

APPENDIX I

Hydrogeological Site Investigation and Groundwater Monitoring Summary Report

Appendix I Hydrogeological Site Investigation and Groundwater Monitoring Summary

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GLOSSARY, ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius.
µS/cm	Micro siemens per centimetre.
mg/L	Milligrams per litre.
AEP	Alberta Environment and Parks.
Alluvial fan	A fan-shaped deposit at the mouth of a mountain canyon, where stream gradient abruptly drops. These are usually coarse-grained sediments.
Anisotropy	The directional variation of a property, e.g., hydraulic conductivity.
Annulus	The opening between an inner and outer cylindrical body, often used to describe the space between the well screen or drill pipe and the surface of the borehole. Also called the annular space.
Aquifer	A geological formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to springs and wells.
Aquitard	A geologic material, stratum, or formation of low permeability (a confining unit) that transmits significant amounts of water on a regional scale or over geologic time.
Bailer	A cylindrical device for withdrawing or collecting water from a well or borehole.
Bedrock	Consolidated rock which occurs may occur at surface or beneath unconsolidated surficial material.
Borehole	A hole drilled into the earth into which well casing or piezometers may be installed.
Boulder	Soil particle with greater than 300 mm effective diameter.
CO ₃	Bicarbonate.
Clay	Soil particles with an effective diameter less than 0.002 mm.
Cobble	Soil particle with an effective diameter between 75 mm and 300 mm.

Conceptual model	A simplified and idealized representation (usually graphical) of the physical hydrogeologic setting and our hydrogeological understanding of the essential flow processes of the system. This includes the identification and description of the geologic and hydrologic framework, media type, hydraulic properties, sources and sinks, and important aquifer flow and surface-groundwater interaction processes.
Confined	A condition in which the potentiometric, or piezometric, surface is above the top of the aquifer. Synonymous with artesian.
Confined aquifer	An aquifer that is immediately overlain by a low permeability unit. A confined aquifer does not have a water table.
Datalogger	A device which stores data collected by an electronic instrument.
Deposition	The accumulation of material left in a new position by natural transporting agent such as water, wind, ice, or gravity; or by the activity of humans.
Discharge	The water leaving a groundwater system by flow to surface water, land surface or to the atmosphere.
Dissolved metals	The content of metal ions in solution, usually after filtration with a 0.45 µm filter.
Drawdown	The vertical distance the water elevation is lowered or the reduction of the pressure head due to the removal of water.
Electrical Conductivity (EC)	The measure of given fluid to conduct an electrical current over a specified distance.
Exceedance	The measure of an ambient concentration that has a measured value greater than applicable government regulations.
Filter pack	Coarse sand packed around the screen of a well.
Flood	An overflow or inundation from a river or other body of water that causes or threatens damage.
Floodplain	The low-lying areas adjacent to a river that are occasionally, are predicted to be, or have been covered by water when the river over tops its bank.
Geotechnical	Of, or relating, to practical applications of geological science in civil engineering, mining, etc.
Gravel	Soil or rock particles with an effective grain diameter between 4.75 mm and 75 mm.

Groundwater	Generally, all water beneath the land surface.
Hydraulic conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium.
Hydraulic gradient	The change in hydraulic head with direction.
Hydraulic head	The elevation in a well in reference to a specific datum.
Hydraulic test	Field or laboratory test undertaken to determine the hydraulic properties of a geologic material.
Hydrogeology	The study of subsurface water including its physical and chemical properties, geological environment, its role in geologic processes, natural movement, recovery, contamination, and utilization.
Hydrograph	A chart depicting either discharge or water level as a function of time for streams, rivers, or wells.
Hydrostratigraphic unit (HSU)	Any soil or rock unit, or units, or zone, which by virtue of its hydraulic properties has a distinct influence on the storage or movement of groundwater. Broadly synonymous with “hydrogeologic unit”.
In-situ	Measurements of components or processes in the field rather than in a laboratory.
Infiltration	The movement of water from the surface of the land into the subsurface (vadose zone).
Ion	A charged molecule in solution.
Kinematic viscosity	The property of fluid describing its resistance to flow.
Lacustrine	Pertaining to, produced by, or formed in a lake.
Leaky aquifer	An aquifer that receives recharge via cross-formational flow through confining layers
Major ions	Pertaining to the most abundant ions present in natural water solution, typically including bicarbonate, carbonate, sulphate, chloride, calcium, magnesium, sodium and potassium.
m/s	Metres per second.
masl	Metres above sea level.
mbgs	Metres below ground surface.

method detection limit (MDL)	The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, and is determined from an analysis of a sample in a given matrix containing the analyte.
Mg ²⁺	Magnesium base cation ion.
Model	A simplified representation of a relationship or system of relationships.
Monitoring well	A well utilized to monitor water level or water quality as opposed to a well operated to produce water. Synonymous with standpipe or Casagrande piezometer.
Permeability	The property of a porous medium to transmit fluids under a hydraulic gradient. Often used synonymously with “hydraulic conductivity”.
pH	A measure of acidity of a solution, based upon the negative logarithm of the hydrogen ion concentration.
Piezometer	A device used to measure groundwater pressure head at a point in the subsurface.
Piezometric	An imaginary surface representing the static head of groundwater and defined by the level to which water will rise in a tightly cased well. Synonymous with potentiometric.
Pressure transducer	An instrument which measures fluid pressure.
Pumping test	A technique used to evaluate the hydraulic properties of an aquifer by observing how water level change with space and time when water is pumped from the aquifer.
QA/QC	Quality assurance/quality control.
Recharge	The process by which water enters the groundwater system.
Saturated	The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.
Sand	Soil or rock particle with an effective grain diameter between 0.75 mm and 4.75 mm.
Silt	Soil particles with an effective grain diameter between 0.002 mm and 0.75 mm.

Specific Yield	The ratio of the volume of water which the porous medium after being saturated, will yield by gravity to the volume of the porous medium.
SO ₄	Sulphate.
Surficial aquifer	Aquifer nearest the ground surface having no overlying confining layer.
TDS	Total dissolved solids.
Till	An unsorted and unstratified accumulation of glacial sediment, deposited directly by glacier ice. Till is a heterogeneous mixture of different sized material deposited by moving ice (lodgement till) or by the melting in-place of stagnant ice (ablation till). After deposition, some tills are reworked by water.
Total metals	Metals contained in a water sample, including dissolved ions and suspended particles and complexes.
Transmissivity	The capacity of rock to transmit water under pressure. Transmissivity (T) = Hydraulic Conductivity (K) x Thickness (b).
Unconfined	A condition in which the upper surface of the zone of saturation forms a water table under atmospheric pressure.
Unconfined aquifer	The upper surface of the aquifer is the water table. Water table aquifer are directly overlain by an unsaturated zone or a surface water body.
Unsaturated	A condition whereby the pore spaces contain water at less than atmospheric pressure, as well as air and potentially other gases.
Water table	The upper surface of unconfined groundwater, at the top of the zone of saturation where the fluid pressure is equal to atmospheric pressure.

I-1 INTRODUCTION

The June 2013 flood in Calgary prompted The City of Calgary (The City) to conduct a Flood Mitigation Measures Assessment. The Assessment concluded that a combination of watershed-level, community-level, and property-level flood mitigation measures should be pursued to reduce Calgary's flood risk. The City identified possible community-level measures being required on the Bow River in the historic communities of Bowness, Sunnyside, and Inglewood, and in downtown Calgary.

In 2018, The City retained Klohn Crippen Berger Ltd. (KCB) to provide engineering, environmental, and geoscience services, including a hydrogeological site investigation, to support the proposed flood barrier design within the riverfront community of Bowness. The purpose of the hydrogeological drilling and hydraulic testing investigation, and groundwater monitoring program was to:

- Understand the distribution and thickness of surficial geological units;
- Identify the lithology and water-bearing potential of the surficial sediments;
- Assess the bedrock depth and lithology, as well as the permeability of the upper contact of the Porcupine Hills Formation;
- Monitor groundwater levels and interpret flow patterns within the alluvial aquifer system based on project installed and existing monitoring wells;
- Undertake hydraulic testing of the monitoring wells to estimate the hydraulic properties of the water-bearing units;
- Assess groundwater quality through sampling of the newly installed monitoring wells and laboratory analysis for a range of typical hydrochemical parameters; and
- To monitor groundwater conditions over an open-water season and preferably over a 12-month period (as a minimum) to assess for diurnal and seasonal groundwater level trends and responses to Bow River water level (flow) changes.

KCB completed the site investigations in support of the overall hydrogeological and geotechnical assessment between January 7, 2019 and October 7, 2019. The hydrogeological site investigation was conducted in conjunction with the geotechnical site investigation (KCB 2019) and comprised the following field activities:

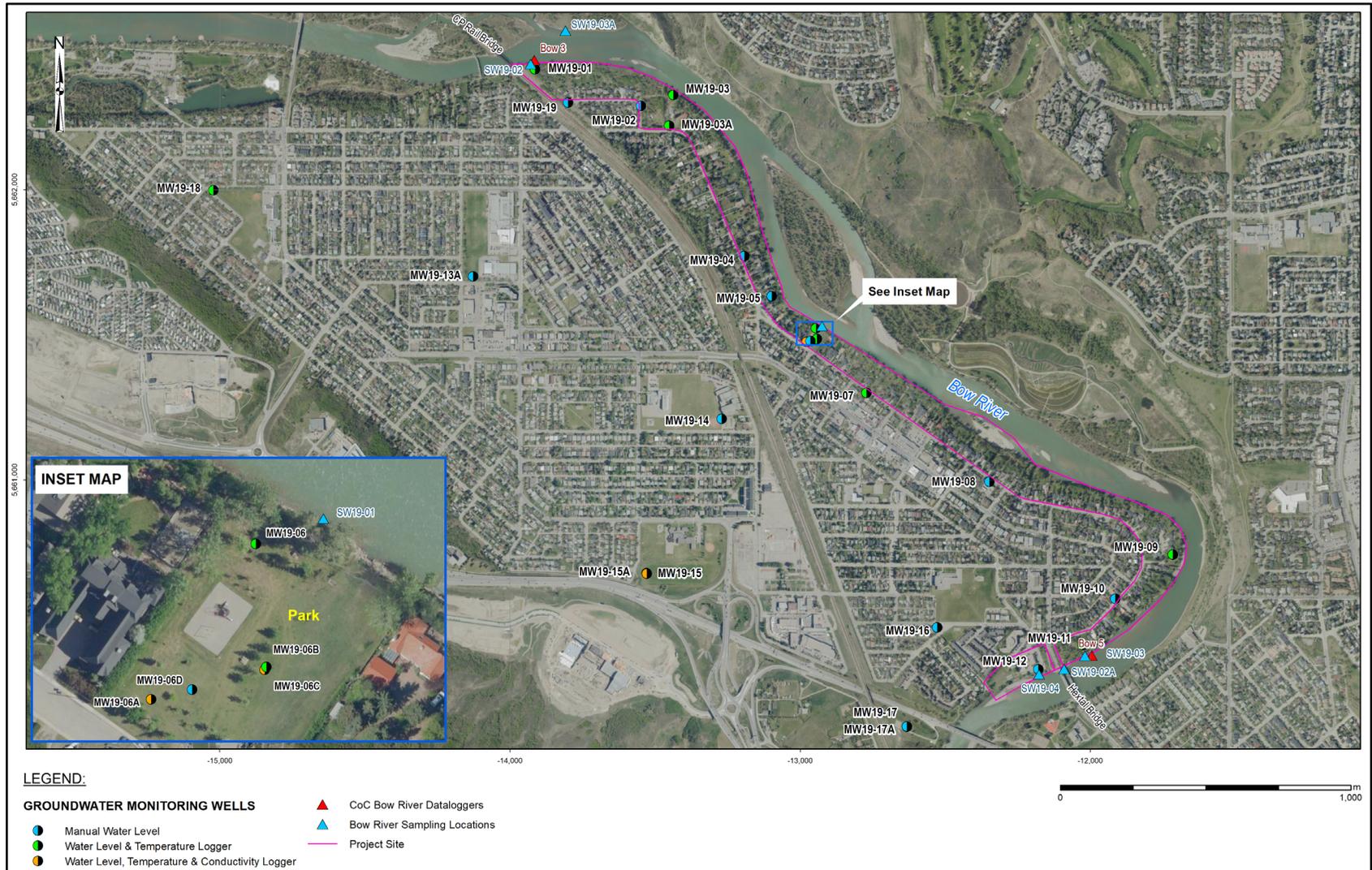
- The drilling of 27 boreholes, installation and development of 25 monitoring wells and one test pumping well at 26 locations;
- Initial installation of pressure-transducer dataloggers (PTDLs) in 13 monitoring wells in April 2019;
- Undertake short-duration hydraulic tests at 18 monitoring wells;
- Multi-rate and constant-rate pumping testing of the pumping well;
- Groundwater chemistry sampling conducted at 21 monitoring wells; and
- Ongoing groundwater level monitoring at 20 monitoring wells and three Bow River locations.

This factual report summarises the methodology and results of the hydrogeological site investigation and monitoring program. The analyses, interpretation, and discussion of these results are contained in the *Bowness Flood Control Barriers - Hydrogeological Characterization and Groundwater Flow Modelling* report (KCB 2021).

I-1.1 Project Area

The Project area comprises the community of Bowness along the southern bank of the Bow River, between the CN Rail Bridge to the west, and slightly south of Hextall Bridge in the east, and covers approximately 5 km². The site investigation was focused mainly within the proposed flood barrier alignment (the Project site); however, several monitoring wells were installed further inland to assess the surficial geology and groundwater conditions on the floodplain away from the Bow River. The Project area and well locations are presented in Figure I-1.1.

Figure I-1.1 Project Area showing Groundwater and Surface Water Monitoring Locations



I-2 FIELD PROGRAM DESCRIPTION

I-2.1 Hydrogeological Investigation Summary

The 2019 field investigation was completed over two stages between January 7 to 18, 2019 and March 25 to April 3, 2019.

A total of 27 boreholes were advanced using a track-mounted sonic drilling-rig owned and operated by Mobile Augers and Research Ltd. of Calgary, Alberta. The field work was supervised by Ms. Amie Sneddon (P.Eng.) of KCB with the support of Senior Hydrogeologist, Mr. Kyle Schepanow (P.Geo).

The boreholes were drilled close to the possible flood barrier alignment and at select locations outside of the Project site limits. Due to access constraints on private properties, 23 boreholes were sited on public land. The City obtained landowner permission to drill four boreholes (MW19-03, MW19-03A, MW19-05, MW19-07 and MW19-09) on private properties within the proposed flood barrier alignment.

All borehole locations were surveyed by Challenger Geomatics Ltd. following drilling activities. The borehole locations are presented in Figure I-1.1 and the borehole information is summarized in Table I-2.1. The borehole logs are presented in Appendix I1.

I-2.2 Monitoring and Pumping Wells

Monitoring wells were installed in 25 of the 27 boreholes. Each monitoring well was completed with 50 mm diameter Schedule 40 polyvinyl chloride (PVC) pipe and a 10-slot (0.01" diameter slot opening) PVC screen. The annulus around the well screen was backfilled with filter sand and the remaining borehole annulus was sealed to ground surface using a bentonite seal to prevent surface water infiltration.

Borehole MW19-06D was completed as a test pumping well with 150 mm diameter Schedule 40 PVC pipe and a 50-slot (0.05" diameter slot opening) PVC screen. The hole was backfilled with bentonite chips from the base of the hole to the base of the well screen. A filter sand pack consisting of 10/20 filter sand was installed from the base of the screen to approximately 0.3 m above the screen. The pumping well annulus was sealed to within 0.3 m from surface using hydrated bentonite chips, and then topped with surface soil drill cuttings.

Monitoring and pumping well installation details are summarized in Table I-2.1 and the well logs are provided in Appendix I1.

Table I-2.1 2019 Borehole and Well Installation Details

Well ID	Installation Date	Northing ⁽¹⁾	Easting ⁽¹⁾	Ground Elevation (masl) ⁽²⁾	Top of Casing Elevation (masl)	Stick-up (m)	Total Depth (mbgs) ⁽³⁾	Borehole Diameter (mm)	Well Diameter (mm)	Top of Sand Pack (mbgs)	Top of Screen (mbgs)	Bottom of Screen (mbgs)	Bottom of Sand Pack (mbgs)	PTDL ⁽⁴⁾ Install Depth (mbTOC) ⁽⁵⁾	Screened Lithology	Comments
MW19-01	17-Jan-2019	5662415.063	-13912.894	1070.37	1070.29	-0.09	7.9	152	51	4.3	4.6	6.1	6.1	5.5	Sand and Gravel	
MW19-02	29-Mar-2019	5662288.698	-13547.753	1070.06	1069.96	-0.10	9.1	152	51	4.0	4.3	6.7	6.8	6.5	Sand and Gravel	Installed May 2020
MW19-03	25-Mar-2019	5662325.579	-13435.829	1067.85	1067.74	-0.11	6.1	152	51	3.7	4	5.5	5.6	4.8	Sand and Gravel	
MW19-03A	25-Mar-2019	5662220.312	-13449.899	1069.02	1068.95	-0.07	7.9	152	51	3.0	3.4	6.4	6.7	4.5	Sand and Gravel	PTDL installed and LTC installed in May 2020
MW19-04	26-Mar-2019	5661771.014	-13191.319	1067.35	1067.22	-0.13	7.9	152	51	2.1	2.4	4	4.2	3.0	Sand and Gravel	Installed May 2020
MW19-05	17-Jan-2019	5661633.522	-13096.818	1067.57	1067.50	-0.07	5.8	152	51	1.5	1.8	3	3	-	Sand and Gravel	No PTDL installed.
MW19-06	15-Jan-2019	5661522.054	-12944.455	1068.80	1068.72	-0.08	12.5	152	51	3.4	3.7	5.2	5.2	-	Sand and Gravel	PTDL removed in November 2019, well dry in fall.
MW19-06A	15-Jan-2019	5661476.086	-12976.596	1068.93	1068.83	-0.10	15.2	152	51	7.3	7.6	10.7	10.7	10.3	Sand and Gravel	LTC ⁽⁶⁾ PTDL installed.
MW19-06B	26-Mar-2019	5661484.675	-12941.843	1068.94	1068.88	-0.06	9.1	152	51	7.3	7.6	9.1	9.1	8.5	Sandstone / Siltstone	LTC PTDL installed.
MW19-06C	26-Mar-2019	5661485.599	-12941.217	1068.92	1068.86	-0.06	6.1	152	51	2.4	2.7	5.8	5.9	5.7	Sand and Gravel	
MW19-06D	4-Apr-2019	5661479.539	-12963.498	1068.95	1068.83	-0.12	12.2	203	150	4.6	4.9	11	11.1	-	Sand and Gravel	Pumping well installation, PTDL installed for pumping test only.
MW19-07	27-Mar-2019	5661299.250	-12770.841	1068.93	1068.87	-0.06	13.7	152	51	4.3	4.6	6.1	6.2	6.0	Sand and Gravel	
MW19-08	28-Mar-2019	5660993.349	-12346.332	1066.48	1066.37	-0.11	6.1	152	51	3.4	4	5.5	5.6	5.0	Sand and Gravel	PTDL installed in November 2019.
MW19-09	27-Mar-2019	5660742.693	-11714.356	1065.18	1065.14	-0.04	9.1	152	51	3.1	3.4	6.4	6.5	6.0	Sand and Gravel	
MW19-10	16-Jan-2019	5660590.556	-11912.006	1063.95	1063.83	-0.12	15.2	152	51	3.4	3.7	6.7	6.7	6.5	Sand and Gravel	Installed LTC in May 2020
MW19-11	16-Jan-2019	5660430.017	-12025.184	1063.26	1063.18	-0.08	9.1	152	51	2.7	3	4.6	4.6	4.0	Sand and Gravel	
MW19-12	29-Mar-2019	5660346.724	-12178.043	1063.71	1063.64	-0.07	11.3	152	51	3.4	3.7	5.2	5.3	5.0	Sand and Gravel	PTDL installed in February 2020.
MW19-13	11-Jan-19	n/a	n/a	n/a	n/a	n/a	6.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Drill rig broke down at 6.1 m, hole abandoned and backfilled with bentonite.
MW19-13A	14-Jan-2019	5661700.960	-14126.078	1076.58	1076.46	-0.12	8.8	152	51	3.7	4	5.5	5.5	-	Sand and Gravel	No PTDL installed.
MW19-14	8-Jan-2019	5661210.525	-13269.083	1075.34	1075.24	-0.10	20.7	152	51	7.3	7.6	9.1	9.1	8.9	Sand and Gravel	PTDL removed in June 2019.
MW19-15	18-Jan-2019	5660677.870	-13527.335	1079.04	1078.92	-0.12	20.4	152	51	9.1	9.4	11	11	10.9	Sand and Gravel	PTDL installed May 2020
MW19-15A	2-Apr-2019	5660676.083	-13527.551	1079.05	1078.96	-0.09	21.2	152	51	19.0	19.7	21.2	21.2	19.0	Siltstone	LTC PTDL installed February 2020.
MW19-16	1-Apr-2019	5660491.598	-12527.179	1067.99	1067.92	-0.07	13.7	152	51	1.8	2.1	3.7	3.8	-	Sand and Gravel	No PTDL installed. Well is dry.
MW19-17	7-Jan-2019	5660149.146	-12630.780	1070.54	1070.49	-0.05	18.3	152	51	14.0	14.3	15.8	15.8	12.6	Silty Lacustrine	PTDL removed in June 2019. PTDL reinstalled in May 2020
MW19-17A	7-Jan-2019	5660150.353	-12630.665	1070.53	1070.40	-0.13	6.1	152	51	2.1	2.4	5.5	5.5	-	Sand and Gravel	No PTDL installed.
MW19-18	1-Apr-2019	5661997.411	-15021.048	1077.85	1077.76	-0.09	6.1	152	51	2.4	2.7	4.3	4.4	4.2	Sand and Gravel	
MW19-19	14-Jan-2019	5662300.682	-13798.816	1070.90	1070.83	-0.07	6.6	152	51	3.7	4	5.4	5.4	-	Sand and Gravel	No PTDL installed.

Notes:

- Northing and easting in NAD83 3TM Zone 11 coordinates.
- masl = meters above sea level.
- mbgs = meters below ground surface.
- PTDL = pressure-transducer datalogger.
- mbTOC = meters below top of casing.
- LTC = Solinst level-temperature-conductivity PTDL.

I-2.2.1 Well Development

The installed monitoring wells were developed between April 3 to 5, 2019. The wells were developed using a one-way foot-valve and surge-block connected to 15 mm diameter HDPE tubing. The well screens were surged and purged repeatedly to remove fine-grained sediment and drilling fluids from the well and filter pack, to improve the hydraulic connection between the natural formation and the filter pack, and to allow groundwater to flow freely into the well. During purging, regular measurements were taken to record the cumulative volume, temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), and oxidation-reduction potential (ORP) of the water removed. Development was determined to be complete once the water quality measurements had stabilized, the fines content had reduced to less than 1 cm³ of sediment per 20 L of water removed (if reasonably achievable), and a minimum of three well volumes were purged.

Each of the monitoring wells was adequately developed with the exception of MW19-05, MW19-14, MW19-15, MW19-16, and MW19-17A. Monitoring wells MW19-05, MW19-16, and MW19-17A were dry at the time of development, and MW19-14 and MW19-15 had limited water inflow (slow recovery).

Pumping well MW19-06D was developed in two stages. Development was started immediately after drilling via airlifting with a rig-mounted compressor on April 4, 2019. The well was redeveloped on July 22, 2019 by Ketek Group (Ketek) using airlifting prior to the constant-rate pumping test (CRT) (see Section 0). The well was developed for a total of 175 min, until the discharge water was clear and measured field water quality parameters (pH, EC, turbidity, etc.) had stabilized. The well produced an approximate yield of 30 L/min to 40 L/min (0.5 L/s to 0.7 L/s). The total volume of groundwater purged during the development process was approximately 7 m³.

I-2.2.2 Groundwater Level Monitoring

Solinst M10 Levellogger™ pressure transducer dataloggers (PTDLs) were installed in 13 monitoring wells to record continuous water level and temperature measurements. PTDLs were installed at depths chosen to maximize the available water column within the monitoring well and to account for seasonal variations in water levels. The PTDLs were initially programmed to collect water level measurements at three-hour intervals. In October 2019, the PTDLs were reprogrammed to record readings every hour. Solinst Level-Temperature-Conductivity (LTC) PTDLs were installed in three monitoring wells to record electrical conductivity in addition to water level and temperature. Manual water level measurements are recorded prior to each sampling event. The distribution of PTDLs has changed since the end of the site investigation. Current (May 2020) PTDL locations and installation depths are presented in Table I-2.1. Water level versus temperature hydrographs for the monitoring wells, current to May 2020, are presented in Appendix I2.

I-2.2.3 Groundwater Quality Sampling

Groundwater samples were collected to characterize the major ion chemistry, identify water types, and assess hydraulic interactions between the shallow groundwater system and the Bow River. Samples were collected in April 2019, June 2019, December 2019, and May 2020. Groundwater

samples were collected from the monitoring and pumping wells using dedicated disposable bailers. Samples that were to be analyzed for dissolved metals were filtered in the field using disposable 0.45 µm Nalgene® filters attached to a Nalgene® hand pump. Samples that required preservation were done so following laboratory instructions and supplied preservative. Samples were collected in laboratory-supplied sterile bottles and stored in a cooler with ice to preserve sample integrity. Samples were transported to AGAT Laboratories (AGAT) in Calgary, Alberta under standard chain-of-custody protocol.

Prior to groundwater sampling, static water level and well bottom measurements were recorded at each monitoring well and used to calculate well volumes. Each monitoring well was purged of approximately three well volumes of groundwater prior to sampling. If the well went dry before three well volumes were removed, the well was given time to recover before purging resumed. If the well became dry a second time before three well volumes were removed, the well was again given time to recover and a sample was collected. Purged well water was discharged to surface adjacent to the monitoring well. The well caps were locked with a keyed padlock following sampling.

The groundwater chemistry results are summarized in Section I-3.2.4. AGAT laboratory analysis results are provided in Appendix I3. Note that the laboratory ionic balance (IB%) are reported as ratios (Cations / Anions × 100) and the correct ionic balance should be $(100 - IB\%) / (100 + IB\%)$; e.g. for MW19-01 dated 2019-04-03: $(100 - 79.4)/(100 + 79.4) = 0.11$ or 11%.

Quality Assurance and Control

As part of routine quality assurance (QA)/quality control (QC) checks, one duplicate sample per approximately 10 samples collected were sent to the laboratory for analysis during the April 2019, June 2019, and May 2020 sampling events. Duplicate samples are collected at the same time as the initial groundwater using the same procedures. The following duplicate samples were collected:

- MW19-06A in April 2019;
- MW19-06B in June 2019; and
- MW19-08 and MW19-12 in May 2020.

The purpose of the duplicate samples is to assess consistency in the analytical results that the laboratory produces. Large variances between duplicate results and the original sample results could indicate errors in the sampling methodology or analysis process conducted by the laboratory. Variances in results are investigated further with the laboratory.

The precision of analytical results may be evaluated by calculating the relative percent difference (*RPD*) and absolute difference (*AD*) of replicate samples using the following formulas:

$$RPD = \frac{(S - D)}{(S + D) / 2} \times 100$$

Where: *RPD* is an absolute percent;
S is the original sample concentration (mg/L); and
D is the duplicate sample concentration (mg/L).

$$AD = (S - D)$$

Where: AD is an absolute difference (mg/L),
 S is the original sample concentration (mg/L), and
 D is the duplicate sample concentration (mg/L).

Zeiner's *Environmental Standard's Field Duplicate Criteria* (Zeiner 1994) has been applied to evaluate the precision of the results for samples where the concentration reported is less than five times the method detection limit (MDL).

If both the original and duplicate groundwater sample concentrations are greater than five times the MDL for a given parameter, the RPD must be less than or equal to 20%. If the concentrations are less than five times the laboratory MDL for any given parameter, the absolute difference (AD) must be less than the laboratory MDL. If the results lie outside of the range, they should be considered as estimates only (Zeiner 1994).

If one of the sample concentrations is above the MDL and its duplicate sample concentration is less than the MDL, the difference between the reported concentration and one-half the MDL should be less than or equal to the MDL. If the difference is greater than the MDL, the results should be considered as estimates only (Zeiner 1994).

The chain-of-custody procedures were followed throughout the sampling program. The chain-of-custody forms were provided by AGAT and filled out in full for samples delivered to the laboratory. A copy of the chain-of-custody is provided in Appendix I3.

AGAT has internal QA/QC protocols and procedures to ensure the accuracy and consistency of laboratory results. These procedures include chain-of-custody tracking, storage and holding times, instrument calibration, and laboratory duplicates, among others. The internal QA/QC can be reviewed in the laboratory reports provided in Appendix I3.

I-2.2.4 Single-Well Hydraulic Tests

Single-well hydraulic testing was completed at 18 monitoring wells. Testing was completed using two methods: falling- and rising-head tests (slug tests), and short-duration constant-rate tests (CRTs). A total of 83 individual slug tests and 18 CRTs were undertaken in between May and June 2019.

The slug tests used a PVC slug to displace a known volume of water within the monitoring wells, while the water level response to the displacement was recorded using manual water level measurements and a PTDL. The CRTs were conducted using a low-flow pump to remove water from the well at a constant flow rate for a set time. The water level response to pumping was measured throughout the test (including recovery once the pump had been shut down) using manual measurements and PTDLs.

The water level responses observed during slug testing of nine (9) wells (MW19-01, MW19-02, MW19-03A, MW19-06A, MW19-08, MW19-09, MW19-10, MW19-11 and MW19-18) were too rapid for reliable analysis. Only four (4) of the 18 CRT's provide data suitable for analysis, the remaining

test data was deemed unreliable due to either insufficient and/or erratic drawdown response due to the limited capacity of the pump or test duration.

The single-well hydraulic tests completed are summarized in Table I-2.2. The test analyses and results are discussed in Section I-3.2.2.

Table I-2.2 Single-Well Hydraulic Test Summary

Monitoring Well ID	Screened Lithology	Test Dates (2019)	Test Method	Number of Tests Completed	Number of Tests Analyzed
MW19-01	Sand and Gravel	May 14	Slug	6	-
			CRT	1	1
MW19-02	Sand and Gravel	May 14	Slug	4	-
			CRT	2	1
MW19-03	Sand and Gravel	June 13	CRT	1	-
MW19-03A	Sand and Gravel	June 13	Slug	6	-
			CRT	1	-
MW19-04	Sand and Gravel	June 14	Slug	6	3
			CRT	1	1
MW19-06A	Sand and Gravel	May 15	Slug	4	-
			CRT	1	-
MW19-06B	Bedrock (Sandstone/Siltstone)	May 15	Slug	4	4
			CRT	2	1
MW19-07	Sand and Gravel	June 13	Slug	4	-
			CRT	1	-
MW19-08	Sand and Gravel	June 13	Slug	6	-
			CRT	1	-
MW19-09	Sand and Gravel	June 13	Slug	6	-
			CRT	1	-
MW19-10	Sand and Gravel	June 13	Slug	6	-
			CRT	1	-
MW19-11	Sand and Gravel	June 13	Slug	6	-
			CRT	1	-
MW19-12	Sand and Gravel	June 14	Slug	6	3
			CRT	1	-
MW19-14	Sand and Gravel	June 14	Slug	6	2
			CRT	-	-
MW19-15	Sand and Gravel	May 15	Slug	1	-
MW19-15A	Bedrock (Siltstone)	May 15	Slug	4	4
MW19-17	Silty Lacustrine	May 15	Slug	2	2
MW19-18	Sand and Gravel	May 14	Slug	6	-
			CRT	1	-
Total				99	22

Table I-2.3 Monitoring Well Constant-Rate Test Summary

Well ID	Test Start Date & Time	Pump Shutdown Date & Time	Total Pumping Time (mins)	End of Recovery Date & Time	Percentage Recovery Observed	Flow Rate (L/min)	Maximum Observed Drawdown (m)
MW19-01	2019-05-14 11:19	2019-05-14 11:29	10	2019-05-14 11:34	100%	10	0.04
MW19-02	2019-05-14 12:54	2019-05-14 13:31	36	2019-05-14 13:37	100%	9	0.03
MW19-04	2019-06-14 9:07	2019-06-14 9:22	15	2019-06-14 9:27	79%	12	0.40
MW19-06B	2019-05-15 15:26	2019-05-15 15:44	18	2019-05-15 15:51	85%	8	0.84

MW19-06D Pumping Test

In July 2019, a 50-hour CRT was conducted at pumping well MW19-06D to assess the hydraulic conductivity and storage properties of the sand and gravel aquifer, as well as the presence of any potential hydraulic boundaries (e.g., recharge from the Bow River). The test was conducted by first completing a multi-rate (step) pumping test to determine an appropriate pumping rate for the subsequent CRT. Following the step test, a CRT was attempted at 200 L/min (3.3 L/s). However, after approximately 11 hours of pumping, it was determined that the pumping rate was too high to maintain for the full 50 hours. The test was, therefore, terminated and the well was left to recover overnight. A second CRT was initiated the next morning at a pumping rate of 160 L/min (2.7 L/s). This test was continued for the full 50 hours, after which recovery was monitored for two hours, by which time full water level recovery was observed. The drawdown was measured at MW19-06D and four adjacent monitoring wells (MW19-06, MW19-06A, MW19-06C, and MW19-07), throughout both the pumping and recovery phases of the CRT using both manual water level measurements and PTDs. Field water quality parameters were measured at MW19-06D throughout the pumping phase. Monitored parameters included temperature, specific conductance, pH, turbidity, total dissolved solids, and dissolved oxygen. A summary of the step test and CRT is presented in Table I-2.4. The pumping test analysis and results are discussed in Section I-3.2.3.

Table I-2.4 MW19-06D Pumping Test Summary

Test	Test Start Date & Time	End of Pumping Date & Time	Total Pumping Time (mins)	End of Recovery Date & Time	Percent Recovery Observed	Flow Rate (L/min)	Maximum Observed Drawdown (m)
Step Test	24-Jul-19 07:50	24-Jul-19 10:26	30	24-Jul-19 12h30	94%	60	0.02
			30			120	0.29
			56			244	2.21
			40			200	1.61
CRT	24-Jul-19 12:30	24-Jul-19 23:35	665	25-Jul-19 08h30	98%	200	2.21
	25-Jul-19 08:30	27-Jul-19 10:30	3000	27-Jul-19 13h15	100%	160	1.76

I-2.3 Bow River Sampling and Water Level Monitoring

The City of Calgary installed two PTDs (Bow 3 and Bow 5) in the Bow River in November 2018 to monitor seasonal water level (flow) fluctuations with particular emphasis during ice formation on the Bow River. The locations of the Bow River monitoring stations are shown in Figure I-1.1. The Bow 3 and Bow 5 water level and temperature hydrographs for the period November 19, 2018 to November 19, 2019 are presented in Appendix I2, Figures I2-30, and Figure I2-31, respectively.

Surface water samples were collected from multiple locations along the Bow River adjacent to monitoring wells installed on the riverbank. Surface water samples were collected using an extendable sampling pole and 1 L laboratory-supplied plastic bottle, which was placed approximately 0.25 m below the water surface and approximately 2 m from the shoreline. The Bow River sampling locations are shown on Figure I-1.1. Samples were placed directly into the laboratory-supplied containers. Samples that were to be analyzed for dissolved metals were filtered in the field using disposable 0.45 µm Nalgene® filters attached to a Nalgene® hand pump. Samples that required preservation were done so following laboratory instructions and supplied preservative. Samples were transported to AGAT Laboratories (AGAT) in Calgary, Alberta under standard chain-of-custody protocol. The surface water sample locations are summarized in Table I-2.5. The surface water laboratory results are provided in Appendix I3. Note that the laboratory ionic balance (IB%) are reported as ratios (Cations / Anions × 100) and the correct ionic balance should be $(100 - IB%) / (100 + IB%)$; e.g. for MW19-01 dated 2019-04-03: $(100 - 102)/(100 + 102) = 0.009$ or 1%.

Table I-2.5 Bow River Surface Water Monitoring and Sampling Locations

Monitoring Point ID	Northing ⁽¹⁾	Easting ⁽¹⁾	Comments
SW19-01	5661530.328	-12924.446	Located along Bow River close to MW19-06
SW19-02	5662433.425	-13928.003	Located along Bow River close to MW19-01
SW19-02A	5660348.055	-12089.424	Located along Bow River close to MW19-12
SW19-03	5660394.162	-12017.284	Located along Bow River close to MW19-11
SW19-03A	5662548.236	-13808.202	Located along Bow River close to MW19-01, on opposite side of River.
SW19-04	5660330.126	-12175.865	Located along Bow River close to MW19-12, Water level only

Notes:

1. Northing and easting in NAD83 3TM Zone 11 coordinates.

I-2.4 Geophysical Survey

Tetra Tech Canada Inc. (Tetra Tech) was retained by KCB to conduct a geophysical survey for the Project between September 29 and October 7, 2019. The purpose of survey was to delineate the depth to bedrock along two profiles within the proposed flood barrier alignment, as well as to map the distribution of sand and gravel and finer-grained layers with the surficial overburden. Five methods were applied as to produce two interpreted geophysical profiles. The following methods were applied (Tetra Tech 2020):

- Electrical Resistivity Tomography (ERT);
- Marine ERT;
- Ground Penetrating Radar (GPR);
- Capacity Coupled Resistivity (CCR/OhmMapper); and
- Seismic Refraction.

Details and results of the geophysical investigation are provided in Appendix I4.

I-3 FIELD INVESTIGATION AND MONITORING PROGRAM RESULTS

I-3.1 Hydrostratigraphy Summary

Based on the borehole data obtained during the KCB drilling program, the following section summarizes the key hydrostratigraphic units (HSUs) encountered from surface to drill depth for the Project area. The general hydrostratigraphy is as follows:

- **Topsoil, Silt, and Clay:** This fine-grained uppermost HSU ranges in thickness from 0 m (MW19-07 and MW19-14) to 8.2 m (MW19-15), based on 2019 drilling and is estimated to be of overall moderate to low permeability. This unit is generally unsaturated but may locally be saturated.
- **Alluvial Sand and Gravel:** The depth of occurrence and thickness of this unit is variable across the Project area, with top depth ranging from 0 meters below ground surface (mbgs) (MW19-07 and MW19-14) to 8.2 mbgs (MW19-15) and bottom depth ranging from 3 mbgs (MW19-05) to 12.2 mbgs (MW19-06A and MW19-15), with thicknesses ranging from 1.1 m (MW19-19) to 11.7 m (MW19-06A). The gravel material is generally described as brown or grey, sandy, with trace clay, silt, and cobbles. At least locally, the unit contains a high content of cobbles and boulders. The gravel content is likely overestimated due to the breaking of larger particles during the drilling process and the inability of the drill sampling method to collect larger particles. The sand and gravel underlying the Bowness floodplain is variably saturated and forms the main aquifer, although in places, it is unsaturated (MW19-05, MW19-16, and MW19-17A) or only partly saturated during the seasonal high river flow periods (MW19-06, MW19-13A, MW19-14, MW19-15, and MW19-19). The aquifer is generally unconfined (especially during low flow periods) but may become confined in localized areas during periods of higher river flows, such as was observed in July 2019 at MW19-02, MW19-03, and MW19-09.
- **Sandy Lacustrine Unit and Till:** This HSU, combining silty clay till and silt, clay, and sand sediments, ranges in thickness (where present) from 0.5 m (MW19-13) to 8.1 m (MW19-10).
- **Weathered / Competent Bedrock:** Comprises of sandstone, siltstone, and mudstone of the Paskapoo Formation. The upper contact of the bedrock is typically weathered and in places weakly jointed (less than 2 m thick), below which the sedimentary units are unweathered and competent. The geophysical survey results were used to help define this HSU. The report documenting the geophysical survey (Tetra Tech 2020) is included in Appendix I4.

For detailed information, refer to the geotechnical investigation report (KCB 2019) and the *Bowness Flood Control Barrier Hydrogeological Characterization and Groundwater Flow Modelling* report (KCB 2021).

I-3.2 Groundwater Investigation and Monitoring Results

I-3.2.1 Groundwater Monitoring Observations

Groundwater level, temperature, and (where Solinst LTC PTDs are installed) electrical conductivity data was collected from the monitoring wells for the period April 2019 to May 2020. The purpose of the monitoring program is to gain a better understanding of the groundwater flow dynamics in the shallow alluvial-bedrock aquifer system and its hydraulic connection to the Bow River. The monitoring data was also used to calibrate the Bowness 3D groundwater flow model to transient conditions. Hydrographs for the 26 monitoring wells are presented in Appendix I2. The groundwater levels in the wells located within ~300 m to ~600 m of the Bow River are strongly controlled by river level (flow) fluctuations in terms of magnitude and timing, both in the sand and gravel aquifer, and the underlying weathered bedrock. Further inland, the groundwater levels in the sand and gravel aquifer show minimal (muted) or no response to Bow River flows. A more detailed discussion of the observed responses is provided in the hydrogeological conceptualization and groundwater flow modelling report (KCB 2021).

It is planned that the current Bowness groundwater monitoring network will be maintained until at least March 2021.

I-3.2.2 Single-Well Hydraulic Tests

The hydraulic tests with reliable results (i.e., those tests with reliable water level measurements) were analyzed using AQTESOLV Pro v4.5 software (Duffield 2007) to estimate the hydraulic conductivity of the tested HSUs. The slug tests were analyzed using either the Bouwer and Rice (1976) or the KGS (Hyder et al. 1994) solution for tests in an unconfined aquifer. The Bouwer and Rice solution makes the following assumptions:

- The aquifer has infinite areal extent, is homogeneous, and is of uniform thickness.
- The aquifer is unconfined.
- Flow to the well is in quasi- steady state (i.e., storage is negligible).
- A volume of water is injected into or discharged from the well instantaneously.

The KGS solution makes the same assumptions, with the following exceptions:

- Flow to the well is unsteady (transient).
- Water is released instantaneously from storage with decline of hydraulic head.

These assumptions are approximately met at the monitoring wells analysed. The zone of influence of a slug test is typically very small (within 1 m to 2 m of the well); therefore, the aquifer areal extent can be assumed to be infinite and the thickness to be approximately uniform. The test data did not indicate that aquifer boundaries were encountered in any of the analyzed slug tests.

The single-well CRTs at MW19-01 (screened in the sand and gravel aquifer) and MW19-06B (screened in the weathered bedrock) were analyzed using the Hantush and Jacob (1955) solution for pumping tests in a semi-confined (leaky) aquifer. The Hantush and Jacob solution makes the following assumptions:

- The aquifer has infinite areal extent, is homogeneous, and is of uniform thickness.
- Flow to the pumping well is horizontal when the pumping well is fully penetrating.
- The aquifer is leaky confined.
- Flow is unsteady.
- Water is released instantaneously from storage with decline of hydraulic head.
- The diameter of the pumping well is very small, so that storage in the well can be neglected.
- The confining bed(s) has infinite areal extent, uniform vertical hydraulic conductivity, and uniform thickness.
- The confining bed(s) is overlain or underlain by an infinite constant-head plane source.
- Flow is vertical in the aquitard(s).

The single-well CRTs at MW19-02 and MW19-04 (screened in the sand and gravel aquifer) were analyzed using the Theis (1935) solution for an unconfined aquifer (Duffield 2007). The Theis solution makes the following assumptions:

- The aquifer has infinite areal extent, is homogeneous and is of uniform thickness.
- Flow to the pumping well is horizontal when the pumping well is fully penetrating.
- The aquifer is unconfined.
- Flow is unsteady.
- Water is released instantaneously from storage with decline of hydraulic head.
- The diameter of the pumping well is very small, so that wellbore storage can be neglected.
- No delayed gravity response.
- Flow is horizontal and uniform through the axis of the well.
- Displacement is small relative to the saturated thickness of the aquifer.

These assumptions are approximately met at the two test sites. The test durations were relatively short (only ~10 minutes at MW19-01, 15 min at MW19-04 etc.), limiting the radius of influence of the tests and thereby minimizing the volume of aquifer assessed and the potential for detection of hydraulic boundaries (i.e. river recharge). The MW19-01 drawdown data showed a good fit to the Hantush and Jacob solution indicating the influence of leakage from bedrock or local low-permeability zones within the sand and gravel aquifer. MW19-02 and MW19-04 drawdown data show a moderate fit using the Theis method.

The short-duration single-well hydraulic test results are summarized in Table I-3.1 and graphically presented in Appendix I5.

Table I-3.1 Single-Well Hydraulic Test Results

Monitoring Well ID	Tested Hydrostratigraphic Unit (HSU)	Test Method	Analytical Solution	Estimated Hydraulic Conductivity (m/s)
MW19-01	Sand and Gravel	CRT	Hantush & Jacob	5.4×10^{-4}
MW19-02	Sand and Gravel	CRT	Theis	2.2×10^{-3}
MW19-04	Sand and Gravel	Slug	Bouwer & Rice	2.0×10^{-4}
		Slug	Bouwer & Rice	2.2×10^{-4}
		Slug	Bouwer & Rice	2.4×10^{-4}
		CRT	Theis	2.6×10^{-4}
MW19-06B	Weathered Bedrock	Slug	Bouwer & Rice	1.7×10^{-4}
		Slug	Bouwer & Rice	1.8×10^{-4}
		Slug	Bouwer & Rice	1.8×10^{-4}
		Slug	Bouwer & Rice	1.8×10^{-4}
		CRT	Hantush & Jacob	1.1×10^{-5}
MW19-12	Sand and Gravel	Slug	Bouwer & Rice	1.2×10^{-4}
		Slug	Bouwer & Rice	1.2×10^{-4}
		Slug	Bouwer & Rice	1.3×10^{-4}
MW19-14	Sand and Gravel	Slug	KGS	6.0×10^{-5}
		Slug	KGS	6.1×10^{-5}
MW19-15A	Weathered Bedrock	Slug	Bouwer & Rice	2.0×10^{-6}
		Slug	Bouwer & Rice	2.0×10^{-6}
		Slug	Bouwer & Rice	2.2×10^{-6}
		Slug	Bouwer & Rice	2.1×10^{-6}
MW19-17	Sandy Lacustrine and Till	Slug	Bouwer & Rice	2.0×10^{-7}
		Slug	Bouwer & Rice	4.6×10^{-7}

I-3.2.3 MW19-06D Pumping Test

The 50-hour CRT completed at well MW19-06D was analyzed using AQTESOLV Pro v4.5 software (Duffield 2007) to estimate the bulk hydraulic conductivity, and storativity of the sand and gravel aquifer. The Moench (1997) analytical solution for pumping tests in an unconfined aquifer was adopted for the analysis. The Moench solution makes the following assumptions:

- The aquifer has infinite areal extent, is homogeneous, and is of uniform thickness.
- The water table in the aquifer is initially horizontal.
- Pumping and observation wells are fully or partially penetrating.
- Flow to the well is unsteady.
- The aquifer is unconfined and exhibits a delayed gravity response.

These assumptions are broadly met at the test site. Drawdown was observed at the pumping well and four observation wells, the furthest being MW19-07 at a radial distance of 193 m from MW19-06D. A maximum drawdown of 0.25 m was observed at this well. The Moench solution provides a good fit to the pumping well drawdown data and the drawdown observed in the nearest observation well (MW19-06A at 13 m radial distance), and a decreasing quality of fit to the observation well data beyond that. This is attributed to the heterogeneous nature of the aquifer, consistent with a typical alluvial sand and gravel. The bulk aquifer properties estimated from the CRT are:

- Transmissivity: 24 m²/day (hydraulic conductivity 5.4 x 10⁻⁵ m/s assuming an average aquifer thickness of 5 m)
- Specific Yield: 0.24
- Anisotropy Ratio: 0.1

The MW19-06D CRT results are graphically presented in Appendix I6.

I-3.2.4 Water Quality Analytical Results

Water quality results for the April 2019, June 2019, December 2019, and May 2020 sampling events were compared to applicable Alberta Environment and Parks guidelines (Alberta Tier 1 Soil and Groundwater Remediation Guidelines - Residential/Parkland [AEP 2019] for groundwater samples; and Environmental Quality Guidelines for Alberta Surface Waters [AEP 2018] for surface water samples). Several groundwater samples exceeded the AEP 2019 guidelines. Exceedances were observed for the following analytes:

- Total Dissolved Solids (TDS) (16 exceedances at eight monitoring wells);
- Nitrate (nine exceedances at five monitoring wells);
- Sodium (one exceedance at MW19-15);
- Chloride (five exceedances at three monitoring wells);
- Fluoride (one exceedance at MW19-17);
- Dissolved Aluminum (14 exceedances at 14 monitoring wells, all in May 2020);
- Dissolved Arsenic (one exceedance at MW19-07);
- Dissolved Barium (two exceedances at MW19-02 and MW19-07);
- Dissolved Cadmium (one exceedance at MW19-11);
- Dissolved Copper (nine exceedances at nine monitoring wells, all in May 2020);
- Dissolved Iron (two exceedances at MW19-04 and MW19-15A);
- Dissolved Manganese (17 exceedances at 13 monitoring wells);
- Dissolved Selenium (10 exceedances at nine monitoring wells); and
- Dissolved Zinc (five exceedances at five monitoring wells, all in May 2020).

