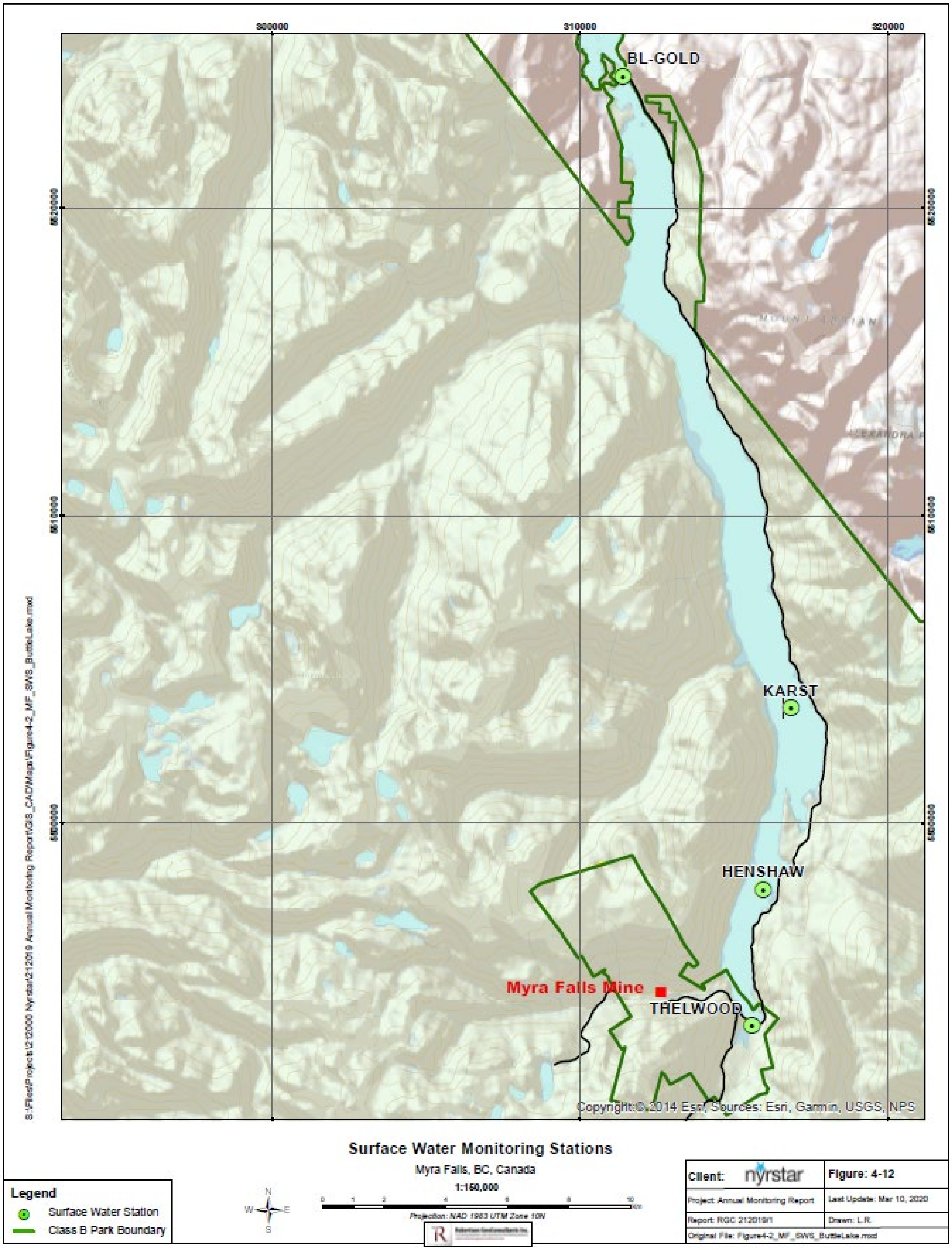
Thelwood Creek receives flows from the Price Pond, which collects mine water flowing from the nearby Price 13L adit. Most metal concentrations were below their respective reporting limits and there were no exceedances of BC WQGs in 2019.

Table 4-8.

Water Quality Results for Thelwood Creek, 2019

Station	Date	SO_4, mg/L	NO3 (N), mg/L	Al-d, ug/L	Al-t, ug/L	Cd-d, ug/L	Cd-t, ug/L	Cu-d, ug/L	Cu-t, ug/L	Fe-d, ug/L	Fe-t, ug/L	P-d, ug/L	P-t, ug/L	Pb-d, ug/L	Pb-t, ug/L	Zn-d, ug/L	Zn-t, ug/L
BC WQG (chronic)		-	-	*50*	-	-	*0.05*	*1*	-	-	-	-	-	-	*3.6*	-	*7.5*
BC WQG (acute)		-	-	*100*	-	-	*0.08*	*7*	-	*350*	*1000*	-	-	-	*6.7*	-	*33*
Thelwood Creek	27-Mar-19	1	0.032	23	24	0.010	0.010	0.4	0.4	10	10	50	50	0.2	0.2	4	4
Thelwood Creek	4-Sep-19	1	0.038	10	13	0.010	0.010	0.4	0.4	10	17	50	50	0.2	0.2	5	4
Thelwood Creek	18-Dec-19	2	0.056	34	51	0.010	0.010	0.4	0.4	10	24	50	50	0.2	0.2	4	4
	n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min:	1	0.032	10	13	0.010	0.010	0.4	0.4	10	10	50	50	0.2	0.2	4	4
	Max:	2	0.056	34	51	0.010	0.010	0.4	0.4	10	24	50	50	0.2	0.2	5	4
	Mean:	1	0.042	22	29	0.010	0.010	0.4	0.4	10	17	50	50	0.2	0.2	4	4
	Standard Deviation:	0	0.012	12	19	0.0	0.000	0.0	0.0	0	7	0	0	0.00	0.00	1	0
	Median:	1	0.038	23	24	0.010	0.010	0.4	0.4	10	17	50	50	0.2	0.2	4	4

Notes:
Shaded values denote a concentration that exceeds the chronic BC WQG
Red numbers denote a concentration that exceeds the acute BC WQG
Green numbers denote a concentration below the indicated reporting limit


300000
310000
320000
5520000
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BL-GOLD
MOUNT
KARST
HENSHAW
Myra Falls Mine
THELWOOD
Copyright:© 2014 Esri, Sources: Esri, Garmin, USGS, NPS
Surface Water Monitoring Stations
Myra Falls, BC, Canada
1:150,000
Projection: NAD 1983 UTM Zone 10N
Legend
Surface Water Station
Class B Park Boundary
Client: nyrstar
Figure: 4-12
Project: Annual Monitoring Report
Last Update: Mar 10, 2020
Report: RGC 212019/1
Drawn: L.R.
Original File: Figure4-2_MF_SWS_ButtleLake.mxd

4.8 BUTTLE LAKE

4.8.1 *Water Quality Results*

Water quality monitoring locations for Buttle Lake are shown in **Figure 4-12**. Depth water quality profiles are completed six times per year at the Henshaw Creek and Karst Creek stations and surface water samples are collected monthly at the Gold River bridge station. The Henshaw Creek station (EMS-ID 0130082) is 2.8 km from the base of Myra Falls. It is in the middle of Buttle Lake across from the Henshaw Creek delta. This is the station that is closest to the area where tailings discharged from 1967 to 1984 have accumulated at the bottom of Buttle Lake. The Karst Creek station is about 6 km further downstream of the Henshaw Creek station and is mid-lake from the Karst Creek boat ramp.

Samples at the Henshaw Creek and Karst Creek stations are collected at the lake surface (0 m) and at 10 m, 20 m, 40 m, 60 m, and 100 m below the lake surface using a Van Dorn or Kemmerer vertical sampler. Field parameters are recorded every 5 m to a depth of 50 m below the lake surface. Water samples are analyzed for a full suite of water quality parameters, including total and dissolved metals by ICP-MS, as required for Permit PE-0658.

Water quality results for the Henshaw Creek and Karst Creek stations are provided in **Table 4-9** and **4-10**, respectively. Water quality results for the Gold River bridge station are provided in **Table 4-11** and shown in **Figure 4-13** to **4-17**. A statistical summary of water quality results at the Gold River bridge stations is provided in **Table 4-12**. The data are summarized by water year, , which is defined here as the period from July 1 to June 30th. A water year is considered twelve months prior to July 1st, i.e. the 2018 water year consists of the 12 months prior to July 2018. The number of samples vary by year but at least twelve were collected for each water year. The statistical summary therefore provides a reasonable approximation of how concentrations have varied since 2008.

Key observations for Buttle Lake water quality are summarized below:

- **Henshaw Creek station**
  - Zn concentrations in Buttle Lake at the Henshaw Creek station are the highest of the three monitoring stations. This is due to the proximity of this station to Myra Creek, which is the largest input of Zn and metals to Buttle Lake.
  - Concentrations of Zn and other metals in 2019 at the Henshaw Creek were highest in February 2019 and had slightly decreased by April 2019. Cu-d, Mn-t, and Zn-t concentrations in each sample (all depths) exceeds long-term (chronic) BC WQGs. Mn-t concentrations exceeded the short-term (acute) BC WQG, whereas Cu-d and Zn-t were lower than the short-term BC WQG.
  - In June and August, concentrations of Zn and other metals in Buttle Lake at surface (0 m) and 10 m below surface decreased, e.g. to 4 – 6 µg/L Zn. Concentrations were 4 to 5 time lower than in February. This decrease is related to the dilution of shallow lake water

by large surface water flows from Myra Creek and other creeks to Buttle Lake during the spring freshet.

- In June and August, concentrations of Zn and other metals remain higher at depths below 20 m, as deeper pit water appears to be less diluted by surface flows from creeks. In October 2019, Zn and metal concentrations at depth are much lower by comparison, suggesting the lake is more thoroughly mixed and may have turned over. The highest metal concentrations in October were observed at surface, where Mn-t and Zn-t concentrations exceeded the long-term (chronic) BC WQG and Mn-t exceeded the short-term (acute) BC WQG.
- In December 2019, concentrations of Zn and other metals increased, which is consistent with the seasonal pattern observed from previous monitoring data. Zn-t and Mn-t concentrations in each of the samples collected at the Henshaw Creek station (all depths) exceeded the long-term (chronic) BC WQGs. Mn-t concentrations also exceeded the short-term (acute) BC WQG.
- The seasonal water quality trends and WQG exceedances are consistent with previous monitoring data.

- **Karst Creek station**
  - Zn concentrations in Buttle Lake at the Karst Creek station are about 50% lower than at the Henshaw Creek station. Lower concentrations at the Karst Creek station are related to the greater distance between the Karst Creek station and the base of Myra Falls, where impacted creek water enters Buttle Lake.
  - The seasonal pattern at the Karst Creek station is similar the pattern at the Henshaw Creek station, as the highest concentrations of Zn and other metals were observed in February and the lowest concentrations were observed in October 2019. Mn-t and Zn-t concentrations in each of the samples collected in February 2019 and April 2019 (all depths) exceeded long-term (chronic) BC WQGs. Mn-t concentrations exceeded the short-term (acute) BC WQG and Cu-d in two samples from February 2019 exceed the long-term BC WQG.
  - None of the samples collected in August 2019, October 2019, or December 2019 exceeded the long-term (chronic) BC WQG for Zn-t. Mn-t concentrations exceeded the long-term and short-term BC WQGs in each of these months at all depths. The Pb-t concentration in the sample from 10 m below the lake surface in December 2019 exceeded the long-term (chronic) BC WQG and was lower than the short-term BC WQG.
  - The seasonal water quality trends and WQG exceedances are consistent with previous monitoring data.
- **Gold River bridge station.**

- Monthly surface samples (0 m) from the Gold River bridge station are consistent the seasonal pattern that is evident at the Henshaw Creek and Karst Creek stations upstream (nearer the base of Myra Falls). Specifically, Zn and Mn (and some other metals) were highest from February to April 2019 and lower from June to December 2019.
- The highest Zn-t concentration (17 µg/L) was observed in April 2019. The Zn-t concentration in April 2019 is one of the highest observed since 2008 and is approximately 2.5 times higher than the chronic BC WQG and about 50% of the short-term (acute) BC WQG.

Table 4-9.

Water Quality Results for Buttle Lake at Henshaw Creek Station

Station	Date	Field pH	Lab pH	EC, mS/cm	Temp, C	DO-F, mg/L	TSS, mg/L	Turbidity, NTU	Alkalinity, mg/L as $CaCO_3$	Ca-d, mg/L	Ca-t, mg/L	SO4, mg/L	N (as NH3), mg/L	NO3 (N), mg/L	Mg-d, mg/L	Mg-t, mg/L	Al-t, ug/L	Al-d, ug/L	Cd-t, ug/L	Cd-d, ug/L	Cu-t, ug/L	Cu-d, ug/L	Fe-t, ug/L	Fe-d, ug/L	Mn-t, ug/L	Mn-d, ug/L	P-t, ug/L	P-d, ug/L	Pb-t, ug/L	Pb-d, ug/L	Zn-t, ug/L	Zn-d, ug/L
BC WQG (Chronic)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*50*	-	*0.09*	-	*1*	-	-	*0.7*	-	-	-	*4.0*	-	*7.5*	-
BC WQG (Acute)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*100*	-	*0.16*	-	*7*	*1000*	*350*	*0.9*	-	-	-	*16.8*	-	*33*	-
BL-HEN-0	07-Feb-19	7.4	7.3	0.061	3.8	13	2	0.1	23	9	8	6	0.02	0.02	1	1	44	27	0.06	0.07	1.7	1.5	13	10	3.4	2.4	50	53	0.20	0.20	21	21
BL-HEN-5	07-Feb-19	7.3	-	0.062	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-10	07-Feb-19	7.2	7.3	0.062	3.8	13	2	0.1	22	9	8	6	0.02	0.02	1	1	36	27	0.07	0.06	1.5	1.5	15	13	3.5	2.4	50	53	0.20	0.20	21	21
BL-HEN-15	07-Feb-19	7.2	-	0.061	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	07-Feb-19	7.2	7.3	0.061	3.8	13	2	0.1	22	9	9	6	0.02	0.03	1	1	35	27	0.07	0.07	1.7	1.4	14	10	3.5	2.3	50	53	0.20	0.20	22	21
BL-HEN-25	07-Feb-19	7.2	-	0.061	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-30	07-Feb-19	7.2	-	0.061	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-35	07-Feb-19	7.2	-	0.061	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-40	07-Feb-19	7.2	7.3	0.061	3.8	13	2	0.1	23	9	8	7	0.02	0.03	1	1	38	28	0.07	0.07	1.8	1.5	24	10	3.8	2.4	50	53	0.20	0.20	29	22
BL-HEN-45	07-Feb-19	7.2	-	0.061	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-50	07-Feb-19	7.2	-	0.060	3.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-60	07-Feb-19	-	7.4	-	-	-	2	0.2	23	9	8	7	0.02	0.03	1	1	35	27	0.07	0.07	1.6	1.8	14	10	3.5	2.5	50	54	0.20	0.20	20	21
BL-HEN-100	07-Feb-19	-	7.3	-	-	-	2	0.1	23	8	10	6	0.02	0.03	1	1	37	27	0.06	0.08	2.1	2.4	16	10	3.7	4.4	50	53	0.20	0.23	20	33
BL-HEN-0	25-Apr-19	7.8	7.5	0.060	8.2	13	2	0.3	26	9	9	6	0.02	0.03	1	1	18	13	0.04	0.03	1.0	0.6	20	6	5.5	0.1	10	12	0.05	0.05	10	8
BL-HEN-5	25-Apr-19	7.4	-	0.063	7.2	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-10	25-Apr-19	7.4	7.5	0.063	6.2	13	2	0.2	24	9	10	7	0.02	0.03	1	1	26	16	0.04	0.03	1.0	0.6	32	14	8.8	0.8	10	12	0.07	0.05	12	10
BL-HEN-15	25-Apr-19	7.3	-	0.063	5.6	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	25-Apr-19	7.3	7.4	0.063	5.3	13	2	0.2	24	9	10	8	0.03	0.02	1	1	31	19	0.05	0.04	1.4	0.7	37	12	9.9	4.1	10	12	0.09	0.05	14	12
BL-HEN-25	25-Apr-19	7.3	-	0.064	5.0	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-30	25-Apr-19	7.2	-	0.065	4.6	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-35	25-Apr-19	7.2	-	0.066	4.3	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-40	25-Apr-19	7.2	7.5	0.067	4.2	12	2	0.2	26	9	10	9	0.06	0.03	1	1	28	17	0.05	0.05	2.8	0.8	28	6	8.6	3.8	10	12	0.08	0.05	18	15
BL-HEN-45	25-Apr-19	7.2	-	0.067	4.0	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-50	25-Apr-19	7.2	-	0.067	3.9	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-60	25-Apr-19	-	7.5	-	-	-	2	0.2	25	10	10	9	0.07	0.02	1	1	26	18	0.06	0.05	1.3	0.9	22	4	7.8	2.6	10	12	0.09	0.05	17	16
BL-HEN-100	25-Apr-19	-	7.5	-	-	-	2	0.3	26	10	11	9	0.05	0.03	1	1	29	17	0.06	0.05	1.3	0.8	23	4	8.6	3.4	10	12	0.08	0.05	18	16
BL-HEN-0	19-Jun-19	-	7.3	0.054	16.5	29	2	0.2	21	8	8	4	0.04	0.02	1	1	17	13	0.02	0.02	0.8	0.6	157	4	2.8	1.3	10	12	0.05	0.05	6	5
BL-HEN-5	19-Jun-19	-	-	0.056	16.1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-10	19-Jun-19	-	7.3	0.055	15.3	19	3.3	0.2	18	8	8	5	0.02	0.02	1	1	20	14	0.02	0.02	0.7	0.6	44	14	2.4	1.6	10	13	0.05	0.05	6	6
BL-HEN-15	19-Jun-19	-	-	0.055	11.8	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	19-Jun-19	-	7.3	0.058	8.7	14	3.3	0.2	18	8	8	5	0.03	0.02	1	1	19	14	0.02	0.02	0.8	0.6	13	8	2.3	0.9	10	13	0.05	0.05	8	7
BL-HEN-25	19-Jun-19	-	-	0.061	7.3	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-30	19-Jun-19	-	-	0.063	6.2	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-35	19-Jun-19	-	-	0.065	5.5	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-40	19-Jun-19	-	7.3	0.066	4.9	11	2	0.2	21	9	10	7	0.02	0.03	1	1	21	13	0.04	0.04	1.2	0.9	26	23	7.9	3.7	10	13	0.07	0.05	13	12
BL-HEN-45	19-Jun-19	-	-	0.067	4.7	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-50	19-Jun-19	-	-	0.067	4.6	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-60	19-Jun-19	-	7.3	-	-	-	2	0.2	21	9	10	8	0.03	0.03	1	1	22	14	0.05	0.04	1.3	1.0	24	10	9.8	5.1	10	12	0.08	0.05	16	14
BL-HEN-100	19-Jun-19	-	7.3	-	-	-	2	0.2	21	9	10	8	0.03	0.04	1	1	22	14	0.06	0.05	1.4	1.2	50	10	11.6	6.7	10	13	0.31	0.34	17	14
BL-HEN-0	21-Aug-19	7.8	7.3	-	19.7	9	2	0.2	23	8	9	5	0.02	0.01	1	1	15	13	0.02	0.02	0.6	0.6	8	4	1.7	0.3	10	12	0.05	0.05	4	4
BL-HEN-5	21-Aug-19	7.7	-	0.061	19.5	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-10	21-Aug-19	7.6	7.4	0.061	19.4	9	2	0.2	23	9	9	5	0.02	0.01	1	1	19	13	0.02	0.01	0.7	0.6	23	15	2.4	0.4	10	13	0.05	0.05	5	4
BL-HEN-15	21-Aug-19	7.5	-	0.063	17.2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	21-Aug-19	7.4	-	0.060	10.8	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	21-Aug-19	7.4	7.3	0.061	8.5	11	2	0.2	24	8	9	5	0.03	0.01	1	1	14	12	0.02	0.02	1.5	0.7	9	20	2.6	1.0	10	12	0.05	0.05	8	7
BL-HEN-30	21-Aug-19	7.4	-	0.063	7.4	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-35	21-Aug-19	7.3	-	0.066	6.3	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-40	21-Aug-19	7.2	7.3	0.067	6.0	11	2	0.2	24	9	10	7	0.03	0.02	1	1	16	11	0.04	0.04	1.0	0.9	17	8	7.1	4.1	10	12	0.05	0.05	12	11
BL-HEN-45	21-Aug-19	7.2	-	0.067	5.8	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-50	21-Aug-19	7.2	-	0.068	5.5	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-60	21-Aug-19	-	7.3	-	-	-	2	0.2	25	9	10	7	0.02	0.02	1	1	17	11	0.04	0.04	1.1	1.0	19	8	8.6	5.1	10	12	0.06	0.05	14	12
BL-HEN-100	21-Aug-19	-	7.3	-	-	-	2	0.2	23	9	9	6	0.03	0.02	1	1	17	12	0.03	0.03	2.3	0.9	18	6	6.1	3.6	10	12	0.29	0.05	12	8
BL-HEN-0	17-Oct-19	9.1	7.4	0.064	13.2	6	2	0.2	24	9	9	5	0.06	0.02	1	1	18	12	0.02	0.02	3.2	0.9	12	4	1.6	0.2	10	12	1.51	0.13	8	5
BL-HEN-5	17-Oct-19	9.0	-	0.064	13.2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-10	17-Oct-19	9.0	7.4	0.065	13.0	4	2	0.2	24	9	9	5	0.05	0.02	1	1	14	12	0.02	0.02	0.7	0.5	11	4	1.6	0.2	10	12	0.15	0.13	5	4
BL-HEN-15	17-Oct-19	8.9	-	0.061	12.2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	17-Oct-19	8.8	7.4	0.063	7.8	4	2	0.2	25	9	9	5	0.06	0.01	1	1	15	12	0.02	0.02	0.8	1.1	10	3	1.6	0.3	10	12	0.19	0.06	5	8
BL-HEN-30	17-Oct-19	8.8	-	0.066	6.9	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-35	17-Oct-19	8.7	-	0.068	6.2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-40	17-Oct-19	8.6	7.4	0.069	5.6	4	2	0.2	24	9	9	5	0.07	0.02	1	1	16	12	0.02	0.02	0.7	1.0	13	5	2.0	0.4	10	12	0.13	0.05	5	5
BL-HEN-50	17-Oct-19	8.6	-	0.070	5.3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-60	17-Oct-19	-	7.4	-	-	-	2	0.3	23	8	9	5	0.06	0.02	1	1	20	13	0.02	0.02	0.8	0.6	16	5	1.9	0.4	10	12	0.15	0.05	5	4
BL-HEN-100	17-Oct-19	-	7.4	-	-	-	2	0.2	25	9	9	5	0.09	0.03	1	1	16	9	0.02	0.02	1.4	0.8	20	3	2.0	0.3	10	12	0.25	0.15	7	11
BL-HEN-0	04-Dec-19	6.5	7.5	0.041	6.9	11	-	0.3	28	9	9	5	0.06	0.01	1	1	26	17	0.03	0.02	1.6	0.6	19	5	2.6	1.2	11	12	0.15	0.05	8	7
BL-HEN-10	04-Dec-19	-	7.5	-	-	-	-	0.2	73	9	9	5	0.06	0.01	1	1	26	17	0.02	0.02	0.8	0.7	18	6	2.7	1.3	13	12	0.09	0.23	10	7
BL-HEN-20	04-Dec-19	-	7.6	-	-	-	-	0.2	26	9	9	5	0.05	0.01	1	1	25	18	0.02	0.03	0.8	0.7	16	6	2.7	1.3	10	12	0.12	0.21	7	7
BL-HEN-40	04-Dec-19	-	7.6	-	-	-	-	0.2	25	9	9	6	0.05	0.01	1	1	27	18	0.03	0.02	0.9	0.7	17	8	2.7	1.2	10	12	0.16	0.16	8	7
BL-HEN-60	04-Dec-19	-	7.6	-	-	-	-	0.3	26	9	9	6	0.05	0.01	1	1	26	18	0.02	0.02	0.9	0.7	16	5	2.8	1.4	10	12	0.12	0.08	8	8
BL-HEN-100	04-Dec-19	-	7.6	-	-	-	-	0.2	25	9	10	6	0.04	0.01	1	1	28	19	0.03	0.03	1.1	0.9	18	6	3.5	2.0	11	12	0.18	0.07	8	11
BL-HEN-5	17-Dec-19	6.5	-	0.041	6.9	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-10	17-Dec-19	6.6	-	0.041	6.9	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-15	17-Dec-19	6.6	-	0.041	6.8	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-20	17-Dec-19	6.6	-	0.041	6.8	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-25	17-Dec-19	6.6	-	0.042	6.7	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-30	17-Dec-19	6.6	-	0.042	6.6	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-35	17-Dec-19	6.6	-	0.042	6.6	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-40	17-Dec-19	6.6	-	0.043	6.5	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-45	17-Dec-19	6.5	-	0.043	6.4	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-HEN-50	17-Dec-19	6.5	-	0.043	5.8	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Duplicates																																
BL-HEN-0 D	25-Apr-19	-	7.5	-	-	-	2	0.3	26	9	10	6	0.03	0.03	1	1	20	12	0.03	0.03	1.0	0.5	20	5	5.8	0.1	10	12	0.06	0.05	11	8
BL-HEN-0 D	19-Jun-19	-	7.3	-	-	-	2	0.2	18	8	8	4	0.03	0.02	1	1	17	13	0.02	0.01	0.7	0.9	8	5	1.8	1.3	10	13	0.05	0.06	5	5

Notes:
Shaded cells indicate concentrations exceed the long-term (chronic) BC WQG
Concentrations in red indicate a concentration that exceeds the acute (short-term) BC WQG

Table 4-10.

