Hydrogeology and Hydrology Characterization Report

Proposed Upland Landfill

Campbell River, British Columbia

Upland Excavating Ltd.

GHD | 10271 Shellbridge Way Richmond British Columbia V6X 2W8 Canada

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Table of Contents

1. Introduction 1

1.1 Background 1

1.1.1 Site Location 1
1.1.2 Site History 1
1.1.3 Adjacent Properties 2
1.1.4 Summary of Off-Site Water Supply Wells 2
1.1.5 Site Permitting 2

1.2 Purpose 2

1.3 Scope of Work 2

1.4 Report Organization 4

2. Summary of Hydrologic, Geologic, and Hydrogeologic Conditions 4

2.1 Hydrologic Conditions 4

2.1.1 Topography 4
2.1.2 Site Drainage 5
2.1.3 Surface Water Features 7

2.2 Geology 8

2.2.1 Regional Geology 8
2.2.2 Site Geology 9
2.2.2.1 Site Overburden Geology 9
2.2.2.2 Site Bedrock Geology 11

2.3 Site Hydrogeology 12

2.3.1 Groundwater Divide 12
2.3.2 Sand and Gravel Aquifer 13
2.3.3 Shallow Aquifer 16
2.3.3.1 Shallow Aquifer - West of Groundwater Divide 16
2.3.3.2 Shallow Aquifer (East of the Groundwater Divide) 17
2.3.4 Horizontal Hydraulic Gradients and Groundwater Velocity 18

3. Hydrogeologic and Hydrologic Conceptual Site Model 19

4. Baseline Water Quality Results 22

4.1 Applicable Water Quality Standards 23

4.2 Water Quality 25

4.2.1 Indicator Parameters 25
4.2.2 Existing Groundwater Quality Results 26
4.2.2.1 Sand and Gravel Aquifer Groundwater Quality 26
4.2.2.2 Shallow Aquifer Groundwater Quality 27
4.2.3 Surface Water Quality 29
4.2.4 Wash Plant Water Quality 30
4.2.5 Residential Groundwater Quality 31

4.3 Water Quality as Compared to Applicable Water Quality Standards 31

4.3.1 Groundwater Quality as Compared to BC CSR Standards 31

4.3.2 RW-98020 Water Quality as Compared to BC WQGs 32
4.3.3 Surface Water Quality as Compared to BC WQGs 32
4.3.4 Wash Plant Water Quality as Compared to Applicable Standards 32

5. Conclusions 32

6. References 35

Figure Index

Figure 1.0 Site Location Map
Figure 1.1 Site Plan
Figure 1.2 Adjacent Land Uses
Figure 1.3 Well Location Map
Figure 1.4 Monitoring Locations
Figure 2.0A Regional Watershed Map
Figure 2.0B Local Watershed Map
Figure 2.1 Drainage Map
Figure 2.2 Cross-Section Plan
Figure 2.3 Cross-Section A-A'
Figure 2.4 Cross-Section B-B'
Figure 2.5 Cross-Section C-C'
Figure 2.6 Cross-Section D-D'
Figure 2.7 Cross-Section E-E'
Figure 2.8 Bedrock Elevation Contours
Figure 2.9 Groundwater Elevation Contours – April 6, 2017
Figure 3.0A Conceptual Groundwater Flow Model – Plan View
Figure 3.0B Conceptual Flow Model – Schematic Cross-Section – North-Southeast
Figure 3.0C Conceptual Flow Model – Schematic Cross-Section– West-Southeast

Table Index

Table 1.0 Well, Borehole and Test Pit Completion Details
Table 2.0 Hydraulic Monitoring Results
Table 4.0A Groundwater Analytical Results – Field Parameters, General Chemistry, Nutrients, Metals
Table 4.0B Groundwater Analytical Results – PAHs, VOCs, Petroleum Products
Table 4.0C Groundwater Analytical Results – Field Parameters, General Chemistry, Nutrients, Metals
Table 4.1A Surface Water Analytical Results – Field Parameters, General Chemistry, Nutrients, Metals
Table 4.1B Surface Water Analytical Results – PAHs, VOCs, Petroleum Products
Table 4.2 Wash Plant Analytical Results

Appendix Index

Appendix A	Permit PR-10487
Appendix B	Detailed Water Supply Well Records
Appendix C	GHD Field Investigations
Appendix D	GHD Standard Operating Procedures
Appendix E	Aquatic Life Assessment Memorandum
Appendix F	Stratigraphic and Instrumentation Logs
Appendix G	Single Well Response Plots
Appendix H	FSK and Laboratory Reports
Appendix I	Quality Assurance Quality Control Memorandum

1. Introduction

GHD Limited (GHD) was retained by Upland Excavating Ltd. (Upland) to prepare this Hydrogeology and Hydrology Characterization Report (Report) for the proposed Upland Landfill (Landfill) located at 7295 Gold River Hwy, Campbell River, British Columbia (Site). This Report forms part of the Waste Discharge Application submitted to the British Columbia (BC) Ministry of Environment (MOE) to obtain an Operational Certificate (OC) for the Landfill. This Report has been prepared in general accordance with the BC MOE's *Landfill Criteria for Municipal Solid Waste* (2016) and *Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills* (BC MOE, 1996).

This Report has been amended from the previous Hydrogeology and Hydrology Characterization Report (GHD, May 27, 2016). The amendment includes additional geologic and hydrogeologic details as well as a more refined understanding of groundwater and surface water flow at the Site and surrounding area. Additional information was obtained through supplemental field investigations completed after the May 2016 submission. The results of the initial and supplemental investigations are described in the sections below.

1.1 Background

1.1.1 Site Location

The Site is located at 7295 Gold River Highway, Campbell River, British Columbia (BC) approximately 7 kilometres (km) southwest of the urban area of Campbell River and approximately 2 km southeast from the Ladore Falls Dam.

The Site's southern property coincides with the boundary between the City of Campbell River and the Strathcona Regional District. The Gold River Highway is located to the north and west of the Site. The legal description is Lot A, District Lot 85, Plan 30709, Sayward District. The total area of the Site is approximately 48.2 hectares (ha). A Site location map is presented on Figure 1.0. A Site Plan is provided on Figure 1.1.

1.1.2 Site History

The Site is currently an active sand and gravel pit (Pit) that has been in operation since 1969 under Mines Act Permit G-8-114 issued December 1989 (last amended in February 2014). Rock blasting and crushing is carried out in the southwestern portion of the Site. Aggregate washing takes place in the centre of the Pit.

Waste Discharge Permit No. PR-10807 (Permit) was issued to the Site in 1992 for the discharge of municipal wastes consisting of construction, demolition, and land clearing waste. Land clearing waste includes stumps, trees, selected building demolition debris and residue of combustion from the open burning of wood waste. Waste discharged at the Site historically has included clean wood wastes that are burned in the permitted burn area located in the southeastern corner of the Site. The Site has also segregated recyclable materials for reuse (specifically asphalt and concrete), which is stockpiled in the northern portion of the Site. The location of the asphalt and concrete stockpiles are indicated on Figure 1.1.

A copy of the Permit is included in Appendix A.

1.1.3 Adjacent Properties

The Site is bound to the north by Gold River Highway (Highway 28), to the east by forested and industrial land parcels, and to the west by Rico Lake, a construction storage yard operated by K&D Contracting Ltd. (K&D), and an undeveloped industrial lot. Adjacent to the northeast corner of the Site is Argonaut Road, and a parcel containing a private utility tower. The Site is bound to the south by forested Upland Resource land located within the administrative boundaries of Strathcona Regional District.

Several residential properties are located on the north side of the Gold River Highway, along the shore line of McIvor Lake. Four of the six residential properties are vacant. An additional vacant residential property is located just north of Rico Lake.

Adjacent properties and associated land uses are presented on Figure 1.2.

1.1.4 Summary of Off-Site Water Supply Wells

Based on information obtained through BC Water Resource Atlas (April, 2017), nine private water supply wells are located within a 2 km radius of the Site and include commercial and industrial wells 74207, 39950, 84136 and 93413; private domestic wells 98020, 73577, 109728 and 103257; and well 74191 categorized as “other”. The locations of these wells are presented on Figure 1.3. The available water supply well records for these wells are provided in Appendix B.

1.1.5 Site Permitting

Upland currently accepts and manages waste at the Site in accordance with the Permit. Upland is currently seeking to obtain an OC to replace the Permit. It is Upland’s intention to develop the Site with an engineered Landfill that satisfies the BC MOE Landfill Criteria for Municipal Solid Waste, Second Edition (June 2016) (Landfill Criteria), the Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (2015) and aligns with the Comox Valley Regional District’s Solid Waste Management Plan (SWMP). The proposed Landfill will be located in a south central location on the Site, as shown in Figure 1.1.

1.2 Purpose

This Report has been prepared to satisfy the hydrogeology and hydrology characterization requirements of the Landfill Criteria (2016) Section 10.1. This Report is being submitted in support of the Design, Operation and Closure Plan (DOCP). An assessment of the design, function, and predicted performance of the proposed engineered Landfill is described in the DOCP.

1.3 Scope of Work

GHD completed the following investigative activities as part of the characterization of the Site:

1. The physical setting of the Site was investigated in terms of subsurface geology and hydrogeology through advancement of boreholes, test pits, and installation of groundwater monitoring wells.

2. Groundwater flow was characterized through surveying of groundwater monitoring wells and measurement of static groundwater elevations.

3. Surface hydrology was evaluated to define the presence and movement of surface water within the Site and immediate vicinity of the Site, in particular how surface water moved to and from McIvor and Rico Lakes, and on-Site stormwater drainage patterns.

4. A review of lands within 500 m of the down-gradient Site boundary to identify any permanent surface water features.

5. Groundwater and surface water quality was characterized by collecting and analysing water samples from on-Site monitoring wells, the on-Site wash plant, surface water bodies (McIvor Lake and Rico Lake), and a private residential water supply well northwest of the Site. This water quality sampling program included the collection of groundwater and surface water samples from background/up-gradient and on-Site locations in order to characterize baseline water quality conditions prior to construction and operation of lined landfill cells.

GHD originally completed various investigative activities between August 2015 and February 2016. Investigative activities completed between August 2015 and February 2016 including the following:

- Review existing documents including regional maps, previous reports, and well completion logs from nearby private wells
- Characterizing the geologic conditions underlying the proposed Landfill and the surrounding areas by advancing several boreholes/monitoring wells across the Site
- Investigating and characterizing the groundwater and surface water flows by measuring static water elevations
- Estimation of hydraulic conductivity through single well response tests at Site area wells
- Investigating and defining groundwater and surface water quality at and in the vicinity of the Site through the collection and analysis of water quality samples

In order to further refine the understanding of hydrogeologic conditions and characterization of groundwater and surface water flows in and around the Site, GHD undertook supplemental field investigative activities in early 2017.

The 2017 supplemental investigative activities included the following:

- Completion of a series of boreholes, test pits, and monitoring well installations parallel to McIvor Lake to further understand the hydraulic connection between McIvor Lake and the Site and for characterizing up-gradient water quality.
- Installation of a down-gradient monitoring well near the eastern Site boundary.
- Surveying the locations and elevations of newly installed monitoring wells and test pit locations.
- Updated topographic Site surveying.
- Topographic surveying of top of bedrock outcrops along the western Site boundary and on the adjoining property to the west in order to map a ridge of elevated bedrock extending from the small mountain in the southwest towards McIvor Lake.

- An assessment of lands within 500 m of the down-gradient Site boundary to identify any permanent surface water features with the potential of supporting fresh water aquatic life.
- Hydraulic and water quality monitoring utilizing the expanded monitoring well network.

The locations of each of the boreholes, monitoring wells and test pits advanced as part of the Site investigations are shown on Figure 1.4. Table 1.0 summarizes the completion details of each of the boreholes, monitoring wells, and test pits completed during the 2015 to 2017 investigations.

