October 1, 2018 Reference No. 088877-03

Mr. Allan Leuschen
Senior Environmental Protection Officer
Authorizations – South
Environmental Protection Division
Ministry of Environment
2080 Labieux Road
Nanaimo, British Columbia V9T 6J9

Dear Mr. Leuschen:

Re: Technical Response to ENV Review (Auth. No.:Pr-10807)
Task 7 – Additional Bedrock Characterization
Upland Landfill
Upland Excavating, Campbell River, British Columbia

1. Introduction

GHD has prepared this letter on behalf of Upland Excavating Ltd. (Upland) in response to the Ministry of Environment & Climate Change Strategy (ENV), February 1, 2018 letter regarding Upland's Waste Discharge Application (Application). ENV's February 1, 2018 letter identifies additional information is required to address the recommendations listed in Section 5.1 of the Ministry Assessment Review Memorandum dated January 31, 2018 (Auth. No.:Pr-10807).

Clarifications of the Section 5.1 recommendations were discussed with ENV during meetings held on February 15 and February 26, 2018. A Technical Work Plan and Schedule (GHD's Work Plan) provided a description of the tasks (Tasks 1 to 8) to be carried out to address the Section 5.1 recommendations and provide additional information required by the ENV. GHD's Work Plan was submitted to ENV on March 7, 2018.

On March 23, 2018[1], the first technical response letter was submitted to ENV to satisfy Tasks 1 to 6 of GHD's Work Plan. This technical response letter has been prepared to satisfy the requested additional information for Task 7 – Additional Bedrock Characterization. On October 1, 2018, the technical response letter for Task 8 – Sand and Gravel Aquifer Pumping Tests was also submitted under separate cover to the ENV.

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[1] Letter to Mr. Allan Leuschen re: Technical Response to ENV review (Auth. No.:Pr-10807) dated March 23, 2018 (088877Leuchen-18).

2. Background

A hydrogeologic and hydrologic conceptual site model (CSM) was developed and presented in the Hydrogeology and Hydrology Characterization Report, GHD, amended May 31, 2017 (HHCR). The CSM provides a large-scale presentation of groundwater and surface water flow, which is particularly useful in light of the Site's complex topography, bedrock surface, the watershed divide, and groundwater flow divide. The interpreted presence of a groundwater flow divide is between Rico Lake and the Site.

The existence of Rico Lake at an elevation that is notably higher (>15 m) than the Pit bottom is dependent on naturally occurring geologic conditions that restricts the eastern migration of the lake water through the subsurface. Based on available stratigraphic records and observed bedrock outcrops, the presence of a bedrock ridge between Rico Lake and the Pit is included in the CSM. The presence of the ridge creates a groundwater and surface water flow divide. The approximate location of the watershed and groundwater flow divide was illustrated on Figure 3.0A of the Characterization Report.

Patrick Consulting Inc. (PCI) was contracted to complete an independent peer review of the hydrogeologic and hydrologic characterization and the groundwater and surface water impact assessment provided in the Design, Operation and Closure Plan, GHD, May 2017 (DOCP). PCI noted the characterization of the bedrock and groundwater flow conditions upgradient of the proposed landfill location may benefit from a more rigorous assessment to better define the groundwater flux entering the Site. It was anticipated the groundwater flux entering the Site from Rico Lake would be low.

ENV requested additional bedrock characterization in terms of bedrock surface, fracture frequencies and hydraulic conductivity be carried out between Rico Lake and the Pit.

3. Summary of Field Activities

During the time period of July 17 to September 17, 2018 GHD carried out various field activities to further characterize the geologic/hydrogeologic conditions in the Site area between Rico Lake and the Pit. Specific focus was to obtain additional information on the bedrock surface that will aid in characterizing groundwater flow patterns and elevations in this area. The additional characterization work carried out included the following field activities:

- Excavation of two test pits and the advancement of four boreholes between July 17 and July 19, 2018. Two of the boreholes were completed as a nested monitoring well. The shallow nested monitoring well was screened within the shallow aquifer and the deep nested monitoring well was screened within the underlying bedrock.
- Single well response tests (SWRT) at each nested well on July 19, 2018 to estimate the hydraulic conductivity of the surrounding aquifer.
- Completion of a geophysical investigation between Rico Lake and the Pit to further characterize the bedrock topography. Between August 21 and 23, 2018, an electrical resistivity (ER) survey was

completed along three transect lines. The geophysical investigation was chosen as a more efficient approach to investigate the bedrock surface as the depth to bedrock and geologic conditions was beyond the capabilities of conventional drilling equipment and methodologies.

- On September 17, 2018, McElhanney Consultants surveyed the top of riser elevations at the new monitoring well nest, the surface elevations along the geophysics transects, and completed a survey of the bedrock outcrops.
- On September 17, 2018, water levels were collected from Rico Lake and the existing monitoring well network, including the new nested well MW15A-18 and MW15B-18.

A figure illustrating the test pits (TP12-18, TP13-18), boreholes (BH13-18, BH14-18), and the existing monitoring well network (including MW15A-18 and MW15B-18) as wells as the three geophysical survey lines are presented on Figure 2.1.

The new monitoring well nest will be included in the upcoming November 2018 groundwater quality monitoring event.

4. Current Geologic and Hydrogeologic Characterization

Between August 2015 and September 2017, GHD developed an understanding of the Site geology and hydrogeology based on subsurface investigations, installation of monitoring wells, groundwater level monitoring data, examination of the Pit sidewalls and bedrock outcrops, and a review of documents such as regional maps, previous reports, and well completion logs from private wells.

GHD concluded that the Site geology consists of a native interbedded sand and gravel unit and an underlying competent bedrock unit.

Bedrock at the Site occurs at ground surface or underlies the sand and gravel overburden at variable depths. Bedrock outcrops are present and visible at the west and south portions of the Site. The bedrock unit consists of fine grained, porphyritic, basalt of the Karmutsen Formation. To the east, bedrock was not observed or encountered due to the significant thickness of the sand and gravel unit. Based on the occurrence of bedrock on Site, GHD described a bedrock ridge that extends from the southwest Site boundary to the northern portion of the adjoining K&D property that continues to the northwest towards McIvor Lake. The northern portion of the bedrock ridge wraps around the northern boundary of Rico Lake and separates Rico Lake and McIvor Lake to the north. Rico Lake is held within a bedrock depression. The bedrock ridge is the geologic feature that was investigated as part of the additional bedrock characterization.

Groundwater is present within bedrock fractures. The fractures observed at BH1-16, BH2-16, MW3-14, MW4A-15 and MW5A-15 vary in size, density and orientation (vertical, horizontal, and oblique). Evidence of weathering (i.e. iron staining) and secondary mineralization was observed by GHD in some fractures. Along the south and southwest face of the Pit, very competent basalt with little to no fracturing was observed.

Groundwater elevations at bedrock monitoring wells are consistently higher than the elevations within the overlying sand and gravel overburden within the western half of the Site. The difference in elevation indicates the presence of an upward vertical hydraulic gradient between the shallow fractured bedrock and the overlying sand and gravel aquifer. The upward gradient indicates groundwater from the shallow fractured bedrock discharge upward into the sand and gravel aquifer.

Between Rico Lake and the Pit, the low hydraulic conductivity measured in the bedrock significantly restricts movement of groundwater between these two features. However, surface water from Rico Lake potentially infiltrates the subsurface and moves through the barrier in the direction of the horizontal hydraulic gradient (i.e. from Rico Lake towards the Pit area), albeit at a very low velocity and negligible flux. Flow in the reverse direction, against the hydraulic gradients, cannot occur.

5. Investigation Results

This section presents the investigation results including borehole advancement, test pitting, monitoring well installation, SWRTs, hydraulic monitoring, and the bedrock outcrop survey.

5.1 Borehole Advancement

Under the direct supervision of GHD, Drillwell of Vancouver Island, BC (Drillwell) advanced four boreholes (BH13-18, BH14-18, BH15A-18 and BH15B-18) to depths ranging from 10.67 and 15.24 metres below ground surface (m BGS) using a track mount geoprobe 7822 multi drill with diamond coring capability.

At BH13-18 and BH4-18, borehole advancement through the sand and gravel unit was completed down to a maximum drilling depth of 14.94 and 10.67 m BGS, respectively. At TP12-18, borehole advancement was attempted using the solid stem geoprobe prior to test pitting to a maximum drilling depth of 6.10 m BGS. At TP13-18, the Site excavator completed the test pit to 6.10 m BGS. Bedrock was not encountered at these four locations.

Since bedrock was not encountered at these four locations, GHD continued the bedrock investigation northeast of Rico Lake. Bedrock was encountered during the advancement of two boreholes. GHD completed the two boreholes as a nested well (MW15A-18 and MW15B-18). At MW15A-18, four bedrock cores were collected from 9.14 to 15.24 m BGS using diamond core drilling. Based on the core samples, no primary porosity or obvious weathering on fractured surfaces was apparent within the upper 1.2 m of bedrock. Weathered sub-vertical and horizontal fractures were observed below the upper 1.2 m of bedrock from 9.5 to 15.24 m BGS. Precipitate on fracture surfaces was also observed.

Details of the stratigraphy encountered in July 2018 are presented on the Stratigraphic and Instrumentation Logs included as Attachment A.

5.2 Monitoring Well Installation

Monitoring wells MW15A-18 and MW15B-18 were constructed with No. 10 slot, 2-inch- (50-mm-) diameter PVC well screens and to 2-inch (50-mm) diameter, PVC riser pipe. A sand pack consisting of #2 silica filter sand was placed around each well screen to an average height of 0.30 m above the top of the well screen.

The annular space above the sand pack was backfilled to ground surface with hydrated bentonite chips to create an impermeable seal above the well screen. The monitoring wells were completed with above ground steel protective casings that were concreted in place.

The shallow monitoring well was screened within the bottom portion of the shallow aquifer directly overlying bedrock. The screened interval is 7.47 to 8.99 m BGS. The deep monitoring well is screened within the fractured bedrock from 13.72 to 15.24 m BGS. A 4.42 m hydrated bentonite seal separates the sand pack surrounding the shallow and deep monitoring wells.

The bottom depth of monitoring well MW15A-18 is at elevation 167.2 m AMSL, which is 13.2 to 10.8 m below the water elevations measured at Rico Lake and 10 m below the April 2017 water elevation measured at McIvor Lake.

Monitoring well installation logs are provided in Attachment A.

5.3 Single Well Response Tests

On July 18 and 26, 2018, GHD performed hydraulic conductivity testing at the newly installed nested monitoring wells to determine the hydraulic characteristics of the sand and gravel overburden and fractured bedrock units. GHD completed single well response tests (SWRTs or slug tests) on monitoring wells MW15A-18 and MW15B-18. SWRTs were completed in accordance with GHD's standard operating procedures (SOPs), which are summarized below. Prior to completing the SWRTs, the monitoring wells were developed using a bailer or a footvalve and surge block positioned within different intervals in the screen to ensure that the entire length of the screen was properly surged.

Each slug test was completed by inducing a sudden change in the water level and measuring the response of the aquifer within the individual monitoring well being tested (i.e. measuring the change in water level over time). The water level change was induced by introducing or removing a known volume or "slug" into and out of each well.

GHD completed five SWRTs at MW15A-18 (3 risings test and 2 falling tests) and three SWRTs at MW15B-18 (3 rising tests).

At MW15A-18, during the first SWRT, a sudden change in the water level was induced by removing groundwater using Waterra © tubing. Groundwater was removed from the well until 3 m of drawdown relative to the static water level was achieved. The change in water level was measured manually using a Solinst © water level until the well recovered to static level (at least 90 percent of the total initial displacement). During the remaining SWRTs at MW15A-18, a sudden change in the water level was induced using a slug. The slug was used to displace the static water level within the monitoring well. The change in water level was measured using a Solinst © Levelogger pressure transducer until the well recovered to static level (at least 90 percent of the total initial displacement). Manual water level measurements were also recorded manually with the Solinst © water level to validate the pressure transducer measurements.

At MW15B-18, the SWRTs were completed by removing a known volume of water from the monitoring well using a bailer. Following this near instantaneous change in the static water level, a Solinst © Levelogger pressure transducer recorded water level measurements during well recovery. Manual water level measurements were also recorded manually with the Solinst © water level to validate the pressure transducer measurements.

GHD analyzed the results of the SWRTs using the computer based software, AQTESOLV© (v. 4.01) and the Hvorslev test solution. The Hvorslev method provides a solution for determining the hydraulic conductivity of an unconfined aquifer. Analysis involves matching a straight line to water-level displacement data collected over time.

Single well response plots generated by AQTESOLV are provided in Attachment B.

The hydraulic conductivity was estimated by calculating the geomean using the SWRT results from each well. The hydraulic conductivity of the fractured bedrock unit at MW15A-18 is estimated to be 8.3×10^{-3} cm/sec and the hydraulic conductivity of the shallow aquifer at MW15B-18 is estimated to be 7.5×10^{-4} cm/sec. Both of these values are lower then the hydraulic conductivity of the sand and gravel aquifer below the Pit of 2.0×10^{-2} cm/sec.

5.4 Hydraulic Monitoring

On September 17, 2018, GHD completed hydraulic monitoring at all existing on-Site monitoring well locations. The depth to water was measured using an electronic water level tape. The water elevation in Rico Lake was surveyed by McElhanney the morning of September 17, 2018. The water level in McIvor Lake was not re-surveyed. The results of the hydraulic monitoring program were used to determine the September groundwater flow direction and vertical hydraulic gradients between the overburden and bedrock units, and to re-visit the hydraulic relationship between the groundwater and surface water between Rico Lake and the Pit.

The groundwater levels and calculated elevations are provided in Table 5.1. The groundwater contour figure is presented on Figure 5.1. An interpretation of the hydrogeology based on new and previously collected data is presented within Section 7.

5.5 Bedrock Outcrop Survey

On September 17, 2018, McElhanney completed a thorough survey of the bedrock outcrops around the eastern perimeter of Rico Lake as directed by GHD and Site staff. The elevations points were used to supplement existing bedrock surface elevation data. The elevation survey was completed using GPS survey equipment. This equipment provides an accuracy level for each data point of approximately 1 to 5 centimetres (cm).

6. Geophysical Survey Results

GHD completed a geophysical investigation August 21 and 23, 2018 along three transects to further investigate the deeper bedrock surface between Rico Lake and the Pit. The transects are shown on Figure 2.1. GHD choose to complete an ER Survey to provide a 2D spatial model of the geologic and hydrogeologic variations underlying each transect. For the purposes of this investigation, the 2D model provides bedrock topography information in m BGS and, when coupled with ground elevation data, bedrock elevations in m AMSL as well The ER survey was selected as the geophysical methodology most appropriate for the Site for two primary reasons: i) ER surveys are well suited to capture and model steeply inclined strata and ii) ER surveys are not significantly effected by noise generated from Site operations (i.e. seismic waves caused by heavy machinery and blasting activities). This method compliments previous drilling and test pitting results, which has provided bedrock topography information only at discrete locations.