Water Quality Results for Buttle Lake at Karst Creek Station

Station	Date	Field pH	Lab pH	EC, mS/cm	Temp, C	DO-F, mg/L	TSS, mg/L	Turbidity, NTU	Alkalinity, mg/L as $CaCO_3$	Ca-d, mg/L	Ca-t, mg/L	SO4, mg/L	N (as NH3), mg/L	NO3 (N), mg/L	Mg-d, mg/L	Mg-t, mg/L	Al-t, ug/L	Al-d, ug/L	Cd-t, ug/L	Cd-d, ug/L	Cu-t, ug/L	Cu-d, ug/L	Fe-t, ug/L	Fe-d, ug/L	Mn-t, ug/L	Mn-d, ug/L	P-t, ug/L	P-d, ug/L	Pb-t, ug/L	Pb-d, ug/L	Zn-t, ug/L	Zn-d, ug/L
BC WQG (Chronic)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*50*	-	*0.09*	-	*1*	-	-	*0.7*	-	-	-	*4.0*	-	*7.5*	-
BC WQG (Acute)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*100*	-	*0.16*	-	*7*	*1000*	*350*	*0.9*	-	-	-	*16.8*	-	*33*	-
BL-KARS-0	07-Feb-19	8.0	7.3	0.055	4.7	13	2	0.1	24	8	8	4	0.02	0.03	0.8	0.8	19	14	0.03	0.03	1.2	0.8	10	10	1.7	0.9	50	53	0.20	0.20	12	10
BL-KARS-5	07-Feb-19	7.6	-	0.055	4.7	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10	07-Feb-19	7.4	7.3	0.057	4.7	15	2	0.1	25	8	9	4	0.02	0.03	0.8	0.8	22	15	0.03	0.03	1.2	0.9	10	10	1.8	0.8	50	54	0.20	0.20	12	11
BL-KARS-15	07-Feb-19	7.4	-	0.057	4.7	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-20	07-Feb-19	7.3	7.3	0.058	4.7	13	2	0.1	24	8	8	4	0.02	0.03	0.8	0.7	19	17	0.03	0.03	1.1	1.2	10	10	1.7	0.9	50	52	0.20	0.33	10	13
BL-KARS-25	07-Feb-19	7.3	-	0.057	4.7	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-30	07-Feb-19	7.2	-	0.057	4.7	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-35	07-Feb-19	7.2	-	0.057	4.7	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-40	07-Feb-19	7.3	7.3	0.057	4.7	12	2	0.1	25	8	8	4	0.02	0.03	0.8	0.8	19	14	0.02	0.03	0.9	0.8	10	10	1.6	0.9	50	52	0.20	0.20	11	10
BL-KARS-45	07-Feb-19	7.2	-	0.057	4.7	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-50	07-Feb-19	7.2	-	0.057	4.7	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-60	07-Feb-19	-	7.5	-	-	-	2	0.1	28	8	9	4	0.02	0.03	0.7	0.8	21	16	0.11	0.03	1.0	1.1	10	10	1.9	1.0	50	52	0.20	0.37	10	11
BL-KARS-100	07-Feb-19	-	7.5	-	-	-	2	0.3	28	8	8	4	0.02	0.03	0.7	0.8	20	14	0.03	0.03	0.9	0.8	10	10	1.7	0.8	50	52	0.20	0.20	10	10
BL-KARS-0	25-Apr-19	7.5	7.6	0.061	7.7	13	2	0.2	28	9	10	5	0.02	0.03	0.8	0.8	18	11	0.03	0.03	2.4	0.6	16	3	3.9	0.3	10	17	0.12	0.05	10	9
BL-KARS-5	25-Apr-19	7.5	-	0.061	7.0	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10	25-Apr-19	7.5	7.6	0.060	6.9	11	2	0.2	27	9	9	5	0.05	0.03	0.8	0.8	16	11	0.03	0.02	0.8	0.5	13	4	3.6	0.2	10	12	0.05	0.05	8	8
BL-KARS-15	25-Apr-19	7.5	-	0.060	6.7	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-20	25-Apr-19	7.5	7.6	0.060	6.5	11	2	0.2	27	9	9	5	0.04	0.03	0.8	0.8	17	13	0.03	0.02	1.0	0.5	14	5	3.6	0.2	10	12	0.05	0.05	8	7
BL-KARS-25	25-Apr-19	7.4	-	0.060	5.9	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-30	25-Apr-19	7.4	-	0.059	5.7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-35	25-Apr-19	7.4	-	0.060	5.3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-40	25-Apr-19	7.4	7.5	0.059	5.2	11	2	0.2	27	9	9	4	0.02	0.03	0.8	0.8	16	11	0.03	0.02	0.9	0.5	10	3	2.5	0.8	10	12	0.08	0.05	8	8
BL-KARS-45	25-Apr-19	7.3	-	0.059	4.9	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-60	25-Apr-19	7.3	7.5	0.059	4.7	10	2	0.2	27	9	9	4	0.03	0.03	0.8	0.8	17	12	0.03	0.02	0.8	0.6	7	2	2.1	0.8	10	12	0.05	0.05	9	8
BL-KARS-100	25-Apr-19	-	7.5	-	-	-	2	0.2	26	9	9	4	0.03	0.04	0.8	0.8	17	11	0.02	0.02	1.6	0.5	8	2	2.2	0.8	10	12	0.08	0.05	9	7
BL-KARS-0	19-Jun-19	-	7.3	0.058	16.8	8	2	0.2	21	8	8	3	0.03	0.01	0.7	0.8	15	11	0.02	0.02	0.9	0.6	14	5	1.5	1.1	10	14	0.14	0.05	5	5
BL-KARS-5	19-Jun-19	-	-	0.058	16.2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10	19-Jun-19	-	7.3	0.057	15.7	5	2	0.2	21	8	7	4	0.03	0.01	0.7	0.8	15	11	0.01	0.01	0.7	0.6	14	3	1.5	0.9	10	13	0.05	0.05	5	4
BL-KARS-15	19-Jun-19	-	-	0.058	13.2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-20	19-Jun-19	-	7.3	0.059	10.9	6	2	0.2	22	8	8	4	0.04	0.02	0.7	0.8	18	11	0.03	0.02	1.1	0.6	35	28	2.2	1.1	10	13	0.05	0.05	7	7
BL-KARS-25	19-Jun-19	-	-	0.061	7.2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-30	19-Jun-19	-	-	0.061	6.1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-35	19-Jun-19	-	-	0.060	5.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-40	19-Jun-19	-	7.3	0.060	5.3	7	2	0.1	22	8	9	4	0.03	0.03	0.8	0.8	15	9	0.02	0.02	0.8	0.6	16	4	2.8	0.9	10	13	0.05	0.05	8	6
BL-KARS-45	19-Jun-19	-	-	0.060	5.0	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-50	19-Jun-19	-	-	0.060	4.9	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-60	19-Jun-19	-	7.3	-			2	0.1	22	8	9	4	0.02	0.03	0.8	0.8	14	9	0.02	0.02	0.8	0.7	11	4	2.6	1.0	10	13	0.05	0.05	8	6
BL-KARS-100	19-Jun-19	-	7.3	-			3.3	0.2	22	8	9	4	0.02	0.03	0.8	0.9	16	9	0.03	0.01	0.9	0.7	24	4	2.9	1.1	10	13	0.07	0.05	8	7
BL-KARS-0	21-Aug-19	7.6	7.4	0.059	19.8	9	2	0.2	24	8	9	4	0.04	0.01	0.7	0.8	15	12	0.02	0.01	0.8	0.7	8	4	1.5	0.3	10	14	0.07	0.07	6	4
BL-KARS-5	21-Aug-19	7.6	-	0.059	19.6	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10	21-Aug-19	7.6	7.3	0.059	19.5	9	2	0.2	22	8	9	4	0.02	0.01	0.7	0.8	14	12	0.01	0.01	0.6	0.6	10	3	1.5	0.2	10	12	0.05	0.05	4	4
BL-KARS-20	21-Aug-19	7.5	7.4	0.060	10.2	11	2	0.2	23	8	9	4	0.02	0.01	0.7	0.7	16	11	0.01	0.01	0.6	0.5	6	2	1.3	0.3	10	13	0.05	0.05	4	4
BL-KARS-25	21-Aug-19	7.4	-	0.060	7.1	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-30	21-Aug-19	7.3	-	0.060	6.3	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-35	21-Aug-19	7.3	-	0.060	6.0	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-40	21-Aug-19	7.3	7.3	0.060	5.8	12	2	0.2	24	8	8	4	0.02	0.02	0.8	0.8	18	9	0.02	0.02	0.7	0.7	7	2	1.9	0.6	10	12	0.05	0.05	9	6
BL-KARS-45	21-Aug-19	7.3	-	0.060	5.8	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-50	21-Aug-19	7.3	-	0.060	5.7	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-60	21-Aug-19	-	7.3	-			2	0.1	23	9	9	4	0.03	0.02	0.8	0.8	12	9	0.02	0.02	0.8	0.5	7	2	2.0	0.2	10	12	0.05	0.05	7	7
BL-KARS-100	21-Aug-19	7.5	7.3	0.059	15.9	10	2	0.1	23	8	9	4	0.02	0.02	0.8	0.8	12	9	0.02	0.02	0.8	0.7	8	3	2.2	0.7	10	18	0.05	0.05	7	6
BL-KARS-0	17-Oct-19	8.9	7.4	0.062	13.4	5	2	0.2	24	9	9	4	0.12	0.01	0.7	0.7	13	11	0.01	0.01	0.6	0.7	8	2	1.1	0.2	10	12	0.05	0.05	4	4
BL-KARS-5	17-Oct-19	8.8	-	0.062	13.3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10	17-Oct-19	8.8	7.3	0.062	13.3	3	2	0.2	25	9	9	4	0.07	0.01	0.7	0.7	13	14	0.02	0.01	0.7	0.6	8	3	1.2	0.2	10	12	0.08	0.13	4	5
BL-KARS-15	17-Oct-19	8.8	-	0.063	12.0	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-20	17-Oct-19	8.7	7.4	0.063	8.5	3	2	0.2	23	9	9	4	0.04	0.01	0.7	0.8	14	10	0.02	0.01	0.7	0.5	10	3	1.2	0.2	10	12	0.15	0.05	4	4
BL-KARS-25	17-Oct-19	8.7	-	0.062	6.4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-30	17-Oct-19	8.7	-	0.062	6.0	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-35	17-Oct-19	8.6	-	0.062	5.8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-40	17-Oct-19	8.6	7.4	0.061	5.6	3	2	0.2	24	9	9	4	0.05	0.01	0.7	0.7	13	11	0.01	0.02	2.2	0.8	13	3	1.4	0.2	10	12	0.21	0.09	6	10
BL-KARS-45	17-Oct-19	8.6	-	0.061	5.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-50	17-Oct-19	8.5	-	0.061	5.4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-60	17-Oct-19	-	7.4	-	-	-	2	0.2	25	9	9	4	0.06	0.02	0.7	0.8	12	8	0.02	0.02	0.8	0.8	8	3	1.3	0.2	10	12	0.11	0.05	7	8
BL-KARS-100	17-Oct-19	-	7.4	-	-	-	2	0.2	24	8	9	4	0.07	0.01	0.7	0.8	12	10	0.03	0.02	0.6	0.7	8	2	1.2	0.2	10	12	0.07	0.07	5	10
BL-KARS-0	04-Dec-19	-	7.5	-	-	-	-	0.2	28	9	9	4	0.06	0.01	0.7	0.8	18	12	0.02	0.02	0.7	0.5	11	3	1.3	0.4	11	12	0.09	0.05	6	5
BL-KARS-10	04-Dec-19	-	7.5	-	-	-	2	0.3	27	9	9	4	0.04	0.01	0.7	0.8	19	13	0.02	0.01	1.2	0.6	12	3	1.4	0.4	10	12	8.70	0.52	6	5
BL-KARS-100	04-Dec-19	-	7.5	-	-	-	-	0.2	27	9	9	4	0.06	0.01	0.8	0.8	16	10	0.02	0.02	0.7	0.6	10	3	1.5	0.4	13	12	0.12	0.05	6	6
BL-KARS-20	04-Dec-19	-	7.5	-	-	-	-	0.2	26	9	9	4	0.05	0.01	0.7	0.8	19	12	0.02	0.02	0.7	0.6	11	3	1.3	0.4	10	12	0.05	0.05	5	5
BL-KARS-40	04-Dec-19	-	7.5	-	-	-	-	0.2	28	8	9	4	0.06	0.01	0.7	0.8	19	12	0.02	0.02	0.7	0.5	12	3	1.3	0.4	10	12	0.12	0.05	5	5
BL-KARS-60	04-Dec-19	-	7.5	-	-	-	-	0.3	27	9	9	4	0.10	0.01	0.7	0.8	19	13	0.02	0.02	0.7	0.6	14	4	1.4	0.5	12	12	0.10	0.05	7	5
BL-KARS-0	17-Dec-19	6.4	-	0.040	7.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10	17-Dec-19	6.6	-	0.040	7.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-15	17-Dec-19	6.5	-	0.040	7.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-20	17-Dec-19	6.6	-	0.040	7.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-25	17-Dec-19	6.7	-	0.040	7.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-30	17-Dec-19	6.7	-	0.040	6.9	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-35	17-Dec-19	6.6	-	0.039	6.6	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-40	17-Dec-19	6.6	-	0.038	6.6	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-45	17-Dec-19	6.6	-	0.038	6.1	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-5	17-Dec-19	6.5	-	0.040	7.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-50	17-Dec-19	6.6	-	0.038	6.0	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Duplicates							-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL-KARS-10 D	07-Feb-19	-	7.5	-	-	-	2	0.1	27	8	8	4	0.02	0.03	0.8	0.8	22	15	0.03	0.03	1.1	1.0	11	10	1.7	0.9	50	52	0.20	0.20	12	12
BL-KARS-10 D	21-Aug-19	-	7.4	-	-	-	3.3	0.2	24	8	9	4	0.03	0.01	0.7	0.8	15	11	0.01	0.01	0.6	0.7	7	3	1.4	0.2	10	12	0.05	0.05	4	3

Notes:
Shaded cells indicate concentrations exceed the long-term (chronic) BC WQG
Concentrations in red indicate a concentration that exceeds the acute (short-term) BC WQG

Table 4-11.

Monthly Grab Samples from Buttle Lake at Gold River Station

Station	Date	Alkalinity, mg/L as $CaCO_3$	Ca-d, mg/L	Ca-t, mg/L	Al-t, ug/L	Al-d, ug/L	Cd-t, ug/L	Cd-d, ug/L	Cu-t, ug/L	Cu-d, ug/L	Fe-t, ug/L	Fe-d, ug/L	Pb-t, ug/L	Pb-d, ug/L	Mn-t, ug/L	Mn-d, ug/L	Zn-t, ug/L	Zn-d, ug/L
BC WQG (Chronic)		-	-	-	-	*50*	-	*0.09*	-	*1*	-	-	*4.0*	-	*0.7*	-	*7.5*	-
BC WQG (Acute)		-	-	-	-	*100*	-	*0.16*	-	*7*	*1000*	*350*	*16.8*	-	*0.9*	-	*33*	-
BL-GOLD	16-Jan-19	24.6	8	8	18	16	0.02	0.02	0.7	0.67	10	10	0.2	0.2	1.4	1	6	7
BL-GOLD	06-Feb-19	25.6	8	8	19	13	0.02	0.02	1.2	0.98	10	10	0.2	0.2	1.5	1	9	10
BL-GOLD	20-Mar-19	25.7	9	9	49	12	0.03	0.02	0.9	0.40	38	10	0.2	0.2	5.5	2	9	6
BL-GOLD	03-Apr-19	25.5	8	9	26	19	0.02	0.03	1.4	0.76	16	19	0.2	0.2	3.3	3	17	9
BL-GOLD	01-May-19	26.2	8	10	22	13	0.04	0.03	1.3	1.17	22	12	0.6	0.2	3.5	2	10	8
BL-GOLD	12-Jun-19	22.6	9	9	48	15	0.02	0.02	0.9	0.58	36	10	0.2	0.2	3.6	2	4	5
BL-GOLD	17-Jul-19	24.3	8	8	23	13	0.02	0.02	0.7	0.55	18	9	0.1	0.1	1.8	1	5	3
BL-GOLD	07-Aug-19	20.5	8	9	34	14	0.02	0.01	0.7	0.40	30	10	0.2	0.2	3.5	1	4	5
BL-GOLD	11-Sep-19	24.4	9	10	18	13	0.02	0.02	0.4	0.48	11	10	0.2	0.2	1.7	0	6	5
BL-GOLD	09-Oct-19	25.6	9	9	16	10	0.01	0.01	0.7	0.44	14	10	0.1	0.1	1.7	1	5	3
BL-GOLD	14-Nov-19	20.7	9	10	20	10	0.02	0.02	0.8	0.95	15	10	0.4	0.2	1.5	1	6	5
BL-GOLD	10-Dec-19	22.3	9	10	36	16	0.01	0.01	0.8	0.55	36	10	0.2	0.2	2.0	1	6	4

Notes:

Shaded cells indicate concentrations exceed the long-term (chronic) BC WQG

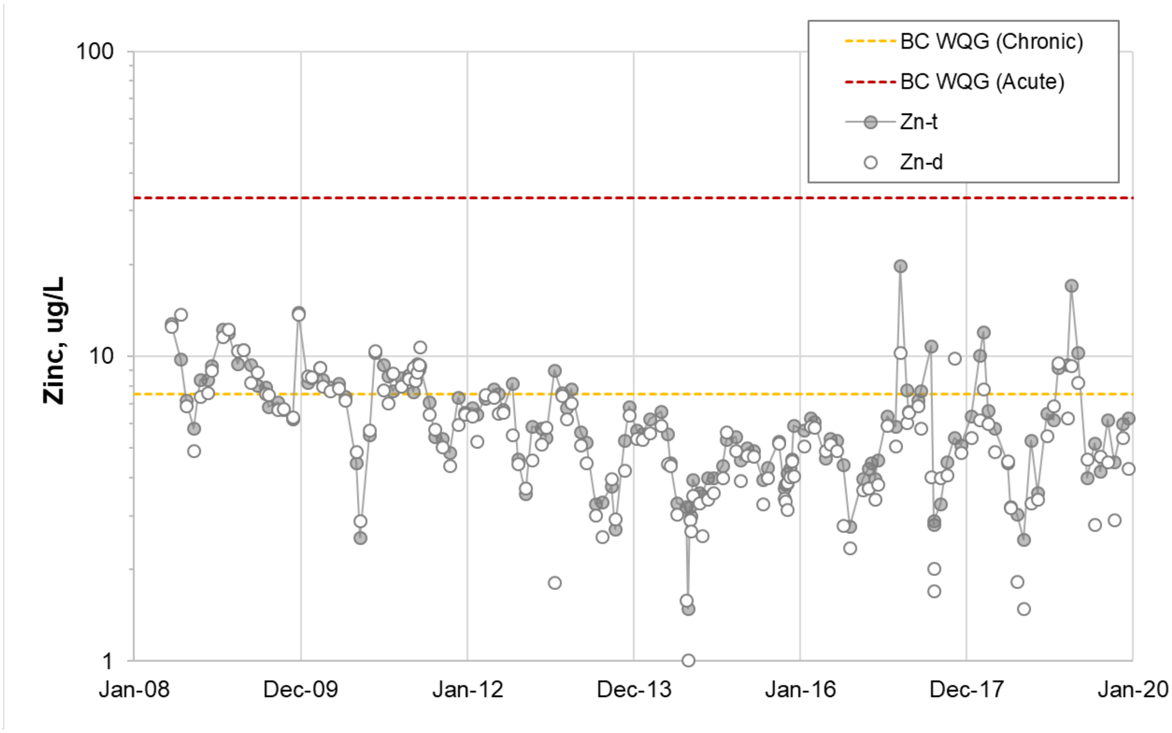
Concentrations in red indicate a concentration that exceeds the acute (short-term) BC WQG

Table 4-12.

Statistical Summary of Monthly Grab Sample Data for Buttle Lake at Gold River Station,

2009 to 2018 Water Years

Water Year	Zn-d, ug/L	Zn-t, ug/L	Alkalinity, mg/L	Hardness, mg/L	Al-t, ug/L	Al-d, ug/L	Cd-t, ug/L	Cd-d, ug/L	Cu-t, ug/L	Cu-d, ug/L	Fe-t, ug/L	Fe-d, ug/L	Mn-t, ug/L	Mn-d, ug/L	Pb-t, ug/L	Pb-d, ug/L
2009 Water Year																
n:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Min:	4.9	5.8	20.3	23.8	8.4	7.6	0.027	0.005	0.5	0.4	3.2	1.7	0.0	0.0	0.8	0.1
Max:	13.7	12.3	27.2	28.1	27.0	16.3	0.045	0.046	1.0	0.7	14.2	5.7	0.4	0.2	2.7	2.8
Median:	8.9	9.4	24.9	26.6	12.7	11.1	0.033	0.030	0.6	0.5	4.9	3.0	0.1	0.0	1.8	1.0
Mean:	9.3	9.2	24.7	26.3	14.6	11.1	0.034	0.030	0.7	0.5	6.4	3.3	0.1	0.1	1.8	1.1
2010 Water Year																
n:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Min:	6.3	6.2	24.8	24.6	10.9	1.7	0.018	0.005	0.5	0.5	3.9	1.7	0.0	0.0	0.9	0.1
Max:	13.7	13.9	27.5	29.2	17.9	17.5	0.116	0.111	1.0	1.1	9.4	7.9	1.7	0.3	2.6	1.4
Median:	7.8	8.1	26.9	26.9	13.7	11.1	0.030	0.028	0.7	0.6	5.3	2.9	0.1	0.1	1.6	0.9
Mean:	8.2	8.3	26.5	26.8	13.4	11.4	0.038	0.032	0.7	0.7	6.2	3.5	0.3	0.1	1.7	0.8
2011 Water Year																
n:	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Min:	2.9	2.6	23.9	22.6	10.6	8.5	0.011	0.005	0.4	0.5	3.5	1.8	0.0	0.0	0.7	0.1
Max:	10.7	10.3	28.4	29.4	20.2	15.7	0.043	0.038	0.7	0.8	9.6	6.0	0.4	0.3	2.9	2.8
Median:	8.3	8.5	24.7	26.5	13.6	12.8	0.027	0.023	0.6	0.6	5.3	3.2	0.0	0.0	1.6	1.0
Mean:	7.8	7.8	25.0	26.2	13.8	12.8	0.028	0.023	0.6	0.6	5.6	3.6	0.1	0.1	1.8	1.3
2012 Water Year																
n:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Min:	4.4	4.8	22.2	22.0	12.6	9.9	0.017	0.015	0.4	0.4	3.1	1.3	0.0	0.0	0.9	0.1
Max:	7.5	7.8	27.6	27.6	29.1	18.0	0.026	0.046	0.7	0.7	17.3	4.0	0.4	0.2	2.2	1.2
Median:	6.4	6.8	24.3	25.9	19.0	12.9	0.022	0.021	0.6	0.5	8.5	2.1	0.0	0.0	1.5	0.6
Mean:	6.1	6.6	24.4	25.3	19.0	13.2	0.022	0.022	0.6	0.5	8.8	2.3	0.1	0.0	1.5	0.6
2013 Water Year																
n:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Min:	1.8	3.6	22.5	23.1	10.3	3.3	0.007	0.005	0.5	0.3	5.4	1.6	0.0	0.0	1.0	0.1
Max:	7.4	9.0	28.6	30.4	19.9	18.3	0.046	0.023	1.2	0.6	17.0	9.7	0.6	0.2	2.1	1.6
Median:	5.1	5.9	25.1	24.9	13.5	10.1	0.019	0.018	0.6	0.5	7.8	2.4	0.1	0.0	1.6	0.6
Mean:	5.1	6.3	24.9	26.1	13.9	10.1	0.019	0.016	0.7	0.5	8.6	3.5	0.2	0.0	1.7	0.7
2014 Water Year																
n:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Min:	2.6	2.7	22.0	24.2	2.7	6.2	0.010	0.009	0.4	0.3	1.0	1.0	0.0	0.0	0.1	0.1
Max:	6.4	6.8	26.9	29.4	20.5	16.0	0.023	0.022	0.9	0.7	16.6	8.6	0.1	0.0	2.3	1.6
Median:	4.4	5.4	25.5	27.1	12.5	9.1	0.017	0.017	0.5	0.5	6.5	2.3	0.0	0.0	1.6	0.6
Mean:	4.5	4.9	24.8	26.9	12.9	10.1	0.016	0.015	0.6	0.5	7.7	3.2	0.0	0.0	1.4	0.6
2015 Water Year																
n:	16	16	12	16	16	16	16	16	16	16	16	16	16	16	16	16
Min:	1.0	1.5	22.7	25.3	10.6	7.0	0.007	0.005	0.6	0.4	5.1	1.6	0.0	0.0	1.0	0.1
Max:	5.6	5.5	27.3	32.2	26.1	13.2	0.023	0.020	0.9	0.7	31.3	14.0	0.1	0.0	4.0	1.6
Median:	3.4	4.0	25.4	27.5	15.0	11.3	0.015	0.014	0.6	0.6	9.0	3.2	0.0	0.0	1.2	0.2
Mean:	3.5	3.9	25.3	27.7	16.0	11.0	0.015	0.014	0.7	0.5	12.4	4.4	0.0	0.0	1.7	0.3
2016 Water Year																
n:	16	16	13	16	16	16	16	16	16	16	16	16	16	16	16	16
Min:	3.2	3.7	24.4	26.0	12.7	10.4	0.012	0.013	0.4	0.4	5.3	1.5	0.0	0.0	0.8	0.1
Max:	5.9	6.3	27.5	31.4	18.5	20.5	0.021	0.023	3.6	1.1	43.8	12.6	0.1	0.0	2.2	1.4
Median:	4.3	4.6	25.5	27.4	14.8	11.8	0.018	0.017	0.6	0.5	9.4	3.4	0.0	0.0	1.4	0.7
Mean:	4.4	4.8	25.6	27.6	15.1	12.5	0.017	0.017	0.8	0.6	11.9	4.4	0.0	0.0	1.4	0.7
2017 Water Year																
n:	14	14	13	13	14	14	14	14	14	14	14	14	14	14	14	14
Min:	0.0	2.8	23.5	23.3	13.1	0.0	0.011	0.000	0.4	0.0	3.4	0.0	0.0	0.0	0.8	0.0
Max:	10.3	19.8	28.5	384.0	147.0	176.0	0.100	0.090	3.0	0.7	28.3	6.8	0.1	0.0	33.4	29.5
Median:	4.4	5.2	24.8	25.7	17.4	12.5	0.018	0.016	0.7	0.5	8.0	1.7	0.0	0.0	1.4	0.2
Mean:	4.7	6.4	25.2	53.1	28.6	23.2	0.023	0.020	0.9	0.5	10.2	2.3	0.0	0.0	3.7	2.4
2018 Water Year																
n:	13	13	11	13	13	13	13	13	13	13	13	13	13	13	13	13
Min:	1.7	2.8	21.9	22.8	13.8	10.0	0.009	0.006	0.5	0.2	7.5	1.6	0.0	0.0	1.2	0.1
Max:	9.9	12.0	27.0	27.7	71.7	17.7	0.039	0.033	2.7	0.8	50.6	5.8	0.7	0.1	14.6	1.3
Median:	4.9	5.4	25.6	25.0	21.3	11.7	0.017	0.015	0.6	0.6	14.9	3.7	0.0	0.0	1.9	0.9
Mean:	5.0	6.2	25.0	25.0	26.5	12.8	0.019	0.015	0.8	0.5	17.1	3.6	0.1	0.0	3.2	0.7
2019 Water Year																
n:	12	12	12	5	12	12	12	12	12	12	12	12	12	12	12	12
Min:	1.5	2.5	22.6	24.0	16.3	11.7	0.012	0.009	0.5	0.4	8.4	3.3	0.0	0.0	0.9	0.2
Max:	9.5	17.1	26.5	26.4	145.0	18.6	0.035	0.025	1.4	1.2	144.0	19.0	0.6	0.2	6.8	2.7
Median:	5.1	5.8	25.2	24.8	24.4	13.4	0.019	0.016	0.8	0.5	19.0	10.0	0.2	0.2	3.4	1.6
Mean:	5.3	6.7	24.9	25.1	39.1	14.2	0.020	0.016	0.9	0.6	33.5	9.8	0.2	0.1	3.4	1.5



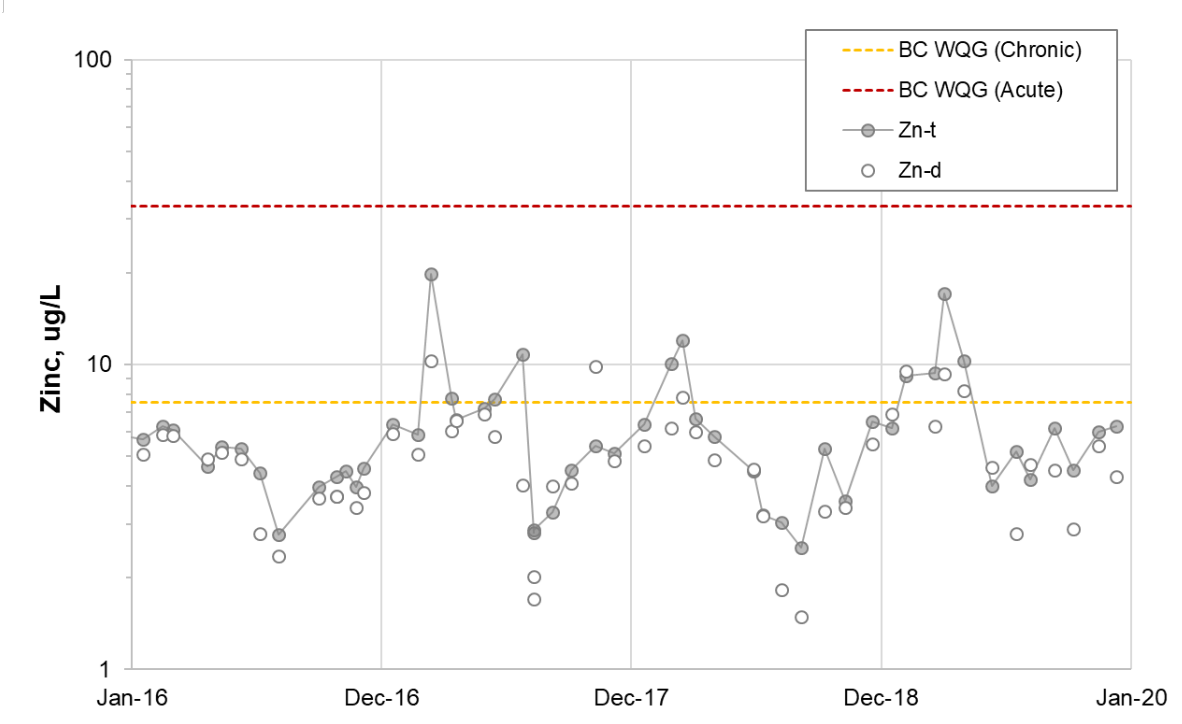
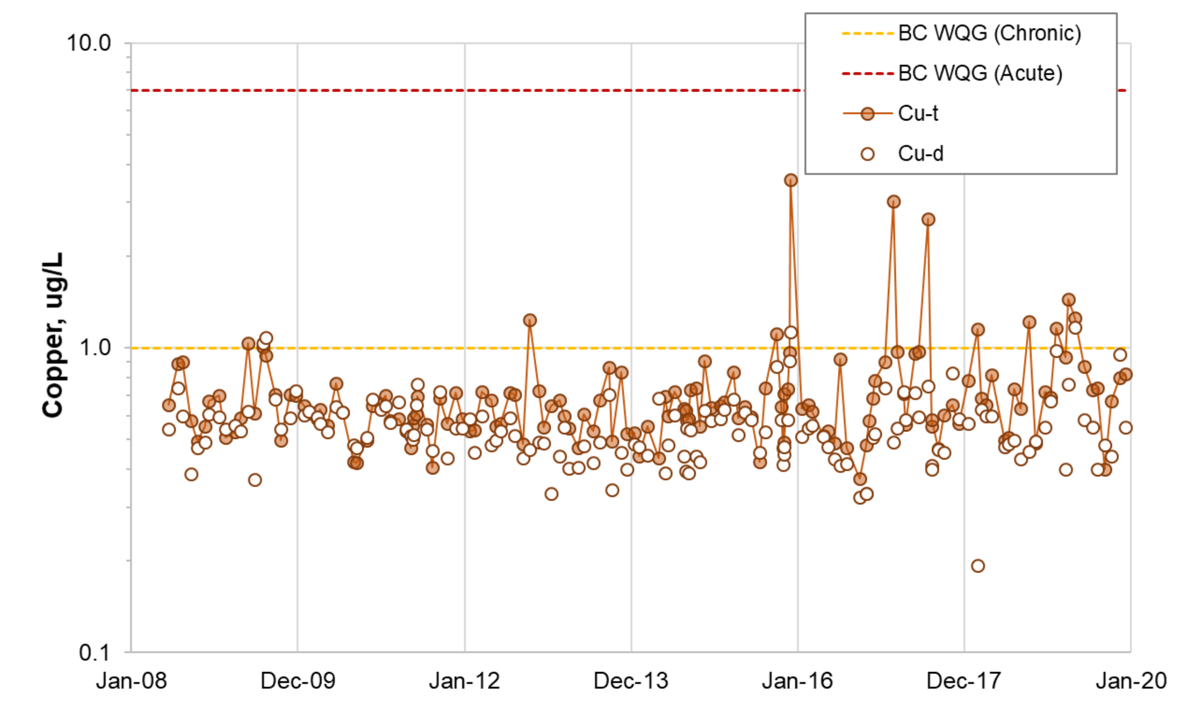


Figure 4-13. Zn Concentrations in Buttle Lake at Gold River Station.