None of the surface water samples exceeded the AEP 2018 guidelines for the tested analytes. Water quality results are summarized in Table I-3.2 (routine parameters), Table I-3.3 (dissolved metals in groundwater), and Table I-3.4 (total metals in surface water). Where there is a reported exceedance in the tables, the cell is highlighted yellow. If the cell is highlighted green, the reported parameter is below the applicable guideline and if there is no highlighting then there is no guideline for that parameter. The laboratory analytical reports are included in Appendix I3.

I-3.2.5 Water Quality QA/QC Results

RPD values were calculated for each pair of duplicate water quality samples and compared to the applicable Zeiner criteria (see Section I-2.2.3). The Zeiner criteria were exceeded for fluoride during the April 2019 sampling event. No exceedances were observed during the June 2019 and May 2020 sampling events.

QA/QC results are summarized in Table I-3.5.

Table I-3.2 Groundwater and Bow River Water Quality Results - Routine and Field Parameters

GENERAL		FIELD PARAMETERS					PHYSICAL PARAMETERS							NUTRIENTS			MACRO PARAMETERS						
Location	Sample Date (dd-mmm-yyyy)	Temperature	pH	Electrical Conductivity	Dissolved Oxygen	Oxidation-Reduction Potential	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO ₃	Carbonate - CO ₃	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fluoride
	Units	°C	-	µS/cm	mg/L	mV	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																							
AEP Residential/Parkland - Coarse Grained		ng	6-8.5	ng	ng	ng	6-8.5	ng	500	ng	ng	ng	ng	Calc	3	ng	ng	200	ng	ng	120	Calc	1.5
AEP Surface Water Quality		ng	6.5-9	ng	ng	ng	6.5-9	ng	ng	<20	ng	ng	ng	Calc	3	ng	ng	ng	ng	ng	120	Calc	ng
GROUNDWATER																							
MW19-01	03-Apr-2019	2.6	7.85	221	8.30	117.0	8.14	427	226	154	187	<5	192	<0.01	0.18	0.180	52.0	5.20	15.2	<0.6	5.0	56.0	0.08
MW19-01	25-Jun-2019	14.0	-	290	-	-	8.06	327	185	137	167	<5	164	<0.01	0.16	0.160	44.7	5.50	12.7	0.70	5.0	34.0	0.06
MW19-01	06-Dec-2019	4.6	7.77	239	8.49	185.8	8.05	399	218	141	172	<5	201	<0.01	0.23	0.230	55.2	7.20	15.4	<0.6	7.0	48.0	0.09
MW19-01	05-May-2020	2.6	7.93	332	10.00	187.0	8.21	371	185	131	160	<5	157	<0.01	0.14	0.140	39.8	4.4	13.9	0.7	3.3	43.0	<0.01
MW19-02	04-Apr-2019	6.7	7.58	335	9.91	250.8	8.14	637	337	237	289	<5	303	0.020	0.18	0.200	82.1	11.50	23.8	1.30	27.0	48.0	0.12
MW19-02	25-Jun-2019	7.5	-	490	-	-	7.99	497	284	198	241	<5	253	<0.01	0.34	0.340	70.0	8.40	18.9	0.80	16.0	50.0	0.06
MW19-02	05-May-2020	5.8	7.54	316	6.70	209.0	8.14	536	255	207	253	<5	171	<0.01	0.36	0.36	40.9	8.50	16.8	1.00	16.7	44.6	<0.01
MW19-03	04-Apr-2019	4.1	7.90	253	7.40	43.9	8.19	504	265	181	220	<5	237	<0.01	0.20	0.200	66.3	5.70	17.4	0.80	13.0	53.0	0.10
MW19-03	25-Jun-2019	7.1	-	350	-	-	8.01	354	201	154	187	<5	185	<0.01	0.16	0.160	51.8	3.80	13.5	0.60	3.0	36.0	0.09
MW19-03	05-May-2020	3.3	7.63	417	7.22	187.0	8.17	446	229	162	198	<5	186	<0.01	0.20	0.20	45.9	6.9	17.4	0.70	10.4	49.8	0.03
MW19-03A	04-Apr-2019	6.5	7.80	301	7.05	-40.5	8.18	532	284	197	240	<5	252	<0.01	0.14	0.140	70.0	7.3	18.7	0.80	18.0	51.0	0.09
MW19-03A	25-Jun-2019	6.7	-	480	-	-	8.05	500	289	194	236	<5	256	<0.01	<0.02	<0.02	67.7	10.1	21.0	0.90	21.0	52.0	0.07
MW19-03A	05-May-2020	4.9	7.65	279	9.94	191.0	8.17	485	243	182	222	<5	172	<0.01	0.27	0.27	41.8	8.6	16.5	0.90	13.7	51	0.04
MW19-04	04-Apr-2019	5.2	7.75	428	5.97	-91.9	8.09	847	475	257	314	<5	456	<0.01	2.24	2.24	114.0	18.9	41.6	1.40	82.0	53.0	0.13
MW19-04	25-Jun-2019	9.7	-	530	-	-	7.99	588	341	251	306	<5	314	<0.01	0.34	0.34	82.4	9.9	26.3	1.00	18.0	51.0	0.09
MW19-04	04-May-2020	4.4	7.44	411	4.71	174.0	8.04	731	356	230	280	<5	223	<0.01	1.78	1.78	40.0	26.4	29.8	1.60	62.3	50.5	0.11
MW19-06	25-Jun-2019	13.1	-	350	-	-	8.13	364	206	152	185	<5	186	<0.01	0.07	0.07	52.8	4.70	13.2	1.40	5.0	38.0	0.10
MW19-06A	05-Apr-2019	8.6	7.64	596	6.83	160.1	8.10	936	487	212	258	<5	373	<0.01	1.24	1.24	88.2	35.5	37.2	3.10	118.0	73.0	0.13
MW19-06A DUP	05-Apr-2019	-	-	-	-	-	8.18	937	492	212	258	<5	379	<0.01	1.20	1.20	90.7	36.2	37.0	3.20	120.0	73.0	0.17
MW19-06A	25-Jun-2019	9.4	-	870	-	-	8.13	541	304	189	230	<5	229	0.07	0.50	0.56	61.7	24.8	18.3	2.50	32.0	49.0	0.13
MW19-06A	04-May-2020	7.1	7.57	708	7.92	113.0	8.12	1153	557	196	239	<5	334	<0.01	4.04	4.04	56.8	53.1	46.7	4.00	196	64.5	0.12
MW19-06B	05-Apr-2019	5.1	7.67	359	4.52	-194.6	8.14	731	393	198	242	<5	291	<0.01	0.70	0.70	74.6	33.4	25.4	3.30	69.0	65.0	0.15
MW19-06B DUP	25-Jun-2019	-	-	-	-	-	8.00	461	250	169	207	<5	202	<0.01	0.23	0.23	51.9	10.9	17.5	1.80	22.0	43.0	0.18
MW19-06B	25-Jun-2019	7.7	-	440	-	-	8.00	460	247	168	205	<5	199	<0.01	0.25	0.25	51.1	10.8	17.3	1.70	22.0	42.0	0.18
MW19-06B	04-May-2020	4.3	7.57	373	4.36	-46.0	8.08	662	346	173	210	<5	276	<0.01	0.72	0.72	65.7	23.3	27.1	4.50	70.2	48.8	0.09
MW19-06C	25-Jun-2019	8.3	-	570	-	-	8.03	916	501	233	284	<5	396	<0.01	1.83	1.83	95.6	36.5	38.2	3.90	104.0	75.0	0.17
MW19-06C	04-May-2020	3.0	7.69	442	7.03	76.2	8.20	840	435	196	239	<5	290	<0.01	2.30	2.30	66.0	32.5	30.4	3.30	113.0	62.3	0.14

GENERAL		FIELD PARAMETERS					PHYSICAL PARAMETERS							NUTRIENTS			MACRO PARAMETERS						
Location	Sample Date (dd-mmm-yyyy)	Temperature	pH	Electrical Conductivity	Dissolved Oxygen	Oxidation-Reduction Potential	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO ₃	Carbonate - CO ₃	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fluoride
	Units	°C	-	µS/cm	mg/L	mV	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																							
AEP Residential/Parkland - Coarse Grained		ng	6-8.5	ng	ng	ng	6-8.5	ng	500	ng	ng	ng	ng	Calc	3	ng	ng	200	ng	ng	120	Calc	1.5
AEP Surface Water Quality		ng	6.5-9	ng	ng	ng	6.5-9	ng	ng	<20	ng	ng	ng	Calc	3	ng	ng	ng	ng	ng	120	Calc	ng
GROUNDWATER																							
MW19-07	04-Apr-2019	6.8	8.94	450	4.23	-308.3	8.27	728	403	191	233	<5	258	0.0600	3.00	3.06	63.1	43.2	24.5	2.80	52.0	89.0	0.25
MW19-07	25-Jun-2019	9.9	-	1170	-	-	8.02	1,230	645	167	204	<5	435	0.0200	8.38	8.41	105.0	64.6	41.9	3.70	249.0	43.0	0.13
MW19-07	04-May-2020	4.7	7.68	689	9.14	226	8.12	1,018	502	196	240	<5	245	<0.01	8.58	8.58	50.4	68.3	29.0	3.6	158.0	36.5	0.14
MW19-08	04-May-2020	6.6	7.54	368	8.97	232.0	8.02	612	301	212	259	<5	200	<0.01	1.11	1.11	33.6	15.4	28.3	1.3	32.7	57.8	0.09
MW18-08 DUP	04-May-2020	-	-	-	-	-	8.18	611	314	211	257	<5	240	<0.01	1.06	1.06	50.0	14.7	28.1	1.2	32.1	57.1	0.10
MW19-09	05-Apr-2019	6.0	7.60	340	2.52	-323.3	7.99	667	373	255	311	<5	316	<0.01	0.180	0.18	88.0	8.1	23.4	1.90	8.0	90.0	0.13
MW19-09	25-Jun-2019	6.7	-	660	-	-	7.85	773	477	270	329	<5	407	<0.01	0.180	0.18	109.0	13.8	32.8	0.70	14.0	144.0	0.08
MW19-09	04-May-2020	4.2	7.60	133	8.29	218.0	8.07	480	254	165	202	<5	205	<0.01	0.23	0.23	48.0	5.8	20.7	0.70	6.8	72.0	0.10
MW19-10	05-Apr-2019	4.4	7.61	307	5.33	127.2	8.08	562	310	225	275	<5	279	<0.01	0.97	0.97	76.2	6.8	21.5	0.70	11.0	54.0	0.11
MW19-10	06-Dec-2019	6.2	7.48	391	5.36	197.0	8.05	628	355	228	278	<5	334	<0.01	2.39	2.39	91.6	12.6	25.5	1.20	24.0	53.0	0.14
MW19-10	04-May-2020	4.4	7.65	307	9.52	178.0	8.12	539	275	194	235	<5	205	<0.01	1.04	1.04	43.9	10.4	23.1	1.0	20.0	55.5	0.04
MW19-11	05-Apr-2019	4.5	7.48	471	3.86	105.4	8.03	870	476	293	358	<5	380	<0.01	2.64	2.64	103.0	29.0	29.9	1.50	53.0	72.0	0.12
MW19-11	25-Jun-2019	7.6	-	620	-	-	7.95	627	365	238	290	<5	299	<0.01	1.69	1.69	81.0	19.2	23.6	1.10	22.0	68.0	0.07
MW19-11	04-May-2020	4.0	7.35	529	5.86	140.0	8.03	946	479	266	325	<5	279	<0.01	5.56	5.56	57.3	44.8	32.9	1.80	76.7	80.6	0.11
MW19-12	03-Apr-2019	6.7	7.82	855	3.98	-196.3	8.07	1,470	761	297	362	<5	497	<0.01	8.20	8.20	118.0	82.5	49.2	3.70	226.0	67.0	0.21
MW19-12	05-May-2020	5.0	7.33	816	6.11	75.0	8.04	1,387	675	288	352	<5	333	<0.01	6.01	6.01	54.7	108	47.7	3.7	201.0	60.3	0.15
MW19-12 DUP	05-May-2020	-	-	-	-	-	8.09	1,393	676	279	340	<5	308	<0.01	5.94	5.94	47.5	105	46.1	3.3	221.0	59.8	0.22
MW19-14	03-Apr-2019	6.0	7.91	676	7.04	134.0	8.20	1,270	778	246	300	<5	341	0.08	0.79	0.87	86.4	122	30.40	3.40	22.0	363.0	0.28
MW19-14	25-Jun-2019	11.6	-	950	-	-	8.06	1,020	667	219	267	<5	332	0.05	0.25	0.30	79.7	105	32.40	2.80	22.0	293.0	0.18
MW19-14	05-May-2020	6.9	7.66	867	4.21	21.0	8.16	942	560	208	254	<5	282	<0.01	0.99	-	57.5	75.9	33.6	3.1	54.7	206.0	0.19
MW19-15	04-Apr-2019	-	-	-	-	-	8.21	1,380	837	440	537	<5	336	0.41	6.87	7.28	78.3	161	34.10	4.50	15.0	248.0	0.43
MW19-15	25-Jun-2019	10.7	-	1320	-	-	8.05	1,480	930	443	541	<5	242	<0.01	2.87	2.87	57.2	248	24.00	4.00	47.0	271.0	0.33
MW19-15A	04-Apr-2019	7.5	8.33	608	1.05	-450.0	8.04	998	528	322	392	<5	239	<0.01	0.25	0.25	59.3	96.5	22.20	4.20	94.0	58.0	0.12
MW19-15A	25-Jun-2019	9.4	-	910	-	-	8.06	937	514	285	348	<5	225	<0.01	0.02	0.02	54.8	113	21.40	4.30	92.0	57.0	0.43
MW19-15A	06-Dec-2019	-	7.51	583	-	185.6	8.08	947	519	260	317	<5	245	<0.01	0.02	0.02	60.5	107	22.90	4.40	107.0	61.0	0.16
MW19-17	05-Apr-2019	6.9	8.05	543	6.19	6.1	8.34	876	494	377	449	5	113	<0.01	0.140	0.140	27.5	136	10.80	2.10	4.0	87.0	0.29
MW19-17	25-Jun-2019	9.0	-	860	-	-	8.00	911	518	418	510	<5	123	<0.01	0.050	0.050	29.3	162	12.00	3.00	5.0	56.0	2.00
MW19-17	05-May-2020	7.2	7.89	570	3.5	-109.0	8.43	930	544	372	349	<5	81	<0.01	<0.02	<0.02	13.3	182	11.50	2.0	3.3	108.0	0.42

GENERAL		FIELD PARAMETERS					PHYSICAL PARAMETERS							NUTRIENTS			MACRO PARAMETERS						
Location	Sample Date (dd-mmm-yyyy)	Temperature	pH	Electrical Conductivity	Dissolved Oxygen	Oxidation-Reduction Potential	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO ₃	Carbonate - CO ₃	Hardness	Nitrite (as N)	Nitrate (as N)	Total Nitrogen	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fluoride
	Units	°C	-	µS/cm	mg/L	mV	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																							
AEP Residential/Parkland - Coarse Grained		ng	6-8.5	ng	ng	ng	6-8.5	ng	500	ng	ng	ng	ng	Calc	3	ng	ng	200	ng	ng	120	Calc	1.5
AEP Surface Water Quality		ng	6.5-9	ng	ng	ng	6.5-9	ng	ng	<20	ng	ng	ng	Calc	3	ng	ng	ng	ng	ng	120	Calc	ng
GROUNDWATER																							
MW19-18	03-Apr-2019	1.6	7.78	267	7.18	-164.0	8.24	514	284	151	184	<5	212	<0.01	0.38	0.380	56.3	17.6	17.30	3.00	34.0	64.0	0.140
MW19-18	25-Jun-2019	9.5	-	500	-	-	8.06	536	293	174	212	<5	223	<0.01	0.16	0.160	62.2	22.5	16.50	2.10	36.0	49.0	0.110
MW19-18	05-May-2020	1.7	7.79	468	8.89	55.0	8.19	507	278	139	170	<5	203	<0.01	0.25	0.25	54.4	21.3	16.30	2.20	35.6	63.8	0.10
MW19-19	25-Jun-2019	13.5	-	440	-	-	7.97	483	283	219	268	<5	255	<0.01	0.23	0.230	65.1	5.5	22.40	1.00	5.0	51	0.070
SURFACE WATER																							
SW19-01	05-Apr-2019	-	-	-	-	-	8.40	360	197	137	159	<5	183	<0.01	0.140	0.140	49.9	2.20	14.20	0.60	2.0	49.0	0.130
SW19-01	04-May-2020	5.3	8.52	174	11.62	134	8.47	352	180	122	141	<5	176	<0.01	<0.02	<0.02	46.9	3.10	14.20	0.70	3.0	42.3	0.04
SW19-02	25-Jun-2019	-	-	-	-	-	8.26	288	161	122	149	<5	148	<0.01	0.110	0.110	39.6	2.90	11.90	<0.6	3.0	30.0	0.050
SW19-02	05-May-2020	6.3	8.56	314	12.34	175	8.40	356	182	125	148	<5	174	<0.01	<0.02	<0.02	46.4	3.10	14.00	0.7	3.1	41.7	0.06
SW19-02A	06-Dec-2019	-0.6	8.18	190	14.65	203.4	8.25	390	206	132	161	<5	202	<0.01	0.160	0.160	55.0	4.00	15.60	<0.6	4.0	48.0	0.130
SW19-03	05-May-2020	5.1	8.53	196	11.3	131.0	8.34	356	184	126	150	<5	176	<0.01	<0.02	<0.02	47.1	3.20	14.30	0.7	2.9	42.3	<0.01
SW19-03A	06-Dec-2019	-0.1	8.37	215	14.63	211.7	8.23	418	218	130	158	<5	204	<0.01	0.160	0.160	55.3	8.00	16.10	0.70	11.0	48.0	0.110

Notes:

- Guidelines are based on Alberta Environment and Parks Alberta Tier 1 Soil and Groundwater Remediation Guidelines - Residential/Parkland (AEP 2019).
- Guidelines are based on Alberta Environment and Parks Environmental Quality Guidelines for Alberta Surface Waters (AEP 2018).
- ng - no guideline
-  = No applicable guideline or concentration less than detection.
-  = Exceeds applicable guideline.
-  = Equal to or below applicable guideline.
- Nitrite-N varies with chloride.
- Sulphate varies with hardness.
- data not available and/or analyzed
- View analytical reports for more comprehensive results.

Table I-3.3 Groundwater Quality Results - Dissolved Metals

GENERAL		DISSOLVED METALS																				
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium (Total)	Cobalt	Copper	Iron	Lead	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																						
Alberta Tier 1 Guideline - Residential/Parkland - Coarse Grained		Calc	0.006	0.005	1	ng	1.5	Calc	0.05	ng	0.007	0.3	Calc	0.05	ng	Calc	0.0015	0.0001	ng	0.015	ng	0.03
GROUNDWATER																						
MW19-01	03-Apr-2019	0.0070	<0.001	<0.001	<0.05	<0.001	<0.01	<0.000016	<0.001	<0.0009	0.00120	<0.1	<0.0005	0.050	0.00100	<0.003	<0.0005	<0.00005	<0.0001	0.00100	<0.001	0.0090
MW19-01	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-01	06-Dec-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-01	05-May-2020	1.98	<0.001	0.004	0.41	<0.001	<0.01	0.00140	0.002	0.0100	0.0194	<0.1	0.0070	<0.005	<0.001	0.009	0.0015	<0.0001	<0.0001	0.002	-	0.031
MW19-02	04-Apr-2019	0.0660	<0.001	<0.001	0.0900	<0.001	0.010	0.0000470	<0.001	0.00290	<0.0008	0.200	<0.0005	0.287	0.00500	0.00500	0.0006	<0.00005	<0.0001	0.00200	<0.001	<0.005
MW19-02	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-02	05-May-2020	4.73	<0.001	0.005	1.42	0.001	0.01	0.00436	0.008	0.0112	0.0288	<0.1	0.0130	<0.005	<0.001	0.011	0.0056	<0.0001	<0.0001	0.003	-	0.054
MW19-03	04-Apr-2019	0.0070	<0.001	<0.001	0.0600	<0.001	<0.01	0.0000200	<0.001	<0.0009	0.00230	<0.1	<0.0005	0.042	0.00200	<0.003	0.0007	<0.00005	<0.0001	0.00200	<0.001	0.0080
MW19-03	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-03	05-May-2020	0.796	<0.001	0.002	0.19	<0.001	<0.01	0.000347	0.002	0.0121	0.0067	<0.1	0.0039	<0.005	<0.001	0.003	0.0010	<0.0001	<0.0001	0.001	-	0.019
MW19-03A	04-Apr-2019	0.0150	<0.001	<0.001	0.0700	<0.001	<0.01	<0.000016	<0.001	<0.0009	<0.0008	<0.1	<0.0005	0.094	0.00100	<0.003	0.0007	<0.00005	<0.0001	0.00200	<0.001	0.0060
MW19-03A	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-03A	05-May-2020	2.19	<0.001	0.003	0.82	<0.001	0.01	0.00211	0.003	0.0095	0.0212	<0.1	0.0070	<0.005	<0.001	0.014	0.0029	<0.0001	<0.0001	0.002	-	0.032
MW19-04	04-Apr-2019	0.0450	<0.001	<0.001	0.1100	<0.001	0.010	0.0000740	0.00100	0.00140	0.00140	0.400	<0.0005	0.154	0.00300	<0.003	0.0009	<0.00005	<0.0001	0.00400	0.001000	0.0070
MW19-04	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.007	-	-	-	-	-	-	-	-
MW19-04	04-May-2020	0.665	<0.001	0.002	0.25	<0.001	0.02	0.000441	0.002	0.0022	0.0065	<0.1	0.0039	<0.005	<0.001	<0.003	0.0014	<0.0001	<0.0001	0.001	-	0.021
MW19-06	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-06A	05-Apr-2019	0.0060	<0.001	<0.001	0.1900	<0.001	0.020	<0.000016	<0.001	<0.0009	0.00080	<0.1	<0.0005	<0.005	0.00200	<0.003	0.0012	<0.00005	<0.0001	0.00200	0.002000	0.0080
MW19-06A DUP	05-Apr-2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW19-06A	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.013	-	-	-	-	-	-	-	-
MW19-06A	04-May-2020	0.494	<0.001	0.001	0.34	<0.001	0.02	0.000359	0.001	0.0024	0.0036	<0.1	0.0023	<0.005	0.002	<0.003	0.0015	<0.0001	<0.0001	0.002	-	0.016
MW19-06B	05-Apr-2019	0.0080	<0.001	<0.001	0.1300	<0.001	0.020	0.0000400	<0.001	0.00260	0.00170	<0.1	<0.0005	0.198	0.01100	0.00500	0.0016	<0.00005	<0.0001	0.00200	0.001000	0.0070
MW19-06B DUP	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-06B	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-06B	04-May-2020	0.184	<0.001	0.003	0.23	<0.001	0.02	0.000141	<0.001	0.0011	0.0026	<0.1	0.0013	<0.005	0.003	<0.003	0.0007	<0.0001	<0.0001	0.001	-	0.007
MW19-06C	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-06C	04-May-2020	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-08	04-May-2020	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-08 DUP	04-May-2020	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-07	04-Apr-2019	0.0230	<0.001	<0.001	0.0700	<0.001	0.030	0.0000500	<0.001	0.00220	0.00150	<0.1	<0.0005	0.183	0.02500	0.00600	0.0013	<0.00005	<0.0001	0.00200	0.002000	0.0080
MW19-07	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.015	-	-	-	-	-	-	-	-
MW19-07	04-May-2020	4.08	<0.001	0.007	1.34	0.002	0.05	0.00845	0.006	0.0210	0.0476	<0.1	0.0167	<0.005	<0.001	0.017	0.0064	<0.0001	<0.0001	0.007	-	0.118

GENERAL		DISSOLVED METALS																				
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium (Total)	Cobalt	Copper	Iron	Lead	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Uranium	Vanadium	Zinc
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GUIDELINES																						
Alberta Tier 1 Guideline - Residential/Parkland - Coarse Grained		Calc	0.006	0.005	1	ng	1.5	Calc	0.05	ng	0.007	0.3	Calc	0.05	ng	Calc	0.0015	0.0001	ng	0.015	ng	0.03
GROUNDWATER																						
MW19-09	05-Apr-2019	0.0090	<0.001	0.00100	0.1000	<0.001	0.020	<0.000016	<0.001	0.00160	<0.0008	<0.1	<0.0005	0.468	0.00600	0.00300	<0.0005	<0.00005	<0.0001	0.00200	0.001000	<0.005
MW19-09	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-09	04-May-2020	1.04	<0.001	0.002	0.17	<0.001	<0.01	0.000569	0.002	0.0047	0.0109	<0.1	0.0061	<0.005	<0.001	0.006	0.0013	<0.0001	<0.0001	0.001	-	0.017
MW19-10	05-Apr-2019	0.0050	<0.001	<0.001	0.0900	<0.001	<0.01	<0.000016	<0.001	<0.0009	<0.0008	<0.1	<0.0005	0.039	0.00200	<0.003	<0.0005	<0.00005	<0.0001	0.00200	<0.001	<0.005
MW19-10	06-Dec-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-10	04-May-2020	0.578	<0.001	0.001	0.19	<0.001	0.01	0.000390	0.002	0.0021	0.0089	<0.1	0.0032	<0.005	<0.001	<0.003	0.0016	<0.0001	<0.0001	0.001	-	0.016
MW19-11	05-Apr-2019	0.0090	<0.001	<0.001	0.1000	<0.001	0.030	0.000049	<0.001	<0.0009	0.00150	<0.1	<0.0005	0.108	0.00100	<0.003	0.0008	<0.00005	<0.0001	0.00300	0.001000	0.0090
MW19-11	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-11	04-May-2020	1.67	<0.001	0.002	0.30	<0.001	0.05	0.000750	0.003	0.0029	0.136	<0.1	0.0421	<0.005	<0.001	<0.003	0.0026	<0.0001	<0.0001	0.002	-	0.116
MW19-12	03-Apr-2019	0.0080	<0.001	<0.001	0.1600	<0.001	0.040	0.000063	0.001	0.00380	0.00220	<0.1	<0.0005	0.296	0.00600	0.01200	0.0025	<0.00005	<0.0001	0.00300	0.002000	0.0100
MW19-12	05-May-2020	0.689	<0.001	0.002	0.30	<0.001	0.04	0.000331	-	0.0032	0.0080	<0.1	0.0040	<0.005	0.001	0.008	0.0027	<0.0001	<0.0001	0.002	-	0.022
MW19-12 DUP	05-May-2020	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-14	03-Apr-2019	-	-	-	-	-	-	-	-	-	-	-	-	0.218	-	-	-	-	-	-	-	-
MW19-14	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.186	-	-	-	-	-	-	-	-
MW19-14	05-May-2020	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-
MW19-15	04-Apr-2019	-	-	-	-	-	-	-	-	-	-	-	-	0.079	-	-	-	-	-	-	-	-
MW19-15	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.043	-	-	-	-	-	-	-	-
MW19-15A	04-Apr-2019	0.0140	<0.001	<0.001	0.0600	<0.001	0.110	<0.000016	<0.001	<0.0009	0.00140	0.600	<0.0005	0.090	0.00300	<0.003	<0.0005	<0.00005	<0.0001	0.00300	<0.001	0.0080
MW19-15A	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.109	-	-	-	-	-	-	-	-
MW19-15A	06-Dec-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.079	-	-	-	-	-	-	-	-
MW19-17	05-Apr-2019	0.0060	<0.001	0.00300	0.1600	<0.001	0.100	0.000018	<0.001	0.00110	0.00090	<0.1	<0.0005	0.152	0.01100	<0.003	<0.0005	<0.00005	<0.0001	0.00400	0.004	0.0080
MW19-17	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.246	-	-	-	-	-	-	-	-
MW19-17	05-May-2020	0.087	<0.001	0.002	0.14	<0.001	0.09	0.000049	<0.001	<0.0009	0.0018	<0.1	0.0006	<0.005	0.008	<0.003	<0.0005	<0.0001	<0.0001	0.004	-	0.007
MW19-18	03-Apr-2019	0.0100	<0.001	<0.001	0.0700	<0.001	0.010	0.000035	<0.001	0.00100	0.00140	<0.1	<0.0005	0.183	0.00800	<0.003	0.0009	<0.00005	<0.0001	0.00100	<0.001	0.0060
MW19-18	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.011	-	-	-	-	-	-	-	-
MW19-18	05-May-2020	3.37	<0.001	0.004	0.95	0.001	0.01	0.00321	-	0.0144	0.0210	<0.1	0.0288	<0.005	<0.001	0.014	0.0037	<0.0001	<0.0001	0.003	-	0.086
MW19-19	25-Jun-2019	-	-	-	-	-	-	-	0.006	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-

Notes:

- Guidelines are based on Alberta Environment and Parks Alberta Tier 1 Soil and Groundwater Remediation Guidelines - Residential/Parkland (AEP 2019).
- ng - no guideline
- = No applicable guideline or concentration less than detection.
- = Exceeds applicable guideline.

- = Equal to or below applicable guideline.
- Cadmium, copper, lead and nickel SEQG dependant on hardness concentration (AEP 2019).
- data not available and/or analyzed
- View analytical reports for more comprehensive results.

Table I-3.4 Bow River Water Quality Results - Total Metals

GENERAL		TOTAL METALS																					
Location	Sample Date (dd-mmm-yyyy)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Total Chromium	Cobalt	Copper	Iron	Lead	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Uranium	Vanadium	Zinc	
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
GUIDELINES																							
Alberta Environmental Quality Guidelines for Alberta Surface Waters		0.1	ng	0.005	ng	ng	1.5	Calc	0.0089	Calc	0.007	0.3	Calc	ng	0.073	Calc	ng	0.00025	0.0008	0.00015	ng	0.03	
SURFACE WATER																							
SW19-01	05-Apr-2019	<0.004	<0.001	<0.001	<0.05	<0.001	<0.01	<0.000016	<0.001	<0.0009	<0.0008	<0.1	<0.0005	<0.005	0.001	<0.003	0.0007	<0.00005	<0.0001	<0.001	-	<0.005	
SW19-01	20-May-202	0.008	<0.001	<0.001	<0.05	<0.001	<0.01	<0.000016	<0.001	<0.0009	<0.0008	<0.1	<0.0005	<0.005	<0.001	<0.003	0.006	<0.0001	<0.0001	<0.001	-	<0.005	
SW19-02	25-Jun-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-	
SW19-02	05-May-2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
SW19-02A	06-Dec-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-	
SW19-03A	06-Dec-2019	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.005	-	-	-	-	-	-	-	-	

Notes:

- Guidelines are based on Alberta Environment and Parks Environmental Quality Guidelines for Alberta Surface Waters (AEP 2018).
- ng - no guideline
- = No applicable guideline or concentration less than detection.
- = Exceeds applicable guideline.
- = Equal to or below applicable guideline.
- Cadmium, copper, lead, and nickel SEQG dependant on hardness concentration (AEP 2019).
- data not available and/or analyzed
- View analytical reports for more comprehensive results.

Table I-3.5 Water Quality Results - QA/QC

Sample Location	Sample Date	Laboratory	Laboratory Reference No.	pH	Electrical Conductivity	Total Dissolved Solids	Total Alkalinity	Bicarbonate - HCO ₃	Carbonate - CO ₃	Hardness	Nitrate (as N)	Nitrite (as N)	Calcium	Sodium	Magnesium	Potassium	Chloride	Sulphate	Fluoride
					µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
April 2019 Sampling Event																			
MW19-06A	Reported Detection Limit			-	5	0.6	5	5	5	1	0.02	0.01	0.3	0.6	0.20	0.6	1	1	0.01
	2019-04-05	AGAT	117532	8.1	936	487	212	258	<5	373	1.24	<0.01	88.2	35.5	37.2	3.1	118	73	0.13
	2019-04-05	AGAT	117535	8.18	937	492	212	258	<5	379	1.2	<0.01	90.7	36.2	37	3.2	120	73	0.17
	Relative Percent Difference %			0.98	0.11	1.02	0.00	0.00	-	1.60	3.28	-	2.79	1.95	0.54	3.17	1.68	0.00	26.67
	Absolute Difference			0.08	1.00	5.00	0.00	0.00	-	6.00	0.04	-	2.50	0.70	0.20	0.10	2.00	0.00	0.04
June 2019 Sampling Event																			
MW19-06B	Reported Detection Limit			-	5	0.6	5	5	5	1	0.02	0.01	0.3	0.6	0.2	0.6	1	1	0.01
	2019-06-25	AGAT	306094	8.00	461	250	169	207	<5	202	0.23	<0.01	51.9	10.9	17.5	1.8	22	43	0.18
	2019-06-25	AGAT	306105	8.00	460	247	168	205	<5	199	0.25	<0.01	51.1	10.8	17.3	1.7	22	42	0.18
	Relative Percent Difference %			0.00	0.22	1.21	0.59	0.97	-	1.50	8.33	-	1.55	0.92	1.15	5.71	0.00	2.35	0.00
	Absolute Difference			0.00	1.00	3.00	1.00	2.00	-	3.00	0.02	-	0.80	0.10	0.20	0.10	0.00	1.00	0.00
May 2020 Sampling Event																			
MW19-08	Reported Detection Limit			-	5	0.6	5	5	5	1	0.02	0.01	0.3	0.6	0.2	0.6	1	1	0.01
	2020-05-04	AGAT		8.02	612	301	-	-	-	200	1.11	-	-	-	-	-	-	-	-
	2020-05-04	AGAT		8.18	611	314	-	-	-	240	1.06	-	-	-	-	-	-	-	-
	Relative Percent Difference %			1.98	0.16	4.23	-	-	-	18.18	4.61	-	-	-	-	-	-	-	-
	Absolute Difference			0.16	1.00	13.00	-	-	-	40.00	0.05	-	-	-	-	-	-	-	-
MW19-12	Reported Detection Limit			-	5	0.6	5	5	5	1	0.02	0.01	0.3	0.6	0.2	0.6	1	1	0.01
	2020-05-05	AGAT		8.04	1387	675	-	-	-	333	6.01	-	-	-	-	-	-	-	-
	2020-05-05	AGAT		8.09	1393	676	-	-	-	308	5.94	-	-	-	-	-	-	-	-
	Relative Percent Difference %			0.62	0.43	0.15	-	-	-	7.80	1.17	-	-	-	-	-	-	-	-
	Absolute Difference			0.05	6.00	1.00	-	-	-	25.00	0.07	-	-	-	-	-	-	-	-

- Notes:
1. - No results or no value
 2. **BOLD** highlights the applicable Zeiner Criteria
 3. = Exceeds Zeiner Criteria for RPD or AD as bolded.

I-4 SUMMARY AND RECOMMENDATIONS

The hydrogeological site investigation in support of the Bowness Flood Control Barriers project began in January 2019 with the drilling, installation, and hydraulic testing of 25 monitoring wells and one pumping well, and concluded in October 2019 with the geophysical survey conducted by Tetra Tech. Groundwater and surface water level, and water quality monitoring has been ongoing since the end of the site investigation. The results of the site investigation and the ongoing monitoring program were used to inform the development of a 3D conceptual hydrogeological model (CHM) for the Project area. The CHM and monitoring data were used to construct and calibrate a 3D groundwater flow model to assess the impacts of groundwater inundation associated with Bow River flood events and various flood mitigation options for Bowness area.

To further refine the Bowness CHM and assessment of flood mitigation options, KCB recommends the following field activities:

1. Continue monitoring groundwater levels within selected wells in the monitoring network;
2. Continue sampling of the groundwater at select monitoring wells, as well as the Bow River; and
3. Undertake further hydraulic testing at the following monitoring wells: MW19-01, -02, -03A, -03A, -04, -06A, -06D, -07, -08, -09, -10, -11, and MW19-18. This testing should be undertaken when static water levels are at, or near seasonal highs to obtain best results. Testing methods should include slug and constant-rate testing.

I-5 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. (KCB). The report has been prepared for the exclusive use of The City of Calgary (Client) for the specific application to the Bowness Flood Control Barriers project and it may not be relied upon by any other party without KCB's written consent. KCB has prepared this report in a manner consistent with the level of care, skill, and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

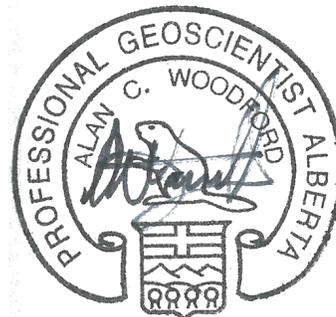
- The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
- The observations, findings, and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
- KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

KLOHN CRIPPEN BERGER LTD.



Brendan Gibbs, M.Sc., P.Geo.
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BG:AW:ap



18 May. 2021

Alan Woodford, M.Sc., P.Geo.
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PERMIT TO PRACTICE KLOHN CRIPPEN BERGER LTD.	
RM SIGNATURE:	
RM APEGA ID #:	224441
DATE:	18 May. 2021
PERMIT NUMBER: P009196	
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)	

I-6 REFERENCES

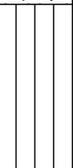
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APPENDIX I1

Investigation Borehole Logs

BOREHOLE LOG MW19-01

Su - kPa				
20	60	100	140	180
VANE PEAK	◆	FIELD	■	LAB
REMOULD	◇		□	▲ UC/2
				△ P.PEN
★ % FINES		● SPT N		
W _p %	○	W%	○	W _L %
x	-	o	-	x
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 17/01/2019 FINISHED: 17/01/2019	INSTRUMENT	DETAILS
					DRILL METHOD: Sonic		
					GROUND ELEV. (m): 1070.37		
					COORDINATES (m): N 5662415.063 E -13912.894		
DESCRIPTION OF MATERIALS							
1		Grab	G1	 0.60 1069.77	TOPSOIL		
				 1.70 1068.67	SILT (ML) sandy, low plasticity, brown, frozen		
2		Grab	G2	 4.10 1066.27	GRAVEL (GW) fine to coarse grained, sandy, trace cobbles (up to 110 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, brown, moist	*	
3					From 3.4 m: wet		
4				 6.10 1064.27	CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage		
5							
6				 7.90 1062.47	SILTSTONE blue grey, slightly weathered, extremely weak		
7		Grab	G3		From 6.7 m: weak		
8					Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 4.6 m to 6.1 m. Filter pack from 4.3 to 6.1 m Bentonite Plug 6.1 to 7.9 m		
9							
10							

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: Bow River Pathway, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 1	

BOREHOLE LOG MW19-02

Su - kPa				
20	60	100	140	180
VANE PEAK	FIELD	LAB	▲ UC/2	
REMOULD	◆	■	▲ P.PEN	
★ % FINES		● SPT N		
W _p %	W%	W _L %		
x	o	x		
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 29/03/2019	FINISHED: 29/03/2019	INSTRUMENT	DETAILS
					DRILL METHOD: Sonic			
					GROUND ELEV. (m): 1070.06			
					COORDINATES (m): N 5662288.698 E -13547.753			
DESCRIPTION OF MATERIALS								
				0.20	TOPSOIL			
1	12/9/6	Grab	G1	1069.86	CLAY (CL)			
					silty, some sand, low plastic, stiff, light brown, moist, rootlets in upper 0.3 m			
2	SPT	SPT1	SPT1	1065.16	From 1.5 m: very stiff, sandy, some clay		o	x x
							●	★
3	8/6/12	SPT	SPT2	1065.16	From 2.7 m: trace gravel			
					Pieces of broken gravel in split spoon sampler		●	
4				4.30	GRAVEL (GW)			
					fine to coarse grained, sandy, trace cobbles (up to 80 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, grey brown, wet			
5		Grab	G2	4.90	CORE LOSS			
6				6.10	GRAVEL (GW)			
					fine to coarse grained, sandy, trace cobbles (up to 80 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, grey brown, wet			
7				6.70	SANDSTONE			
					completely weathered, weak, layers of medium to weak sandstone			
8				7.90	SILTSTONE			
					dark brown, weak			
9				9.10	Borehole backfilled with sand and bentonite.			
					60 mm OD monitoring well installed with screen from 4.3 m to 6.7 m. Filter pack from 4.0 to 6.8 m Bentonite Plug 6.8 to 9.1 m			
10								

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ KCBLL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 20 Bow Village Cres NW, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 1	

BOREHOLE LOG MW19-03

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMOVED	◆	■	▲ UC/2
	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 25/03/2019 FINISHED: 25/03/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1067.85 COORDINATES (m): N 5662325.579 E -13435.829		
1					SILT (ML) sandy, trace gravel, trace clay, low plasticity, brown, frozen From 0.6 m: soft to firm, moist		
2	12/12/9	SPT	SPT1	1.50 1066.35	CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage Broken pieces of gravel in split spoon sampler		●
5		Grab	G1	4.60 1063.25	GRAVEL (GW) fine to coarse grained, some sand, trace cobbles (up to 80 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, grey brown, wet		○
6		Grab	G2	5.60 1062.25 5.80 1062.05 6.10 1061.75	SILTSTONE brown, slightly weathered, weak SILTSTONE blue, fresh, weak Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 4.0 m to 5.5 m. Filter pack from 3.7 to 5.6 m Bentonite Plug 5.6 to 6.1 m		
7							
8							
9							
10							

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 7220 Bow Cres NW, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 1

BOREHOLE LOG MW19-03A

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS	Su - kPa				
							20	60	100	140	180
					STARTED: 25/03/2019 FINISHED: 25/03/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1069.02 COORDINATES (m): N 5662220.312 E -13449.899						
					DESCRIPTION OF MATERIALS						
1					SILT (ML) sandy, some gravel, trace clay, low plasticity, brown, frozen From 0.6 m: soft to firm, moist						
	2/2/2	SPT	SPT1	1.20	1067.82	SILT (ML) sandy, trace clay, low plasticity, soft, brown, moist					
2		Grab	G1								
				2.40	1066.62	CORE LOSS					
3	6/16/19	SPT	SPT2	3.00	1066.02	GRAVEL (GW) fine to coarse grained, sandy, trace cobbles (up to 100 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, brown, wet					
		Grab	G2								
4				3.80	1065.22	CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage					
5											
6				6.10	1062.92	GRAVEL (GW) fine to coarse grained, sandy, trace cobbles (up to 100 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, brown, wet					
		Grab	G3	6.40	1062.62	CLAY (CL) silty, sandy, trace gravel, low plasticity, very stiff, brown, dry (CLAY TILL)					
7				7.60	1061.42	SILTSTONE					
				7.90	1061.12	grey, fresh, weak Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 3.4 m to 6.4 m. Filter pack from 3.0 to 6.7 m Bentonite Plug 6.7 to 7.9 m					
8											
9											
10											

Su - kPa

20	60	100	140	180
----	----	-----	-----	-----

VANE PEAK FIELD LAB
 REMOLD ◆ ▲ UC/2
 ◇ □ ▲ P.PEN
 ★ % FINES ● SPT N

W _p %	W%	W _L %		
x	o	x	x	x
20	40	60	80	

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ KCBLL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 7220 Bow Cres NW, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 1	

BOREHOLE LOG MW19-04

Su - kPa				
20	60	100	140	180
VANE PEAK	◆	FIELD	■	LAB
REMOULD	◇		□	▲ UC/2
				△ P.PEN
★ % FINES		● SPT N		
W _p %	W%	W _L %		
x	o	x		
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 26/03/2019 FINISHED: 26/03/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1067.35 COORDINATES (m): N 5661771.014 E -13191.319		
					DESCRIPTION OF MATERIALS		
0.30					TOPSOIL		
1067.05		Grab	G1		SAND (SM) and SILT (ML) trace gravel, trace clay, fine grained, non-plastic, brown, frozen		
1.5	3/4/3	SPT	SPT1		From 1.5 m: loose, moist		● ★
2.30		Grab	G2		SAND and GRAVEL (GW) fine to coarse grained, trace cobbles (up to 80 mm in diameter), trace silt, trace clay, well graded, dense, rounded to angular, brown, moist		★
3.0	9/15/17	SPT	SPT2		From 3.0 m: wet		●
4.10		Grab	G3		SAND (SM) fine to coarse grained, some gravel (fine grained), some silt, trace clay, well graded, dense, black, dry		○ ★
4.30					GRAVEL (GW) fine to coarse grained, sandy (fine to coarse grained), well graded, dense, angular, blue-grey and orange mottled, dry (COMPLETELY WEATHERED BEDROCK)		
6.10					SILTSTONE grey with interbedded dark grey layers, fresh, weak		
7.90					Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 2.4 m to 4.0 m. Filter pack from 2.1 to 4.2 m Bentonite Plug 4.2 to 7.9 m		

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01
PROJECT: Bowness Flood Barrier
LOCATION: 6844 Bow Cres NW, Calgary
LOGGED BY: AS CHECKED BY: APB
SHEET 1 OF 1

BOREHOLE LOG MW19-05

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMOULD	◆	■	▲ UC/2
	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

STARTED: 17/01/2019 **FINISHED:** 17/01/2019

DRILL METHOD: Sonic

GROUND ELEV. (m): 1067.57

COORDINATES (m): N 5661633.522 E -13096.818

INSTRUMENT
DETAILS

DESCRIPTION OF MATERIALS

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	Su - kPa
0.30					TOPSOIL			
1067.27		Grab	G1		GRAVEL (GW) fine to coarse grained, sandy, trace cobbles (up to 120 mm in diameter), trace silt, trace clay, well graded, rounded to angular, brown, moist			
1.80					From 1.5 m: wet			
1065.77					CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage			
3.00		SPT	SPT1		SILT (ML) sandy, trace gravel, trace clay, low plasticity, stiff, dark blue, moist to wet			
		Grab	G2					
4.30		Grab	G3		SILTSTONE blue grey, slightly weathered, weak			
5.80					Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 1.8 m to 3.0 m. Filter pack from 1.5 to 3.0 m Bentonite Plug 3.0 to 5.8 m			
1061.77								

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6764 Bow Cres NW, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 1

BOREHOLE LOG MW19-06

Su - kPa

20 60 100 140 180

VANE FIELD LAB
 PEAK ◆ ■ ▲ UC/2
 REMOLD ◇ □ △ P.PEN

★ % FINES ● SPT N

W_p% W% W_L%

x - - - - o - - - - x

20 40 60 80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	Su - kPa	W _p %	W%	W _L %
					STARTED: 15/01/2019 FINISHED: 15/01/2019						
					DRILL METHOD: Sonic						
					GROUND ELEV. (m): 1068.80						
					COORDINATES (m): N 5661522.054 E -12944.455						
					DESCRIPTION OF MATERIALS						
0.30					TOPSOIL						
1068.50					Coring through cobbles/boulders						
0.60					CORE LOSS						
1068.20					Sampler unable to retrieve core due to cobble/boulder blockage						
0.90					Coring through cobbles/boulders						
1067.90											
1.50					GRAVEL (GW)						
1067.30		Grab	G1		fine to coarse grained, sandy, trace cobbles (up to 120 mm in diameter), trace silt, trace clay, well graded, rounded to angular, brown, wet						
2.60					CORE LOSS						
1066.20					Sampler unable to retrieve core due to cobble/boulder blockage						
3.00					GRAVEL (GW)						
1065.80					fine to coarse, sandy, trace cobbles (up to 80 mm in diameter), trace silt, trace clay, well graded, rounded to angular, brown, wet						
5.20					At 5.1 m: coring through cobbles						
1063.60		Grab	G3		CLAY (CL)						
5.60					some silt, some sand, trace gravel, low plasticity, stiff to very stiff, brown, dry, blocky (CLAY TILL)						
1063.20		Grab	G4		CLAY (CL)						
					some silt, trace sand, gravelly, low plasticity, hard, blue grey orange mottled, dry, blocky (CLAY TILL)						
					From 6.1 m: moist						
8.50					CLAY (CL)						
1060.30		Grab	G5		silty, trace sand, trace gravel, low plasticity, hard, blue grey, moist (CLAY TILL)						
9.8 to 10.1					clayey gravel						

Continued Next Page

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6712 Bow Cres NW (Playground)