Along each line, the ER survey was completed using a Syscal R1 Plus resistivity meter (R1 Plus) manufactured by Iris instruments. The R1 Plus operates simultaneously as a receiver and transmitter, and has a maximum power output of 200 Watts (W). The output current applied by the transmitter is automatically adjusted for each reading, to optimize the input voltage detected by the receiver and ensure the best measurement quality. The receiver automatically “switches” between pre-defined sets of resistivity measurements, yielding a vertical profile or “pseudosection” of apparent resistivity.

The ER survey also utilized a 72-electrode spread configuration with 2 meter electrode spacings. A Wenner array was employed, whereby the two voltage electrodes were at the center of the profile and bound by the two current electrodes for each measurement. This array yielded a depth of investigation of approximately 18 to 21 metres (m) below ground surface (bgs), along survey lines which ranged from 108 to 180 metres in length, respectively.

Upon return from the Site, the ER survey data were downloaded to a computer and compiled for data processing. A vertical section or "pseudo-section" of measured apparent resistivity was then plotted, to confirm that the integrity of the measured data was good. The apparent resistivity data were imported into an inversion software program and processed to yield a modeled profile section of resistivity for the line of survey.

For this investigation, it was anticipated that the sand and gravel overburden sequences would be identified as zones of lower resistivity compared to the basalt bedrock yielding higher resistivity responses.

The modeled profiles were generated by processing the measured apparent resistivity data with the inversion program RES2DINV, to yield modeled resistivity sections for each line of survey. The modeled sections represent the resistance of soils and bedrock in the shallow subsurface, and thus provide an interpretation of the shallow overburden sequences along the lines of survey as well as bedrock topography.

The elevation of the bedrock surface was determined by applying the bedrock edge detection option in the RES2DINV inversion model, whereby the program picks the bedrock interface from the model section. The bedrock edge detection is most successful where the bedrock has a sharp interface (and not gradational) with the overlying soil, such as the conditions observed at the Site. The bedrock edge detection is the function of a number of parameters determined by the inversion program. These include the bedrock resistivity value, the resistivity gradient used as the marker for the edge of the bedrock, and the maximum change in bedrock depth between adjacent electrodes. The approximate location of the bedrock surface as predicted by the model is presented as blue dashed lines on the modeled profiles.

The highest resistivity values on the modeled sections are coloured dark blue, while areas of low resistivity (or conversely, high conductivity) are colored red to purple. All remaining intermediate responses correspond to the colour scale presented at the bottom of the section. Review of the coloured plot reveals that contour intervals ranging from 20 to 2,000 Ohm-m were applied for Lines 1 and 2; for the highly resistive responses observed for Line 3, contour intervals ranging from 200 to 15,000 Ohm-m were applied.

The results of the ER survey for each line are presented on Figures 6.1 to 6.3. A description of the results for each Line are presented below.

Line 1 commenced on the east side of the access road adjacent to a concrete stockpile, and extended across the road to the area north of the Site water truck filling station. Exposed bedrock was observed to the east of the concrete stockpile, and was anticipated that shallow bedrock would extend westward across the south end of Line 1. Evidence of bedrock at two locations along the line of survey is reflected in the high resistivity responses (1,000 to 2,000 Ohm.m) which were measured from the start of the line to station 42 m and from 55.5 to 62 m.

Along stations 1 to 42 m, the inversion program modeled bedrock dipping steeply toward the north (i.e. blue dashed line on Figures 6.1). The bedrock dip modelled along Line 1 closely approximates the dip of the outcrop, which can be observed to the south of the west access ramp where the three elevation values (189.7 to 189.94 m AMSL) are labelled on Figure 7.1B.

Along stations 55.5 to 62 m, the inversion program modeled bedrock at the bottom of the profile. Similar resistivity values were measured in the shallow subsurface (to 6 m bgs) between station 55 m and 80 m. These elevated responses are attributed to crushed basalt aggregate, which, according to Site staff, was used to build the access road. A decrease in resistivity response (400 to 750 Ohm.m) with increasing depth indicates that fine-grained sediments may be present beneath the crushed aggregate.

Line 2 is located on the west edge of the quarry access road, and extended from south to north. The modeled resistivity section provided on Figure 6.2 reveals that similarities exist between the results for Line 2 and those observed for Line 1. Evidence of bedrock at three locations along the line of survey is reflected in the high resistivity responses (1,000 to 2,000 Ohm.m) which were measured from the start of the line to station 52 m, from 65 to 105 m, and centered on station 130 m.

Along stations 1 to 52 m, resistivity responses are indicative of shallow bedrock (approx. 192 m AMSL) which is steeply dipping to the north.

Along stations 65 to 105 m, resistivity values in excess of 1500 Ohm.m were attributed to crushed basalt aggregate in the shallow subsurface (to 8 m bgs), similar to Line 1. However, unlike Line 1 where the crushed aggregate was underlain by silty sand, on Line 2 this sequence appears to be underlain by bedrock as indicated by the elevated resistivity response observed at depth between stations 65 m and 90 m. The deep bedrock along Line 2 (177.25 m AMSL) is in line with the modelled deep bedrock response on Line 1, centered on station 60 m (177 m AMSL). A similar deep response was also observed on Line 2, centered on station 130 m (172.8 m AMSL).

Line 3 was located to the east of Rico Lake along the Site boundary. Line 3 commenced on a closed access road and extended to the road south of the K&D Contracting heavy equipment shop. The modeled resistivity profile presented on Figure 6.3 indicates one bedrock location centered at station 70 m based on the elevated response of 7,500 Ohm.m. The remaining shallow subsurface along the line of survey is characterized by highly elevated responses up to 20,000 Ohm.m, typical of very dry sand and gravel (crushed basalt) sequences. These sequences were underlain by saturated sand and gravel beneath the water table (approx. 178 m AMSL), which yielded responses ranging from 500 to 2,000 Ohm.m.

7. Updated Site Geology and Hydrogeology Characterization

Based on the results of the field investigations and geophysics survey carried out during the July to September 2018 for Task 7, the geologic and hydrogeologic conditions at the Site between Rico Lake and the Pit have been updated.

7.1 Updated Site Geology

Updated bedrock contours are presented on Figure 7.1A. The Site bedrock contours reflect bedrock encountered during the July 2018 subsurface investigation (at MW15A-18 and MW15B-18), bedrock outcrops surveyed by McElhanney, and bedrock topography modelled using the ER survey data. Bedrock surface elevations are illustrated on Figure 7.1B.

Although bedrock conditions on-Site remain the same, dipping steeply from west to east, the conditions immediately east of Rico Lake have been updated to include the new data. The results of the additional bedrock characterization supports that the bedrock surface at elevations above Rico Lake extends from the southwest Site boundary to the northern portion of the adjoining K&D property that continues to the northwest towards McIvor Lake. Rico Lake is held within a bedrock depression.

Amendments to the Site bedrock contours include:

- The bedrock contours representing the mountain and mountain ridge adjacent to the south property boundary have been added to the bedrock contour figure (Figure 7.1A).

- Bedrock previously interpreted to be along the northern of Rico Lake has been removed. During the bedrock survey completed by McElhanney on September 17, 2018, bedrock was observed around Rico Lake at and in the vicinity of elevation point 184.99 as shown on Figure 7.1B. This bedrock outcrop is located along the south shore of Rico Lake. Crushed aggregate is present in some areas surrounding Rico Lake. Site staff reported that aggregate was historically placed in these areas.
- The updated bedrock elevations supports that Rico Lake is held within a bedrock depression. This interpretation is further supported by the ER Survey completed at Line 3. From approximately 0 to 12 m BGS (189 to 177 m AMSL), the resistivity responses are typical of unsaturated sand and gravel sequences. Below 177 m AMSL, the responses are typical of saturated sand and gravel.
- Bedrock encountered at MW15A-18, MW5A-15, and at outcrops located between these two monitoring wells represent bedrock conditions that likely exist between Rico Lake and the Pit. Bedrock conditions vary from competent to fractured. Bedrock was observed in the 2015 - 2018 Production Area at elevations 193.46, 192.87, and 187.1 to 183.4 m AMSL, in the Pit east of Rico Lake at elevation 189.9 m AMSL, at the southern limit of Rico Lake at elevation 184.99 m AMSL (see Figure 7.1B). The remaining outcrops were either damaged and broken due to blasting and excavation of the rock or were only in part exposed and could not be characterized. Competent bedrock was encountered at MW5A-15. Fractured bedrock was encountered at MW15A-18.
- Bedrock elevations between Rico Lake and the Pit were initially interpreted to range in elevations from 180 to 192 m AMSL. Based on new data collected, bedrock elevations between Rico Lake and the Pit are now observed to range between 170.5 to 191.1 m AMSL. A very narrow sand and gravel filled incised trough or crevice in the bedrock surface may exist northeast of BH13-18 and BH14-18.

7.2 Updated Site Hydrogeology

Updated groundwater contours are presented on Figure 5.1. The groundwater contours reflect water levels measured on September 17, 2018 from the existing monitoring well network and Rico Lake, and at the water level measured at McIvor Lake on April 6, 2017.

The updated groundwater contours vary slightly from previous versions. The interpretation of the hydrogeologic properties of the overburden and bedrock remain the same with the exception of the hydraulic connection between Rico Lake and the Site.

The results of the additional bedrock characterization support the following hydrogeologic interpretations:

- The predominant groundwater flow direction within the sand and gravel aquifer is from McIvor Lake toward the Site, in a southeast direction.
- A relatively thin, discontinuous shallow aquifer is present in areas within the northern portion of the Site throughout the K&D property, between Rico Lake and the Pit, and in the southeast corner of the Site (outside of the Pit). Monitoring well MW15B-18 and the geophysics transects verify the presence of the shallow aquifer between Rico Lake and the Pit. The geophysics transects are located between Rico Lake and the Pit.

- Bedrock between Rico Lake and the Site significantly restricts the movement of groundwater between these two features. Previously, this interpretation was based on the low hydraulic conductivity of bedrock measured at MW5A-15. Based on SWRTs, the hydraulic conductivity of bedrock at MW5A-15 is approximately 1.4 x 10^{-5} cm/sec. In July 2018, SWRTs were completed at MW15A-18. Based on the results of these tests, the fractured bedrock unit surrounding this well is 8.3 x 10^{-3} cm/sec, which is a difference of two orders of magnitude then previously reported. The results of the July 2018 SWRTs demonstrate that the hydraulic conductivity of the bedrock is variable across the Site. In areas where bedrock is competent the groundwater flux is negligible as compared to areas where the bedrock is fractured.
- Water from Rico Lake flows horizontally toward nested well MW15A-18 and MW15B-18. This interpretation is based on the water levels measured on September 17, 2018. The water elevation at Rico Lake is 178 m AMSL and the water elevation at overburden well MW15B-18 is 174.3 m AMSL. Previously water from Rico Lake was interpreted to only discharge west toward McIvor Lake.
- On September 17, 2018, the water level within Rico Lake was surveyed at 178 m AMSL indicating horizontal flow in the sand and gravel towards the Pit below elevation 178 m AMSL is occurring. Water from Rico Lake also has the potential to flow through bedrock fractures and recharge the sand and gravel aquifer underlying the Site, based on the hydraulic conductivity of the bedrock measured at MW15A-18. Considering this, a portion of the groundwater divide has been revised to be located along the eastern shore of Rico Lake (Figure 5.1).
- The vertical hydraulic gradient between the sand and gravel overburden and the underlying shallow bedrock is upward in the western half of the Site. The hydraulic vertical gradient calculated for the new nested well showed a strong upward vertical gradient of 0.18 m/m. The hydraulic gradient calculated at MW4A-16 and MW4B-16 continues to show an upward gradient indicating that groundwater within the bedrock fractures discharges to the overlying sand and gravel unit across the western portion of the Site. Flow in the reverse direction, against the hydraulic gradients, cannot occur.

8. Conclusions

Conclusions made based on the results of this additional bedrock characterization include:

- Between Rico Lake and the Pit, the bedrock surface is present at elevations above Rico Lake. Rico Lake is held within a bedrock depression.
- Fracturing is apparent within the upper bedrock unit including evidence of weathering and secondary mineralization. The size and permeability of the shallow bedrock fractures are variable.
- A small sand and gravel filled incised trough or crevice may exist within the bedrock. Flow through this crevice would discharge down into the sand and gravel aquifer.
- Groundwater flow from Rico Lake towards the Pit occurs through the shallow sand and gravel aquifer and fractured bedrock. The groundwater contours shown on Figure 5.1 illustrates the hydraulic connection between Rico Lake and the Pit.

- The hydraulic conductivity of the thin shallow overburden aquifer and the fractured bedrock west of the Pit are lower than the sand and gravel aquifer beneath the Pit.
- An upward vertical gradient exists between the shallow bedrock and the overburden aquifers within the western portion of the Site.
- The predominant groundwater flow direction in the sand and gravel aquifer is southeast from McIvor Lake across the Site.
- Groundwater migrating from the eastern shore of Rico Lake flows east within the Quinsam River Watershed. The groundwater divide is further west then initially interpreted. The watershed divide is now interpreted to be located along the eastern shore of Rico Lake.