GHD's field activities are documented in detail in Appendix C. GHD's Standard Operating Procedures (SOPs), which were followed during the field activities, are provided in Appendix D.

1.4 Report Organization

This Report is organized into the following sections:

- ***Section 1.0 Introduction:*** Presents the introduction, background, purpose, and scope of work
- ***Section 2.0 Summary of Hydrologic, Geologic, and Hydrogeologic Conditions***: Presents a summary of the observed regional and Site hydrologic, geologic, and hydrogeologic conditions
- ***Section 3.0 Hydrogeologic and Hydrologic Conceptual Site Model***: Presents the Conceptual Site Model developed to understand the hydrogeologic and hydrologic flow patterns for the Site
- ***Section 4.0 Baseline Water Quality Results***: Presents a summary of baseline surface and groundwater quality prior to the construction and operation of the proposed Landfill
- ***Section 5.0 Conclusions and Recommendations***: Presents a list of conclusions and recommendations based on the Report findings
- ***Section 6.0 References***: Presents a list of references cited in this Report

2. Summary of Hydrologic, Geologic, and Hydrogeologic Conditions

2.1 Hydrologic Conditions

The hydrologic conditions of the Site are affected by topography, drainage, and surface water features. These hydrologic features are discussed in the following sections.

2.1.1 Topography

On a regional scale, the Site is primarily located on a terrace that is partially surrounded by mountainous terrain to the south and southwest. The terrace gradually slopes towards the Quinsam River located approximately 3.8 km to the southeast of the east Site boundary. The Quinsam River channel is at an elevation that is greater than 100 meters below the Site.

On-Site, the topography is relatively level at approximate elevation 190 mAMSL with the exception of the Pit located in the centre of the Site. The Pit area has been excavated to a depth of approximately 170 mAMSL, 20 m below the surrounding land surface. Along the western Site boundary, above the Pit wall where gravel extraction has not occurred, a ridge of elevated surface topography, created by elevated bedrock, discussed further below, is present. Further to the west, the ridge dips towards Rico Lake. Along the eastern Site boundary surface topography dips to the east towards the adjoining property also operating as a gravel extraction pit.

Prominent topographic features on and in the vicinity of the Site include a small mountain near the southwestern Site boundary that rises approximately 100 m above the Site. A bedrock outcrop at the base of this mountain and multiple bedrock outcrops delineating a ridge of elevated bedrock (bedrock ridge) extend from the base of this small mountain to the northern portion of the K&D property north and northwest of the Site towards McIvor Lake, as discussed in Section 2.2.2.2.

Figure 1.1 illustrates the current topographic contours on-Site including the Pit, as well as portions of the western, southern, and eastern Site boundaries.

2.1.2 Site Drainage

Watersheds

The area in the vicinity of the Site is divided between two tertiary watersheds; the Campbell River Watershed and the Quinsam River Watershed, both of which are situated within the Campbell River Watershed Group. The locations of these watersheds are presented on Figure 2.0A and Figure 2.0B. A description of each watershed, the local surface water flow directions on-site, and the watershed divide in the vicinity of the Site is discussed in the following four sections.

Campbell River Watershed

The Campbell River Watershed is a sub-watershed of the Campbell River Watershed Group and covers an area of 182,000 ha. The Campbell River Watershed is intersected by three manmade dams which form Upper Campbell Lake, Campbell Lake, and John Hart Lake. There are two lakes that are in close proximity to the Site include McIvor Lake and Rico Lake. McIvor Lake is contiguous with Campbell Lake and is located approximately 50 to 150 m north of the northern boundary of the Site. McIvor and Campbell Lakes drain into John Hart Lake north of the Ladore Falls Dam. John Hart Lake drains into Campbell River (Figure 2.1).

The most eastern edge of Rico Lake is located approximately 10 to 15 m west of the west Site boundary. As previously stated, Rico Lake is held within a bedrock depression. Rico Lake drains west toward McIvor Lake.

Quinsam River Watershed

The Quinsam River Watershed is a sub-watershed of the Campbell River Watershed Group and covers an area of 20,900 ha. The Quinsam River Watershed is bound to the north and west by a mountainous divide that isolates it from the Campbell River Watershed (Blackmun, Lukyn, McLean and Ewart, 1985). There is a bedrock ridge that is part of this mountainous divide and forms the western boundary of the Quinsam River Watershed along the western boundary of the Site. The confluence of Campbell and Quinsam Rivers is located approximately 6 km northeast of the Site.

The principle surface water feature of the Quinsam River Watershed is the Quinsam River which is located approximately 3.8 km to the southeast of the eastern Site boundary. As shown on Figure 2.1 several ephemeral creeks located approximately 1.0 km to the southeast of the Site provides local drainage. Based on the local topography in this area which slopes toward the Quinsam River, it is assumed that when these creeks are flowing they discharge into the Quinsam River. Lost Lake (also known as Hidden Lake) is located 1.8 km to the northeast of the south east corner of the Site. It drains through Cold Creek which feeds the Quinsam Hatchery before discharging into the Quinsam River.

Local Surface Water Flow Directions

According to the BC Water Resource Atlas (2017) the Site is located on the watershed divide between the Campbell River and Quinsam River Watersheds.

The local drainage is inferred based on topography and watershed information provided by BC Water Resource Atlas (2017), on-site topographic data, hydrogeologic, and geologic investigative results for the area near the Site.

The location of the watershed divide between the Campbell River Watershed and the Quinsam River Watershed primarily is derived from the BC Water Resource Atlas (2017), which uses information based upon Terrain Resource Information Mapping (TRIM), which generally provides topographic contour information on a scale of 1:20,000. The source date of the topographical data is unknown and may not necessarily present up to date topography based on residential, commercial, or industrial development.

On November 21, 2016, McElhanney Consultants Ltd. completed a topographical survey, which was used to supplement the BC Water Resource Atlas data. The topographical survey data was completed using GPS survey equipment. This equipment provides an accuracy level for each data point of approximately 1 to 5 cm. The contours generated from the GPS survey provide a more accurate depiction of the on-site topography compared to the data used by the BC Water Resource Atlas (2017).

GHD developed a surface water flow model using ESRI ArcGIS software with spatial analyst capabilities including the hydrology toolset. This surface water flow model was based on the topographical information discussed above and was used to estimate localized surface water flow directions on-site, and to infer the surface water connections to surrounding watersheds.

At the outer limits of the surface water flow model, site specific information observed on-site was used to determine the ultimate flow direction of the surface water leaving the Site.

The inferred flow directions resulting from the surface water model are presented on Figure 2.0B. Key features of the model results are described as follows:

- Precipitation landing in and near the aggregate Pit runs towards the base of the Pit as depicted on Figure 2.0B
- Surface water flow that terminates at the base of the Pit infiltrates into the subsurface and recharges groundwater

- Precipitation infiltrating at the base of the Pit recharges the sand and gravel aquifer which, in turn, flows to the south east. The sand and gravel aquifer (discussed in Section 2.2.2) ultimately discharges into the Quinsam River Watershed
- South of the Pit surface water flows to the east and southeast to off-Site locations then follows the general topography to the southeast toward Quinsam River
- East of the Pit surface water flows towards the east where it follows the adjacent property access roads towards Argonaut Road along the general topographic eastward slope
- Northeast of the Pit surface water flows towards the northeast and towards Argonaut Road where it then flows to the east
- North of the Pit surface water flows towards the east and northeast toward the ditch along Highway 28 (Gold River Highway) – a culvert is not present under the road at this location and surface water flow is inferred to be along the road ditch toward Argonaut then follows the general topography towards the east
- West of the Pit surface water flows west towards Rico Lake

Local Surface Water Divide

Local surface water flow directions indicate that the vast majority of the Site is located within the Quinsam River Watershed with the exception of the southwest corner of the Site. A surface water divide has been identified in the southwestern portion of the Site, as shown on Figure 2.0B.

The inferred extension of the surface water divide off-Site, shown on Figure 2.0B, extends south of the Site and is based on observed Site surface water flow on the mountainous terrain southwest of the Site. The inferred Site-specific watershed divide aligns with the BC Water Resource (2017) watershed divide approximately 450 m south of the southwest corner of the Site, beyond which no additional Site specific information was collected.

West of the Site, the watershed divide is inferred based on the test pit program and survey of bedrock outcrop conducted on the adjacent K&D property.

North of the Site, the watershed divide runs in approximate alignment with Gold River Highway for the entire length of the Site. The watershed divide in this area was inferred based on on-site observations. The watershed divide is likely north of the road to the west of the Site entrance due to the elevated berm north of the road. The surface water divide likely crosses onto or south of the road near the Site entrance as the road is the high point in this area east of the Site entrance.

Northeast of the Site the watershed divide aligns with the BC Water Resource Watershed (2017) divide near the corner of Gold River Highway and Argonaut Road, where no additional Site specific information was collected.

2.1.3 Surface Water Features

Two lakes are located near Site. Rico Lake is located approximately 10 to 15 m west of the western Site boundary and approximately 250 m west of the proposed Landfill footprint. McIvor Lake is located 50 m to 150 m north and northwest of the northern Site boundary and approximately 440 m north of the proposed Landfill footprint. McIvor Lake is a BC Hydro reservoir.

On April 6 and 7, 2017, a registered professional biologist representing Current Environmental, completed a ground-level aquatic life assessment in the area between the Site boundary and a distance of 500 m to the east and south. The ground-level aquatic life assessment for the area of interest (AOI) is attached as Appendix E.

The objective of the aquatic life assessment was to identify any surface water features with the potential to sustain freshwater aquatic life in the AOI. Aquatic life water use, as defined by BC Contaminated Sites Regulations (CSR) (BC Reg. 375/96), means, "the use of water as habitat for any component of the freshwater or marine aquatic ecosystem, including phytoplankton, zooplankton, benthos, macrophytes and fish."

Two surface water features were identified in the AOI. A watercourse approximately 1.3 m wide that flows from west to east-southeast approximately 100 m south of the southern Site boundary. That watercourse eventually infiltrates into the subsurface in a gravel borrow area located approximately 375 m south of Site. A second water course, approximately 1.8 m wide, flows from west to southeast approximately 310 m south of the southern Site boundary. This watercourse continues to flow to the southeast, away from Site and likely joins tributaries of Quinsam River.

Within the AOI, both water courses flow from an elevation of approximately 219 to 185 mAMSL. Both water courses are sourced from a small wetland swamp located approximately 300 m southwest of the Site on a plateau within the highlands. Recharge of the wetland swamp is inferred to occur via run-off from the surrounding highlands. Flow from the wetland swamp is likely seasonal.

2.2 Geology

2.2.1 Regional Geology

The Site is located on the eastern portion of central Vancouver Island approximately 7 km southwest of Campbell River, BC. Vancouver Island is part of the Wrangellia Terrane, which includes most of Vancouver Island, the Queen Charlotte Islands and parts of central Alaska. The Wrangellia Terrane is composed mostly of widespread, late Triassic aged flood basalts, including the Karmutsen Formation. The Karmutsen Formation consists mostly of submarine flood basalts up to 6 km in thickness. Vancouver Island is extensively faulted with thrust faults associated with the subduction of the Juan de Fuca Plate under the North American Plate (BC MOE and Guthrie, 2005) (Greene, Scoates and Weis, 2005). There is a bedrock outcrop on the southwestern portion of the Site and bedrock encountered in boreholes advanced below the overburden that are Karmutsen basalt.

At several time periods during the Pleistocene Epoch, Vancouver Island was glaciated with ice thicknesses to 2 km. During the recession of the last glaciation approximately 14,000 years ago, glacial and glacio-fluvial sediments were deposited, and in some cases reworked and redeposited, to make up many of the present surficial deposits of Vancouver Island. These deposits consist of till that was deposited directly by glacial activity[1] and of glacial outwash composed primarily of poorly sorted, coarse-grained sand and gravel sediments deposited by glacial melt water (Greene, Scoates, and Weis, 2005; McCammon, 1977).