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 2



Klohn Crippen Berger

BOREHOLE LOG MW19-06

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMOVED	◆	■	▲ UC/2
	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
×	○	×	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 15/01/2019 FINISHED: 15/01/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1068.80 COORDINATES (m): N 5661522.054 E -12944.455		
11							
12		Grab	G6		11.40 1057.40 SILTSTONE blue grey, slightly weathered, extremely weak		
10/42	>50, for 0.8 SPT		SPT1		12.50 1056.30 Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 3.7 m to 5.2 m. Filter pack from 3.4 to 5.2 m Bentonite Plug 5.2 to 12.5 m		●
13							
14							
15							
16							
17							
18							
19							
20							

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 6712 Bow Cres NW (Playground)	
LOGGED BY: AS	CHECKED BY: APB
SHEET 2 OF 2	

BOREHOLE LOG MW19-06A

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMO	◆	■	▲ UC/2
★ % FINES	◇	□	△ P.PEN
			● SPT N
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 15/01/2019 FINISHED: 15/01/2019	INSTRUMENT	DETAILS
					DRILL METHOD: Sonic		
					GROUND ELEV. (m): 1068.93		
					COORDINATES (m): N 5661476.086 E -12976.596		
DESCRIPTION OF MATERIALS							

1		Grab	G1		TOPSOIL 0.50 1068.43 GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 130 mm in diameter), trace clay, well graded, rounded to angular, brown, wet		
2		Grab	G2				
3					From 3.0 m: wet		
4		Grab	G3			○★	
5		Grab	G4				
6							
7					6.10 1062.83 CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage		
8							
9					9.10 1059.83 GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 160 mm in diameter), trace clay, well graded, rounded to angular, brown, wet		
10			G5				

Continued Next Page

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6712 Bow Cres NW (Playground)

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 2

BOREHOLE LOG MW19-06A

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 15/01/2019 FINISHED: 15/01/2019		INSTRUMENT	DETAILS	Su - kPa					
					DRILL METHOD: Sonic				20	60	100	140	180	
					GROUND ELEV. (m): 1068.93				VANE	FIELD	LAB			
					COORDINATES (m): N 5661476.086 E -12976.596				PEAK	◆	■	▲	UC/2	
					DESCRIPTION OF MATERIALS				REMO	◇	□	△	P.PEN	
										★	% FINES	●	SPT N	
									W _p %	W%	W _L %			
									x - - - - x	o - - - - o	x - - - - x			
									20	40	60	80		
10.20		Grab		●●●●	1058.73	CORE LOSS								
12.20				▨	1056.73	CLAY (CL) silty, trace sand, trace gravel, low plasticity, hard, blue grey, moist (CLAY TILL)								
13.00		Grab	G6											
14.60				▨	1054.33	SILTSTONE blue grey, slightly weathered, extremely weak								
15.20		Grab	G7		1053.73	Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 7.6 m to 10.7 m. Filter pack from 7.3 to 10.7 m Bentonite Plug 10.7 to 15.2 m								

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6712 Bow Cres NW (Playground)

LOGGED BY: AS

CHECKED BY: APB

SHEET 2 OF 2

BOREHOLE LOG MW19-06C

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMO	◆	■	▲ UC/2
REMO	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - -	o - - - - -	x - - - - -	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
				TOPSOIL			
1				0.50 1068.42	GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 80 mm in diameter), trace clay, well graded, rounded to angular, grey, dry		
2							
3							
4							
5					From 5.0 m: wet		
6				6.10 1062.82	Borehole backfilled with sand and bentonite. 60 mm monitoring well installed with screen from 2.7 m to 5.8 m. Filter pack from 2.4 to 5.9 m Bentonite Plug 5.9 to 6.1 m		
7							
8							
9							
10							

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6712 Bow Cres NW (Playground)

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 1

BOREHOLE LOG MW19-06D

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	STARTED: 04/04/2019 FINISHED: 04/04/2019		INSTRUMENT	DETAILS	Su - kPa					
					DRILL METHOD: Sonic				20	60	100	140	180	
					GROUND ELEV. (m): 1068.95				VANE	FIELD	LAB			
					COORDINATES (m): N 5661479.539 E -12963.498				PEAK	◆	■	▲	UC/2	
					DESCRIPTION OF MATERIALS				REMO	◇	□	△	P.PEN	
									★ % FINES ● SPT N					
									W _p %	W%	W _L %			
									x - - - - x	o - - - - o	x - - - - x			
									20	40	60	80		
10.40				●										
1058.55				●	SAND (SM) fine to coarse grained, silty, some clay, trace gravel, well graded, blue grey, wet									
11.00				●										
1057.95				●	CLAY (CL) silty, trace sand, trace gravel, low plasticity, hard, blue grey, dry to moist (CLAY TILL)									
12.20				●										
1056.75				●	Borehole backfilled with sand and bentonite. 150 mm ID (167 mm OD) monitoring well installed with screen from 4.9 m to 11.0 m. Filter pack from 4.6 to 11.1 m Bentonite Plug 11.1 to 12.2 m									
13														
14														
15														
16														
17														
18														
19														
20														

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6712 Bow Cres NW (Playground)

LOGGED BY: AS

CHECKED BY: APB

SHEET 2 OF 2

BOREHOLE LOG MW19-07

Su - kPa

20 60 100 140 180

VANE PEAK FIELD LAB
 REMOLD ◆ ▲ UC/2
 ★ % FINES ● SPT N
 W_p% W% W_L%
 x - - - - o - - - - x
 20 40 60 80

STARTED: 27/03/2019 FINISHED: 27/03/2019
DRILL METHOD: Sonic
GROUND ELEV. (m): 1068.93
COORDINATES (m): N 5661299.25 E -12770.841
DESCRIPTION OF MATERIALS

INSTRUMENT
DETAILS

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	Su - kPa
1					GRAVEL (GW) fine to coarse grained, some sand, trace silt, trace cobbles (up to 200 mm in diameter), trace clay, well graded, compact, rounded to angular, grey, dry, some rootlets			
					0.80 1068.13 CORE LOSS			
2	11/11/10	SPT	SPT1		1.50 1067.43 GRAVEL (GW) fine to coarse grained, some sand, trace silt, trace cobbles (up to 200 mm in diameter), trace clay, well graded, compact, rounded to angular, grey, dry		●	
		Grab	G1				○*	
3								
4		Grab	G2		At 4.0 m: clayey layer			
					At 4.3 m: clayey layer			
5					4.60 1064.33 CORE LOSS			
6					6.10 1062.83 GRAVEL (GW) fine to coarse grained, some sand, trace silt, trace cobbles (up to 200 mm in diameter), trace clay, well graded, compact, rounded to angular, grey, wet			
					6.40 1062.53 SAND (SM) medium to fine grained, trace gravel, trace silt, trace clay, well graded, blue grey, moist to wet, rapid dilation noted			
7		Grab	G3				○*	
8		Grab	G4		8.20 1060.73 CLAY (CL) some sand (fine to coarse grained), trace gravel, low plasticity, very stiff, blue grey, dry to moist (CLAY TILL)		△	
9								
10								

Continued Next Page

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6527 Bow Cres NW, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 2



Klohn Crippen Berger

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20

BOREHOLE LOG MW19-08

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMOULD	◆	■	▲ UC/2
	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

STARTED: 28/03/2019 **FINISHED:** 28/03/2019

DRILL METHOD: Sonic

GROUND ELEV. (m): 1066.48

COORDINATES (m): N 5660993.349 E -12346.332

DESCRIPTION OF MATERIALS

INSTRUMENT
DETAILS

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	Su - kPa
0.30				[Symbol]	TOPSOIL			
1066.18				[Symbol]	SILT (ML) clayey, some sand, low plasticity, soft, brown, moist, trace rootlets From 0.6 m: rootlets no longer noted			
1	3/2/1	SPT	SPT1	[Symbol]			●	
2		Grab	G1	[Symbol]			○ x x	★
3				[Symbol]	3.00			
1063.48		SPT	SPT2	[Symbol]	GRAVEL (GW) fine to coarse grained, some sand, trace clay, trace cobbles (up to 100 mm in diameter), trace silt, well graded, dense, rounded to angular, brown, wet			>>●
4	23/62/44			[Symbol]				
5		Grab	G2	[Symbol]			★	
5.50				[Symbol]	5.50			
1060.98				[Symbol]	SILTSTONE brown, completely weathered, very weak			
5.80				[Symbol]	SILTSTONE blue, weak			
1060.68				[Symbol]				
6.10				[Symbol]	Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 4.0 m to 5.5 m. Filter pack from 3.4 to 5.6 m Bentonite Plug 5.6 to 6.1 m			
1060.38				[Symbol]				
6				[Symbol]				
7				[Symbol]				
8				[Symbol]				
9				[Symbol]				
10				[Symbol]				

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 6211 Bow Cres NW, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 1



Klohn Crippen Berger

BOREHOLE LOG MW19-09

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS	Su - kPa			
							20	60	100	140
					STARTED: 27/03/2019 FINISHED: 27/03/2019					
					DRILL METHOD: Sonic					
					GROUND ELEV. (m): 1065.18					
					COORDINATES (m): N 5660742.693 E -11714.356					
					DESCRIPTION OF MATERIALS					
1				0.20 TOPSOIL						
				1064.98 CLAY (CI) silty, some sand, trace gravel, intermediate plasticity, brown to black, frozen becoming moist (FILL)						
2	7/5/4	SPT	SPT1	1.80 ORGANIC CLAY (OL) silty, trace sand, low plastic, firm, dark brown to black, organic odour, moist, some rootlets (BURIED TOPSOIL)						
		Grab	G1	2.10 1063.08						
3				2.70 SILT (ML) sandy, trace clay, low plasticity, firm, brown, moist						
				1062.48 CORE LOSS						
	7/5/7	SPT	SPT2	3.00 GRAVEL (GW) fine to coarse grained, sandy, clayey, trace cobbles (up to 100 mm in diameter), trace silt, well graded, compact, rounded to angular, brown, wet						
		Grab	G2	1062.18	From 3.4 m: trace clay					
4				4.30 CORE LOSS						
5				1060.88						
6				6.10 GRAVEL (GW) fine to coarse grained, sandy, trace cobbles (up to 100 mm in diameter), trace silt, trace clay, well graded, compact, rounded to angular, brown, wet						
		Grab	G3	1059.08 6.40 1058.78	CLAY (CI) silty, some sand, trace gravel, intermediate plasticity, very stiff, blue grey, moist (CLAY TILL)					
7				7.60 SILTSTONE dark grey, weathered, weak						
				1057.58						
8				7.90 SILTSTONE light grey, weak						
				1057.28						
9				9.10 Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 3.4 m to 6.4 m. Filter pack from 3.1 to 6.5 m Bentonite Plug 6.5 to 9.1 m						
				1056.08						

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 12 Bowbank Cres NW, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 1

BOREHOLE LOG MW19-10

Su - kPa				
20	60	100	140	180
VANE PEAK	◆	FIELD	■	LAB
REMOLD	◇		□	▲ UC/2
				△ P.PEN
★	% FINES		●	SPT N
W _p %	W%	W _L %		
x	-	o	-	x
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 16/01/2019 FINISHED: 16/01/2019		
					DRILL METHOD: Sonic		
					GROUND ELEV. (m): 1063.95		
					COORDINATES (m): N 5660590.556 E -11912.006		
1		Grab	G1	0.10 1063.85	TOPSOIL SAND (SM) fine grained, silty, trace gravel (up to 70 mm in diameter), well graded, compact, brown, moist, some rootlets		
2	11/18/15	SPT	SPT1	1.80	From 1.5 m: wet		●
		Grab	G2	1062.15	GRAVEL (GW) fine to coarse grained, trace cobble fragments (up to 90 mm in diameter), sandy, trace cobbles, trace silt, trace clay, well graded, dense, rounded to angular, grey, moist		
3	12/20/21	SPT	SPT2				●
4		Grab	G3		From 3.7m: some clay		★
5				4.40 1059.55	CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage Groundwater level at 4.9 mbgs on January 18, 2019		
6				6.10 1057.85	GRAVEL (GW) fine to coarse grained, trace cobbles (up to 90 mm in diameter), sandy, trace cobbles, some clay, trace silt, well graded, dense, rounded to angular, grey, moist		
7				6.70 1057.25	CLAY (CL) some sand, trace gravel, low plasticity, very stiff to hard, blue grey, moist, blocky (CLAY TILL)		
8		Grab	G4				▲
9	11/33/4	SPT	SPT3				●
10							

Continued Next Page

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 5859 Bow Cres NW, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 2	

BOREHOLE LOG MW19-11

Su - kPa				
20	60	100	140	180
VANE PEAK	FIELD	LAB	▲ UC/2	
REMOULD	◆	■	▲ P.PEN	
★ % FINES	● SPT N			
W _p %	W%	W _L %		
x - - - - x	o - - - - o	x - - - - x		
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 16/01/2019 FINISHED: 16/01/2019		
					DRILL METHOD: Sonic		
					GROUND ELEV. (m): 1063.26		
					COORDINATES (m): N 5660430.017 E -12025.184		
					DESCRIPTION OF MATERIALS		
0.30					TOPSOIL		
1062.96					CLAY (CL)		
0.60					some gravel, some sand, low plasticity, brown, frozen, pieces of metal noted throughout (FILL)		
1062.66					SAND (SM)		
1		Grab	G1		fine grained, silty, well graded, loose, dark brown, moist, trace rootlets		
	2/2/4	SPT	SPT1		From 1.5 m: wet		●
2					CORE LOSS		
2.10					GRAVEL (GW)		
1061.16					fine to coarse grained, trace cobbles, sandy, trace silt, trace clay, well graded, compact, rounded to angular, brown, wet		
2.40					CORE LOSS		
1060.86					GRAVEL (GW)		
3	12/9/8	SPT	SPT2		fine to coarse grained, trace cobbles, sandy, trace silt, trace clay, well graded, compact, rounded to angular, brown, wet		●
2.90					CORE LOSS		
1060.36					Sampler unable to retrieve core due to cobble/boulder blockage		
4							
5		Grab	G2		CLAY (CL)		▲
4.60					trace sand, trace gravel, low plasticity, very stiff to hard, blue grey, dry to moist (CLAY TILL)		
1058.66							
6	24/18/10	SPT	SPT3				x - - - x ● ★
7							
8					From 8.2 m: wet		
8.50					SILTSTONE		
1054.76					blue grey, slightly weathered, weak		
9							
9.10					Borehole backfilled with sand and bentonite.		
1054.16					60 mm OD monitoring well installed with screen from 3.0 m to 4.6 m.		
10					Filter pack from 2.7 to 4.6 m		
					Bentonite Plug 4.6 to 9.1 m		

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ KCBLL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: Hextail Park, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 1	

BOREHOLE LOG MW19-12

Su - kPa

20 60 100 140 180

VANE PEAK FIELD LAB
 REMOLD ◆ ■ ▲ UC/2
 ★ % FINES ● SPT N
 W_p% W% W_L%
 x - - - - o - - - - x
 20 40 60 80

STARTED: 29/03/2019 FINISHED: 29/03/2019

DRILL METHOD: Sonic

GROUND ELEV. (m): 1063.71

COORDINATES (m): N 5660346.724 E -12178.043

DESCRIPTION OF MATERIALS

INSTRUMENT
DETAILS

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	Su - kPa
0.00					TOPSOIL			
0.30					1063.41 GRAVEL (GW) fine to coarse grained, clayey, some sand, trace silt, trace clay, well graded, compact, rounded to angular, dark brown, moist to wet (POSSIBLE FILL)			
0.90					1062.81 GRAVEL (GW) fine to coarse grained, sandy, trace silt, trace clay, well graded, compact, rounded to angular, brown, dry to moist			
1.50		Grab	G1		1062.21 SILT (ML) sandy, trace clay, low plasticity, firm, dark brown, moist			
1.80					1061.91 CORE LOSS			
3.00					1060.71 SILT (ML) sandy, trace clay, low plasticity, firm, dark brown, moist			
3.40					1060.31 GRAVEL (GW) fine to coarse grained, trace cobbles (up to 75 mm in diameter), sandy, trace silt, trace clay, well graded, compact, rounded to angular, dark grey to brown, wet			
4.40		Grab	G2					
4.90		Grab	G3		1059.31 CLAY (CL) silty, trace sand, intermediate plasticity, stiff, blue brown, moist			
4.90					1058.81 CORE LOSS			
6.10					1057.61 CLAY (CL) trace sand, trace gravel, trace cobbles, low plasticity, very stiff to hard, blue grey, dry to moist (CLAY TILL)			
9.40		Grab	G4		1054.31 SILTSTONE dark grey, weathered, very weak			

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BOREHOLE LOG_INSTRUMENT SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: River Valley School, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 2

BOREHOLE LOG MW19-12

Su - kPa

20 60 100 140 180

VANE FIELD LAB
 PEAK ◆ ■ ▲ UC/2
 REMOLD ◇ □ △ P.PEN
 ★ % FINES ● SPT N
 W_p% W% W_L%
 x - - - - - o - - - - - x
 20 40 60 80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	
					STARTED: 29/03/2019 FINISHED: 29/03/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1063.71 COORDINATES (m): N 5660346.724 E -12178.043			
11				10.40 1053.31	SILTSTONE blue grey, weak			
12				11.30 1052.41	Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 3.7 m to 5.2 m. Filter pack from 3.4 to 5.3 m Bentonite Plug 5.3 to 11.3 m			
13								
14								
15								
16								
17								
18								
19								
20								

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: River Valley School, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 2 OF 2

BOREHOLE LOG MW19-13

Su - kPa

20 60 100 140 180

VANE PEAK	FIELD	LAB	
REMOVED	◆	■	▲ UC/2
	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x	o	x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 11/01/2019 FINISHED: 11/01/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1076.58 COORDINATES (m): N 5661700.96 E -14126.078		
1				TOPSOIL			
		Grab	G1	1.40 1075.18	CLAY (CL) silty, some sand, low plasticity, hard, light brown, dry, blocky		
2				2.10 1074.48	CORE LOSS		
3				3.00 1073.58 3.20 1073.38	CLAY (CL) silty, some sand, low plasticity, hard, light brown, dry, blocky		
4		Grab	G2	GRAVEL (GW)	fine to coarse grained, sandy, trace silt, trace clay, trace cobbles (up to 110 mm in diameter), well graded, rounded to angular, brown, moist At 4.1 m: coring through cobbles/boulders	★	
5					At 4.9 m: silty, wet		
		Grab	G3	5.60 1070.98	CLAY (CI) gravelly, trace sand, intermediate plasticity, stiff, brown, moist		
6		Grab	G4	6.10 1070.48	Borehole terminated at 6.1 m due to mechanical failure of drill rig Borehole backfilled with bentonite.		
7							
8							
9							
10							

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 7904 43 Ave NW (Bowness Community Association)

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 1

BOREHOLE LOG MW19-13A

Su - kPa				
20	60	100	140	180
VANE PEAK	◆	LAB	■	▲ UC/2
REMOLD	◇		□	△ P.PEN
★ % FINES		● SPT N		
W _p %	○	W%	○	W _L %
x	-	o	-	x
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 14/01/2019 FINISHED: 14/01/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1076.58 COORDINATES (m): N 5661700.96 E -14126.078		
1				[Symbol]	TOPSOIL At 1.1 m: cored through cobble/boulder (full diameter of sampler)		
2				[Symbol]	1.50 1075.08 CLAY (CL) silty, some sand, low plasticity, hard, light brown, dry, blocky		
3				[Symbol]	2.40 1074.18 CORE LOSS 2.70 1073.88 CLAY (CL) silty, some sand, low plasticity, hard, light brown, wet, blocky		
4				[Symbol]	3.40 1073.18 GRAVEL (GW) fine to coarse grained, sandy, trace silt, trace clay, trace cobbles (up to 110 mm in diameter), well graded, rounded to angular, brown, moist At 3.7 m: coring through cobbles		
5				[Symbol]	5.30 1071.28 CLAY (CI) gravelly, some sand, trace cobbles, intermediate plasticity, soft, brown, wet		
6				[Symbol]	5.50 1071.08 CORE LOSS 6.10 1070.48 CLAY (CI) gravelly, some sand, trace cobbles, intermediate plasticity, soft, brown, wet From 6.4 m: firm, moist		
7		Grab	G1	[Symbol]			
8		Grab	G2	[Symbol]	7.60 1068.98 SILTSTONE blue, slightly weathered, very weak		
9				[Symbol]	8.80 1067.78 Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 4.0 m to 5.5 m. Filter pack from 3.7 to 5.5 m Bentonite Plug 5.5 to 8.8 m		
10							

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 7904 43 Ave NW (Bowness Community Association)	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 1	

BOREHOLE LOG MW19-14

Su - kPa

20 60 100 140 180

VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMOLD	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x	o	x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
		Grab	G10	▨	-20.10 1055.24 SILTSTONE blue grey, highly weathered, extremely weak		
21					20.70 1054.64 Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 7.6 m to 9.1 m. Filter pack from 7.3 to 9.1 m Bentonite Plug 9.1 to 20.7 m		
22							
23							
24							
25							
26							
27							
28							
29							
30							

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 3803 69 Street NW, Calgary (Foothills United Church)

LOGGED BY: AS

CHECKED BY: APB

SHEET 3 OF 3



Klohn Crippen Berger

BOREHOLE LOG MW19-15

Su - kPa

20 60 100 140 180

VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMO	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

STARTED: 18/01/2019 **FINISHED:** 18/01/2019

DRILL METHOD: Sonic

GROUND ELEV. (m): 1079.04

COORDINATES (m): N 5660677.87 E -13527.335

DESCRIPTION OF MATERIALS

INSTRUMENT
DETAILS

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					TOPSOIL		
		Grab	G1	0.30 1078.74	CLAY (CL) sandy, trace gravel, low plastic, black, frozen (FILL)		
1				0.80 1078.24	CORE LOSS		
2							
3				3.00 1076.04	SILT (ML) sandy, trace clay, low plastic, compact, light brown, moist		
4		Grab	G2				
5				4.60 1074.44	CORE LOSS		
6				6.10 1072.94	CLAY (CI) some silt, trace sand, trace gravel, intermediate plasticity, firm to stiff, brown, moist		
7							
8		Grab	G3				
9		Grab	G4	8.20 1070.84	GRAVEL (GW) fine to coarse grained, sandy, trace cobbles (up to 100 mm in diameter), trace silt, trace clay, well graded, rounded to angular, grey, moist		★
10					From 9.8 m: wet		

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PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 3408 73 Street NW (Our Lady of Assumption School)

LOGGED BY: AS

CHECKED BY: APB

SHEET 1 OF 3



Klohn Crippen Berger

BOREHOLE LOG MW19-15

Su - kPa

20 60 100 140 180

VANE PEAK FIELD LAB
 REMOLD ◆ ◻ ▲ UC/2
 ★ % FINES ● SPT N
 W_p% W% W_L%
 x - - - - o - - - - x
 20 40 60 80

STARTED: 18/01/2019 **FINISHED:** 18/01/2019

DRILL METHOD: Sonic

GROUND ELEV. (m): 1079.04

COORDINATES (m): N 5660677.87 E -13527.335

DESCRIPTION OF MATERIALS

INSTRUMENT
DETAILS

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS	Su - kPa					
11.00		Grab	G5		At 10.1 m: coring through boulder or cobbles								
1068.04					CLAY (CL) trace sand, trace gravel, low to intermediate plasticity, stiff, brown, moist								
12.20					CLAY (CL) silty, high plasticity, firm to stiff, blue grey, moist								
1066.84													
14.00		Grab	G6										
15.80					SAND (SW) fine to coarse grained, trace cobble fragments, trace gravel, trace silt, trace clay, well graded, brown, moist								
1063.24													
16.80					CORE LOSS								
1062.24													
18.30					CLAY (CL) trace sand, trace gravel, low plasticity, hard, dark grey, dry to moist (CLAY TILL)								
1060.74													
19.80		Grab	G8										
1059.24					SILTSTONE								

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PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 3408 73 Street NW (Our Lady of Assumption School)

LOGGED BY: AS

CHECKED BY: APB

SHEET 2 OF 3



Klohn Crippen Berger

BOREHOLE LOG MW19-15

Su - kPa

20 60 100 140 180

VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMO	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 18/01/2019 FINISHED: 18/01/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1079.04 COORDINATES (m): N 5660677.87 E -13527.335		
					blue grey, slightly weathered, extremely weak 20.40 1058.64 Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 9.4 m to 11.0 m. Filter pack from 9.1 to 11.0 m Bentonite Plug 11.0 to 20.4 m		
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: 3408 73 Street NW (Our Lady of Assumption School)

LOGGED BY: AS

CHECKED BY: APB

SHEET 3 OF 3

BOREHOLE LOG MW19-15A

Su - kPa			
20	60	100	140 180
VANE PEAK	◆	LAB	▲ UC/2
REMOLD	◇		△ P.PEN
★ % FINES		● SPT N	
W _p %	○	W%	W _L %
x	-	o	-
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 02/04/2019 FINISHED: 02/04/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1079.05 COORDINATES (m): N 5660676.083 E -13527.551		
10.70				[Symbol: Cobble]	CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage		
10.70 - 10.85				[Symbol: Diagonal Lines]			
12.20				[Symbol: Diagonal Lines]	CLAY (CL) silty, high plasticity, firm to stiff, grey, moist		
12.20 - 1066.85				[Symbol: Diagonal Lines]			
15.80					From 15.5 mbgs: trace gravel		
15.80 - 1063.25				[Symbol: Dotted]	SAND (SW) fine to coarse grained, trace silt, trace clay, well graded, brown, moist		
16.50				[Symbol: Diagonal Lines]	CLAY (CI) some sand, some gravel, intermediate plasticity, very stiff, brown, moist		
16.50 - 1062.55				[Symbol: Diagonal Lines]			
17.70				[Symbol: Diagonal Lines]	CLAY (CL) trace sand, trace gravel, low plasticity, hard, blue grey, dry (CLAY TILL)		
17.70 - 1061.35				[Symbol: Diagonal Lines]			
18.90				[Symbol: Diagonal Lines]	SILTSTONE light grey, weak		
18.90 - 1060.15				[Symbol: Diagonal Lines]			

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BOREHOLE LOG - INST - SPT BOREHOLE LOGS CITY COORDS.GPJ KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 3408 73 Street NW (Our Lady of Assumption School)	
LOGGED BY: AS	CHECKED BY: APB
SHEET 2 OF 3	

BOREHOLE LOG MW19-16

Su - kPa			
20	60	100	140 180
VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMOLD	◇	□	△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x - - - - x	o - - - - o	x - - - - x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
				TOPSOIL			
1				0.50 1067.49	GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 100 mm in diameter), trace clay, well graded, rounded to angular, grey, dry to moist		
2		Grab	G1	2.40 1065.59	CORE LOSS drill shoe blocked by cobble/boulder		
3				3.00 1064.99	From 3.0 mbgs: wet		
4				3.70 1064.29	CLAY (CL) trace sand, trace gravel, trace cobbles, low plasticity, hard, blue grey, dry to moist (CLAY TILL)		
5		Grab	G2	5.20 1062.79	CORE LOSS		
6				6.10 1061.89	CLAY (CL) trace sand, trace gravel, trace cobbles, low plasticity, hard, blue grey, dry to moist (CLAY TILL)		
7							
8		Grab	G3				
9				9.10 1058.89	CORE LOSS Sampler unable to retrieve core due to cobble/boulder blockage		
10							

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BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ KCBIL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: Adjacent to 6355 31 Ave NW, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 2	

BOREHOLE LOG MW19-16

Su - kPa

20 60 100 140 180

VANE FIELD LAB
 PEAK ◆ ■ ▲ UC/2
 REMOLD ◇ □ △ P.PEN
 ★ % FINES ● SPT N
 W_p% W% W_L%
 x - - - - o - - - - x
 20 40 60 80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 01/04/2019 FINISHED: 01/04/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1067.99 COORDINATES (m): N 5660491.598 E -12527.179		
11				10.70 1057.29	CLAY (CL) trace sand, trace gravel, trace cobbles, low plasticity, hard, blue grey, dry to moist (CLAY TILL)		
12				12.20 1055.79	CLAY (CL) low plasticity, hard, blue grey, dry to moist (completely weathered bedrock)		
13				13.10 1054.89	SILTSTONE grey, weak		
14				13.70 1054.29	Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 2.1 to 3.7 m. Filter pack from 1.8 to 3.8 m Bentonite Plug 3.8 to 13.7 m		
15							
16							
17							
18							
19							
20							

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01

PROJECT: Bowness Flood Barrier

LOCATION: Adjacent to 6355 31 Ave NW, Calgary

LOGGED BY: AS

CHECKED BY: APB

SHEET 2 OF 2

BOREHOLE LOG MW19-17

Su - kPa			
20	60	100	140
180			
VANE PEAK	◆	LAB	▲ UC/2
REMOULD	◇		△ P.PEN
★ % FINES		● SPT N	
W _p %	W%	W _L %	
x	o	x	
20	40	60	80

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 07/01/2019 FINISHED: 07/01/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1070.54 COORDINATES (m): N 5660149.146 E -12630.78		
1		Grab	G1	0.60 1069.94	TOPSOIL CLAY (CI) some sand, intermediate plasticity, light brown orange mottled, frozen (FILL)		
2							
3		Grab	G2	3.00 1067.54	CLAY (CI) some sand, some silt, intermediate plasticity, firm, dark brown, moist, trace rootlets (FILL)		
4		Grab	G3	3.70 1066.84	GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 90 mm in diameter), trace clay, well graded, rounded to angular, light grey, dry From 4.0 to 4.4 m: clayey, dark brown and moist From 4.7 m: light brown to grey, cobbles up to 130 mm in diameter From 4.9 m: 100 mm layer of brown clayey sand		
5		Grab	G4				
6				5.90 1064.64	CORE LOSS		
7				6.10 1064.44	CLAY (CI-CH) silty, trace gravel, intermediate to high plasticity, stiff, grey, moist Groundwater level at 6.8 mbgs on January 18, 2019		
8		Grab	G5				
9				8.40 1062.14	CORE LOSS		
10				9.10 1061.44	CLAY (CI-CH) silty, trace gravel, intermediate to high plasticity, stiff, grey, moist		

Continued Next Page

BOREHOLE LOG INST_SPT BOREHOLE LOGS CITY COORDS.GPJ KCBLL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 6771 16 Avenue NW, Calgary	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 2	

BOREHOLE LOG MW19-18

Su - kPa				
20	60	100	140	180
VANE PEAK	◆	FIELD	■	LAB
REMOLD	◇		□	▲ UC/2
				△ P.PEN
★	% FINES			● SPT N
W _p %	W%	W _L %		
x	o	x		
20	40	60	80	

DEPTH (m)	SPT BLOWS	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT	DETAILS
					STARTED: 01/04/2019 FINISHED: 01/04/2019 DRILL METHOD: Sonic GROUND ELEV. (m): 1077.85 COORDINATES (m): N 5661997.411 E -15021.048		
0.30				[Pattern]	TOPSOIL		
1077.55		Grab	G1	[Pattern]	GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 100 mm in diameter), trace clay, well graded, rounded to angular, grey, dry		
2.10					From 2.1 mbgs: moist		
2.60				[Pattern]	CORE LOSS		
1075.25				[Pattern]			
3.00				[Pattern]	GRAVEL (GW) fine to coarse grained, sandy, some silt, trace cobbles (up to 100 mm in diameter), trace clay, well graded, rounded to angular, grey, wet		
1074.85				[Pattern]			
4.30				[Pattern]	SILTSTONE brown orange mottled, slightly weathered, very weak		
1073.55				[Pattern]			
5.20				[Pattern]	SILTSTONE blue grey orange mottled, slightly weathered, very weak		
1072.65				[Pattern]			
6.10				[Pattern]	Borehole backfilled with sand and bentonite. 60 mm OD monitoring well installed with screen from 2.7 m to 4.3 m. Filter pack from 2.4 to 4.4 m Bentonite Plug 4.4 to 6.1 m		
1071.75				[Pattern]			

BOREHOLE LOG_INST_SPT BOREHOLE LOGS CITY COORDS.GPJ_KCBL CALGARY.GDT 22-12-20



Klohn Crippen Berger

PROJECT No.: A03330C01	
PROJECT: Bowness Flood Barrier	
LOCATION: 4631 85 Street NW (Belvedere Parkway School)	
LOGGED BY: AS	CHECKED BY: APB
SHEET 1 OF 1	