Sincerely,

GHD

RoseMarie Ro

Rose Marie Rocca, GIT

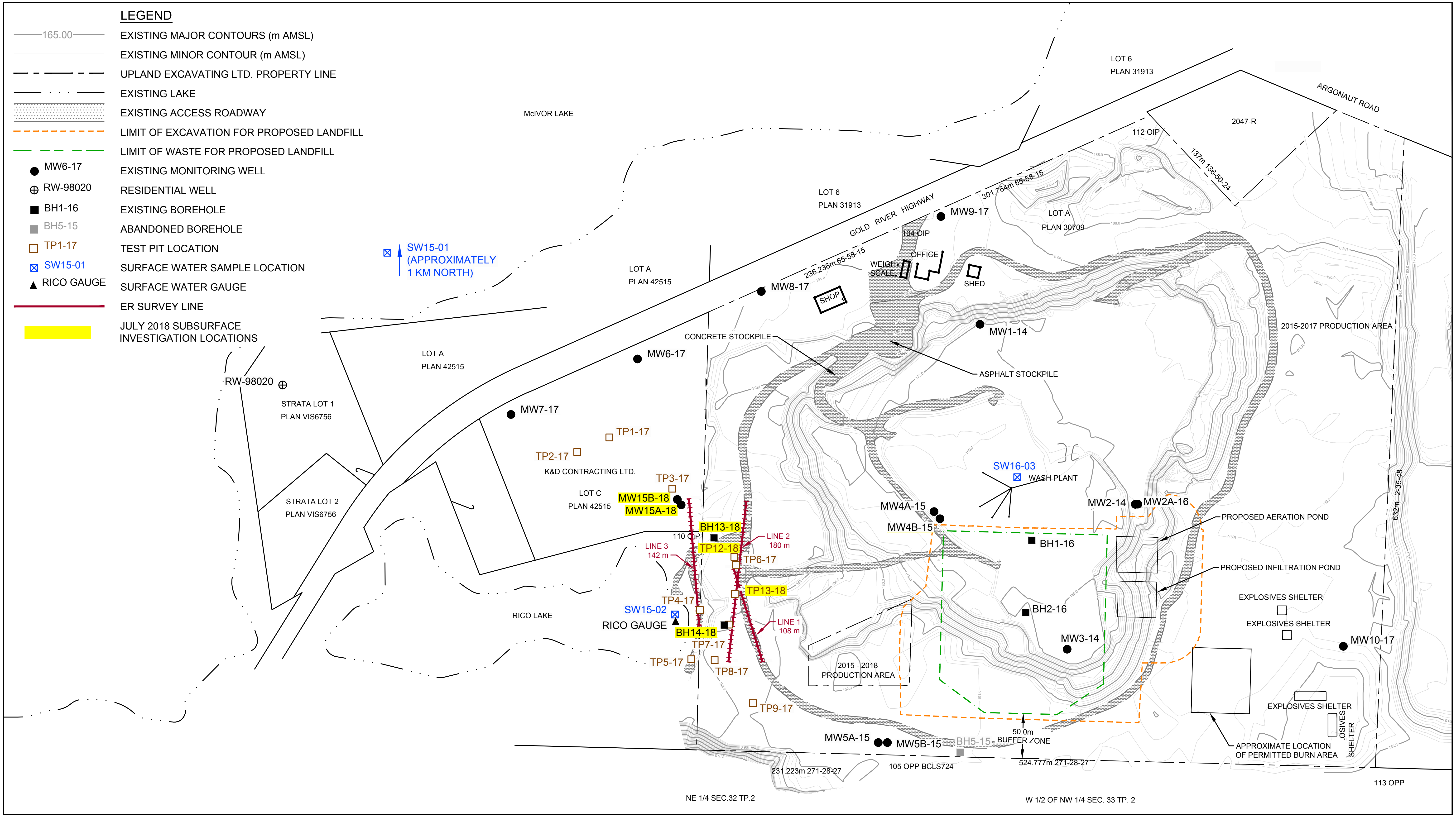
Joe Rothfischer

Joe Rothfischer, M.Eng., P.Eng.

Gregory D. Ferraro, P. Eng.

JR/cs/20

Encl.



SOURCE: TOPOGRAPHICAL SURVEY CONDUCTED BY McELHANNEY ASSOCIATES LAND SURVEYING LTD., NOVEMBER 21, 2016.

0 40 80 120m

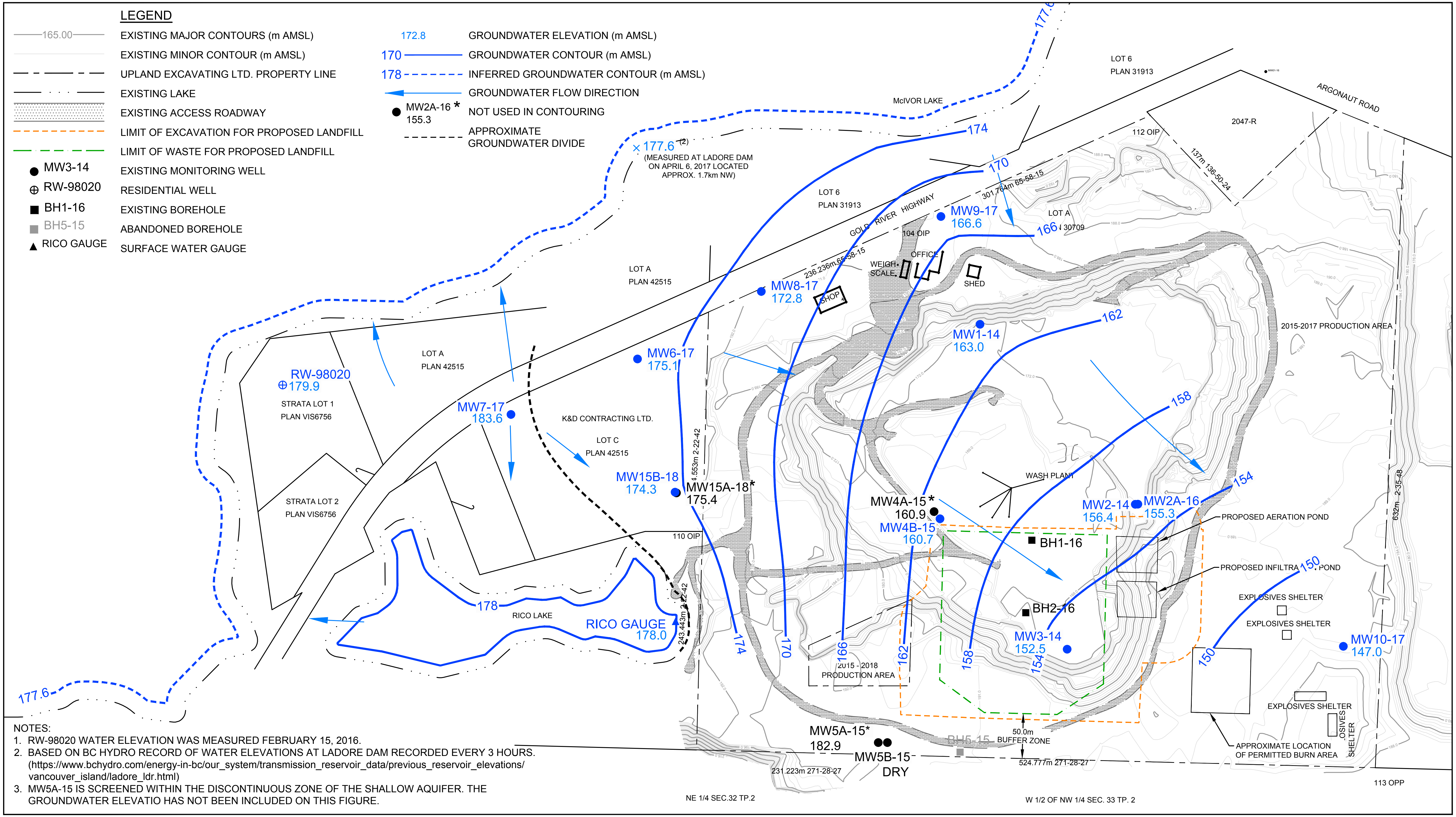
UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

088877-00
Sep 28, 2018

MONITORING AND INVESTIGATION LOCATIONS

FIGURE 2.1

CAD File: 088877-00(LEUS020)GN-SC006.DWG



NOTES:
1. RW-98020 WATER ELEVATION WAS MEASURED FEBRUARY 15, 2016.
2. BASED ON BC HYDRO RECORD OF WATER ELEVATIONS AT LADORE DAM RECORDED EVERY 3 HOURS. (https://www.bchydro.com/energy-in-bc/our_system/transmission_reservoir_data/previous_reservoir_elevations/vancouver_island/ladore_ldr.html)
3. MW5A-15 IS SCREENED WITHIN THE DISCONTINUOUS ZONE OF THE SHALLOW AQUIFER. THE GROUNDWATER ELEVATIO HAS NOT BEEN INCLUDED ON THIS FIGURE.

SOURCE: TOPOGRAPHICAL SURVEY CONDUCTED BY McELHANNEY ASSOCIATES LAND SURVEYING LTD., NOVEMBER 21, 2016.

0 40 80 120m

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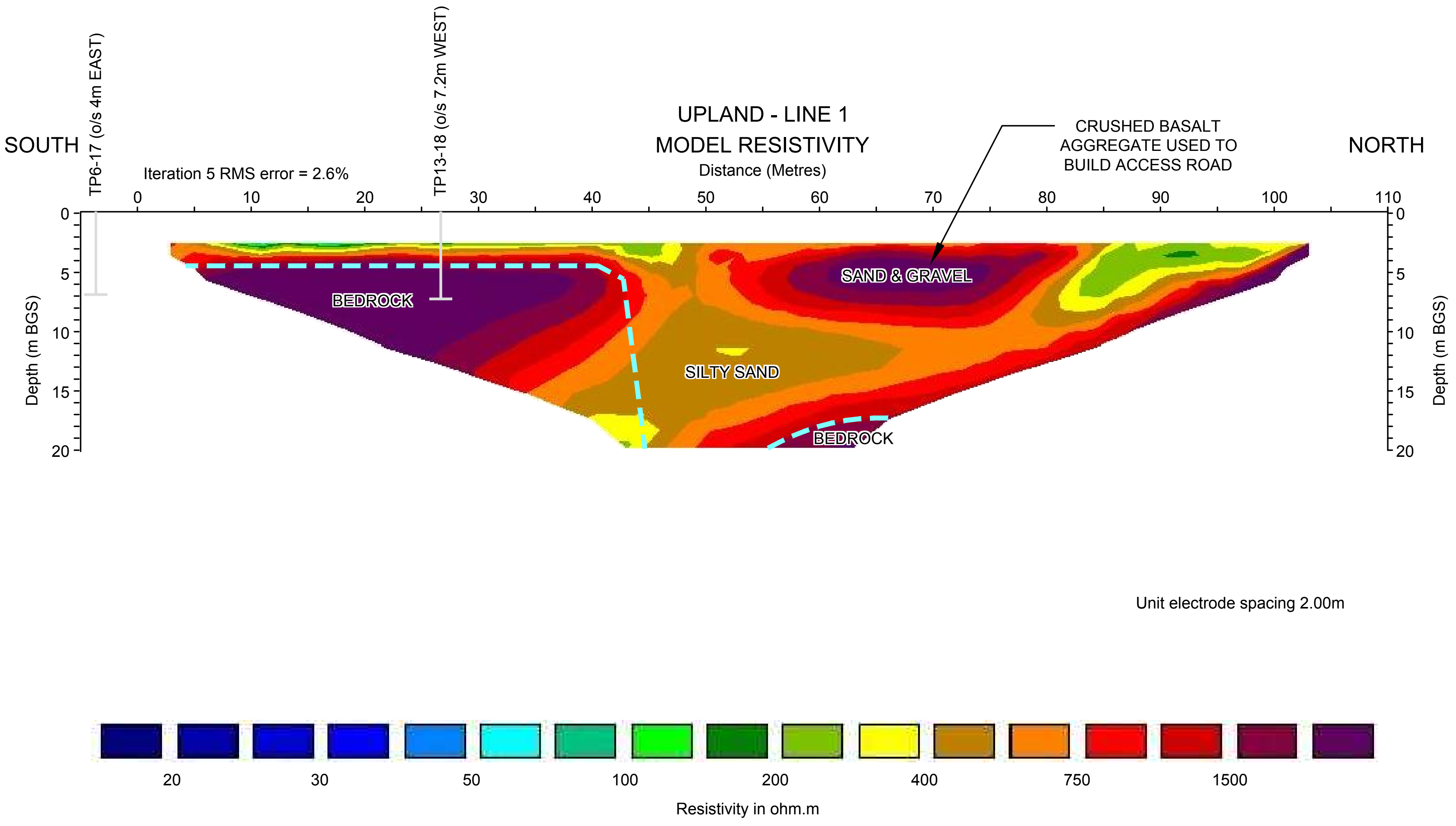
UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

GROUNDWATER ELEVATION CONTOURS
SAND & GRAVEL AQUIFER - SEPTEMBER 17, 2018

088877-00
Oct 1, 2018

FIGURE 5.1

CAD File: 088877-00(LEUS020)GN-SC005.DWG



0 5 10 15m

▬ ▬ ▬ INTERPRETED TOP OF BEDROCK SURFACE

GHD

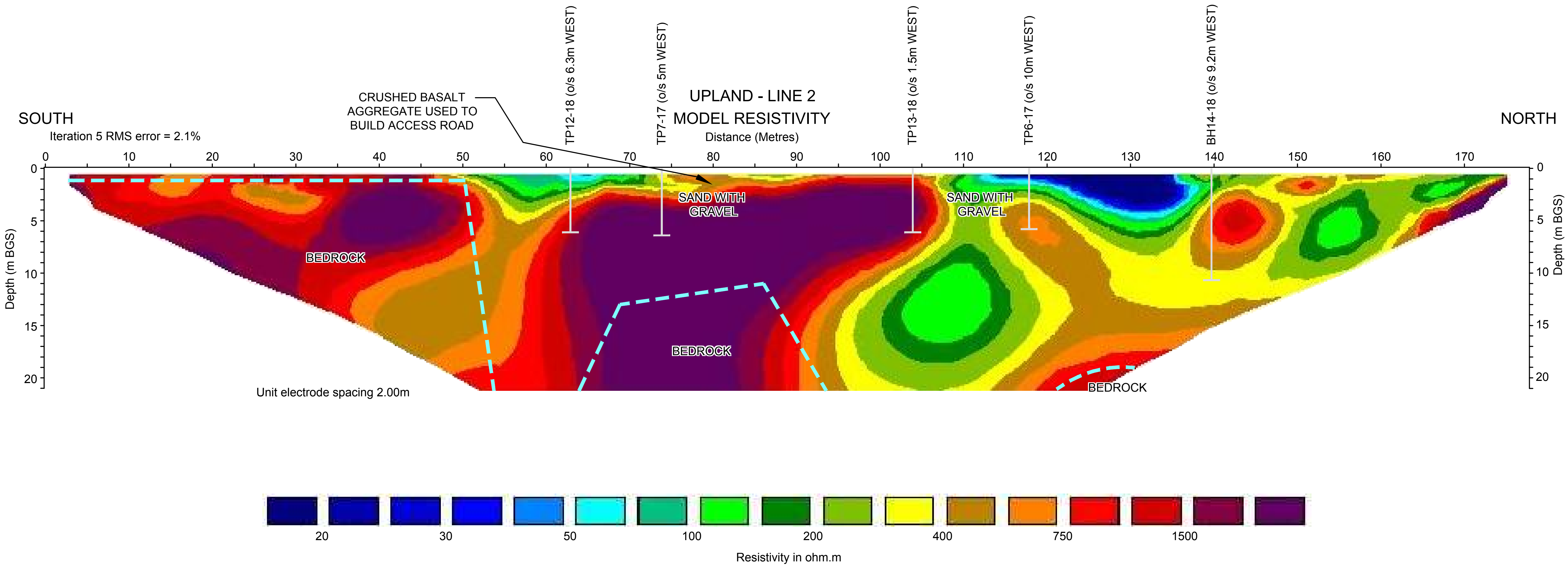
UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