2008 to 2020 (top) and 2016 to 2020 (bottom)



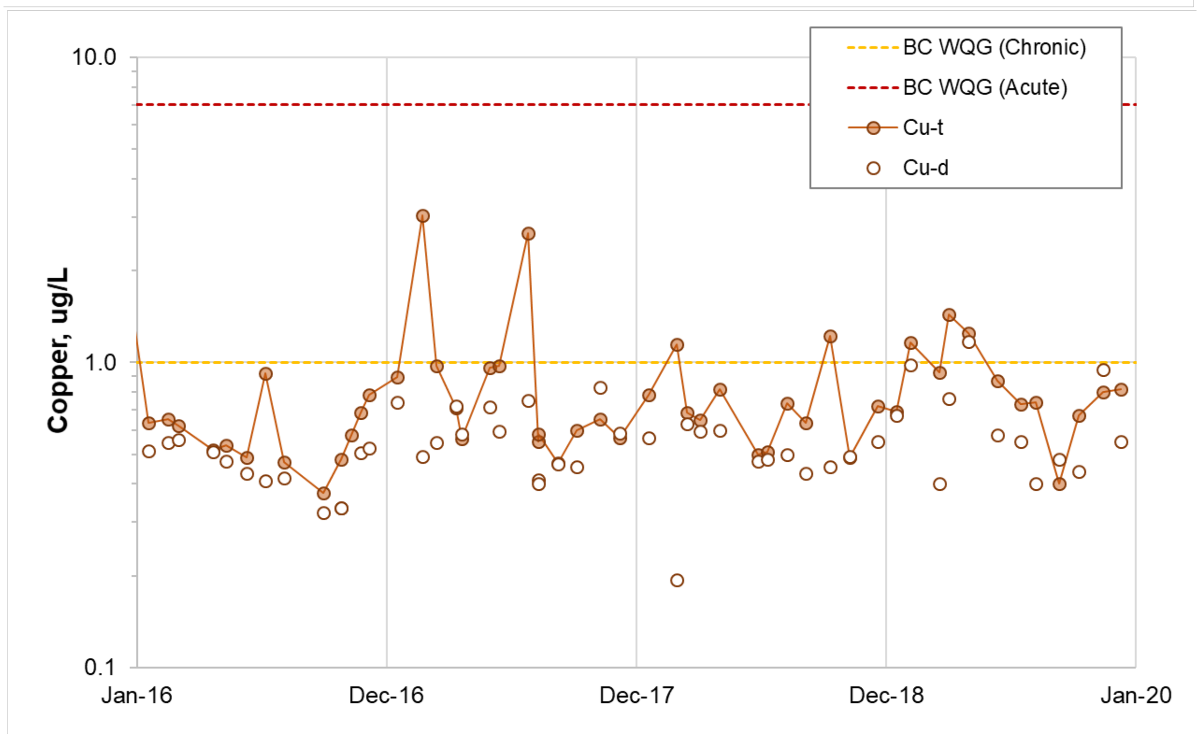


Figure 4-14. Copper Concentrations in Buttle Lake at Gold River Station.

2008 to 2020 (top) and 2016 to 2020 (bottom)

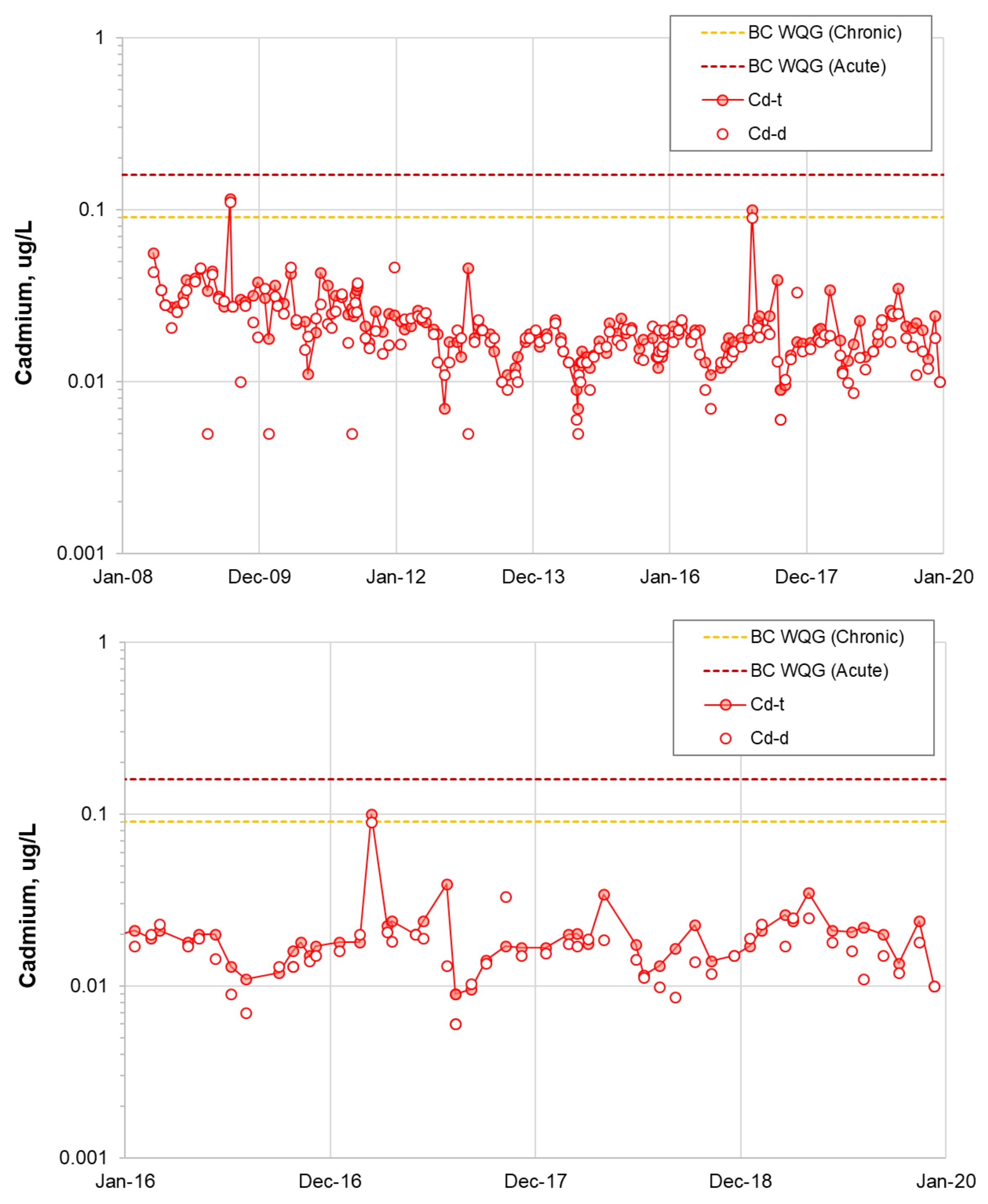
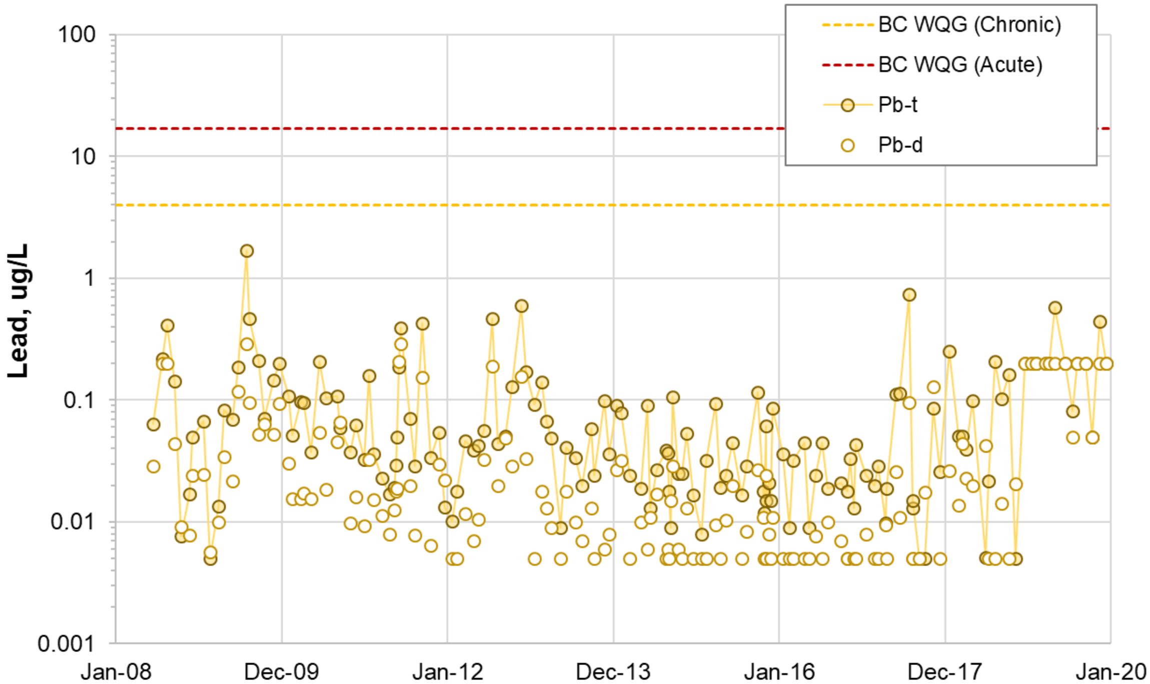


Figure 4-15. Cd Concentrations in Buttle Lake at Gold River Station.

2008 to 2020 (top) and 2016 to 2020 (bottom)



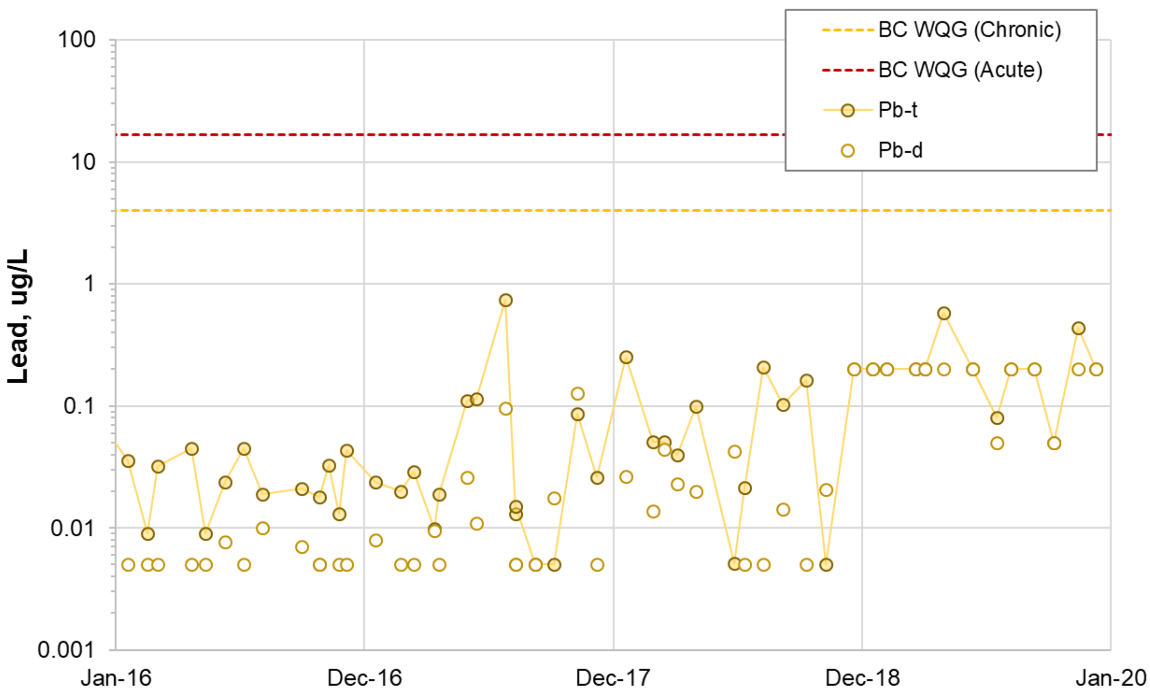


Figure 4-16. Pb Concentrations in Buttle Lake at Gold River Station.

2008 to 2020 (top) and 2016 to 2020 (bottom)

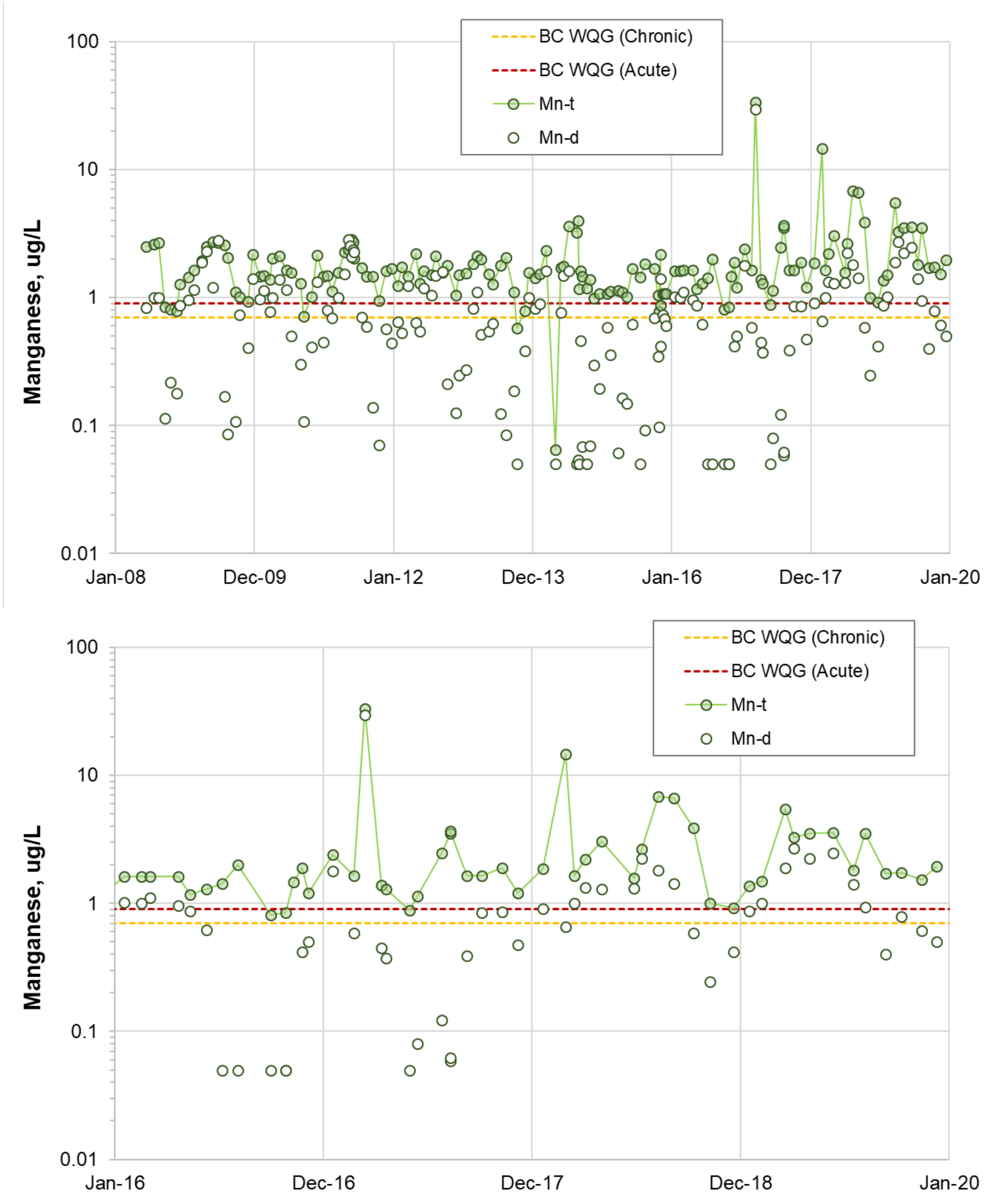


Figure 4-17. Mn Concentrations in Buttle Lake at Gold River Station.

2008 to 2020 (top) and 2016 to 2020 (bottom)

4.8.2 *Plankton Counts and Lake Turbidity*

Zooplankton counts in Buttle Lake in 2019 are summarized in **Table 4-13**. Phytoplankton counts and chlorophyll “a” measurements in Buttle Lake at the Henshaw Creek station and Karst Creek station are summarized in **Table 4-14** and **Table 4-15**, respectively. These data represent a surface grab (Phytoplankton) and a 25 m vertical haul (zooplankton) at each station.

Samples were sent to Fraser Environmental Services (Zooplankton) and Munro Environmental Consulting (Phytoplankton) for plankton identification and enumeration (see Appendix E for original lab reports). It is noted that the plankton samples for October sampling were not received by the respective laboratories and as such, results are not available.

Sechi depths at the Karst Creek station in 2019 ranged from 8.8 m in April to 14.3 m in August 2019. At Henshaw Creek, Sechi depths range from 8.6 m in February to 15.8 m in August.

Table 4-13.

Zooplankton Counts for Buttle Lake at Henshaw Creek and Karst Creek Stations, 2019

Zooplankton	7-Feb-19		25-Apr-19		19-Jun-19		21-Aug-19		7-Dec-19	
	Henshaw	Karst	Henshaw	Karst	Henshaw	Karst	Henshaw	Karst	Henshaw	Karst
Sub-class : Copepoda										
Order : Cyclopoida										
Cryptocyclops bicolor	3				15	23	7	55		
Diacyclops thomasi	16	25	28	86	103	11	13	167		5
Microcyclops varicans	3	15			44	57		56	3	3
Ectocyclops phaleratus									4	2
UID		1	49	382	50	116	69	205	6	2
Order : Calanoida										
Skistodiaptomus oregonensis		12	6	19	8	8	38	33	16	3
UID				2	13	30	27	30		
UID Calanoida/Cyclopoida			145	243	31	173	237	1001	133	22
Sub-class : Branchiopoda										
Bosmina longirostris (a)	9	8	5	23	391	249	28	131	6	26
Bosmina longirostris (j)					27	72	13	11	2	2
Ceriodaphnia reticulata	1									
Daphnia rosea (a)	4	1	22	51	461	428	107	111	35	21
Daphnia rosea (j)			10	25		42	21	52	6	1
Daphnia sp.					54					
Holopedium gibberum			14	53	61	63		2		
Polyphemus pediculus					11	23	21	17		
Sida crystallina							28	11		
Leptodora kindtii							2			
Phylum : Rotifera										
Kellicottia longispina	3	3	18	19	34	70	400	244	241	22
Keratella cochlearis	1		5	8	3	2	1	6	16	2
Filinia sp.					2		3	2		
Keratella quadrata			4	6	2			43		3
Polyarthra sp.							2		12	
UID									7	2
Order Diptera										
Family : Chironomidae	1									
Group Hydracarina		1	2	9	10			11		
TOTAL:	**41**	**66**	**308**	**926**	**1,320**	**1,367**	**1,017**	**2,188**	**487**	**116**

Table 4-14.

Phytoplankton Counts for Buttle Lake at Henshaw Creek Station, 2019

Phytoplankton	7-Feb-19		25-Apr-19		19-Jun-19		2-Aug-19		17-Oct-19		10-Dec-19	
Chlorophyll "a" , mg/L	0.00016		0.00043		0.00024		0.00012		0.00031		-	
1000X magnification - 100 fields	**number counted**	**cells per mL**	**number counted**	**cells per mL**	**number counted**	**cells per mL**	**number counted**	**cells per mL**	**number counted**	**cells per mL**	**number counted**	**cells per mL**
CHRYSOPHYCEAE												
Ochromonas/Chromulina spp. (2-3 um)	36	324	29	522	34	306	20	180			19	342
Ochromonas/Chromulina spp. (4-5 um)	12	108	15	270	18	162	12	108			28	504
Ochromonas/Chromulina spp. (6-7 um)	1	9	2	36	2	18	3	27			2	36
Pseudokephyrion sp.			1	18			1	9				
Chrysolikos sp.			1	18							1	18
CHLOROPHYCEAE												
Oocystis sp. (5 x 3 um)							2	18				
TOTAL:	**49**	**441**	**48**	**864**	**54**	**486**	**38**	**342**			**50**	**900**
400X magnification by strip - (Count):	4 strips	4 strips	2 strips	2 strips	3 strips	3 strips	3 strips	3 strips			2 strips	2 strips
CHRYSOPHYCEAE												
Diceras chodatii							1	1				
Chrysocapsa paludosum (cols)					2	1						
Ochromonas spp. (8-10 um)	55	23									91	77
unidentified cyst											1	1
Dinobryon sp. (cells)			5	4			85	48				
Dinobryon sociale (14 cols, 30 cells)			30	26								
Ochromonas spp. (8-10 um)			113	96	102	58	108	61				
BACILLARIOPHYCEAE												
Achnanthes sp.			1	1								
Cyclotella glomerata (cols + cells)	3	1	15	13	11	6	15	9			12	10
Melosira italica (filaments)	9	4	7	6	8	5	16	9			2	2
Rhizosolenia longiseta	1	0.4	89	76	3	2	1	1			86	73
Synedra sp. (small)	3	1.3										
Synedra radians			56	48								
CHLOROPHYCEAE												
Cosmarium sp.					2	1	2	1				
Dictyosphaerium pulchellum (cols)					2	1						
Gloeocystis sp. (cols + cells)					2	1	2	1				
Oocystis sp. (cells + cols)					2	1	4	2			2	2
Scenedesmus sp. (cols)	1	0.4	2	2	1	1	1	1			1	1
Crucigenia sp. (col)							4	2			1	1
Nephrocytium sp. (cells)							1	1				
unidentified cyst											1	1
DINOPHYCEAE												
Peridinium sp.			2	2			4	2				
CRYPTOPHYCEAE												
Cryptomonas spp.	3	1	15	13	21	12	18	10			7	6
Rhodomonas minuta	1	0.4	10	9	2	1	6	3			23	20
CYANOPHYCEAE												
Dactylococcopsis acicularis (cols)	1	0.4			11	6	2	1			1	1
Rhabdoderma sp. (cols)			1	1								
TOTAL:	**77**	**33**	**346**	**294**	**169**	**96**	**270**	**153**			**228**	**194**
100X magnification - whole sample												
BACILLARIOPHYCEAE												
Asterionella formosa (4 col, 33 cells)											33	1.32
Synedra radians	18	0.72			3	0.1	1	0.04			6	0.24
Tabellaria fenestrata (2 cols, 3 cells)											3	0.12
Tabellaria fenestrata (11 cols, 32 cells)	32	1.28										
Navicula sp. (100 um)							1	0.04				
CHRYSOPHYCEAE												
Dinobryon bavaricum (1 col, 3 cells)							3	0.12				
Dinobryon cylindricum (2 cells)											2	0.08
Dinobryon cylindricum (2 col, 3 cells)	3	0.12										
Dinobryon cylindricum (1 col, 4 cells)			1	0.04								
CHLOROPHYCEAE		0.00										
Cosmarium sp.											3	0.1
Mougeotia sp. (cells)	1	0.04										
Botryococcus braunii (cols)			5	0.2			2	0.1				
Elakatothrix gelatinosa (cols)							1	0.04				
CYANOPHYCEAE												
Aphanocapsa sp. (col)							1	0.04				
TOTAL:	**54**	**2.2**	**6**	**0.2**	**3.0**	**0.1**	**9**	**0.4**			**47**	**1.9**

Table 4-15.