[1] This till consists of larger clasts supported in a matrix of fine-grained sediment

2.2.2 Site Geology

The Site-specific geology presented in the following sections is based on subsurface investigations and documents reviewed by GHD. Documents reviewed included regional maps, previous reports, and well completion logs from private wells. Refer to the references included in Section 6 for a complete listing of documents reviewed.

2.2.2.1 Site Overburden Geology

GHD evaluated the geologic conditions within the Site by examining the Pit sidewalls and soil samples collected during borehole and test pit advancement.

The following cross-sections were prepared based on available borehole and test pit stratigraphic data and illustrate the interpreted stratigraphy of the Site. The detailed stratigraphic and instrumentation logs used to prepare the following cross-sections are provided in Appendix F.

An overview of cross-section locations is presented on Figure 2.2.

- Cross-Section A-A' (Figure 2.3), from southwest to northeast.
- Cross-Section B-B' (Figure 2.4), from west to east.
- Cross-Section C-C' (Figure 2.5), from northwest to southeast.
- Cross-Section D-D' (Figure 2.6), from northwest to southeast.
- Cross-Section E-E' (Figure 2.7), from southwest to northeast parallel to Gold River Highway

With the exception of the southwestern corner, stratigraphy within the Site boundaries can be characterized as follows (in order from shallowest to deepest):

1. A native interbedded sand and gravel unit is present throughout the Site. The thickness of this unit is highly variable due to the sharp easterly dip of the bedrock surface along the western portion of the Site. This bedrock dip is described in greater detail below. In the south-eastern portion of the Site, illustrated on cross-Section C-C' - Figure 2.5, the sand and gravel unit is greater than 47 m thick (based on the Pit sidewall geology).

   A substantial sand unit was encountered at MW2A-16 and MW4A/B-15 in the central portion of Site and at MW10-17 in the southeast portion of Site. This sand unit ranges in thickness from approximately 12 m (at MW4A/B-15) to greater than 33 m (at MW2A-16). This sand unit varies in composition from sand with gravel to silty sand/sandy silt.

   Water supply well records from the north to northeast of the Site (provided in Appendix B) indicate the presence of sand and gravel beneath the maximum depths of MW2A-16, MW4A/B-15, MW9-17, and MW10-17 (i.e. greater than the maximum depths reached in the eastern portion of the Site).

2. Fractured bedrock composed of igneous basaltic rock underlies the unconsolidated overburden.

The structure of the overburden unit is consistent with glacio-fluvial and outwash depositional sources.

Soil samples were collected for grain size analysis (sieve and hydrometer) from BH1-16, BH2-16 and MW2A-16. The following table summarizes the results of the analyses:

Sample location	Subsoil Unit	Sample Depth (mBGS)	Soil Samples				
			Particle Size Distribution				USCS Classification
			% Gravel	% Sand	% Silt	% < 0.002 mm (clay)	
BH1-16	Sand, trace gravel, trace silt	8.84-10.36	3.9	93.3	2.8		SW
BH2-16	Sand, some silt, some gravel	11.89-13.41	28.3	39.4	32.3		SM
MW2A-16	gravelly Sand, trace silt	14.94-16.46	41.7	55.5	2.8		SW
MW2A-16	Sand, some silt and clay	24.38-24.69	0.4	65.8	33.8		SM
MW2A-16	Sand, trace silt	38.10-38.7	0.0	91.9	8.1		SP

The particle size analysis sheets and a complete discussion on grain size analysis are provided in the 2015 Geotechnical Investigation, Upland Landfill (GHD, 2016).

The overburden stratigraphy in the southwestern area of the Site, and the adjoining properties west of Site, where bedrock is present at surface or shallow depths is variable but can be generally characterized as follows:

1. On the property west of the Site (K&D property) the following stratigraphy was encountered:
    a. Granular fill consisting primarily of sand and gravel was encountered in several of the investigative locations. A maximum thickness of 4.7 m was encountered at MW6-17.
    b. A thin topsoil layer underlain by sand with varying degrees of silt and/or gravel was encountered beneath the fill materials or where fill was absent, at surface.
    c. Bedrock composed of igneous basaltic rock was encountered at surface or at a maximum depth of 11.6 m at MW6-17.
2. In the southwest corner of the Site, at MW5A/B-15, the following stratigraphy was encountered:
    a. A discontinuous, interbedded sand and silt unit consisting of layers of sand with silt, silty sand, or silt with clay was observed underlying a sand and gravel fill unit. The thickness of the interbedded layers was approximately 2.1 m at MW5A-15. Stratigraphic data from BH5-15, which is located approximately 85 m east of

MW5A-15, indicates that the sand and silt layer is discontinuous as it is not present at this location.

b. Bedrock composed of igneous basaltic rock underlies the unconsolidated overburden in the south-western corner of the Site.

There are numerous bedrock outcrops near the south-western corner of the Site provide additional evidence that the presence of overburden materials is discontinuous west of the Site or not present at all in the southwest corner of the Site.

2.2.2.2 Site Bedrock Geology

Bedrock was encountered near surface within test pits TP2-17, TP3-17, TP8-17, and TP9-17 and outcrops at surface near the southwest and west Site boundary and on the adjoining K&D property west of the Site. Bedrock samples were collected from boreholes MW4A-15, MW5A-15, MW6-17, and MW7-17. Additionally, bedrock was noted in residential well RW-98020 and Red William's stratigraphic log for MW3-14.

Bedrock at the Site consists of fine grained, porphyritic, igneous rock of the Karmutsen Formation which varies in colour from blueish black to dark grey and green to dark grey and pink to dark brown (Golder, 2014). Fractures of various sizes, densities and orientations (vertical, horizontal, and oblique) were observed in bedrock samples collected from the boreholes listed above. The most significant fracturing was noted in the boring advanced within the Pit (MW4A-15). Evidence of weathering (i.e. iron staining) and secondary mineralization was observed in some fractures. According to laboratory tests completed by Golder in 2014, calcite is present in fractures and amygdules.

The water well records for RW-98020 as well as Red Williams' stratigraphic log for MW3-14 describe the rock as granite; however, the BC MOE identifies rock in the Karmutsen Formation as basalt.

Residential well RW-98020 was completed at a depth of 60.96 m bgs (200 feet BGS). The stratigraphic log, included in Appendix B, indicates that bedrock was encountered at 1.8 m bgs. The log also shows that the bedrock unit was relatively competent with few water bearing fractures which is important in understanding the Site area hydrogeology west of the Site discussed in Section 2.3.3.

At the base of the mountain near the southwestern Site boundary there is a large bedrock outcrop where rock blasting and crushing is actively conducted. Native topography in the southwest portion of Site is unknown.

Figure 2.8 illustrates the bedrock surface elevations based on borehole stratigraphy, test pit stratigraphy, and bedrock outcrops encountered near the Site. As shown on Figure 2.8, there is 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 (in the vicinity of RW-98020). The northern portion of the bedrock ridge wraps around the northern boundary of Rico Lake.

A line of smaller bedrock outcrops is present from the base of the mountain near the southwestern Site boundary following a northwest orientation and are present in the northern portion of the

adjoining K&D property. This line of bedrock outcropping is indicative of the presence of the bedrock ridge extending from the southwest corner of the Site to the northern portion of the K&D property. Bedrock was encountered at depths less than 5.5 m bgs (177.12 mAMSL) in several test pits along the western Site boundary, at depths of 5.03 and 11.3 m bgs (182.59 and 173.92 mAMSL) in two boreholes advanced within the K&D property (as discussed in Appendix C). Bedrock outcrops were noted on the K&D property at elevations ranging from 182.07 to 184.06 mAMSL). This bedrock ridge extends further to the west of the K&D property, as bedrock was noted at a depth of 1.8 m bgs (193.8 mAMSL) at the private well RW-98020 located adjacent to McIvor Lake. A bedrock cliff is noted between the private well RW-98020 and the lake surface, suggesting that the bedrock ridge does not extend into McIvor Lake.

East of the bedrock ridge and the current blasting area on the Site, bedrock is inferred to plunge steeply towards the Pit area to approximately 150 mAMSL in the west side of the Pit based on the confirmed elevations of bedrock. The bedrock surface continues to dip sharply to the east and is encountered at approximately 145 mAMSL in the centre of the Pit (BH1-16). Further to the east, the bedrock is inferred to continue to dip steeply as no bedrock was encountered during borehole advancement at MW10-17 to a depth of 47.85 m bgs (140.83 mAMSL).

West of the bedrock ridge, near the southwestern Site boundary, bedrock slopes downward towards Rico Lake. The bottom of Rico Lake was reported to be 168 mAMSL (CREC, August 2016). Based on this depth, the bottom of Rico Lake is within a depression in the local bedrock surface.

The northern portion of the bedrock ridge wraps around the northern boundary of Rico Lake and separates Rico Lake from McIvor Lake (to the north). The northern portion of the bedrock ridge slopes downward gradually to the south towards Rico Lake, and steeply to the north towards to McIvor Lake.

Bedrock topography is highly variable near the Site. Bedrock ranges from at surface near the southwest and west Site boundaries and the northern portion of the adjoining K&D property, to greater than 47.9 m bgs near the eastern Site boundary (MW10-17). A topographically elevated bedrock ridge extends from the base of the mountain near the southwest corner of the Site to the northern portion of the adjoining K&D property and west to McIvor Lake.

2.3 Site Hydrogeology

The bedrock ridge discussed in Section 2.2.2.2 induces a groundwater flow divide on the groundwater flow system. In general, groundwater flow may be grouped into the following two hydrogeological flow systems:

1. A sand and gravel aquifer
2. A shallow aquifer

2.3.1 Groundwater Divide

There is a notable topographic difference between the bedrock ridge and the remainder of the Site. The ridge is composed of competent bedrock and is interpreted to form a barrier to groundwater flow. East of the bedrock ridge, the principal groundwater flow zone is through the sand and gravel aquifer in a southeasterly direction from McIvor Lake towards the southeast Site boundary. West of

the bedrock ridge groundwater flow is controlled by bedrock surface topography. Flow in this area occurs from points of high bedrock elevation within the ridge to areas of low elevation.

Precipitation that falls east of the bedrock ridge infiltrates into the subsurface, flowing to the southeast as saturated flow within the principal flow zone. Precipitation that falls to the west of the bedrock ridge and hydraulic divide (watershed and groundwater divide) is interpreted to runoff of areas of bedrock outcrop, infiltrate into the subsurface and flow towards areas of low topography (i.e. Rico Lake and or McIvor Lake).

2.3.2 Sand and Gravel Aquifer

An unconfined, sand and gravel aquifer was identified within the overburden unit in boreholes advanced across the Site. The aquifer consists of coarse grained materials, primarily sand and gravel of varying degrees, with occasional seams of sand and silty sand. Based on the consistency and spatial distribution of borehole locations, this aquifer is interpreted to be continuous across the Site (with the exception of the southwestern and western portions of Site). As no bedrock was encountered during drilling along the northern Site boundary (MW8-17 and MW9-17) the sand and gravel aquifer is inferred to be continuous off-Site along the shore of McIvor Lake.

The sand and gravel aquifer identified on-Site is a major aquifer in the region, and is identified in the BC Water Resource Atlas (2017) as aquifer 975 IIA (10). This aquifer is interpreted to be the principal groundwater flow zone at the Site. In the context of the future proposed Landfill, this aquifer represents the only receptor to infiltrating water east of the divide. As such, this aquifer is of particular importance to this hydrogeologic characterization.