GEOPHYSICAL INVESTIGATION
ELECTRICAL RESISTIVITY SURVEY RESULTS - LINE 1

088877-00
Oct 1, 2018

FIGURE 6.1

CAD File: I:\DRAWINGS\88000s\088877\088877-CORRES\088877-00(LEUS020)\088877-00(LEUS020)GN\088877-00(LEUS020)GN-SC003.DWG



0 5 10 15m

INTERPRETED TOP OF BEDROCK SURFACE

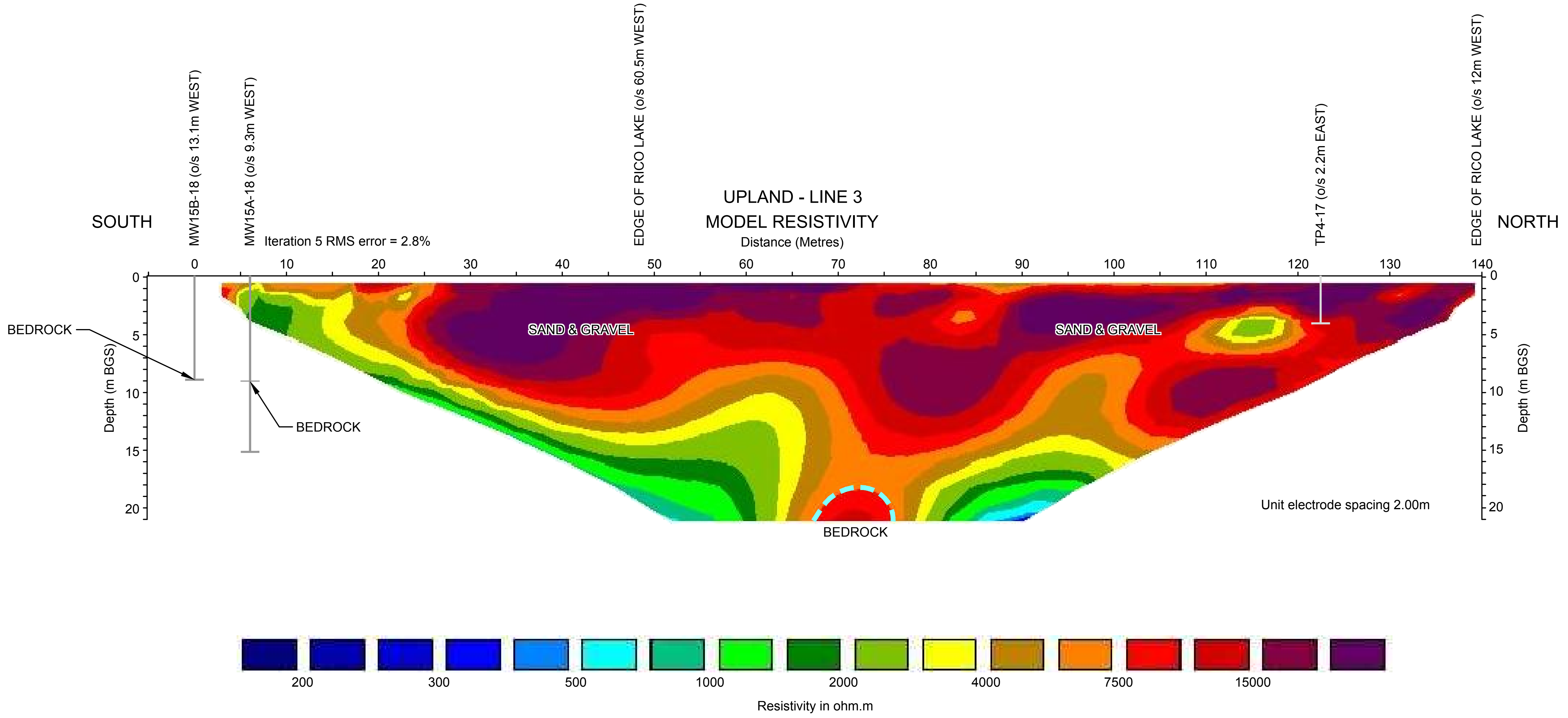
UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

GEOPHYSICAL INVESTIGATION
ELECTRICAL RESISTIVITY SURVEY RESULTS - LINE 2

088877-00
Oct 1, 2018

FIGURE 6.2

CAD File: I:\DRAWINGS\88000s\088877\088877-CORRES\088877-00(LEUS020)\088877-00(LEUS020)GN\088877-00(LEUS020)GN-SC002.DWG



0 5 10 15m

INTERPRETED TOP OF BEDROCK SURFACE

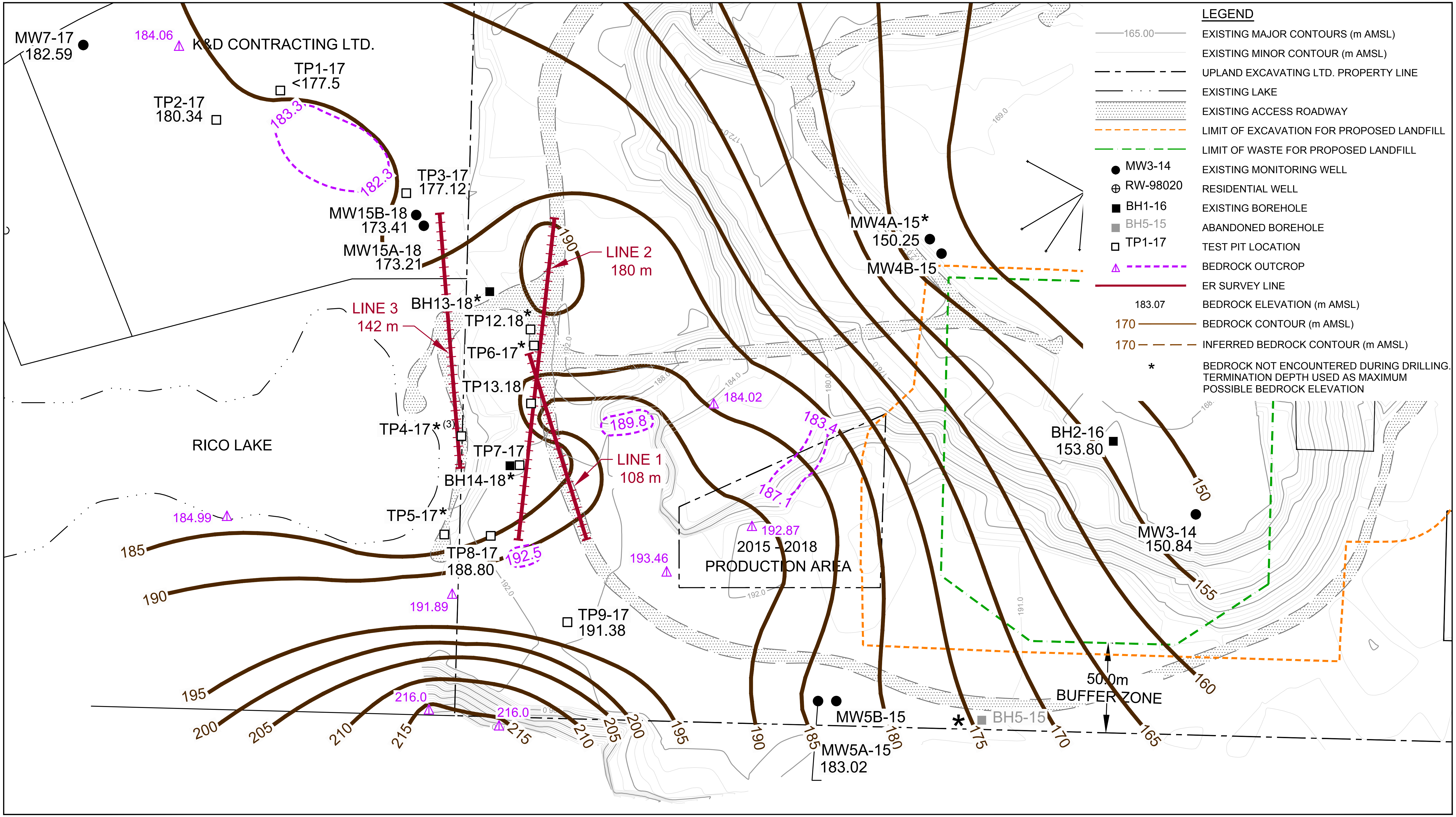
UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

GEOPHYSICAL INVESTIGATION
ELECTRICAL RESISTIVITY SURVEY RESULTS - LINE 3

088877-00
Oct 1, 2018

FIGURE 6.3

CAD File: I:\DRAWINGS\88000s\088877\088877-CORRES\088877-00(LEUS020)\088877-00(LEUS020)GN\088877-00(LEUS020)GN-SC001.DWG



SOURCE: TOPOGRAPHICAL SURVEY CONDUCTED BY McELHANNEY ASSOCIATES LAND SURVEYING LTD., NOVEMBER 21, 2016.

NOTES:
1. TP2-17 HAS NOT BEEN SURVEYED, ELEVATION IS ESTIMATED.
2. BEDROCK ELEVATIONS ARE BASED ON SURVEYS CONDUCTED BY McELHANNEY ON MARCH 16 AND 31, 2017 AND BY UPLAND EXCAVATING ON JANUARY 29, 2015, APRIL 6, 2016, AND MARCH 8, 2016.
3. TP4-17 LOCATION IS APPROXIMATE.

GHD

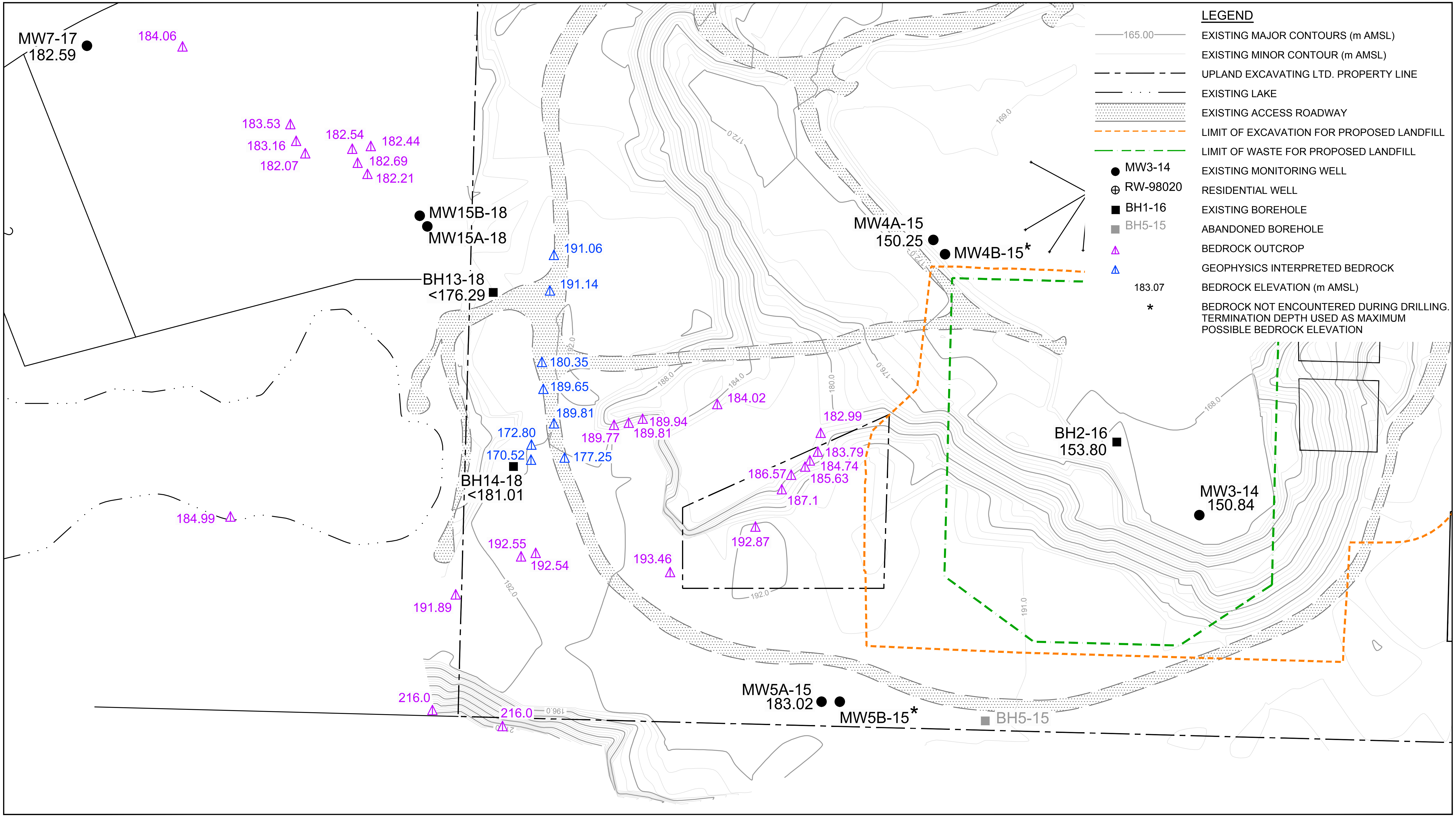
UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

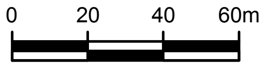
BEDROCK CONTOURS

088877-00
Sep 28, 2018

FIGURE 7.1A

CAD File: 088877-00(LEUS020)GN-SC007.DWG





UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
CAMPBELL RIVER, BRITISH COLUMBIA

BEDROCK ELEVATIONS

088877-00
Sep 28, 2018

FIGURE 7.1B

CAD File: 088877-00(LEUS020)GN-SC004.DWG

Table 5.1

Hydraulic Monitoring Results
Technical Response to ENV Review (Auth. No.:Pr-10807)
Task 7 – Additional Bedrock Characterization
Upland Landfill