Phytoplankton Counts for Buttle Lake at Karst Creek Station, 2019

Phytoplankton	7-Feb-19		25-Apr-19		19-Jun-19		2-Aug-19		17-Oct-19		10-Dec-19	
Chlorophyll "a" , mg/L	0.00015		0.0005		0.00021		0.00011		0.00026		-	
1000X magnification - 100 fields	**number counted**	**cells per ml**	**number counted**	**cells per ml**	**number counted**	**cells per ml**	**number counted**	**cells per ml**	**number counted**	**cells per ml**	**number counted**	**cells per ml**
CHRYSOPHYCEAE												
Ochromonas/Chromulina spp. (2-3 um)	20	180	28	504	34	306	16	144			20	360
Ochromonas/Chromulina spp. (4-5 um)	9	81	14	252	18	162	16	144			23	414
Ochromonas/Chromulina spp. (6-7 um)	1	9	1	18	2	18	3	27			6	108
Pseudokephyrion sp.							1	9			1	18
Chrysolikos sp.											1	18
CHLOROPHYCEAE												
Oocystis sp. (5 x 3 um)							2	18				
TOTAL	**30**	**270**	**43**	**774**	**54**	**486**	**38**	**342**			**51**	**918**
400X magnification by strip - (Count):	4 strips	4 strips	2 strips	2 strips	3 strips	3 strips	3 strips	3 strips			2 strips	2 strips
CHRYSOPHYCEAE												
Chrysocapsa paludosa (cells+ cols)	1	0.4			2	1						
Ochromonas spp. (8-10 um)	51	22			102	58	103	58			90	77
Dinobryon sp. (cells)			5	4.3			26	15				
Dinobryon sociale (14 cols, 30 cells)			6	5.1								
Ochromonas spp. (8-10 um)			51	43.4								
unidentified cyst												
BACILLARIOPHYCEAE												
Achnanthes sp.							1	1				
Cyclotella glomerata (cols + cells)	1	0.4	17	14.5	11	6					8	7
Melosira italica (filaments)	11	5	8	6.8	8	5	12	7			2	2
Rhizosolenia longiseta	4	2	108	91.8	3	2	1	1			45	38
Navicula sp. (25 um)							2	1				
Synedra radians			78	66.3								
CHLOROPHYCEAE												
Crucigenia sp. (col)												
Cosmarium sp.			2	1.7	2	1	1	1				
Dictyosphaerium pulchellum (cols)					2	1						
Gloeocystis sp. (cols + cells)					2	1	4	2			4	3
Oocystis sp. (cells + cols)	2	1			2	1	2	1				
Scenedesmus sp. (cols)	1	0.4	1	1	1	1	1	1			1	1
Nephrocytium sp. (cells)							1	1				
Tetraedron sp.											1	1
DINOPHYCEAE												
Gymnodinium sp.											1	1
Peridinium sp.	2	1					5	3				
CRYPTOPHYCEAE												
Cryptomonas spp.	3	1	3	2.6	21	12	5	3			7	6
Rhodomonas minuta	1	0.4	3	2.6	2	1	15	9			33	28
unidentified cyst												
CYANOPHYCEAE												
Dactylococcopsis acicularis (cols)					11	6	4	2			2	2
TOTAL	**77**	**33**	**282**	**240**	**169**	**96**	**183**	**104**			**194**	**165**
100X magnification - whole sample												
BACILLARIOPHYCEAE												
Asterionella formosa (28 cols, 155 cells)											155	6.2
Synedra radians	30	1.2			3	0.1	4	0.2			7	0.28
Synedra ulna	1	0.04										
Gyrosigma sp.							1	0.04				
Tabellaria fenestrata (1 col, 12ccells)	12	0.5										
Tabellaria fenestrata (2 cols, 3 cells)												
CHRYSOPHYCEAE												
Dinobryon cylindricum (1 col, 4 cells)			4	0.2							2	0.1
Cosmarium sp. (large)							1	0.04				
Elakatothrix gelatinosa (cols)							1	0.04				
CHLOROPHYCEAE												
Botryococcus braunii (cols)			2	0.1								
CYANOPHYCEAE												
Aphanocapsa sp. (col)							1	0.04				
TOTAL	**43**	**1.7**	**6**	**0.2**	**3**	**0.1**	**8**	**0.3**			**164**	**6.6**

5 SUMMARY

5.1 LYNX SIS PERFORMANCE

5.1.1 *Phase I Lynx SIS*

The Phase I Lynx SIS has been operating since October 1st, 2017. The Phase I pumping wells (PW14-01, PW14-03, and PW14-04) were operated for the majority of the 27-month assessment period covered in this report. Pumping was discontinued for up to 59 days starting on December 4th, 2018, due to power supply issues. Pumping from all three wells resumed by February 1st, 2019, and there were no extended shutdowns for the remainder of 2019.

The Phase Lynx SIS pumping wells were pumped at an average combined pumping rate of 48.7 L/s from October 2017 to the end of December 2019. This average rate does not include the periods in December 2018 and January and February 2019 when the pumps were shut off. Pumping rates generally increased in response to rainfall and gradually decreased once rainfall had ceased. Together, the inferred capture zones for the Phase I Lynx SIS pumping wells cover most of the Lynx Reach. The Phase I Lynx SIS does not capture perched seepage near the Superpond.

Average pumping rates for the individual pumping wells were 24.6 L/s for PW14-01, 12.5 L/s for PW14-03, and 16.1 L/s for PW14-04. The Phase I Lynx SIS captured a total of 1,492,967 m^3 of ARD-impacted groundwater from the Lynx Reach during the 27-month assessment period. The PW14 pumping wells captured a total Zn load of 58.2 tonnes since October 2017. This represents 59% of the Zn load captured by the Old TDF under-drains during the 27-month assessment period.

5.1.2 *Interim Phase II Lynx SIS*

The Interim Phase II Lynx SIS has operated during high flow periods in groundwater since March 2019. The Interim Phase II Lynx SIS captured approximately 321,230 m^3 of slightly impacted groundwater from the shallow MVA downgradient of the carbridge from March 2019 to December 2019. The average pumping rate over the first ten months of operation was 13.4 L/s, which is lower than the 20 to 24 L/s design capacity of the system due to pumping wells PW18-02 and PW18-04 not operating for extended periods.

The Interim Phase II Lynx SIS is estimated to have captured 148 kg of Zn from the shallow MVA between March and June 2019. This represents only about 3% of the total load captured by Phase I Lynx SIS over the same period. On average, the system appears to capture only 2% of the typical Zn load in Myra Creek during average flow conditions and less than 1% of the Zn load in Myra Creek at MC-TP4 during high flow.

The Interim Phase II Lynx SIS is intended to capture highly impacted acidic seepage that expresses along the creek bank immediately downgradient of the car bridge following high rainfall periods. An unlined surface runoff storage pond (Duck Pond) and associated channels are identified as the most likely source of these acidic seeps. The performance assessment provided in this report suggests the system is not intercepting the highly impacted and acidic seepage that it was intended to capture. Future operation of the system should, therefore, be re-evaluated and alternative approaches to collecting this seepage should be considered.

5.2 Groundwater Quality

5.2.1 *Upstream Reach*

Groundwater quality in bedrock in the Upstream Reach is characterized by low SO_4 and metal concentrations. Previous samples suggest some potential impact due to local ARD and/or mineralized areas. Further characterization of these potential sources and/or background water quality is not a priority, however, and this well is not routinely monitored.

5.2.2 *Lynx Reach*

Groundwater quality in the MVA in the Lynx Reach remains moderately impacted by ARD generated mainly by the Lynx TDF embankment berm. Sulphide-bearing waste rock in the mill area and in the former ETA also appears to contribute loads to groundwater. Operating the Phase I Lynx SIS has improved groundwater quality in some areas, although groundwater quality did deteriorate (temporarily) in early 2019 due to the shutdown of the SIS in December 2018 and January 2019.

More than 300 mg/L Zn was observed in perched seepage sampled from well MW14-04S near the Superpond in late 2019. These high concentrations suggest more concentrated ARD in this area than previously observed and the loads associated with this seepage to groundwater in the MVA downgradient (and possibly Myra Creek) should be assessed, as they are not captured by the Phase I Lynx SIS.

5.2.3 *Old TDF Reach*

Groundwater quality in the Upper Old TDF Reach near the Surge Pond appears to have been substantially improved by operating the Phase I Lynx SIS. This is consistent with modeling predictions from RGC (2018a) but future monitoring is needed to confirm this preliminary interpretation.

The flow field in this area indicates that most of the ARD-impacted groundwater captured by the Phase I Lynx SIS would likely be captured by the Old TDF under-drains in the Lower Old TDF Reach. This implies that operating the Phase I Lynx SIS may improve groundwater quality in the Old TDF Reach but may have limited effect on Myra Creek water quality. Groundwater quality in the Lower Old TDF Reach has thus far been unaffected by operation of the Phase I Lynx SIS in 2019.

5.2.4 *Downstream Reach*

Groundwater quality in the Downstream Reach is impacted in some areas by small loads associated with ARD-impacted groundwater from the Lower Old TDF Reach that bypasses the Old TDF under-drains. The under-drains are, however, very effective so bypass is low and groundwater in the Downstream Reach is typically characterized by relatively low concentrations of SO_4, Cu, Zn, and other metals related to ARD. Groundwater quality observed in the reach downstream of the Old TDF in 2019 is consistent with previous trends and suggests no change in this reach in 2019. Elevated Zn concentrations in groundwater at wells MW17-13S and MW17-13D (last sampled in 2018) are a cause of some concern and these wells are to be sampled again in 2020.

5.3 Effluent Quality

5.3.1 *DDSD Monitoring (TDF-EFF)*

In 2019, DDSD flows at station TD-EFF in January, February, April, and May were characterized by TSS and metal concentrations that were typically an order-of-magnitude lower than the applicable discharge limits. Metal concentrations in samples from December 2019 are much higher by comparison, although none of the concentrations exceed discharge limits. These data are consistent with an initial flushing period in November or December, after which much lower concentrations are observed due to less impacted water reporting to the DDSD. Too few monitoring data are available, however, to determine when the DDSD and DDUD are flowing and the relative contributions of each to station TDF-EFF.

5.3.2 *Treated Effluent Discharge (MP-EFF)*

Effluent discharge rates in 2019 ranged from 20,069 m^3/day (on June 22nd) to 124,088 m^3/day (on January 3rd). The average daily discharge rate in 2019 was 40,327 m^3/day. This is 7,673 m^3/d day lower than the 48,000 m^3/day that is authorized by Permit PE-6858. In total, 14,414,971 m^3 of treated effluent was discharged to Myra Creek in 2019.

Groundwater flows from the Old TDF under-drains (via Pumphouse No. 4) accounted for approximately 50% (7,129,615 m^3) of the volume of water requiring treatment in 2019. Flows from the Phase I Lynx SIS pumping wells accounted for approximately 10% (1,492,967 m^3) of the volume of water treated and the other 40% (5,792,389 m^3) is mainly related to precipitation runoff from the mill area and Old TDF (via the Surge Pond). None of the Cd-d, Cu-d, Cu-t, Pb-d, Zn-d, or Zn-t concentrations observed in treated effluent exceeded discharge limits in 2019.

5.4 Streamflow Monitoring for Myra Creek

In 2019, NMF commissioned the installation of a new streamflow monitoring gauge. The gauge conforms to RISC (2018) Grade A data quality standards and was installed by Swiftwater Consulting Ltd. ("Swiftwater"). The new gauge instrumentation consists of a Campbell Scientific datalogger and radio telemetry system. The stage sensor is a non-contact FTS radar sensor, installed in the center of the pipe bridge overlooking the creek.

There are two continuous streamflow monitoring stations for Myra Creek:

- MYR-BDG-US, and
- MYR-BDG.

Station MYR-BDG-US is the original monitoring station for Myra Creek and is located beneath the main access road bridge. MYR-BDG is the new, long-term streamflow monitoring station installed in 2019. It is located on the pipe bridge that crosses Myra Creek approximately 1 km downstream of MYR-BDG-US. The new gauge is downstream of the effluent discharge point (MP-EFF).

Daily discharge in Myra Creek at station MYR-BDG-US are used in this report until March 18th. Flows in October, November, and December are from the new gauging station (MYR-BDG-US). There is a gap in the streamflow discharge record in 2019 as site staff could not download data from the original gauge from February 2019 to October 2019.

5.5 Surface Water Quality

5.5.1 *Myra Creek*

At station MC-M1, upstream of the mine site, Al-d concentration in Myra Creek exceeded the long-term (chronic) BC WQG in March 2019. All other concentrations in Myra Creek at MC-M1 were below the long-term BC WQG in 2019.

Monthly monitoring of water quality in 2019 at stations MC-TP4 (immediately downgradient of the site), and MC-M2 (further downgradient) indicate that Cu-d, Cu-t, and Zn-t concentrations in Myra Creek exceeded long-term (chronic) and short-term (acute) BC WQGs. The highest concentrations were observed in January 2019, when Zn-t concentrations were approximately four times higher than the short-term BC WQG.

In 2019, Zn-t concentrations in all daily composite samples from Myra Creek at MC-TP4 exceeded the long-term (7.5 µg/L Zn-t) BC WQG for the protection of aquatic life. Zn-t concentrations exceeded the short-term (33 µg/L Zn) WQG in 97% of the daily composite samples in 2019. Zn-t concentrations were lowest in the summer months when streamflow discharge in Myra Creek is highest. Cu-d concentrations exceeded the long-term (chronic) BC WQG in all daily composite samples from Myra Creek at MC-TP4 and occasionally exceeded the short-term (acute) BC WQG for Myra Creek.

Concentrations of Zn, Cu, and other metals in Myra Creek in 2019 are consistent with previous data and seasonal trends and Zn concentrations do not appear to have decreased or increased substantially in 2019. The Phase I Lynx SIS is, however, working as intended in terms of hydraulic control of groundwater and the SIS has improved groundwater quality downgradient in the Upper Old TDF Reach. This could lead to improved water quality in Myra Creek over time but future monitoring results (while the Phase I Lynx SIS is operating continuously) are needed to confirm recent improvements in groundwater quality and determine if water quality in Myra Creek improves as a result.

5.5.2 *Thelwood Creek*

Thelwood Creek receives flows from the Price Pond, which collects mine water flowing from the nearby Price 13L adit. Most metal concentrations were below their respective reporting limits and there were no exceedances of BC WQGs in 2019.

5.5.3 *Buttle Lake*

Water quality trends in Buttle Lake in 2019 were consistent with previous trends. Concentrations of Zn and other metals at the Henshaw Creek station were, therefore, the highest of the three monitoring stations in 2019, as this station is the closest to Myra Creek. Concentrations of Zn and other metals in Buttle Lake were highest in February 2019 and lowest in October. In the winter, Cu-d, Mn-t, and Zn-t concentrations (all depths) often exceed long-term (chronic) BC WQGs. Mn-t concentrations exceeded the short-term (acute) BC WQG, whereas Cu-d and Zn-t were lower than the short-term BC WQGs.

Metal concentrations in Buttle Lake at the Karst Creek station are much lower than at the Henshaw Creek station. Mn-t and Zn-t concentrations in each of the samples collected in February 2019 and April 2019 (all depths) exceeded long-term (chronic) BC WQGs. Mn-t concentrations exceeded the short-term (acute) BC WQG and Cu-d in two samples from February 2019 exceed the long-term BC WQG. None of the samples collected in August 2019, October 2019, or December 2019 exceeded the long-term (chronic) BC WQG for Zn-t.

Monthly surface samples (0 m) from the Gold River bridge station are consistent with the seasonal pattern that is evident at the Henshaw Creek and Karst Creek stations upstream (nearer the base of Myra Falls). Specifically, Zn and Mn (and some other metals) were highest from February to April 2019 and lower from June to December 2019. Mean and median metal concentrations in Buttle Lake in 2019 are consistent with previous monitoring years.

6 CLOSURE

Robertson GeoConsultants Inc. (RGC) is pleased to submit this report entitled ‘2019 Surface Water and Groundwater Monitoring Report, Nyrstar Myra Falls’. We trust that the information provided in this report meets NMF’s requirements at this time. Should you have any questions or if we can be of further assistance, please do not hesitate to contact the undersigned.

Respectfully Submitted,

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Appendix A.

Monthly Loads Captured by Phase I Lynx SIS

Table A-1 Calculated Contaminant Loads for PW14-01

Year	Month	Average Pumping Rate [L/s]	Days Operating [days]	Pumped Volume [m^3]	SO_4 Load [t]	Cd Load [t]	Cu Load [t]	Zn Load [t]
2017	Oct	29.8	24	61,766	19.0	0.001	0.011	0.85
	Nov	30.8	19	50,495	13.6	0.001	0.008	0.68
	Dec	29.4	15	38,075	15.6	0.001	0.012	0.75
2018	Jan	29.8	13	33,516	8.2	0.001	0.006	0.40
	Feb	30.0	19	49,327	20.2	0.001	0.016	0.98
	Mar	27.0	30	70,073	24.0	0.002	0.020	1.16
	Apr	30.1	25	65,083	17.8	0.001	0.015	0.87
	May	29.9	30	77,378	22.3	0.002	0.017	0.95
	Jun	27.7	27	64,690	17.3	0.001	0.016	0.73
	Jul	25.4	10	21,912	5.9	0.000	0.005	0.25
	Aug	27.9	28	67,424	18.0	0.001	0.017	0.76
	Sep	27.6	30	71,589	19.1	0.001	0.018	0.81
	Oct	25.8	31	69,057	17.0	0.001	0.011	0.70
	Nov	28.8	30	74,756	35.7	0.003	0.034	1.43
	Dec	29.8	3	7,736	5.5	0.000	0.006	0.22
2019	Jan	0.0	0	-	-	-	-	-
	Feb	19.4	28	46,967	34.1	0.003	0.059	1.47
	Mar	19.5	31	52,282	17.5	0.001	0.017	0.77
	Apr	20.8	30	53,935	16.6	0.001	0.016	0.69
	May	20.6	31	55,285	15.5	0.001	0.015	0.60
	Jun	20.8	30	52,506	12.2	0.001	0.014	0.57
	Jul	20.8	31	55,602	11.6	0.001	0.013	0.57
	Aug	20.2	31	54,010	10.6	0.001	0.011	0.50
	Sep	20.3	30	52,319	9.6	0.001	0.010	0.43
	Oct	21.2	31	56,854	8.6	0.001	0.010	0.43
	Nov	21.8	30	55,976	10.1	0.001	0.011	0.47
	Dec	22.8	31	60,026	10.9	0.001	0.012	0.50
Total		**24.4**	**668 (82%)**	**1,418,639**	**416.3**	**0.030**	**0.401**	**18.53**

Table A-2 Calculated Contaminant Loads for PW14-03

Year	Month	Average Pumping Rate [L/s]	Days Operating [d]	Pumped Volume [m^3]	SO_4 Load [t]	Cd Load [t]	Cu Load [t]	Zn Load [t]
2017	Oct	13.6	23	26,984	5.5	0.001	0.031	0.51
	Nov	13.0	19	21,291	8.3	0.001	0.036	0.60
	Dec	14.8	28	35,780	13.4	0.001	0.043	1.21
2018	Jan	17.6	31	47,034	16.2	0.002	0.052	1.43
	Feb	16.2	28	39,134	11.3	0.001	0.036	0.97
	Mar	9.6	30	24,825	11.0	0.001	0.051	0.95
	Apr	14.9	25	32,103	12.4	0.001	0.057	1.03
	May	13.5	31	36,152	12.0	0.001	0.048	0.84
	Jun	12.2	28	29,441	8.9	0.001	0.038	0.56
	Jul	10.3	27	24,001	7.3	0.001	0.031	0.51
	Aug	7.8	31	20,768	6.3	0.001	0.027	0.44
	Sep	9.8	30	25,519	7.7	0.001	0.033	0.54
	Oct	11.4	31	30,606	6.2	0.001	0.035	0.58
	Nov	14.8	29	37,176	14.5	0.002	0.063	1.06
	Dec	18.1	13	20,329	11.7	0.001	0.046	0.77
2019	Jan	20.8	31	55,617	26.9	0.003	0.102	1.64
	Feb	12.3	28	29,688	14.4	0.001	0.054	0.88
	Mar	9.7	31	25,934	10.1	0.001	0.037	0.55
	Apr	13.2	30	34,228	11.8	0.001	0.049	0.70
	May	12.8	31	34,356	10.2	0.001	0.046	0.63
	Jun	11.5	30	29,808	8.3	0.001	0.037	0.46
	Jul	9.5	31	25,311	5.4	0.001	0.021	0.33
	Aug	7.4	31	19,927	3.7	0.000	0.014	0.21
	Sep	8.6	30	22,213	3.4	0.000	0.013	0.18
	Oct	11.1	31	29,623	4.6	0.000	0.017	0.27
	Nov	12.2	30	31,596	6.9	0.001	0.027	0.42
	Dec	14.9	31	40,015	8.7	0.001	0.035	0.53
Total		**12.6**	**769 (94%)**	**829,458**	**267.2**	**0.027**	**1.080**	**18.80**

Table A-3 Calculated Contaminant Loads for PW14-04

Year	Month	Average Pumping Rate [L/s]	Days Operating [d]	Pumped Volume [m^3]	SO_4 Load [t]	Cd Load [t]	Cu Load [t]	Zn Load [t]
2017	Oct	14.9	23	29,549	22.8	0.002	0.067	0.80
	Nov	14.6	19	23,962	16.6	0.002	0.048	0.58
	Dec	15.2	28	36,676	36.6	0.004	0.124	1.34
2018	Jan	17.9	31	48,028	34.4	0.003	0.104	1.32
	Feb	18.7	15	24,262	16.1	0.001	0.046	0.58
	Mar	10.3	30	26,743	17.8	0.002	0.051	0.64
	Apr	18.4	24	38,248	23.9	0.002	0.068	0.80
	May	19.3	31	51,724	31.3	0.003	0.082	0.99
	Jun	17.8	30	46,248	25.4	0.002	0.061	0.73
	Jul	16.1	31	43,002	23.7	0.002	0.057	0.68
	Aug	14.4	31	38,607	21.2	0.002	0.051	0.61
	Sep	15.8	30	40,873	22.5	0.002	0.054	0.64
	Oct	17.2	31	46,064	25.3	0.002	0.061	0.72
	Nov	20.3	17	29,817	20.6	0.002	0.060	0.72
	Dec	19.1	10	16,514	25.8	0.002	0.077	0.72
2019	Jan	23.8	28	57,571	34.2	0.004	0.158	2.27
	Feb	17.9	28	43,247	30.2	0.003	0.096	1.31
	Mar	14.8	31	39,575	31.8	0.002	0.067	0.84
	Apr	17.2	30	44,671	32.9	0.002	0.074	0.88
	May	16.9	31	45,189	17.0	0.001	0.049	0.66
	Jun	14.2	30	36,703	24.5	0.001	0.047	0.49
	Jul	14.7	31	39,346	21.4	0.001	0.039	0.54
	Aug	12.5	31	33,453	15.5	0.001	0.025	0.36
	Sep	12.5	30	32,452	12.5	0.001	0.016	0.26
	Oct	14.2	31	37,980	15.1	0.001	0.030	0.38
	Nov	15.0	30	38,880	18.9	0.001	0.036	0.46
	Dec	16.8	31	45,077	22.0	0.001	0.042	0.53
Total		**16.3**	**743 (91%)**	**1,034,462**	**640.0**	**0.052**	**1.691**	**20.83**

Appendix B.

QA/QC Results

Quality control (QC) was undertaken as per the Surface Water and Groundwater Monitoring Plan. Duplicates and field blanks were compared and a Charge Balance Analysis (CBA) was undertaken.

CBA

A Charge Balance Analysis (CBA) was conducted as part of the QC assessment of water quality results for 2019. 211 groundwater samples were analyzed, a minimum of 0% was calculated with a max of 133%, and the median of these samples was 14%. These values can be seen in Table B-1 through B-4.

88 surface water samples of Buttle Lake were analyzed, a minimum of 0% was calculated with a max of 99%, and the median of these samples was 12%. These values can be seen in Table B-5 and B-6.

47 surface water samples of Myra Creek were analyzed, a minimum of 0% was calculated with a max of 145%, and the median of these samples was 12%. These values can be seen in Table B-7.

Duplicates

During sampling non-blind field duplicates are taken to assess the consistency of the sampling process and gauge the homogeneity of the sample stream. A comparison is made between samples to determine the relative percent difference (RPD). If the RPD is above twenty percent (20%), and the concentration of the analyte is more than double the detection limit for the sampling method the analyte is flagged as not meeting the expected QA/QC standard. There were four duplicates manually taken in 2019 with an additional 45 taken by auto samplers.

Two of the manually drawn duplicates were taken at Henshaw station at water surface level (0 meters), one on April 25th and the second on June 19th. This comparison can be seen in Table B-8 and B-9. The April 25th sampled 92 Analytes and had 5 with flagged RPD values but all were all under twice the detection limit. The June 19th also sampled 92 parameters and had 15 of the analytes outside the 20% RPD with 9 of these parameters being greater than double the detection limit. These include the dissolved values for copper (47%) and molybdenum (35%) and the total values for chromium (47%), cobalt (57%), copper (24%), iron (128%), manganese (45%), molybdenum (40%) and vanadium (36%). This result suggests the suspended solids in the water sample may not have been well mixed before filling the sample bottles, resulting in non-homogenous samples.

The two additional manually drawn duplicates were taken at Karst station 10 meters below water surface, one on February 7th and the other sampled on August 21st. This comparison can be seen in Table B-10 and B-11. The February 7th sample had 2 analytes greater than 20% RPD but both were less than double the detection limit. The August 21st sample had 6 flagged parameters with 2 being greater than double the detection limit, dissolved molybdenum (126%) and total iron (39%). It is unknown why these analytes are outside the acceptable RPD limit.

Blanks

Field-blanks are used to assess potential contaminations that can emerge during sample handling, by sampling apparatus or influences from other factors, such as air-borne particulates. Field blanks are containers of laboratory reagent water (analyte-free) that mirror the sampling method, handling, preservation, storage and shipment of regulatory samples to the third party lab. There were three field blank tests completed in 2019 and can be seen in Table B-12 and B-13. All the samples were negative implying no contaminates being introduced during sample preparation.

Travel-blanks consist of de-ionized water provided by the third party laboratory that remained sealed. The container is transported with the regulatory samples and exposed to the same conditions during the monitoring event. There were four travel blanks tested in 2019 and can be seen in Table B-14 and B-15. All travel blanks were positive, suggesting a possibility of cross contamination at the third party laboratory or the water provided was not analyte-free, or there was some potential introduction of contaminates in the samples.