APPENDIX I2

Groundwater Monitoring and Bow River Hydrographs

Figure I2-1 MW19-01 (Sand and Gravel) – Water Level vs. Temperature

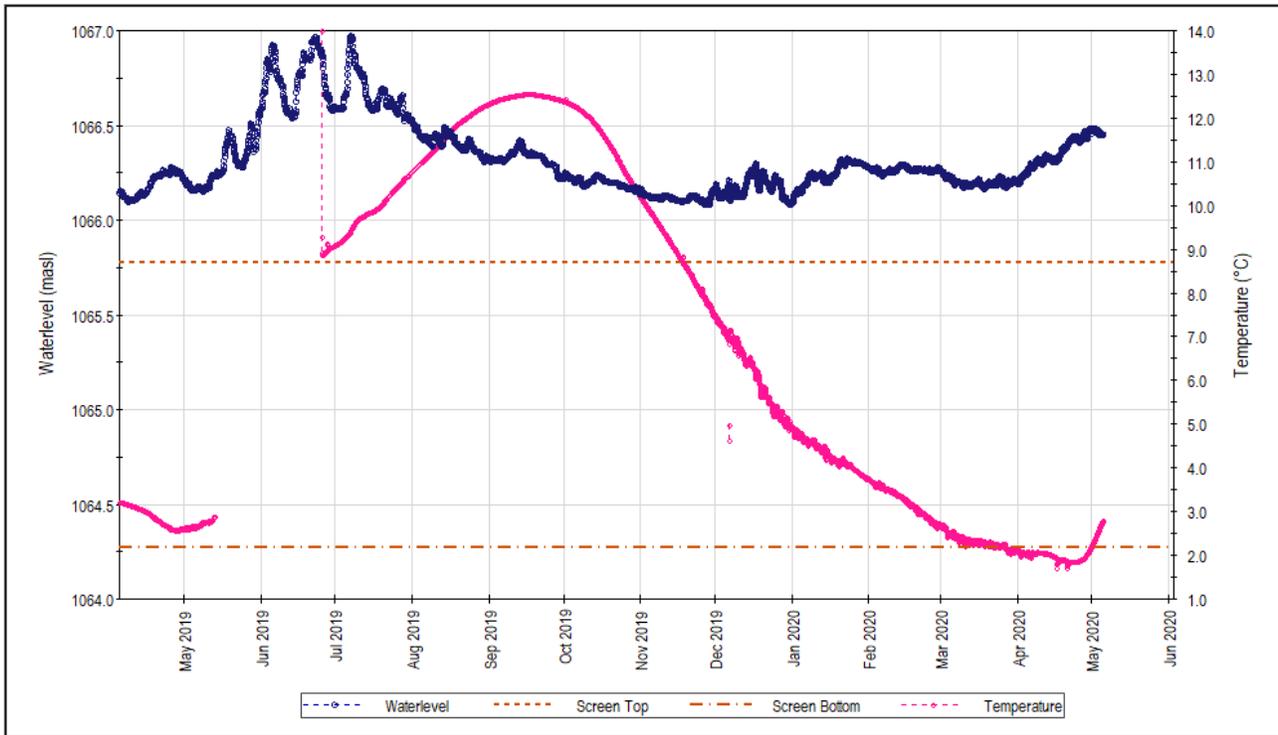


Figure I2-2 MW19-02 (Sand and Gravel) – Water Level vs. Temperature

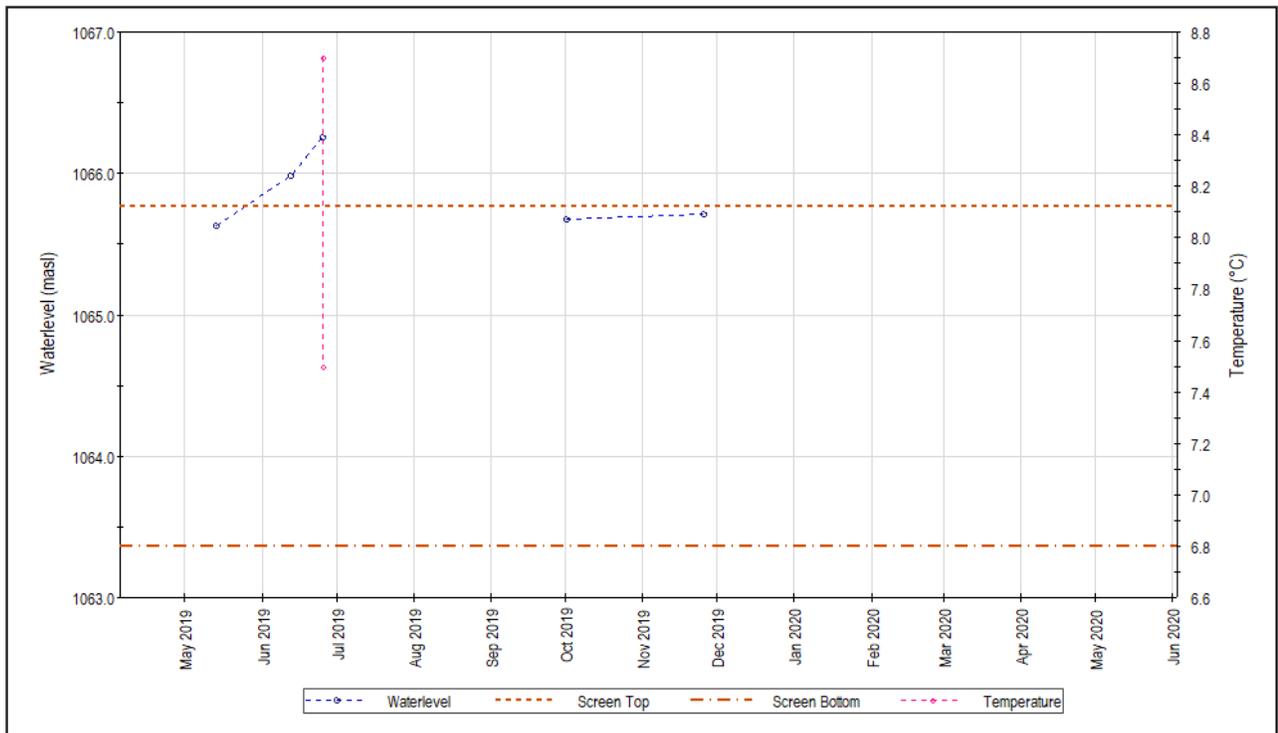


Figure I2-3 MW19-03 (Sand and Gravel) – Water Level vs. Temperature

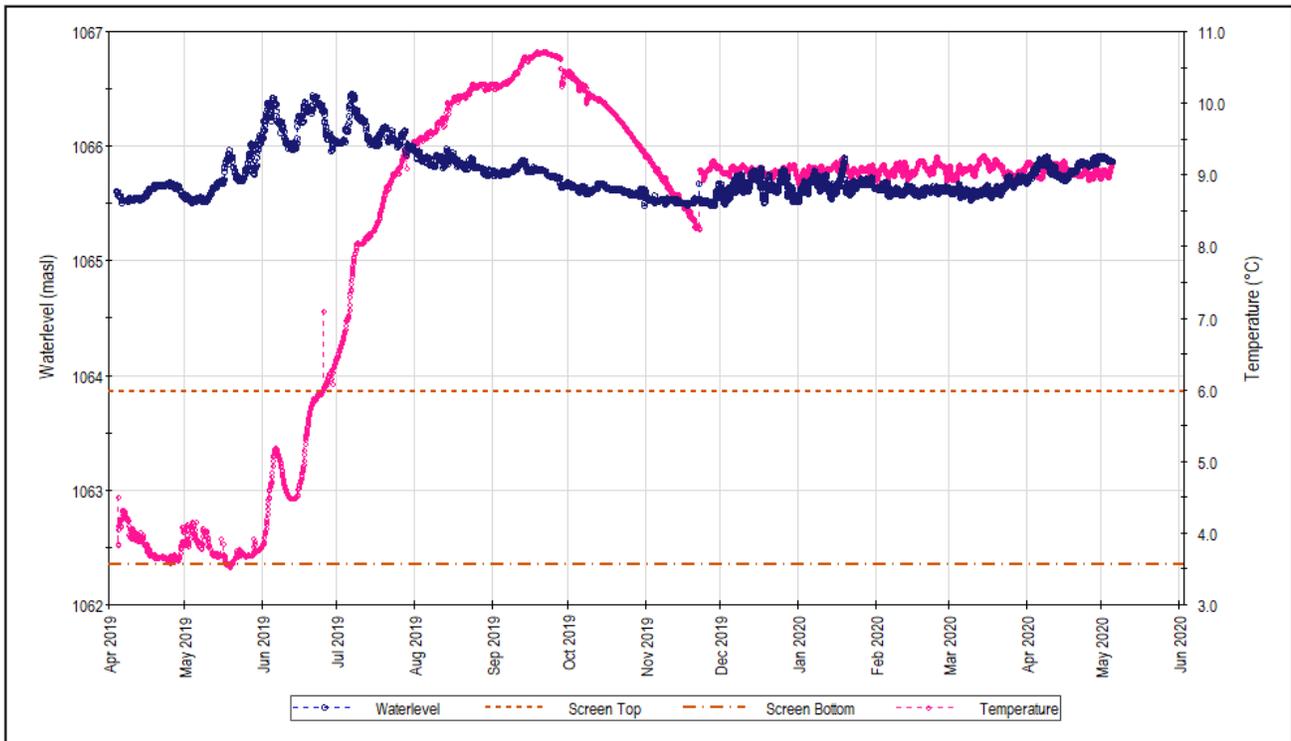


Figure I2-4 MW19-03A (Sand and Gravel) – Water Level vs. Temperature

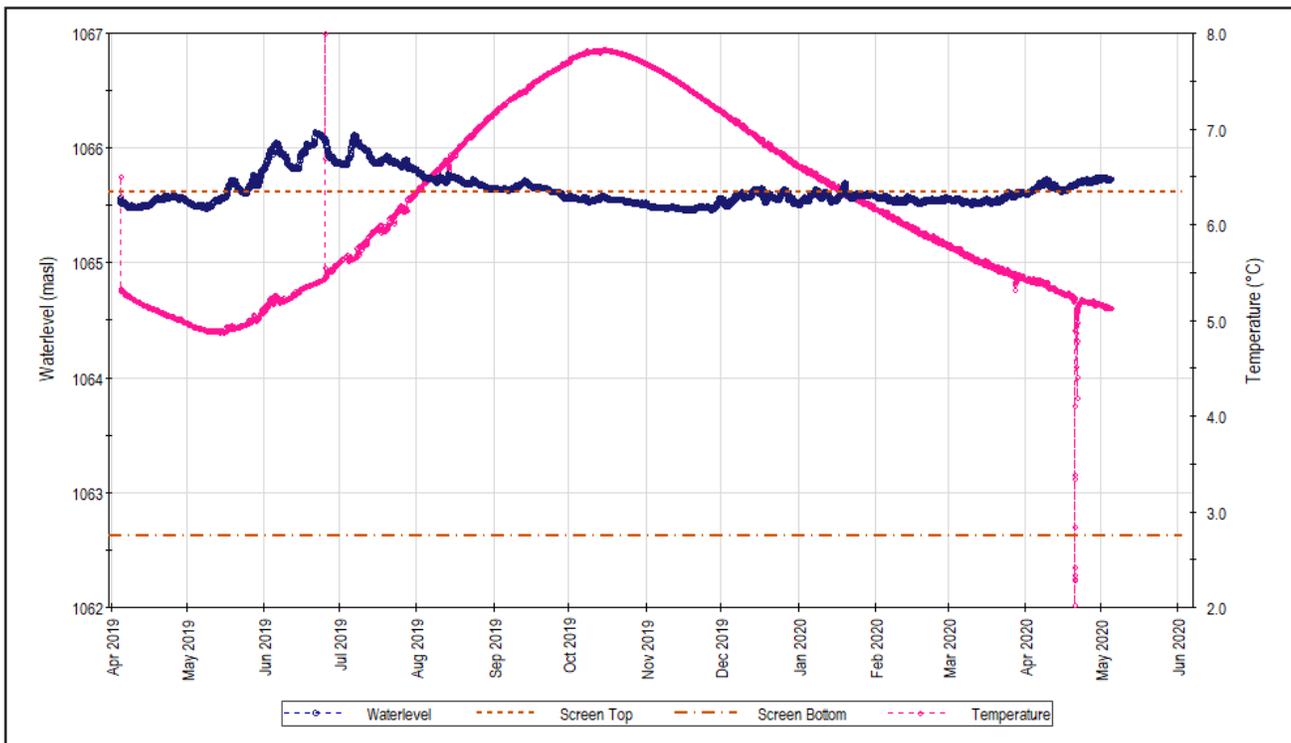


Figure I2-5 MW19-04 (Sand and Gravel) – Water Level vs. Temperature

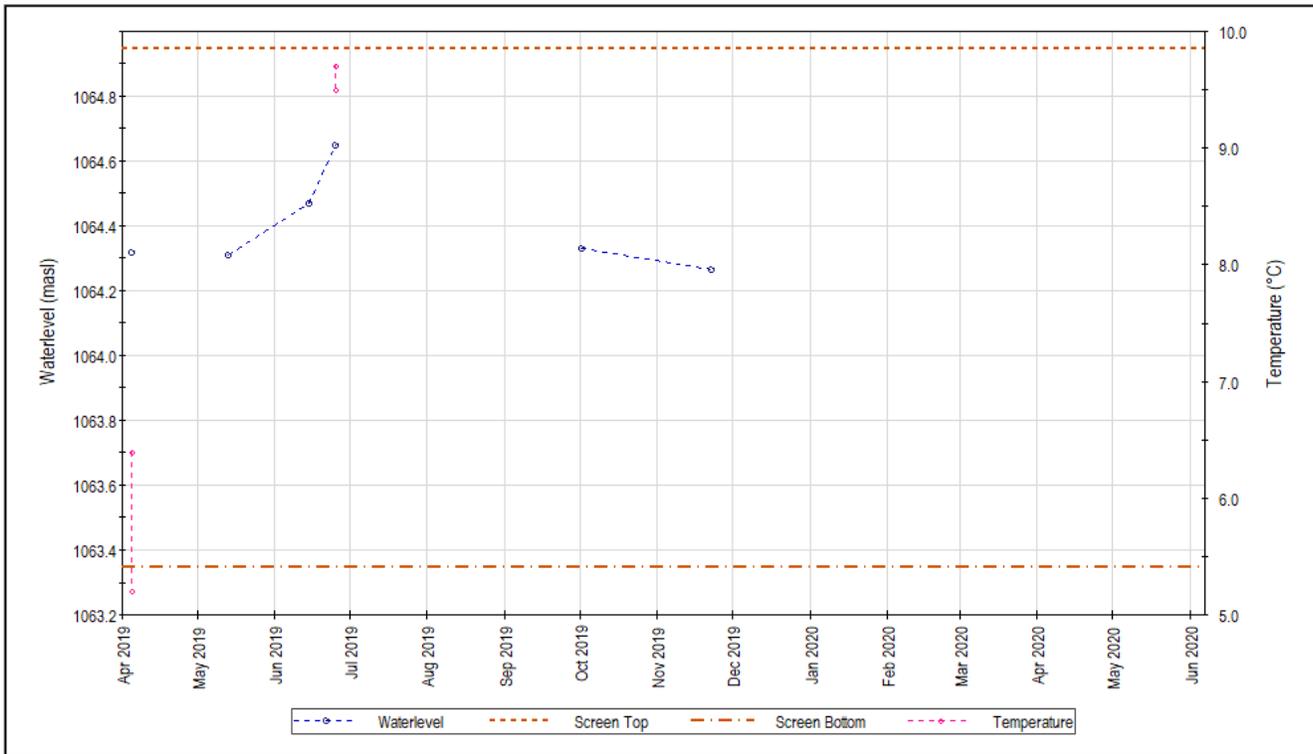


Figure I2-6 MW19-05 (Sand and Gravel) – Water Level vs. Temperature

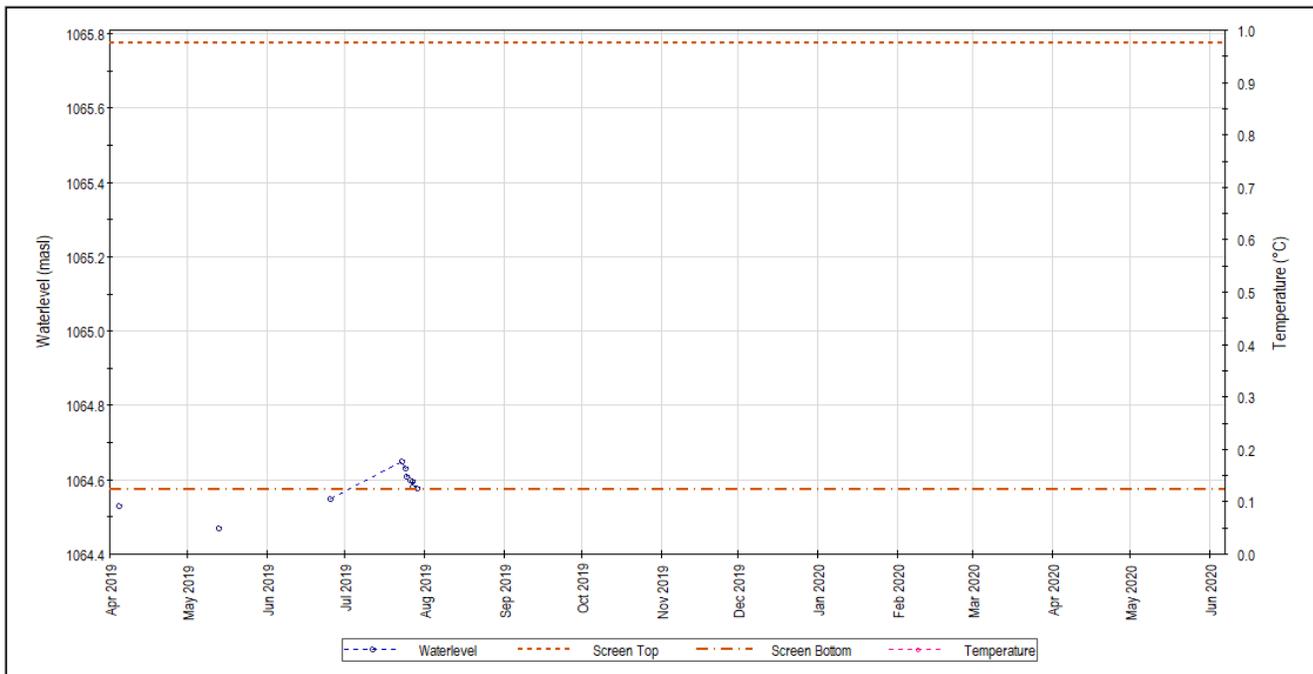


Figure I2-7 MW19-06 (Sand and Gravel) – Water Level vs. Temperature

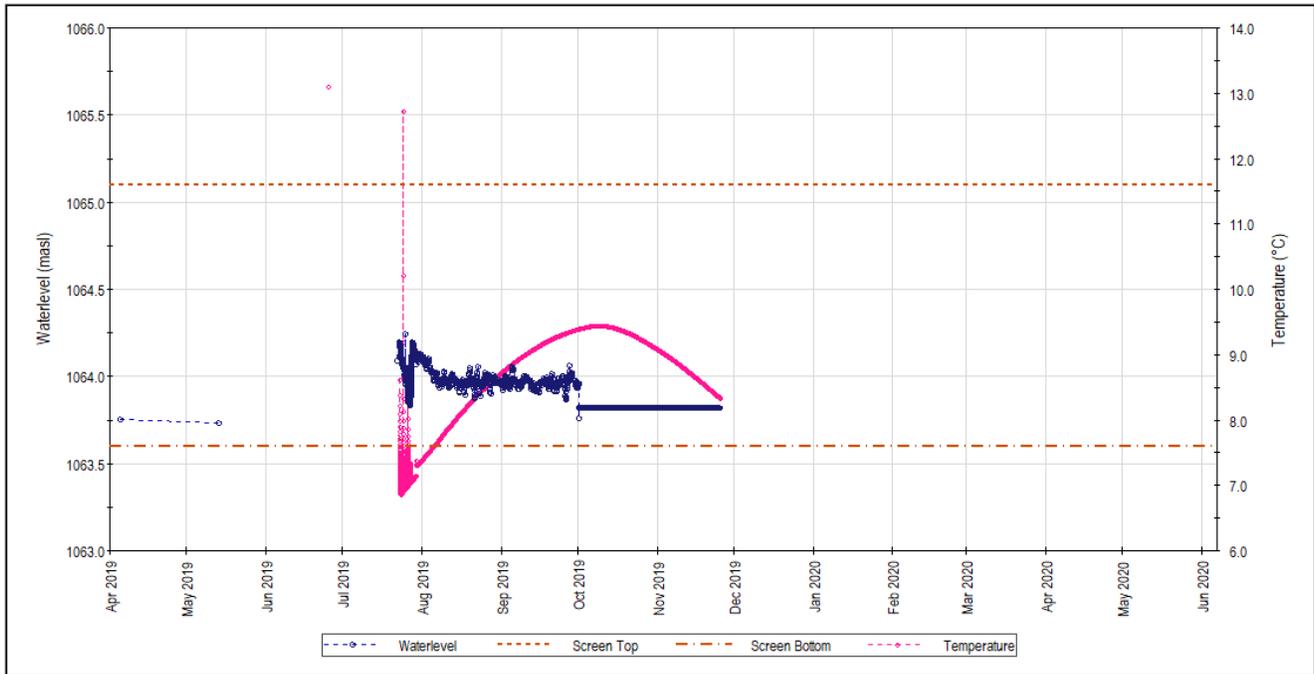


Figure I2-8 MW19-06A (Sand and Gravel) – Water Level vs. Temperature

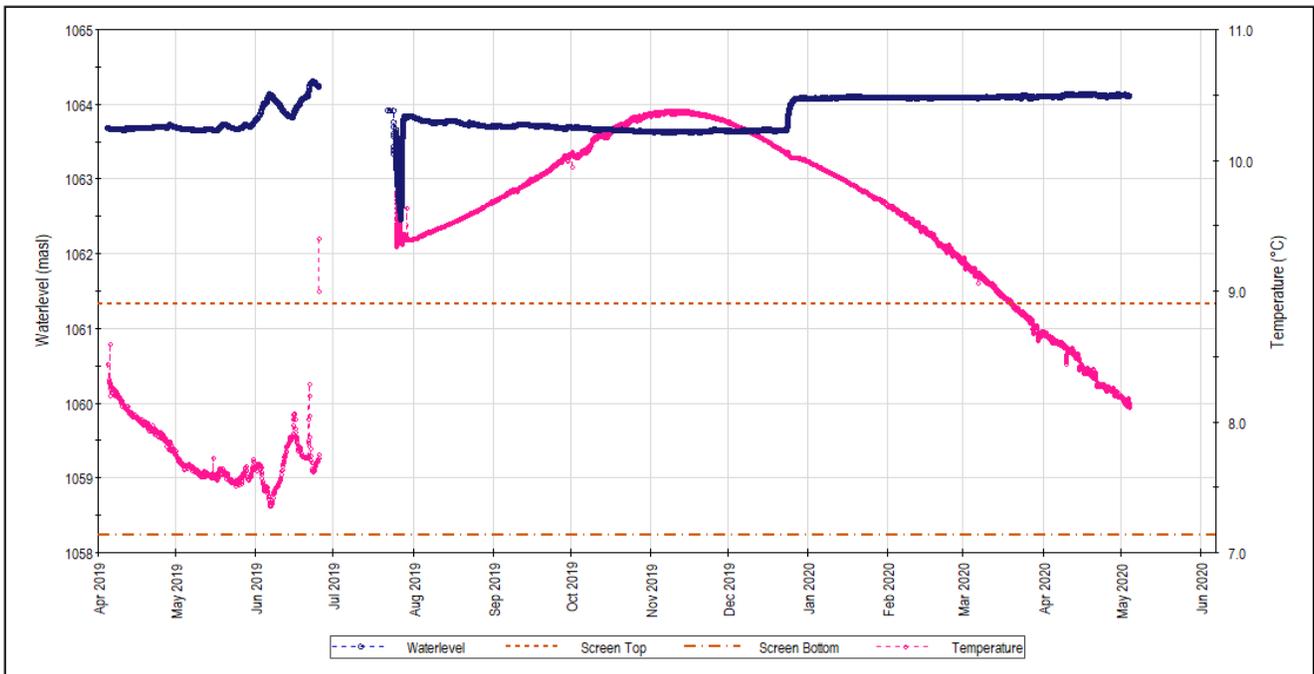


Figure I2-9 MW19-06A (Sand and Gravel) – Water Level vs. Electrical Conductivity

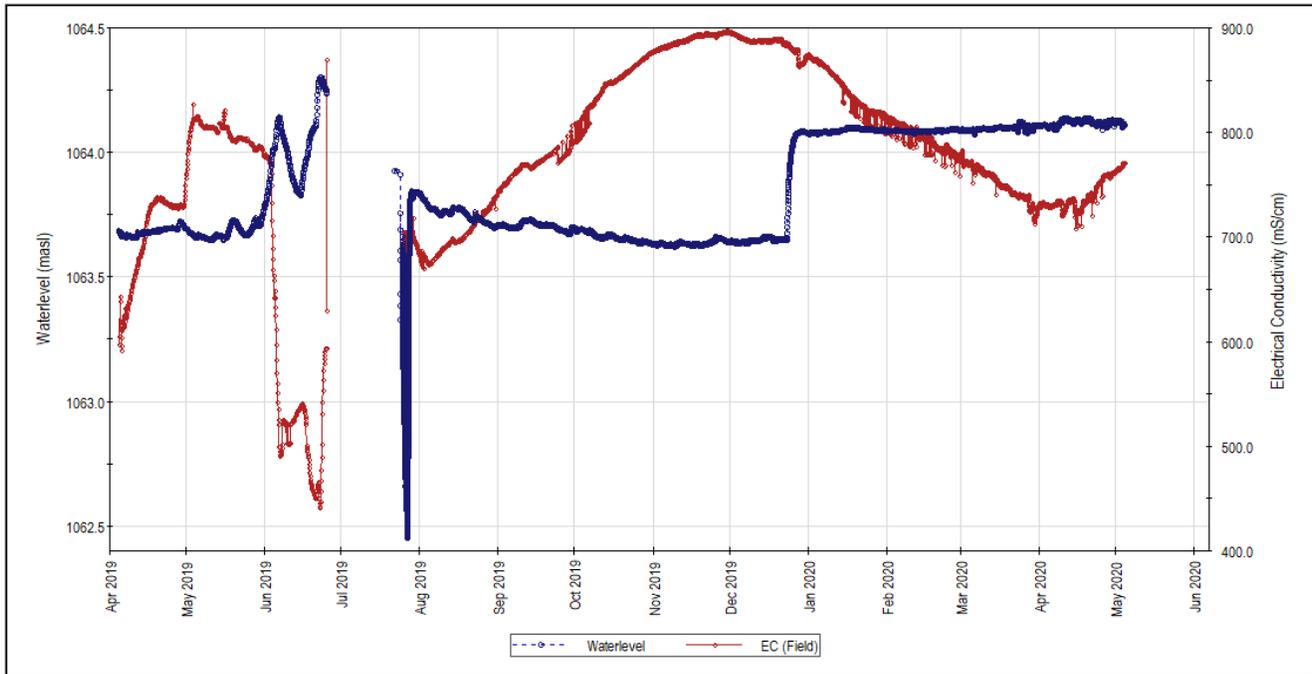


Figure I2-10 MW19-06B (Bedrock) – Water Level vs. Temperature

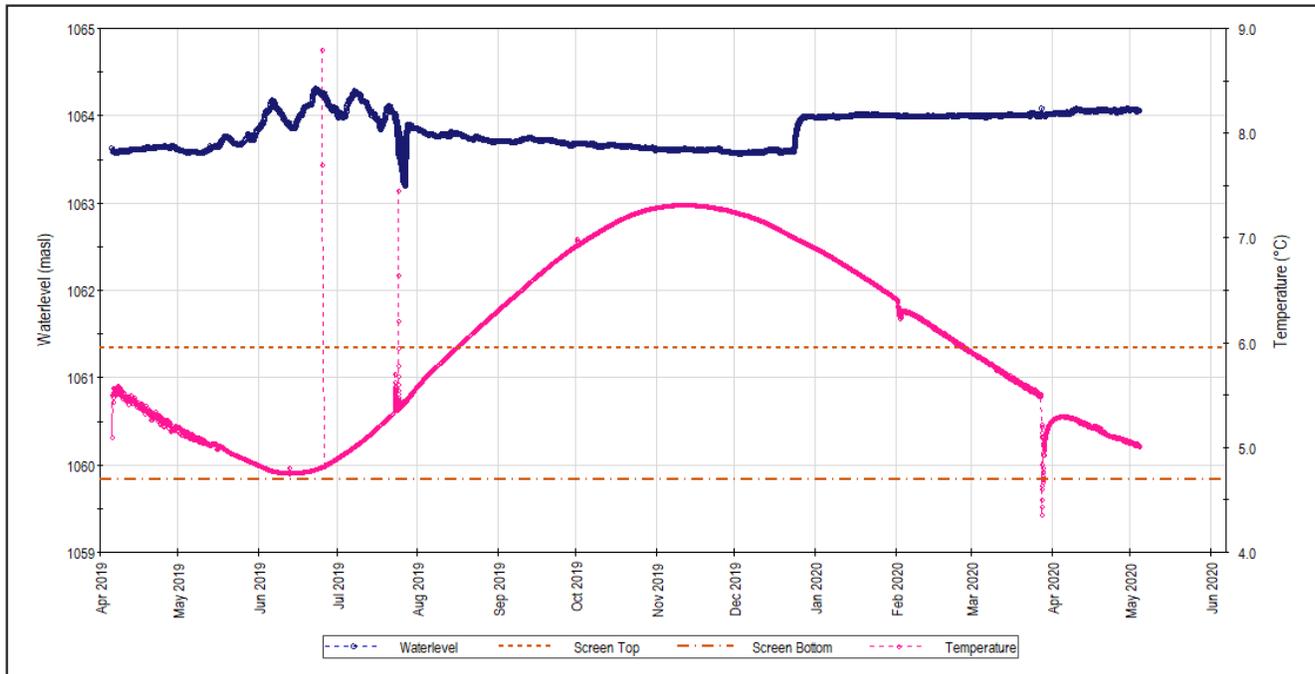


Figure I2-11 MW19-06B (Bedrock) – Water Level vs. Electrical Conductivity

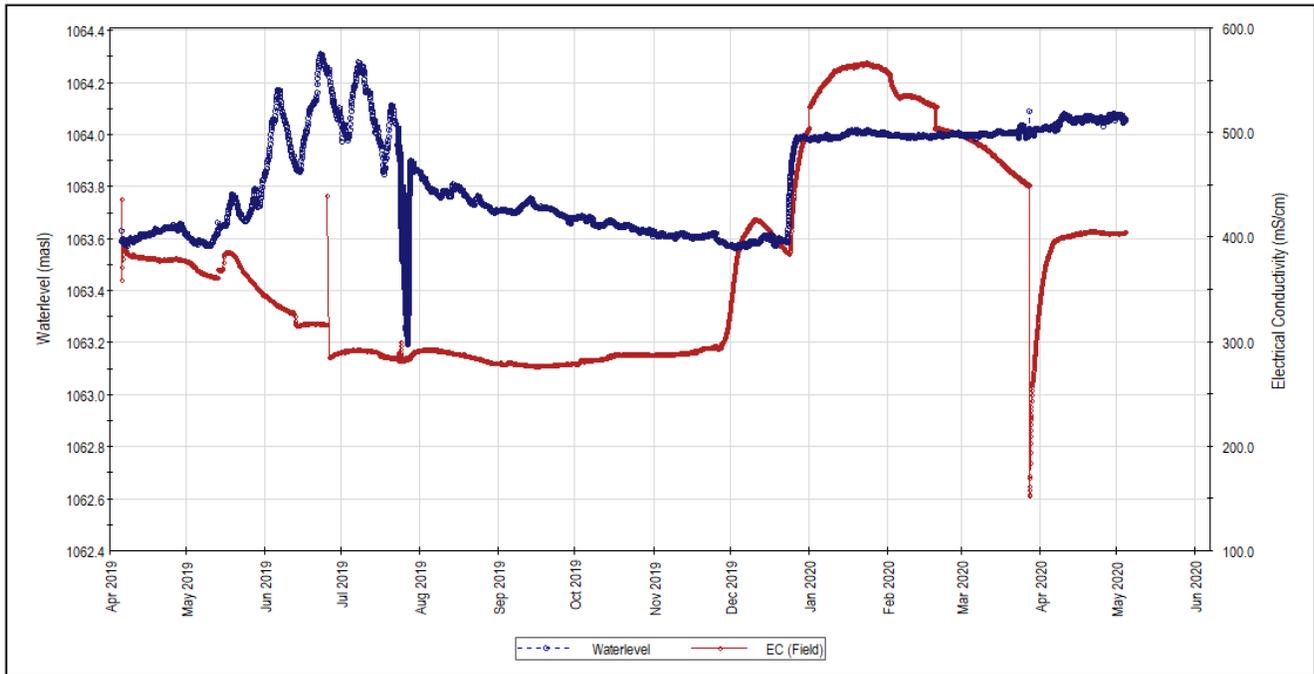


Figure I2-12 MW19-06C (Sand and Gravel) – Water Level vs. Temperature

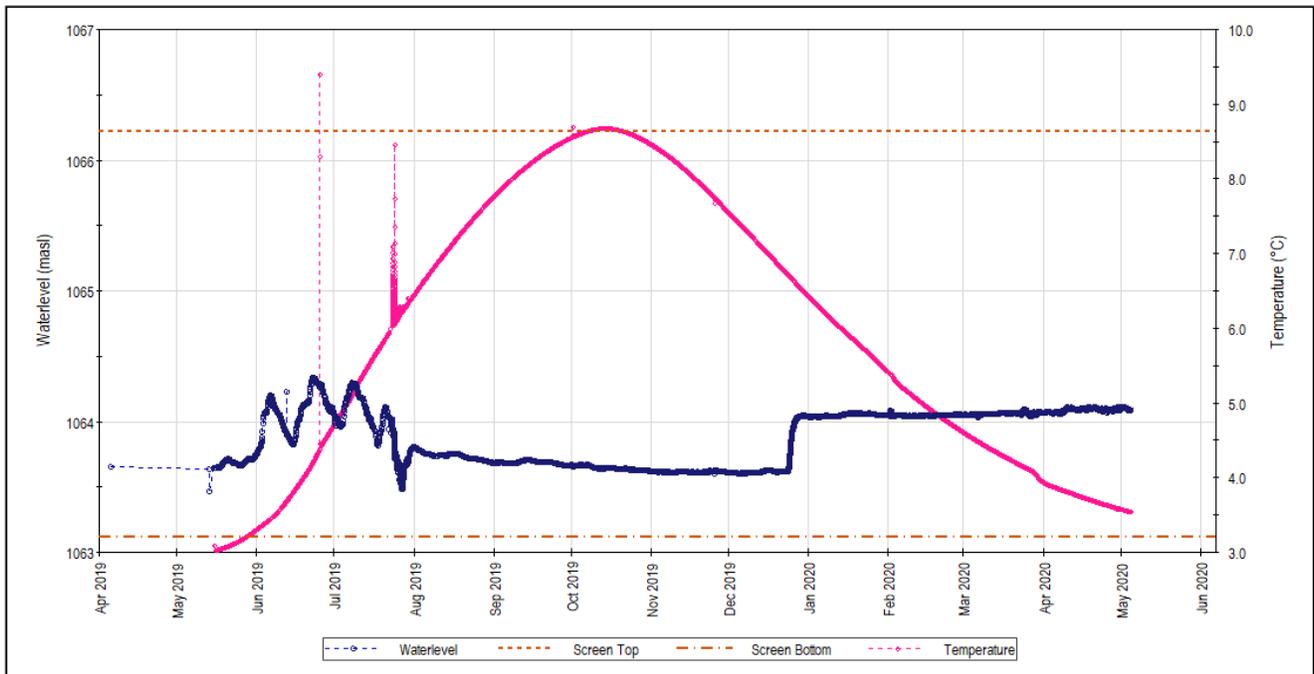


Figure I2-13 MW19-06D (Sand and Gravel) – Water Level

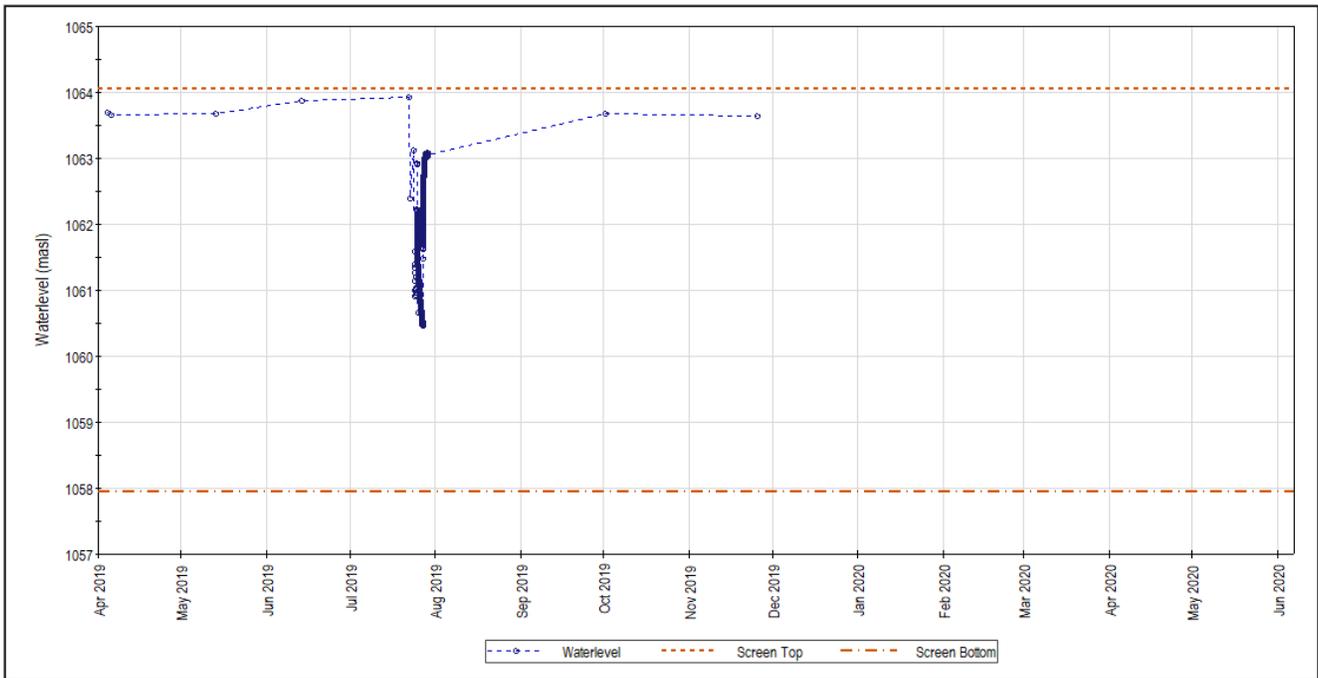


Figure I2-14 MW19-07 (Sand and Gravel) – Water Level vs. Temperature

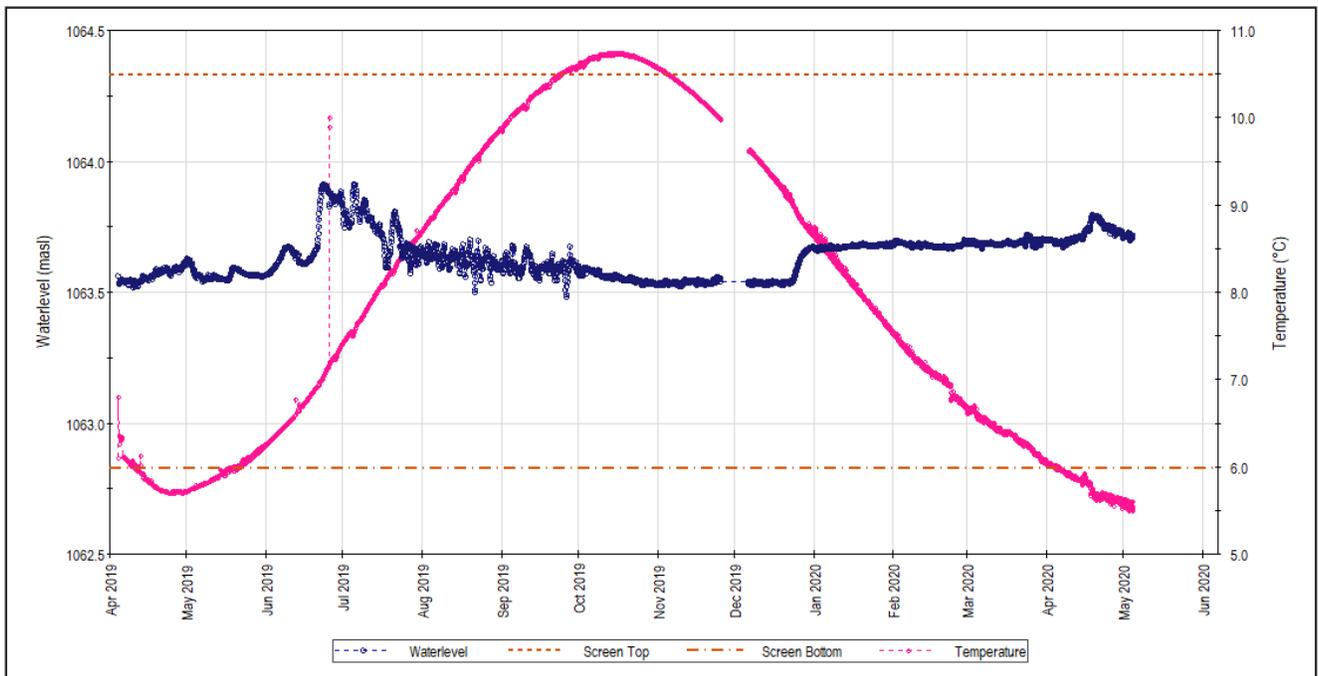


Figure I2-15 MW19-08 (Sand and Gravel) – Water Level vs. Temperature

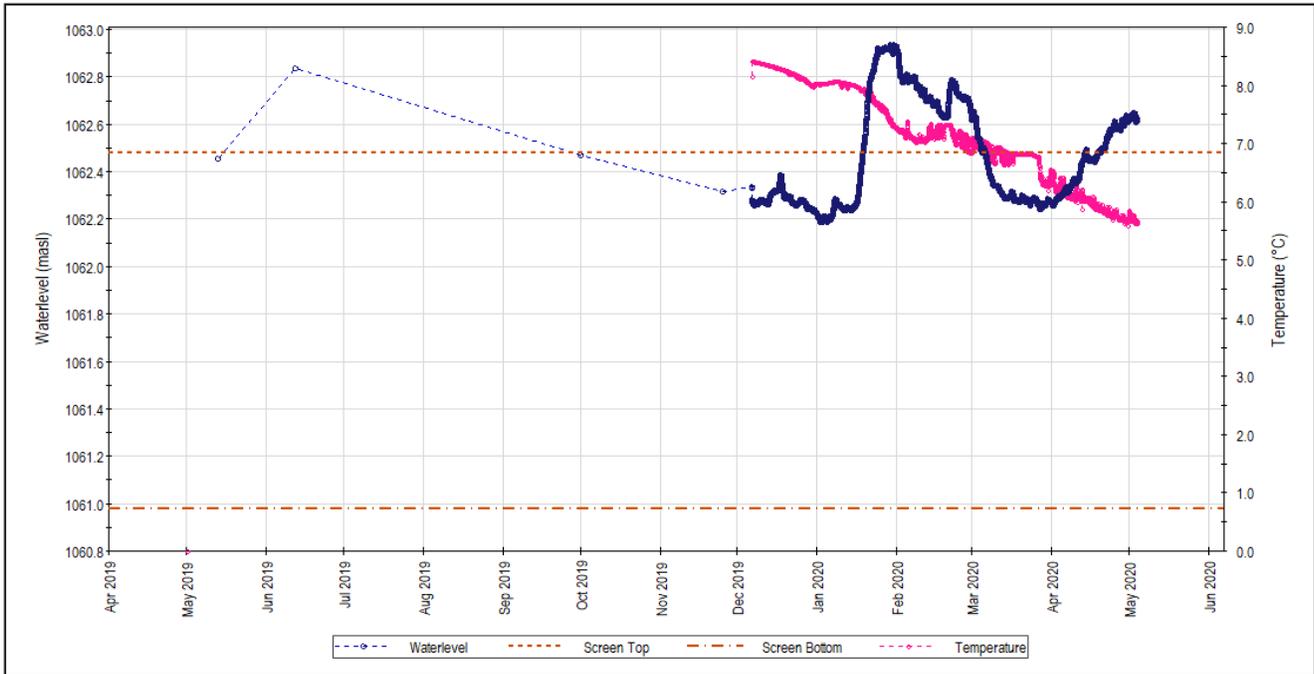


Figure I2-16 MW19-09 (Sand and Gravel) – Water Level vs. Temperature

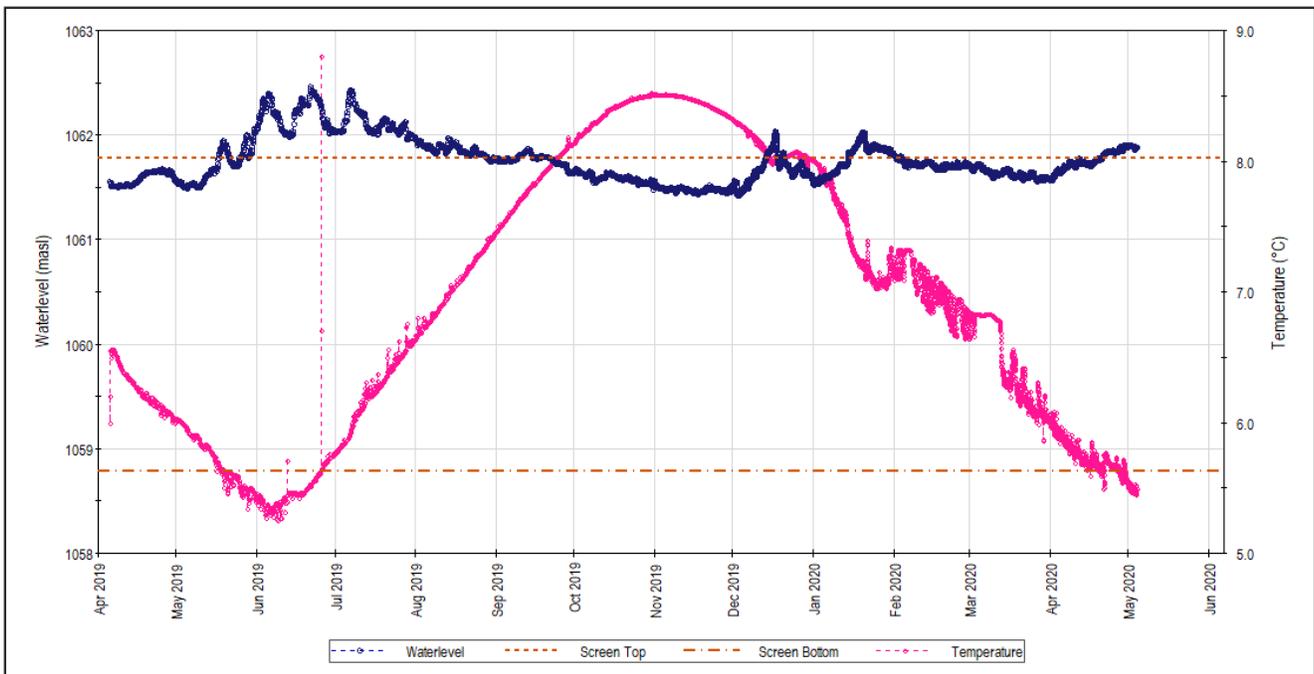


Figure I2-17 MW19-10 (Sand and Gravel) – Water Level vs. Temperature

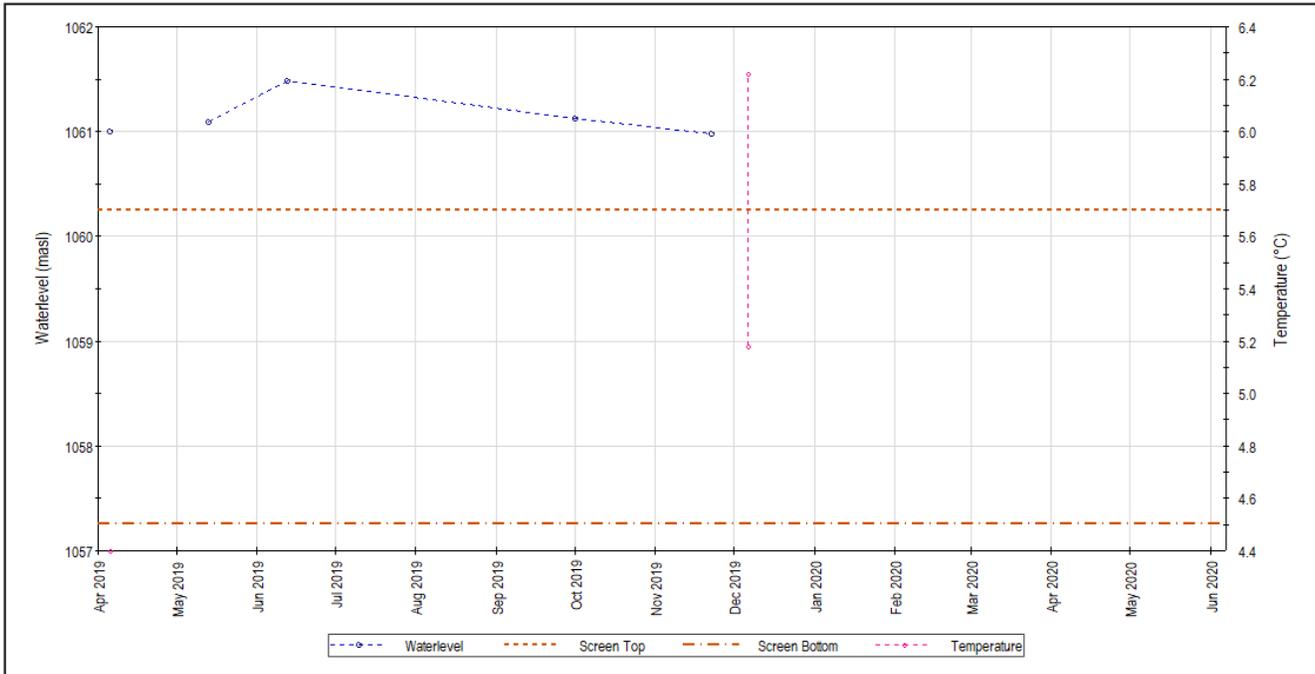


Figure I2-18 MW19-11 (Sand and Gravel) – Water Level vs. Temperature

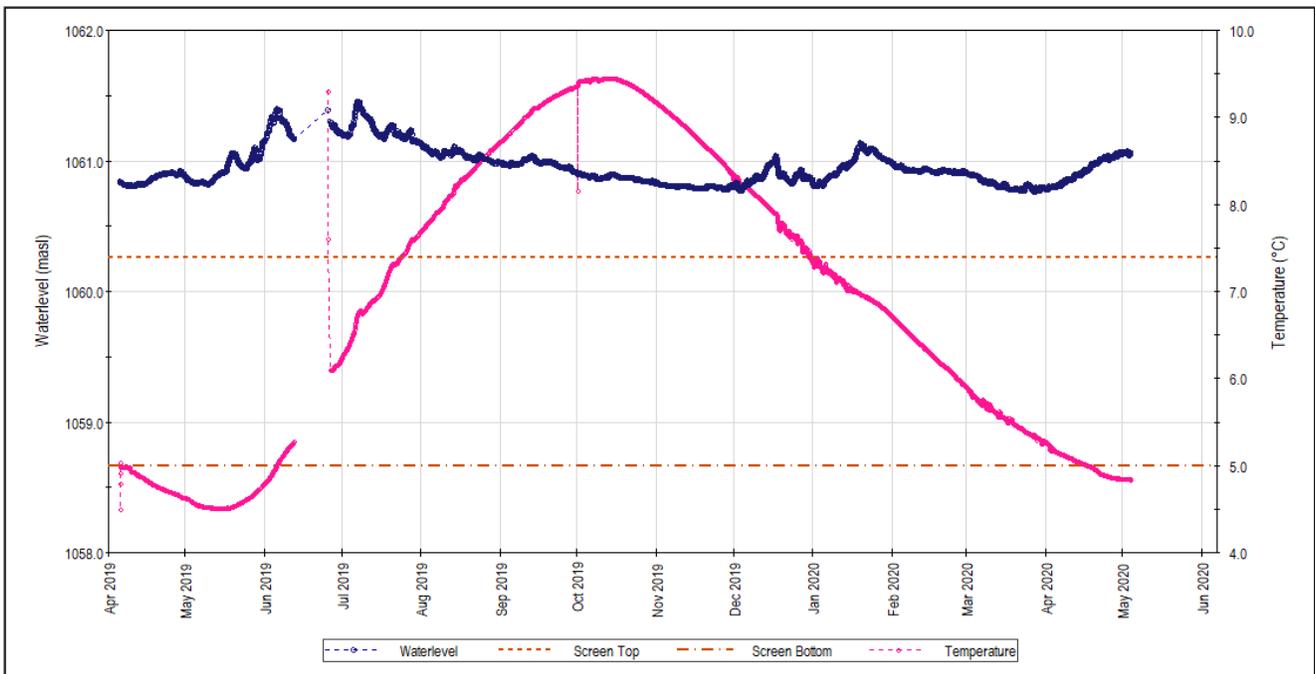


Figure I2-19 MW19-12 (Sand and Gravel) – Water Level vs. Temperature

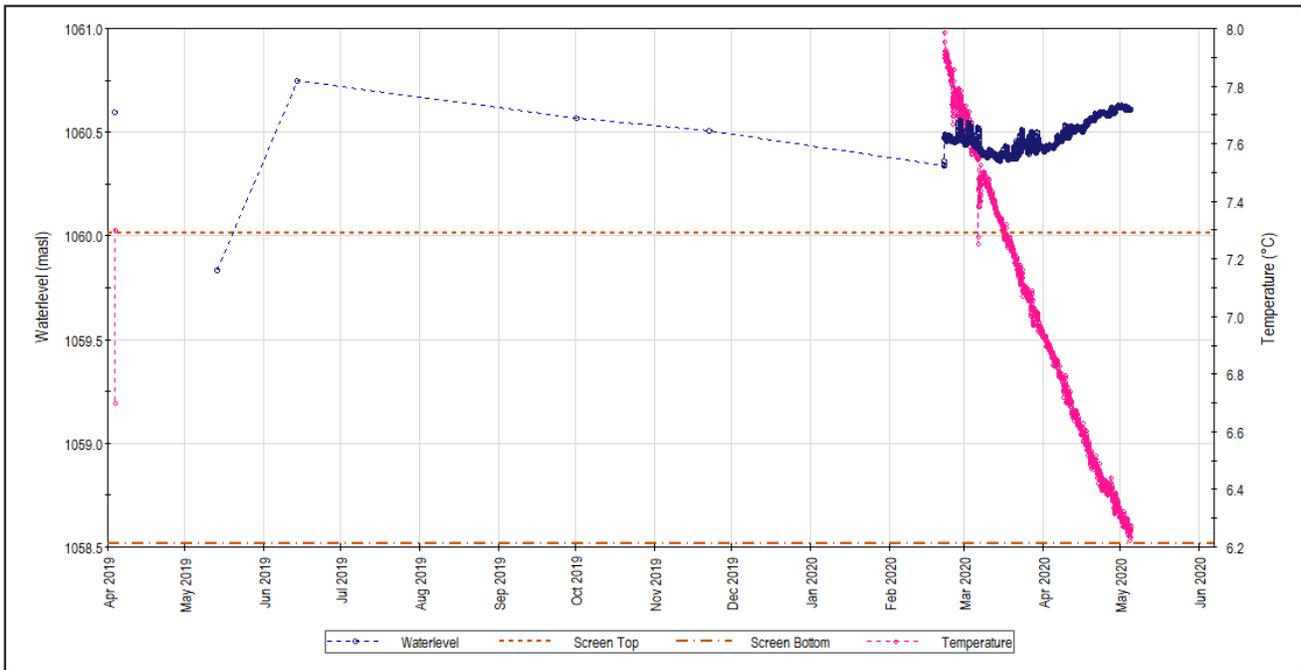


Figure I2-20 MW19-13A (Sand and Gravel) – Water Level

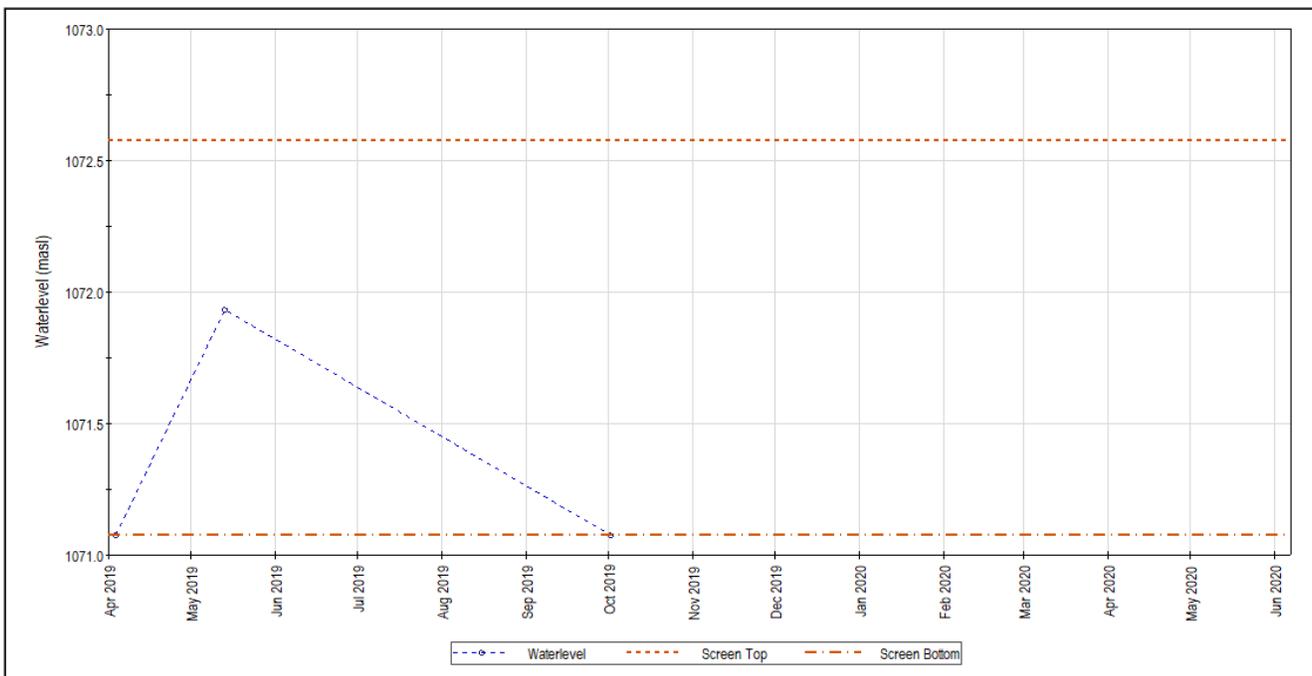


Figure I2-21 MW19-14 (Sand and Gravel) – Water Level vs. Temperature

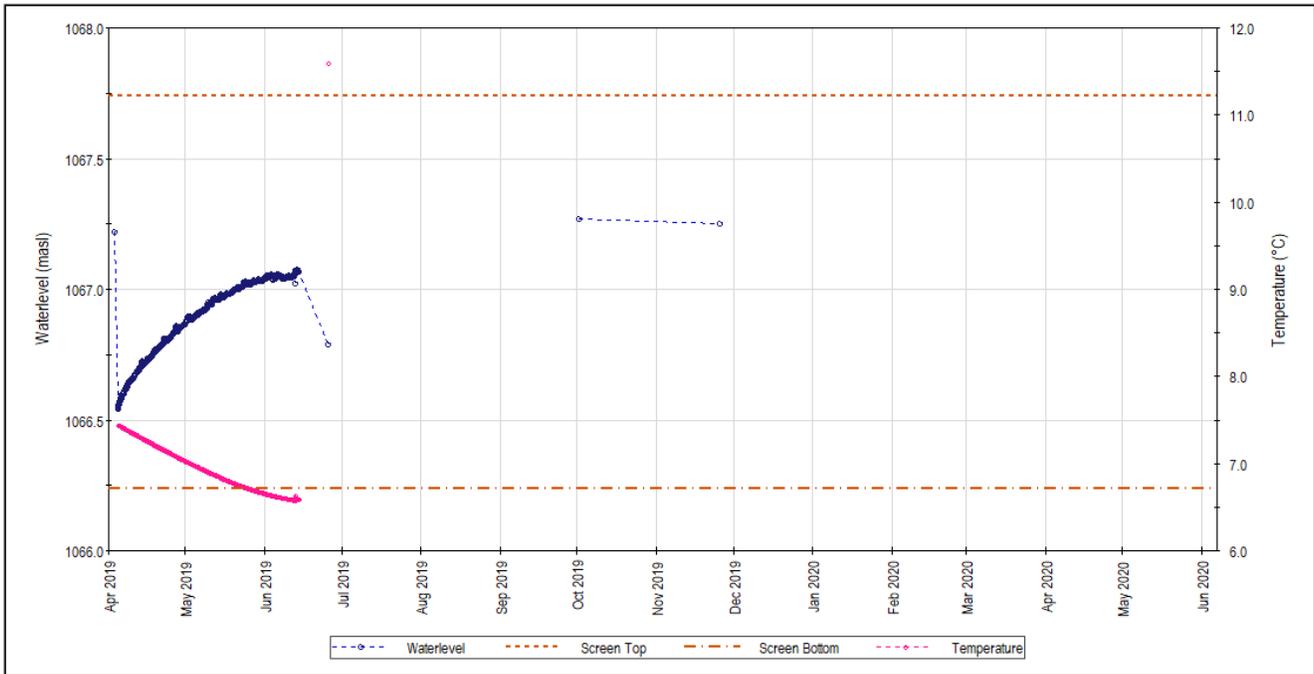


Figure I2-22 MW19-15 (Sand and Gravel) – Water Level vs. Temperature

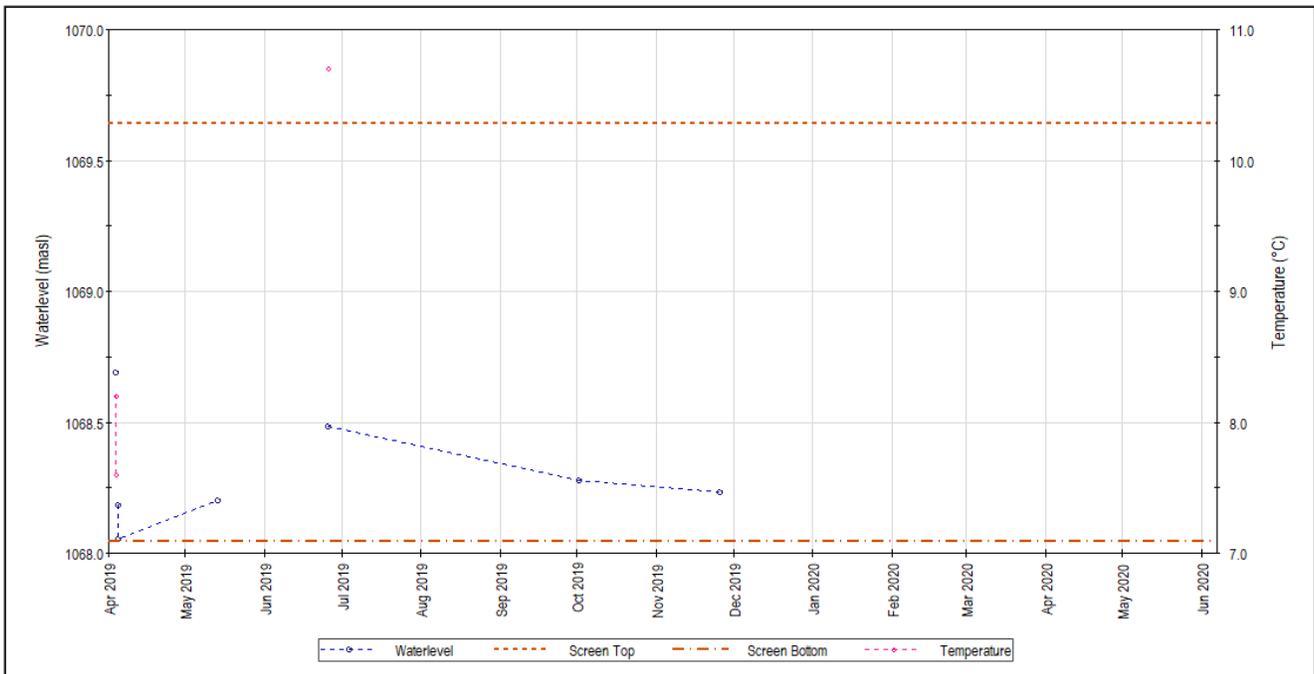


Figure I2-23 MW19-15A (Bedrock) – Water Level vs. Temperature

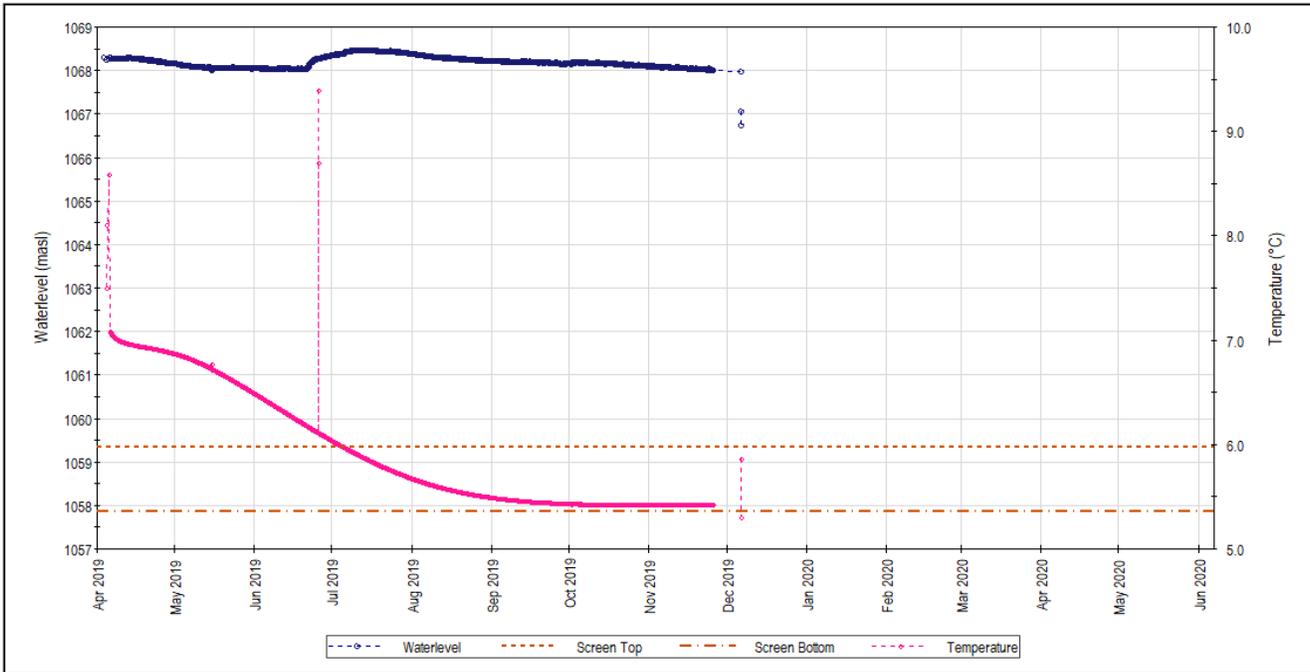


Figure I2-24 MW19-15B (Bedrock) – Water Level vs. Electrical Conductivity

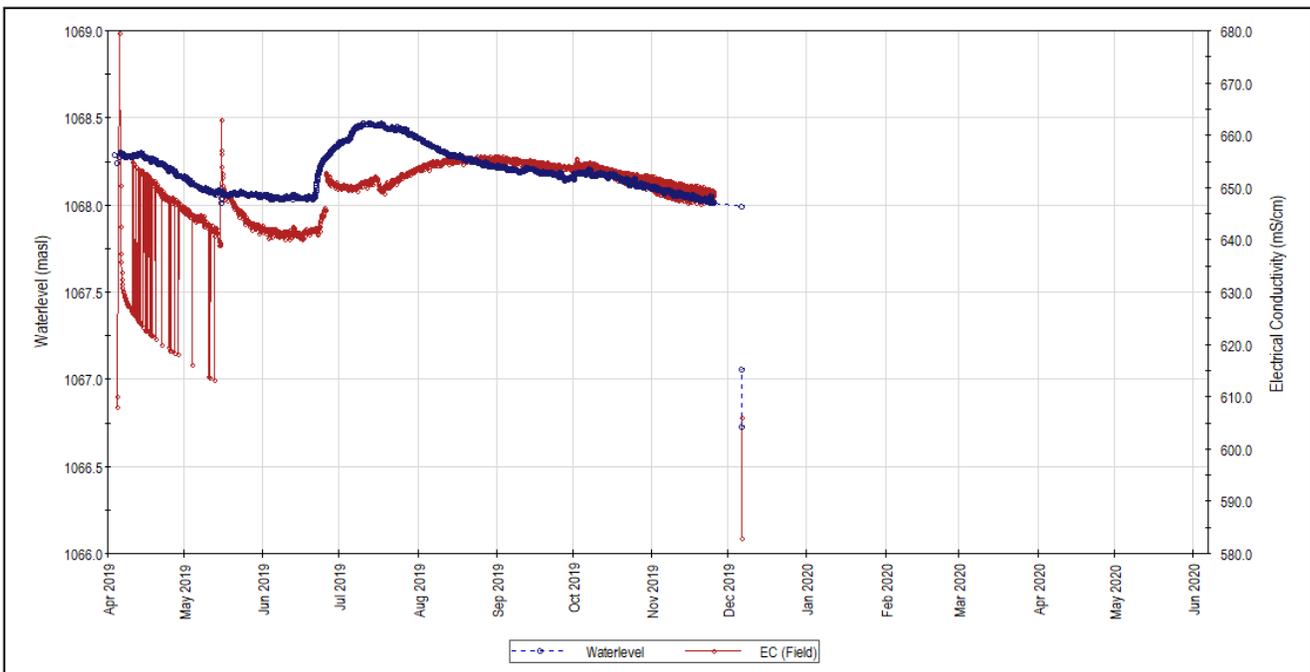


Figure I2-25 MW19-16 (Sand and Gravel) – Water Level

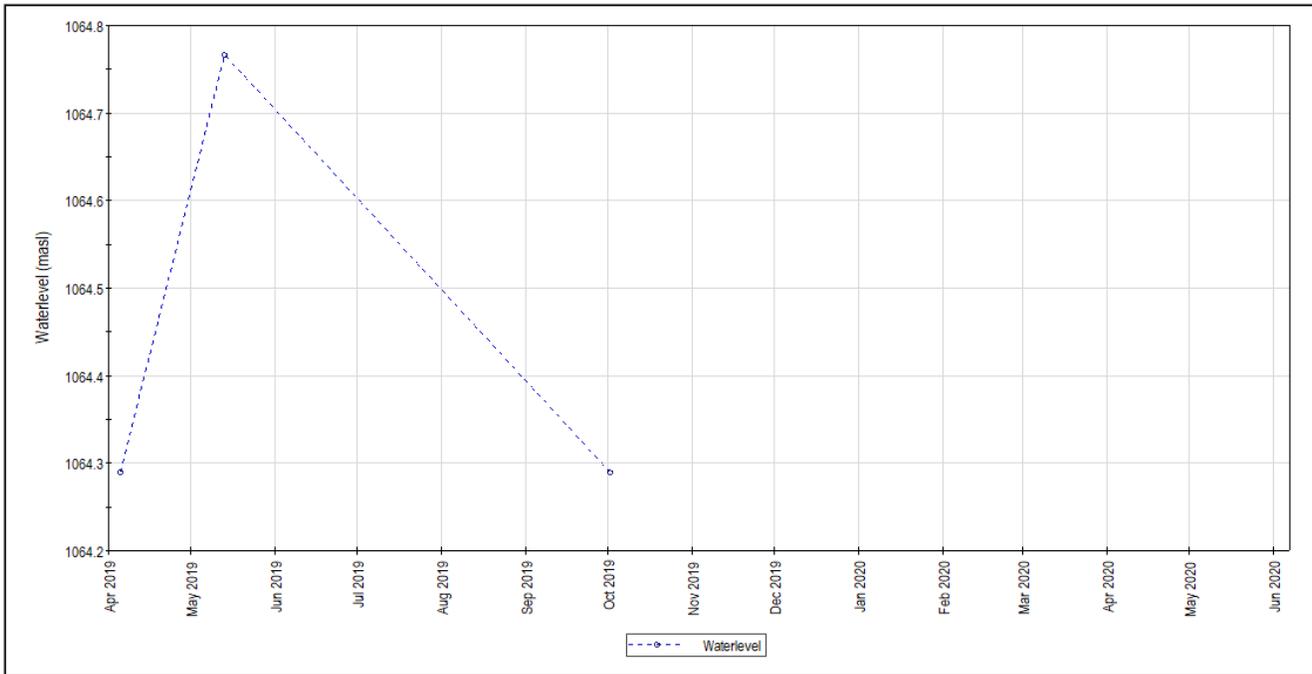


Figure I2-26 MW19-17 (Silt) – Water Level vs. Temperature

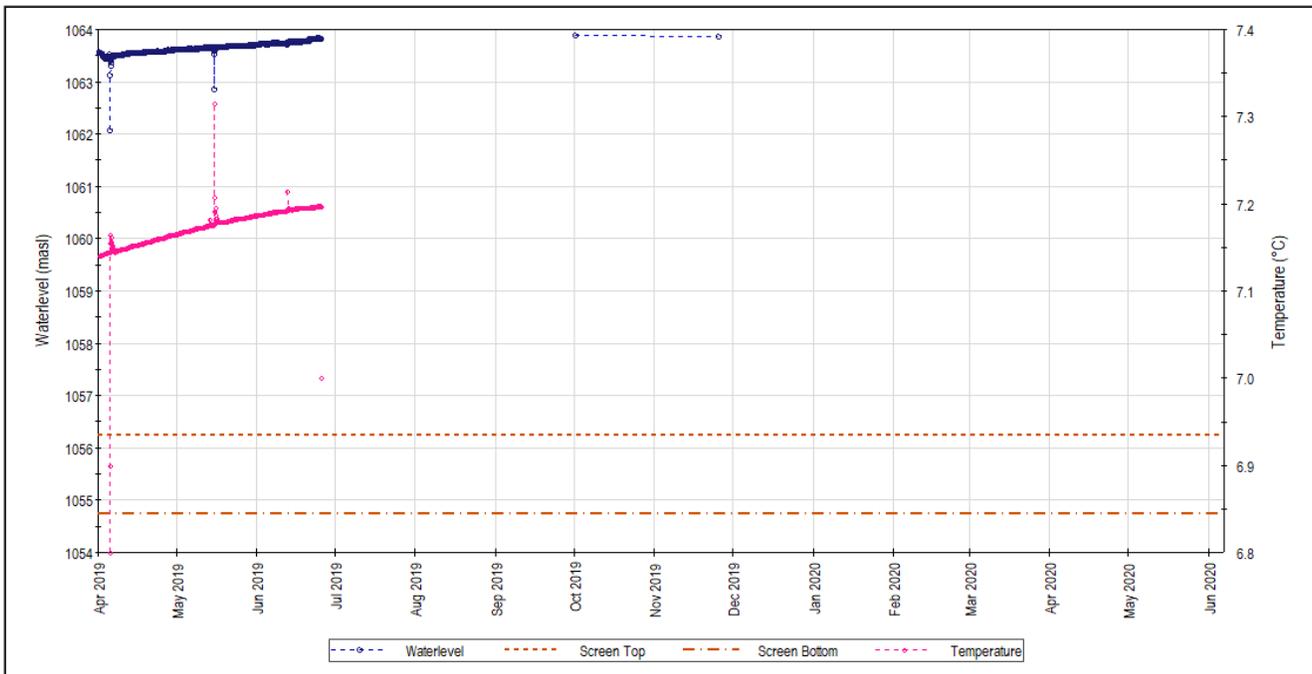


Figure I2-27 MW19-17A (Sand and Gravel) – Water Level (dry)

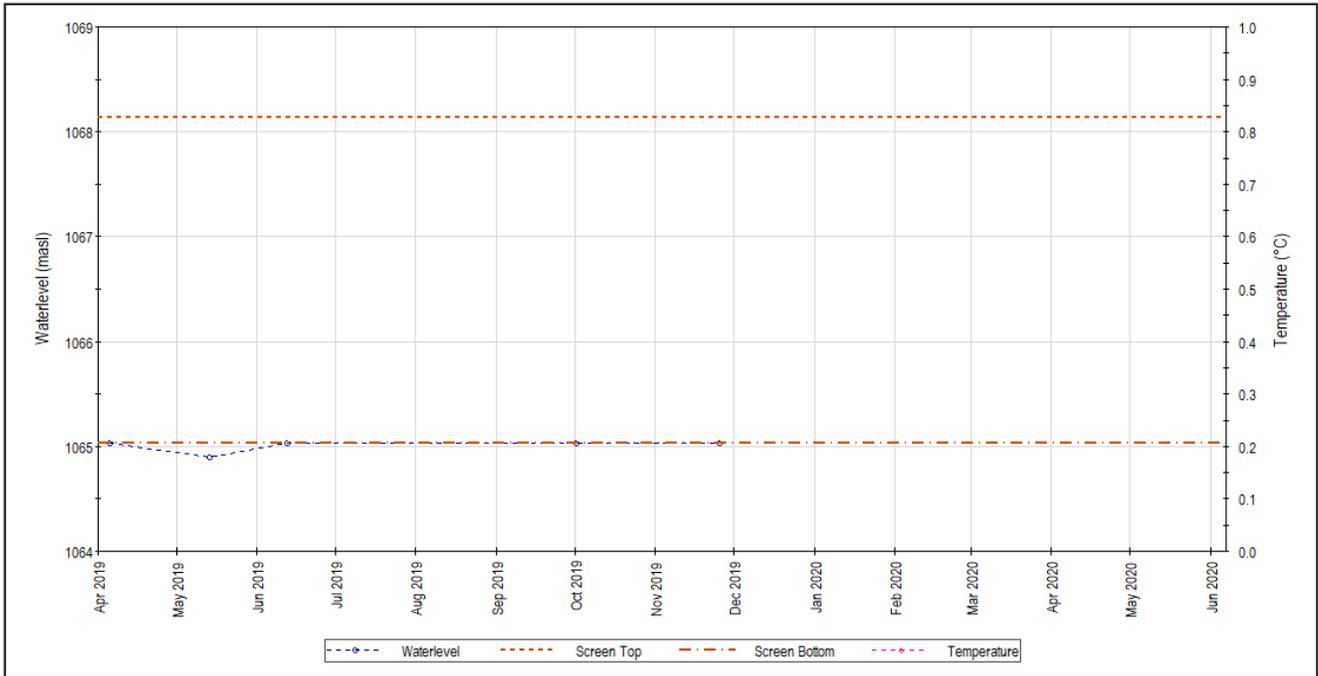


Figure I2-28 MW19-18 (Sand and Gravel) -Water Level vs. Temperature

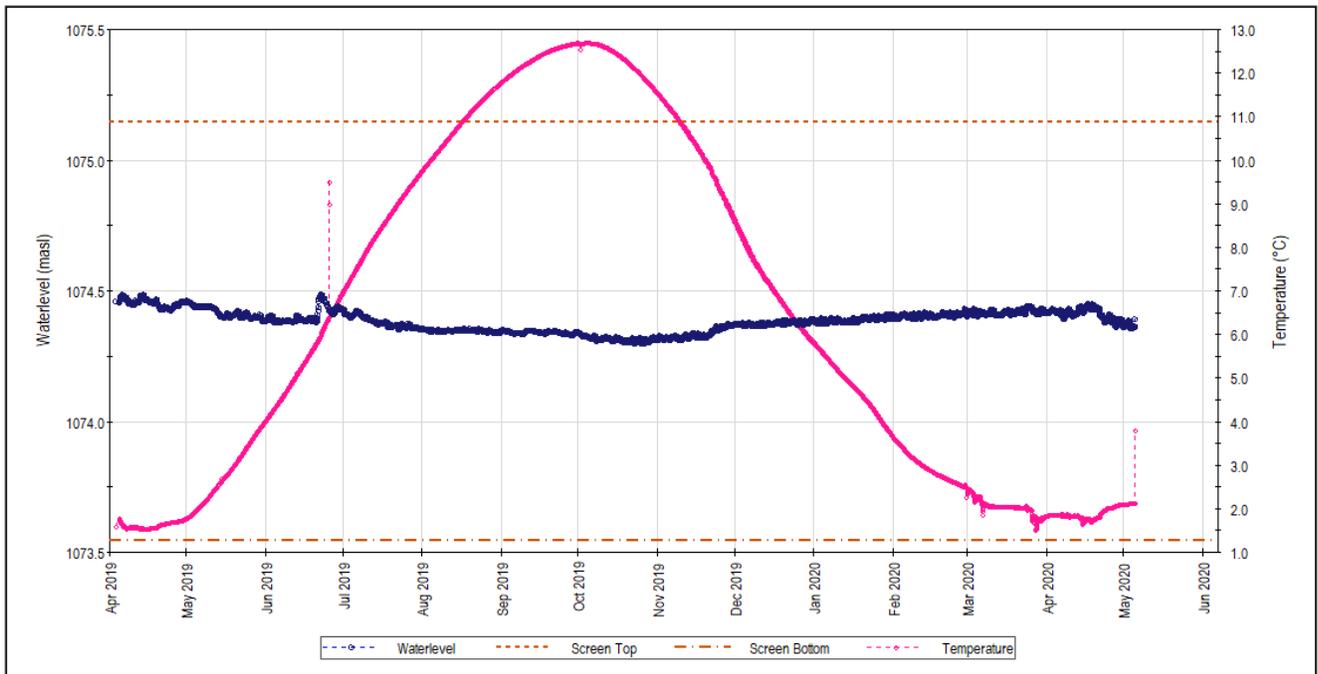


Figure I2-29 MW19-19 (Sand and Gravel) -Water Level vs. Temperature

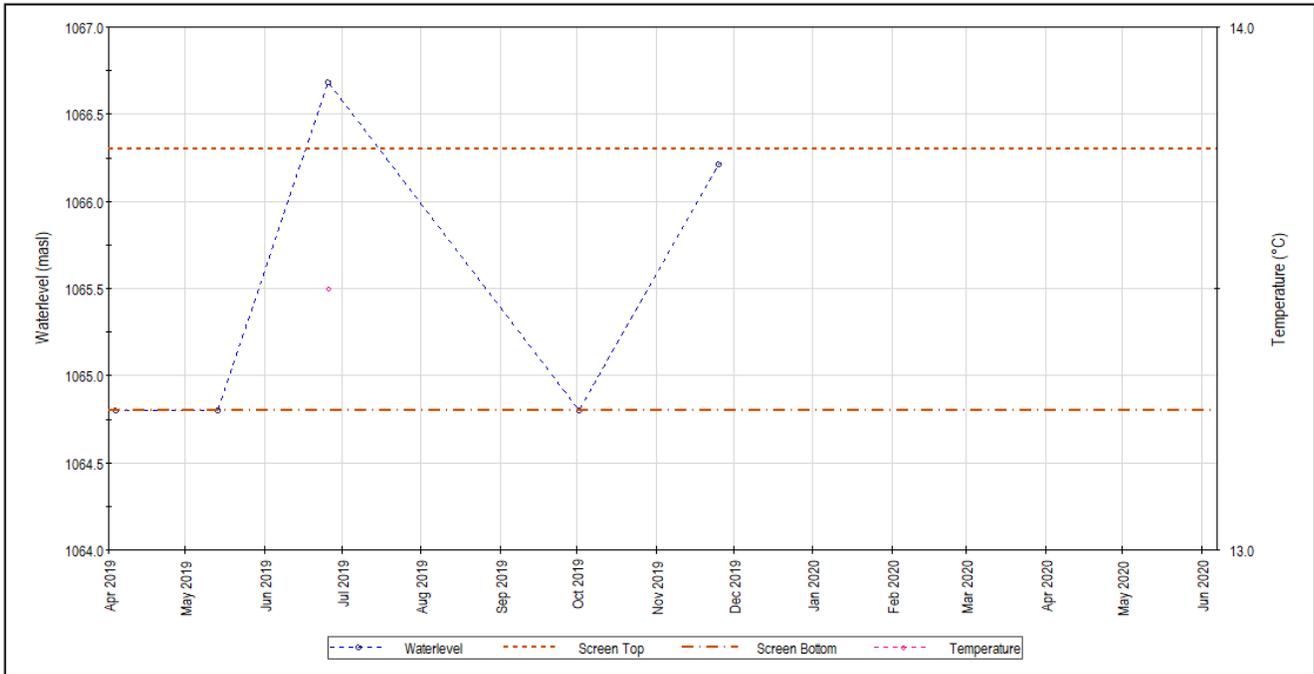


Figure I2-30 Bow River (Bow 3) - Water Level vs. Temperature

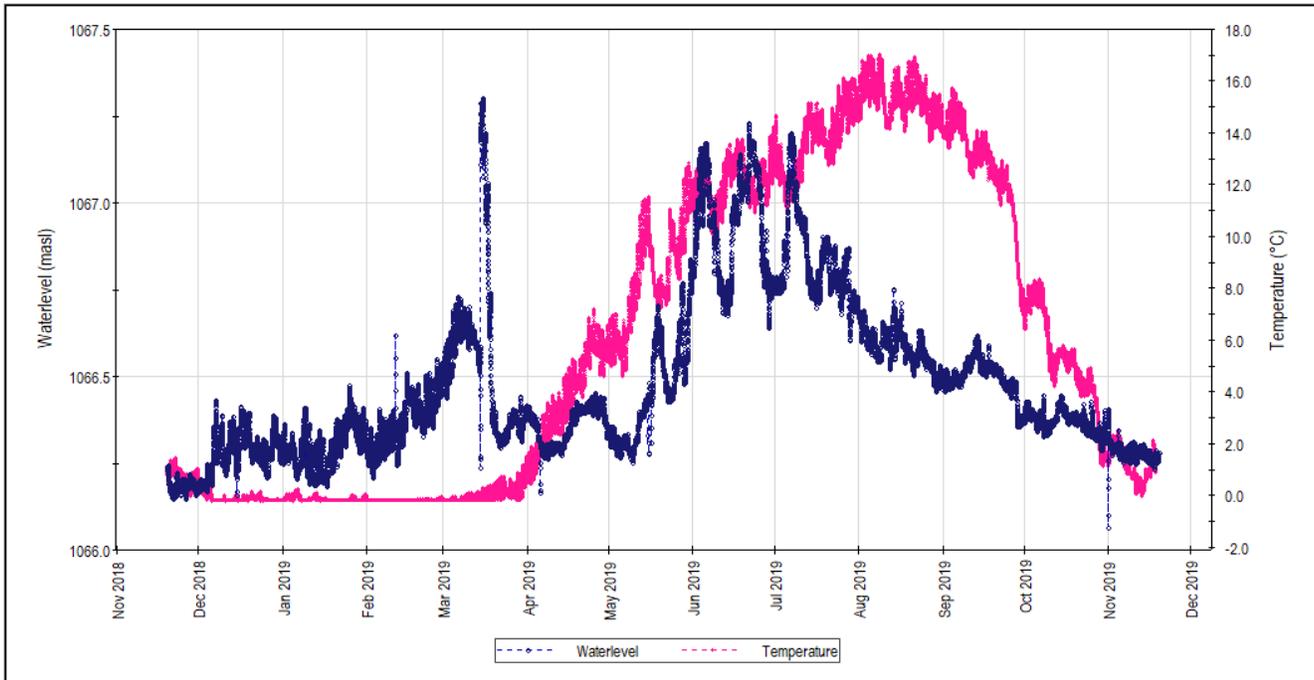
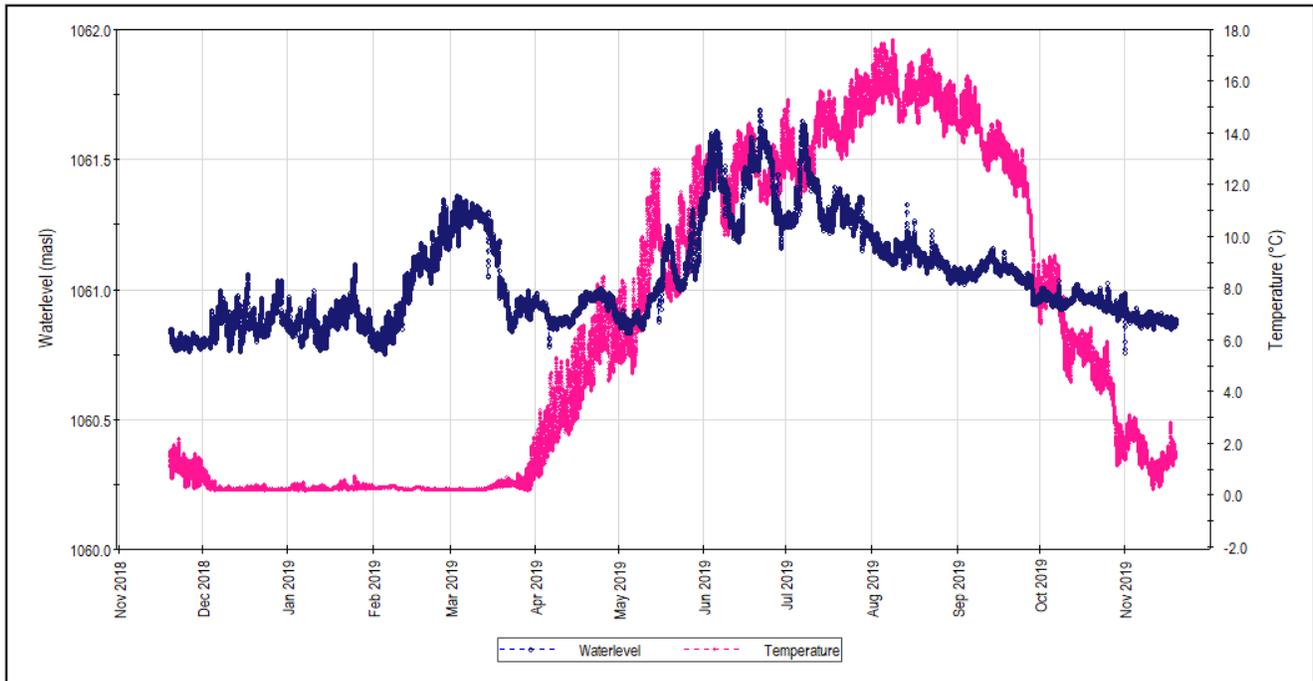


Figure I2-31 Bow River (Bow 5) - Water Level vs. Temperature



APPENDIX I3

Laboratory Analytical Reports



**CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
500-2618 HOPEWELL PLACE NE
CALGARY, AB T1Y7J7
(403) 274-3424**

ATTENTION TO: Accounts Payable

PROJECT: A03330C01

AGAT WORK ORDER: 19C454390

TRACE ORGANICS REVIEWED BY: Elena Gorobets, Report Writer

WATER ANALYSIS REVIEWED BY: Krystyna Krauze, Senior Analyst

DATE REPORTED: Apr 09, 2019

PAGES (INCLUDING COVER): 20

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Petroleum Hydrocarbons (BTEX/F1-F2) in Water

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-01	MW19-07	MW19-12	MW19-18	MW19-06A	MW19-06B
		G / S	RDL	Water	Water	Water	Water	Water	Water
DATE SAMPLED:		2019-04-03	2019-04-04	2019-04-03	2019-04-03	2019-04-03	2019-04-03	2019-04-05	2019-04-05
Benzene	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	mg/L	0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Ethylbenzene	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Xylenes	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
C6 - C10 (F1)	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C6 - C10 (F1 minus BTEX)	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C10 - C16 (F2)	mg/L	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate	Unit	Acceptable Limits							
Toluene-d8 (BTEX)	%	50-150	104	111	107	94	104	104	90
o-Terphenyl (F2)	%	50-150	102	111	101	108	109	109	99

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

117518-117533

The F1 (C6 - C10) fraction is determined by integrating the FID chromatogram from the beginning of the nC6 peak to the apex of the last nC10 peak.
 The C6 - C10 fraction is calculated from the FID toluene response factor.
 The F2 (C10 - C16) fraction is determined by integrating the FID chromatogram from the apex of the nC10 peak to the apex of the nC16 peak.
 The F2 (C10 - C16) fraction is calculated using the average response factor for nC10, nC16, and nC34.
 Quality control for the calibration follows the guidelines set out in the CCME Contaminated Sites Method for Soils.
 C6 - C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
 C>10 - C16 (F2- Naphthalene) is a calculated parameter. The calculated value is F2 - Naphthalene (if requested). The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
 Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylenes + o-Xylene. The calculated parameter is non-accredited. The parameters that are components of the calculation are accredited.
 Extraction and holding times were met for this sample.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:

Elena Gorobets



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Metals - Dissolved - Alberta Tier 1

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-01	MW19-02	MW19-03	MW19-03A	MW19-04	MW19-07	MW19-10	MW19-11	
		SAMPLE TYPE:		Water								
		DATE SAMPLED:		2019-04-03	2019-04-04	2019-04-04	2019-04-04	2019-04-04	2019-04-04	2019-04-04	2019-04-05	2019-04-05
		G / S	RDL	117518	117519	117520	117521	117522	117523	117524	117525	
Dissolved Aluminum	mg/L	0.004	0.007	0.066	0.007	0.015	0.045	0.023	0.005	0.009		
Dissolved Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Dissolved Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Dissolved Barium	mg/L	0.05	<0.05	0.09	0.06	0.07	0.11	0.07	0.09	0.10		
Dissolved Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Dissolved Boron	mg/L	0.01	<0.01	0.01	<0.01	<0.01	0.01	0.03	<0.01	0.03		
Dissolved Cadmium	mg/L	0.000016	<0.000016	0.000047	0.000020	<0.000016	0.000074	0.000050	<0.000016	0.000049		
Dissolved Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001		
Dissolved Cobalt	mg/L	0.0009	<0.0009	0.0029	<0.0009	<0.0009	0.0014	0.0022	<0.0009	<0.0009		
Dissolved Copper	mg/L	0.0008	0.0012	<0.0008	0.0023	<0.0008	0.0014	0.0015	<0.0008	0.0015		
Dissolved Iron	mg/L	0.1	<0.1	0.2	<0.1	<0.1	0.4	<0.1	<0.1	<0.1		
Dissolved Lead	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005		
Dissolved Manganese	mg/L	0.005	0.050	0.287	0.042	0.094	0.154	0.183	0.039	0.108		
Dissolved Molybdenum	mg/L	0.001	0.001	0.005	0.002	0.001	0.003	0.025	0.002	0.001		
Dissolved Nickel	mg/L	0.003	<0.003	0.005	<0.003	<0.003	<0.003	0.006	<0.003	<0.003		
Dissolved Selenium	mg/L	0.0005	<0.0005	0.0006	0.0007	0.0007	0.0009	0.0013	<0.0005	0.0008		
Dissolved Silver	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		
Dissolved Sodium	mg/L	0.6	5.2	11.5	5.7	7.3	18.9	43.2	6.8	29.0		
Dissolved Thallium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		
Dissolved Titanium	mg/L	0.001	0.001	0.002	0.002	0.002	0.004	0.002	0.002	0.003		
Dissolved Uranium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	0.001		
Dissolved Zinc	mg/L	0.005	0.009	<0.005	0.008	0.006	0.007	0.008	<0.005	0.009		

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Metals - Dissolved - Alberta Tier 1

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-12	MW19-15A	MW19-17	MW19-18	MW19-06A	MW19-06B	SW19-01	MW19-09
		SAMPLE TYPE:		Water							
		DATE SAMPLED:		2019-04-03	2019-04-04	2019-04-05	2019-04-03	2019-04-05	2019-04-05	2019-04-05	2019-04-05
		G / S	RDL	117526	117529	117530	117531	117532	117533	117534	117537
Dissolved Aluminum	mg/L		0.004	0.008	0.014	0.006	0.010	0.006	0.008	<0.004	0.009
Dissolved Antimony	mg/L		0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved Arsenic	mg/L		0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.001
Dissolved Barium	mg/L		0.05	0.16	0.06	0.16	0.07	0.19	0.13	<0.05	0.10
Dissolved Beryllium	mg/L		0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved Boron	mg/L		0.01	0.04	0.11	0.10	0.01	0.02	0.02	<0.01	0.02
Dissolved Cadmium	mg/L		0.000016	0.000063	<0.000016	0.000018	0.000035	<0.000016	0.000040	<0.000016	<0.000016
Dissolved Chromium	mg/L		0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved Cobalt	mg/L		0.0009	0.0038	<0.0009	0.0011	0.0010	<0.0009	0.0026	<0.0009	0.0016
Dissolved Copper	mg/L		0.0008	0.0022	0.0014	0.0009	0.0014	0.0008	0.0017	<0.0008	<0.0008
Dissolved Iron	mg/L		0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Lead	mg/L		0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Dissolved Manganese	mg/L		0.005	0.296	0.090	0.152	0.183	<0.005	0.198	<0.005	0.468
Dissolved Molybdenum	mg/L		0.001	0.006	0.003	0.011	0.008	0.002	0.011	0.001	0.006
Dissolved Nickel	mg/L		0.003	0.012	<0.003	<0.003	<0.003	<0.003	0.005	<0.003	0.003
Dissolved Selenium	mg/L		0.0005	0.0025	<0.0005	<0.0005	0.0009	0.0012	0.0016	0.0007	<0.0005
Dissolved Silver	mg/L		0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Dissolved Sodium	mg/L		0.6	82.5	96.5	136	17.6	35.5	33.4	2.2	8.1
Dissolved Thallium	mg/L		0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dissolved Titanium	mg/L		0.001	0.003	0.003	0.004	0.001	0.002	0.002	<0.001	0.002
Dissolved Uranium	mg/L		0.001	0.002	<0.001	0.004	<0.001	0.002	0.001	<0.001	0.001
Dissolved Zinc	mg/L		0.005	0.010	0.008	0.008	0.006	0.008	0.007	<0.005	<0.005