Monitoring ID	Borehole Depth (m BGS)	Reference Elevation TOR (m AMSL)	Depth to Water (m BTOR)										
Date:			**11-Sep-15**	**17-Sep-15**	**5-Oct-15**	**25-Jan-16**	**29-Jan-16**	**15-Feb-16**	**8-Mar-16**	**15-Mar-17**	**6-Apr-17**	**7-Jun-18**	**17-Sep-18**
MW1-14	10.97	172.9	5.6	6.3	6.1	6.0	-	-	-	8.1	7.7	10.5	9.9
MW2-14	21.64	173.8	14.5	14.7	15.2	14.7	-	14.6	-	15.9	15.8	18.4	17.5
MW2A-16	45.42	173.9	-	-	-	14.5	-	14.5	-	15.9	15.8	18.4	18.6
MW3-14	18.59	168.6	12.8	12.7	12.8	11.3	-	-	-	12.1	12.1	14.8	16.1
MW4A-15	21.33	169.3	3.9	4.3	4.9	4.0	-	-	-	5.7	3.4	8.2	8.4
MW4B-15	18.28	169.3	4.1	4.5	5.1	4.2	-	-	-	5.9	5.7	8.4	8.6
MW5A-15	10.66	191.9	9.0	9.0	8.3	7.3	-	-	-	8.1	7.7	8.7	9.0
MW5B-15	8.22	192.0	7.1	7.2	7.0	5.4	-	-	-	7.1	6.1	8.4	-
MW6-17	11.28	185.4	-	-	-	-	-	-	-	-	7.5	8.8	10.3
MW7-17	4.29	187.5	-	-	-	-	-	-	-	3.3	2.9	3.8	3.9
MW8-17	18.80	192.5	-	-	-	-	-	-	-	19.7	19.7	19.7	19.7
MW9-17	33.54	191.7	-	-	-	-	-	-	-	24.8	24.4	26.5	25.0
MW10-17	46.25	189.1	-	-	-	-	-	-	-	-	39.0	40.9	42.0
MW15A-18	15.24	183.1	-	-	-	-	-	-	-	-	-	-	7.6
MW15B-18	8.99	183.2	-	-	-	-	-	-	-	-	-	-	8.8
RW-98020	60.96	196.9	-	-	-	-	-	17.1	-	-	-	-	-
McIvor Lake	-	-	-	-	-	-	-	-	-	-	-	-	-
SW15-02 Rico Lake	-	180.33*	-	-	-	-	0.88	-	0.91	0.06	0.09	-	-

Notes:

1 - Surveys completed by McElhanney on April 6, 2016 and March 16 and 31, 2017

2 - Survey completed by Upland Excavating Ltd. on January 29th, 2015, March 8, 2016 and April 6th, 2016. Elevations measured with respect to AMSL.

3 - Based on BC Hydro record of water elevations at Ladore Dam recorded every three hours. (https://www.bchydro.com/energy-in-bc/our_system/transmission_reservoir_data/previous_reservoir_elevations/vancouver_island/ladore_ldr.html)

* Surface water gauge reference elevation refers to the bottom of the gauge. (0 m on gauge = 180.33 m amsl)

m BGS - metres below ground surface

m AMSL - metres above mean sea level (WGS1984)

TOR - top of riser

S&G - Sand and gravel

Table 5.1

Hydraulic Monitoring Results
Technical Response to ENV Review (Auth. No.:Pr-10807)
Task 7 – Additional Bedrock Characterization
Upland Landfill

Monitoring ID	**Borehole Depth (m BGS)**	**Reference Elevation TOR (m AMSL)**	**Water Elevation (m AMSL)**												**Hydraulic Conductivity (cm/s)**	**Screened Unit (Aquifer)**
Date:			**11-Sep-15**	**17-Sep-15**	**5-Oct-15**	**25-Jan-16**	**29-Jan-16**	**15-Feb-16**	**8-Mar-16**	**6-Apr-16**	**15-Mar-17**	**6-Apr-17**	**7-Jun-18**	**17-Sep-18**		**Primary Constituent**
MW1-14	10.97	172.9	167.3	166.6	166.9	166.9	-	-	-	-	164.8	165.2	162.5	163.0	-	Sand/gravel (S&G Aquifer)
MW2-14	21.64	173.8	159.4	159.1	158.6	159.1	-	159.3	-	-	158.0	158.0	155.4	156.4	-	Sand/gravel (S&G Aquifer)
MW2A-16	45.42	173.9	-	-	-	159.3	-	159.3	-	-	158.0	158.1	155.5	155.3	-	Sand (S&G Aquifer)
MW3-14	18.59	168.6	155.8	155.9	155.8	157.2	-	-	-	-	156.5	156.4	153.8	152.5	-	Sand/gravel (S&G Aquifer)
MW4A-15	21.33	169.3	165.4	165.0	164.4	165.3	-	-	-	-	163.6	165.9	161.1	160.9	2.2×10^{-2}	Bedrock (S&G Aquifer)
MW4B-15	18.28	169.3	165.2	164.8	164.1	165.0	-	-	-	-	163.3	163.6	160.9	160.7	2.0×10^{-2}	Sand (S&G Aquifer)
MW5A-15	10.66	191.9	182.9	182.9	183.6	184.6	-	-	-	-	183.8	184.2	183.2	182.9	1.4×10^{-5}	Bedrock Ridge (Shallow Aquifer)
MW5B-15	8.22	192.0	184.9	184.9	185.0	186.6	-	-	-	-	184.9	185.9	183.7	Dry	-	Sand/Silt with clay (Shallow Aquifer)
MW6-17	11.28	185.4	-	-	-	-	-	-	-	-	-	177.9	176.6	175.1	-	Sand (S&G Aquifer)
MW7-17	4.29	187.5	-	-	-	-	-	-	-	-	184.2	184.6	183.7	183.6	-	Gravel (Shallow Aquifer)
MW8-17	18.80	192.5	-	-	-	-	-	-	-	-	172.8	172.8	172.8	172.8	-	Gravel (S&G Aquifer)
MW9-17	33.54	191.7	-	-	-	-	-	-	-	-	166.8	167.2	165.1	166.6	-	Sand/gravel (S&G Aquifer)
MW10-17	46.25	189.1	-	-	-	-	-	-	-	-	-	150.1	148.1	147.0	-	Sand (S&G Aquifer)
MW15A-18	15.24	183.1	-	-	-	-	-	-	-	-	-	-	-	175.4	8.3×10^{-3}	Bedrock (S&G Aquifer)
MW15B-18	8.99	183.2	-	-	-	-	-	-	-	-	-	-	-	174.3	7.5×10^{-4}	Silty/Clayey Sand (S&G Aquifer)
RW-98020	60.96	196.9	-	-	-	-	-	179.9	-	-	-	-	-	-	-	Bedrock Ridge
McIvor Lake	-	-	-	-	-	-	$177.5^{(3)}$	-	$177.9^{(2)}$	$177.0^{(2)}$	$177.6^{(3)}$	$177.6^{(3)}$	-	-	-	-
SW15-02 Rico Lake	-	180.33*	-	-	-	-	181.2	-	$181.2^{(2)}$	$180.8^{(2)}$	180.4	180.4	-	178.0	-	-

Notes:

1 - Surveys completed by McElhanney on April 6, 2016 and March 16 and 31, 2017

2 - Survey completed by Upland Excavating Ltd. on January 29th, 2015, March 8, 2016 and April 6th, 2016. Elevations measured with respect to AMSL.

3 - Based on BC Hydro record of water elevations at Ladore Dam recorded every three hours. (https://www.bchydro.com/energy-in-bc/our_system/transmission_reservoir_data/previous_reservoir_elevations/vancouver_island/ladore_ldr.html)

* Surface water gauge reference elevation refers to the bottom of the gauge. (0 m on gauge = 180.33 m amsl)

m BGS - metres below ground surface

m AMSL - metres above mean sea level (WGS1984)

TOR - top of riser

S&G - Sand and gravel

Attachment A
Stratigraphic and Instrumentation Logs

STRATIGRAPHIC LOG
(OVERBURDEN)

PROJECT NAME: Upland

PROJECT NUMBER: 088877

CLIENT: Upland Contracting

LOCATION: Campbell River, British Columbia

DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: BH13-18

DATE COMPLETED: 16 July 2018

DRILLING METHOD: Geoprobe HQ casing advancing the wet coring.

FIELD PERSONNEL: M. Dyck/B. Kempel

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	SAMPLE				
			NUMBER	INTERVAL	REC (%)		
	GROUND SURFACE	191.23					
	SW/GW - SAND and GRAVEL, with cobbles, occassional boulders, medium to coarse grained sand and gravel, grey/brown. Drill unable to advance any further than 14.94 m bgs.						
0.5							
1.0							
1.5							
2.0							
2.5							
3.0							
3.5							
4.0							
4.5							
5.0							
5.5							
6.0							
6.5							
7.0							
7.5							
8.0							
8.5							
9.0							
9.5							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC LOG
(OVERBURDEN)

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: BH13-18
DATE COMPLETED: 16 July 2018
DRILLING METHOD: Geoprobe HQ casing advancing the wet coring.
FIELD PERSONNEL: M. Dyck/B. Kempel

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	SAMPLE NUMBER	 INTERVAL	 REC (%)		
10.5							
11.0							
11.5							
12.0							
12.5							
13.0							
13.5							
14.0							
14.5							
15.0	END OF BOREHOLE @ 14.94m BGS	176.29					
15.5							
16.0							
16.5							
17.0							
17.5							
18.0							
18.5							
19.0							
19.5							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC LOG
(OVERBURDEN)

PROJECT NAME: Upland

PROJECT NUMBER: 088877

CLIENT: Upland Contracting

LOCATION: Campbell River, British Columbia

DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: BH14-18

DATE COMPLETED: 16 July 2018

DRILLING METHOD: Geoprobe Solid Stem

FIELD PERSONNEL: M. Dyck/B. Kempel

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	SAMPLE			
			NUMBER	INTERVAL	REC (%)	
	GROUND SURFACE	191.68				
	FILL - SAND and GRAVEL, some wood pieces, fill					
0.5	No bedrock down to 10.67 m bgs.					
1.0						
1.5						
2.0						
2.5						
3.0						
3.5						
4.0						
4.5						
5.0						
5.5						
6.0						
6.5						
7.0						
7.5						
8.0						
8.5						
9.0						
9.5						

<u>NOTES:</u> MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC LOG
(OVERBURDEN)

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell
HOLE DESIGNATION: BH14-18
DATE COMPLETED: 16 July 2018
DRILLING METHOD: Geoprobe Solid Stem
FIELD PERSONNEL: M. Dyck/B. Kempel

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	SAMPLE				
			NUMBER	INTERVAL	REC (%)		
10.5							
	END OF BOREHOLE @ 10.67m BGS	181.01					
11.0							
11.5							
12.0							
12.5							
13.0							
13.5							
14.0							
14.5							
15.0							
15.5							
16.0							
16.5							
17.0							
17.5							
18.0							
18.5							
19.0							
19.5							

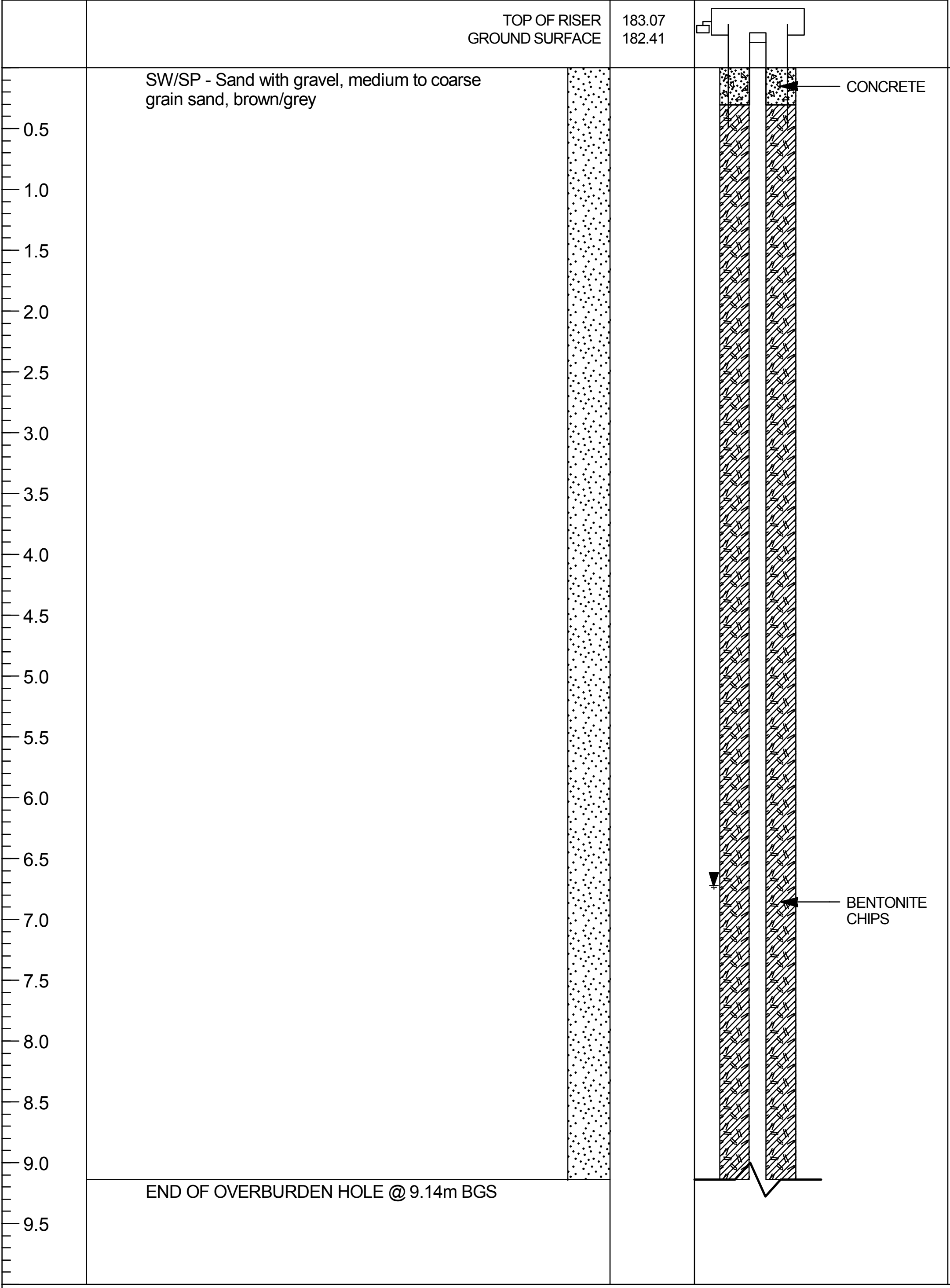
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: MW15A-18
DATE COMPLETED: 18 July 2018
DRILLING METHOD: HW Casing, HQ Coring
FIELD PERSONNEL: M. Dyck/B. Kempel