Table B- 1 CBA of the 2019 Groundwater Chemistry Data at ETA/Cookhouse and Interim Phase II Lynx SIS Areas

Station	Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
ETA/Cookhouse Area											
MW13-02S	6-Mar-19	1.40	0.22	0.08	0.00	0.86	1.00	0.09	1.70	1.95	**14**
MW13-02S	21-Nov-19	2.05	0.31	0.10	0.00	0.91	1.61	0.10	2.47	2.61	**6**
MW13-02D	6-Mar-19	2.41	0.19	0.10	0.01	1.45	1.61	0.05	2.70	3.11	**14**
MW13-02D	21-Nov-19	2.44	0.20	0.11	0.01	1.43	1.63	0.05	2.75	3.11	**12**
MW11-02	9-Aug-19	1.60	0.35	0.07	0.02	0.06	2.64	0.03	2.04	2.74	**29**
MW11-02	21-Nov-19	5.64	1.54	0.15	0.03	0.06	7.97	0.05	7.36	8.08	**9**
Interim Phase II Lynx SIS											
PW18-01	7-Mar-19	1.02	0.22	0.05	0.01	0.64	0.79	0.03	1.3	1.5	**11**
PW18-01	10-Apr-19	0.77	0.17	0.05	0.01	0.70	0.57	0.02	1.0	1.3	**27**
PW18-01	10-May-19	0.81	0.16	0.04	0.00	0.59	0.54	0.02	1.0	1.2	**12**
PW18-01	10-Jun-19	0.74	0.15	0.04	0.00	0.60	0.42	-	0.9	1.0	**9**
PW18-01	31-Jul-19	0.71	0.11	0.04	0.00	0.58	0.31	0.02	0.9	0.9	**5**
PW18-01	11-Sep-19	0.63	0.12	0.04	0.01	0.54	0.32	0.02	0.8	0.9	**10**
PW18-01	9-Oct-19	0.76	0.14	0.04	0.00	0.56	0.43	0.02	0.9	1.0	**7**
PW18-01	9-Nov-19	0.77	0.15	0.04	0.01	0.62	0.50	0.02	1.0	1.1	**15**
PW18-02	7-Mar-19	1.01	0.22	0.05	0.01	0.65	0.80	0.03	1.3	1.5	**13**
PW18-02	10-Apr-19	0.91	0.23	0.05	0.01	0.58	0.82	0.03	1.2	1.4	**18**
PW18-02	10-May-19	0.88	0.19	0.05	0.00	0.58	0.73	0.03	1.1	1.3	**18**
PW18-02	10-Jun-19	0.82	0.18	0.04	0.00	0.61	0.59	-	1.0	1.2	**14**
PW18-02	31-Jul-19	0.80	0.14	0.04	0.00	0.60	0.50	0.02	1.0	1.1	**13**
PW18-02	11-Sep-19	0.71	0.15	0.04	0.01	0.57	0.45	0.02	0.9	1.0	**13**
PW18-03	7-Mar-19	0.97	0.20	0.05	0.01	0.64	0.70	0.03	1.2	1.4	**10**
PW18-03	10-Apr-19	0.89	0.22	0.05	0.01	0.58	0.76	0.02	1.2	1.4	**16**
PW18-03	10-May-19	0.82	0.16	0.05	0.00	0.61	0.59	0.03	1.0	1.2	**17**
PW18-03	10-Jun-19	0.75	0.16	0.04	0.00	0.59	0.53	-	1.0	1.1	**15**
PW18-03	31-Jul-19	0.78	0.13	0.04	0.00	0.54	0.47	0.02	1.0	1.0	**7**
PW18-03	11-Sep-19	0.70	0.14	0.05	0.01	0.54	0.45	0.02	0.9	1.0	**11**
PW18-03	9-Oct-19	0.75	0.14	0.04	0.01	0.56	0.46	0.02	0.9	1.0	**11**
PW18-03	9-Nov-19	0.76	0.15	0.04	0.01	0.55	0.52	0.02	1.0	1.1	**12**
PW18-04	7-Mar-19	0.91	0.20	0.06	0.01	0.56	0.74	0.02	1.2	1.3	**12**
PW18-04	10-Apr-19	0.80	0.17	0.05	0.01	0.61	0.59	0.03	1.0	1.2	**17**
PW18-04	31-Jul-19	0.78	0.13	0.04	0.00	0.54	0.46	0.02	1.0	1.0	**6**
MW13-19	22-Nov-19	0.68	0.07	0.03	0.00	0.80	0.09	0.02	0.8	0.9	**14**
MW16-05	23-Jan-19	3.10	0.23	0.05	0.01	0.77	3.16	-	3.4	3.9	**15**
MW16-05	18-Dec-19	3.92	0.35	0.34	0.02	1.24	3.79	0.19	4.6	5.2	**12**
MW18-07S	29-Jan-19	1.67	0.15	0.05	0.01	0.94	1.28	0.03	1.9	2.2	**17**
MW18-07S	18-Dec-19	1.65	0.48	0.07	0.02	0.08	2.91	0.02	2.2	3.0	**31**
MW18-07D	29-Jan-19	0.88	0.12	0.04	0.00	0.93	0.26	0.03	1.0	1.2	**15**
MW18-07D	7-Mar-19	0.97	0.18	0.06	0.01	0.57	0.75	0.02	1.2	1.3	**11**
MW18-07D	8-May-19	0.90	0.18	0.06	0.00	0.45	0.65	0.02	1.1	1.1	**2**
MW18-07D	2-Jul-19	1.45	0.38	0.06	0.02	0.15	1.78	0.02	1.9	2.0	**2**
MW18-07D	4-Jul-19	0.91	0.18	0.08	0.01	0.42	0.70	0.02	1.2	1.1	**3**
MW18-07D	16-Oct-19	0.69	0.13	0.06	0.00	0.41	0.54	0.02	0.9	1.0	**9**
MW18-07D	15-Nov-19	0.72	0.11	0.05	0.00	0.22	0.53	0.02	0.9	0.8	**15**
MW18-07D	18-Dec-19	1.52	0.40	0.06	0.02	0.26	2.10	0.02	2.0	2.4	**17**
MW18-08S	29-Jan-19	1.60	0.42	0.10	0.01	0.24	2.27	0.03	2.1	2.5	**18**
MW18-08S	1-Mar-19	1.60	0.42	0.09	0.01	0.53	1.92	0.03	2.1	2.5	**15**
MW18-08S	10-May-19	1.46	0.38	0.07	0.01	0.64	1.60	0.03	1.9	2.3	**16**
MW18-08S	2-Jul-19	1.22	0.37	0.07	0.01	0.51	1.40	0.02	1.7	1.9	**15**
MW18-08S	23-Oct-19	1.26	0.36	0.07	0.01	0.33	1.41	0.03	1.7	1.8	**4**
MW18-08S	31-Oct-19	1.34	0.38	0.08	0.01	0.36	1.40	0.03	1.8	1.8	**2**
MW18-08D	29-Jan-19	1.38	0.33	0.09	0.01	0.54	1.60	0.03	1.8	2.2	**18**
MW18-08D	1-Mar-19	1.35	0.36	0.08	0.01	0.51	1.59	0.03	1.8	2.1	**16**
MW18-08D	10-May-19	1.10	0.27	0.07	0.01	0.45	1.18	0.03	1.4	1.7	**14**
MW18-08D	2-Jul-19	1.02	0.26	0.06	0.01	0.32	1.11	0.02	1.4	1.4	**7**
MW18-08D	23-Oct-19	0.93	0.22	0.06	0.01	0.34	0.86	0.02	1.2	1.2	**1**
MW18-08D	31-Oct-19	0.99	0.25	0.06	0.01	0.35	0.87	0.02	1.3	1.2	**5**

Table B- 2 CBA of the 2019 Groundwater Chemistry Data at Super Pond Area

Station	Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
Super Pond Area											
MW14-03S	5-Mar-19	2.56	0.57	0.17	0.02	0.54	3.25	0.06	3.32	3.85	**15**
MW14-03S	20-Sep-19	1.38	0.30	0.07	0.01	0.71	1.24	0.03	1.76	1.98	**12**
MW14-03S	21-Nov-19	2.59	0.61	0.14	0.02	0.71	3.02	0.05	3.36	3.78	**12**
MW14-03D	5-Mar-19	1.04	0.23	0.07	0.00	0.64	0.93	0.05	1.35	1.62	**18**
MW14-03D	20-Sep-19	0.74	0.16	0.04	0.01	0.70	0.35	0.03	0.94	1.08	**14**
MW14-03D	29-Nov-19	0.67	0.14	0.05	0.00	1.56	0.38	0.03	0.86	1.97	**78**
MW14-04S	1-Feb-19	18.96	21.07	0.20	0.00	0.02	129.91	0.06	40.23	129.99	**105**
MW14-04S	21-Nov-19	20.61	31.52	0.26	0.01	0.02	262.32	0.06	52.39	262.39	**133**
MW14-04D	1-Feb-19	7.54	2.48	0.36	0.02	0.10	15.26	0.07	10.38	15.43	**39**
MW14-04D	26-Sep-19	2.28	0.61	0.15	0.01	0.31	2.81	0.03	3.05	3.16	**3**
MW14-04D	29-Nov-19	2.98	1.11	0.19	0.01	0.03	4.81	0.04	4.29	4.87	**13**
MW14-05M	9-Aug-19	2.14	0.36	0.07	0.01	0.69	2.21	0.03	2.58	2.93	**13**
MW14-05M	15-Nov-19	2.16	0.37	0.07	0.01	0.62	1.84	0.03	2.61	2.49	**5**
MW14-05D	9-Aug-19	2.09	0.34	0.07	0.01	0.73	2.14	0.03	2.50	2.90	**15**
MW14-05D	15-Nov-19	2.19	0.36	0.07	0.01	0.66	1.85	0.03	2.63	2.54	**4**
PW14-01	7-Mar-19	4.85	1.42	0.27	0.02	0.43	6.97	0.08	6.56	7.48	**13**
PW14-01	10-May-19	3.54	1.07	0.22	0.01	0.47	5.83	0.06	4.85	6.36	**27**
PW14-01	10-Jun-19	3.34	1.03	0.22	0.01	0.45	4.83	-	4.60	5.28	**14**
PW14-01	31-Jul-19	3.19	0.86	0.18	0.01	0.45	4.33	0.05	4.24	4.83	**13**
PW14-01	11-Sep-19	2.53	0.79	0.19	0.01	0.45	3.81	0.05	3.51	4.30	**20**
PW14-01	9-Oct-19	2.49	0.70	0.16	0.01	0.47	3.14	0.04	3.36	3.66	**9**
PW14-01	12-Nov-19	2.69	0.78	0.16	0.01	0.46	3.77	0.04	3.65	4.27	**16**
MW13-05D	1-Feb-19	8.43	2.53	0.39	0.03	0.10	18.34	0.16	11.38	18.60	**48**
MW13-05D	21-Nov-19	1.45	0.33	0.08	0.01	0.56	1.56	0.03	1.88	2.14	**13**
MW18-06S	29-Jan-19	1.68	0.49	0.07	0.02	0.22	2.29	0.02	2.25	2.53	**12**
MW18-06S	7-Mar-19	2.00	0.59	0.08	0.02	0.19	2.87	0.02	2.68	3.08	**14**
MW18-06S	9-May-19	1.86	0.56	0.07	0.02	0.10	2.75	0.02	2.5	2.9	**14**
MW18-06S	16-Oct-19	1.56	0.45	0.06	0.02	0.05	2.05	0.02	2.1	2.1	**1**
MW18-06S	31-Oct-19	1.70	0.50	0.07	0.02	0.04	2.19	0.02	2.3	2.2	**2**
MW18-06S	18-Dec-19	4.38	0.95	0.08	0.01	0.02	18.63	0.01	5.4	18.7	**110**
MW18-06D	29-Jan-19	1.39	0.34	0.06	0.01	0.50	1.52	0.03	1.8	2.1	**13**
MW18-06D	7-Mar-19	1.81	0.48	0.07	0.02	0.29	2.19	0.02	2.4	2.5	**5**
MW18-06D	9-May-19	1.53	0.39	0.06	0.01	0.26	1.97	0.02	2.0	2.3	**12**
MW18-06D	16-Oct-19	1.28	0.33	0.06	0.01	0.12	1.59	0.02	1.7	1.7	**3**
MW18-06D	31-Oct-19	1.33	0.35	0.06	0.02	0.18	1.51	0.02	1.8	1.7	**3**
MW18-06D	18-Dec-19	2.02	0.56	0.07	0.01	0.02	11.74	0.02	2.7	11.8	**126**
PW14-04	31-Jan-19	6.44	2.04	0.40	0.02	-	12.37	0.19	8.9	12.6	**34**
PW14-04	7-Mar-19	8.78	3.40	0.28	0.02	0.02	16.74	0.06	12.5	16.8	**30**
PW14-04	10-Apr-19	7.73	3.26	0.27	0.02	0.02	15.34	0.06	11.3	15.4	**31**
PW14-04	10-Jun-19	6.64	2.63	0.25	0.02	0.02	13.91	-	9.5	13.9	**37**
PW14-04	31-Jul-19	6.24	2.08	0.22	0.02	0.02	11.30	0.05	8.6	11.4	**28**
PW14-04	11-Sep-19	4.23	1.51	0.23	0.02	0.02	7.99	0.04	6.0	8.1	**30**
PW14-04	9-Oct-19	5.29	1.79	0.21	0.02	0.02	8.27	0.04	7.3	8.3	**13**
PW14-04	12-Nov-19	5.69	2.02	0.22	0.02	0.02	10.14	0.04	7.9	10.2	**25**
MW13-06S	21-Nov-19	16.72	4.92	0.44	0.04	0.04	23.94	0.03	22.1	24.0	**8**
MW13-06D	1-Feb-19	10.63	3.23	0.54	0.03	0.65	18.17	0.11	14.4	18.9	**27**
MW13-06D	21-Nov-19	0.64	0.19	0.07	0.01	0.32	0.67	0.02	0.9	1.0	**11**
MW16-01	23-Jan-19	3.56	0.82	0.14	0.02	1.02	4.04	-	4.5	5.1	**11**
MW16-01	1-Mar-19	4.29	0.56	0.08	0.01	2.38	3.10	0.03	4.9	5.5	**11**
MW16-01	23-Oct-19	4.61	0.33	0.03	0.01	0.95	4.27	0.02	5.0	5.2	**5**
MW16-01	18-Dec-19	2.83	0.35	0.03	0.01	0.28	3.10	0.00	3.2	3.4	**5**
MW16-02	23-Oct-19	8.88	1.73	0.11	0.03	0.02	12.30	0.02	10.7	12.3	**14**
MW16-02	18-Dec-19	4.99	0.50	0.04	0.01	0.02	14.26	0.01	5.5	14.3	**88**
MW16-03	23-Jan-19	5.44	0.62	0.13	0.01	1.08	6.33	-	6.2	7.4	**18**
MW16-03	18-Dec-19	8.13	1.00	0.21	0.02	1.53	9.89	0.02	9.4	11.4	**20**
MW11-04	29-Jan-19	5.39	2.64	0.18	0.03	0.02	13.51	0.10	8.2	13.6	**49**
MW11-04	1-Mar-19	1.86	0.70	0.10	0.01	0.05	3.60	0.04	2.7	3.7	**32**
MW11-04	10-May-19	3.64	1.39	0.15	0.02	0.02	6.18	0.05	5.2	6.3	**18**
MW11-04	2-Jul-19	3.06	1.13	0.13	0.02	0.02	5.31	0.04	4.3	5.4	**21**
MW11-04	23-Oct-19	3.67	1.33	0.16	0.02	0.03	5.31	0.04	5.2	5.4	**4**
MW11-04	31-Oct-19	3.69	1.45	0.19	0.02	0.02	5.56	0.05	5.4	5.6	**5**

Table B- 3 CBA of the 2019 Groundwater Chemistry Data at Near Myra Creek and Polishing Ponds, Outer Drain and Near Myra Creek

Station	Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
Near Myra Creek and Polishing Ponds											
MW13-11S	28-Mar-19	4.72	0.74	0.26	0.05	1.08	5.79	0.07	5.8	6.9	**18**
MW13-11S	31-Oct-19	6.84	0.81	0.25	0.06	1.19	6.66	0.10	8.0	7.9	**0**
MW13-11D	28-Mar-19	4.07	0.65	0.27	0.05	1.09	5.04	0.07	5.0	6.2	**20**
MW13-11D	1-Aug-19	4.45	0.62	0.26	0.06	1.36	5.48	0.10	5.4	6.9	**25**
MW13-11D	31-Oct-19	5.14	0.81	0.33	0.06	0.72	5.20	0.12	6.4	6.0	**5**
MW17-4	9-May-19	1.00	0.14	0.07	0.01	0.46	0.94	0.04	1.2	1.4	**16**
MW17-4	9-Aug-19	1.07	0.14	0.08	0.01	0.33	1.15	0.04	1.3	1.5	**14**
MW17-4	22-Nov-19	0.55	0.11	0.04	0.00	0.61	0.14	0.02	0.7	0.8	**7**
MW17-8	28-Mar-19	3.79	0.70	0.14	0.02	1.18	4.14	0.04	4.6	5.4	**14**
MW17-8	8-May-19	3.66	0.65	0.13	0.02	1.00	5.00	0.04	4.4	6.0	**30**
MW17-8	2-Aug-19	2.83	0.48	0.12	0.02	1.13	2.66	0.04	3.4	3.8	**11**
Outer Drain											
MW13-14S	31-Jan-19	2.09	0.78	0.12	0.03	-	4.31	0.03	3.0	4.3	**36**
MW13-14S	6-May-19	1.22	0.42	0.07	0.01	0.19	1.65	0.02	1.7	1.9	**8**
MW13-14S	8-Aug-19	1.00	0.25	0.08	0.01	0.17	1.35	0.03	1.3	1.5	**14**
MW13-14S	31-Oct-19	2.00	0.72	0.11	0.02	0.15	2.62	0.03	2.9	2.8	**2**
MW13-14D	31-Jan-19	1.99	0.71	0.11	0.02	-	2.35	0.02	2.8	2.4	**17**
MW13-14D	6-May-19	1.84	0.63	0.11	0.03	0.12	2.81	0.02	2.6	2.9	**12**
MW13-14D	8-Aug-19	1.88	0.63	0.10	0.02	0.15	3.31	0.03	2.6	3.5	**28**
MW13-14D	22-Nov-19	2.90	1.15	0.14	0.03	0.15	5.70	0.03	4.2	5.9	**33**
MW13-15S	16-Aug-19	1.09	0.33	0.07	0.01	0.57	0.92	0.03	1.5	1.5	**0**
MW13-15S	15-Nov-19	1.20	0.26	0.08	0.01	0.47	1.03	0.03	1.6	1.5	**1**
MW13-15D	16-Aug-19	2.10	0.55	0.10	0.01	1.91	1.59	0.02	2.8	3.5	**24**
MW13-15D	15-Nov-19	2.43	0.56	0.09	0.01	1.37	1.59	0.02	3.1	3.0	**4**
MW-A	8-Mar-19	2.38	1.00	0.13	0.03	0.02	4.79	0.02	3.5	4.8	**31**
MW-A	26-Jun-19	3.89	1.89	0.15	0.03	0.02	9.31	0.03	6.0	9.4	**44**
MW-A	26-Sep-19	5.19	2.33	0.18	0.04	0.02	9.53	0.04	7.7	9.6	**21**
MW-A	19-Dec-19	4.39	2.26	0.18	0.03	0.02	13.93	0.04	6.9	14.0	**68**
MW-C	8-Mar-19	2.24	0.97	0.13	0.02	0.02	5.20	0.03	3.4	5.3	**44**
MW-C	26-Mar-19	5.84	2.26	0.22	0.01	0.61	9.20	0.04	8.3	9.9	**17**
MW-C	9-May-19	6.44	2.40	0.23	0.01	0.57	8.72	0.05	9.1	9.3	**3**
MW-C	8-Aug-19	6.04	2.39	0.21	0.01	0.54	10.20	0.04	8.7	10.8	**22**
MW-C	29-Nov-19	6.24	2.49	0.22	0.01	0.66	9.87	0.04	9.0	10.6	**16**
MW-D	26-Jun-19	4.04	2.02	0.16	0.03	0.02	9.87	0.03	6.2	9.9	**45**
MW-D	26-Sep-19	5.19	2.43	0.18	0.04	0.02	9.45	0.04	7.8	9.5	**19**
MW-D	29-Nov-19	3.32	1.59	0.19	0.03	0.02	7.20	0.03	5.1	7.3	**34**
MW-F	26-Mar-19	0.52	0.08	0.05	0.00	0.16	0.37	0.03	0.7	0.6	**17**
MW-F	9-May-19	1.33	0.44	0.07	0.01	0.22	0.35	0.03	1.9	0.6	**101**
MW-F	18-Dec-19	1.69	0.64	0.11	0.02	0.35	0.78	0.03	2.5	1.2	**72**
Near Myra Creek											
MW13-16S	28-Mar-19	0.77	0.10	0.04	0.00	0.81	0.23	0.02	0.9	1.1	**14**
MW13-16S	19-Sep-19	1.28	0.16	0.05	0.00	0.82	0.80	0.09	1.5	1.7	**13**
MW13-16S	15-Nov-19	1.50	0.18	0.06	0.00	0.86	0.84	0.03	1.7	1.7	**1**
MW13-16D	28-Mar-19	1.17	0.26	0.06	0.00	0.93	0.81	0.02	1.5	1.8	**17**
MW13-16D	19-Sep-19	1.38	0.27	0.04	0.00	0.89	0.95	0.02	1.7	1.9	**9**
MW13-16D	15-Nov-19	1.41	0.28	0.06	0.00	0.78	0.92	0.03	1.7	1.7	**1**
MW13-17	28-Mar-19	2.02	0.28	0.05	0.01	0.87	1.74	0.02	2.4	2.6	**11**
MW13-17	1-Aug-19	0.96	0.09	0.03	0.00	0.90	0.36	0.01	1.1	1.3	**16**
MW13-17	31-Oct-19	2.36	0.28	0.06	0.01	1.20	1.61	0.02	2.7	2.8	**4**
MW13-18S	28-Mar-19	1.82	0.51	0.07	0.01	1.16	1.60	0.02	2.4	2.8	**15**
MW13-18S	1-Aug-19	1.19	0.28	0.06	0.01	0.74	1.03	0.03	1.5	1.8	**16**
MW13-18S	31-Oct-19	2.41	0.64	0.10	0.01	1.03	2.10	0.03	3.2	3.2	**0**
MW13-18D	28-Mar-19	3.21	0.96	0.11	0.01	1.81	2.96	0.03	4.3	4.8	**11**
MW13-18D	1-Aug-19	3.19	0.82	0.10	0.01	1.69	3.06	0.03	4.1	4.8	**14**
MW13-18D	31-Oct-19	4.07	1.20	0.13	0.01	1.79	3.50	0.03	5.4	5.3	**2**

Table B- 4 CBA of the 2019 Groundwater Chemistry Data at Mill Area, Surge Pond Area, Near Myra Creek and HW Offices and Old TDF Footprint

Station	Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
Mill Area											
MW14-01S	7-Mar-19	2.88	0.63	0.22	0.01	0.23	3.98	0.21	3.74	4.41	**17**
MW14-01S	20-Sep-19	3.63	0.71	0.22	0.01	-	4.41	0.17	4.57	4.58	**0**
MW14-01S	7-Nov-19	3.89	0.75	0.22	0.01	0.32	4.81	0.18	4.87	5.32	**9**
MW14-01D	20-Sep-19	4.32	1.01	1.40	0.05	2.24	4.91	0.51	6.78	7.66	**12**
MW14-02D	12-Jun-19	4.43	0.86	0.49	0.01	1.25	4.73	0.12	5.78	6.09	**5**
PW14-03	7-Mar-19	4.27	1.28	0.27	0.02	0.12	8.12	0.13	5.84	8.38	**36**
PW14-03	10-Apr-19	3.85	1.24	0.26	0.02	0.11	7.20	0.13	5.37	7.44	**32**
PW14-03	10-May-19	3.77	1.09	0.23	0.02	0.13	6.18	0.13	5.11	6.44	**23**
PW14-03	10-Jun-19	3.48	1.06	0.23	0.01	0.17	5.79	-	4.78	5.95	**22**
PW14-03	31-Jul-19	3.12	0.78	0.18	0.01	0.23	4.43	0.10	4.09	4.77	**15**
PW14-03	11-Sep-19	2.27	0.61	0.20	0.01	0.30	3.21	0.09	3.09	3.59	**15**
PW14-03	9-Oct-19	2.50	0.62	0.16	0.01	0.30	3.21	0.10	3.29	3.60	**9**
PW14-03	12-Nov-19	2.92	0.81	0.18	0.01	0.21	4.52	0.12	3.93	4.85	**21**
Surge Pond Area											
MW17-2D	31-Jan-19	3.21	1.98	0.23	0.02	0.02	8.85	0.04	5.4	8.9	**48**
MW17-2D	5-Mar-19	3.95	2.22	0.13	0.02	0.02	10.83	0.03	6.3	10.9	**53**
MW17-2D	8-May-19	8.43	4.87	0.34	0.05	0.02	18.32	0.03	13.7	18.4	**29**
MW17-2D	20-Sep-19	2.59	1.27	0.11	0.02	0.02	5.75	0.02	4.0	5.8	**37**
MW17-2D	26-Sep-19	3.74	1.51	0.12	0.02	0.02	7.00	0.02	5.4	7.0	**26**
MW17-2D	7-Nov-19	0.95	0.36	0.06	0.01	0.19	1.52	0.02	1.4	1.7	**23**
MW17-2D	31-Dec-19	1.14	0.45	0.08	0.01	0.12	1.64	0.02	1.7	1.8	**6**
MW17-3	1-Feb-19	11.13	6.80	0.25	0.03	0.02	34.77	0.05	18.2	34.8	**63**
MW17-3	5-Mar-19	6.34	3.78	0.19	0.02	0.02	16.03	0.04	10.3	16.1	**44**
MW17-3	20-Sep-19	2.56	0.67	0.16	0.03	0.15	3.54	0.03	3.4	3.7	**8**
MW17-3	7-Nov-19	1.91	0.66	0.12	0.02	0.02	3.21	0.02	2.7	3.2	**18**
MW17-3	31-Dec-19	1.14	1.65	0.13	0.02	0.02	10.93	0.03	2.9	11.0	**116**
Near Myra Creek and HW Offices											
MW17-5	9-May-19	1.34	0.16	0.07	0.01	1.14	0.69	0.02	1.6	1.9	**16**
MW17-5	8-Aug-19	1.07	0.15	0.06	0.01	0.75	0.78	0.02	1.3	1.5	**18**
MW17-5	22-Nov-19	1.79	0.25	0.12	0.02	0.58	1.73	0.05	2.2	2.4	**8**
MW17-6	26-Sep-19	0.97	0.25	0.09	0.01	0.44	0.94	0.02	1.3	1.4	**6**
MW17-6	7-Nov-19	1.81	0.48	0.09	0.01	0.56	1.84	0.02	2.4	2.4	**2**
MW17-7	9-May-19	0.96	0.16	0.06	0.01	0.68	0.69	0.02	1.2	1.4	**16**
MW17-7	9-Aug-19	1.07	0.16	0.07	0.01	0.70	0.82	0.02	1.3	1.5	**17**
MW17-7	22-Nov-19	1.16	0.18	0.06	0.01	0.78	0.81	0.02	1.4	1.6	**13**
MW13-13	28-Mar-19	1.16	0.25	0.05	0.00	0.54	1.29	0.03	1.5	1.9	**23**
MW13-13	8-May-19	2.04	0.56	0.07	0.00	0.45	2.96	0.04	2.7	3.4	**25**
MW13-13	31-Oct-19	1.23	0.27	0.06	0.00	0.30	1.24	0.02	1.6	1.6	**0**
Old TDF Footprint											
TD13-01D	20-Dec-19	7.09	4.45	0.59	0.03	0.02	17.80	0.05	12.2	17.9	**38**
TD13-02D	20-Dec-19	4.36	1.52	0.26	0.04	0.02	12.49	0.04	6.2	12.5	**68**
TD13-03D	20-Dec-19	12.13	3.28	1.23	0.23	0.83	15.66	0.18	16.9	16.7	**1**
TD13-04D	30-Dec-19	2.05	0.80	0.08	0.01	0.02	10.56	0.02	2.9	10.6	**113**
TD13-05D	7-Nov-19	5.29	2.23	0.29	0.06	0.02	11.70	0.04	7.9	11.8	**40**

Table B- 5 CBA of the 2019 Surface Water Chemistry Data in Buttle Lake at Henshaw Station

Station	Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
Location: Henshaw											
at 0 m	7-Feb-19	0.44	0.06	0.03	0.003	0.46	0.13	0	0.53	0.59	**11**
at 0 m	25-Apr-19	0.44	0.06	0.03	0.002	0.52	0.12	0	0.53	0.64	**18**
at 0 m	19-Jun-19	0.39	0.06	0.03	0.002	0.42	0.09	0	0.47	0.51	**7**
at 0 m	21-Aug-19	0.42	0.06	0.03	0.002	0.46	0.09	0	0.51	0.56	**9**
at 0 m	17-Oct-19	0.44	0.06	0.03	0.002	0.48	0.11	0	0.52	0.59	**12**
at 0 m	4-Dec-19	0.44	0.06	0.03	0.002	0.55	0.11	0	0.52	0.67	**24**
at 0 m (Dup)	25-Apr-19	0.43	0.06	0.03	0.002	0.52	0.12	0	0.52	0.64	**20**
at 0 m (Dup)	19-Jun-19	0.39	0.06	0.02	0.002	0.37	0.09	0	0.47	0.45	**4**
at 10 m	7-Feb-19	0.45	0.06	0.03	0.003	0.45	0.13	0	0.53	0.58	**8**
at 10 m	25-Apr-19	0.46	0.06	0.03	0.002	0.48	0.15	0	0.55	0.63	**15**
at 10 m	19-Jun-19	0.39	0.05	0.03	0.002	0.36	0.11	0	0.47	0.47	**1**
at 10 m	21-Aug-19	0.43	0.06	0.03	0.002	0.46	0.10	0	0.52	0.56	**8**
at 10 m	17-Oct-19	0.44	0.06	0.03	0.002	0.48	0.11	0	0.52	0.59	**12**
at 10 m	4-Dec-19	0.44	0.06	0.03	0.002	1.45	0.11	0	0.53	1.56	**99**
at 20 m	7-Feb-19	0.43	0.06	0.03	0.003	0.44	0.13	0	0.51	0.58	**12**
at 20 m	25-Apr-19	0.46	0.06	0.03	0.002	0.48	0.17	0	0.55	0.65	**16**
at 20 m	19-Jun-19	0.39	0.05	0.03	0.002	0.35	0.10	0	0.47	0.46	**3**
at 20 m	21-Aug-19	0.42	0.06	0.03	0.002	0.47	0.09	0	0.51	0.57	**10**
at 20 m	17-Oct-19	0.44	0.06	0.03	0.002	0.49	0.11	0	0.53	0.60	**11**
at 20 m	4-Dec-19	0.44	0.06	0.03	0.002	0.53	0.11	0	0.53	0.64	**19**
at 40 m	7-Feb-19	0.44	0.06	0.03	0.003	0.45	0.14	0	0.53	0.59	**11**
at 40 m	25-Apr-19	0.47	0.06	0.03	0.002	0.51	0.18	0	0.56	0.69	**20**
at 40 m	19-Jun-19	0.45	0.06	0.03	0.002	0.42	0.15	0	0.54	0.57	**6**
at 40 m	21-Aug-19	0.46	0.06	0.03	0.002	0.48	0.14	0	0.55	0.62	**12**
at 40 m	17-Oct-19	0.43	0.06	0.03	0.002	0.48	0.11	0	0.52	0.59	**12**
at 40 m	4-Dec-19	0.43	0.06	0.03	0.002	0.50	0.11	0	0.52	0.61	**15**
at 60 m	7-Feb-19	0.44	0.06	0.03	0.003	0.46	0.14	0	0.53	0.59	**12**
at 60 m	25-Apr-19	0.49	0.06	0.03	0.002	0.50	0.18	0	0.58	0.68	**15**
at 60 m	19-Jun-19	0.46	0.06	0.03	0.002	0.43	0.17	0	0.55	0.59	**7**
at 60 m	21-Aug-19	0.47	0.06	0.03	0.002	0.49	0.15	0	0.56	0.64	**13**
at 60 m	17-Oct-19	0.42	0.06	0.03	0.002	0.46	0.10	0	0.51	0.56	**9**
at 60 m	4-Dec-19	0.44	0.06	0.03	0.002	0.51	0.12	0	0.53	0.63	**17**
at 100 m	7-Feb-19	0.42	0.06	0.03	0.003	0.46	0.13	0	0.51	0.59	**14**
at 100 m	25-Apr-19	0.49	0.06	0.03	0.002	0.51	0.18	0	0.58	0.69	**17**
at 100 m	19-Jun-19	0.47	0.06	0.03	0.002	0.43	0.17	0	0.56	0.60	**6**
at 100 m	21-Aug-19	0.44	0.06	0.03	0.002	0.47	0.12	0	0.54	0.59	**10**
at 100 m	17-Oct-19	0.43	0.06	0.03	0.002	0.50	0.10	0	0.51	0.60	**15**
at 100 m	4-Dec-19	0.45	0.06	0.03	0.003	0.50	0.13	0	0.55	0.63	**14**