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

117518-117537 < - Values refer to Report Detection Limit.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Metals - Total - Alberta Tier 1

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION: MW19-06A		MW19-06B		SW19-01		
		SAMPLE TYPE: Water		Water		Water		
		DATE SAMPLED: 2019-04-05		2019-04-05		2019-04-05		
		G / S	RDL	117532	RDL	117533	RDL	117534
Total Aluminum	mg/L		0.004	2.09	0.4	30.6	0.004	0.025
Total Antimony	mg/L		0.001	<0.001	0.001	0.001	0.001	<0.001
Total Arsenic	mg/L		0.001	0.003	0.001	0.071	0.001	<0.001
Total Barium	mg/L		0.05	0.27	0.05	1.30	0.05	<0.05
Total Beryllium	mg/L		0.0005	<0.0005	0.0005	0.0030	0.0005	<0.0005
Total Boron	mg/L		0.01	0.02	0.01	0.03	0.2	<0.2
Total Cadmium	mg/L		0.000016	0.000189	0.000016	0.00287	0.000016	<0.000016
Total Chromium	mg/L		0.0005	0.0040	0.0005	0.0671	0.0005	<0.0005
Total Cobalt	mg/L		0.0009	0.0020	0.0009	0.0479	0.0009	<0.0009
Total Copper	mg/L		0.0008	0.0056	0.0008	0.0613	0.0008	<0.0008
Total Iron	mg/L		0.1	3.9	0.1	71.0	0.1	<0.1
Total Lead	mg/L		0.0005	0.0028	0.0005	0.0526	0.0005	<0.0005
Total Manganese	mg/L		0.005	0.135	0.005	2.37	0.005	<0.005
Total Molybdenum	mg/L		0.001	0.003	0.001	0.007	0.001	0.001
Total Nickel	mg/L		0.003	0.006	0.003	0.103	0.003	<0.003
Total Selenium	mg/L		0.0005	0.0009	0.0005	0.0044	0.0005	0.0007
Total Silver	mg/L		0.00005	<0.00005	0.00005	0.00057	0.00005	<0.00005
Total Sodium	mg/L		0.6	41.2	0.6	28.6	0.6	2.7
Total Thallium	mg/L		0.0005	<0.0005	0.0005	0.0006	0.0005	<0.0005
Total Titanium	mg/L		0.001	0.021	0.001	0.112	0.001	0.002
Total Uranium	mg/L		0.001	0.002	0.001	0.007	0.001	<0.001
Total Zinc	mg/L		0.001	0.036	0.001	0.338	0.001	0.004

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

117532-117533 < - Values refer to Report Detection Limit.
Some dissolved metals are higher than total metals; the results have been confirmed.

117534 < - Values refer to Report Detection Limit.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-01	MW19-02	MW19-03	MW19-03A	MW19-04	MW19-07	MW19-10	MW19-11
		SAMPLE TYPE:		Water	Water	Water	Water	Water	Water	Water	Water
		DATE SAMPLED:		2019-04-03	2019-04-04	2019-04-04	2019-04-04	2019-04-04	2019-04-04	2019-04-04	2019-04-05
		G / S	RDL	117518	117519	117520	117521	117522	117523	117524	117525
pH	pH Units	7.0-10.5	N/A	8.14	8.14	8.19	8.18	8.09	8.27	8.08	8.03
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	154	237	181	197	257	191	225	293
Bicarbonate	mg/L		5	187	289	220	240	314	233	275	358
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	427	637	504	532	847	728	562	870
Chloride	mg/L	(250)	1	5	27	13	18	82	52	11	53
Fluoride	mg/L	1.5	0.01	0.08	0.12	0.10	0.09	0.13	0.25	0.11	0.12
Nitrate	mg/L	45	0.1	0.8	0.8	0.9	0.6	9.9	13.3	4.3	11.7
Nitrate-N	mg/L	10	0.02	0.18	0.18	0.20	0.14	2.24	3.00	0.97	2.64
Nitrite	mg/L	3	0.05	<0.05	0.06	<0.05	<0.05	<0.05	0.19	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.06	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	0.18	0.20	0.20	0.14	2.24	3.06	0.97	2.64
Sulfate	mg/L	(500)	1	56	48	53	51	53	89	54	72
Dissolved Calcium	mg/L		0.3	52.0	82.1	66.3	70.0	114	63.1	76.2	103
Dissolved Magnesium	mg/L		0.2	15.2	23.8	17.4	18.7	41.6	24.5	21.5	29.9
Dissolved Sodium	mg/L	(200)	0.6	5.2	11.5	5.7	7.3	18.9	43.2	6.8	29.0
Dissolved Potassium	mg/L		0.6	<0.6	1.3	0.8	0.8	1.4	2.8	0.7	1.5
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	0.2	<0.1	<0.1	0.4	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.05	0.005	0.050	0.287	0.042	0.094	0.154	0.183	0.039	0.108
Calculated TDS	mg/L		0.6	226	337	265	284	475	403	310	476
Sodium Adsorption Ratio	N/A			0.16	0.29	0.16	0.20	0.39	1.17	0.18	0.65
Hardness	mg CaCO3/L		1	192	303	237	252	456	258	279	380
Ion Balance	%		1	93	101	98	97	114	97	98	98

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-12	MW19-14	MW19-15	MW19-15A	MW19-17	MW19-18	MW19-06A	MW19-06B
		SAMPLE TYPE:		Water	Water	Water	Water	Water	Water	Water	Water
		DATE SAMPLED:		2019-04-03	2019-04-03	2019-04-04	2019-04-04	2019-04-05	2019-04-03	2019-04-05	2019-04-05
		G / S	RDL	117526	117527	117528	117529	117530	117531	117532	117533
pH	pH Units	7.0-10.5	N/A	8.07	8.20	8.21	8.04	8.34	8.24	8.10	8.14
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	297	246	440	322	377	151	212	198
Bicarbonate	mg/L		5	362	300	537	392	449	184	258	242
Carbonate	mg/L		5	<5	<5	<5	<5	5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	1470	1270	1380	998	876	514	936	731
Chloride	mg/L	(250)	1	226	22	15	94	4	34	118	69
Fluoride	mg/L	1.5	0.01	0.21	0.28	0.43	0.12	0.29	0.14	0.13	0.15
Nitrate	mg/L	45	0.1	36.3	3.5	30.4	1.1	0.6	1.7	5.5	3.1
Nitrate-N	mg/L	10	0.02	8.20	0.79	6.87	0.25	0.14	0.38	1.24	0.70
Nitrite	mg/L	3	0.05	<0.05	0.25	1.36	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	0.08	0.41	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	8.20	0.87	7.28	0.25	0.14	0.38	1.24	0.70
Sulfate	mg/L	(500)	1	67	363	248	58	87	64	73	65
Dissolved Calcium	mg/L		0.3	118	86.4	78.3	59.3	27.5	56.3	88.2	74.6
Dissolved Magnesium	mg/L		0.2	49.2	30.4	34.1	22.2	10.8	17.3	37.2	25.4
Dissolved Sodium	mg/L	(200)	0.6	82.5	122	161	96.5	136	17.6	35.5	33.4
Dissolved Potassium	mg/L		0.6	3.7	3.4	4.5	4.2	2.1	3.0	3.1	3.3
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.05	0.005	0.296	0.218	0.079	0.090	0.152	0.183	<0.005	0.198
Calculated TDS	mg/L		0.6	761	778	837	528	494	284	487	393
Sodium Adsorption Ratio	N/A			1.61	2.87	3.82	2.71	5.56	0.53	0.80	0.85
Hardness	mg CaCO3/L		1	497	341	336	239	113	212	373	291
Ion Balance	%		1	95	93	93	88	87	95	99	100

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION:		SW19-01	Dup 1	MW19-09
		SAMPLE TYPE:		Water	Water	Water
		DATE SAMPLED:		2019-04-05	2019-04-05	2019-04-05
		G / S	RDL	117534	117535	117537
pH	pH Units	7.0-10.5	N/A	8.40	8.18	7.99
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	137	212	255
Bicarbonate	mg/L		5	159	258	311
Carbonate	mg/L		5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5
Electrical Conductivity	uS/cm		5	360	937	667
Chloride	mg/L	(250)	1	2	120	8
Fluoride	mg/L	1.5	0.01	0.13	0.17	0.13
Nitrate	mg/L	45	0.1	0.6	5.3	0.8
Nitrate-N	mg/L	10	0.02	0.14	1.20	0.18
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	0.14	1.20	0.18
Sulfate	mg/L	(500)	1	49	73	90
Dissolved Calcium	mg/L		0.3	49.9	90.7	88.0
Dissolved Magnesium	mg/L		0.2	14.2	37.0	23.4
Dissolved Sodium	mg/L	(200)	0.6	2.2	36.2	8.1
Dissolved Potassium	mg/L		0.6	0.6	3.2	1.9
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.05	0.005	<0.005	<0.005	0.468
Calculated TDS	mg/L		0.6	197	492	373
Sodium Adsorption Ratio	N/A			0.07	0.81	0.20
Hardness	mg CaCO3/L		1	183	379	316
Ion Balance	%		1	102	100	93

Certified By:



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

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CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to 2017 Canadian Drinking Water Quality MAC (AO)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

117518-117537 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Water Analysis - TSS

DATE RECEIVED: 2019-04-06

DATE REPORTED: 2019-04-09

Parameter	Unit	SAMPLE DESCRIPTION: MW19-06A		MW19-06B		SW19-01	
		G / S	RDL	RDL		RDL	
		SAMPLE TYPE: Water		Water		Water	
		DATE SAMPLED: 2019-04-05		2019-04-05		2019-04-05	
			117532	20	117533	2	117534
Total Suspended Solids	mg/L		2	182	6040	2	2

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By: _____

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
PROJECT: A03330C01
SAMPLING SITE:

AGAT WORK ORDER: 19C454390
ATTENTION TO: Accounts Payable
SAMPLED BY:

Trace Organics Analysis

RPT Date: Apr 09, 2019			DUPLICATE				Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE		MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Measured Value		Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Petroleum Hydrocarbons (BTEX/F1-F2) in Water															
Benzene	3339	113282	0.0082	0.0075	8.9%	< 0.0005	94%	80%	120%	108%	80%	120%	105%	70%	130%
Toluene	3339	113282	0.0960	0.0940	2.1%	< 0.0003	102%	80%	120%	107%	80%	120%	100%	70%	130%
Ethylbenzene	3339	113282	0.0184	0.0172	6.7%	< 0.0005	99%	80%	120%	98%	80%	120%	94%	70%	130%
Xylenes	3339	113282	0.106	0.100	5.8%	< 0.0005	101%	80%	120%	101%	80%	120%	101%	70%	130%
C6 - C10 (F1)	3339	113282	0.6	0.6	0.0%	< 0.1	92%	80%	120%	106%	80%	120%	108%	70%	130%
C10 - C16 (F2)	121	117523	0.1	0.1	NA	< 0.1	105%	80%	120%	96%	80%	120%	99%	70%	130%

Comments: If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.
 The sample spikes and dups are not from the same sample ID.

Certified By: *Elena Gorobets*

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
AGAT WORK ORDER: 19C454390
PROJECT: A03330C01
ATTENTION TO: Accounts Payable
SAMPLING SITE:
SAMPLED BY:

Water Analysis																
RPT Date: Apr 09, 2019			DUPLICATE				Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Measured Value		Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits		
								Lower	Upper		Lower	Upper		Lower	Upper	

Routine Chemistry Water Analysis

pH	117518	117518	8.14	8.21	0.9%	N/A	100%	90%	110%						
T - Alkalinity (as CaCO ₃)	117518	117518	154	155	0.6%	< 5	106%	80%	120%						
Electrical Conductivity	117518	117518	427	434	1.6%	< 5	104%	80%	120%						
Chloride	117535	117535	120	120	0.0%	< 1	96%	80%	120%	92%	80%	120%	NA	80%	120%
Fluoride	117535	117535	0.16	0.17	NA	< 0.01	100%	80%	120%	105%	80%	120%	110%	80%	120%
Nitrate	117535	117535	5.3	5.1	3.8%	< 0.1	97%	80%	120%	96%	80%	120%	98%	80%	120%
Nitrite	117535	117535	<0.20	<0.20	NA	< 0.05	90%	80%	120%	88%	80%	120%	94%	80%	120%
Sulfate	117535	117535	72	73	1.4%	< 1	103%	80%	120%	102%	80%	120%	NA	80%	120%
Dissolved Calcium	114998		18.2	18.3	0.5%	< 0.3	117%	80%	120%	114%	80%	120%	NA	80%	120%
Dissolved Magnesium	114998		4.4	4.5	2.2%	< 0.2	105%	80%	120%	101%	80%	120%	NA	80%	120%
Dissolved Sodium	114998		5.4	5.4	0.0%	< 0.6	95%	80%	120%	89%	80%	120%	NA	80%	120%
Dissolved Potassium	114998		12.3	12.4	0.8%	< 0.6	94%	80%	120%	90%	80%	120%	NA	80%	120%
Dissolved Iron	114998		<0.1	<0.1	NA	< 0.1	119%	80%	120%	110%	80%	120%	96%	80%	120%
Dissolved Manganese	114998		<0.005	<0.005	NA	< 0.005	117%	80%	120%	107%	80%	120%	96%	80%	120%

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

pH has been analyzed past the recommended holding time of 15 minutes from sampling (field measurement ideal if more accurate data required)

Nitrate and Nitrite: The regulatory hold time for the analysis of nitrate and/or nitrite in water is 72 hours.