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)		
	TOP OF RISER	183.07						
	GROUND SURFACE	182.41						
	SW/SP - Sand with gravel, medium to coarse grain sand, brown/grey							
	END OF OVERBURDEN HOLE @ 9.14m BGS							



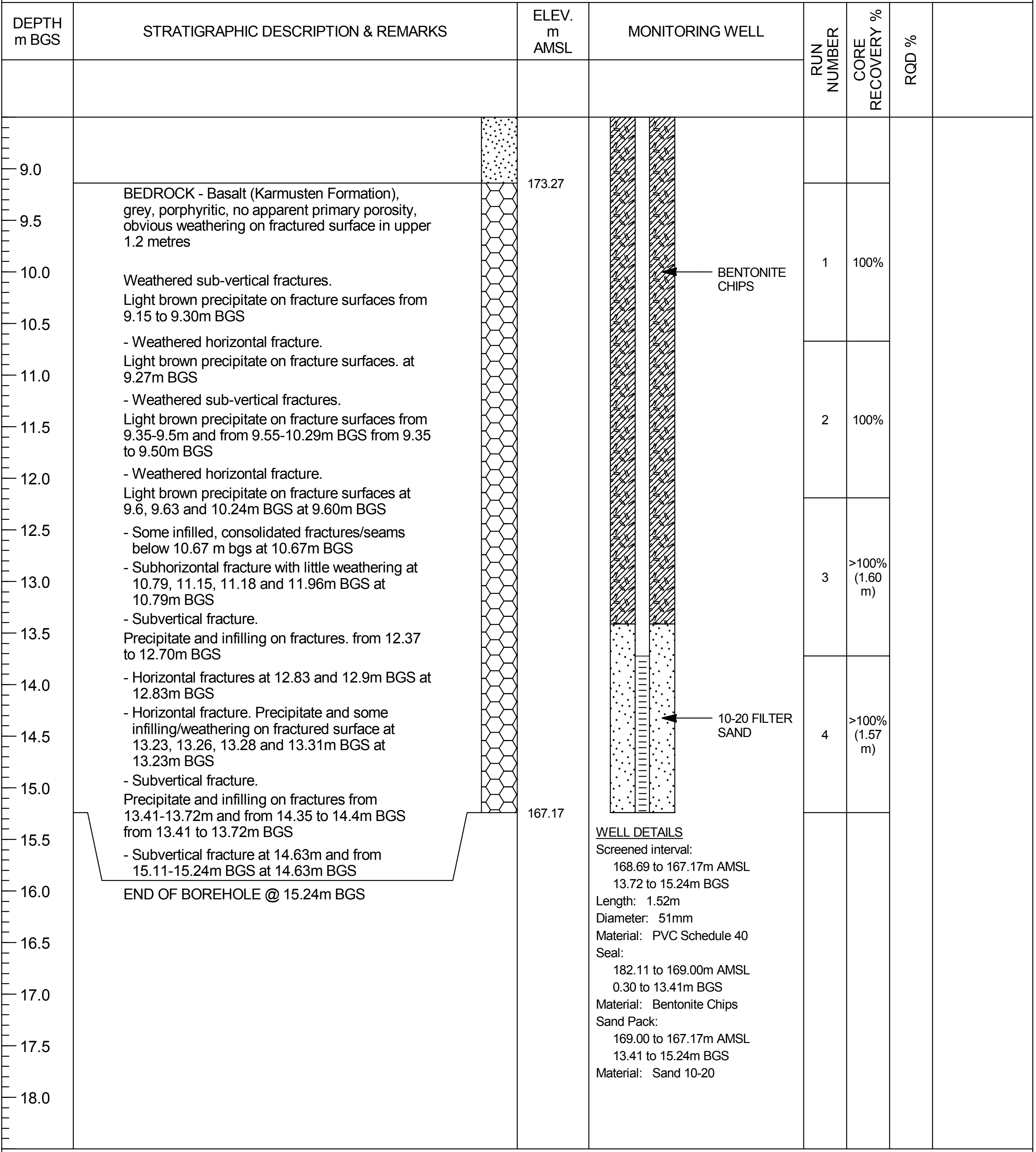
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(BEDROCK)

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: MW15A-18
DATE COMPLETED: 18 July 2018
DRILLING METHOD: HW Casing, HQ Coring
FIELD PERSONNEL: M. Dyck/B. Kempel



BEDROCK - Basalt (Karmusten Formation), grey, porphyritic, no apparent primary porosity, obvious weathering on fractured surface in upper 1.2 metres

Weathered sub-vertical fractures.
Light brown precipitate on fracture surfaces from 9.15 to 9.30m BGS

- Weathered horizontal fracture.

Light brown precipitate on fracture surfaces. at 9.27m BGS

- Weathered sub-vertical fractures.

Light brown precipitate on fracture surfaces from 9.35-9.5m and from 9.55-10.29m BGS from 9.35 to 9.50m BGS

- Weathered horizontal fracture.

Light brown precipitate on fracture surfaces at 9.6, 9.63 and 10.24m BGS at 9.60m BGS

- Some infilled, consolidated fractures/seams below 10.67 m bgs at 10.67m BGS
- Subhorizontal fracture with little weathering at 10.79, 11.15, 11.18 and 11.96m BGS at 10.79m BGS
- Subvertical fracture.

Precipitate and infilling on fractures. from 12.37 to 12.70m BGS

- Horizontal fractures at 12.83 and 12.9m BGS at 12.83m BGS
- Horizontal fracture. Precipitate and some infilling/weathering on fractured surface at 13.23, 13.26, 13.28 and 13.31m BGS at 13.23m BGS
- Subvertical fracture.

Precipitate and infilling on fractures from 13.41-13.72m and from 14.35 to 14.4m BGS from 13.41 to 13.72m BGS

- Subvertical fracture at 14.63m and from 15.11-15.24m BGS at 14.63m BGS

END OF BOREHOLE @ 15.24m BGS

RUN NUMBER	CORE RECOVERY %	RQD %
1	100%	
2	100%	
3	>100% (1.60 m)	
4	>100% (1.57 m)	

WELL DETAILS
Screened interval:
168.69 to 167.17m AMSL
13.72 to 15.24m BGS
Length: 1.52m
Diameter: 51mm
Material: PVC Schedule 40
Seal:
182.11 to 169.00m AMSL
0.30 to 13.41m BGS
Material: Bentonite Chips
Sand Pack:
169.00 to 167.17m AMSL
13.41 to 15.24m BGS
Material: Sand 10-20

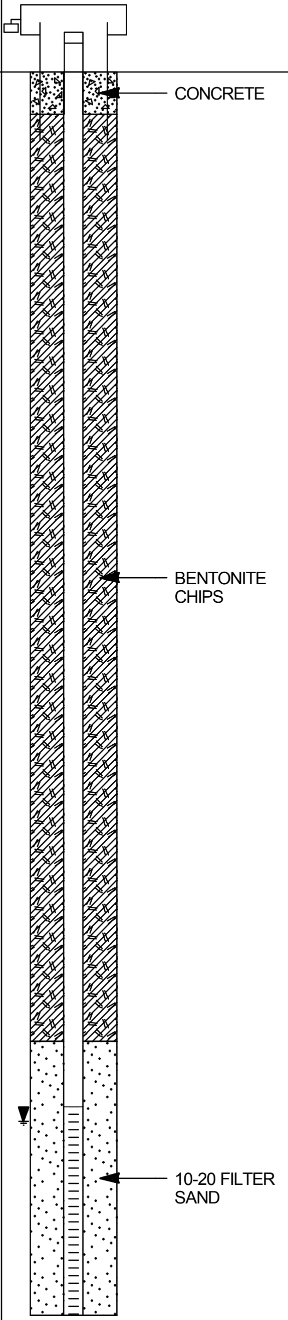
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: MW15B-18
DATE COMPLETED: 23 July 2018
DRILLING METHOD: Air Rotary
FIELD PERSONNEL: M. Dyck
DRILLER: Scott Burrows

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)
	TOP OF RISER GROUND SURFACE	183.17 182.40				
	SP/SW - SAND with minor gravel, fine to medium grained sand, medium gravel, brown/grey					
0.5						
1.0						
1.5						
2.0						
2.5						
3.0						
3.5						
4.0						
4.5						
5.0						
5.5						
6.0						
	SM/SC - SILTY/CLAYEY SAND, fine grained sand, low plasticity, brown	176.30				
6.5						
7.0						
7.5						
8.0						
8.5						
9.0	- BASALT (Bedrock) at 8.99m BGS	173.41				
	END OF BOREHOLE @ 8.99m BGS					
9.5						



WELL DETAILS
Screened interval:
174.93 to 173.41m AMSL
7.47 to 8.99m BGS
Length: 1.52m

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
STATIC WATER LEVEL ▼ July 23, 2018

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: MW15B-18
DATE COMPLETED: 23 July 2018
DRILLING METHOD: Air Rotary
FIELD PERSONNEL: M. Dyck
DRILLER: Scott Burrows

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE			
				NUMBER	INTERVAL	REC (%)	
			Diameter: 51mm Material: PVC Schedule 40 Seal: 182.10 to 175.39m AMSL 0.30 to 7.01m BGS Material: Bentonite Chips Sand Pack: 175.39 to 173.41m AMSL 7.01 to 8.99m BGS Material: Sand 10-20				
10.5							
11.0							
11.5							
12.0							
12.5							
13.0							
13.5							
14.0							
14.5							
15.0							
15.5							
16.0							
16.5							
17.0							
17.5							
18.0							
18.5							
19.0							
19.5							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STATIC WATER LEVEL ▼ July 23, 2018

TEST PIT STRATIGRAPHIC LOG

PROJECT NAME: Upland
PROJECT NUMBER: 088877
CLIENT: Upland Contracting
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: TP12-18
DATE COMPLETED: 16 July 2018
TEST PIT METHOD: Excavator.
FIELD PERSONNEL: M. Dyck/B. Kempel

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	SAMPLE		
			NUMBER	INTERVAL	
	GROUND SURFACE	191.88			
	SW/GW - SAND and GRAVEL, medium to coarse sand and gravel, some cobbles and boulders.				
0.5	3 attempts with solid stem geoprobe, refused each attempt. Re-attempted with excavator.				
1.0					
1.5					
2.0					
2.5					
3.0					
3.5					
4.0					
4.5	SP - SAND, medium grained, grey, moist	187.31			
5.0	- Becoming wet, more cobbles at 4.88m BGS				
5.5	- Wet, but no visible water in borehole at 5.49m BGS				
6.0	END OF TEST PIT @ 6.10m BGS	185.78			
6.5					
7.0					
7.5					
8.0					
8.5					
9.0					
9.5					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

TEST PIT STRATIGRAPHIC LOG

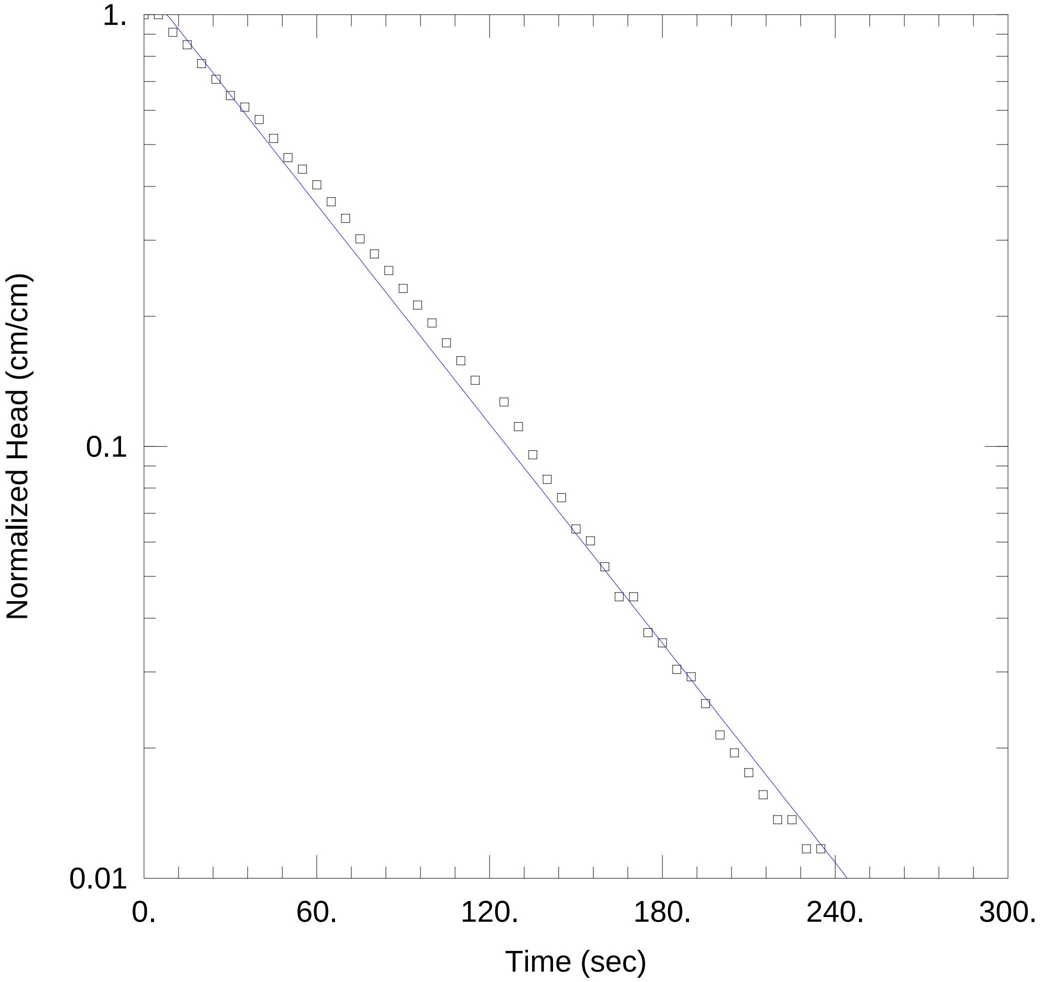
PROJECT NAME: Upland Landfill
PROJECT NUMBER: 088877
CLIENT: Uplands
LOCATION: Campbell River, British Columbia
DRILLING CONTRACTOR: Drillwell

HOLE DESIGNATION: TP13-18
DATE COMPLETED: 16 July 2018
TEST PIT METHOD: Excavator
FIELD PERSONNEL: B. Kempel/M. Dyck

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	DEPTH m AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	
2 4	SW/GW-SAND/GRAVEL, some cobble and boulders, medium to coarse grained 4 attempts with solid stem geoprobe, refused each attempt. Re-attempted with excavator				
6	SP-SAND, medium grained, grey, moist	4.57			
8 10 12 14 16 18 20 22 24 26 28	END OF TEST PIT @ 6.10m BGS	6.10			