Table B- 6 CBA of the 2019 Surface Water Chemistry Data in Buttle Lake at Karst and Gold Stations

Station	Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
Location: Karst											
at 0 m	7-Feb-19	0.41	0.06	0.03	0.003	0.48	0.08	0	0.51	0.57	**12**
at 0 m	25-Apr-19	0.43	0.06	0.03	0.002	0.56	0.10	0	0.52	0.66	**23**
at 0 m	19-Jun-19	0.39	0.06	0.02	0.002	0.42	0.07	0	0.48	0.49	**2**
at 0 m	21-Aug-19	0.41	0.06	0.03	0.003	0.48	0.08	0	0.50	0.56	**11**
at 0 m	17-Oct-19	0.42	0.06	0.03	0.002	0.49	0.09	0	0.51	0.58	**12**
at 0 m	4-Dec-19	0.43	0.06	0.03	0.002	0.55	0.09	0	0.52	0.64	**21**
at 10 m	7-Feb-19	0.42	0.06	0.03	0.003	0.49	0.08	0	0.51	0.57	**11**
at 10 m	25-Apr-19	0.43	0.06	0.03	0.002	0.55	0.10	0	0.52	0.64	**20**
at 10 m	19-Jun-19	0.38	0.06	0.02	0.001	0.42	0.07	0	0.47	0.49	**5**
at 10 m	21-Aug-19	0.41	0.06	0.02	0.002	0.45	0.08	0	0.49	0.53	**7**
at 10 m	17-Oct-19	0.43	0.06	0.03	0.002	0.49	0.09	0	0.51	0.58	**13**
at 10 m	4-Dec-19	0.43	0.06	0.03	0.002	0.54	0.09	0	0.52	0.63	**20**
at 10 m (Dup)	7-Feb-19	0.42	0.06	0.03	0.003	0.54	0.08	0	0.51	0.62	**19**
at 10 m (Dup)	21-Aug-19	0.40	0.06	0.02	0.002	0.48	0.08	0	0.49	0.56	**13**
at 20 m	7-Feb-19	0.42	0.06	0.03	0.003	0.49	0.08	0	0.51	0.57	**11**
at 20 m	25-Apr-19	0.43	0.06	0.03	0.002	0.54	0.09	0	0.52	0.64	**20**
at 20 m	19-Jun-19	0.40	0.06	0.03	0.001	0.43	0.09	0	0.49	0.52	**6**
at 20 m	21-Aug-19	0.41	0.06	0.02	0.002	0.46	0.08	0	0.50	0.53	**7**
at 20 m	17-Oct-19	0.43	0.06	0.03	0.002	0.46	0.09	0	0.52	0.56	**7**
at 20 m	4-Dec-19	0.43	0.06	0.03	0.002	0.53	0.09	0	0.52	0.62	**17**
at 40 m	7-Feb-19	0.41	0.06	0.03	0.003	0.49	0.08	0	0.50	0.58	**14**
at 40 m	25-Apr-19	0.43	0.06	0.03	0.002	0.53	0.09	0	0.52	0.62	**17**
at 40 m	19-Jun-19	0.41	0.06	0.03	0.001	0.44	0.08	0	0.50	0.53	**6**
at 40 m	21-Aug-19	0.42	0.06	0.03	0.002	0.48	0.08	0	0.51	0.56	**10**
at 40 m	17-Oct-19	0.43	0.06	0.03	0.002	0.48	0.09	0	0.51	0.57	**11**
at 40 m	4-Dec-19	0.42	0.06	0.03	0.002	0.57	0.09	0	0.51	0.66	**25**
at 60 m	7-Feb-19	0.40	0.06	0.03	0.003	0.55	0.08	0	0.49	0.64	**26**
at 60 m	25-Apr-19	0.43	0.06	0.03	0.002	0.54	0.09	0	0.52	0.63	**18**
at 60 m	19-Jun-19	0.41	0.06	0.03	0.001	0.44	0.08	0	0.50	0.52	**4**
at 60 m	21-Aug-19	0.46	0.06	0.03	0.002	0.47	0.08	0	0.55	0.55	**1**
at 60 m	17-Oct-19	0.43	0.06	0.03	0.002	0.49	0.09	0	0.52	0.58	**11**
at 60 m	4-Dec-19	0.43	0.06	0.03	0.002	0.55	0.09	0	0.52	0.64	**21**
at 100 m	7-Feb-19	0.40	0.06	0.03	0.003	0.55	0.08	0	0.49	0.63	**26**
at 100 m	25-Apr-19	0.43	0.06	0.03	0.002	0.52	0.09	0	0.52	0.60	**15**
at 100 m	19-Jun-19	0.40	0.06	0.03	0.001	0.43	0.08	0	0.49	0.51	**4**
at 100 m	21-Aug-19	0.42	0.06	0.03	0.002	0.46	0.08	0	0.51	0.54	**6**
at 100 m	17-Oct-19	0.42	0.06	0.03	0.002	0.48	0.09	0	0.51	0.57	**12**
at 100 m	4-Dec-19	0.43	0.06	0.03	0.002	0.54	0.09	0	0.52	0.64	**20**
Location: Gold											
	16-Jan-19	0.38	0.06	0.02	0.003	0.49	0.00	0	0.47	0.49	**5**
	6-Feb-19	0.41	0.07	0.03	0.003	0.51	0.00	0	0.51	0.51	**0**
	20-Mar-19	0.43	0.07	0.02	0.003	0.51	0.00	0	0.52	0.51	**1**
	3-Apr-19	0.42	0.07	0.03	0.003	0.51	0.00	0	0.52	0.51	**2**
	1-May-19	0.42	0.07	0.04	0.004	0.52	0.00	0	0.53	0.52	**0**
	12-Jun-19	0.43	0.07	0.03	0.003	0.45	0.00	0	0.54	0.45	**18**
	17-Jul-19	0.41	0.06	0.03	0.001	0.49	0.00	0	0.50	0.49	**4**
	7-Aug-19	0.41	0.07	0.03	0.003	0.41	0.00	0	0.51	0.41	**22**
	11-Sep-19	0.44	0.07	0.03	0.003	0.49	0.00	0	0.54	0.49	**9**
	9-Oct-19	0.43	0.06	0.03	0.002	0.51	0.00	0	0.52	0.51	**1**
	14-Nov-19	0.44	0.07	0.03	0.003	0.41	0.00	0	0.53	0.41	**25**
	10-Dec-19	0.44	0.07	0.03	0.003	0.45	0.00	0	0.54	0.45	**19**

Table B- 7 CBA of the 2019 Surface Water Chemistry Data in Myra Creek at MC-M1, MC-TP4, MC-TP4 M and TDF-EFF

Sample Date	Ca-d, meq/L	Mg-d, meq/L	Na-d, meq/L	K-d, meq/L	HCO_3, meq/L	SO_4, meq/L	Cl^--d, meq/L	Sum Cations	Sum Anions	RPD, %
Location: MC-M1										
20-Mar-19	0.23	0.02	0.02	0.003	0.23	0.03	0.02	0.27	0.28	**6**
14-May-19	0.13	0.01	0.02	0.003	0.14	0.02	0.02	0.17	0.18	**6**
7-Aug-19	0.21	0.02	0.03	0.003	0.17	0.03	0	0.26	0.20	**28**
14-Aug-19	0.24	0.02	0.03	0.003	0.26	0.04	0.01	0.29	0.31	**4**
13-Nov-19	0.24	0.02	0.03	0.003	0.25	0.04	0.02	0.28	0.31	**9**
14-Nov-19	0.05	0.01	0.02	0.003	0.02	0.02	0	0.08	0.04	**62**
16-Jan-19	0.84	0.13	0.04	0.003	0.47	0.79	0	1.02	1.27	**22**
6-Feb-19	1.10	0.20	0.06	0.005	0.49	1.15	0	1.37	1.63	**17**
20-Mar-19	0.76	0.12	0.04	0.004	0.27	0.71	0	0.93	0.98	**5**
3-Apr-19	0.47	0.07	0.04	0.003	0.26	0.35	0	0.58	0.61	**5**
1-May-19	0.60	0.09	0.05	0.004	0.34	0.48	0	0.75	0.82	**9**
12-Jun-19	0.43	0.04	0.04	0.003	0.23	0.30	0	0.52	0.53	**2**
17-Jul-19	0.41	0.05	0.03	0.003	0.18	0.34	0	0.50	0.53	**6**
7-Aug-19	1.10	0.14	0.09	0.025	0.24	1.14	0	1.35	1.38	**2**
11-Sep-19	1.31	0.25	0.12	0.011	0.33	1.38	0	1.68	1.71	**2**
9-Oct-19	0.84	0.07	0.07	0.014	0.36	0.71	0	0.99	1.07	**8**
14-Nov-19	0.90	0.13	0.07	0.015	0.27	0.78	0	1.13	1.05	**7**
10-Dec-19	0.86	0.11	0.07	0.013	0.42	0.71	0	1.05	1.13	**7**
Location: MC-TP4										
6-Feb-19	1.23	0.23	0.07	0.006	0.44	0	0	1.53	0.44	**111**
1-May-19	0.60	0.09	0.05	0.004	0.31	0	0	0.74	0.31	**83**
10-Jun-19	0.39	0.04	0.04	0.005	0.20	0.31	0	0.48	0.52	**8**
3-Jul-19	0.69	0.10	0.05	0.004	0.19	0.65	0	0.84	0.84	**0**
7-Aug-19	1.12	0.14	0.09	0.027	0.22	0	0	1.38	0.22	**145**
28-Aug-19	1.74	0.27	0.16	0.024	0.30	1.73	0	2.20	2.03	**8**
27-Sep-19	0.74	0.07	0.06	0.014	0.27	0.69	0	0.89	0.96	**8**
8-Nov-19	1.08	0.14	0.08	0.020	0.45	1.03	0	1.32	1.49	**12**
14-Nov-19	0.85	0.13	0.07	0.015	0.25	0	0	1.07	0.25	**125**
10-Dec-19	0.85	0.12	0.07	0.014	0.32	0	0	1.05	0.32	**106**
Location: MC-TP4 M										
16-Jan-19	0.90	0.13	0.04	0.003	0.41	0	0	1.08	0.41	**90**
13-Mar-19	1.66	0.22	0.10	0.008	0.44	0	0	1.98	0.44	**128**
3-Apr-19	0.46	0.07	0.04	0.003	0.24	0	0	0.58	0.24	**82**
12-Jun-19	0.43	0.04	0.04	0.004	0.19	0	0	0.52	0.19	**92**
17-Jul-19	0.51	0.05	0.04	0.004	0.21	0	0	0.61	0.21	**99**
11-Sep-19	1.27	0.22	0.10	0.009	0.32	0	0	1.59	0.32	**133**
9-Oct-19	0.85	0.07	0.07	0.015	0.32	0	0	1.00	0.32	**104**
Location: TDF-EFF										
3-Jan-19	0.57	0.06	0.02	0.003	0.45	0	0	0.66	0.45	**37**
4-Jan-19	0.70	0.06	0.02	0.003	0.57	0	0	0.79	0.57	**32**
19-Jan-19	0.75	0.05	0.03	0.003	1.23	0	0	0.83	1.23	**39**
20-Jan-19	1.00	0.06	0.03	0.003	1.23	0	0	1.09	1.23	**12**
6-Feb-19	0.93	0.06	0.03	0.003	1.13	0.02	0	1.02	1.15	**12**
3-Apr-19	0.79	0.05	0.03	0.003	1.00	0.04	0	0.87	1.04	**18**
24-Apr-19	0.85	0.05	0.03	0.003	1.05	0	0	0.94	1.05	**11**
1-May-19	0.87	0.05	0.03	0.003	1.06	0.03	0	0.96	1.10	**13**
6-May-19	0.75	0.04	0.03	0.003	0.90	0	0	0.82	0.90	**10**
7-May-19	0.68	0.04	0.03	0.003	0.81	0	0	0.75	0.81	**8**
8-May-19	0.67	0.04	0.02	0.003	0.82	0	0	0.73	0.82	**11**
18-Dec-19	0.70	0.08	0.03	0.003	0.44	0.45	0	0.82	0.89	**8**

Table B- 8 Duplicate Comparisons for 2019 Surface Water Chemistry Data in Buttle Lake at Henshaw Station. Part 1

Analyte	Station ID / Date Sampled / Units MRL	HEN-0 25-Apr-19	HEN-0 D 25-Apr-19	RPD, %	HEN-0 19-Jun-19	HEN-0 D 19-Jun-19	RPD, %
Nitrate (as N)	mg/L 0.01	0.028	0.025	**11**	0.015	0.017	**13**
Nitrite (as N)	mg/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Sulfate	mg/L 1	5.7	5.7	**0**	4.2	4.2	**0**
Hardness, Total (as CaCO3)	mg/L 0.1	25.2	24.7	**2**	22.3	22.3	**0**
Nitrate+Nitrite (as N)	mg/L 0.005	0.0283	0.0252	**12**	*0.02*	*0.02*	**0**
Aluminum, dissolved	ug/L 1	13.4	12.4	**8**	13	12.6	**3**
Antimony, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	0.065	**26**
Arsenic, dissolved	ug/L 0.05	0.153	0.156	**2**	0.188	0.184	**2**
Barium, dissolved	ug/L 0.1	4.85	4.77	**2**	3.6	3.71	**3**
Beryllium, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Bismuth, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Boron, dissolved	ug/L 2	3.5	3.3	**6**	3.3	3.1	**6**
Cadmium, dissolved	ug/L 0.002	0.03	0.0285	**5**	0.016	0.0149	**7**
Calcium, dissolved	ug/L 40	8820	8620	**2**	7750	7760	**0**
Chromium, dissolved	ug/L 0.1	*0.1*	*0.1*	**0**	0.68	0.85	**22**
Cobalt, dissolved	ug/L 0.005	*0.005*	*0.005*	**0**	0.0102	0.0119	**15**
Copper, dissolved	ug/L 0.1	0.56	0.54	**4**	0.56	0.9	**47**
Iron, dissolved	ug/L 2	5.8	4.9	**17**	4	5.2	**26**
Lead, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	0.057	**13**
Lithium, dissolved	ug/L 0.05	0.057	0.054	**5**	0.052	0.05	**4**
Magnesium, dissolved	ug/L 5	763	753	**1**	700	701	**0**
Manganese, dissolved	ug/L 0.05	0.108	0.069	**44**	1.33	1.33	**0**
Molybdenum, dissolved	ug/L 0.01	0.153	0.154	**1**	0.198	0.159	**22**
Nickel, dissolved	ug/L 0.04	*0.04*	*0.04*	**0**	0.07	0.049	**35**
Phosphorus, dissolved	ug/L 10	*10*	*10*	**0**	*10*	*10*	**0**
Potassium, dissolved	ug/L 10	65	63	**3**	68	60	**13**
Selenium, dissolved	ug/L 0.1	*0.1*	*0.1*	**0**	*0.1*	*0.1*	**0**
Silicon, dissolved	ug/L 100	1610	1570	**3**	1400	1420	**1**
Silver, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Sodium, dissolved	ug/L 20	645	639	**1**	590	570	**3**
Strontium, dissolved	ug/L 0.1	14.6	14.5	**1**	12.4	12.4	**0**
Sulfur, dissolved	ug/L 1000	1920	1720	**11**	1400	1540	**10**
Tellurium, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Thallium, dissolved	ug/L 0.004	*0.004*	*0.004*	**0**	*0.004*	*0.004*	**0**
Thorium, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Tin, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Titanium, dissolved	ug/L 0.2	*0.2*	*0.2*	**0**	*0.2*	*0.2*	**0**
Tungsten, dissolved	ug/L 0.2	*0.2*	*0.2*	**0**	*0.2*	*0.2*	**0**
Uranium, dissolved	ug/L 0.001	0.0098	0.0096	**2**	0.0118	0.0112	**5**
Vanadium, dissolved	ug/L 0.2	0.23	0.23	**0**	0.29	0.3	**3**
Zinc, dissolved	ug/L 1	8.4	8.2	**2**	4.7	4.6	**2**
Zirconium, dissolved	ug/L 0.02	*0.02*	*0.02*	**0**	*0.02*	*0.02*	**0**

Note: *Italic* values are Below Detection Limit

Above the 20% RPD threshold and less than double the detection limit

Above the 20% RPD threshold and more than double the detection limit

Table B- 9 Duplicate Comparisons for 2019 Surface Water Chemistry Data in Buttle Lake at Henshaw Station. Part 2

Analyte	Station ID / Date Sampled / Units MRL	HEN-0 25-Apr-19	HEN-0 D 25-Apr-19	RPD, %	HEN-0 19-Jun-19	HEN-0 D 19-Jun-19	RPD, %
Alkalinity, Total (as CaCO3)	mg/L 1	26	26.1	0	21	18.3	14
Alkalinity, Phenolphthalein (as CaCO3)	mg/L 1	*1*	*1*	0	*1*	*1*	0
Alkalinity, Bicarbonate (as CaCO3)	mg/L 1	26	26.1	0	21	18.3	14
Alkalinity, Carbonate (as CaCO3)	mg/L 1	*1*	*1*	0	*1*	*1*	0
Alkalinity, Hydroxide (as CaCO3)	mg/L 1	*1*	*1*	0	*1*	*1*	0
Ammonia, Total (as N)	mg/L 0.02	0.02	0.025	22	0.035	0.029	19
Phosphorus, Total (as P)	mg/L 0.002	0.0036	0.0031	15	0.0058	0.0036	47
Phosphorus, Total Dissolved	mg/L 0.002	*0.002*	*0.002*	0	0.0024	0.0031	25
Silica, Reactive (as SiO2)	mg/L 0.4	3.49	3.53	1	2.83	3	6
Solids, Total Suspended	mg/L 2	*2*	*2*	0	*2*	*2*	0
Turbidity	NTU 0.1	0.29	0.26	11	0.15	0.15	0
pH	pH units 0.1	7.5	7.52	0	7.34	7.34	0
Conductivity (EC)	uS/cm 2	58.8	58.8	0	54	52.9	2
Aluminum, total	ug/L 2	18.4	20.4	10	16.8	16.7	1
Antimony, total	ug/L 0.05	*0.05*	*0.05*	0	*0.05*	*0.05*	0
Arsenic, total	ug/L 0.05	0.183	0.189	3	0.231	0.202	13
Barium, total	ug/L 0.1	5.1	5.04	1	4.07	3.98	2
Beryllium, total	ug/L 0.01	*0.01*	*0.01*	0	0.01	*0.01*	0
Bismuth, total	ug/L 0.01	*0.01*	*0.01*	0	*0.01*	*0.01*	0
Boron, total	ug/L 2	3.9	4.6	16	4.2	4.2	0
Cadmium, total	ug/L 0.002	0.0357	0.0314	13	0.0189	0.0158	18
Calcium, total	ug/L 40	9170	9600	5	8430	8390	0
Chromium, total	ug/L 0.1	0.85	0.19	127	1.59	0.98	47
Cobalt, total	ug/L 0.005	0.0195	0.0183	6	0.0201	0.0112	57
Copper, total	ug/L 0.2	0.99	1	1	0.83	0.65	24
Iron, total	ug/L 2	19.5	20.1	3	157	8.2	180
Lead, total	ug/L 0.05	*0.05*	0.056	11	*0.05*	*0.05*	0
Lithium, total	ug/L 0.05	0.072	0.075	4	0.088	0.088	0
Magnesium, total	ug/L 5	781	809	4	762	759	0
Manganese, total	ug/L 0.05	5.5	5.79	5	2.79	1.77	45
Molybdenum, total	ug/L 0.01	0.144	0.182	23	0.227	0.151	40
Nickel, total	ug/L 0.04	0.098	0.058	51	0.275	0.056	132
Phosphorus, total	ug/L 10	*10*	*10*	0	*10*	*10*	0
Potassium, total	ug/L 10	62	65	5	62	57	8
Selenium, total	ug/L 0.1	*0.1*	*0.1*	0	0.16	0.12	29
Silicon, total	ug/L 100	1560	1650	6	1470	1450	1
Silver, total	ug/L 0.01	*0.01*	*0.01*	0	*0.01*	0.012	18
Sodium, total	ug/L 20	632	668	6	622	613	1
Strontium, total	ug/L 0.1	14.1	14.6	3	13.5	13.1	3
Sulfur, total	ug/L 1000	2100	2100	0	1500	1400	7
Tellurium, total	ug/L 0.05	*0.05*	*0.05*	0	*0.05*	*0.05*	0
Thallium, total	ug/L 0.004	*0.004*	*0.004*	0	*0.004*	*0.004*	0
Thorium, total	ug/L 0.01	*0.01*	*0.01*	0	*0.01*	*0.01*	0
Tin, total	ug/L 0.05	*0.05*	*0.05*	0	*0.05*	*0.05*	0
Titanium, total	ug/L 0.2	0.22	0.23	4	0.23	*0.2*	14
Tungsten, total	ug/L 0.2	*0.2*	*0.2*	0	*0.2*	*0.2*	0
Uranium, total	ug/L 0.001	0.0111	0.0111	0	0.0128	0.012	6
Vanadium, total	ug/L 0.2	0.29	0.31	7	1.09	0.76	36
Zinc, total	ug/L 1	9.9	10.5	6	6.2	5.2	18
Zirconium, total	ug/L 0.02	*0.02*	*0.02*	0	*0.02*	0.024	18

Note: *Italic* values are Below Detection Limit

Above the 20% RPD threshold and less than double the detection limit

Above the 20% RPD threshold and more than double the detection limit

Table B- 10 Duplicate Comparisons for 2019 Surface Water Chemistry Data in Buttle Lake at Karst Station. Part 1

	Station ID	KARS-10	KARS-10 D		KARS-10	KARS-10 D	
	Date Sampled	7-Feb-19	7-Feb-19		21-Aug-19	21-Aug-19	
Analyte	Units MRL			RPD, %			RPD, %
Nitrate (as N)	mg/L 0.01	0.034	0.031	**9**	*0.01*	*0.01*	**0**
Nitrite (as N)	mg/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Sulfate	mg/L 1	4	4	**0**	3.9	3.8	**3**
Hardness, Total (as CaCO3)	mg/L 0.1	24.2	24.1	**0**	23.3	23.2	**0**
Nitrate+Nitrite (as N)	mg/L 0.005	0.0342	0.0311	**9**	*0.02*	*0.02*	**0**
Aluminum, dissolved	ug/L 1	14.6	14.8	**1**	11.8	11.3	**4**
Antimony, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Arsenic, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	0.172	0.176	**2**
Barium, dissolved	ug/L 0.1	*0.1*	*0.1*	**0**	3.74	3.76	**1**
Beryllium, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Bismuth, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Boron, dissolved	ug/L 2	*2*	*2*	**0**	5	4.4	**13**
Cadmium, dissolved	ug/L 0.002	0.029	0.032	**10**	0.0112	0.0134	**18**
Calcium, dissolved	ug/L 40	8390	8360	**0**	8140	8100	**0**
Chromium, dissolved	ug/L 0.1	*0.1*	*0.1*	**0**	0.96	1.03	**7**
Cobalt, dissolved	ug/L 0.005	*0.005*	*0.005*	**0**	*0.005*	*0.005*	**0**
Copper, dissolved	ug/L 0.1	0.93	0.99	**6**	0.59	0.69	**16**
Iron, dissolved	ug/L 2	*2*	*2*	**0**	3.3	2.7	**20**
Lead, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Lithium, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Magnesium, dissolved	ug/L 5	773	768	**1**	725	722	**0**
Manganese, dissolved	ug/L 0.05	0.84	0.86	**2**	0.24	0.219	**9**
Molybdenum, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	0.32	1.41	**126**
Nickel, dissolved	ug/L 0.04	*0.04*	*0.04*	**0**	0.043	0.047	**9**
Phosphorus, dissolved	ug/L 10	*10*	*10*	**0**	*10*	*10*	**0**
Potassium, dissolved	ug/L 10	*10*	*10*	**0**	62	61	**2**
Selenium, dissolved	ug/L 0.1	*0.1*	*0.1*	**0**	*0.1*	*0.1*	**0**
Silicon, dissolved	ug/L 100	1400	1400	**0**	1510	1480	**2**
Silver, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Sodium, dissolved	ug/L 20	640	730	**13**	571	566	**1**
Strontium, dissolved	ug/L 0.1	12.9	13	**1**	13.1	13.2	**1**
Sulfur, dissolved	ug/L 1000	*1000*	*1000*	**0**	1280	1250	**2**
Tellurium, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Thallium, dissolved	ug/L 0.004	*0.004*	*0.004*	**0**	*0.004*	*0.004*	**0**
Thorium, dissolved	ug/L 0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Tin, dissolved	ug/L 0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Titanium, dissolved	ug/L 0.2	*0.2*	*0.2*	**0**	*0.2*	*0.2*	**0**
Tungsten, dissolved	ug/L 0.2	*0.2*	*0.2*	**0**	*0.2*	*0.2*	**0**
Uranium, dissolved	ug/L 0.001	*0.001*	*0.001*	**0**	0.0105	0.0104	**1**
Vanadium, dissolved	ug/L 0.2	*0.2*	*0.2*	**0**	0.33	0.32	**3**
Zinc, dissolved	ug/L 1	10.8	12.2	**12**	3.9	3.4	**14**
Zirconium, dissolved	ug/L 0.02	*0.02*	*0.02*	**0**	*0.02*	*0.02*	**0**

Note: *Italic* values are Below Detection Limit

Above the 20% RPD threshold and less than double the detection limit

Above the 20% RPD threshold and more than double the detection limit

Table B- 11 Duplicate Comparisons for 2019 Surface Water Chemistry Data in Buttle Lake at Karst Station. Part 2