Metals - Dissolved - Alberta Tier 1

Dissolved Aluminum	113504		0.028	0.025	11.3%	< 0.004	103%	80%	120%	101%	80%	120%	101%	80%	120%
Dissolved Antimony	113504		<0.001	<0.001	NA	< 0.001	104%	80%	120%	100%	80%	120%	106%	80%	120%
Dissolved Arsenic	113504		<0.001	<0.001	NA	< 0.001	104%	80%	120%	105%	80%	120%	114%	80%	120%
Dissolved Barium	113504		0.07	0.07	NA	< 0.05	97%	80%	120%	101%	80%	120%	109%	80%	120%
Dissolved Beryllium	113504		<0.001	<0.001	NA	< 0.001	101%	80%	120%	101%	80%	120%	87%	80%	120%
Dissolved Boron	113504		0.02	0.01	NA	< 0.01	93%	80%	120%	106%	80%	120%	103%	80%	120%
Dissolved Cadmium	113504		0.000018	<0.	NA	< 0.000016	101%	80%	120%	102%	80%	120%	109%	80%	120%
Dissolved Chromium	113504		<0.001	<0.001	NA	< 0.001	107%	80%	120%	100%	80%	120%	108%	80%	120%
Dissolved Cobalt	113504		<0.0009	<0.0009	NA	< 0.0009	108%	80%	120%	102%	80%	120%	109%	80%	120%
Dissolved Copper	113504		0.0018	0.0018	NA	< 0.0008	103%	80%	120%	102%	80%	120%	107%	80%	120%
Dissolved Iron	114998		<0.1	<0.1	NA	< 0.1	119%	80%	120%	110%	80%	120%	96%	80%	120%
Dissolved Lead	113504		<0.0005	<0.0005	NA	< 0.0005	99%	80%	120%	103%	80%	120%	108%	80%	120%
Dissolved Manganese	114998		<0.005	<0.005	NA	< 0.005	117%	80%	120%	107%	80%	120%	96%	80%	120%
Dissolved Molybdenum	113504		<0.001	<0.001	NA	< 0.001	103%	80%	120%	100%	80%	120%	110%	80%	120%
Dissolved Nickel	113504		<0.003	<0.003	NA	< 0.003	103%	80%	120%	102%	80%	120%	105%	80%	120%
Dissolved Selenium	113504		<0.0005	<0.0005	NA	< 0.0005	99%	80%	120%	102%	80%	120%	109%	80%	120%
Dissolved Silver	113504		0.00013	0.00009	NA	< 0.00005	91%	80%	120%	92%	80%	120%	86%	80%	120%
Dissolved Sodium	114998		5.4	5.4	0.0%	< 0.6	95%	80%	120%	89%	80%	120%	NA	80%	120%
Dissolved Thallium	113504		<0.0001	<0.0001	NA	< 0.0001	103%	80%	120%	100%	80%	120%	106%	80%	120%

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
PROJECT: A03330C01
SAMPLING SITE:

AGAT WORK ORDER: 19C454390
ATTENTION TO: Accounts Payable
SAMPLED BY:

Water Analysis (Continued)																
RPT Date: Apr 09, 2019			DUPLICATE				Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Measured Value		Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits		
								Lower	Upper		Lower	Upper		Lower	Upper	
Dissolved Titanium	113504		0.001	<0.001	NA	< 0.001	105%	80%	120%	101%	80%	120%	103%	80%	120%	
Dissolved Uranium	113504		<0.001	<0.001	NA	< 0.001	101%	80%	120%	103%	80%	120%	109%	80%	120%	
Dissolved Zinc	113504		<0.005	<0.005	NA	< 0.004	99%	80%	120%	104%	80%	120%	111%	80%	120%	

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

Metals - Total - Alberta Tier 1

Total Aluminum	118657		0.647	0.658	1.7%	< 0.004	90%	80%	120%	86%	80%	120%	NA	80%	120%
Total Antimony	118657		<0.001	<0.001	NA	< 0.001	113%	80%	120%	108%	80%	120%	113%	80%	120%
Total Arsenic	118657		<0.001	<0.001	NA	< 0.001	104%	80%	120%	108%	80%	120%	116%	80%	120%
Total Barium	118657		0.14	0.14	NA	< 0.05	102%	80%	120%	104%	80%	120%	104%	80%	120%
Total Beryllium	118657		<0.0005	<0.0005	NA	< 0.0005	103%	80%	120%	107%	80%	120%	113%	80%	120%
Total Boron	118657		<0.01	<0.01	NA	< 0.01	114%	80%	120%	93%	80%	120%	101%	80%	120%
Total Cadmium	118657		<0.	<0.	NA	< 0.000016	103%	80%	120%	107%	80%	120%	109%	80%	120%
Total Chromium	118657		<0.0005	<0.0005	NA	< 0.0005	103%	80%	120%	99%	80%	120%	102%	80%	120%
Total Cobalt	118657		<0.0009	<0.0009	NA	< 0.0009	102%	80%	120%	97%	80%	120%	102%	80%	120%
Total Copper	118657		0.0009	<0.0008	NA	< 0.0008	100%	80%	120%	99%	80%	120%	102%	80%	120%
Total Iron	118657		<0.1	<0.1	NA	< 0.1	100%	80%	120%	106%	80%	120%	95%	80%	120%
Total Lead	118657		<0.0005	<0.0005	NA	< 0.0005	106%	80%	120%	107%	80%	120%	108%	80%	120%
Total Manganese	118657		<0.005	0.005	NA	< 0.005	99%	80%	120%	100%	80%	120%	94%	80%	120%
Total Molybdenum	118657		0.003	<0.001	NA	< 0.001	104%	80%	120%	101%	80%	120%	101%	80%	120%
Total Nickel	118657		<0.003	<0.003	NA	< 0.003	103%	80%	120%	97%	80%	120%	102%	80%	120%
Total Selenium	118657		<0.0005	<0.0005	NA	< 0.0005	101%	80%	120%	107%	80%	120%	107%	80%	120%
Total Silver	118657		0.00028	0.00016	NA	< 0.00005	97%	80%	120%	87%	80%	120%	89%	80%	120%
Total Sodium	118657		7.6	7.7	1.3%	< 0.6	101%	80%	120%	104%	80%	120%	NA	80%	120%
Total Thallium	118657		<0.0005	<0.0005	NA	< 0.0005	102%	80%	120%	102%	80%	120%	103%	80%	120%
Total Titanium	118657		0.002	0.002	NA	< 0.001	107%	80%	120%	99%	80%	120%	104%	80%	120%
Total Uranium	118657		<0.001	<0.001	NA	< 0.001	103%	80%	120%	102%	80%	120%	106%	80%	120%
Total Zinc	118657		0.003	0.005	NA	< 0.001	94%	80%	120%	98%	80%	120%	109%	80%	120%

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

Water Analysis - TSS

Total Suspended Solids	121045		<2	<2	NA	< 2	99%	80%	120%				101%	80%	120%
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Comments: If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 19C454390

PROJECT: A03330C01

ATTENTION TO: Accounts Payable

SAMPLING SITE:

SAMPLED BY:

Water Analysis (Continued)

RPT Date: Apr 09, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Certified By:



Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
AGAT WORK ORDER: 19C454390
PROJECT: A03330C01
ATTENTION TO: Accounts Payable
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Trace Organics Analysis			
Benzene	TO 0332	EPA SW-846 5021/8260-W	GC/MS
Toluene	TO 0332	EPA SW-846 5021/8260-W	GC/MS
Ethylbenzene	TO 0332	EPA SW-846 5021/8260-W	GC/MS
Xylenes	TO 0332	EPA SW-846 5021/8260-W	GC/MS
C6 - C10 (F1)	TO 0542	EPA SW-846 5021, CCME Tier 1 Method-W	GC/FID
C6 - C10 (F1 minus BTEX)	TO 0542	EPA SW-846 5021, CCME Tier 1 Method-W	GC/FID
C10 - C16 (F2)	TO 0511	EPA SW-846 3511, CCME Tier 1 Method-W	GC/FID
Toluene-d8 (BTEX)	TO-0543	EPA SW-846 5021/8260-W	GC/MS
o-Terphenyl (F2)	TO 0511	EPA SW-846 3511, CCME Tier 1 Method-W	GC/FID

Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
AGAT WORK ORDER: 19C454390
PROJECT: A03330C01
ATTENTION TO: Accounts Payable
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Dissolved Aluminum	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Antimony	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Arsenic	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Barium	INST 0141	SM 3125 B DW	ICP-MS
Dissolved Beryllium	INST 0141	SM 3125 B	ICP-MS
Dissolved Boron	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Cadmium	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Chromium	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Cobalt	INST 0141	SM 3125 B DW	ICP-MS
Dissolved Copper	INST 0141	SM 3125 B DW	ICP-MS
Dissolved Iron	INST 0140	SM 3120 B DW	ICP/OES
Dissolved Lead	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Manganese	INST 0140	SM 3120 B DW	ICP/OES
Dissolved Molybdenum		SM 3125 B	ICP-MS
Dissolved Nickel	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Selenium	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Silver	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Sodium	INST 0140	SM 3120 B DW	ICP/OES
Dissolved Thallium	INST 0141	SM 3125 B DW	ICP-MS
Dissolved Titanium	INST 0141	SM 3125 B	ICP-MS
Dissolved Uranium	INST 0141	SM 3125 B DW	ICP/MS
Dissolved Zinc	INST 0141	SM 3125 B DW	ICP/MS
Total Aluminum	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Antimony	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Arsenic	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Barium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Beryllium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B	ICP-MS
Total Boron	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Cadmium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Chromium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Cobalt	WATR 0200; INST 0141	SM 3030 E; SM 3125 B	ICP-MS
Total Copper	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Iron	WATR 0200; INST 0140	SM 3030 E; SM 3120 B TW	ICP/OES
Total Lead	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Manganese	WATR 0200; INST 0140	SM 3030 E; SM 3120 B TW	ICP/OES
Total Molybdenum	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Nickel	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Selenium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Silver	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Sodium	WATR 0200; INST 0140	SM 3030 E; SM 3120 B TW	ICP/OES
Total Thallium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Titanium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B	ICP-MS
Total Uranium	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
Total Zinc	WATR 0200; INST 0141	SM 3030 E; SM 3125 B TW	ICP/MS
pH	INST 0101, INST 0104	SM 4500 H+	PH METER
p - Alkalinity (as CaCO ₃)	INST 0101	SM 2320 B	TITRATION
T - Alkalinity (as CaCO ₃)	INST 0101	SM 2320 B	TITRATION
Bicarbonate	INST 0101	SM 2320 B	PC TITRATE
Carbonate	INST 0101	SM 2320 B	PC TITRATE

Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
AGAT WORK ORDER: 19C454390
PROJECT: A03330C01
ATTENTION TO: Accounts Payable
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Hydroxide	WAT 0310	SM 2320 B	TITRATION
Electrical Conductivity	INST 0101, INST 0120	SM 2510 B	CONDUCTIVITY METER
Chloride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Fluoride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate-N	INST 0150	SM 4110 B	CALCULATION
Nitrite	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrite-N	INST 0150	SM 4110 B	CALCULATION
Nitrate+Nitrite - Nitrogen	INST 0150	SM 4110 B	CALCULATION
Sulfate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Dissolved Calcium	INST 0140	SM 3120 B DW -R	ICP/OES
Dissolved Magnesium	INST 0140	SM 3120 B DW -R	ICP/OES
Dissolved Sodium	INST 0140	SM 3120 B DW -R	ICP/OES
Dissolved Potassium	INST 0140	SM 3120 B DW -R	ICP/OES
Dissolved Iron	INST 0140	SM 3120 B DW -R	ICP/OES
Dissolved Manganese	INST 0140	SM 3120 B DW -R	ICP/OES
Calculated TDS		SM 1030E	CALCULATION
Sodium Adsorption Ratio		CARTER & GREGORICH 2007	CALCULATION
Hardness		SM 2340 B	CALCULATION
Ion Balance		SM 1030E	CALCULATION
Total Suspended Solids	WATR 0600	SM 2540 D	GRAVIMETRIC

Chain of Custody Record

Emergency Support Services Hotline **1-855-AGAT 245 (1-855-242-8245)**

Report Information
 Company: KCB
 Contact: KYLE SCHEPANOW
 Address: 500-2616 HAYDEN PLACE NE
Calgary AB T1Y 7J7
 Phone: 403 098 4292 Fax: _____
 LSD: N/A
 Client Project #: A03330C01
 Sampled By: Kyle Schepanow

Report Information
 1. Name: Kyle Schepanow
 Email: Kschepanow@klohn.com
 2. Name: _____
 Email: _____
 3. Name: _____
 Email: _____

Turnaround Time Required (TAT)
 Regular TAT 5 to 7 Business Days
 <24 Hours (200%)
 Two Day / Next Day (100%)
 Rush TAT Three Day (50%)
 Four Day (25%)
 Date Required: _____

SEE BACK FOR
 SURCHARGE
 BREAKDOWN.
 CONTACT YOUR CPM
 FOR ADDITIONAL
 INFORMATION

Invoice To Same Yes No
 Company: KCB
 Contact: Accounting
 Address: _____
 Phone: _____ Fax: _____
 PO/AFE#: _____
 Standing Offer #: _____

Requirements (Selection may impact detection limits)
 CCME AB Tier 1
 Agricultural Agricultural
 Industrial Industrial
 Residential/Park Residential/Park
 Commercial Commercial
 FWAL Natural Area
 Drinking Water Alberta Surface Water
 Other: Chronic Acute

Report Format
 Single Sample Per Page
 Multiple Samples Per Page
 Export

LABORATORY USE (LAB ID #)	SAMPLE IDENTIFICATION	DEPTH	DATE/TIME SAMPLED	SAMPLE MATRIX	COMMENTS (FILTERED, PRESERVED, HAZARDOUS*) *ADDITIONAL FEE	# OF CONTAINERS			Detailed Salinity: <input type="checkbox"/> AB <input type="checkbox"/> SK <input type="checkbox"/> BC <input type="checkbox"/> D50	<input type="checkbox"/> CCME/AB : BTEX/F1-F2	<input type="checkbox"/> BC: BTEXS/VP/EPH <input type="checkbox"/> BC: LEPH/HEPH	SK: BTEX/TVH/C11-C22, C23-C60	Soil Metals: <input type="checkbox"/> HWS-B <input type="checkbox"/> SP-B <input type="checkbox"/> Hg <input type="checkbox"/> Cr ⁶⁺	Water Metals: <input checked="" type="checkbox"/> Dissolved <input type="checkbox"/> Total <input type="checkbox"/> Hg <input type="checkbox"/> Cr ⁶⁺	Routine Water Chemistry	Landfill: <input type="checkbox"/> AB Class 2 <input type="checkbox"/> BC <input type="checkbox"/> SK	Coliforms: <input type="checkbox"/> Total <input type="checkbox"/> Fecal <input type="checkbox"/> E.coli	Particle Size: <input type="checkbox"/> Sieve (75µm) <input type="checkbox"/> Texture	HOLD FOR 30 DAYS NO ANALYSIS (Additional Fee)	HOLD FOR 30 DAYS AFTER ANALYSIS (Additional Fee)
						VIALS / JARS	BAGS	BOTTLES												
1	117518 MW19-01		APR 3/19 PM	Water	Filtered/PRES				X				X	X						
2	519 MW19-02		APR 4/19 PM										X							
3	520 MW19-03		APR 4/19 PM										X							
4	0120 MW19-03A		APR 4/19 PM										X							
5	0207 MW19-04		APR 4/19 PM										X							
6	0322 MW19-07		APR 7/19 AM						X				X							
7	0423 MW19-10		APR 5/19 PM										X							
8	0524 MW19-11		APR 5/19 AM										X							
9	0625 MW19-12		APR 3/19 PM						X				X							
10	527 MW19-17		APR																	Lots of sediment

Samples Relinquished By (Print Name and Sign): <u>Kyle Schepanow</u> <u>[Signature]</u>	Date/Time: <u>2019/04/06 1552</u>	Samples Received By (Print Name and Sign): <u>PM MAGNILLIS</u> <u>[Signature]</u>	Date/Time: <u>4/6/19</u>	Pink Copy - Client	Page <u>1</u> of <u>2</u>
Samples Relinquished By (Print Name and Sign): _____	Date/Time: _____	Samples Received By (Print Name and Sign): _____	Date/Time: _____	Yellow Copy - AGAT	No: AB 081049
Samples Relinquished By (Print Name and Sign): _____	Date/Time: _____	Samples Received By (Print Name and Sign): _____	Date/Time: _____	White Copy - AGAT	



Laboratories

190474390

2910 12 Street NE
Calgary, Alberta
T2E 7P7

webearth.agatlabs.com

Chain of Custody Record

P: 403.735.2005 • F: 403.735.2771

Report to:

Company:

KCB

Same as COC#:

80149

LABORATORY USE (LAB ID #)	SAMPLE IDENTIFICATION	SAMPLE MATRIX	DATE/TIME SAMPLED	COMMENTS - SITE SAMPLE INFO. SAMPLE CONTAINMENT	# OF CONTAINERS	Detailed Soil Salinity (Saturated Paste) CCME BTEX/F1 <input checked="" type="checkbox"/> F2 Soil Metals <input type="checkbox"/> HWS-B <input type="checkbox"/> Cr <input type="checkbox"/> Hg	Water Metals <input checked="" type="checkbox"/> Dissolved <input type="checkbox"/> Total <input type="checkbox"/> Hg	Routine Water Potability	AB Class 2 Landfill	BC Landfill	D50 Detailed Soil Salinity (As Received)	Microtox	BTEX/VPH/EPH <input type="checkbox"/> LEPH/HEPH <input type="checkbox"/>	TSS	torr metal	HOLD FOR 60 DAYS	PRESERVED (Y/N)	CONTAMINATED/HAZARDOUS (Y/N)
11228	MW19-15	Water	APR 4 2019 4:00 AM	only routine	1			X										
129	MW19-15A		APR 4/19 4:00 PM	Filtered & Pres	2		X	X										
130	MW19-17		APR 5/19 AM		2		X	X										
131	MW19-18		APR 3/19 PM		1	X	X	X										
132	MW19-06A		APR 5/19 PM		1	X	X	X					X	X				
133	MW19-06B		APR 5/19 PM		1	X	X	X					X	X				
134	MW19-06C																	
134	SW19-01	Water	APR 5/19 PM	take TSS From Routine BOTTLE	3		X	X					X	X				
135	DUP1	Water	APR 5/19 PM					X										
137	MW19-09	Water	APR 5/19 PM	Field Filter/Pier	2		X	X										

Samples Relinquished By (Print Name and Sign):
Kyle Scherrow
 Samples Relinquished By (Print Name and Sign):
 Samples Relinquished By (Print Name and Sign):

Date/Time: 4/19/2019 15:52
 Date/Time:
 Date/Time:

Samples Received By (Print Name and Sign):
PM MAGNUS
 Samples Received By (Print Name and Sign):
 Samples Received By (Print Name and Sign):

Date/Time:
 Date/Time:
 Date/Time:

Pink Copy - Client
 Yellow Copy - AGAT
 White Copy - AGAT

Page 2 of 2
 No: AB 051190 A

RECEIVING BASICS - Shipping

Company/Consultant: KCB
 Courier: DROP OFF Prepaid Collect
 Waybill# NONE
 Branch: EDM GP FN FM RD VAN LYD FSJ EST Other: C
 If multiple sites were submitted at once: Yes No
 Custody Seal Intact: Yes No NA
 TAT: <24hr 24-48hr 48-72hr Reg Other _____
 Cooler Quantity: 1

TIME SENSITIVE ISSUES - Shipping

ALREADY EXCEEDED HOLD TIME? Yes No
 Inorganic Tests (Please Circle): Mibi , BOD , Nitrate/Nitrite , Turbidity ,
 Microtox , Ortho PO4 , Tedlar Bag , Residual Chlorine , Chlorophyll* ,
 Chloroamines*
 Earliest Expiry: April 6 2019
 Hydrocarbons: Earliest Expiry _____

SAMPLE INTEGRITY - Shipping

Hazardous Samples: YES NO Precaution Taken: _____
 Legal Samples: Yes No
 International Samples: Yes No
 Tape Sealed: Yes No
 Coolant Used: Icepack Bagged Ice Free Ice Free Water None

Temperature (Bottles/Jars only) N/A if only Soil Bags Received

FROZEN (Please Circle if samples received Frozen)

1 (Bottle/Jar) 4 + 4 + 4 = 4 °C 2(Bottle/Jar) ___ + ___ + ___ = ___ °C
 3 (Bottle/Jar) ___ + ___ + ___ = ___ °C 4 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 5 (Bottle/Jar) ___ + ___ + ___ = ___ °C 6 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 7 (Bottle/Jar) ___ + ___ + ___ = ___ °C 8 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 9 (Bottle/Jar) ___ + ___ + ___ = ___ °C 10 (Bottle/Jar) ___ + ___ + ___ = ___ °C

(If more than 10 coolers are received use another sheet of paper and attach)

LOGISTICS USE ONLY

Workorder No: 190452390
 Samples Damaged: Yes No If YES why?
 No Bubble Wrap Frozen Courier
 Other: _____
 Account Project Manager: _____ have they been notified of the
 above issues: Yes No
 Whom spoken to: _____ Date/Time: _____
 CPM Initial _____
 General Comments: _____

* Subcontracted Analysis (See CPM)

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
500-2618 HOPEWELL PLACE NE
CALGARY, AB T1Y7J7
(403) 274-3424

ATTENTION TO: Kyle Schepanow

PROJECT: A03330CO1

AGAT WORK ORDER: 19C485094

WATER ANALYSIS REVIEWED BY: Jennifer Liu, Analyst

DATE REPORTED: Jul 07, 2019

PAGES (INCLUDING COVER): 10

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



Certificate of Analysis

AGAT WORK ORDER: 19C485094

PROJECT: A03330CO1

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Kyle Schepanow

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-06-25

DATE REPORTED: 2019-07-03

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-01	MW19-02	MW19-03	MW19-03A	MW19-04	MW19-06	MW19-06A	MW19-06B
		SAMPLE TYPE:		Water							
		DATE SAMPLED:		2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25
		G / S	RDL	306085	306088	306089	306090	306091	306092	306093	306094
pH	pH Units	7.0-10.5	N/A	8.06	7.99	8.01	8.05	7.99	8.13	8.13	8.00
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	137	198	154	194	251	152	189	169
Bicarbonate	mg/L		5	167	241	187	236	306	185	230	207
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	327	497	354	500	588	364	541	461
Chloride	mg/L	(250)	1	5	16	3	21	18	5	32	22
Fluoride	mg/L	1.5	0.01	0.06	0.06	0.09	0.07	0.09	0.10	0.13	0.18
Nitrate	mg/L	45	0.1	0.7	1.5	0.7	<0.1	1.5	0.3	2.2	1.0
Nitrate-N	mg/L	10	0.02	0.16	0.34	0.16	<0.02	0.34	0.07	0.50	0.23
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.22	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	0.16	0.34	0.16	<0.02	0.34	0.07	0.56	0.23
Sulfate	mg/L	(500)	1	34	50	36	52	51	38	49	43
Dissolved Calcium	mg/L		0.3	44.7	70.0	51.8	67.7	82.4	52.8	61.7	51.9
Dissolved Magnesium	mg/L		0.2	12.7	18.9	13.5	21.0	26.3	13.2	18.3	17.5
Dissolved Sodium	mg/L	(200)	0.6	5.5	8.4	3.8	10.1	9.9	4.7	24.8	10.9
Dissolved Potassium	mg/L		0.6	0.7	0.8	0.6	0.9	1.0	1.4	2.5	1.8
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.05	0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	0.013	<0.005
Sodium Adsorption Ratio				0.19	0.23	0.12	0.27	0.24	0.15	0.71	0.33
Calculated TDS	mg/L		0.6	185	284	201	289	341	206	304	250
Hardness	mg CaCO3/L		1	164	253	185	256	314	186	229	202
Ion Balance	%		1	98	99	99	100	102	100	100	92

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C485094

PROJECT: A03330CO1

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Kyle Schepanow

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-06-25

DATE REPORTED: 2019-07-03

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-06C	MW19-07	MW19-09	MW19-11	MW19-14	MW19-15	MW19-15A	MW19-17
		SAMPLE TYPE:		Water							
		DATE SAMPLED:		2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25	2019-06-25
		G / S	RDL	306095	306096	306097	306098	306099	306100	306101	306102
pH	pH Units	7.0-10.5	N/A	8.03	8.02	7.85	7.95	8.06	8.05	8.06	8.00
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	233	167	270	238	219	443	285	418
Bicarbonate	mg/L		5	284	204	329	290	267	541	348	510
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	916	1230	773	627	1020	1480	937	911
Chloride	mg/L	(250)	1	104	249	14	22	22	47	92	5
Fluoride	mg/L	1.5	0.01	0.17	0.13	0.08	0.07	0.18	0.33	0.43	2.00
Nitrate	mg/L	45	0.1	8.1	37.1	0.8	7.5	1.1	12.7	0.1	0.2
Nitrate-N	mg/L	10	0.02	1.83	8.38	0.18	1.69	0.25	2.87	0.02	0.05
Nitrite	mg/L	3	0.05	<0.05	0.08	<0.05	<0.05	0.16	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	0.02	<0.01	<0.01	0.05	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	1.83	8.41	0.18	1.69	0.30	2.87	0.02	0.05
Sulfate	mg/L	(500)	1	75	43	144	68	293	271	57	56
Dissolved Calcium	mg/L		0.3	95.6	105	109	81.0	79.7	57.2	54.8	29.3
Dissolved Magnesium	mg/L		0.2	38.2	41.9	32.8	23.6	32.4	24.0	21.4	12.0
Dissolved Sodium	mg/L	(200)	0.6	36.5	64.6	13.8	19.2	105	248	113	162
Dissolved Potassium	mg/L		0.6	3.9	3.7	0.7	1.1	2.8	4.0	4.3	3.0
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.05	0.005	<0.005	0.015	<0.005	<0.005	0.186	0.043	0.109	0.246
Sodium Adsorption Ratio			0.80	1.35	0.30	0.48	2.51	6.94	3.28	6.37	
Calculated TDS	mg/L		0.6	501	645	477	365	667	930	514	518
Hardness	mg CaCO3/L		1	396	435	407	299	332	242	225	123
Ion Balance	%		1	103	98	99	99	101	98	100	98

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 19C485094

PROJECT: A03330CO1

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Kyle Schepanow

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-06-25

DATE REPORTED: 2019-07-03

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-18	MW19-19	DUP 1	SW19-02
		SAMPLE TYPE:		Water	Water	Water	Water
		DATE SAMPLED:		2019-06-25	2019-06-25	2019-06-25	2019-06-25
		G / S	RDL	306103	306104	306105	306106
pH	pH Units	7.0-10.5	N/A	8.06	7.97	8.00	8.26
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	174	219	168	122
Bicarbonate	mg/L		5	212	268	205	149
Carbonate	mg/L		5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	536	483	460	288
Chloride	mg/L	(250)	1	36	5	22	3
Fluoride	mg/L	1.5	0.01	0.11	0.07	0.18	0.05
Nitrate	mg/L	45	0.1	0.7	1.0	1.1	0.5
Nitrate-N	mg/L	10	0.02	0.16	0.23	0.25	0.11
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	0.16	0.23	0.25	0.11
Sulfate	mg/L	(500)	1	49	51	42	30
Dissolved Calcium	mg/L		0.3	62.2	65.1	51.1	39.6
Dissolved Magnesium	mg/L		0.2	16.5	22.4	17.3	11.9
Dissolved Sodium	mg/L	(200)	0.6	22.5	5.5	10.8	2.9
Dissolved Potassium	mg/L		0.6	2.1	1.0	1.7	<0.6
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.05	0.005	0.011	<0.005	<0.005	<0.005
Sodium Adsorption Ratio				0.65	0.15	0.33	0.10
Calculated TDS	mg/L		0.6	293	283	247	161
Hardness	mg CaCO3/L		1	223	255	199	148
Ion Balance	%		1	99	95	92	97

Certified By:



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19C485094

PROJECT: A03330CO1

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Kyle Schepanow

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-06-25

DATE REPORTED: 2019-07-03

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to 2017 Canadian Drinking Water Quality MAC (AO)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

306085-306106 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:

Quality Assurance

 CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
 PROJECT: A03330CO1
 SAMPLING SITE:

 AGAT WORK ORDER: 19C485094
 ATTENTION TO: Kyle Schepanow
 SAMPLED BY: Kyle Schepanow

Water Analysis

RPT Date:		DUPLICATE					Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Measured Value		Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits		
								Lower	Upper		Lower	Upper		Lower	Upper	
Routine Chemistry Water Analysis																
pH	306837		8.11	8.16	0.6%	N/A	101%	90%	110%							
T - Alkalinity (as CaCO ₃)	306837		126	126	0.0%	< 5	107%	80%	120%							
Electrical Conductivity	306837		250	250	0.0%	< 5	102%	80%	120%							
Chloride	306093	306093	28	28	0.0%	< 1	98%	80%	120%	95%	80%	120%	98%	80%	120%	
Fluoride	306093	306093	<0.06	<0.06	NA	< 0.01	98%	80%	120%	102%	80%	120%	83%	80%	120%	
Nitrate	306093	306093	2.0	2.3	NA	< 0.1	100%	80%	120%	100%	80%	120%	98%	80%	120%	
Nitrite	306093	306093	<0.20	<0.20	NA	< 0.05	96%	80%	120%	95%	80%	120%	95%	80%	120%	
Sulfate	306093	306093	44	46	4.4%	< 1	98%	80%	120%	97%	80%	120%	96%	80%	120%	
Dissolved Calcium	311173		323	316	2.2%	< 0.3	104%	80%	120%	107%	80%	120%	NA	80%	120%	
Dissolved Magnesium	311173		126	125	0.8%	< 0.2	99%	80%	120%	94%	80%	120%	NA	80%	120%	
Dissolved Sodium	311173		353	347	1.7%	< 0.6	100%	80%	120%	94%	80%	120%	NA	80%	120%	
Dissolved Potassium	311173		13.9	13.7	1.4%	< 0.6	93%	80%	120%	87%	80%	120%	NA	80%	120%	
Dissolved Iron	311173		<0.1	<0.1	NA	< 0.1	90%	80%	120%	89%	80%	120%	82%	80%	120%	
Dissolved Manganese	311173		0.232	0.231	0.4%	< 0.005	91%	80%	120%	87%	80%	120%	NA	80%	120%	

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

pH has been analyzed past the recommended holding time of 15 minutes from sampling (field measurement ideal if more accurate data required)

Nitrate and Nitrite: The regulatory hold time for the analysis of nitrate and/or nitrite in water is 72 hours.

Certified By: _____





Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
 PROJECT: A03330CO1
 SAMPLING SITE:

AGAT WORK ORDER: 19C485094
 ATTENTION TO: Kyle Schepanow
 SAMPLED BY: Kyle Schepanow

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
pH	INST 0101, INST 0104	SM 4500 H+	PH METER
p - Alkalinity (as CaCO3)	INST 0101	SM 2320 B	TITRATION
T - Alkalinity (as CaCO3)	INST 0101	SM 2320 B	TITRATION
Bicarbonate	INST 0101	SM 2320 B	PC TITRATE
Carbonate	INST 0101	SM 2320 B	PC TITRATE
Hydroxide	INST 0101	SM 2320 B	PC TITRATE
Electrical Conductivity	INST 0101, INST 0120	SM 2510 B	CONDUCTIVITY METER
Chloride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Fluoride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate-N	INST 0150	SM 4110 B	CALCULATION
Nitrite	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrite-N	INST 0150	SM 4110 B	CALCULATION
Nitrate+Nitrite - Nitrogen	INST 0150	SM 4110 B	CALCULATION
Sulfate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Dissolved Calcium	INST 0140	SM 3120 B	ICP/OES
Dissolved Magnesium	INST 0140	SM 3120 B	ICP/OES
Dissolved Sodium	INST 0140	SM 3120 B	ICP/OES
Dissolved Potassium	INST 0140	SM 3120 B	ICP/OES
Dissolved Iron	INST 0140	SM 3120 B	ICP/OES
Dissolved Manganese	INST 0140	SM 3120 B	ICP/OES
Sodium Adsorption Ratio		CARTER & GREGORICH 2007	CALCULATION
Calculated TDS		SM 1030E	CALCULATION
Hardness		SM 2340 B	CALCULATION
Ion Balance		SM 1030E	CALCULATION



AGAT Laboratories

SAMPLE INTEGRITY RECEIPT FORM

RECEIVING BASICS - Shipping

Company/Consultant: Disc. KCB
 Courier: D/O Prepaid Collect
 Waybill# _____
 Branch: EDM GP FN FM RD VAN LYD FSJ EST Other: C
 If multiple sites were submitted at once: Yes No
 Custody Seal Intact: Yes No NA
 TAT: <24hr 24-48hr 48-72hr Reg Other _____
 Cooler Quantity: _____

TIME SENSITIVE ISSUES - Shipping

ALREADY EXCEEDED HOLD TIME? Yes No
 Inorganic Tests (Please Circle): Mibi , BOD , Nitrate/Nitrite , Turbidity ,
 Microtox , Ortho PO4 , Tedlar Bag , Residual Chlorine , Chlorophyll* ,
 Chloroamines*
 Earliest Expiry: June 29, 2014
 Hydrocarbons: Earliest Expiry NA

SAMPLE INTEGRITY - Shipping

Hazardous Samples: YES NO Precaution Taken: NA
 Legal Samples: Yes No
 International Samples: Yes No
 Tape Sealed: Yes No
 Coolant Used: Icepack Bagged Ice Free Ice Free Water None

Temperature (Bottles/Jars only) N/A if only Soil Bags Received

FROZEN (Please Circle if samples received Frozen)

1 (Bottle/Jar) 15 + 15 + 15 = 15 °C 2 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 3 (Bottle/Jar) ___ + ___ + ___ = ___ °C 4 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 5 (Bottle/Jar) ___ + ___ + ___ = ___ °C 6 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 7 (Bottle/Jar) ___ + ___ + ___ = ___ °C 8 (Bottle/Jar) ___ + ___ + ___ = ___ °C
 9 (Bottle/Jar) ___ + ___ + ___ = ___ °C 10 (Bottle/Jar) ___ + ___ + ___ = ___ °C

(If more than 10 coolers are received use another sheet of paper and attach)

LOGISTICS USE ONLY

Workorder No: 19C485094
 Samples Damaged: Yes No If YES why?
 No Bubble Wrap Frozen Courier
 Other: _____
 Account Project Manager: _____ have they been notified of the
 above issues: Yes No
 Whom spoken to: _____ Date/Time: _____
 CPM Initial _____
 General Comments: _____

* Subcontracted Analysis (See CPM)



CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
500-2618 HOPEWELL PLACE NE
CALGARY, AB T1Y7J7
(403) 274-3424

ATTENTION TO: Amber Lapshinoff

PROJECT: A03330001

AGAT WORK ORDER: 19C553310

WATER ANALYSIS REVIEWED BY: Dev Vyas, Inorganics Laboratory Manager

DATE REPORTED: Dec 11, 2019

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



Certificate of Analysis

AGAT WORK ORDER: 19C553310

PROJECT: A03330001

2910 12TH STREET NE
 CALGARY, ALBERTA
 CANADA T2E 7P7
 TEL (403)735-2005
 FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Amber Lapshinoff

SAMPLING SITE:

SAMPLED BY:

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-12-06

DATE REPORTED: 2019-12-11

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-01	MW19-10	MW19-15A	SW19-02A	SW19-03A
		SAMPLE TYPE:		Water	Water	Water	Water	Water
		DATE SAMPLED:		2019-12-06	2019-12-06	2019-12-06	2019-12-06	2019-12-06
		G / S	RDL	779500	779502	779503	779504	779505
pH	pH Units	7.0-10.5	N/A	8.05	8.05	8.08	8.25	8.23
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	141	228	260	132	130
Bicarbonate	mg/L		5	172	278	317	161	158
Carbonate	mg/L		5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	399	628	947	390	418
Chloride	mg/L	(250)	1	7	24	107	4	11
Fluoride	mg/L	1.5	0.01	0.09	0.14	0.16	0.13	0.11
Nitrate	mg/L	45	0.1	1.0	10.6	0.1	0.7	0.7
Nitrate-N	mg/L	10	0.02	0.23	2.39	0.02	0.16	0.16
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	0.23	2.39	0.02	0.16	0.16
Sulfate	mg/L	(500)	1	48	53	61	48	48
Dissolved Calcium	mg/L		0.3	55.2	91.6	60.5	55.0	55.3
Dissolved Magnesium	mg/L		0.2	15.4	25.5	22.9	15.6	16.1
Dissolved Sodium	mg/L	(200)	0.6	7.2	12.6	107	4.0	8.0
Dissolved Potassium	mg/L		0.6	<0.6	1.2	4.4	<0.6	0.7
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.12 (0.02)	0.005	<0.005	<0.005	0.079	<0.005	<0.005
Sodium Adsorption Ratio			0.22	0.30	2.97	0.12	0.24	
Calculated TDS	mg/L		0.6	218	355	519	206	218
Hardness	mg CaCO3/L		1	201	334	245	202	204
Ion Balance	%		1	107	111	102	111	114

Certified By:



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19C553310

PROJECT: A03330001

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Amber Lapshinoff

SAMPLING SITE:

SAMPLED BY:

Routine Chemistry Water Analysis

DATE RECEIVED: 2019-12-06

DATE REPORTED: 2019-12-11

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to 2019 Canadian Drinking Water Quality MAC (AO)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

779500-779505 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:

Quality Assurance

 CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
 PROJECT: A03330001
 SAMPLING SITE:

 AGAT WORK ORDER: 19C553310
 ATTENTION TO: Amber Lapshinoff
 SAMPLED BY:

Water Analysis															
RPT Date:			DUPLICATE				Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE		MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Measured Value		Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Routine Chemistry Water Analysis

pH	779753		8.68	8.67	0.1%	N/A	100%	90%	110%	NA			NA		
T - Alkalinity (as CaCO ₃)	779753		1060	1070	0.9%	< 5	114%	80%	120%	NA			NA		
Electrical Conductivity	779753		2770	2760	0.4%	< 5	101%	80%	120%	NA			NA		
Chloride	779502	779502	21	25	15.5%	< 1	101%	80%	120%	100%	80%	120%	101%	80%	120%
Fluoride	779502	779502	0.26	0.26	NA	< 0.01	111%	80%	120%	103%	80%	120%	107%	80%	120%
Nitrate	779502	779502	11.1	11.9	6.5%	< 0.1	103%	80%	120%	104%	80%	120%	98%	80%	120%
Nitrite	779502	779502	<0.20	<0.20	NA	< 0.05	101%	80%	120%	103%	80%	120%	98%	80%	120%
Sulfate	779502	779502	50	56	10.6%	< 1	102%	80%	120%	102%	80%	120%	98%	80%	120%
Dissolved Calcium	791230		1.3	1.4	NA	< 0.3	112%	80%	120%	112%	80%	120%	100%	80%	120%
Dissolved Magnesium	791230		0.3	0.3	NA	< 0.2	107%	80%	120%	95%	80%	120%	101%	80%	120%
Dissolved Sodium	791230		110	111	0.8%	< 0.6	108%	80%	120%	98%	80%	120%	NA	80%	120%
Dissolved Potassium	791230		<0.6	<0.6	NA	< 0.6	99%	80%	120%	93%	80%	120%	100%	80%	120%
Dissolved Iron	791230		<0.1	<0.1	NA	< 0.1	105%	80%	120%	103%	80%	120%	107%	80%	120%
Dissolved Manganese	791230		<0.005	<0.005	NA	< 0.005	106%	80%	120%	103%	80%	120%	106%	80%	120%

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

pH has been analyzed past the recommended holding time of 15 minutes from sampling (field measurement ideal if more accurate data required)

Nitrate and Nitrite: The regulatory hold time for the analysis of nitrate and/or nitrite in water is 72 hours.

Certified By:



Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 19C553310

PROJECT: A03330001

ATTENTION TO: Amber Lapshinoff

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
pH	INST 0101, INST 0104	SM 4500 H+	PH METER
p - Alkalinity (as CaCO ₃)	INST 0101	SM 2320 B	TITRATION
T - Alkalinity (as CaCO ₃)	INST 0101	SM 2320 B	TITRATION
Bicarbonate	INST 0101	SM 2320 B	PC TITRATE
Carbonate	INST 0101	SM 2320 B	PC TITRATE
Hydroxide	INST 0101	SM 2320 B	PC TITRATE
Electrical Conductivity	INST 0101, INST 0120	SM 2510 B	CONDUCTIVITY METER
Chloride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Fluoride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate-N	INST 0150	SM 4110 B	CALCULATION
Nitrite	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrite-N	INST 0150	SM 4110 B	CALCULATION
Nitrate+Nitrite - Nitrogen	INST 0150	SM 4110 B	CALCULATION
Sulfate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Dissolved Calcium	INST 0140	SM 3120 B	ICP/OES
Dissolved Magnesium	INST 0140	SM 3120 B	ICP/OES
Dissolved Sodium	INST 0140	SM 3120 B	ICP/OES
Dissolved Potassium	INST 0140	SM 3120 B	ICP/OES
Dissolved Iron	INST 0140	SM 3120 B	ICP/OES
Dissolved Manganese	INST 0140	SM 3120 B	ICP/OES
Sodium Adsorption Ratio		CARTER & GREGORICH 2007	CALCULATION
Calculated TDS		SM 1030E	CALCULATION
Hardness		SM 2340 B	CALCULATION
Ion Balance		SM 1030E	CALCULATION



19C 553310

Chain of Custody Record

Emergency Support Services Hotline **1-855-AGAT 245 (1-855-242-8245)**

Report Information

Company: VCB
 Contact: Amber Lapshinoff
 Address: _____
 Phone: 403 464 9677 (Fax: _____)
 LSD: _____
 Client Project #: A03330C01
 Sampled By: AZ

Report Information

1. Name: Amber Lapshinoff
 Email: alapshinoff@klohn.com
 2. Name: Kyle Scheperanow
 Email: kscheperanow@klohn.com
 3. Name: _____
 Email: _____

Turnaround Time Required (TAT)

Regular TAT 5-7 Business Days
 <24 Hours (200%)
 Rush TAT Two Day / Next Day (100%)
 (Surcharge) Three Day (50%)
 Four Day (25%)
 Date Required: _____

SEE BACK FOR
 SURCHARGE BREAKDOWN.
 CONTACT YOUR CPM FOR
 ADDITIONAL INFORMATION.