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

Attachment B
Single Well Response Plots



WELL TEST ANALYSIS

Data Set: \...\MW15A-18 Aqtw2.aqt
Date: 08/14/18 Time: 16:02:03

PROJECT INFORMATION

Company: GHD Ltd.
Project: 088877
Location: Campbell River, BC
Test Well: Test 2
Test Date: July 18, 2018

AQUIFER DATA

Saturated Thickness: 951.5 cm
Anisotropy Ratio (Kz/Kr): 0.1

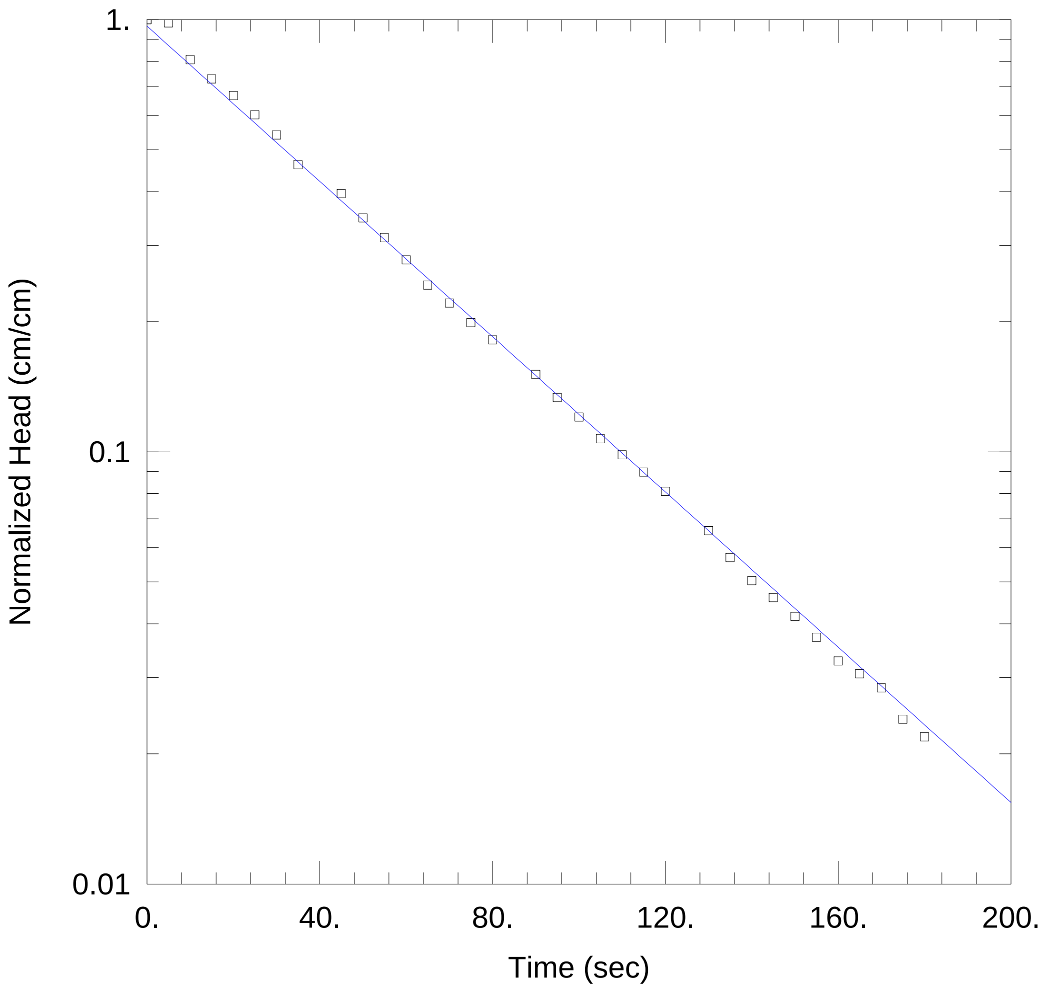
WELL DATA (MW15A-18)

Initial Displacement: 256.5 cm
Total Well Penetration Depth: 951.9 cm
Casing Radius: 2.54 cm
Static Water Column Height: 951.5 cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.009187 cm/sec
y0 = 299.7 cm



WELL TEST ANALYSIS

Data Set: \...\MW15A-18 Aqtw3.aqt
Date: 08/14/18
Time: 16:04:46

PROJECT INFORMATION

Company: GHD Ltd.
Project: 088877
Location: Campbell River, BC
Test Well: Test 3
Test Date: July 18, 2018

AQUIFER DATA

Saturated Thickness: 951.5 cm
Anisotropy Ratio (Kz/Kr): 0.1

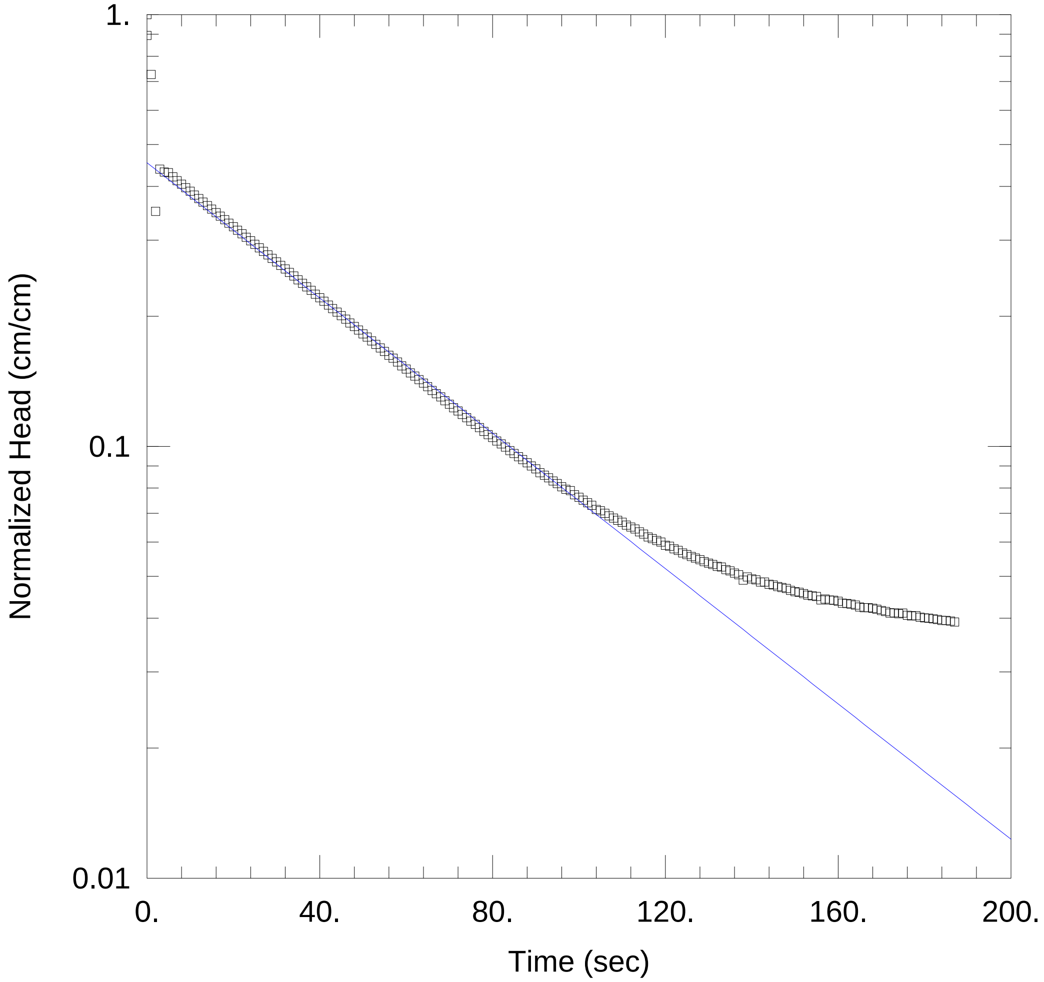
WELL DATA (MW15A-18)

Initial Displacement: 228.5 cm
Total Well Penetration Depth: 951.9 cm
Casing Radius: 2.54 cm
Static Water Column Height: 951.5 cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.009746 cm/sec
y0 = 220.6 cm



WELL TEST ANALYSIS

Data Set: \...\MW15A-18 Aqtw4 aug 14 mnd.aqt
Date: 08/14/18 Time: 16:07:54

PROJECT INFORMATION

Company: GHD LTD.
Project: 088877
Location: Campbell River, BC
Test Well: MW15A-18
Test Date: July 19, 2018

AQUIFER DATA

Saturated Thickness: 951. cm
Anisotropy Ratio (Kz/Kr): 0.1

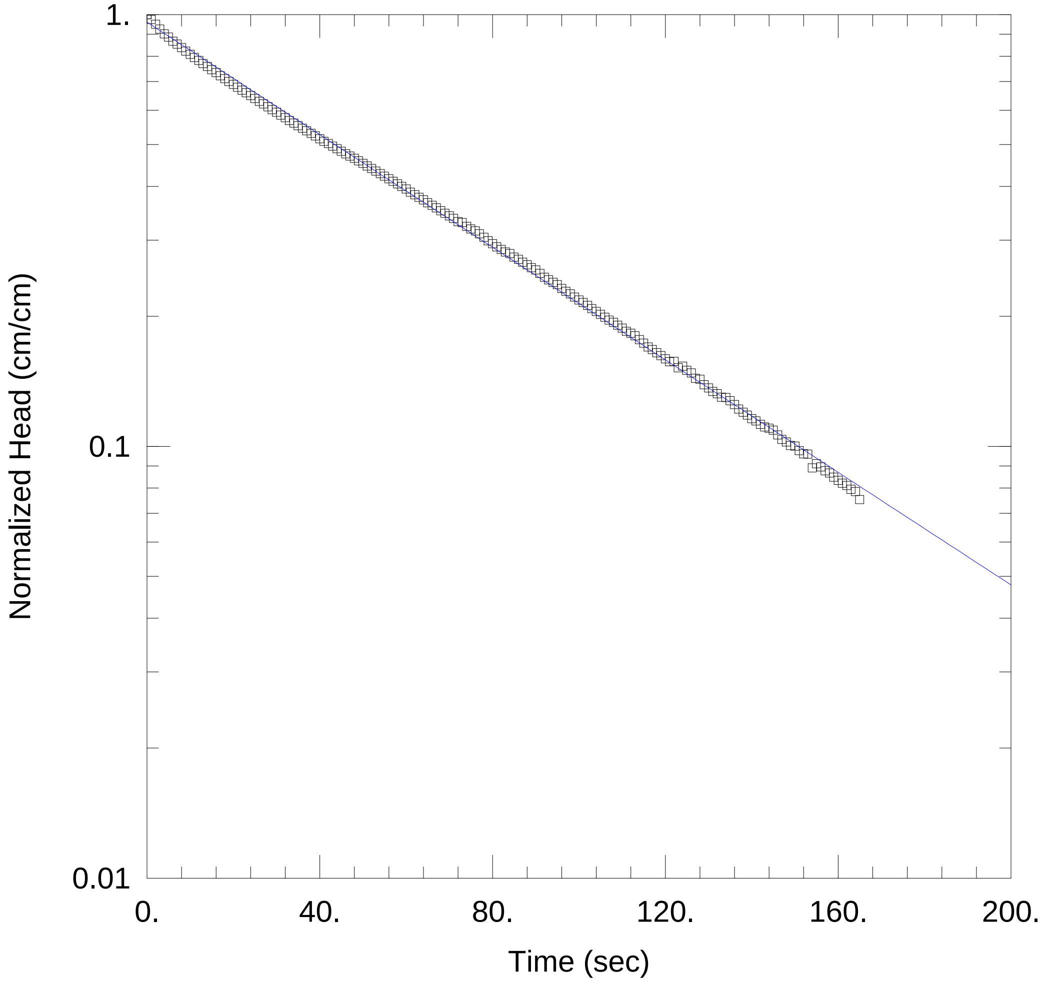
WELL DATA (MW15A-18)

Initial Displacement: 228. cm
Total Well Penetration Depth: 951.4 cm
Casing Radius: 2.54 cm
Static Water Column Height: 951. cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.008502 cm/sec
y0 = 103.5 cm



WELL TEST ANALYSIS

Data Set: \...\MW15A-18 Aqtw5 aug 14 mnd.aqt
Date: 08/14/18 Time: 16:12:01

PROJECT INFORMATION

Company: GHD LTD.
Project: 088877
Location: Campbell River, BC
Test Well: MW15A-18
Test Date: July 19, 2018

AQUIFER DATA

Saturated Thickness: 951. cm
Anisotropy Ratio (Kz/Kr): 0.1

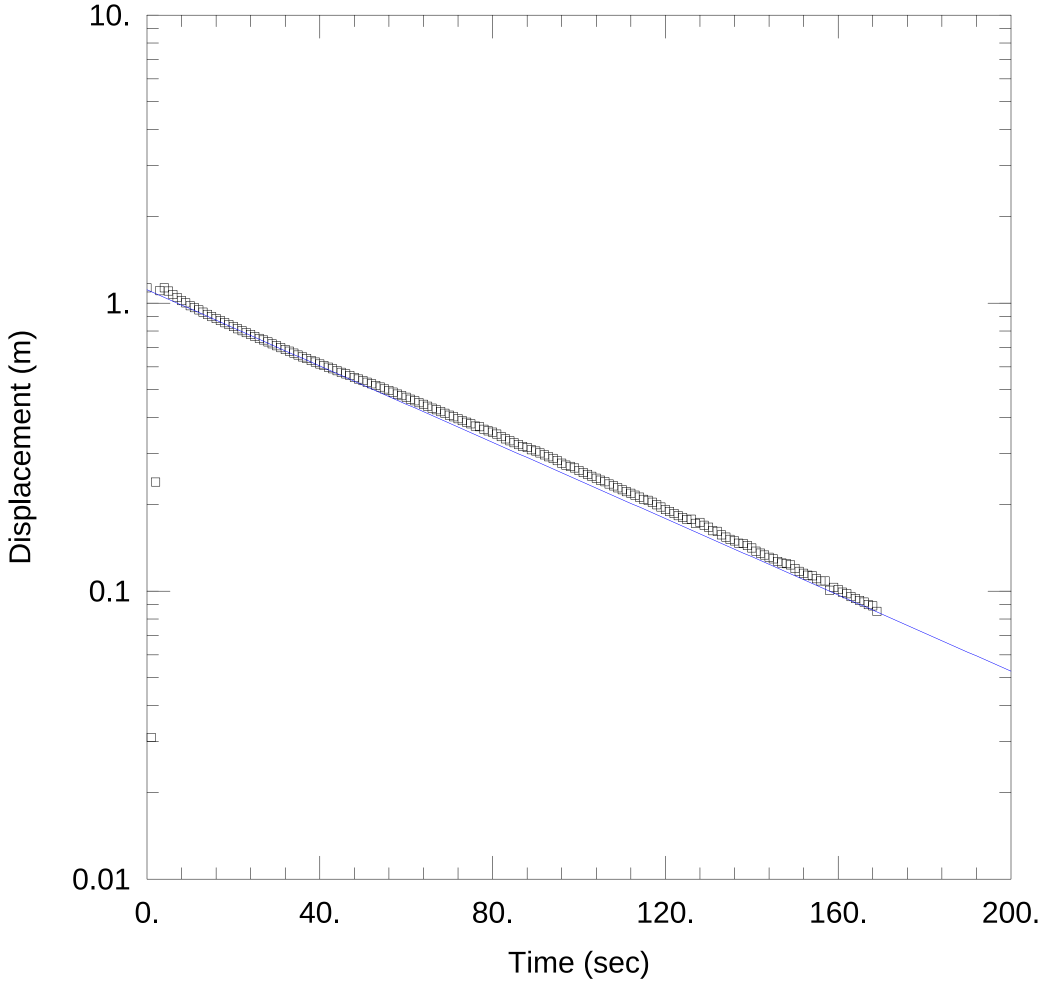
WELL DATA (MW15A-18)