		Station ID	KARS-10	KARS-10 D		KARS-10	KARS-10 D	
		Date Sampled	7-Feb-19	7-Feb-19		21-Aug-19	21-Aug-19	
Analyte	**Units**	**MRL**			**RPD, %**			**RPD, %**
Alkalinity, Total (as CaCO3)	mg/L	1	24.5	26.9	**9**	22.4	23.9	**6**
Alkalinity, Phenolphthalein (as CaCO3)	mg/L	1	*1*	*1*	**0**	*1*	*1*	**0**
Alkalinity, Bicarbonate (as CaCO3)	mg/L	1	24.5	26.9	**9**	22.4	23.9	**6**
Alkalinity, Carbonate (as CaCO3)	mg/L	1	*1*	*1*	**0**	*1*	*1*	**0**
Alkalinity, Hydroxide (as CaCO3)	mg/L	1	*1*	*1*	**0**	*1*	*1*	**0**
Ammonia, Total (as N)	mg/L	0.02	*0.02*	*0.02*	**0**	0.022	0.031	**34**
Phosphorus, Total (as P)	mg/L	0.002	0.0044	0.0021	**71**	*0.002*	0.0035	**55**
Phosphorus, Total Dissolved	mg/L	0.002	0.0036	*0.002*	**57**	*0.002*	*0.002*	**0**
Silica, Reactive (as SiO2)	mg/L	0.4	3.05	3.09	**1**	3.22	3.18	**1**
Solids, Total Suspended	mg/L	2	*2*	*2*	**0**	*2*	*2*	**0**
Turbidity	NTU	0.1	*0.1*	*0.1*	**0**	0.15	0.16	**6**
pH	H units	0.1	7.32	7.45	**2**	7.32	7.35	**0**
Conductivity (EC)	uS/cm	2	56.5	61.4	**8**	54.7	56.2	**3**
Aluminum, total	ug/L	2	22	21.6	**2**	13.7	15.1	**10**
Antimony, total	ug/L	0.05	*0.05*	*0.05*	**0**	0.054	0.068	**23**
Arsenic, total	ug/L	0.05	*0.05*	*0.05*	**0**	0.221	0.216	**2**
Barium, total	ug/L	0.1	*0.1*	*0.1*	**0**	4.07	4	**2**
Beryllium, total	ug/L	0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Bismuth, total	ug/L	0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Boron, total	ug/L	2	5.2	*5*	**4**	7.2	5.9	**20**
Cadmium, total	ug/L	0.002	0.03	0.028	**7**	0.0134	0.0148	**10**
Calcium, total	ug/L	40	8700	8440	**3**	9070	8900	**2**
Chromium, total	ug/L	0.1	*0.1*	*0.1*	**0**	0.9	1.09	**19**
Cobalt, total	ug/L	0.005	*0.005*	*0.005*	**0**	0.006	0.0072	**18**
Copper, total	ug/L	0.2	1.16	1.11	**4**	0.63	0.6	**5**
Iron, total	ug/L	2	10	11	**10**	10.4	7	**39**
Lead, total	ug/L	0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Lithium, total	ug/L	0.05	*0.05*	*0.05*	**0**	0.069	0.065	**6**
Magnesium, total	ug/L	5	820	794	**3**	760	780	**3**
Manganese, total	ug/L	0.05	1.75	1.72	**2**	1.46	1.42	**3**
Molybdenum, total	ug/L	0.01	0.12	0.11	**9**	0.138	0.154	**11**
Nickel, total	ug/L	0.04	*0.04*	*0.04*	**0**	0.173	0.054	**105**
Phosphorus, total	ug/L	10	*10*	*10*	**0**	*10*	*10*	**0**
Potassium, total	ug/L	10	*10*	*10*	**0**	70	70	**0**
Selenium, total	ug/L	0.1	*0.1*	*0.1*	**0**	*0.1*	*0.1*	**0**
Silicon, total	ug/L	100	1300	1300	**0**	1580	1580	**0**
Silver, total	ug/L	0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Sodium, total	ug/L	20	680	660	**3**	612	631	**3**
Strontium, total	ug/L	0.1	13.7	13.3	**3**	14.3	14	**2**
Sulfur, total	ug/L	1000	*1000*	*1000*	**0**	1400	1500	**7**
Tellurium, total	ug/L	0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Thallium, total	ug/L	0.004	*0.004*	*0.004*	**0**	*0.004*	*0.004*	**0**
Thorium, total	ug/L	0.01	*0.01*	*0.01*	**0**	*0.01*	*0.01*	**0**
Tin, total	ug/L	0.05	*0.05*	*0.05*	**0**	*0.05*	*0.05*	**0**
Titanium, total	ug/L	0.2	*0.2*	*0.2*	**0**	*0.2*	*0.2*	**0**
Tungsten, total	ug/L	0.2	*0.2*	*0.2*	**0**	*0.2*	*0.2*	**0**
Uranium, total	ug/L	0.001	*0.001*	*0.001*	**0**	0.0115	0.0111	**4**
Vanadium, total	ug/L	0.2	1.1	1.1	**0**	0.68	0.64	**6**
Zinc, total	ug/L	1	12.4	12.2	**2**	4.1	4.2	**2**
Zirconium, total	ug/L	0.02	*0.02*	*0.02*	**0**	*0.02*	*0.02*	**0**

Note: *Italic* values are Below Detection Limit

Above the 20% RPD threshold and less than double the detection limit

Above the 20% RPD threshold and more than double the detection limit

Table B- 12 2019 Field Blank Analysis. Part 1

Field Blanks		Station ID	MFB	MFB	MFB
		Date Sampled	2019-03-20	2019-05-14	2019-06-26
Analyte	Units	MRL			
Nitrate (as N)	mg/L	0.01		<0.010	
Nitrite (as N)	mg/L	0.005		<0.010	
Sulfate	mg/L	1		<1.0	
Hardness, Total (as CaCO3)	mg/L	0.5	<0.500	<0.500	<0.500
Nitrate+Nitrite (as N)	mg/L	0.005		<0.0200	
Lithium, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Aluminum, dissolved	mg/L	0.005	<0.0050	<0.0050	<0.0050
Antimony, dissolved	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Arsenic, dissolved	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Barium, dissolved	mg/L	0.005	<0.0050	<0.0050	<0.0050
Beryllium, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Bismuth, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Boron, dissolved	mg/L	0.005	<0.0050	<0.0050	<0.0050
Cadmium, dissolved	mg/L	0.00001	<0.000010	<0.000010	<0.000010
Calcium, dissolved	mg/L	0.2	<0.20	<0.20	<0.20
Chromium, dissolved	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Cobalt, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Copper, dissolved	mg/L	0.0004	<0.00040	<0.00040	<0.00040
Iron, dissolved	mg/L	0.01	<0.010	<0.010	<0.010
Lead, dissolved	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Magnesium, dissolved	mg/L	0.01	<0.010	<0.010	<0.010
Manganese, dissolved	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Molybdenum, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Nickel, dissolved	mg/L	0.0004	<0.00040	<0.00040	<0.00040
Phosphorus, dissolved	mg/L	0.05	<0.050	<0.050	<0.050
Potassium, dissolved	mg/L	0.1	<0.10	<0.10	<0.10
Selenium, dissolved	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Silicon, dissolved	mg/L	1	<1.0	<1.0	<1.0
Silver, dissolved	mg/L	0.00005	<0.000050	<0.000050	<0.000050
Sodium, dissolved	mg/L	0.1	<0.10	<0.10	<0.10
Strontium, dissolved	mg/L	0.001	<0.0010	<0.0010	<0.0010
Sulfur, dissolved	mg/L	3	<3.0	<3.0	<3.0
Tellurium, dissolved	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Thallium, dissolved	mg/L	0.00002	<0.000020	<0.000020	<0.000020
Thorium, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Tin, dissolved	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Titanium, dissolved	mg/L	0.005	<0.0050	<0.0050	<0.0050
Tungsten, dissolved	mg/L	0.001	<0.0010	<0.0010	<0.0010
Uranium, dissolved	mg/L	0.00002	<0.000020	<0.000020	<0.000020
Vanadium, dissolved	mg/L	0.001	<0.0010	<0.0010	<0.0010
Zinc, dissolved	mg/L	0.004	<0.0040	<0.0040	<0.0040
Zirconium, dissolved	mg/L	0.0001	<0.00010	<0.00010	<0.00010

Table B- 13 2019 Field Blank Analysis. Part 2

Field Blanks	Station ID		MFB	MFB	MFB
	Date Sampled		2019-03-20	2019-05-14	2019-06-26
Analyte	Units	MRL			
Alkalinity, Total (as CaCO3)	mg/L	1	<1.0	<1.0	
Alkalinity, Phenolphthalein (as CaCO3)	mg/L	1	<1.0	<1.0	
Alkalinity, Bicarbonate (as CaCO3)	mg/L	1	<1.0	<1.0	
Alkalinity, Carbonate (as CaCO3)	mg/L	1	<1.0	<1.0	
Alkalinity, Hydroxide (as CaCO3)	mg/L	1	<1.0	<1.0	
Ammonia, Total (as N)	mg/L	0.02		<0.02	
Phosphorus, Total Dissolved	mg/L	0.002		<0.0020	
Solids, Total Suspended	mg/L	2		<2.0	
pH	pH units	0.1	4.97	5.13	
Conductivity (EC)	uS/cm	2	<2.0	<2.0	
Aluminum, total	mg/L	0.005	<0.0050	<0.0050	<0.0050
Antimony, total	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Arsenic, total	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Barium, total	mg/L	0.005	<0.0050	<0.0050	<0.0050
Beryllium, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Bismuth, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Boron, total	mg/L	0.005	<0.0050	<0.0050	<0.0050
Cadmium, total	mg/L	0.00001	<0.000010	<0.000010	<0.000010
Calcium, total	mg/L	0.2	<0.20	<0.20	<0.20
Chromium, total	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Cobalt, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Copper, total	mg/L	0.0004	<0.00040	<0.00040	<0.00040
Iron, total	mg/L	0.01	<0.010	<0.010	<0.010
Lead, total	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Lithium, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Magnesium, total	mg/L	0.01	<0.010	<0.010	<0.010
Manganese, total	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Molybdenum, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Nickel, total	mg/L	0.0004	<0.00040	<0.00040	<0.00040
Phosphorus, total	mg/L	0.05	<0.050	<0.050	<0.050
Potassium, total	mg/L	0.1	<0.10	<0.10	<0.10
Selenium, total	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Silicon, total	mg/L	1	<1.0	<1.0	<1.0
Silver, total	mg/L	0.00005	<0.000050	<0.000050	<0.000050
Sodium, total	mg/L	0.1	<0.10	<0.10	<0.10
Strontium, total	mg/L	0.001	<0.0010	<0.0010	<0.0010
Sulfur, total	mg/L	3	<3.0	<3.0	<3.0
Tellurium, total	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Thallium, total	mg/L	0.00002	<0.000020	<0.000020	<0.000020
Thorium, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Tin, total	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Titanium, total	mg/L	0.005	<0.0050	<0.0050	<0.0050
Tungsten, total	mg/L	0.001	<0.0010	<0.0010	<0.0010
Uranium, total	mg/L	0.00002	<0.000020	<0.000020	<0.000020
Vanadium, total	mg/L	0.001	<0.0010	<0.0010	<0.0010
Zinc, total	mg/L	0.004	<0.0040	<0.0040	<0.0040
Zirconium, total	mg/L	0.0001	<0.00010	<0.00010	<0.00010

Table B- 14 2019Travel Blank Analysis. Part 1

Traveling Blanks	Station ID	MTB		MTB 1	MTB 2	MTB
	Date Sampled	25-Apr-19		7-Feb-19	7-Feb-19	14-Aug-19
Analyte	Units MRL		Units MRL			
Nitrate (as N)	mg/L 0.01	<0.010	mg/L 0.01	<0.010	<0.010	<0.010
Nitrite (as N)	mg/L 0.01	<0.010	mg/L 0.01	<0.010	<0.010	<0.010
Sulfate	mg/L 1	<1.0	mg/L 1	<1.0	<1.0	<1.0
Hardness, Total (as CaCO3)	mg/L 0.1	<0.100	mg/L 0.5	<0.500	<0.500	<0.500
Nitrate+Nitrite (as N)	mg/L 0.005	<0.0200	mg/L 0.005	<0.0200	<0.0200	<0.0200
Aluminum, dissolved	ug/L 1	<1.0	mg/L 0.005	<0.0050	<0.0050	<0.0050
Antimony, dissolved	ug/L 0.05	<0.050	mg/L 0.0002	<0.00020	<0.00020	<0.00020
Arsenic, dissolved	ug/L 0.05	<0.050	mg/L 0.0005	<0.00050	<0.00050	<0.00050
Barium, dissolved	ug/L 0.1	<0.10	mg/L 0.005	<0.0050	<0.0050	<0.0050
Beryllium, dissolved	ug/L 0.01	<0.010	mg/L 0.0001	<0.00010	<0.00010	<0.00010
Bismuth, dissolved	ug/L 0.01	<0.010	mg/L 0.0001	<0.00010	<0.00010	<0.00010
Boron, dissolved	ug/L 2	<2.0	mg/L 0.005	<0.0050	<0.0050	<0.0050
Cadmium, dissolved	ug/L 0.002	<0.0020	mg/L 0.00001	<0.000010	<0.000010	<0.000010
Calcium, dissolved	ug/L 40	<40	mg/L 0.2	<0.20	<0.20	<0.20
Chromium, dissolved	ug/L 0.1	<0.10	mg/L 0.0005	<0.00050	<0.00050	<0.00050
Cobalt, dissolved	ug/L 0.005	<0.0050	mg/L 0.0001	<0.00010	<0.00010	<0.00010
Copper, dissolved	ug/L 0.1	<0.10	mg/L 0.0004	<0.00040	<0.00040	<0.00040
Iron, dissolved	ug/L 2	<2.0	mg/L 0.01	<0.010	<0.010	<0.010
Lead, dissolved	ug/L 0.05	<0.050	mg/L 0.0002	<0.00020	<0.00020	<0.00020
Lithium, dissolved	ug/L 0.05	<0.050	mg/L 0.0001	<0.00010	<0.00010	<0.00010
Magnesium, dissolved	ug/L 5	<5.0	mg/L 0.01	<0.010	<0.010	<0.010
Manganese, dissolved	ug/L 0.05	<0.050	mg/L 0.0002	<0.00020	<0.00020	<0.00020
Molybdenum, dissolved	ug/L 0.01	<0.010	mg/L 0.0001	<0.00010	<0.00010	<0.00010
Nickel, dissolved	ug/L 0.04	<0.040	mg/L 0.0004	<0.00040	<0.00040	<0.00040
Phosphorus, dissolved	ug/L 10	<10	mg/L 0.05	<0.050	<0.050	<0.050
Potassium, dissolved	ug/L 10	<10	mg/L 0.1	<0.10	<0.10	<0.10
Selenium, dissolved	ug/L 0.1	<0.10	mg/L 0.0005	<0.00050	<0.00050	<0.00050
Silicon, dissolved	ug/L 100	<100	mg/L 1	<1.0	<1.0	<1.0
Silver, dissolved	ug/L 0.01	<0.010	mg/L 0.00005	<0.000050	<0.000050	<0.000050
Sodium, dissolved	ug/L 20	<20	mg/L 0.1	<0.10	<0.10	<0.10
Strontium, dissolved	ug/L 0.1	<0.10	mg/L 0.001	<0.0010	<0.0010	<0.0010
Sulfur, dissolved	ug/L 1000	<1000	mg/L 3	<3.0	<3.0	<3.0
Tellurium, dissolved	ug/L 0.05	<0.050	mg/L 0.0005	<0.00050	<0.00050	<0.00050
Thallium, dissolved	ug/L 0.004	<0.0040	mg/L 0.00002	<0.000020	<0.000020	<0.000020
Thorium, dissolved	ug/L 0.01	<0.010	mg/L 0.0001	<0.00010	<0.00010	<0.00010
Tin, dissolved	ug/L 0.05	<0.050	mg/L 0.0002	<0.00020	<0.00020	<0.00020
Titanium, dissolved	ug/L 0.2	<0.20	mg/L 0.005	<0.0050	<0.0050	<0.0050
Tungsten, dissolved	ug/L 0.2	<0.20	mg/L 0.001	<0.0010	<0.0010	<0.0010
Uranium, dissolved	ug/L 0.001	<0.0010	mg/L 0.00002	<0.000020	<0.000020	<0.000020
Vanadium, dissolved	ug/L 0.2	<0.20	mg/L 0.001	<0.0010	<0.0010	<0.0010
Zinc, dissolved	ug/L 1	<1.0	mg/L 0.004	<0.0040	<0.0040	<0.0040
Zirconium, dissolved	ug/L 0.02	<0.020	mg/L 0.0001	<0.00010	<0.00010	<0.00010

Note: Highleted cells indicate presence of analyte in blank sample

Table B- 15 2019Travel Blank Analysis. Part 2

Traveling Blanks	Station ID		MTB			MTB 1	MTB 2	MTB
	Date Sampled		25-Apr-19			7-Feb-19	7-Feb-19	14-Aug-19
Analyte	Units	MRL		Units	MRL			
Alkalinity, Total (as CaCO3)	mg/L	1	<1.0	mg/L	1	<1.0	35.8	<1.0
Alkalinity, Phenolphthalein (as CaCO3)	mg/L	1	<1.0	mg/L	1	<1.0	<1.0	<1.0
Alkalinity, Bicarbonate (as CaCO3)	mg/L	1	<1.0	mg/L	1	<1.0	35.8	<1.0
Alkalinity, Carbonate (as CaCO3)	mg/L	1	<1.0	mg/L	1	<1.0	<1.0	<1.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	1	<1.0	mg/L	1	<1.0	<1.0	<1.0
Ammonia, Total (as N)	mg/L	0.02	<0.020	mg/L	0.02	<0.020	<0.020	<0.020
Phosphorus, Total (as P)	mg/L	0.002	0.002	mg/L	0.002	0.0034	0.008	0.0026
Phosphorus, Total Dissolved	mg/L	0.002	<0.0020	mg/L	0.002	0.003	<0.0020	
Silica, Reactive (as SiO2)	mg/L	0.4	<0.40	mg/L	0.4		<0.40	
Solids, Total Suspended	mg/L	2	<2.0	mg/L	2	<2.0	<3.3	<2.0
Turbidity	NTU	0.1	<0.10	pH units	0.1	<0.10	<0.10	
pH	pH units	0.1	5.24	uS/cm	0.1	5.02	5.48	4.88
Conductivity (EC)	uS/cm	2	<2.0	Bq/L	2	<2.0	<2.0	<2.0
Aluminum, total	ug/L	2	<2.0	mg/L	0.005	<0.0050	<0.0050	<0.0050
Antimony, total	ug/L	0.05	<0.050	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Arsenic, total	ug/L	0.05	<0.050	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Barium, total	ug/L	0.1	<0.10	mg/L	0.005	<0.0050	<0.0050	<0.0050
Beryllium, total	ug/L	0.01	<0.010	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Bismuth, total	ug/L	0.01	<0.010	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Boron, total	ug/L	2	<2.0	mg/L	0.005	<0.0050	<0.0050	<0.0050
Cadmium, total	ug/L	0.002	<0.0020	mg/L	0.00001	<0.000010	0.000025	<0.000010
Calcium, total	ug/L	40	<40	mg/L	0.2	<0.20	<0.20	<0.20
Chromium, total	ug/L	0.1	0.7	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Cobalt, total	ug/L	0.005	<0.0050	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Copper, total	ug/L	0.2	<0.20	mg/L	0.0004	<0.00040	<0.00040	<0.00040
Iron, total	ug/L	2	<2.0	mg/L	0.01	<0.010	<0.010	<0.010
Lead, total	ug/L	0.05	<0.050	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Lithium, total	ug/L	0.05	<0.050	mg/L	0.0001	<0.00010	0.00018	<0.00010
Magnesium, total	ug/L	5	<5.0	mg/L	0.01	<0.010	0.011	<0.010
Manganese, total	ug/L	0.05	<0.050	mg/L	0.0002	<0.00020	0.00022	<0.00020
Molybdenum, total	ug/L	0.01	<0.010	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Nickel, total	ug/L	0.04	<0.040	mg/L	0.0004	<0.00040	<0.00040	<0.00040
Phosphorus, total	ug/L	10	<10	mg/L	0.05	<0.050	<0.050	<0.050
Potassium, total	ug/L	10	<10	mg/L	0.1	<0.10	<0.10	<0.10
Selenium, total	ug/L	0.1	<0.10	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Silicon, total	ug/L	100	<100	mg/L	1	<1.0	<1.0	<1.0
Silver, total	ug/L	0.01	<0.010	mg/L	0.00005	<0.000050	<0.000050	<0.000050
Sodium, total	ug/L	20	<20	mg/L	0.1	<0.10	<0.10	<0.10
Strontium, total	ug/L	0.1	<0.10	mg/L	0.001	<0.0010	<0.0010	<0.0010
Sulfur, total	ug/L	1000	<1000	mg/L	3	<3.0	<3.0	<3.0
Tellurium, total	ug/L	0.05	<0.050	mg/L	0.0005	<0.00050	<0.00050	<0.00050
Thallium, total	ug/L	0.004	<0.0040	mg/L	0.00002	<0.000020	<0.000020	<0.000020
Thorium, total	ug/L	0.01	<0.010	mg/L	0.0001	<0.00010	<0.00010	<0.00010
Tin, total	ug/L	0.05	<0.050	mg/L	0.0002	<0.00020	<0.00020	<0.00020
Titanium, total	ug/L	0.2	<0.20	mg/L	0.005	<0.0050	<0.0050	<0.0050
Tungsten, total	ug/L	0.2	<0.20	mg/L	0.001	<0.0010	<0.0010	<0.0010
Uranium, total	ug/L	0.001	<0.0010	mg/L	0.00002	<0.000020	<0.000020	<0.000020
Vanadium, total	ug/L	0.2	<0.20	mg/L	0.001	<0.0010	<0.0010	<0.0010
Zinc, total	ug/L	1	<1.0	mg/L	0.004	<0.0040	0.0069	<0.0040
Zirconium, total	ug/L	0.02	<0.020	mg/L	0.0001	<0.00010	<0.00010	<0.00010

Note: Highleted cells indicate presence of analyte in blank sample

Appendix C.

Memo from Swiftwater Consulting Inc. on New Streamflow Gauge

Swiftwater Consulting Ltd.
300 - 1055 West Hastings Street
Vancouver, BC
Canada
V6E 2E9
+1-778-952-3569

Robertson Geoconsultants Inc.
To: Paul Ferguson
900 - 580 Hornby Street
Vancouver, British Columbia
V6C 3B6

RE: MYRA FALLS MINE
2019 HYDROMETRIC MONITORING

Dear Paul,

Swiftwater Consulting Ltd. (Swiftwater) commenced hydrometric monitoring at the Myra Falls Mine (Myra Falls) on September 30th, 2019. Since then Swiftwater has completed four visits to the project site to complete various monitoring activities, including servicing dataloggers and sensors, and obtaining surveyed stage and measured discharge.

This letter summarizes the quality of data collection throughout this period of monitoring.

Hydrometric Methods Overview

All field and data processing methods conform to RISC (2018) Grade A data quality standards. All streamflow records, including field sheet, data files, photographs, and data downloads, are managed using Aquatic Informatics AQUARIUS software, and continuous discharge data are made available in real-time through Swiftwater's AQUARIUS WebPortal.

Salt dilution was used to measure discharge at both stations. The method required positioning a Sommer TQ dilution gauging instrument on each bank, a sufficient distance downstream of the salt injection location, and measuring the conductivity plume as it passes. A comparison of the two concurrent plumes indicated the degree of mixing based on the shape and area of the plumes. All salt dilution measurements were undertaken using best practice methodologies described in the guidelines and are of high quality. Salt dilution is an excellent method for reliable flow measurements at these stations. However, salt dilution at MYR-BDG is complicated by a shifting baseline conductivity, which tends to change throughout the day, likely as a result of flow contributions from MYR-EFF and/or seepage in the creek. These baseline conductivity changes required minor post-processing to correct the calculated discharge.

A network of three benchmarks are installed at each monitoring station, and stage is measured during each visit using a reference mark, also called a dipping point. Field technicians would measure down from the reference mark, which has a known elevation, to the water surface using a metal tape, and a simple calculation would determine the surveyed stage. The technicians would invest time obtaining an accurate and precise water level, to minimize uncertainty in the calculated stage.

Myra Falls Streamflow Monitoring Network

There are two continuous streamflow monitoring stations, as shown on Figure 1[1].

1. MYR-BDG-US, and
2. MYR-BDG

MYR-BDG-US

MYR-BDG-US is the original Myra Creek monitoring station and is located beneath the main access road bridge. The station was first visited on September 30th, 2019, the instrumentation inspected, and a reference mark[2] installed. The instrumentation consisted of an INW PT2X, which was in poor condition and required replacing. The batteries were changed and after some troubleshooting a datalogger download was obtained. The PT2X was then reinitialized and reinstalled. The salvaged record was from October 27th 2016 to March 18th 2019, at which time the logger had stopped recording data, presumably due to a power failure. Following reinitialization, the logger continued to record stage until it ran out of power again on December 7th, 2019. The station was visited on December 13th and a replacement PT2X was installed and initialized. The period of record between December 7th and December 13th was infilled with a reliable stage correlation from MYR-BDG. The 2019 stage hydrograph is shown on Figure 2, along with pertinent notes and station visit information. Two discharge measurements were performed in 2019, and one thus far in early 2020. The continuous discharge record is shown on Figure 3, and the developing rating curve is shown on Figure 4. Summary details of the 2019 station visits are included on Table 1, and the current rating equation is included in Table 2. Photographs of the station are included in Plate 1 to Plate 4.

MYR-BDG

MYR-BDG is the new long-term monitoring station located on Myra Creek, and is installed on the pipe bridge crossing approximately one kilometer downstream of MYR-BDG-US. The station was first visited by Swiftwater on September 30th, 2019, and a set of instrumentation was installed. The instrumentation consists of a Campbell Scientific datalogger and radio telemetry system. The stage sensor is a non-contact FTS radar sensor, installed in the center of the pipe bridge overlooking the creek. Due to some technical issues with the radio telemetry system, the stage sensor was remotely initialized on October 8th, 2019. The continuous corrected stage record is shown on Figure 5. The continuous discharge record is shown on Figure 6, and the rating curve is shown on Figure 7. Summary details of the 2019 station visits are included on [3], and the current rating equation is included in Table 4. Photographs of the station are included in Plate 5 to Plate 8.

Comparison of Concurrent Discharge

Figure 8 and Figure 9 show the comparison of concurrent calculated discharge at MYR-BDG-US and MYR-BDG. MYR-EFF contributes to Myra Creek between these monitoring stations and explains some of the flow differences observed between the two hydrographs. Travel-time differences are also apparent from Figure 9.

Extended Discharge Records

Data salvaged from the old pressure sensor at MYR-BDG-US consisted of an extended period of unverifiable stage records, spanning several years. Assuming the records are accurate; the offset required to correct the raw data to the corrected record is consistent, and; the current rating curve is representative of past

[1] *MYR-EFF is the treated effluent discharge location*
[2] *Reference marks are used to provide a straightforward method of obtaining surveyed water level (stage)*
[3] Table 3

conditions, Figure 10 shows the extended period of discharge that is available. These records should be considered estimates.

Closing

Streamflow monitoring should continue throughout 2020 to better define the rating curves at both monitoring stations, across the range of flows but especially at higher flows. It would be useful to obtain the time-series of flow records from the MYR-EFF station, as we could use this information to further validate the accuracy of the measured discharge at both streamflow monitoring stations.

We trust that this scope will satisfy your requirement. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

SWIFTWATER CONSULTING LTD.