Invoice To

Same Yes No

Company: _____
 Contact: _____
 Address: _____
 Phone: _____ Fax: _____
 PO/AFE# _____
 Standing Offer #: _____

Requirements (Selection may impact detection limits)

CCME Alberta Tier 1
 Agricultural Agricultural
 Industrial Industrial
 Residential/ Park Residential/ Park
 Commercial Commercial
 FWAL Natural Area
 Drinking Water Alberta Surface Water
 Other Chronic Acute

Report Format

Single Sample Per Page
 Multiple Samples Per Page
 Export

Detailed Salinity AB BC SK D50
 CCME / AB: BTEX/F1-F2 CCME / AB: BTEX/F1-F2
 BC: BTEX/VPH/EPH BC: LEPH/HEPH
 SK: BTEX/TWH/C11-C22, C23-C60
 Soil Metals: HWS-B SP-B Hg Cr6+ Cr6+
 Water Metals: Dissolved Total Hg Cr6+
 Routine Water Chemistry
 Landfill: AB Class 2 BC SK
 Coliforms: Total Fecal E. coli
 Particle Size: Sieve (75 µm) Texture

LABORATORY USE (LINE/ LAB ID#)	SAMPLE IDENTIFICATION	DEPTH	DATE/ TIME SAMPLED	SAMPLE MATRIX	COMMENTS (Filtered, Preserved, Hazardous*) *Additional Fee	# of CONTAINERS				Detailed Salinity	CCME / AB: BTEX/F1-F2	BC: BTEX/VPH/EPH	SK: BTEX/TWH/C11-C22, C23-C60	Soil Metals: HWS-B, SP-B, Hg, Cr6+	Water Metals: Dissolved, Total, Hg, Cr6+	Routine Water Chemistry	Landfill: AB Class 2, BC, SK	Coliforms: Total, Fecal, E. coli	Particle Size: Sieve (75 µm), Texture	HOLD FOR 30 DAYS NO ANALYSIS (Additional Fee)	HOLD FOR 30 DAYS AFTER ANALYSIS (Additional Fee)
						Vials	Jars	Bags	Bottles												
1	<u>TP15W</u> MW19-01		<u>06 Dec 19</u>	<u>W</u>	<u>None</u>																
2	<u>SDZ</u> MW19-10		<u>06 Dec 19</u>	<u>W</u>	<u>None</u>																
3	<u>SDZ</u> MW19-15A		<u>06 Dec 19</u>	<u>W</u>	<u>None</u>																
4	<u>SDZ</u> SW19-02A		<u>06 Dec 19</u>	<u>W</u>	<u>None</u>																
5	<u>SDZ</u> SW19-03A		<u>06 Dec 19</u>	<u>W</u>	<u>None</u>																
6																					
7																					
8																					
9																					
10																					
11																					
12																					

Samples Relinquished By (Print Name and Sign): Amber Lapshinoff

Date/Time: 06 Dec 19 16:15

Samples Relinquished By (Print Name and Sign): [Signature]

Date/Time: Dec 6 19

Samples Relinquished By (Print Name and Sign): _____

Date/Time: _____

Samples Relinquished By (Print Name and Sign): _____

Date/Time: 04:47

Samples Relinquished By (Print Name and Sign): _____

Date/Time: _____

Samples Relinquished By (Print Name and Sign): _____

Date/Time: _____

Page _____ of _____
107336
 N°: AB



AGAT Laboratories

SAMPLE INTEGRITY RECEIPT FORM

RECEIVING BASICS - Shipping

Company/Consultant: KCB

Courier: D/D Prepaid Collect

Waybill# N/A

Branch: EDM GP FN FM RD VAN LYD FSJ EST Other: C

If multiple sites were submitted at once: Yes No

Custody Seal Intact: Yes No NA

TAT: <24hr 24-48hr 48-72hr Reg Other _____

Cooler Quantity: 1

TIME SENSITIVE ISSUES - Shipping

ALREADY EXCEEDED HOLD TIME? Yes No

Inorganic Tests (Please Circle): Mibi , BOD, Nitrate/Nitrite, Turbidity , Microtox , Ortho PO4 , Tedlar Bag , Residual Chlorine , Chlorophyll* , Chloroamines*

Earliest Expiry: Dec 9/15

Hydrocarbons: Earliest Expiry N/A

SAMPLE INTEGRITY - Shipping

Hazardous Samples: YES NO Precaution Taken: _____

Legal Samples: Yes No

International Samples: Yes No

Tape Sealed: Yes No

Coolant Used: Icepack Bagged Ice Free Ice Free Water None

Temperature (Bottles/Jars only) N/A if only Soil Bags Received

FROZEN (Please Circle if samples received Frozen)

1 (Bottle/Jar) 1.4 + 1.4 = 1.4 °C 2 (Bottle/Jar) _____ + _____ + _____ = _____ °C

3 (Bottle/Jar) _____ + _____ + _____ = _____ °C 4 (Bottle/Jar) _____ + _____ + _____ = _____ °C

5 (Bottle/Jar) _____ + _____ + _____ = _____ °C 6 (Bottle/Jar) _____ + _____ + _____ = _____ °C

7 (Bottle/Jar) _____ + _____ + _____ = _____ °C 8 (Bottle/Jar) _____ + _____ + _____ = _____ °C

9 (Bottle/Jar) _____ + _____ + _____ = _____ °C 10 (Bottle/Jar) _____ + _____ + _____ = _____ °C

(If more than 10 coolers are received use another sheet of paper and attach)

LOGISTICS USE ONLY

Workorder No: 19053310

Samples Damaged: Yes No If YES why?
 No Bubble Wrap Frozen Courier

Other: _____

Account Project Manager: _____ have they been notified of the above issues: Yes No

Whom spoken to: _____ Date/Time: _____

CPM Initial _____

General Comments: _____

* Subcontracted Analysis (See CPM)



CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
500-2618 HOPEWELL PLACE NE
CALGARY, AB T1Y7J7
(403) 274-3424

ATTENTION TO: Kyle Schepanow

PROJECT: A03330C01

AGAT WORK ORDER: 20C599891

WATER ANALYSIS REVIEWED BY: Justin Mossi, Coordinator

DATE REPORTED: May 20, 2020

PAGES (INCLUDING COVER): 16

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

***Notes**

VERSION 2:Supersedes Version 1: Updated cation values. 16SEP20 MGU

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days following analysis, unless expressly agreed otherwise in writing. Please contact your Client Project Manager if you require additional sample storage time.
- AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.
- This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
- The test results reported herewith relate only to the samples as received by the laboratory.
- Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.
- All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Metals - Dissolved - Alberta Tier 1

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-04	MW19-06A	MW19-06B			MW19-07	MW19-09	MW19-10
		SAMPLE TYPE:		Water	Water	Water			Water	Water	Water
		DATE SAMPLED:		2020-05-04	2020-05-04	2020-05-04			2020-05-04	2020-05-04	2020-05-04
		G / S	RDL	1115899	1115902	1115904	RDL	1115905	RDL	1115907	1115908
Dissolved Aluminum	mg/L		0.004	0.665	0.494	0.184	0.015	4.08	0.004	1.04	0.578
Dissolved Antimony	mg/L		0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001
Dissolved Arsenic	mg/L		0.001	0.002	0.001	0.003	0.001	0.007	0.001	0.002	0.001
Dissolved Barium	mg/L		0.05	0.25	0.34	0.23	0.05	1.34	0.05	0.17	0.19
Dissolved Beryllium	mg/L		0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	<0.001	<0.001
Dissolved Boron	mg/L		0.01	0.02	0.02	0.02	0.01	0.05	0.01	<0.01	0.01
Dissolved Cadmium	mg/L		0.000016	0.000441	0.000359	0.000141	0.000016	0.00845	0.000016	0.000569	0.000390
Dissolved Chromium	mg/L		0.001	0.002	0.001	<0.001	0.001	0.006	0.001	0.002	0.002
Dissolved Cobalt	mg/L		0.0009	0.0022	0.0024	0.0011	0.0009	0.0210	0.0009	0.0047	0.0021
Dissolved Copper	mg/L		0.0008	0.0065	0.0036	0.0026	0.0008	0.0476	0.0008	0.0109	0.0089
Dissolved Iron	mg/L		0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	<0.1
Dissolved Lead	mg/L		0.0005	0.0039	0.0023	0.0013	0.0005	0.0167	0.0005	0.0061	0.0032
Dissolved Manganese	mg/L		0.005	<0.005	<0.005	<0.005	0.005	<0.005	0.005	<0.005	<0.005
Dissolved Molybdenum	mg/L		0.001	<0.001	0.002	0.003	0.001	<0.001	0.001	<0.001	<0.001
Dissolved Nickel	mg/L		0.003	<0.003	<0.003	<0.003	0.003	0.017	0.003	0.006	<0.003
Dissolved Selenium	mg/L		0.0005	0.0014	0.0015	0.0007	0.0005	0.0064	0.0005	0.0013	0.0016
Dissolved Silver	mg/L		0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001
Dissolved Sodium	mg/L		0.6	26.4	53.1	23.3	0.6	68.3	0.6	5.8	10.4
Dissolved Thallium	mg/L		0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001
Dissolved Titanium	mg/L		0.001	0.012	0.005	0.003	0.001	0.053	0.001	0.016	0.007
Dissolved Uranium	mg/L		0.001	0.001	0.002	0.001	0.001	0.007	0.001	0.001	0.001
Dissolved Zinc	mg/L		0.005	0.021	0.016	0.007	0.005	0.118	0.005	0.017	0.016

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Metals - Dissolved - Alberta Tier 1

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-11	SW19-01	MW19-18		MW19-12	MW19-03	MW19-01	
		SAMPLE TYPE:		Water	Water	Water		Water	Water	Water	
		DATE SAMPLED:		2020-05-04	2020-05-04	2020-05-05		2020-05-05	2020-05-05	2020-05-05	
		G / S	RDL	1115909	1115910	RDL	1115913	RDL	1115915	1115916	1115917
Dissolved Aluminum	mg/L		0.004	1.67	0.008	0.015	3.37	0.004	0.689	0.796	1.98
Dissolved Antimony	mg/L		0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001
Dissolved Arsenic	mg/L		0.001	0.002	<0.001	0.001	0.004	0.001	0.002	0.002	0.004
Dissolved Barium	mg/L		0.05	0.30	<0.05	0.05	0.95	0.05	0.30	0.19	0.41
Dissolved Beryllium	mg/L		0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001
Dissolved Boron	mg/L		0.01	0.05	<0.01	0.01	0.01	0.01	0.04	<0.01	<0.01
Dissolved Cadmium	mg/L		0.000016	0.000750	<0.000016	0.000016	0.00321	0.000016	0.000331	0.000347	0.00140
Dissolved Chromium	mg/L		0.001	0.003	<0.001	0.001	0.006	0.001	0.001	0.002	0.002
Dissolved Cobalt	mg/L		0.0009	0.0029	<0.0009	0.0009	0.0144	0.0009	0.0032	0.0121	0.0100
Dissolved Copper	mg/L		0.0008	0.136	<0.0008	0.0008	0.0210	0.0008	0.0080	0.0067	0.0194
Dissolved Iron	mg/L		0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1
Dissolved Lead	mg/L		0.0005	0.0421	<0.0005	0.0005	0.0288	0.0005	0.0040	0.0039	0.0070
Dissolved Manganese	mg/L		0.005	<0.005	<0.005	0.005	<0.005	0.005	<0.005	<0.005	<0.005
Dissolved Molybdenum	mg/L		0.001	<0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001	<0.001
Dissolved Nickel	mg/L		0.003	<0.003	<0.003	0.003	0.014	0.003	0.008	0.003	0.009
Dissolved Selenium	mg/L		0.0005	0.0026	0.0006	0.0005	0.0037	0.0005	0.0027	0.0010	0.0015
Dissolved Silver	mg/L		0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Dissolved Sodium	mg/L		0.6	44.8	3.1	0.6	21.3	0.6	108	6.9	4.4
Dissolved Thallium	mg/L		0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Dissolved Titanium	mg/L		0.001	0.015	0.001	0.001	0.035	0.001	0.009	0.012	0.017
Dissolved Uranium	mg/L		0.001	0.002	<0.001	0.001	0.003	0.001	0.002	0.001	0.002
Dissolved Zinc	mg/L		0.005	0.116	<0.005	0.005	0.086	0.005	0.022	0.019	0.031

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Metals - Dissolved - Alberta Tier 1

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Parameter	Unit	SAMPLE DESCRIPTION: MW19-03A		MW19-02		MW19-17		
		SAMPLE TYPE: Water		Water		Water		
		DATE SAMPLED: 2020-05-05		2020-05-05		2020-05-05		
		G / S	RDL	1115918	RDL	1115919	RDL	1115922
Dissolved Aluminum	mg/L		0.004	2.19	0.015	4.73	0.004	0.087
Dissolved Antimony	mg/L		0.001	<0.001	0.001	<0.001	0.001	<0.001
Dissolved Arsenic	mg/L		0.001	0.003	0.001	0.005	0.001	0.002
Dissolved Barium	mg/L		0.05	0.82	0.05	1.42	0.05	0.14
Dissolved Beryllium	mg/L		0.001	<0.001	0.001	0.001	0.001	<0.001
Dissolved Boron	mg/L		0.01	0.01	0.01	0.01	0.01	0.09
Dissolved Cadmium	mg/L		0.000016	0.00211	0.000016	0.00436	0.000016	0.000049
Dissolved Chromium	mg/L		0.001	0.003	0.001	0.008	0.001	<0.001
Dissolved Cobalt	mg/L		0.0009	0.0095	0.0009	0.0112	0.0009	<0.0009
Dissolved Copper	mg/L		0.0008	0.0212	0.0008	0.0288	0.0008	0.0018
Dissolved Iron	mg/L		0.1	<0.1	0.1	<0.1	0.1	<0.1
Dissolved Lead	mg/L		0.0005	0.0070	0.0005	0.0130	0.0005	0.0006
Dissolved Manganese	mg/L		0.005	<0.005	0.005	<0.005	0.005	<0.005
Dissolved Molybdenum	mg/L		0.001	<0.001	0.001	<0.001	0.001	0.008
Dissolved Nickel	mg/L		0.003	0.014	0.003	0.011	0.003	<0.003
Dissolved Selenium	mg/L		0.0005	0.0029	0.0005	0.0056	0.0005	<0.0005
Dissolved Silver	mg/L		0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001
Dissolved Sodium	mg/L		0.6	8.6	0.6	8.5	0.6	182
Dissolved Thallium	mg/L		0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001
Dissolved Titanium	mg/L		0.001	0.015	0.001	0.033	0.001	0.007
Dissolved Uranium	mg/L		0.001	0.002	0.001	0.003	0.001	0.004
Dissolved Zinc	mg/L		0.005	0.032	0.005	0.054	0.005	0.007

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

1115899-1115922 < - Values refer to Report Detection Limit.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

2910 12TH STREET NE
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CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Routine Chemistry Water Analysis

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-04	MW19-06A	MW19-06C	MW19-06B	MW19-07	MW19-08	MW19-09	MW19-10
		SAMPLE TYPE:		Water							
		DATE SAMPLED:		2020-05-04	2020-05-04	2020-05-04	2020-05-04	2020-05-04	2020-05-04	2020-05-04	2020-05-04
		G / S	RDL	1115899	1115902	1115903	1115904	1115905	1115906	1115907	1115908
pH	pH Units	7.0-10.5	N/A	8.04	8.12	8.20	8.08	8.12	8.02	8.07	8.12
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	230	196	196	173	196	212	165	194
Bicarbonate	mg/L		5	280	239	239	210	240	259	202	236
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	731	1153	840	662	1018	612	480	539
Chloride	mg/L	(250)	1.0	62.3	196	113	70.2	158	32.7	6.8	20.0
Fluoride	mg/L	1.5	0.01	0.11	0.12	0.14	0.09	0.14	0.09	0.10	0.04
Nitrate	mg/L	45	0.5	7.9	17.9	10.2	3.2	38.0	4.9	1.0	4.6
Nitrate-N	mg/L	10	0.02	1.78	4.04	2.30	0.72	8.58	1.11	0.23	1.04
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	1.78	4.04	2.30	0.72	8.58	1.11	0.23	1.04
Sulfate	mg/L	(500)	1.0	50.5	64.5	62.3	48.8	36.5	57.8	72.0	55.5
Dissolved Calcium	mg/L		0.3	40.0	56.8	66.0	65.7	50.4	33.6	48.0	43.9
Dissolved Magnesium	mg/L		0.2	29.8	46.7	30.4	27.1	29.0	28.3	20.7	23.1
Dissolved Sodium	mg/L	(200)	0.6	26.4	53.1	32.5	23.3	68.3	15.4	5.8	10.4
Dissolved Potassium	mg/L		0.6	1.6	4.0	3.3	4.5	3.6	1.3	0.7	1.0
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.12 (0.02)	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium Adsorption Ratio				0.77	1.26	0.83	0.61	1.90	0.47	0.18	0.32
Calculated TDS	mg/L		0.6	356	557	435	346	502	301	254	275
Hardness	mg CaCO3/L		1	223	334	290	276	245	200	205	205
Ion Balance	%		1	75	82	85	102	82	73	87	81

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

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CALGARY, ALBERTA
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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Routine Chemistry Water Analysis

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-11	SW19-01	MW19-14	SW19-03	MW19-18	DUP-2	MW19-12	MW19-03
		SAMPLE TYPE:		Water							
		DATE SAMPLED:		2020-05-04	2020-05-04	2020-05-05	2020-05-05	2020-05-05	2020-05-05	2020-05-05	2020-05-05
		G / S	RDL	1115909	1115910	1115911	1115912	1115913	1115914	1115915	1115916
pH	pH Units	7.0-10.5	N/A	8.03	8.47	8.16	8.34	8.19	8.09	8.04	8.17
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	266	122	208	126	139	279	288	162
Bicarbonate	mg/L		5	325	141	254	150	170	340	352	198
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	946	352	942	356	507	1393	1387	446
Chloride	mg/L	(250)	1.0	76.7	3.0	54.7	2.9	35.6	221	201	10.4
Fluoride	mg/L	1.5	0.01	0.11	0.04	0.19	<0.01	0.10	0.22	0.15	0.03
Nitrate	mg/L	45	0.5	24.6	<0.5	4.4	<0.5	1.1	26.3	26.6	0.9
Nitrate-N	mg/L	10	0.02	5.56	<0.02	0.99	<0.02	0.25	5.94	6.01	0.20
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	5.56	<0.02	0.99	<0.02	0.25	5.94	6.01	0.20
Sulfate	mg/L	(500)	1.0	80.6	42.3	206	42.3	63.8	59.8	60.3	49.8
Dissolved Calcium	mg/L		0.3	57.3	46.9	57.5	47.1	54.4	47.5	54.7	45.9
Dissolved Magnesium	mg/L		0.2	32.9	14.2	33.6	14.3	16.3	46.1	47.7	17.4
Dissolved Sodium	mg/L	(200)	0.6	44.8	3.1	75.9	3.2	21.3	105	108	6.9
Dissolved Potassium	mg/L		0.6	1.8	0.7	3.1	0.7	2.2	3.3	3.7	0.7
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.12 (0.02)	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium Adsorption Ratio				1.17	0.10	1.97	0.10	0.65	2.60	2.58	0.22
Calculated TDS	mg/L		0.6	479	180	560	184	278	676	675	229
Hardness	mg CaCO3/L		1	279	176	282	176	203	308	333	186
Ion Balance	%		1	79	112	89	108	98	80	87	88

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Routine Chemistry Water Analysis

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Parameter	Unit	SAMPLE DESCRIPTION:		MW19-01	MW19-03A	MW19-02	SW19-02	DUP-1	MW19-17
		SAMPLE TYPE:		Water	Water	Water	Water	Water	Water
		DATE SAMPLED:		2020-05-05	2020-05-05	2020-05-05	2020-05-05	2020-05-05	2020-05-05
		G / S	RDL	1115917	1115918	1115919	1115920	1115921	1115922
pH	pH Units	7.0-10.5	N/A	8.21	8.17	8.14	8.40	8.18	8.43
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	6
T - Alkalinity (as CaCO3)	mg/L		5	131	182	207	125	211	372
Bicarbonate	mg/L		5	160	222	253	148	257	439
Carbonate	mg/L		5	<5	<5	<5	<5	<5	8
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm		5	371	485	536	356	611	930
Chloride	mg/L	(250)	1.0	3.3	13.7	16.7	3.1	32.1	3.3
Fluoride	mg/L	1.5	0.01	<0.01	0.04	<0.01	0.06	0.10	0.42
Nitrate	mg/L	45	0.5	0.6	1.2	1.6	<0.5	4.7	<0.5
Nitrate-N	mg/L	10	0.02	0.14	0.27	0.36	<0.02	1.06	<0.02
Nitrite	mg/L	3	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N	mg/L	1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate+Nitrite - Nitrogen	mg/L		0.02	0.14	0.27	0.36	<0.02	1.06	<0.02
Sulfate	mg/L	(500)	1.0	43.2	51.2	44.6	41.7	57.1	108
Dissolved Calcium	mg/L		0.3	39.8	41.8	40.9	46.4	49.9	13.3
Dissolved Magnesium	mg/L		0.2	13.9	16.5	16.8	14.0	28.1	11.5
Dissolved Sodium	mg/L	(200)	0.6	4.4	8.6	8.5	3.1	14.7	182
Dissolved Potassium	mg/L		0.6	0.7	0.9	1.0	0.7	1.2	2.0
Dissolved Iron	mg/L	(0.3)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Manganese	mg/L	0.12 (0.02)	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium Adsorption Ratio			0.15	0.29	0.28	0.10	0.41	8.83	
Calculated TDS	mg/L		0.6	185	243	255	182	314	544
Hardness	mg CaCO3/L		1	157	172	171	174	240	81
Ion Balance	%		1	92	75	69	107	86	97

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

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<http://www.agatlabs.com>

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Routine Chemistry Water Analysis

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to 2020 Canadian Drinking Water Quality MAC (AO)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

- 1115899 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
Note: Balance Reviewed: Interference or Non- Measured Component.
- 1115902 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
- 1115903 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
Note: Balance Reviewed: Interference or Non- Measured Component.
- 1115904 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
- 1115905-1115909 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
Note: Balance Reviewed: Interference or Non- Measured Component.
- 1115910 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
- 1115911 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
Note: Balance Reviewed: Interference or Non- Measured Component.
- 1115912 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
- 1115913-1115919 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
Note: Balance Reviewed: Interference or Non- Measured Component.
- 1115920 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.
- 1115921 < - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.

Certified By:



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

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CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Routine Chemistry Water Analysis

DATE RECEIVED: 2020-05-06

DATE REPORTED: 2020-05-20

Note: Balance Reviewed: Interference or Non- Measured Component.

1115922

< - Values refer to Report Detection Limits.

If sodium results in mg/L are less than detection, SAR is non-calculable and is reported as 0.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By:

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

Water Analysis														
RPT Date: May 20, 2020			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE	
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits
						Lower		Upper	Lower		Upper	Lower		Upper

Routine Chemistry Water Analysis

pH	1116691		7.99	8.00	0.1%	N/A	100%	90%	110%						
p - Alkalinity (as CaCO3)	1116691		<5	<5	NA	< 5	NA	80%	120%						
T - Alkalinity (as CaCO3)	1116691		183	177	3.3%	< 5	102%	80%	120%						
Bicarbonate	1116691		223	216	3.2%	< 5									
Carbonate	1116691		<5	<5	NA	< 5									
Hydroxide	1116691		<5	<5	NA	< 5									
Electrical Conductivity	1116691		499	500	0.2%	< 5	100%	90%	110%						
Chloride	1115204		16.1	16.2	1.0%	< 1.0	103%	70%	130%	100%	80%	120%	NA	70%	130%
Fluoride	1115204		0.08	0.08	2.5%	< 0.01	102%	70%	130%	89%	80%	120%	99%	70%	130%
Nitrate	1115204		0.7	0.7	NA	< 0.5	105%	70%	130%	103%	80%	120%	100%	70%	130%
Nitrite	1115204		0.09	0.08	NA	< 0.05	102%	70%	130%	98%	80%	120%	102%	70%	130%
Sulfate	1115204		43.8	44.4	1.4%	< 1.0	106%	70%	130%	105%	80%	120%	NA	70%	130%
Dissolved Calcium	1090432		58.9	60.7	2.9%	< 0.3	107%	70%	130%	110%	80%	120%	NA	70%	130%
Dissolved Magnesium	1090432		19.5	18.8	3.7%	< 0.2	112%	70%	130%	118%	80%	120%	NA	70%	130%
Dissolved Sodium	1090432		8.6	8.6	0.3%	< 0.6	105%	70%	130%	119%	80%	120%	NA	70%	130%
Dissolved Potassium	1090432		3.4	3.4	1.9%	< 0.6	103%	70%	130%	106%	80%	120%	114%	70%	130%
Dissolved Iron	1090432		<0.1	<0.1	NA	< 0.1	99%	70%	130%	105%	80%	120%	115%	70%	130%
Dissolved Manganese	1090432		<0.005	<0.005	NA	< 0.005	99%	70%	130%	111%	80%	120%	120%	70%	130%

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

pH has been analyzed past the recommended holding time of 15 minutes from sampling (field measurement ideal if more accurate data required)

Nitrate and Nitrite: The regulatory hold time for the analysis of nitrate and/or nitrite in water is 72 hours.

Routine Chemistry Water Analysis

pH	1114587		8.17	8.20	0.4%	N/A	100%	90%	110%						
p - Alkalinity (as CaCO3)	1114587		<5	<5	NA	< 5	NA	80%	120%						
T - Alkalinity (as CaCO3)	1114587		102	103	1.0%	< 5	100%	80%	120%						
Bicarbonate	1114587		125	126	0.8%	< 5									
Carbonate	1114587		<5	<5	NA	< 5									
Hydroxide	1114587		<5	<5	NA	< 5									
Electrical Conductivity	1114587		516	515	0.2%	< 5	100%	90%	110%						
Chloride	1115907	1115907	6.5	6.8	4.9%	< 1.0	100%	70%	130%	100%	80%	120%	106%	70%	130%
Fluoride	1115907	1115907	<0.06	<0.06	NA	< 0.01	102%	70%	130%	98%	80%	120%	82%	70%	130%
Nitrate	1115907	1115907	1.0	1.0	NA	< 0.5	102%	70%	130%	102%	80%	120%	105%	70%	130%
Nitrite	1115907	1115907	<0.20	<0.20	NA	< 0.05	99%	70%	130%	98%	80%	120%	103%	70%	130%
Sulfate	1115907	1115907	70.8	70.9	0.1%	< 1.0	103%	70%	130%	107%	80%	120%	NA	70%	130%
Dissolved Calcium	1090432		60.0	63.6	5.7%	< 0.3	105%	70%	130%	120%	80%	120%	NA	70%	130%
Dissolved Magnesium	1090432		19.5	19.9	2.1%	< 0.2	111%	70%	130%	113%	80%	120%	NA	70%	130%
Dissolved Sodium	1090432		8.6	9.0	4.9%	< 0.6	103%	70%	130%	112%	80%	120%	NA	70%	130%

Quality Assurance

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.
 PROJECT: A03330C01
 SAMPLING SITE:

AGAT WORK ORDER: 20C599891
 ATTENTION TO: Kyle Schepanow
 SAMPLED BY: Michael O'Byrne

Water Analysis (Continued)

RPT Date: May 20, 2020			DUPLICATE				Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Measured Value		Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits		
								Lower	Upper		Lower	Upper		Lower	Upper	
Dissolved Potassium	1090432		3.4	3.6	3.6%	< 0.6	101%	70%	130%	114%	80%	120%	91%	70%	130%	
Dissolved Iron	1090432		<0.1	<0.1	NA	< 0.1	101%	70%	130%	113%	80%	120%	115%	70%	130%	
Dissolved Manganese	1090432		<0.005	<0.005	NA	< 0.005	101%	70%	130%	118%	80%	120%	120%	70%	130%	

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

pH has been analyzed past the recommended holding time of 15 minutes from sampling (field measurement ideal if more accurate data required)

Nitrate and Nitrite: The regulatory hold time for the analysis of nitrate and/or nitrite in water is 72 hours.

Metals - Dissolved - Alberta Tier 1

Dissolved Aluminum	1111081		0.022	0.021	2.2%	< 0.004	106%	70%	130%	104%	80%	120%	105%	70%	130%
Dissolved Antimony	1111081		<0.001	<0.001	NA	< 0.001	115%	70%	130%	99%	80%	120%	98%	70%	130%
Dissolved Arsenic	1111081		<0.001	<0.001	NA	< 0.001	93%	70%	130%	94%	80%	120%	101%	70%	130%
Dissolved Barium	1111081		0.10	0.10	NA	< 0.05	103%	70%	130%	100%	80%	120%	101%	70%	130%
Dissolved Beryllium	1111081		<0.001	<0.001	NA	< 0.001	100%	70%	130%	100%	80%	120%	102%	70%	130%
Dissolved Boron	1111081		0.01	<0.01	NA	< 0.01	107%	70%	130%	103%	80%	120%	102%	70%	130%
Dissolved Cadmium	1111081		0.000041	<0.	NA	< 0.000016	102%	70%	130%	99%	80%	120%	98%	70%	130%
Dissolved Chromium	1111081		<0.001	<0.001	NA	< 0.001	107%	70%	130%	101%	80%	120%	106%	70%	130%
Dissolved Cobalt	1111081		<0.0009	<0.0009	NA	< 0.0009	105%	70%	130%	102%	80%	120%	108%	70%	130%
Dissolved Copper	1111081		0.0023	0.0022	NA	< 0.0008	103%	70%	130%	101%	80%	120%	105%	70%	130%
Dissolved Iron	1090432		<0.1	<0.1	NA	< 0.1	99%	70%	130%	105%	80%	120%	115%	70%	130%
Dissolved Lead	1111081		<0.0005	<0.0005	NA	< 0.0005	104%	70%	130%	102%	80%	120%	99%	70%	130%
Dissolved Manganese	1090432		<0.005	<0.005	NA	< 0.005	99%	70%	130%	111%	80%	120%	120%	70%	130%
Dissolved Molybdenum	1111081		<0.001	<0.001	NA	< 0.001	101%	70%	130%	97%	80%	120%	99%	70%	130%
Dissolved Nickel	1111081		<0.003	<0.003	NA	< 0.003	108%	70%	130%	101%	80%	120%	107%	70%	130%
Dissolved Selenium	1111081		0.0011	<0.0005	NA	< 0.0005	103%	70%	130%	96%	80%	120%	98%	70%	130%
Dissolved Silver	1111081		<0.0001	<0.0001	NA	< 0.0001	94%	70%	130%	88%	80%	120%	86%	70%	130%
Dissolved Sodium	1090432		8.6	8.6	0.3%	< 0.6	105%	70%	130%	119%	80%	120%	NA	70%	130%
Dissolved Thallium	1111081		<0.0001	<0.0001	NA	< 0.0001	97%	70%	130%	99%	80%	120%	97%	70%	130%
Dissolved Titanium	1111081		0.002	0.002	NA	< 0.001	98%	70%	130%	99%	80%	120%	100%	70%	130%
Dissolved Uranium	1111081		<0.001	<0.001	NA	< 0.001	105%	70%	130%	102%	80%	120%	100%	70%	130%
Dissolved Zinc	1111081		<0.005	<0.005	NA	< 0.004	107%	70%	130%	100%	80%	120%	105%	70%	130%

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
 If the RPD value is NA, the results of the duplicates are under 5X the RDL and will not be calculated.

Certified By: _____



Method Summary

CLIENT NAME: KLOHN CRIPPEN BERGER LTD.

AGAT WORK ORDER: 20C599891

PROJECT: A03330C01

ATTENTION TO: Kyle Schepanow

SAMPLING SITE:

SAMPLED BY: Michael O'Byrne

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Dissolved Aluminum	INST 0141	SM 3125 B	ICP-MS
Dissolved Antimony	INST 0141	SM 3125 B	ICP-MS
Dissolved Arsenic	INST 0141	SM 3125 B	ICP-MS
Dissolved Barium	INST 0141	SM 3125 B	ICP-MS
Dissolved Beryllium	INST 0141	SM 3125 B	ICP-MS
Dissolved Boron	INST 0141	SM 3125 B	ICP-MS
Dissolved Cadmium	INST 0141	SM 3125 B	ICP-MS
Dissolved Chromium	INST 0141	SM 3125 B	ICP-MS
Dissolved Cobalt	INST 0141	SM 3125 B	ICP-MS
Dissolved Copper	INST 0141	SM 3125 B	ICP-MS
Dissolved Iron	INST 0140	SM 3120 B	ICP/OES
Dissolved Lead	INST 0141	SM 3125 B DW	ICP-MS
Dissolved Manganese	INST 0140	SM 3120 B	ICP/OES
Dissolved Molybdenum		SM 3125 B	ICP-MS
Dissolved Nickel	INST 0141	SM 3125 B	ICP-MS
Dissolved Selenium	INST 0141	SM 3125 B	ICP-MS
Dissolved Silver	INST 0141	SM 3125 B	ICP-MS
Dissolved Sodium	INST 0140	SM 3120 B	ICP/OES
Dissolved Thallium	INST 0141	SM 3125 B	ICP-MS
Dissolved Titanium	INST 0141	SM 3125 B	ICP-MS
Dissolved Uranium	INST 0141	SM 3125 B	ICP-MS
Dissolved Zinc	INST 0141	SM 3125 B	ICP-MS
pH	INST 0101, INST 0104	SM 4500 H+	PH METER
p - Alkalinity (as CaCO ₃)	INST 0101	SM 2320 B	TITRATION
T - Alkalinity (as CaCO ₃)	INST 0101	SM 2320 B	TITRATION
Bicarbonate	INST 0101	SM 2320 B	PC TITRATE
Carbonate	INST 0101	SM 2320 B	PC TITRATE
Hydroxide	INST 0101	SM 2320 B	PC TITRATE
Electrical Conductivity	INST 0101, INST 0120	SM 2510 B	CONDUCTIVITY METER
Chloride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Fluoride	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrate-N	INST 0150	SM 4110 B	CALCULATION
Nitrite	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Nitrite-N	INST 0150	SM 4110 B	CALCULATION
Nitrate+Nitrite - Nitrogen	INST 0150	SM 4110 B	CALCULATION
Sulfate	INST 0150	SM 4110 B	ION CHROMATOGRAPH
Dissolved Calcium	INST 0140	SM 3120 B	ICP/OES
Dissolved Magnesium	INST 0140	SM 3120 B	ICP/OES
Dissolved Potassium	INST 0140	SM 3120 B	ICP/OES
Sodium Adsorption Ratio		CARTER & GREGORICH 2007	CALCULATION
Calculated TDS		SM 1030E	CALCULATION
Hardness		SM 2340 B	CALCULATION
Ion Balance		SM 1030E	CALCULATION



AGAT Laboratories

SAMPLE INTEGRITY RECEIPT FORM

RECEIVING BASICS - Shipping

Company/Consultant: Klohn cripper

Courier: D/O Prepaid Collect

Waybill# _____

Branch: EDM GP FN FM RD VAN LYD FSJ EST SASK Other: C

If multiple sites were submitted at once: Yes No

Custody Seal Intact: Yes No NA

TAT: <24hr 24-48hr 48-72hr Reg Other _____

Cooler Quantity: 1

TIME SENSITIVE ISSUES - Shipping

ALREADY EXCEEDED HOLD TIME? Yes No

Inorganic Tests (Please Circle): Mibi , BOD , Nitrate/Nitrite , Turbidity , Color , Microtox , Ortho PO4 , Tedlar Bag , Residual Chlorine , Chlorophyll* , Chloroamines* Routine

Earliest Expiry: May 7, 2020

Hydrocarbons: Earliest Expiry N/A

SAMPLE INTEGRITY - Shipping

Hazardous Samples: YES NO Precaution Taken: _____

Legal Samples: Yes No

International Samples: Yes No

Tape Sealed: Yes No

Coolant Used: Icepack Bagged Ice Free Ice Free Water None

Temperature (Bottles/Jars only) N/A if only Soil Bags Received

FROZEN (Please Circle if samples received Frozen)

1 (Bottle/Jar) 9 + 9 + 9 = 9 °C 2 (Bottle/Jar) ___ + ___ + ___ = ___ °C

3 (Bottle/Jar) ___ + ___ + ___ = ___ °C 4 (Bottle/Jar) ___ + ___ + ___ = ___ °C

5 (Bottle/Jar) ___ + ___ + ___ = ___ °C 6 (Bottle/Jar) ___ + ___ + ___ = ___ °C

7 (Bottle/Jar) ___ + ___ + ___ = ___ °C 8 (Bottle/Jar) ___ + ___ + ___ = ___ °C

9 (Bottle/Jar) ___ + ___ + ___ = ___ °C 10 (Bottle/Jar) ___ + ___ + ___ = ___ °C

(If more than 10 coolers are received use another sheet of paper and attach)

LOGISTICS USE ONLY

Workorder No: 20C59891

Samples Damaged: Yes No If YES why?

No Bubble Wrap Frozen Courier

Other: _____

Account Project Manager: _____ have they been notified of the above issues: Yes No

Whom spoken to: _____ Date/Time: _____

CPM Initial _____

General Comments: _____

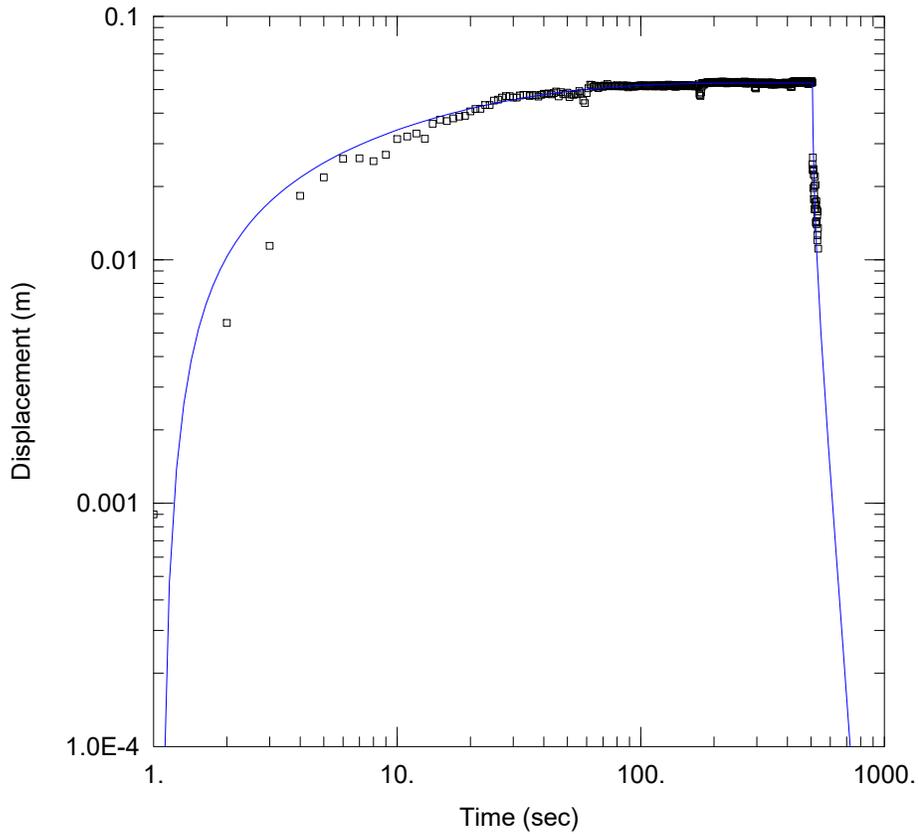
* Subcontracted Analysis (See CPM)

APPENDIX I4

Tetra Tech Geophysical Investigation Report

APPENDIX I5

Single-Well Hydraulic Test Results



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-01 Pump Theis.aqt

Date: 07/12/20

Time: 13:47:32

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-01

Test Date: 14-May19

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MW19-01	0	0

Observation Wells

Well Name	X (m)	Y (m)
□ MW19-01	0	0

SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush-Jacob

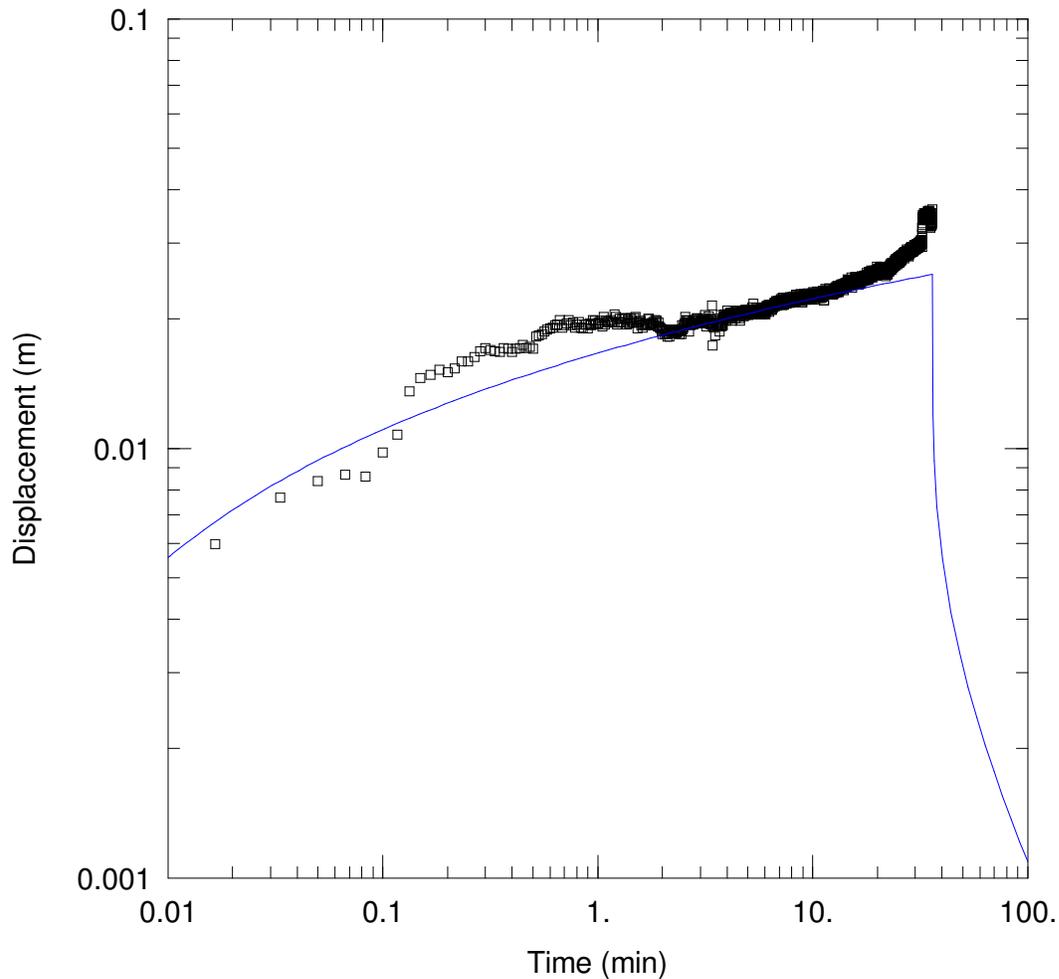
T = 93.2 m²/day

S = 0.27

r/B = 0.15

Kz/Kr = 0.5

b = 1.99 m



WELL TEST ANALYSIS

Data Set: \...\MW19-02 rev1 theis_AW.aqt

Date: 01/04/21

Time: 11:25:43

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: CoC

Project: A03330C01

Location: Calgary

Test Well: MW19-02

Test Date: 14-May-2019

WELL DATA

Pumping Wells

Observation Wells

Well Name	X (m)	Y (m)
MW19-02	0	0

Well Name	X (m)	Y (m)
□ MW19-02	0	0

SOLUTION

Aquifer Model: Unconfined

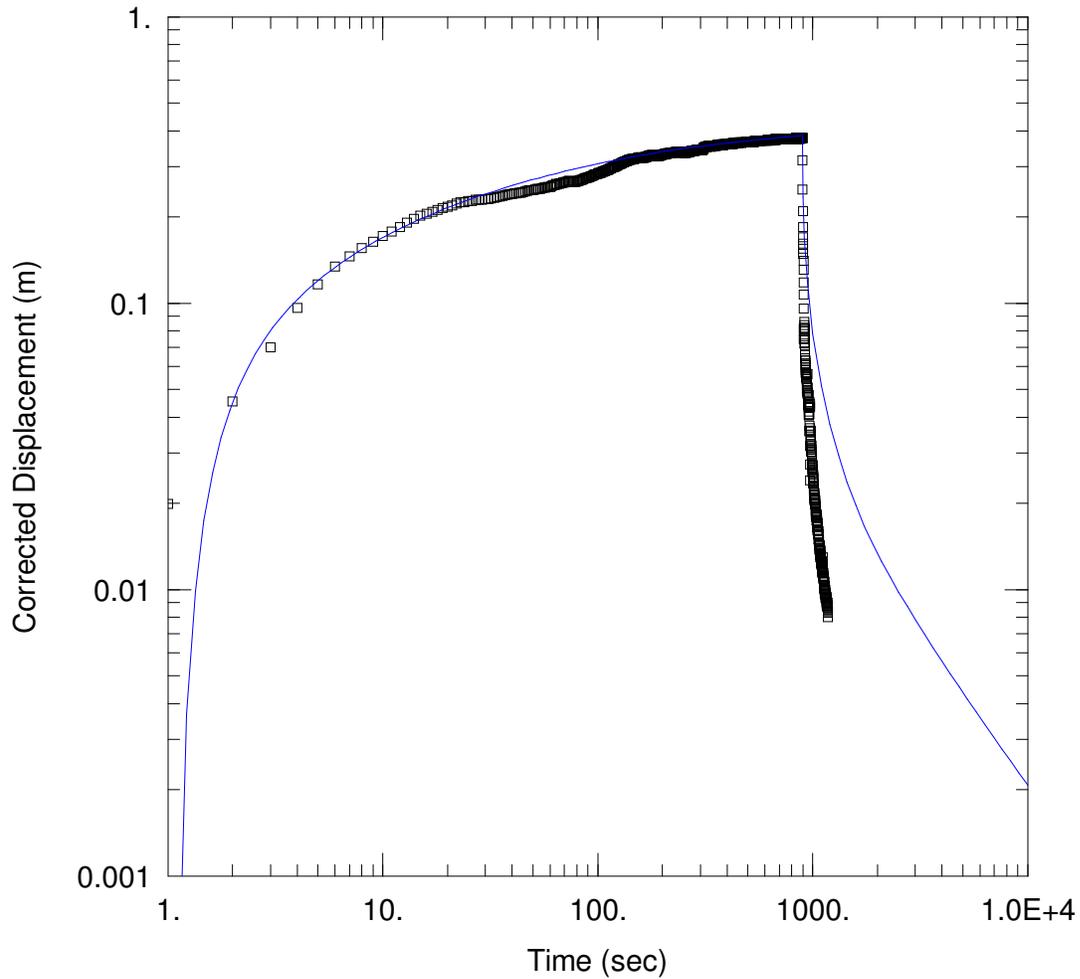
Solution Method: Theis

T = 427.3 m²/day

S = 0.1253

Kz/Kr = 1.

b = 2.29 m



WELL TEST ANALYSIS

Data Set: \...\MW19-04 CRT theis_AW.aqt

Date: 01/04/21

Time: 11:24:58

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: CoC

Project: A03330C01

Location: Calgary

Test Well: MW19-04

Test Date: 14-Jun-2019

WELL DATA

Pumping Wells

Observation Wells

Well Name	X (m)	Y (m)
MW19-04	0	0

Well Name	X (m)	Y (m)
□ MW19-04	0	0

SOLUTION

Aquifer Model: Unconfined

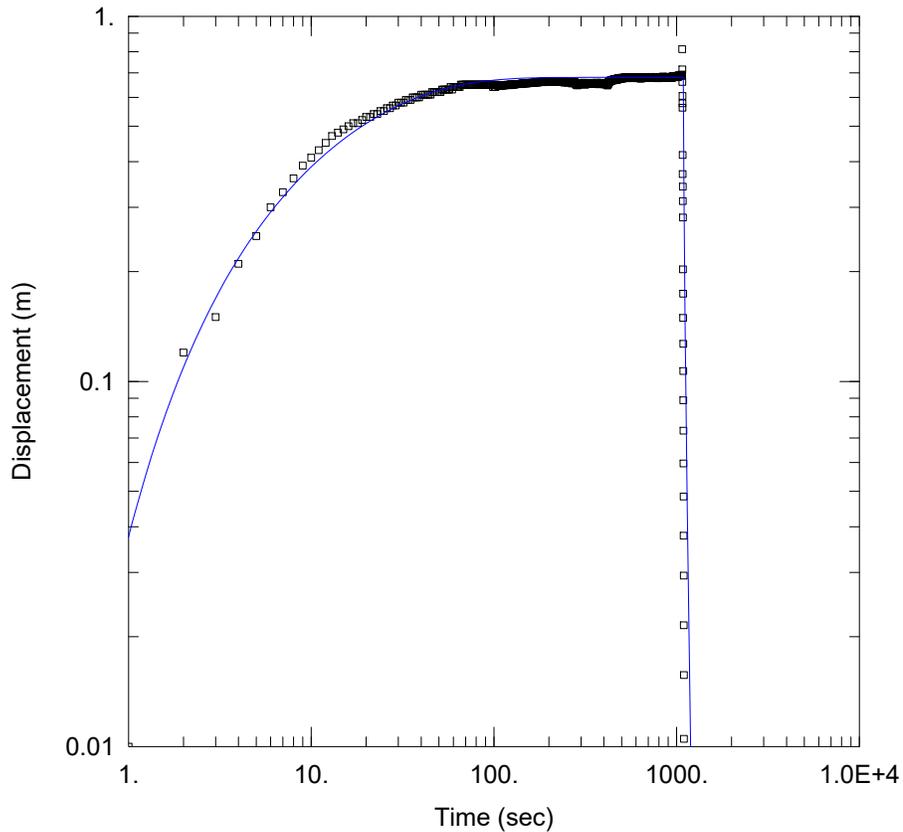
Solution Method: Theis

T = 60. m²/day

S = 0.2101

Kz/Kr = 1.

b = 3.24 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-6B Pumping Leaky Hantush.aqt
 Date: 07/12/20 Time: 13:48:24

PROJECT INFORMATION

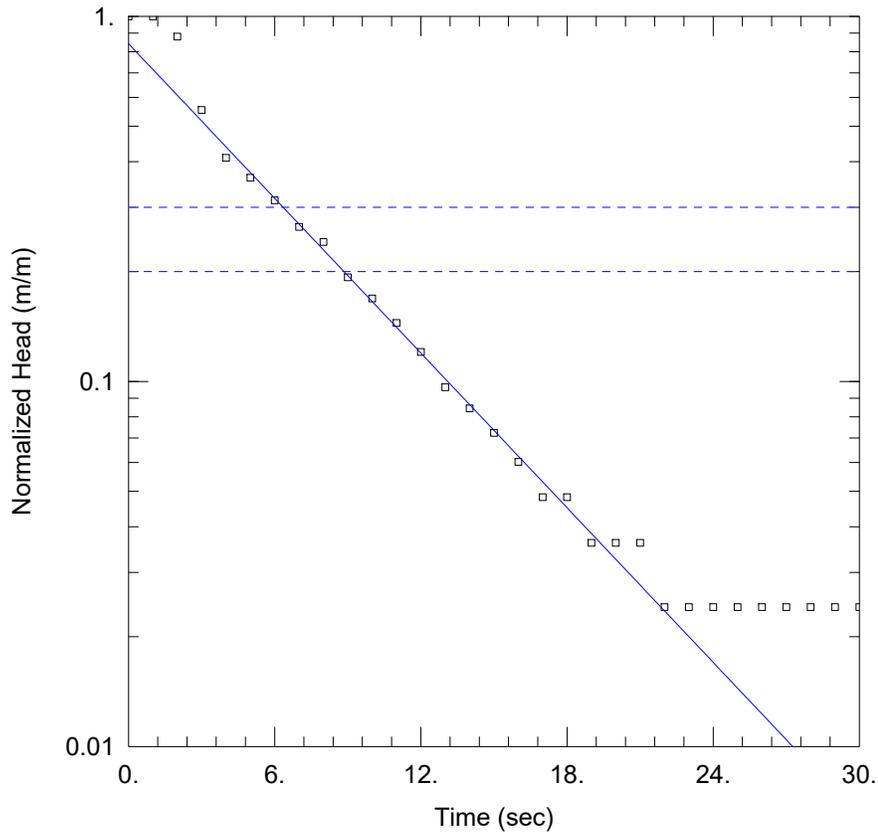
Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-6B
 Test Date: 15-June-19

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW19-6B	0	0	□ MW19-6B	0	0

SOLUTION

Aquifer Model: <u>Leaky</u>	Solution Method: <u>Hantush-Jacob</u>
T = <u>3.5 m²/day</u>	S = <u>0.035</u>
r/B = <u>0.32</u>	Kz/Kr = <u>1.</u>
b = <u>3.82 m</u>	



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-6B FHT1_Sandstone.aqt

Date: 07/12/20

Time: 13:25:34

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-6B

Test Date: 15-June-19

AQUIFER DATA

Saturated Thickness: 0.3 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-6B)

Initial Displacement: 0.83 m

Static Water Column Height: 3.82 m

Total Well Penetration Depth: 0.3 m

Screen Length: 0.3 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

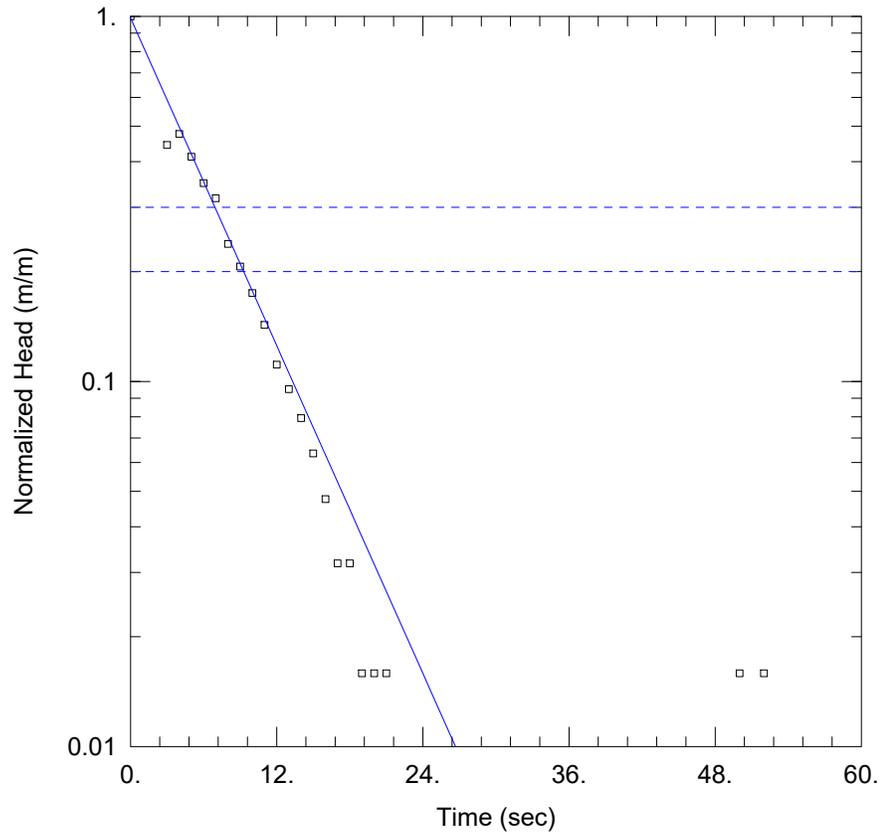
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 0.0001709 m/sec

y0 = 0.6985 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-6B FHT2_Sandstone.aqt