Historical groundwater elevations are presented in Table 2.0. The most comprehensive hydraulic monitoring event to date was April 6, 2017 and included all Site area groundwater monitoring wells and surface water locations. Water levels measured on April 6, 2017 were used to evaluate the variation of water levels across Site and generate groundwater elevation contours. Groundwater elevations at monitoring wells installed in the sand and gravel aquifer ranged from 172.8 m AMSL (MW8-17) to 150.1 m AMSL (MW10-17).

Seasonal trends were evaluated for monitoring wells installed from 2014 through 2016. Hydraulic monitoring events were conducted in September 2015, October 2015, January 2016, March 2017, and April 2017, representing dry season (September/October 2015), rainy season (January 2016), and upon freshet (March and April 2017). Historical data is not available for monitoring wells installed in 2017. In general, groundwater elevations were highest during the September 2015 monitoring event and lowest during the March 2017 monitoring event. Seasonal groundwater elevation fluctuations within each monitoring well ranged from 1.3 m (MW2A-16) to 2.5 m (MW1-14). This significant seasonal fluctuation in water levels is expected in regions like Campbell River that experience on average 1,489 millimetres of precipitation annually with much of the rainfall occurring between November and January (Environment Canada, Campbell River Airport – 1981 – 2010 climate normal).

Groundwater elevation contours are presented on Figure 2.9 and represent lines of inferred equipotential groundwater elevations within the sand and gravel aquifer east of the groundwater flow divide and within the shallow aquifer west of the groundwater flow divide. As illustrated on Figure 2.9, primary groundwater flow at the Site within the sand and gravel aquifer is directed from

the north and northwest towards the southeast (i.e. from McIvor Lake towards the southeast corner of the Site).

The following table summarizes the surface water elevations within McIvor Lake as compared to static groundwater elevations within the sand and gravel aquifer recorded on April 6, 2017. Measurements are presented in order of up-gradient to down-gradient.

Monitoring Location	Water Level (mBTOR)	Water Elevation (mAMSL)
McIvor Lake	-	177.6
MW8-17	19.7	172.8
MW9-17	24.4	167.2
MW1-14	7.7	165.2
MW4B-15	5.7	163.6
MW2-14	15.8	158.0
MW3-14	12.1	156.4
MW10-17	39.0	150.1

As indicated in the above table, surface water elevations within McIvor Lake are substantially higher than groundwater elevation in the principal groundwater flow system on-Site (sand and gravel aquifer). Water levels in McIvor Lake are controlled by BC Hydro.

As described in Appendix C, single well response tests (SWRT) were completed in the sand and gravel aquifer. The results of the SWRTs show that hydraulic conductivity of the sand and gravel aquifer is approximately 2 x 10^{-2} cm/sec. For reference, the single well response plots are provided in Appendix G.

The substantial difference between the static water elevation in McIvor Lake and the static groundwater elevations and the hydraulic conductivity of the sand and gravel aquifer supports the following interpretations:

- McIvor Lake and the principal groundwater flow system on-Site (sand and gravel aquifer) are hydraulically connected.
- The surface water elevation of McIvor Lake is approximately 10.4 m higher than the groundwater water elevation measured at MW9-17 and approximately 4.8 m higher than the groundwater elevation measure at MW8-17, located along the northern Site boundary.
- The horizontal component of the hydraulic gradient is inferred to be southeast from McIvor Lake to the sand and gravel aquifer on-Site.
- The vertical component of the hydraulic gradient is inferred to be downward from McIvor Lake to the sand and gravel aquifer on-Site.
- The hydraulic conductivity of the sand and gravel aquifer and measured hydraulic gradients between McIvor Lake and the Pit area are sufficiently high that drainage from the lake is very fast.
- McIvor Lake recharges the sand and gravel aquifer near the-Site.

- The significant difference in static water elevations between McIvor Lake and monitoring wells located along the northern Site boundary (MW9-17 and MW8-17) confirms groundwater does not flow up-gradient from beneath the Site to McIvor Lake.

The hydraulic relationship described above concludes that McIvor Lake is not a receptor of groundwater from the Site.

The sand and gravel aquifer is recharged by precipitation infiltration east of the groundwater flow divide, surface water that flows into the Pit and infiltrates, and wash plant water from the settling ponds that infiltrates. Infiltration from the above sources joins the principle groundwater flow system (sand and gravel aquifer) flowing in a southeasterly direction and ultimately discharges into the Quinsam River Watershed.

Figure 2.7, Cross-section E-E' shows the crest of the bedrock ridge west of MW6-17 on the K&D property. Outcrops of competent bedrock were identified just south of the line between MW7-17 and MW6-17; thus, MW6-17 is located on the northeastern flank of the bedrock ridge within the sand and gravel aquifer unit. Groundwater elevations at this location, 173.92 m AMSL, indicates groundwater flow along the eastern flank of the bedrock ridge, east of the flow divide, is directed towards the Pit (as shown on Figure 2.9).

Underlying Bedrock

Shallow fractured bedrock was encountered underlying the sand and gravel aquifer at MW3-14, MW4A-15, BH1-16, and BH2-16. The fractured bedrock aquifer was encountered in the west portion of Site as shown in the borehole stratigraphy (see Appendix F). Due to the significant thickness of the sand and gravel aquifer in the eastern portion of the Site the bedrock was not encountered in the eastern portion of the Site.

Groundwater within the shallow fractured bedrock is monitored at MW4A-15 in the central portion of the Site[2].

Groundwater elevations at bedrock monitoring well MW4A-15 were on average 0.3 m higher than at nested well MW4B-15 which is screened within the sand and gravel aquifer, with the exception of the 2.3 m difference recorded during the April 6, 2017 monitoring event which appears to be anomalous and will be verified with future monitoring. 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 discharges upward into the sand and gravel aquifer.

The SWRT results for MW4A-15 indicated a hydraulic conductivity of approximately 2.2×10^{-2} cm/sec (Appendix G). This value is similar to the calculated conductivity in the sand and gravel aquifer (2.0×10^{-2} cm/sec).

[2] MW3-14 is located in the west side of the aggregate pit and is partially screened in the bedrock aquifer and partially screened in the sand and gravel. The predominant flow system in this area is the sand and gravel. Groundwater elevations measured in MW3-14 are more representative of overburden groundwater conditions in the sand and gravel aquifer.

It is expected that the flow in the shallow fractured bedrock will follow regional flow (i.e., southeast towards the Quinsam River) for two reasons as follows:

1. The shallow fractured bedrock unit is in direct hydraulic contact with the overlying sand and gravel aquifer
2. The similar hydraulic conductivity measured in the sand and gravel aquifer and the shallow fractured bedrock unit will limit groundwater flow-line inflections (i.e., direction changes)

The upward gradient noted above indicates that a component of groundwater from the shallow fractured bedrock aquifer will flow upwards join the principle groundwater flow in the sand and gravel aquifer towards the south-southeast.

Vadose Zone Overlying Sand and Gravel Aquifer

The vadose zone is the unsaturated zone between the ground surface and the water table in the subsurface. The vadose zone within the Site that overlies the sand and gravel aquifer ranged in thickness from 4.8 m at MW4B-15 to 38.1 m at MW10-17 during the April 2017 monitoring event. As discussed above, seasonal fluctuations of groundwater levels in the sand and gravel aquifer range from 1.3 m (MW2A-16) to 2.5 m (MW1-14) and should be considered when evaluating the thickness of the vadose zone. The thickness of the vadose zone within the footprint of the proposed Landfill (MW3-14) and down-gradient of the proposed Landfill (MW10-17) was 11.2 m and 38.1 m, respectively, measured during the April 2017 monitoring event.

2.3.3 Shallow Aquifer

Throughout the investigative activities, a relatively thin, discontinuous zone of shallow saturated overburden materials was encountered along the bedrock ridge (where overburden is present) to the west of the groundwater divide throughout the K&D property, as well as in the southeast corner of the Site (along the eastern flank of the groundwater divide at MW5A/B-15). The following subsections describe the groundwater flow in these areas which are collectively referred to as the shallow aquifer.

2.3.3.1 Shallow Aquifer - West of Groundwater Divide

Shallow groundwater was identified at MW7-17 located on the K&D property and in test pits completed along the western flank of the bedrock ridge and the K&D property (TP1-17, TP2-17, and TP3-17). Stratigraphic logs for this area indicate that competent bedrock is shallow or at ground surface. Based on the presence of the competent bedrock ridge to the east and southeast, groundwater flow within the shallow aquifer is directed to points of lower topography to the south or north (Rico Lake or McIvor Lake).

As previously mentioned bedrock within the bedrock ridge area (southwest and west of the Site) and at RW-98020 is characterized as being competent igneous rock. This bedrock has a high rock quality designation (RQD), low hydraulic conductivity, and few fractures. Thus, while some infiltration and groundwater flow will occur through bedrock in these areas, it will be limited. Primary flow in the bedrock ridge area and west of the Site will be through the overburden soil or, where overburden is not present, by overland flow.

Recharge of the shallow aquifer in this area occurs by infiltration of precipitation.

The static water elevations measured on April 6, 2017 are presented on Figure 2.9 along with the interpreted flow directions west of the groundwater divide Groundwater flow west of the flow divide is interpreted to be largely controlled by bedrock surface topography. A comparison of Figures 2.8 and 2.9 shows that groundwater flows from points of high bedrock elevation to areas of low topographic elevation.

In contrast to the top layer of fractured bedrock underlying the sand and gravel aquifer, bedrock encountered west of the groundwater divide, at depth, is competent with limited fractures and limited water availability as shown on the stratigraphic log for RW-98020 (Appendix B). The estimated yield of RW-98020 is 6 gallons per minute or 27 litres per minute. This yield corresponds to a hydraulic conductivity much lower than what was calculated at MW4A-15.

The low hydraulic conductivity measured in the bedrock ridge between the Pit and Rico Lake significantly restricts movement of groundwater between these two features. However, surface water from Rico Lake could potentially infiltrate the subsurface and move 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, will not occur. For this reason, it is not possible for groundwater from the sand and gravel aquifer beneath the Pit to flow westward to Rico Lake. As such Rico Lake is not a receptor to the sand and gravel aquifer.

The following table compares the surface water elevations within McIvor and Rico Lakes. Measurements are presented in order of up-gradient to down-gradient.

Monitoring Location	Water Elevation (mAMSL)
Rico Lake	180.4
McIvor Lake	177.6
Notes: Water levels recorded April 6, 2017.	

As indicated in the table above, the static water elevation within Rico Lake is significantly higher (2.8 m) than the static water elevation within McIvor Lake. Groundwater seepage has also been observed along the shores of McIvor Lake in close proximity to the northwestern end of Rico Lake. Seepage occurs where the separation between the two lakes is limited to the width of Gold River Highway, evidencing sub-surface flow between the two water bodies.

These observations support the following interpretations:

- Any hydraulic connection between Rico Lake and McIvor Lake is necessarily a weak hydraulic connection. The connection is through the subsurface as groundwater flow.
- Water flows from Rico Lake to McIvor Lake.

2.3.3.2 Shallow Aquifer (East of the Groundwater Divide)

MW5A-15 and MW5B-15 are located along the southeastern flank of the bedrock ridge approximately 23 m above the base of the Pit. Groundwater at this location is present within a thin overburden layer overlying competent bedrock. Based on the presence of a mountain to the south,

groundwater will likely flow downwards (potentially daylighting as seepage or through overburden materials as unsaturated flow) towards the Pit area where it will ultimately join the principal flow zone, flowing to the southeast. Flow from the vicinity of MW5A/B-15, is expected to be limited. This is evidenced by the relatively thin saturated thickness compared to the remaining sand and gravel aquifer monitoring wells.

MW5A-15 is screened in bedrock and MW5B-15 is screened in overburden composed of interbedded sand and silt with clay, immediately overlying the bedrock. Single well response tests were completed in MW5A-15. Based on the results of these tests, the hydraulic conductivity of the bedrock in the southwest is approximately 1.4×10^{-5} cm/sec. This indicates bedrock is relatively competent along the bedrock ridge.