Cameron McCarthy, M.A.Sc., P.Eng., P.Geo., A.Sc.T.
Principal Water Resource Engineer

Table 1. MYR-BDG-US Station Visit Summary

Date & Time	Stage (m)	Stage Uncertainty (+/- m)	Discharge (m^3/s)	Discharge Method	Discharge Uncertainty[1]
2020-01-27 09:35:00	5.431	0.002	9.60	Salt Dilution	0.8%
2019-12-13 10:14:00	5.124	0.002	4.14	Salt Dilution	1.2%
2019-11-11 14:00:00	4.863	0.005	1.00	Salt Dilution	0.1%

Table 2. MYR-BDG-US Rating Equation

Corrected Stage H		Rating Equation Parameters $Q = C \times (H - a)^n$			Period of Applicability	
From	To[2]	C	a	n	From	To
4.700	5.475	15.3379	4.700	1.5092	2019-10-27	-
5.476	8.262	16.9999	4.700	1.9129		

Table 3. MYR-BDG Station Visit Summary

Date & Time	Stage (m)	Stage Uncertainty (+/- m)	Discharge (m^3/s)	Discharge Method	Discharge Uncertainty[1]
2020-01-27 17:30:00	10.407	0.050	13.5	Salt Dilution	1.0%
2019-12-13 09:14:00	10.110	0.002	5.079	Salt Dilution	0.5%
2019-11-11 14:00:00	9.870	0.002	1.732	Salt Dilution	0.5%
2019-10-01 09:52:00	-	-	1.550	Area-Velocity	-
2019-09-30 08:00:00[3]	-	-	-	-	-

Table 4. MYR-BDG Rating Equation

Corrected Stage H		Rating Equation Parameters $Q = C \times (H - a)^n$			Period of Applicability	
From	To[4]	C	a	n	From	To
9.350	10.117	11.4031	9.350	2.8392	2019-09-30	-
10.118	10.419	11.4469	9.350	2.9746		
10.420	12.598	36.0286	10.000	1.090		

[1] *Uncertainty is a measure of the deviation around the average of the concurrent measurements*
[2] *Rating curve is considered reliable up to 14.4 m^3/s. Calculated discharge above this should be considered preliminary*
[3] *Station Installed*
[4] *Rating curve is considered reliable up to 20.4 m^3/s. Calculated discharge above this should be considered preliminary*

Figure 1. Myra Falls monitoring station locations

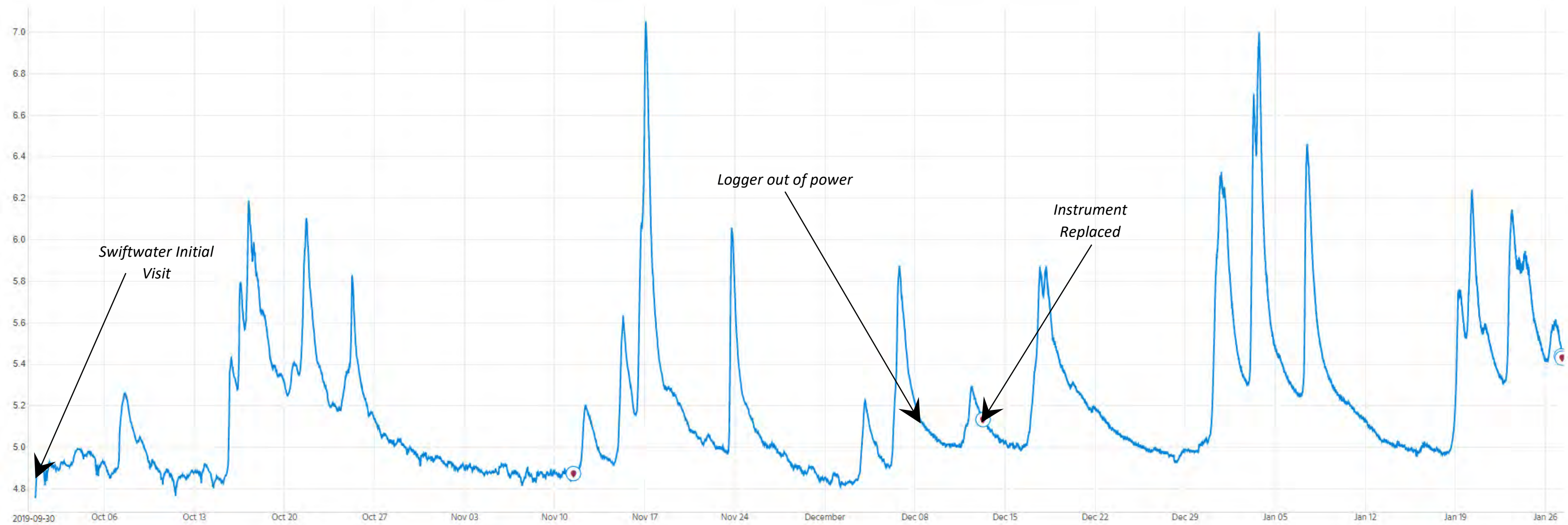

Figure 2. MYR-BDG-US 2019 Corrected Stage Hydrograph

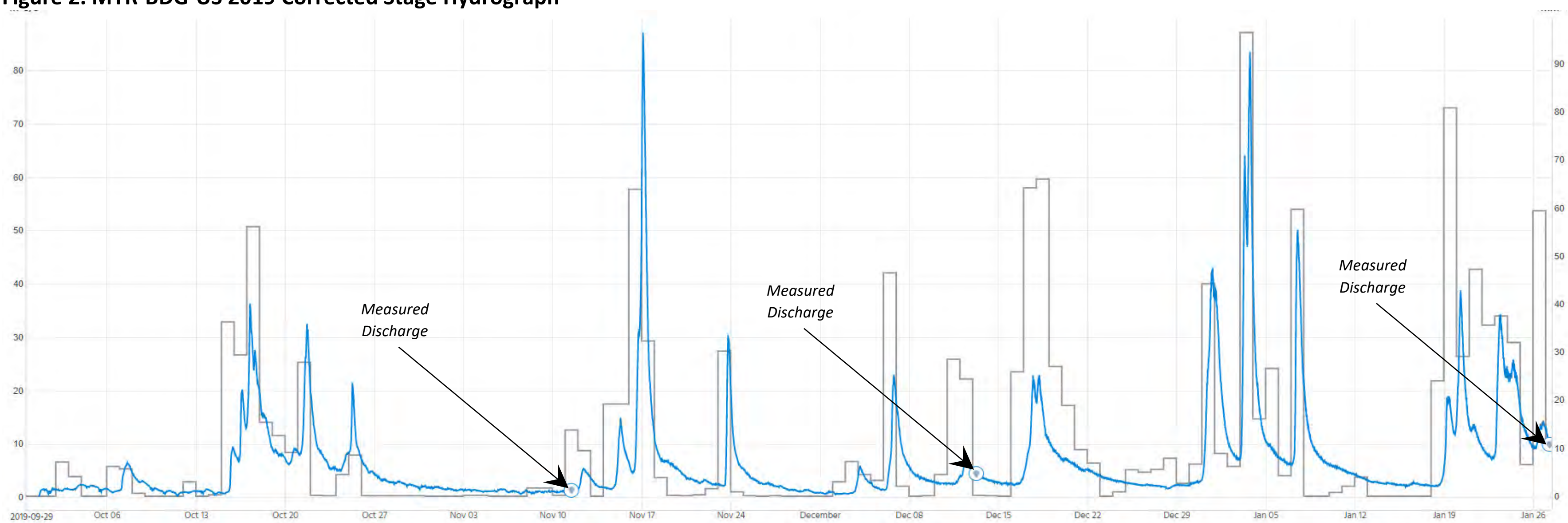

Figure 3. MYR-BDG-US 2019 Discharge (left axis) and Daily Precipitation (right axis)

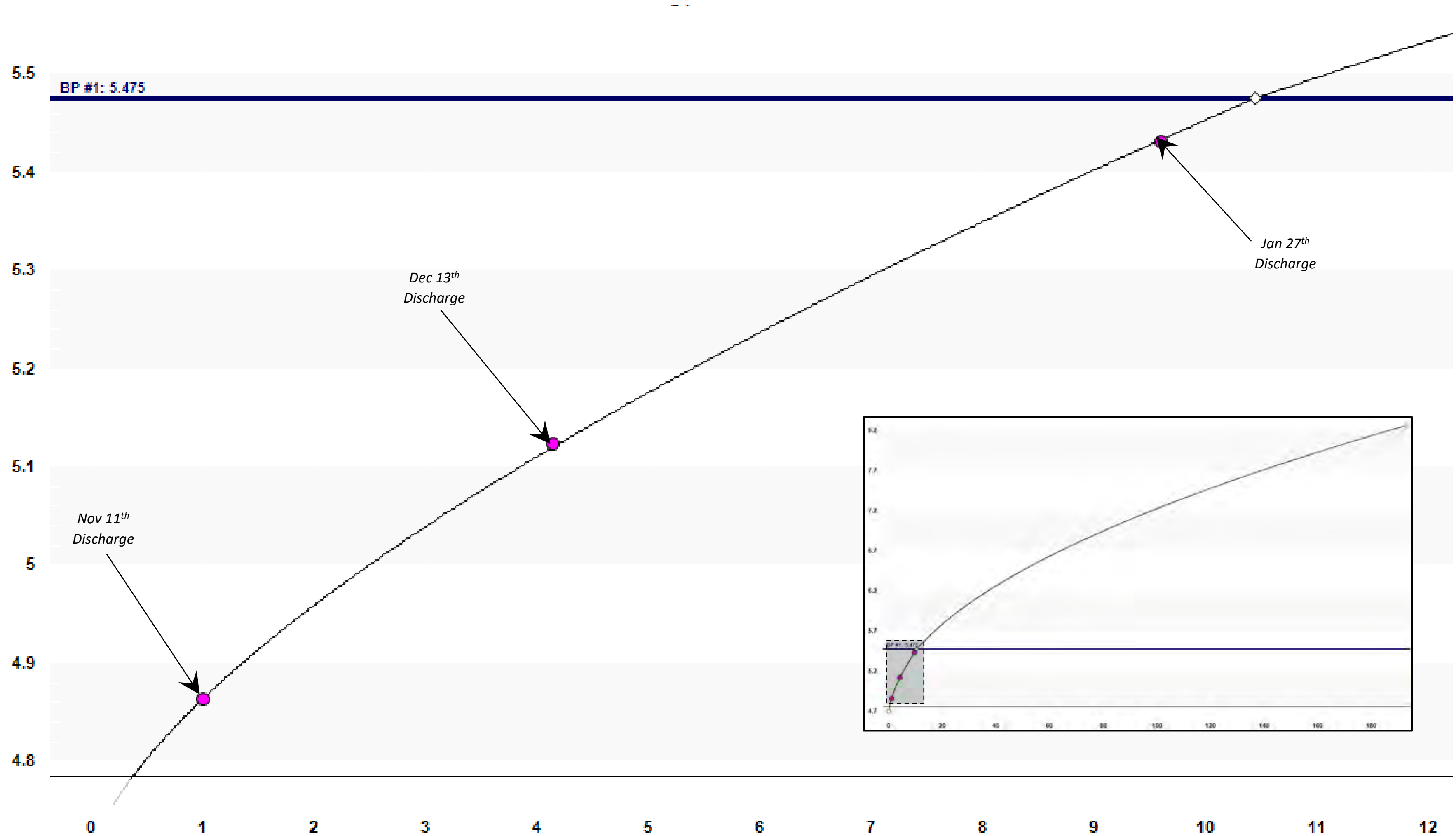

Figure 4. MYR-BDG-US 2019 Rating Curve (inset image is full scale)

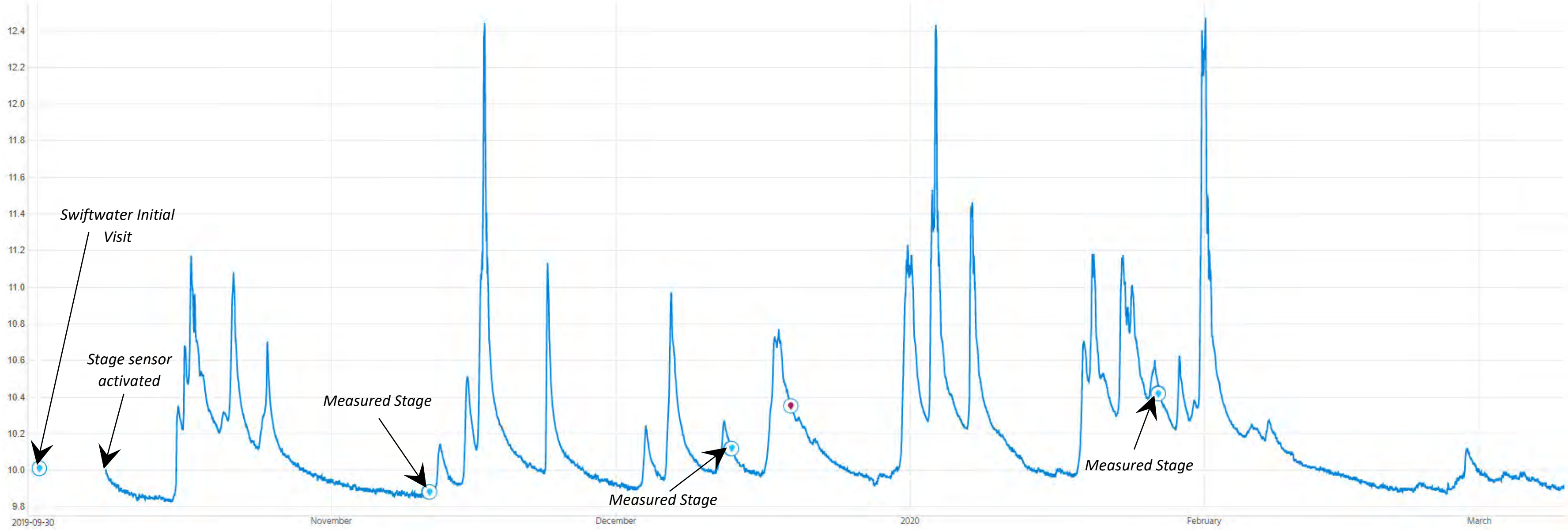

Figure 5. MYR-BDG 2019 Corrected Stage Hydrograph

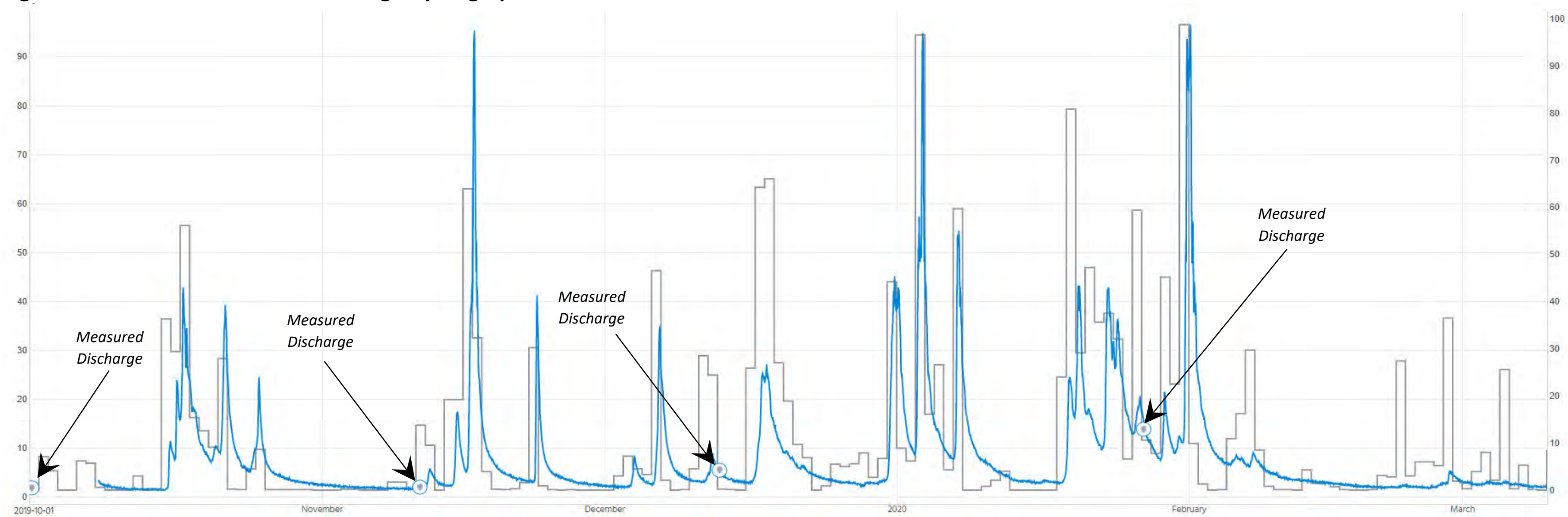

Figure 6. MYR-BDG 2019 Discharge (left axis) and Daily Precipitation (right axis)

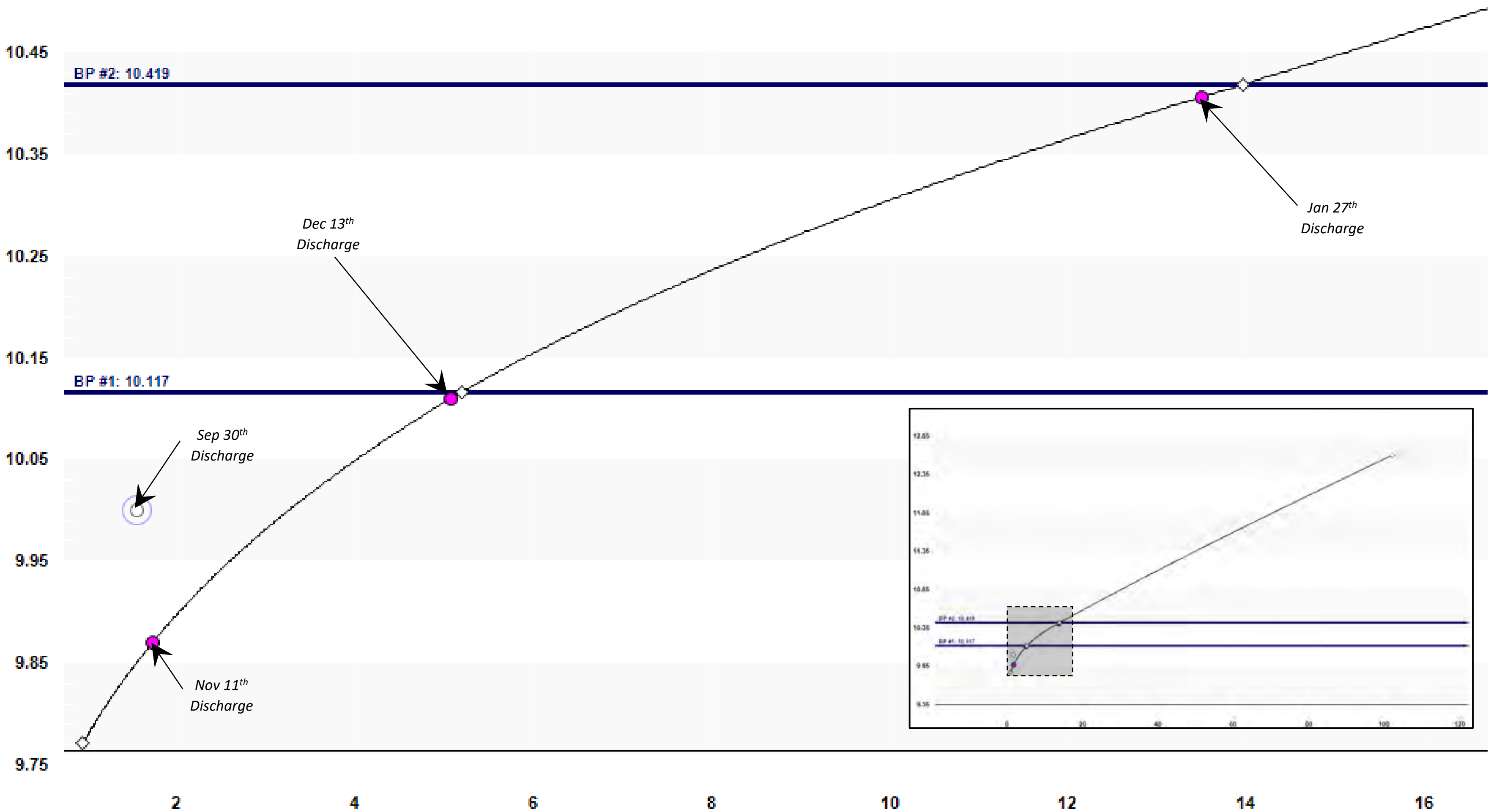

Figure 7. MYR-BDG 2019 Rating Curve (inset image is full scale)

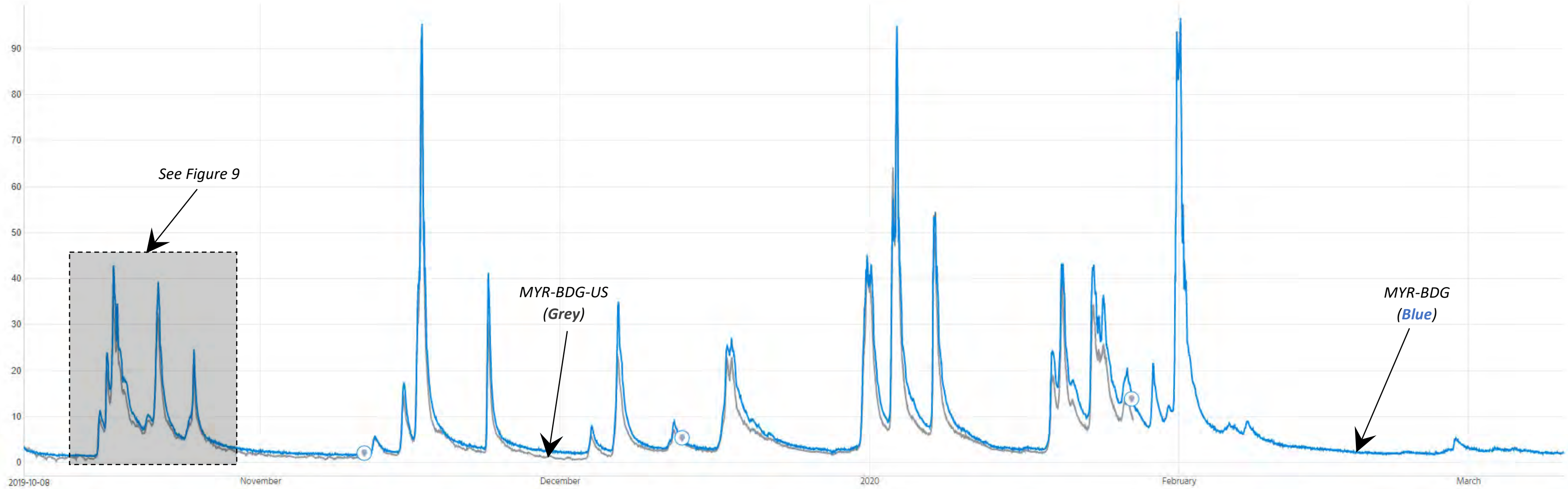

Figure 8. Comparison of calculated discharge at MYR-BDG-US and MYR-BDG

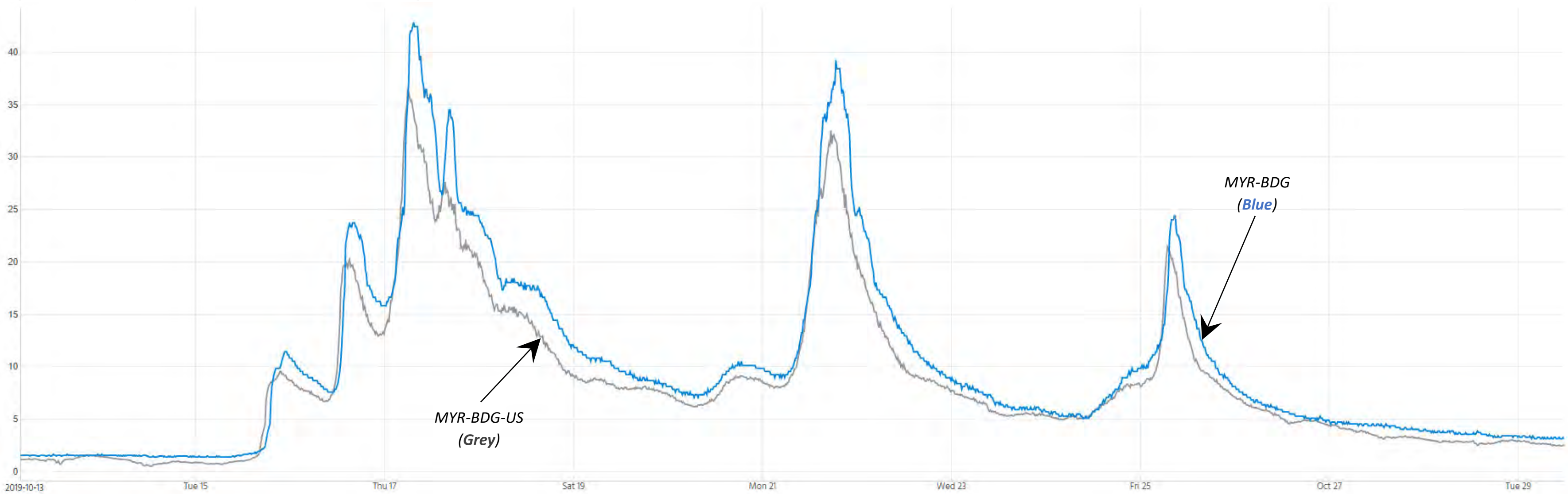

Figure 9. Comparison of calculated discharge at MYR-BDG-US and MYR-BDG

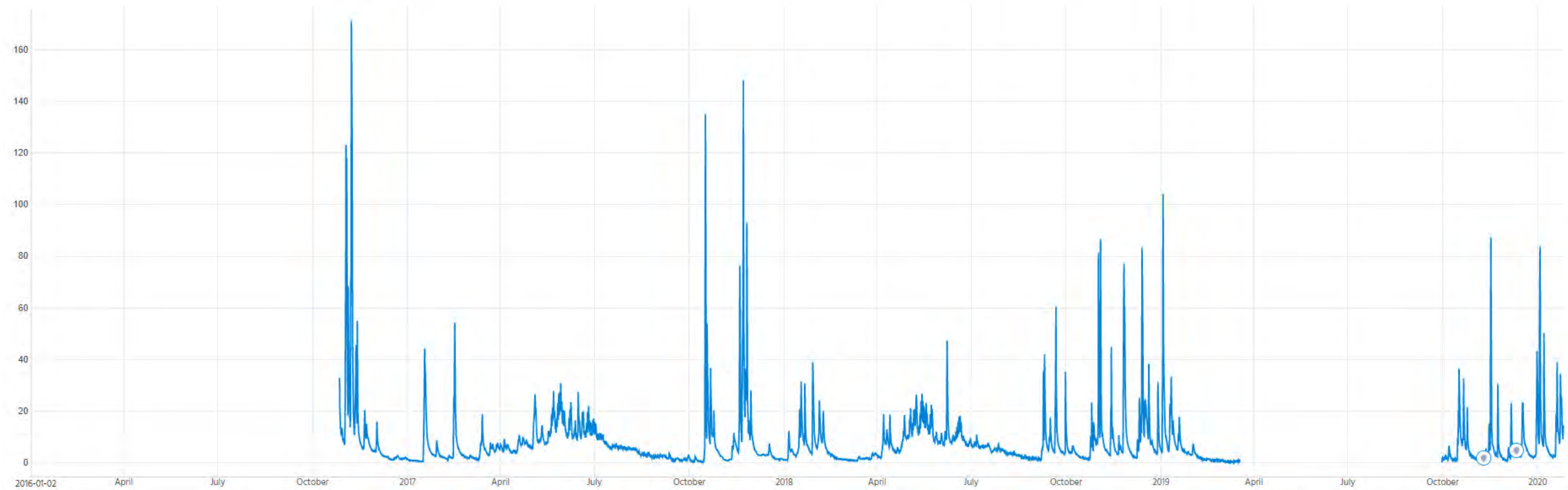

Figure 10. MYR-BDG-US calculated discharge from the beginning of 2016

Plate 1. MYR-BDG-US during a salt dilution discharge measurement (January 27th, 2020)

Plate 2. MYR-BDG-US looking upstream from bridge crossing (December 13th, 2019)

Plate 3. MYR-BDG-US, recording stage using a surveyed reference mark (January 27th, 2020)

Plate 4. MYR-BDG-US, newly installed monitoring station instrumentation (December 13th, 2019)

Plate 5. MYR-BDG, looking upstream (September 30th, 2019)

Plate 6. MYR-BDG, looking downstream (September 30th, 2019)

Plate 7. MYR-BDG monitoring station instrumentation enclosure (January 27th, 2020)

Plate 8. MYR-BDG monitoring station access. The station solar panel and radio antennae can be seen half-way along the bridge length (January 27th, 2020)

Appendix D

Events Outside of Normal Operational Parameters in 2019

Incident Date	Incident Description	Permit or Regulation
February 3-5	Regulatory samples not collected – autosampler freezing	PE-06858
March 11	Freezing temperatures led to overtop of HW Runoff Sump and release to Webster Creek	MDMER / PE-06858
June 5-11	Regulatory samples not collected – Autosampler failure	PE-06858
May 29	Exceedance of BOD limit at Myra Sewage Treatment Plant	PE-06858
October 30	Regulatory sample not collected (Weekly Grab - Lead)	PE-06858
December 18	Exceedance of regulatory limits (Zinc, Total Suspended Solids)	MDMER / PE-06858
February – October 8	Myra Creek Logger did not collect data between Feb and Oct 8	PE-06858

Appendix E.

Analytical Results