Date: 07/12/20

Time: 13:28:12

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-6B

Test Date: 15-June-19

AQUIFER DATA

Saturated Thickness: 0.3 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-6B)

Initial Displacement: 0.63 m

Static Water Column Height: 3.82 m

Total Well Penetration Depth: 0.3 m

Screen Length: 0.3 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

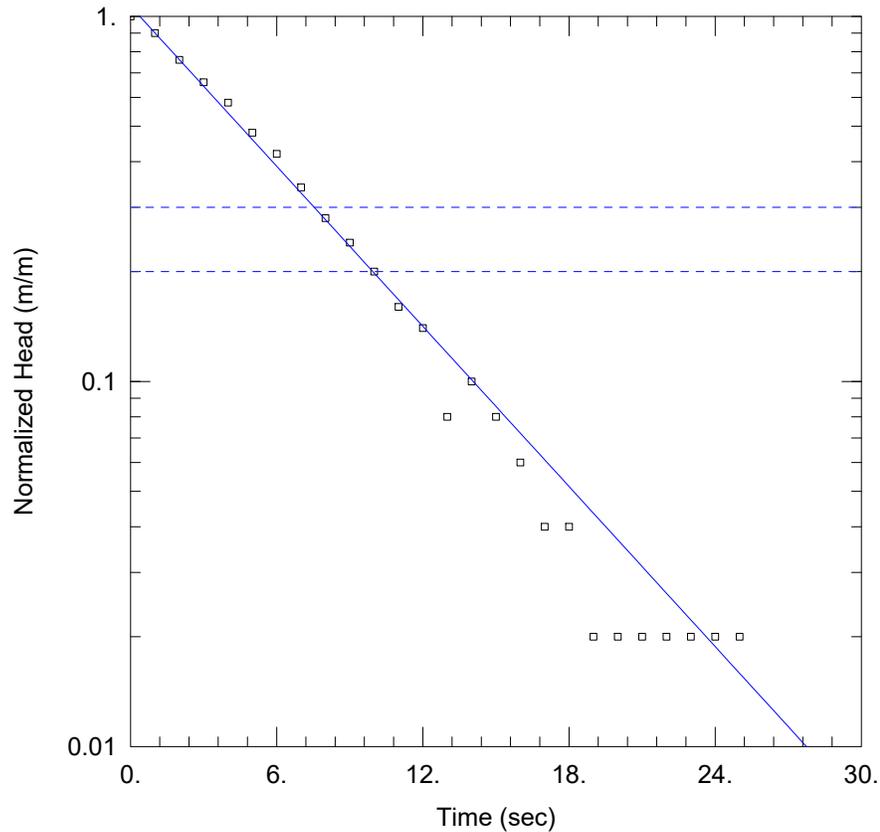
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 0.000181 m/sec

y0 = 0.6241 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-6B RHT2_Sandstone.aqt
 Date: 07/12/20 Time: 13:29:50

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-6B
 Test Date: 15-June-19

AQUIFER DATA

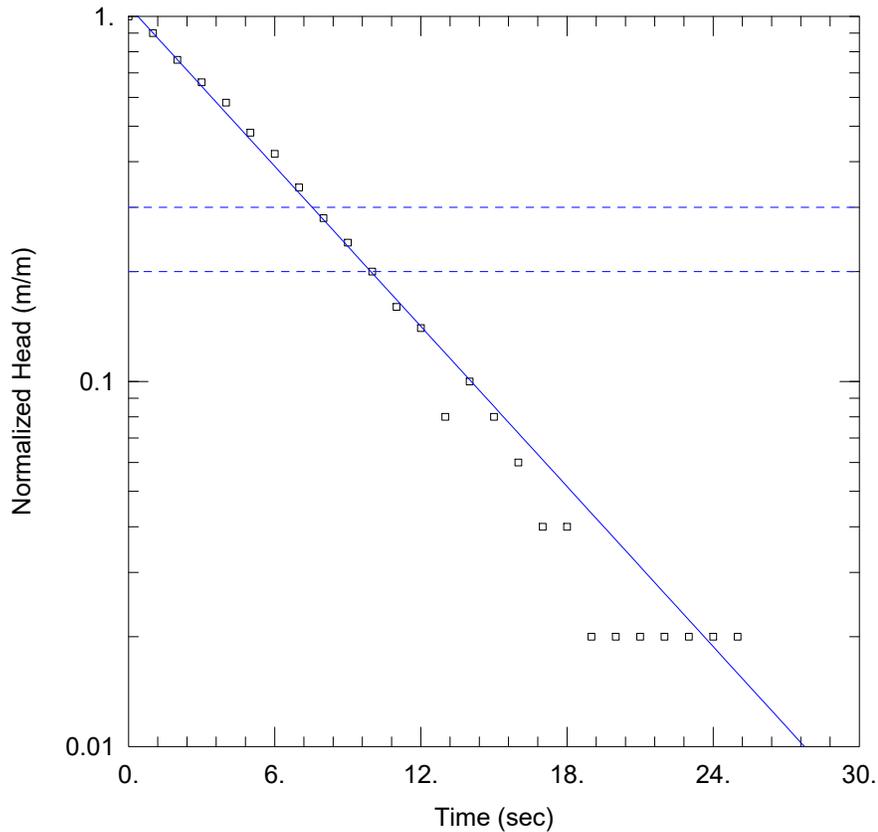
Saturated Thickness: 0.3 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-6B)

Initial Displacement: 0.5 m Static Water Column Height: 3.82 m
 Total Well Penetration Depth: 0.3 m Screen Length: 0.3 m
 Casing Radius: 0.025 m Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bower-Rice
 K = 0.0001769 m/sec y0 = 0.5332 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-6B RHT2_Sandstone.aqt
 Date: 07/12/20 Time: 13:31:05

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-6B
 Test Date: 15-June-19

AQUIFER DATA

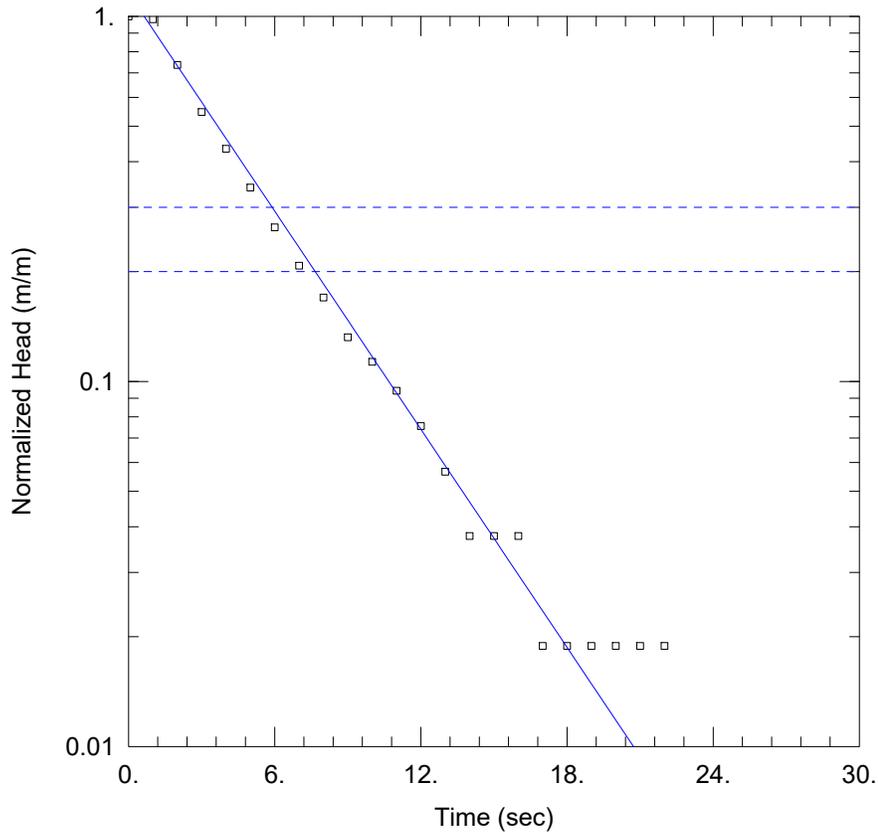
Saturated Thickness: 0.3 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-6B)

Initial Displacement: 0.5 m Static Water Column Height: 3.82 m
 Total Well Penetration Depth: 0.3 m Screen Length: 0.3 m
 Casing Radius: 0.025 m Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bower-Rice
 K = 0.0001769 m/sec y0 = 0.5332 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-12 RHT1.aqt
 Date: 07/12/20

Time: 13:31:45

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-12
 Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 2.26 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-12)

Initial Displacement: 0.53 m

Static Water Column Height: 2.26 m

Total Well Penetration Depth: 1.46 m

Screen Length: 1. m

Casing Radius: 0.025 m

Well Radius: 0.076 m

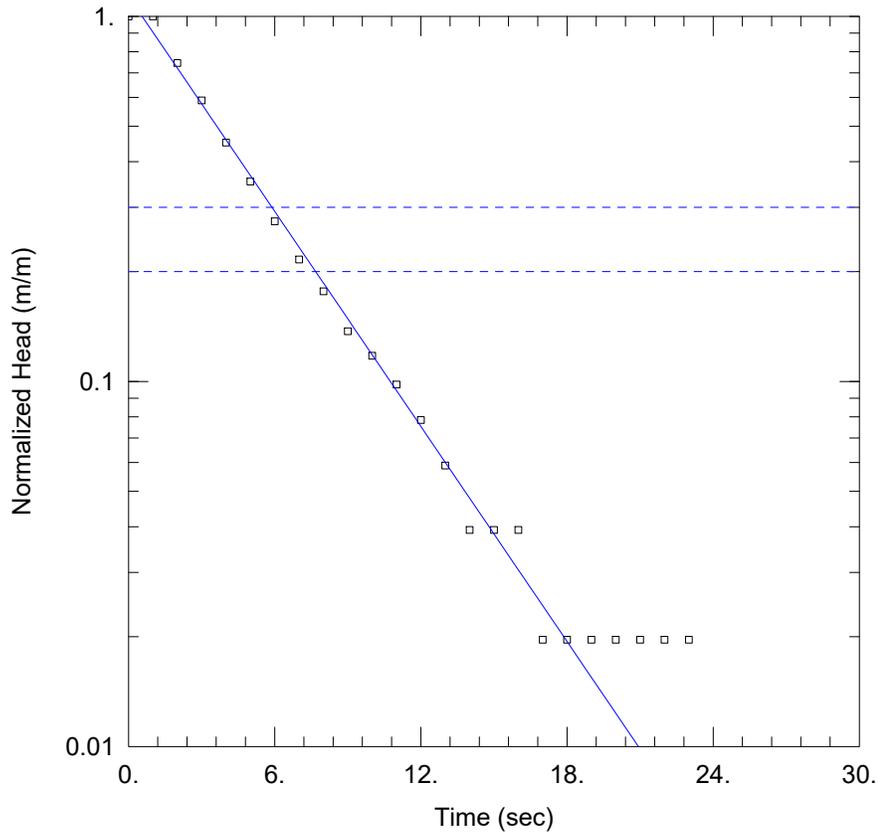
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bower-Rice

K = 0.0001249 m/sec

y0 = 0.6141 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-12 RHT2.aqt
 Date: 07/12/20

Time: 13:32:10

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-12
 Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 2.26 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-12)

Initial Displacement: 0.51 m

Static Water Column Height: 2.26 m

Total Well Penetration Depth: 1.46 m

Screen Length: 1. m

Casing Radius: 0.025 m

Well Radius: 0.076 m

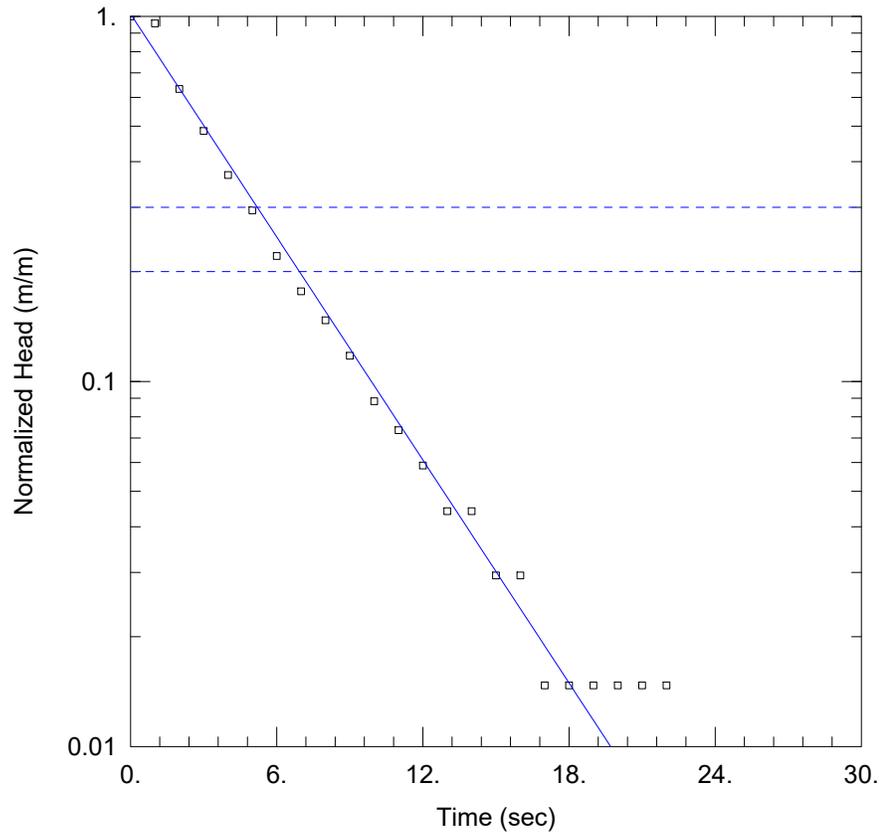
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bower-Rice

K = 0.0001231 m/sec

y0 = 0.5788 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-12 RHT3.aqt
 Date: 07/12/20

Time: 13:33:31

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-12
 Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 2.26 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-12)

Initial Displacement: 0.68 m

Static Water Column Height: 2.26 m

Total Well Penetration Depth: 1.46 m

Screen Length: 1. m

Casing Radius: 0.025 m

Well Radius: 0.076 m

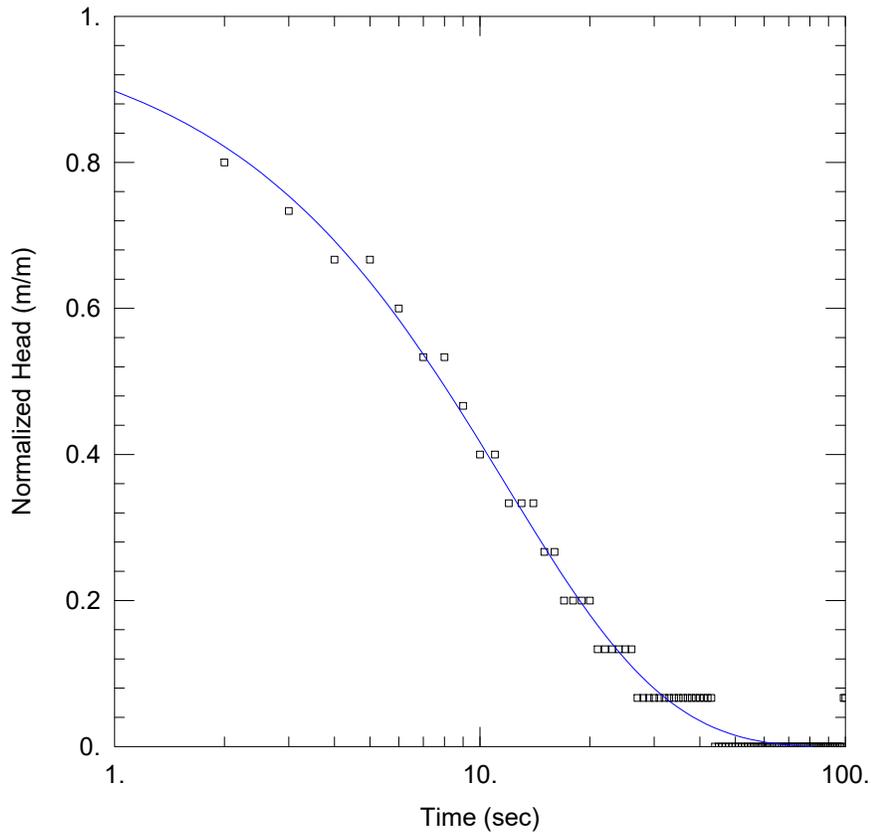
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bower-Rice

K = 0.0001277 m/sec

y0 = 0.6906 m



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-14 RHT1.aqt
 Date: 07/12/20

Time: 13:34:19

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-14
 Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 0.87 m

WELL DATA (MW19-14)

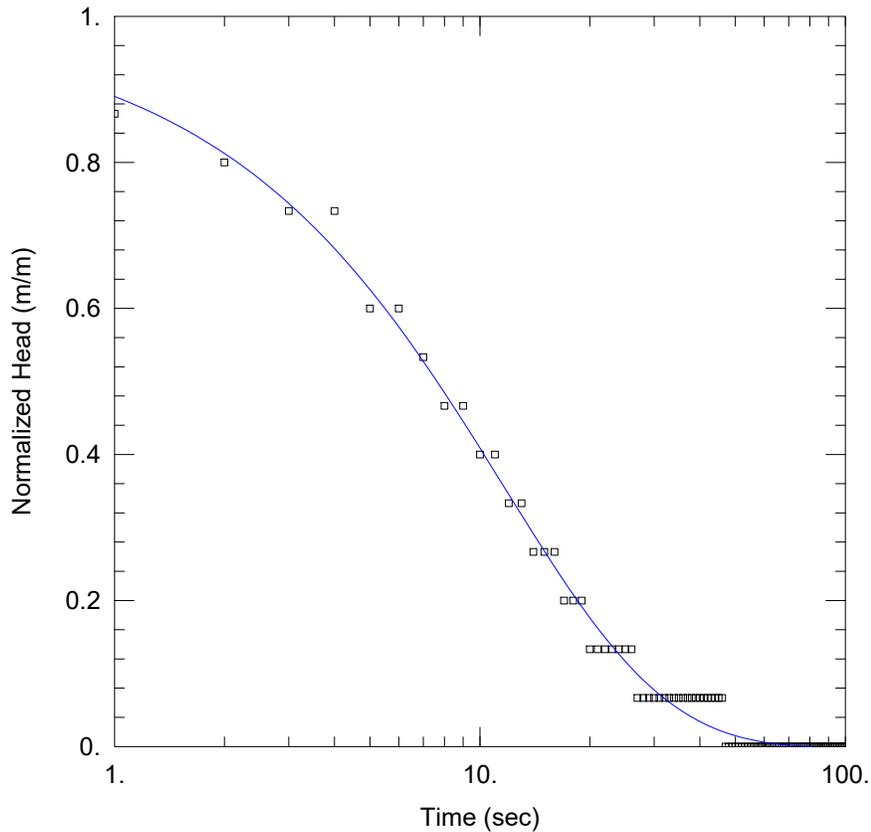
Initial Displacement: 0.15 m
 Total Well Penetration Depth: 0.77 m
 Casing Radius: 0.025 m

Static Water Column Height: 0.77 m
 Screen Length: 0.77 m
 Well Radius: 0.076 m

SOLUTION

Aquifer Model: Unconfined
 $K_r = 6.014E-5$ m/sec
 $K_z/K_r = 1.$

Solution Method: KGS Model
 $S_s = 0.0003783$ m⁻¹



WELL TEST ANALYSIS

Data Set: Z:\...\200622_MW19-14 RHT3.aqt
 Date: 07/12/20

Time: 13:34:52

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-14
 Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 0.87 m

WELL DATA (MW19-14)

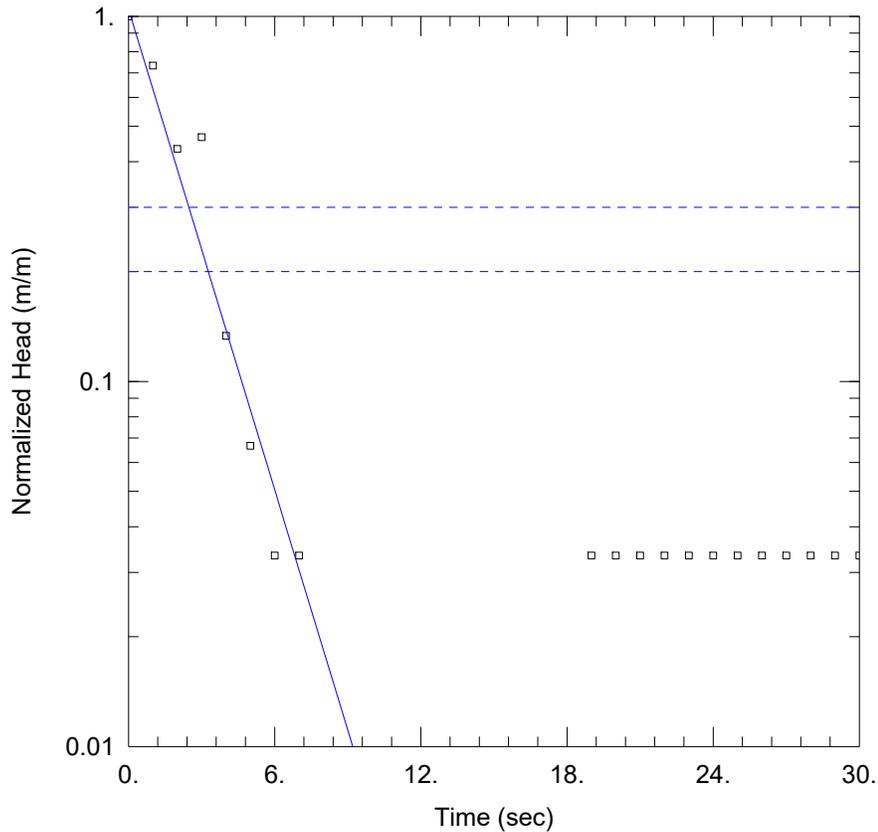
Initial Displacement: 0.15 m
 Total Well Penetration Depth: 0.77 m
 Casing Radius: 0.025 m

Static Water Column Height: 0.87 m
 Screen Length: 0.77 m
 Well Radius: 0.076 m

SOLUTION

Aquifer Model: Unconfined
 $K_r = 6.124E-5$ m/sec
 $K_z/K_r = 1.$

Solution Method: KGS Model
 $S_s = 0.000545$ m⁻¹



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-04 RHT1_BR.aqt

Date: 07/12/20

Time: 13:18:43

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-4

Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 3.24 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-4)

Initial Displacement: 0.3 m

Static Water Column Height: 1.24 m

Total Well Penetration Depth: 1.44 m

Screen Length: 1.44 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

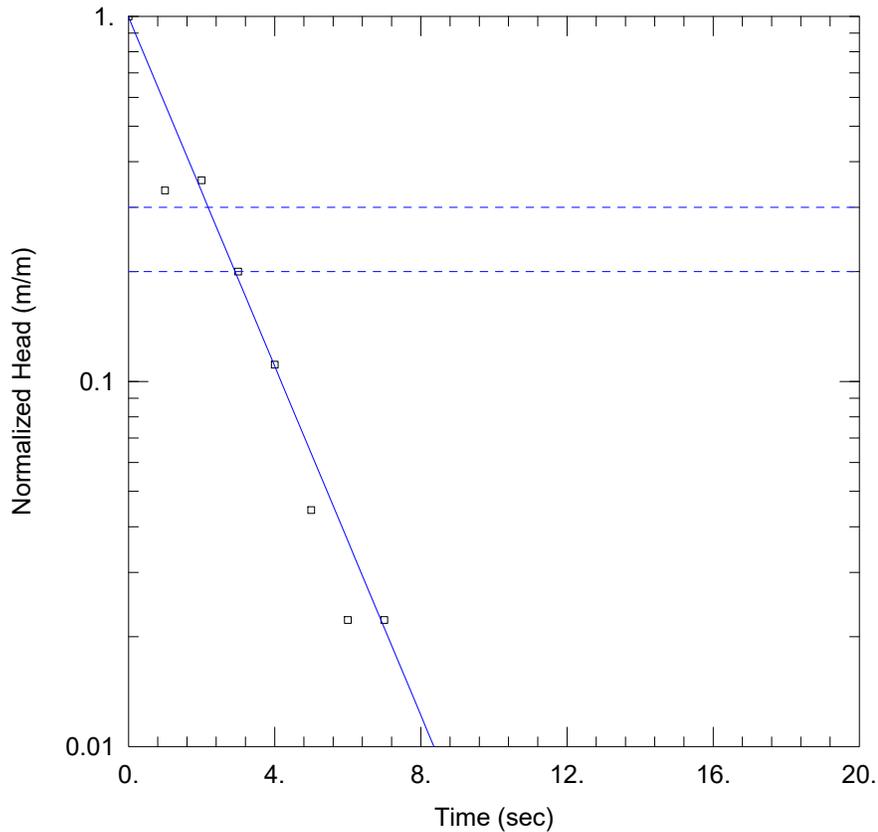
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bower-Rice

K = 0.0002027 m/sec

y0 = 0.3144 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-04 RHT2 BR.aqt

Date: 07/12/20

Time: 13:19:54

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-4

Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 3.24 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-4)

Initial Displacement: 0.45 m

Static Water Column Height: 1.34 m

Total Well Penetration Depth: 1.44 m

Screen Length: 1.44 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

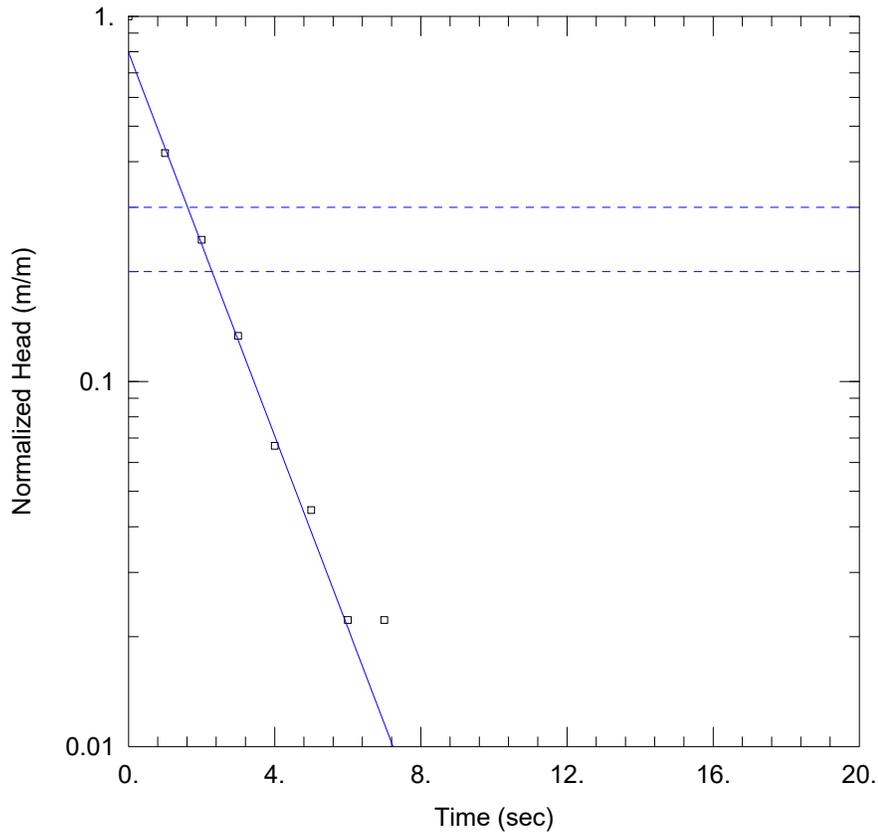
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bower-Rice

K = 0.0002208 m/sec

y0 = 0.4481 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-04 RHT3 BR.aqt

Date: 07/12/20

Time: 13:23:55

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-4

Test Date: 14-June-19

AQUIFER DATA

Saturated Thickness: 3.24 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-4)

Initial Displacement: 0.45 m

Static Water Column Height: 1.34 m

Total Well Penetration Depth: 1.44 m

Screen Length: 1.44 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

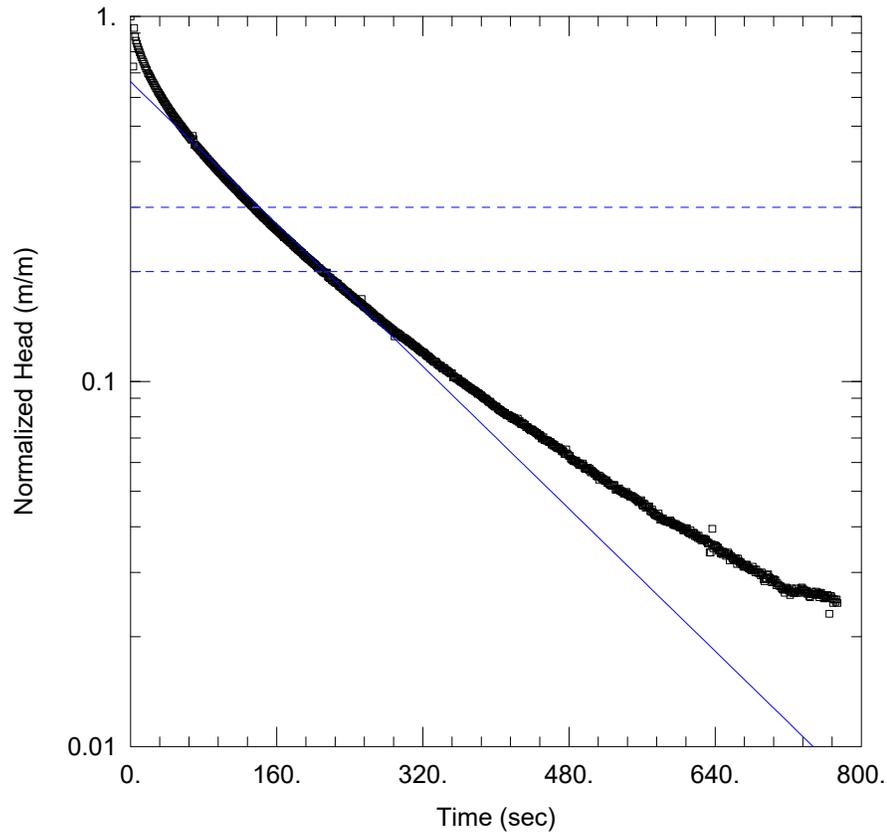
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bower-Rice

K = 0.0002426 m/sec

y0 = 0.3586 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-15A FHT1_BR.aqt

Date: 07/12/20

Time: 13:39:13

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-15A

Test Date: 15-May-19

AQUIFER DATA

Saturated Thickness: 2.2 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-15A)

Initial Displacement: 0.55 m

Static Water Column Height: 10.21 m

Total Well Penetration Depth: 2.2 m

Screen Length: 2.2 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

Gravel Pack Porosity: 0.2

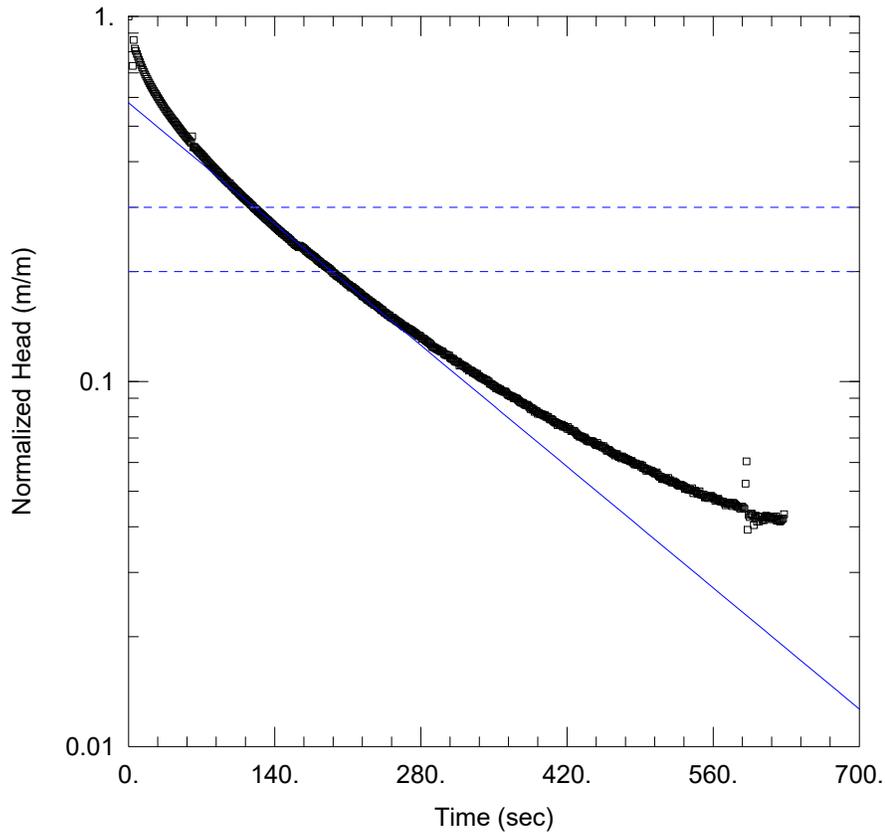
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 2.025E-6 m/sec

y0 = 0.3643 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-15A FHT2_BR.aqt

Date: 07/12/20

Time: 13:39:51

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-15A

Test Date: 15-May-19

AQUIFER DATA

Saturated Thickness: 2.2 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-15A)

Initial Displacement: 0.52 m

Static Water Column Height: 10.21 m

Total Well Penetration Depth: 2.2 m

Screen Length: 2.2 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

Gravel Pack Porosity: 0.2

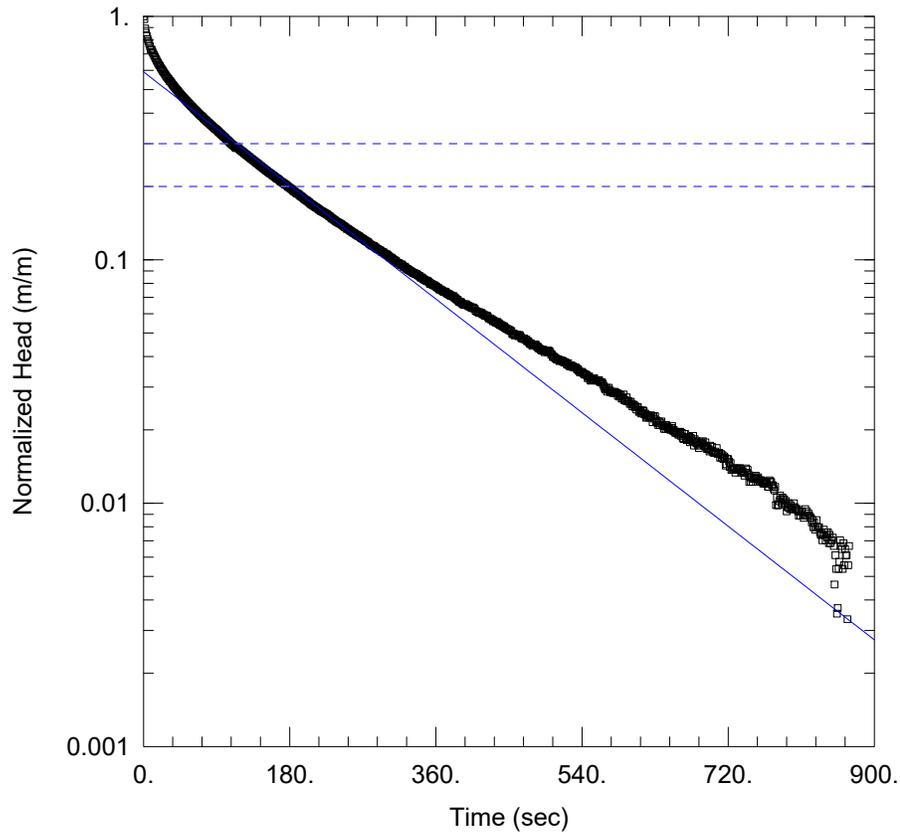
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 1.971E-6 m/sec

y0 = 0.3014 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-15A RHT1 BR.aqt

Date: 07/12/20

Time: 13:40:27

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-15A

Test Date: 15-May-19

AQUIFER DATA

Saturated Thickness: 2.2 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-15A)

Initial Displacement: 0.54 m

Static Water Column Height: 10.21 m

Total Well Penetration Depth: 2.2 m

Screen Length: 2.2 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

Gravel Pack Porosity: 0.2

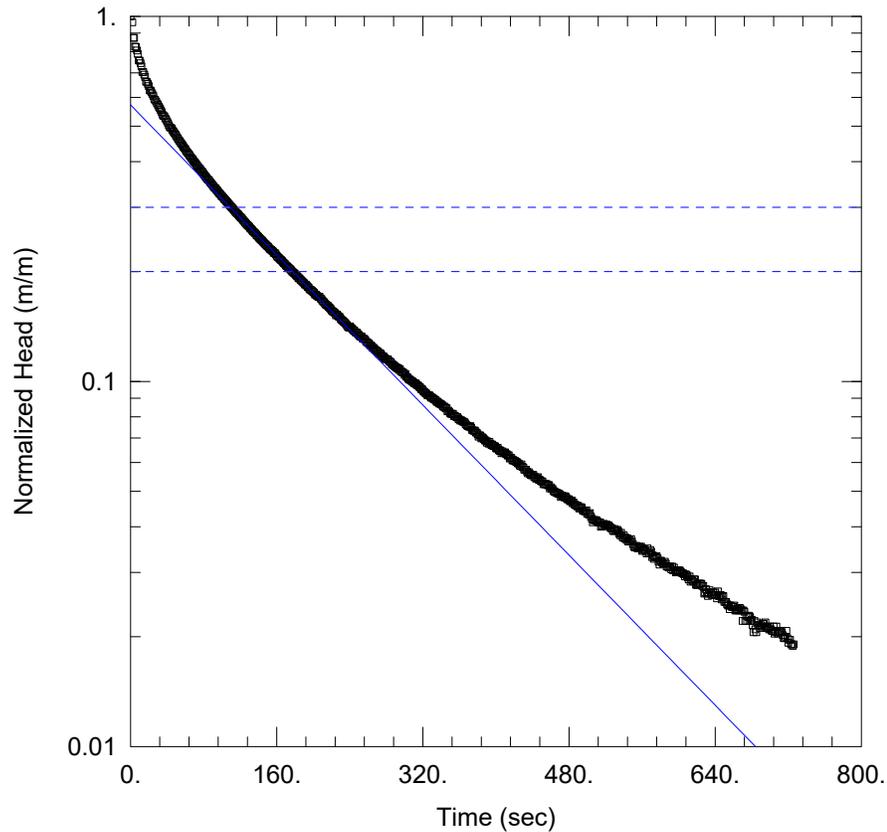
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 2.154E-6 m/sec

y0 = 0.3195 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-15A RHT2_BR.aqt

Date: 07/12/20

Time: 13:40:59

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-15A

Test Date: 15-May-19

AQUIFER DATA

Saturated Thickness: 2.2 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-15A)

Initial Displacement: 0.53 m

Static Water Column Height: 10.21 m

Total Well Penetration Depth: 2.2 m

Screen Length: 2.2 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

Gravel Pack Porosity: 0.2

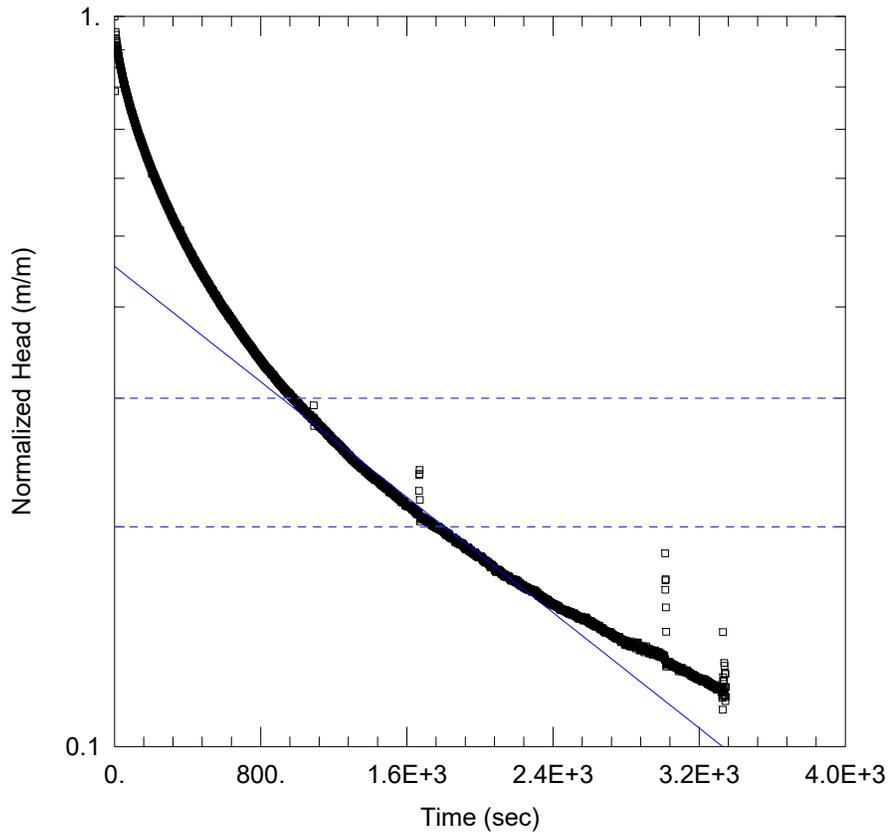
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 2.134E-6 m/sec

y0 = 0.3032 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-17 FHT1 BR.aqt

Date: 07/12/20

Time: 13:43:58

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-17

Test Date: 15-May-19

AQUIFER DATA

Saturated Thickness: 2.5 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-17)

Initial Displacement: 0.61 m

Static Water Column Height: 8.92 m

Total Well Penetration Depth: 2.5 m

Screen Length: 1.8 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

Gravel Pack Porosity: 0.2

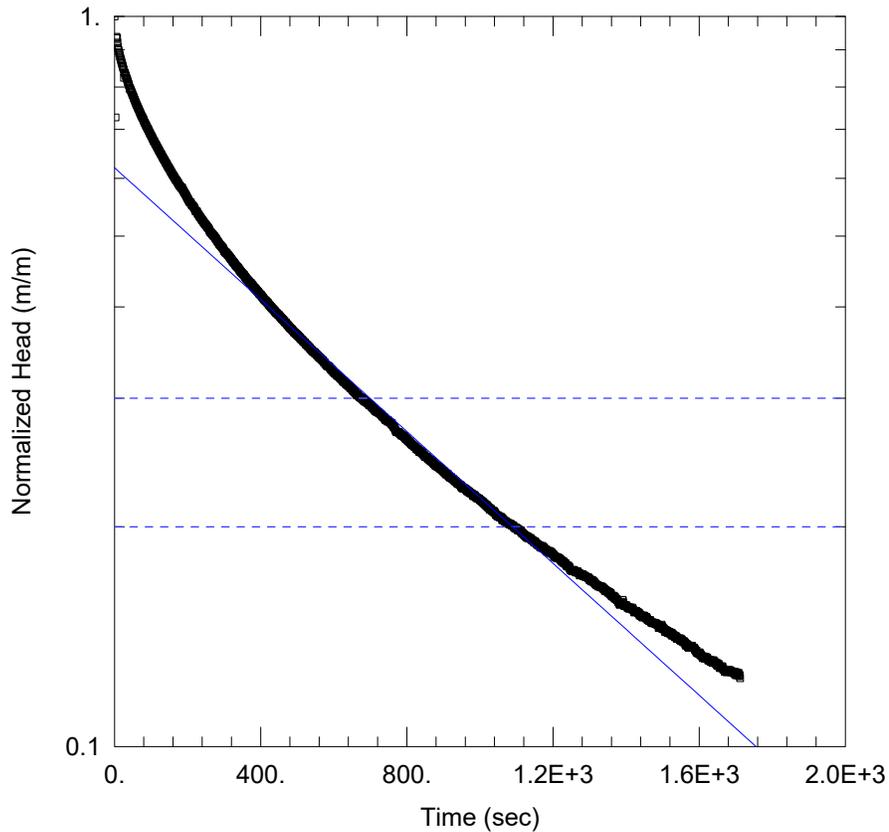
SOLUTION

Aquifer Model: Confined

Solution Method: Bower-Rice

K = 2.027E-7 m/sec

y0 = 0.2773 m



WELL TEST ANALYSIS

Data Set: Z:\...\200626_MW19-17 RHT1 BR.aqt

Date: 07/12/20

Time: 13:44:31

PROJECT INFORMATION

Company: Klohn Crippen Berger

Client: City of Calgary

Project: A03330C01

Location: Bowness

Test Well: MW19-17

Test Date: 15-May-19

AQUIFER DATA

Saturated Thickness: 2.5 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19-17)

Initial Displacement: 0.52 m

Static Water Column Height: 8.92 m

Total Well Penetration Depth: 2.5 m

Screen Length: 1.8 m

Casing Radius: 0.025 m

Well Radius: 0.076 m

Gravel Pack Porosity: 0.2

SOLUTION

Aquifer Model: Confined

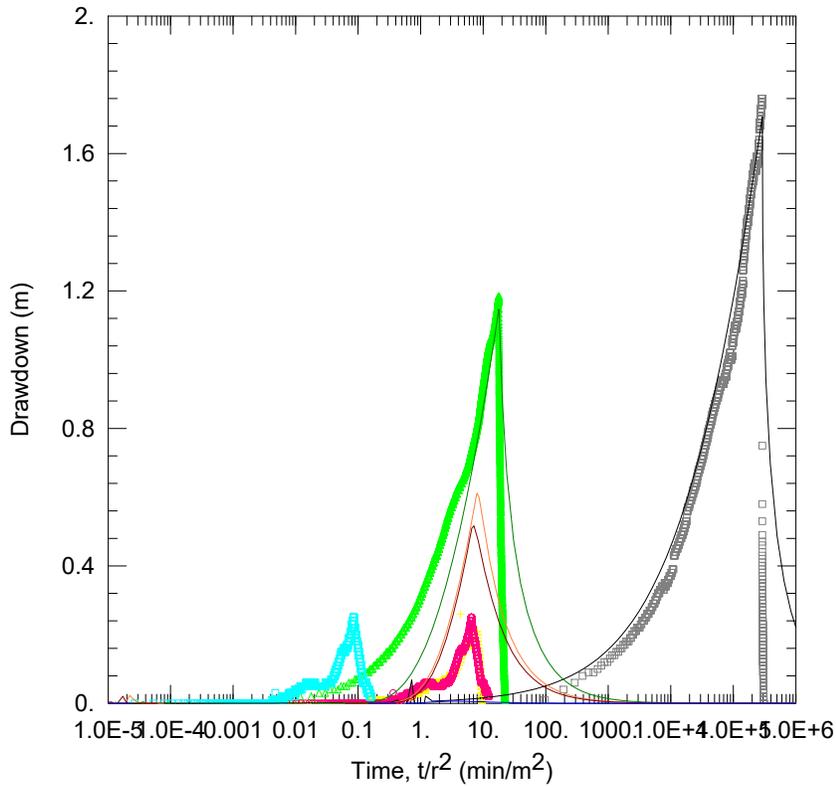
Solution Method: Bower-Rice

K = 4.631E-7 m/sec

y0 = 0.3226 m

APPENDIX I6

MW19-06D Pumping Test Results



WELL TEST ANALYSIS

Data Set: Z:\...\200703_MW19-06D_CRT.aqt
 Date: 07/13/20

Time: 14:30:59

PROJECT INFORMATION

Company: Klohn Crippen Berger
 Client: City of Calgary
 Project: A03330C01
 Location: Bowness
 Test Well: MW19-06D
 Test Date: 25-Jul-2019

AQUIFER DATA

Saturated Thickness: 5 m

Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW19-06D	0	0	□ MW19-06D	0	0
			+ MW19-06	0	20
			△ MW19-06A	0	13
			○ MW19-06C	0	22
			□ MW19-07	0	193

SOLUTION

Aquifer Model: Unconfined

Solution Method: Moench

T = 23.5 m²/day

S = 0.24

Sy = 0.24

Kz/Kr = 0.1

Sw = -4.475

r(w) = 0.1016 m

r(c) = 0.0762 m

alpha = 1.0E-10 min⁻¹