During the April 2017 hydraulic monitoring event, groundwater was encountered within the overburden monitoring well (MW5B-15) at an elevation of 185.9 mAMSL and within the bedrock well (MW5A-15) at an elevation of 184.2 mAMSL. In comparison, groundwater within the principal flow zone (sand and gravel aquifer) was measured greater than 10 m lower (i.e., 156.4 mAMSL as measured in MW3-14). Horizontal hydraulic gradients show groundwater in the vicinity of MW5A/B-15 will drain towards the Pit area; however, the significant difference in groundwater elevations indicates that a significant hydraulic connection is unlikely. This is also evidenced by differing water chemistry from the remaining sand and gravel aquifer (discussed further in Section 4.0 below). On average, groundwater elevations are 2 m higher in MW5B-15 when compared to MW5A-15. The difference in water levels provides evidence for the competency of bedrock along the bedrock ridge. Water levels would be measured at similar elevations if bedrock along the ridge was significantly fractured.

Recharge in the vicinity of MW5A-15 and MW5B-15 is via infiltration of precipitation on the east flank of the bedrock ridge and potentially from groundwater flow originating from the small mountain located south of the well nest.

2.3.4 Horizontal Hydraulic Gradients and Groundwater Velocity

An average hydraulic gradient of 0.03 m/m is calculated for the sand and gravel aquifer across the Site (gradient calculated between McIvor Lake and MW10-17). Using the most comprehensive round of water elevation measurements (April 2017), the calculated hydraulic gradients varied between 0.02 m/m and 0.09 m/m. The higher hydraulic gradient, 0.09 m/m, is calculated between McIvor Lake and MW9-17. The lower hydraulic gradient, 0.02, m/m is calculated between MW2-14 and MW10-17, in the southeast corner of the Site. The range of horizontal hydraulic gradients calculated in April 2017 are generally consistent with 2015 and 2016. For example, the horizontal hydraulic gradient calculated between MW1-14 and MW3-14 on September 11, 2015 and January 25, 2016 are both 0.03 m/m.

The hydraulic conductivity for the sand and gravel aquifer is approximately 2.0×10^{-2} cm/s. Using an effective porosity estimate of 30 percent and the average hydraulic gradient, 0.03 m/m, an average linear groundwater velocity in the sand and gravel aquifer of 1.7 m/day can be calculated using Darcy's equation. For reference, Darcy's equation is provided below.

$$V_x = \frac{Ki}{\eta_e}$$

Where:

V_x = average linear groundwater velocity

K = hydraulic conductivity

i = horizontal hydraulic gradient in the direction of groundwater flow

η_e = effective porosity

3. Hydrogeologic and Hydrologic Conceptual Site Model

The hydrogeologic and hydrologic Conceptual Site Model (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, and the watershed and groundwater flow divide which separates Rico Lake from the Site.

The location of the watershed and groundwater flow divide is illustrated in plan view on Figure 3.0A along with the interpreted groundwater flow directions which are described below.

Watershed and Groundwater Divide

The hydrology and hydrogeology west of the Site (in the vicinity of Rico Lake) is characterized by a hydraulic (watershed and groundwater flow) divide. The existence of Rico Lake at an elevation that is notably higher than the Pit bottom is necessarily dependent on a natural low permeability barrier which restricts the infiltration and eastern migration of the lake water through the subsurface. Based on the available stratigraphic record and field observations, the low permeability barrier is a ridge of largely competent bedrock that extends from the southwest corner of the Site in a northwest direction around the northern boundary of Rico Lake and ends at the shores of McIvor Lake in the vicinity of RW-98020. The bedrock ridge is interpreted to create a hydraulic barrier between the Pit area and the properties west of the Site (including Rico Lake and the K&D property).

Although the low permeability barrier between the Pit and Rico Lake significantly restricts the movement of groundwater, surface water from Rico Lake has the potential to infiltrate the subsurface and move through the barrier in the direction of the horizontal hydraulic gradient (i.e. from Rico Lake to the Pit area) albeit at a very low velocity and very low flux. Flow in the reverse direction, against the hydraulic gradients, will not occur.

Sand and Gravel Aquifer

The principal groundwater flow zone at the Site is found in the sand and gravel aquifer. The sand and gravel aquifer unit was encountered at varying thickness across the Site. Based on the substantial saturated thickness of the sand and gravel unit across much of the Site area and

relatively high hydraulic conductivity the sand and gravel aquifer is anticipated to be the primary zone through which groundwater will flow across the Site. Groundwater flow in this high permeability aquifer is directed from the north and northwest towards the southeast. Recharge to this aquifer occurs by two mechanisms:

1. Infiltration of precipitation east of the hydraulic divide
2. Groundwater inflow from McIvor Lake (to the North of the Site)

Groundwater flowing off-Site (to the southeast) in this aquifer continues to flow through the Quinsam River Watershed towards the Quinsam River following regional groundwater flow direction (BC Water Resource Atlas, 2017 - aquifer 975 IIA (10)). Based on the elevation of groundwater leaving the Site (150 mAMSL) and the approximate 100 m change in topographic elevations between the Site and the Quinsam River (190 mAMSL versus 90 mAMSL), shallow groundwater discharges to the Quinsam River Watershed southeast of the Site and ultimately flows enters the Quinsam River.

Precipitation that falls within the upper terrace west of the Pit infiltrates into the subsurface and migrates, through unsaturated flow, towards the Pit area where it joins the principal groundwater flow system. Similarly, precipitation that falls into the Pit infiltrates into the subsurface and joins the principal groundwater flow system.

The horizontal rate of groundwater flow (i.e. linear velocity) within the sand and gravel aquifer is calculated to be on the order of 1.7 m/day. The specific discharge, q, is 30 % (i.e., the effective porosity value) of the groundwater flow rate (i.e., 0.51 m/day). The estimated saturated thickness across the proposed landfill area is approximately 5.46 m based on the average groundwater elevation and bedrock surface elevations measured in MW3-14.

The groundwater flow passing through the cross-sectional area can be calculated using Darcy's Law and is expressed with the following equation:

$$Q = KiA$$

Where:

Q = groundwater flow rate passing through the cross-sectional area

A = cross-sectional area through which groundwater is flowing

i = horizontal hydraulic gradient

The cross-sectional area for groundwater flow is calculated as follows:

$$A = L_x \times d$$

Where:

L_x = source length perpendicular to groundwater flow (250 m based on the northeast to southwest diagonal of the Landfill footprint perpendicular to the direction of groundwater flow)

The calculated cross-sectional area for groundwater flux beneath the proposed landfill is 1,365 m^2. The corresponding groundwater flow rate is 706 m^3/day (i.e., 258,000 m^3/yr).

Figure 3.0B and Figure 3.0C provide schematic cross-section views of water flow in the vicinity of the Site. Figure 3.0B provides an illustration of flow in a north to southeasterly direction following groundwater flow through the principal flow zone. Figure 3.0C illustrates the hydraulic divide separating Rico Lake and the Pit area of the Site (discussed below).

As shown in Figure 3.0B, surface water from McIvor Lake recharges groundwater in the sand and gravel aquifer to the north and northwest of the Site. Groundwater then flows to the southeast beneath the Site and continues to travel further southeast until it discharges to surface in the Quinsam River Watershed.

Shallow Aquifer

A relatively thin, discontinuous shallow aquifer is present along the northern portion of the bedrock ridge (where overburden is present), to the west of the groundwater flow divide throughout the K&D property, as well as in the southeast corner of the Site (along the southeastern flank of the groundwater flow divide at MW5A/B-15). Based on the presence of competent bedrock, groundwater flow in the vicinity of the bedrock ridge will be largely controlled by bedrock topography. Where present, groundwater flows from areas of high bedrock elevation to areas of low topography. In the vicinity of MW7-17, flow is directed towards Rico Lake to the south and McIvor Lake to the north.

Bedrock along the ridge is generally competent igneous rock with a high RQD, low hydraulic conductivity, and few fractures. Thus, while some infiltration and groundwater flow will occur through the competent bedrock west and southwest of the Site, it will be limited. Primary flow in the shallow aquifer west of the Site is through the overburden or, where overburden is not present, by overland flow on top of the bedrock.

Recharge of the shallow aquifer in the vicinity of the bedrock ridge is by infiltration of precipitation.

Figure 3.0C illustrates hydraulic flow in the shallow aquifer to the west of the Site. As shown on Figure 3.0C, flow west of the bedrock ridge is towards Rico Lake.

Surface Water Features

The elevation of McIvor Lake is partially controlled by BC Hydro's Ladore Dam located on the northern shore of McIvor Lake approximately 1.7 km northwest of Site. BC Hydro attempts to maintain a preferred water elevation at Ladore Dam between 176 and 178 mAMSL and has established and a minimum operational water elevation of 174 mAMSL (BC Hydro, 2016). Based on BC Hydro records, water elevations at Ladore Dam have fluctuated between 174.5 and 177.9 mAMSL since 2008.

Recharge into Rico Lake originates from a combination of groundwater flowing west of the groundwater flow divide and south from the hydraulic highpoint noted at MW7-17, as well as a large component of runoff from the small mountain located southwest of the Site. Areas of groundwater seepage have been identified discharging into McIvor Lake just west of Rico Lake. Given the difference in surface water elevations (Rico Lake is approximately 3 m higher than McIvor Lake)

and the observed groundwater seepage west of Rico Lake, a hydraulic connection between the two lakes exists and is directed from Rico Lake towards McIvor Lake. Surface water is draining from Rico Lake through the shallow soils (likely the road base materials) into McIvor Lake.

In both cases, hydraulic gradients between the Site and the lakes are directed from the lake towards the Site. Based on the hydraulic relationship, it is not possible for McIvor or Rico Lake to be receptors of groundwater within the sand and gravel aquifer beneath the Site.

The two small surface water courses identified within 500 m south of Site are located cross-gradient of groundwater flow on-Site within the sand and gravel aquifer. These surface water courses are flowing south easterly away from the Site, approximately 35 m above the groundwater elevation at the southeast Site boundary. Therefore, it is not possible for the water courses to be receptors of groundwater from on-site sand and gravel aquifer.

4. Baseline Water Quality Results

The purpose of the water quality sampling program was to characterize baseline groundwater quality prior to the construction and operation of the proposed lined Landfill. Understanding the existing, pre-landfilling water quality is important for several reasons, including:

1. Existing water quality needs to be taken into account in predictive modelling used to assess future Landfill performance.
2. Existing water quality is useful for comparing water quality results during and post Landfill development in order to quantify and assess the effects of landfilling to on-Site water quality.

Groundwater and surface water samples were collected from the existing monitoring network on September 17 and 18, 2015, October 5 and 6, 2015 and April 6 and 7, 2017. Select monitoring locations were sampled on January 29, 2016 (wash plant – SW16-03) and February 15, 2016 (MW2-14, MW2A-16 and private domestic well RW-98020).

Samples were analyzed for a full or partial list of field parameters, general chemistry, nutrients, metals, hydrogen sulfide, polycyclic aromatic hydrocarbons (PAHs), extractable petroleum hydrocarbons (EPH), VOCs, and total oil and grease. These parameters were selected to characterize baseline water quality near the future Landfill footprint. The analytical results along with the selected comparative criteria, discussed below, are summarized in Table 4.0A and 4.0B (groundwater), Table 4.1A and 4.1B (surface water), and Table 4.2 (wash plant water).

Tables 4.0A and 4.1A include field parameters, general chemistry, nutrients, and dissolved and total metals (surface water only) results. Tables 4.0B and 4.1B include PAH, EPH and total oil and grease, and VOC compound results with the respective CSR criteria. Table 4.0C provides the field parameter, general chemistry, nutrients, and dissolved metals results from RW-98020.