Initial Displacement: 112.8 cm
Total Well Penetration Depth: 951.4 cm
Casing Radius: 2.54 cm
Static Water Column Height: 951. cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.007072 cm/sec
y0 = 108.3 cm



WELL TEST ANALYSIS

Data Set: \...\MW15A-18 test 5 rising head aug 14 mnd.aqt
Date: 08/14/18 Time: 16:13:22

PROJECT INFORMATION

Company: GHD
Client: Upland
Project: 88877
Location: Campbell River BC
Test Well: MW15A-18
Test Date: Jul 18, 2018

AQUIFER DATA

Saturated Thickness: 9.51 m
Anisotropy Ratio (Kz/Kr): 0.1

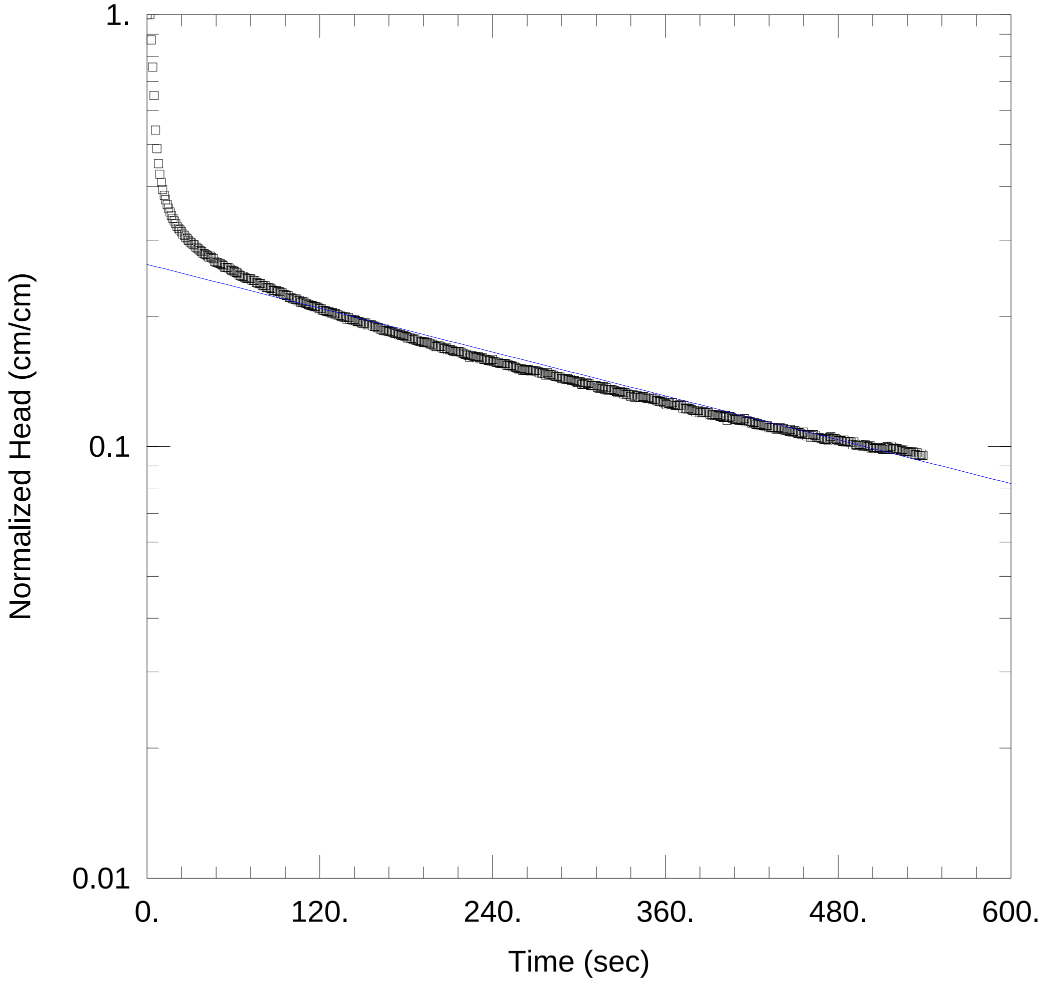
WELL DATA (MW15A-18)

Initial Displacement: 1.129 m
Total Well Penetration Depth: 9.51 m
Casing Radius: 0.0254 m
Static Water Column Height: 9.51 m
Screen Length: 1.52 m
Well Radius: 0.0762 m
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.007203 cm/sec
y0 = 1.112 m



TEST 1 (STARTED AT 11:28)

Data Set: \...\MW15B-18 Aqtw1 aug 14

Date: 08/14/18 mnd.aqt Time: 16:15:10

PROJECT INFORMATION

Company: GHD LTD.
Project: 088877
Location: Campbell River, BC
Test Well: MW15B-18
Test Date: July 26, 2018

AQUIFER DATA

Saturated Thickness: 190.2 cm

Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW15B-18)

Initial Displacement: 28.46 cm
Total Well Penetration Depth: 190.6 cm
Casing Radius: 2.54 cm

Static Water Column Height: 190.2 cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

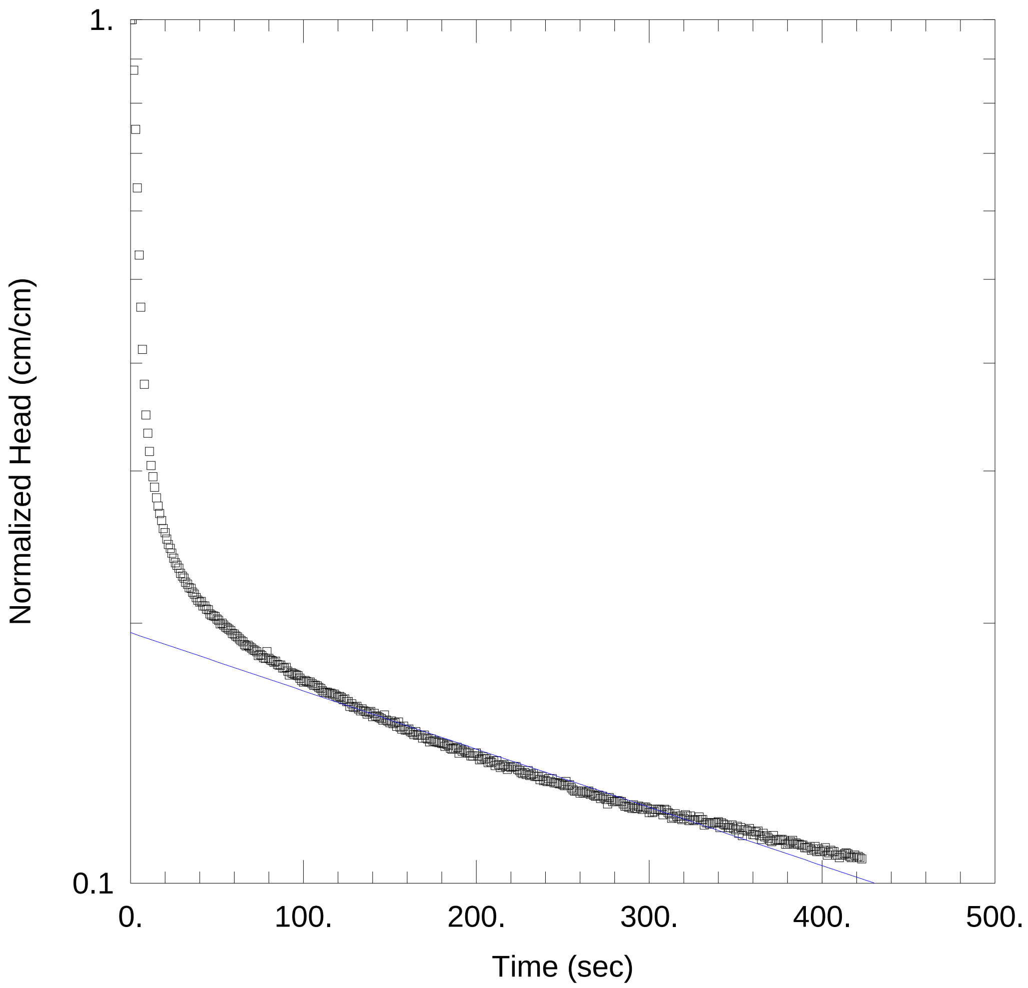
SOLUTION

Aquifer Model: Unconfined

Solution Method: Hvorslev

K = 0.0009185 cm/sec

y0 = 7.509 cm



TEST #2 @11:42

Data Set: \...\MW15B-18 Aqtw2 agu 14 mnd.aqt
Date: 08/14/18 Time: 16:17:08

PROJECT INFORMATION

Company: GHD LTD.
Project: 088877
Location: Campbell River, BC
Test Well: MW15B-18
Test Date: July 26, 2018

AQUIFER DATA

Saturated Thickness: 190.2 cm
Anisotropy Ratio (Kz/Kr): 0.1

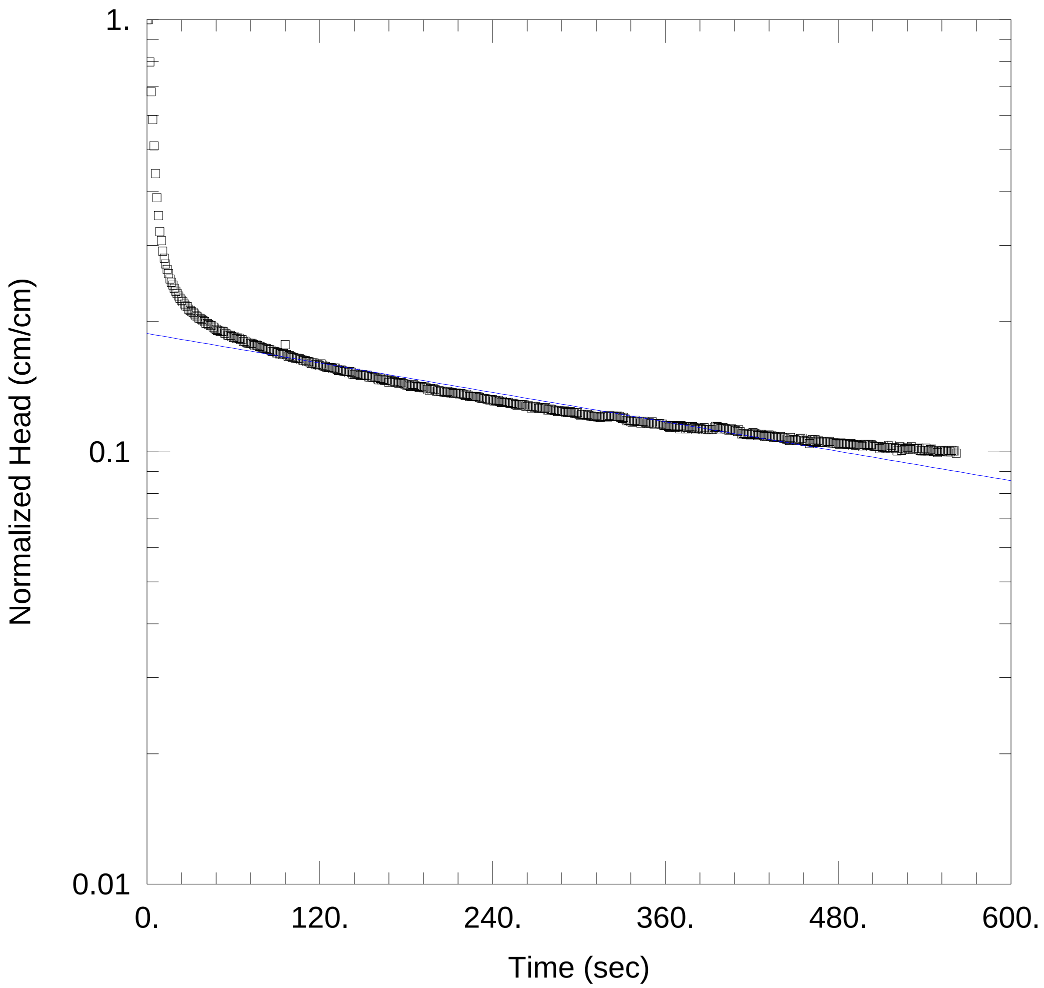
WELL DATA (MW15B-18)

Initial Displacement: 27.85 cm
Total Well Penetration Depth: 190.6 cm
Casing Radius: 2.54 cm
Static Water Column Height: 190.2 cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.0007316 cm/sec
y0 = 5.43 cm



TEST #3 @ 11:55

Data Set: \...\MW15B-18 Aqtw3 aug 14

Date: 08/14/18

mnd.aqt

Time: 16:18:34

PROJECT INFORMATION

Company: GHD LTD.
Project: 088877
Location: Campbell River, BC
Test Well: MW15B-18
Test Date: July 26, 2018

AQUIFER DATA

Saturated Thickness: 190.2 cm

Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW15B-18)

Initial Displacement: 32.64 cm
Total Well Penetration Depth: 190.6 cm
Casing Radius: 2.54 cm

Static Water Column Height: 190.2 cm
Screen Length: 152.4 cm
Well Radius: 7.62 cm
Gravel Pack Porosity: 0.45

SOLUTION

Aquifer Model: Unconfined

Solution Method: Hvorslev

K = 0.0006161 cm/sec

y0 = 6.128 cm