The most recent water quality sampling, April 2017, included groundwater samples collected from each of the groundwater monitoring locations (excluding MW7-17 and MW8-17), surface water samples collected from Rico Lake, McIvor Lake, and the wash plant water. The 2017 water quality parameters did not include PAH, EPH, total oil and grease, or VOCs because all previous analyses showed concentrations were below detection limits for these parameters.

Copies of the original laboratory reports are included in Appendix H.

All analytical data received were validated by a review of the standard quality control criteria including blind duplicate sample analysis. As well, the laboratory QA/QC data were reviewed. The complete analytical data assessment and validation report for the current reporting period is included in Appendix I.

The qualifications indicated in Appendix I do not significantly alter the interpretation of the data or affect the conclusions provided in this Report. Each of the water quality tables have been updated with the data qualifications made during the QA/QC assessment.

4.1 Applicable Water Quality Standards

Various water quality standards and guidelines have been reviewed in order to determine the appropriate criteria for evaluating water quality at the Site. The Landfill Criteria states that the following standards and guidelines should be given consideration in determining the appropriate water quality criteria for a landfill:

- The BC Approved and Working Water Quality Guidelines
- BC Water Quality objectives.
- The Contaminated Sites Regulation, Generic Numerical Water Standards for the applicable water use(s) as defined in Protocol 21 "Water Use Determination" under the Contaminated Sites Regulation. (Protocol 21)
- The Canadian Drinking Water Quality Guidelines.
- Other water quality criteria for parameters not addressed by the preceding water quality criteria.

A comprehensive review of the above standards and guidelines was completed in order to determine suitable evaluation criteria for water quality at the Site. As previously mentioned an aquatic life assessment of the down-gradient properties east and southeast of the Site was also completed[3]. Based on a review of the applicable criteria the appropriate criteria to apply to groundwater quality within the sand and gravel aquifer on-Site east of the groundwater flow divide and at the south and east Site boundaries are as follows:

- Contaminated Sites Regulation (CSR) (BC Reg. 375/96)
  - Drinking Water (DW) Standards from Schedules 6 and 10

Based on a review of the applicable criteria and the results of the biological assessment, the appropriate criteria to apply to shallow aquifer west of the groundwater flow divide and surface water in the area surrounding Site boundaries are as follows:

- BC Approved and Working Water Quality Guidelines (WQGs)
  - Drinking Water (DW)
  - Freshwater Aquatic Life (FWAL)

[3] This analysis is provided in Appendix E

Rationale

BC Contaminated Sites Regulation (CSR)

The Site has operated as an active sand and gravel pit since 1969. On-Site activities include rock blasting, crushing, aggregate excavation, and aggregate washing. As described in Section 1.1.2, the Permit was issued to the Site in 1992. Waste discharged at the Site historically has included burnt, clean wood wastes, land clearing debris and demolition debris. Given the historic use of the Site and current use as an active sand and gravel pit, the most appropriate standards to apply at the Site are the generic groundwater standards for contaminated sites.

As outlined in the BC MOE document Protocol 21 the applicability of the various CSR standards depends on the potential for groundwater or surface water at the Site to flow to surface water bodies that may support aquatic life as well as the current and future water uses in the vicinity of the site.

CSR Aquatic Life Water Use – Freshwater (FWAL) standards

Protocol 21 states that CSR FWAL standards apply to sites located within 500 m of an aquatic receiving environment (i.e. a surface water body containing aquatic life) unless it can be demonstrated that the groundwater discharges into a different surface water body (located greater than 500 m from the site) or that groundwater does not migrate to within 500 m of a surface water body that contains aquatic life.

The results of the aquatic life assessment down-gradient of the Site revealed that no surface water bodies are present within 500 m east of the Site. The assessment identified two watercourses within 500 m of the southeast Site boundary; however, the watercourses are located cross-gradient of the proposed Landfill and at an elevation of approximately 185 mAMSL, well above groundwater leaving the Site (approximately 150 mAMSL). Thus, surface water within the watercourses cannot be receptors to groundwater originating from the Site (i.e. the watercourses are not aquatic receiving environments). Rico Lake and McIvor Lake are located up-gradient based on documented flow patterns of the Site (Figure 2.9) and are, therefore, also not considered aquatic receiving environments.

The AW standards identified in Schedule 6 of the CSR do not apply to groundwater quality at the Site.

CSR Drinking Water (DW) standards

Protocol 21 states that both current and future drinking water use must be considered when determining whether CSR DW standards apply to a site. Future land use in the vicinity of the Site may include potable water supply thus; the drinking water exposure pathway is applicable for the Site. Therefore, DW standards identified in Schedules 6 and 10 of the CSR apply to groundwater quality at the Site.

BC Water Quality Guidelines (WQG)

Technical Guidance 15: Concentration Limits for the Protection of Aquatic Receiving Environments (TG15) states that WQGs apply to water quality in aquatic receiving environments [surface water or porewater (i.e., groundwater)] located at or beyond 10 m of the high water mark.

There are no known aquatic receiving environments located in close proximity (<500 m) to the down-gradient Site boundary. Therefore, it is not necessary to compare groundwater water quality at the Site boundary or surface water quality in the surrounding area to the WQGs. However, for comparison purposes only, WQGs are voluntarily applied to the water quality of Rico and McIvor Lakes as well as the shallow aquifer west of the groundwater flow divide and residential water at RW-98020.

4.2 Water Quality

Analytical results for all groundwater and surface water samples collected to date are presented in Tables 4.0A, 4.0B, and 4.0C (groundwater), Tables 4.1A and 4.1B (surface water), and Table 4.2 (wash plant water). Baseline surface water and groundwater quality have been evaluated based on these analytical results. A discussion of that evaluation is presented below.

4.2.1 Indicator Parameters

Analytical results, including a full list of parameter concentrations, are presented in Tables 4.0 through 4.2; however, a select list of typical water quality indicator parameters has been selected in order to focus the discussion of baseline water quality near the Site. Water quality indicator parameters were selected based on parameters that are typically elevated in construction and demolition landfill leachate as well as contaminated soils. It is important to establish baseline concentrations of this list in existing, pre-landfilling water for future comparison to water collected during and post landfill development.

The list of selected water quality indicator parameters for the Site is as follows:

- Hardness
- Total Dissolved Solids (TDS) (lab)
- Conductivity (lab)
- Chloride
- Alkalinity (total)
- Hydrogen Sulphide
- Sulphate
- Ammonia
- Boron
- Iron
- Manganese

Hardness	Caused by the increased concentrations of calcium and magnesium ions due to the waste materials and more acidic pH breaking down the native lime-rich soils
TDS	Caused by the increased amount of cations and anions in solution due to the waste materials and dissolution of salts
Conductivity	Electrical or specific conductivity increases in leachate-affected groundwater due to the increased conductive capacity of water as a result of increased dissolved ions.
Chloride	Chloride is generally abundant in municipal solid waste, however, is often found at lower concentrations in construction and demolition waste (Townsend, 2000). Chloride is formed in part by the degradation of various wastes and can be a very useful leachate indicator parameter because it is not subject to retardation processes and is therefore a conservative tracer.

Alkalinity	Alkalinity typically increases down-gradient of landfills primarily due to elevated levels of dissolved carbon dioxide in affected water (produced by the biological breakdown of organic material) causing the dissolution of carbonate from natural geologic materials within the aquifer.
Hydrogen Sulphide	Under anaerobic conditions, sulphide (as H_2S) is observed through the reduction of sulphur species. The reducing conditions resulting from the presence of buried waste favor the development of sulphide in leachate.
Sulphate	Construction and demolition waste landfills often generate elevated concentrations of sulphate in leachate due to the abundance of sulphate available from gypsum in drywall in the waste stream.
Ammonia	High concentrations of ammonia are observed when the landfill enters its anaerobic stage. In the anaerobic stage, anaerobic decomposition dominates, resulting in more ammonia than nitrate or nitrite.
Boron	Boron is a useful leachate indicator parameter as it is not subject to retardation processes and is therefore a conservative tracer.
Iron and Manganese	Concentrations typically increase in landfill-affected groundwater due to the alteration of redox conditions within the groundwater. The breakdown of dissolved organic matter within leachate consumes dissolved oxygen and related oxygen sources in groundwater and creates reducing conditions. Where conditions are reducing, naturally-occurring iron and manganese oxides within the geologic material are reduced to more soluble forms.

The parameter concentration ranges summarized in the tables below are representative of baseline water quality for assessing potential on-Site Landfill-related water quality alterations should they occur. Each of the ranges presented below includes the analytical results from the 2015 to 2017 data set (wherever water quality samples were collected).

4.2.2 Existing Groundwater Quality Results

4.2.2.1 Sand and Gravel Aquifer Groundwater Quality

Groundwater quality in the sand and gravel aquifer was characterized based on groundwater samples collected between 2015 and 2017 from monitoring wells MW6-17 and MW9-17 located along the up-gradient, northern Site boundary, monitoring wells MW1-14, MW2-14, MW2A-16, MW3-14, and MW4B-15, located in the Pit area, and from MW10-17, located near the down-gradient Site boundary.

The following table summarizes the ranges of selected water quality indicator parameter concentrations up-gradient of the Site.

Hydrogeologic Unit:	Units	Sand and Gravel Aquifer		
Location:		Upgradient	Pit Area	Downgradient
Selected Indicator Parameters:				
Hardness (dissolved)	mg/L	26.6 – 200	16.8 – 81.1	51.9
TDS (lab)	mg/L	28 – 354	44 -224	74
Conductivity (lab)	µS/cm	59 - 535	55.5 – 397	128
Chloride (dissolved)	mg/L	1 – 88	0.83 – 55	7.3
Alkalinity (total)	mg/L	28.6 – 119	15.4 – 79.4	49.7
Hydrogen Sulphide	mg/L	ND (0.002) – 0.01	ND (0.0019) – 0.029	ND (0.0019)
Sulphate (dissolved)	mg/L	2.75 – 8.47	ND (0.50) – 14.2	5.19
Ammonia-N	mg/L	0.017 – 0.034	ND (0.0050) – 0.2	0.037
Boron (dissolved)	µg/L	ND (50) – ND (50)	ND (50) – ND (50)	ND (50)
Iron (dissolved)	µg/L	ND (5.0) – ND (5.0)	ND(5.0) – 305	ND (5.0)
Manganese (dissolved)	µg/L	1.9 – 151	ND(1.0) – 24	1.25

Notes:

ND Concentration below reportable detection limit. Detection limit in brackets.

As summarized above, the concentrations ranges in groundwater samples from the sand and gravel aquifer wells are generally similar between the up-gradient (particularly MW9-17), the Pit area, and down-gradient monitoring well locations. Water quality on-Site within the sand and gravel aquifer can be generally characterized as relatively fresh with low concentrations of alkalinity, hardness (soft to moderately hard), chloride and TDS.

Some minor evidence of water quality impacts may be present in the vicinity of up-gradient well, MW6-17. Several indicator parameters were reported at slightly elevated concentrations in comparison to the remaining on-Site locations. This includes hardness, TDS (lab), conductivity (lab), chloride, and alkalinity. Continued monitoring as part of the proposed Environmental Monitoring Program[4] for the proposed Landfill is required to confirm the initial sampling results from MW6-17.

MW4A-15 is screened in the fractured bedrock underlying the sand and gravel aquifer and water quality results show similar water quality characteristics to the sand and gravel aquifer with slightly elevated TDS, sodium, and electrical conductivity.

It should be noted that PAHs and VOCs were evaluated in groundwater collected from MW4A/B-15 during the September 2015 monitoring event. All results were below reportable limits.

4.2.2.2 Shallow Aquifer Groundwater Quality

West of the Groundwater Flow Divide

As previously described, a hydraulic barrier significantly restricts the movement of groundwater and surface water between the sand and gravel aquifer in the Pit area and the properties west of the

4 The Environmental Monitoring Program is detailed in the Design, Operation, Closure Plan (GHD, 2017)

Site (including Rico Lake and the K&D property). Accordingly, the shallow aquifer to the west of this barrier is not a receptor of groundwater flow from the sand and gravel aquifer within the Site (Note it does receive infiltrating drainage from along the west property line).

Water quality in the shallow aquifer, west of the groundwater flow divide, was not analyzed as part of this characterization.

It should be noted that the residential well, RW-98020, was sampled on February 15, 2016. However, this well is completed at depth of 60 m bgs within the bedrock and does not reflect shallow aquifer water quality. The results of the RW-98020 sample are discussed in Section 4.2.5.

East of the Groundwater Flow Divide

Ground water samples were also collected from the on-site monitoring wells MW5A-15 and MW5B-15, Analytical results from MW5A-15 and MW5B-15 are representative of the groundwater flowing through the shallow aquifer along the southeastern flank of the bedrock ridge, east of the groundwater flow divide (outside of the Pit area) thus; water quality is not expected to be representative of Pit area groundwater. However, groundwater from the vicinity of MW5A-15 and MW5B-15 is inferred to flow towards the Pit area and into the sand and gravel aquifer. MW5A-15 and MW5B-15 are respectively screened within competent bedrock and within the thin overburden layer overlying bedrock.

The following table summarizes the ranges of selected water quality indicator parameter concentrations from on-Site groundwater.

Hydrogeologic Unit:		Shallow Aquifer (East of Groundwater Flow Divide)	
Location:	Units	MW5A/B-15	
Selected Indicator Parameters:		Minimum Concentration	Maximum Concentration
Hardness (dissolved)	mg/L	101	228
TDS (lab)	mg/L	166	420
Conductivity (lab)	µS/cm	280	589
Chloride (dissolved)	mg/L	2.2	20
Alkalinity (total as CaCO3)	mg/L	42	160
Hydrogen Sulphide	mg/L	ND(0.0019)	0.013
Sulphate (dissolved)	mg/L	3.32	87.5
Ammonia-N	mg/L	0.019	0.065
Boron (dissolved)	µg/L	ND(50)	100
Iron (dissolved)	µg/L	ND(5.0)	20.5
Manganese (dissolved)	µg/L	9.6	226

Notes:

ND Concentration below reportable detection limit. Detection limit in brackets.

Based on differences in stratigraphic and hydraulic elevations, groundwater likely has only a minor connection to the sand and gravel aquifer within the Pit area. The water quality results from MW5A-15 and MW5B-15 provide additional evidence of the disconnection as water quality is dissimilar between the two wells and the rest of the Site. Concentrations of most water quality

indicator parameters are higher in the samples collected from MW5A/B-15, most notably sulphate and nitrate. Elevated sulphate and nitrate concentrations are interpreted to be the result of bedrock blasting and crushing carried out in the southwest portion of Site.

MW5A/B-15 are located at elevations much higher than the proposed Landfill base. Water quality in the vicinity of MW5A/B-15 will not be receive flow from below the Pit. As such, additional investigation or monitoring of at MW5A/B-15 is not necessary following the proposed Landfill development.

It should be noted that PAHs were evaluated in groundwater collected from MW5A/B-15 during the October 2015 monitoring event. All results were below reportable limits.

4.2.3 Surface Water Quality

Surface water samples were collected from McIvor Lake (SW15-01) and Rico Lake (SW15-02) between September 2015 and April 2017.

The following table summarizes the ranges of selected water quality indicator parameter concentrations from surface water.

Location:	Units	Rico Lake (SW15-02)		McIvor Lake (SW15-01)	
Selected Indicator Parameters:		Minimum Concentration	Maximum Concentration	Minimum Concentration	Maximum Concentration
Hardness (dissolved)	mg/L	16.3	48.3	21.8	22.4
TDS (lab)	mg/L	32J	192	18	ND (51)
Conductivity (lab)	µS/cm	55.3	317	47.1	53.1
Chloride (dissolved)	mg/L	5.6	25	0.65	1.6
Alkalinity (total as CaCO3)	mg/L	14.5	105	21.2	22.5
Hydrogen Sulphide	mg/L	ND (0.0019)	ND (0.0019)	ND (0.0019)	ND (0.0019)
Sulphate (dissolved)	mg/L	0.75	8.51	2.22	3.04
Ammonia-N	mg/L	0.017	0.022	0.016	0.02
Boron (total)	µg/L	ND (50)	ND (50)	ND (50)	ND (50)
Iron (total)	µg/L	ND (10)	255	14	ND (29)
Manganese (total)	µg/L	17.7	251	1.8	25.1

Notes:

ND Concentration below reportable detection limit. Detection limit in brackets.

J The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.

Surface water quality in McIvor and Rico Lakes is similar to that observed in the sand and gravel aquifer and is characterized as being low in alkalinity, hardness, conductivity, and TDS and with low concentrations of nutrients and major ions.

McIvor and Rico Lakes are not interpreted to be receptors of groundwater flow under the area of the proposed Landfill based on the documented flow direction (Figure 2.9). However, as Rico Lake discharges into McIvor Lake and McIvor Lake recharges the sand and gravel aquifer, analytical results from McIvor and Rico Lakes are useful in characterizing water quality up-gradient of the Site.

Seasonal variation was evident in water quality at Rico Lake as concentrations of most parameters appear elevated during the October 2015 monitoring event. Continued monitoring as part of the proposed Environmental Monitoring Program for the proposed Landfill may be used to determine if this is a temporal trend or isolated occurrence. Minimal seasonal variation in water quality between spring and fall monitoring events was evident at McIvor Lake. McIvor Lake is fed by an extensive network of connected surface water bodies and is less susceptible to chemistry changes related to increased or decreased precipitation.

It should be noted that PAHs and VOCs were evaluated in surface water collected from Rico Lake and McIvor Lake during the September 2015 monitoring event and were below reportable limits.

4.2.4 Wash Plant Water Quality

The settling ponds of the wash plant on-Site are used to rinse gravel extracted from on-site sources. Water from the settling ponds infiltrates the subsurface as recharge in the Pit and joins the principle groundwater flow system on-Site. In order to determine if the wash plant is a source of impact to the sand and gravel aquifer, samples were collected from the third settling pond of the on-Site wash plant (SW16-03) on January 29, 2016 and April 6, 2017.

The following table summarizes ranges of selected water quality indicator parameter concentrations from the wash plant settling pond (SW16-03).

Location:	Units	Wash Plant Settling Pond (SW16-03)	
Selected Indicator Parameters:		Minimum Concentration	Maximum Concentration
Hardness (dissolved)	mg/L	26.8	37.8
TDS (lab)	mg/L	32	42
Conductivity (lab)	µS/cm	65.5	89.3
Chloride (dissolved)	mg/L	3.6	5.5
Alkalinity (total as CaCO3)	mg/L	23.6	33.7
Hydrogen Sulphide	mg/L	0.002J	0.008
Sulphate (dissolved)	mg/L	3.57	4.94
Ammonia-N	mg/L	0.016	0.028
Boron (total)	µg/L	ND (50)	ND (50)
Iron (total)	µg/L	11.8*	1190
Manganese (total)	µg/L	20.9*	46.3

Notes:

*	Dissolved concentration
ND	Concentration below reportable detection limit. Detection limit in brackets.
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.

Water quality indicator parameter concentrations from samples collected at the wash plant settling pond are similar to concentrations in the groundwater within the sand and gravel aquifer, with the exception of the total iron concentration measured during the April 2017 monitoring event. Total iron was elevated in the Wash Plant sample in comparison to the sand and gravel aquifer. However, the total iron concentration measured in the settling pond is not accurately comparable to the dissolved iron concentration measured in the groundwater within the sand and gravel aquifer because of the sediment present in the wash plant ponds.

Based on these results surface water from the wash plant is not a source of impact to the sand and gravel aquifer. Additional investigation or monitoring of the wash plant is not necessary.

4.2.5 Residential Groundwater Quality

In order to determine baseline residential groundwater quality, residential well, RW-98020 was sampled during the February 15, 2016 monitoring event. The results from RW-98020 are summarized in Table 4.0C.

The analytical results of that sample indicate that water quality is similar to the water quality of the on-Site shallow fractured bedrock well – MW4A-15. Results indicate fresh groundwater with slightly elevated TDS, sodium, and specific conductivity.

This residential well, and potential future wells on the lakeshore residential properties north of Gold River Highway, are not interpreted to be receptors of groundwater flow from the Site.

4.3 Water Quality as Compared to Applicable Water Quality Standards

This section evaluates groundwater and surface water quality described in Section 4.2 against applicable water quality standards as described in Section 4.1.

4.3.1 Groundwater Quality as Compared to BC CSR Standards

Groundwater analytical results compared to CSR DW standards are presented in Table 4.0A and 4.0B. Groundwater parameter concentrations were detected below CSR DW standards at all groundwater monitoring locations during all monitoring events with the exception of nitrate and nitrate/nitrite at MW5A-15 during the April 2017 monitoring event. Nitrate concentrations measured during the September and October 2015 monitoring events at MW5A-15 were below CSR DW standards and were two orders of magnitude lower than the April 2017 nitrate concentration (47 mg/L). The elevated nitrate at MW5A-15 is likely a result of the bedrock blasting and crushing activities carried out in the southwestern portion of Site. Nitrate is a common component of industrial explosives. This interpretation is consistent with the elevated sulphate concentrations noted at MW5A-15 as sulphate is also a common component of industrial explosives (Akhavan, 2011).

Comparison of groundwater parameter concentrations to CSR DW standards indicates groundwater of an overall good quality.

4.3.2 RW-98020 Water Quality as Compared to BC WQGs

Groundwater analytical results from RW-98020, located west of the groundwater flow divide, is presented in Table 4.0C. All parameters analyzed at RW-98020 were detected below the WQG for DW and FWAL.

4.3.3 Surface Water Quality as Compared to BC WQGs

Surface water analytical results from Rico Lake and McIvor Lake compared to BC WQGs is presented in Tables 4.1A and 4.1B. Surface water parameter concentrations were detected below WQG for DW and FWAL during all monitoring events with the following exceptions.

- Temperature (field) at McIvor Lake and Rico Lake (FWAL)
- Dissolved Oxygen (DO) (field) at Rico Lake (FWAL and DW)
- Dissolved Sulphide at McIvor Lake and Rico Lake (FWAL)

Field measurements of temperature are susceptible to atmospheric conditions. Field temperatures detected above WQG for FWAL could be attributed to the hot weather during the monitoring event and does not necessarily indicate poor water quality.

Sulphide concentrations were detected marginally above WQGs for FWAL at McIvor and Rico Lakes during the September 2015 monitoring event. Sulphide concentrations were detected below laboratory reportable detection limits during the two subsequent monitoring events at both lakes indicating sulphide concentrations are variable.

Comparison of surface water parameter concentrations to the BC WQG for DW and FWAL indicates surface water of an overall good quality.

4.3.4 Wash Plant Water Quality as Compared to Applicable Standards

Wash plant analytical results compared to applicable standards are presented in Table 4.2. Water from the wash plant ponds on-Site eventually infiltrates the subsurface in the Pit and joins the principle groundwater flow system on-Site. For this reason, wash plant water quality was compared to CSR DW standards. Additionally, wash plant water quality was voluntarily compared to WQG DW and FWAL for comparison purposes only.

Concentrations of sulphide, aluminum, copper and iron were above the applicable WQGs for FWAL or DW, however, were well below CSR DW standards.

5. Conclusions

This updated hydrogeology and hydrology characterization was undertaken in support of Upland's Waste Discharge Application. This Report has been prepared to satisfy the hydrogeology and hydrology characterization requirements of the Landfill Criteria Section 10.1. This Report provides information pertaining to the Site's background, the scope of characterization work completed, the physical setting of the Site, the environmental, hydrogeologic and hydrologic conditions at the Site,

and an assessment of existing water quality at the Site. The pertinent conclusions and recommendations resulting from the characterization are as follows:

1. Site geology consists of granular overburden deposits (primarily sand and gravel) overlying basaltic bedrock.
2. The top of bedrock is highly variable near the Site. A small mountain is present near the southwestern Site boundary; a ridge of bedrock extends from this small mountain along the western Site boundary towards McIvor Lake. The presence of the bedrock ridge is supported by numerous bedrock outcrops observed on-site and on adjacent properties, and by bedrock elevations in the southwest corner of the Site and the K&D property west of Site, as well as by bedrock elevations observed at boreholes and test pits in the same area.
3. Surface water bodies within 500 m of the Site include Rico Lake, McIvor Lake, and two small water courses flowing west to the southeast, south of Site. These surface water bodies are located cross-gradient or up-gradient of the proposed Landfill. Rico Lake and the two small water courses are not hydraulically connected to the principle groundwater flow system (i.e., the sand and gravel aquifer) on-Site.
4. The presence of a competent bedrock ridge creates a hydraulic divide (groundwater flow divide and watershed divide) between the Site and properties to the west. This divide prevents a hydraulic connection between the sand and gravel aquiferon-Site and the properties to the west including Rico Lake.
5. The sand and gravel aquifer is the principal groundwater flow system at the Site. Groundwater flow within the sand and gravel aquifer on-Site is to the southeast.
6. McIvor Lake recharges the sand and gravel aquifer north and northwest of the Site.
7. Based on the hydraulic gradients directed from both McIvor and Rico Lakes toward the sand and gravel aquifer beneath the Site, any flow exchange between the Site and the lakes occurs from the lakes to the Site and not from the Site to the lakes.
8. The vertical hydraulic gradient between the sand and gravel aquifer and the shallow fractured bedrock beneath the base of the Pit is upward.
9. Groundwater quality in the sand and gravel aquifer can be generally characterized as relatively fresh with low concentrations of alkalinity, hardness (soft to moderately hard), chloride, and TDS. The underlying fractured bedrock has similar water quality characteristics with slightly more elevated TDS, sodium, and electrical conductivity.
10. Surface water quality in McIvor and Rico Lakes is similar to that observed in the sand and gravel aquifer and is characterized as being low in alkalinity, hardness, conductivity, and TDS and with low concentrations of nutrients and major ions.
11. The applicable CSR standards that apply at the boundary of the Site are as follows:
    - Schedule 6 numerical Drinking Water (DW) standards
    - Schedule 10 numerical DW standards

All of Which is Respectfully Submitted,

GHD

Cassie Ragan, B.Sc.

Allan Molenhuis, B.Sc.

Steven M. Harris, M.A.Sc., P.Eng.(ON)

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
G.D. FERRARO
#25938

Gregory D. Ferraro, P.Eng.

6. References

Akhavan, J., 2011. The Chemistry of Explosives, Royal Society of Chemistry. RSC Publishing. 2011.

BC Water Resource Atlas, accessed April 2017. http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools

BC Hydro, December 2016. BC Hydro Campbell River System Water Use Plan (December 2016). https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/vancouver-island/campbell-river/jhtmon-1-terms-of-reference-2016-12-01.pdf

BC Hydro, 2016. BC Hydro Ladore Dam Reservoir Levels, accessed April 2017. https://www.bchydro.com/energy-in-bc/our_system/transmission_reservoir_data/previous_reservoir_elevations/vancouver_island/ladore_ldr.html

BC MOE, 2016. Landfill Criteria For Municipal Solid Waste, Second Edition June 2016.

BC MOE and R.H. Guthrie, 2005. Geomorphology of Vancouver Island: Extended Legends to Nine Thematic Maps.

BC MOE, 1996. Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills.

Blackmun, G.J, B.V. Lukyn, W.E. McLean and D. Ewart, 1983. Quinsam Watershed Study, Canadian Manuscript Report of Fisheries and Aquatic Sciences No, 183.

Campbell River Environmental Committee (CREC), August 31, 2016. Letter Re: Upland Excavating Ltd. Application # 107689.

GHD Ltd., May 2016. Hydrogeology and Hydrogeology Characterization Report, Upland Landfill, Campbell River, BC.

Golder Associates, 2014. Static Testing Results for Acid Rock Draining (ARD) and Metal Leaching (ML) Potential, Upland Contracting Pit #1, Campbell River, BC.

Greene, A.R., J.S. Scoates and D. Weis, 2005. Wrangellia Terrane on Vancouver Island, British Columbia: Distribution of Flood Basalts with Implications for Potential Ni Cu PGE Mineralization in Southwestern British Columbia.

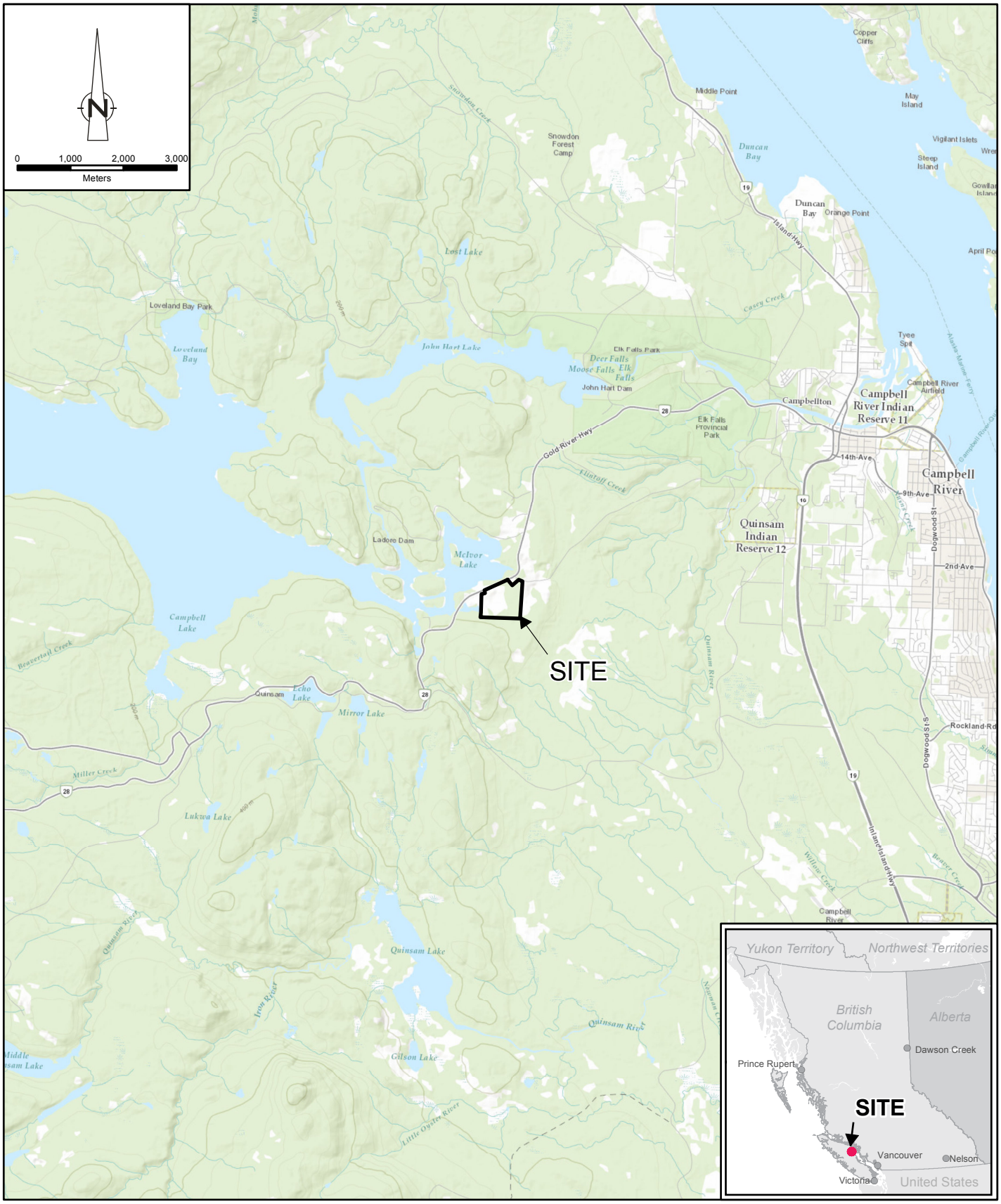
Massey, N.W.D, D.G. MacIntyre and P.J. Desjardins, 2003 Digital Map of British Columbia: Tile Nm10Southwest BC, British Columbia Ministry of Energy and Mines, Geofile 2003-4.

Massey, N.W.D, D.G. MacIntyre, P.J. Desjardines and R.T. Cooney, 2005. Digital Geology Map of British Columbia: Whole Province; B.C. Ministry of Energy and Mines, Geofile 2005-1.

McCammon, J.W., 1977. Bulletin 65: Surficial Geology and Sand and Gravel Deposits of Sunshine Coast, Powell River, and Campbell River Areas. http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/BulletinInformation/BulletinsAfter1940/Pages/Bulletin65.aspx

Townsend, G., Y. Jang and W. Weber, 2000. *Continued Research into the Characteristics of Leachate from Construction and Demolition Waste Landfills*. Report 00-04. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida.

Figures



Source: ESRI Topographic Basemap, Accessed 2017, Inset Map: ESRI Data & Maps 2008 Data Distribution Application (DDA)
Coordinate System: NAD 1983 UTM Zone 10N

UPLANDS EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

088877-03
May 23, 2017

SITE LOCATION MAP

FIGURE 1.0

GIS File: Q:\GIS\PROJECTS\88000s\88877\Layouts\009\88877-03(009)GIS-OT001.mxd

LEGEND

- 165.00 — EXISTING MAJOR CONTOURS (m AMSL)
- EXISTING MINOR CONTOUR (m AMSL)
- UPLAND EXCAVATING LTD. PROPERTY LINE
- EXISTING LAKE
- EXISTING ACCESS ROADWAY
- LIMIT OF EXCAVATION FOR PROPOSED LANDFILL
- LIMIT OF WASTE FOR PROPOSED LANDFILL

McIVOR LAKE

LOT 6
PLAN 31913

ARGONAUT ROAD

2047-R

112 OIP

137m 136-50-24

301.764m 65-58-15

GOLD RIVER HIGHWAY

LOT 6
PLAN 31913

LOT A
PLAN 30709

104 OIP

236.236m 65-58-15

OFFICE

WEIGH SCALE

SHED

SHOP

LOT A
PLAN 42515

CONCRETE STOCKPILE

ASPHALT STOCKPILE

2015-2017 PRODUCTION AREA

LOT A
PLAN 42515

STRATA LOT 1
PLAN VIS6756

K&D CONTRACTING LTD.

LOT C
PLAN 42515

244.553m 2-22-42

WASH PLANT

632m 2-35-48

PROPOSED AERATION POND

PROPOSED INFILTRATION POND

STRATA LOT 2
PLAN VIS6756

110 OIP

EXPLOSIVES SHELTER

EXPLOSIVES SHELTER

RICO LAKE

243.443m 2-22-42

2015 - 2018
PRODUCTION AREA

EXPLOSIVES SHELTER

OSIVES SHELTER

50.0m
BUFFER ZONE

APPROXIMATE LOCATION
OF PERMITTED BURN AREA

231.223m 271-28-27

105 OPP BCLS724

524.777m 271-28-27

113 OPP

NE 1/4 SEC.32 TP.2

W 1/2 OF NW 1/4 SEC. 33 TP. 2

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

0 40 80 120m

N

GHD

UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

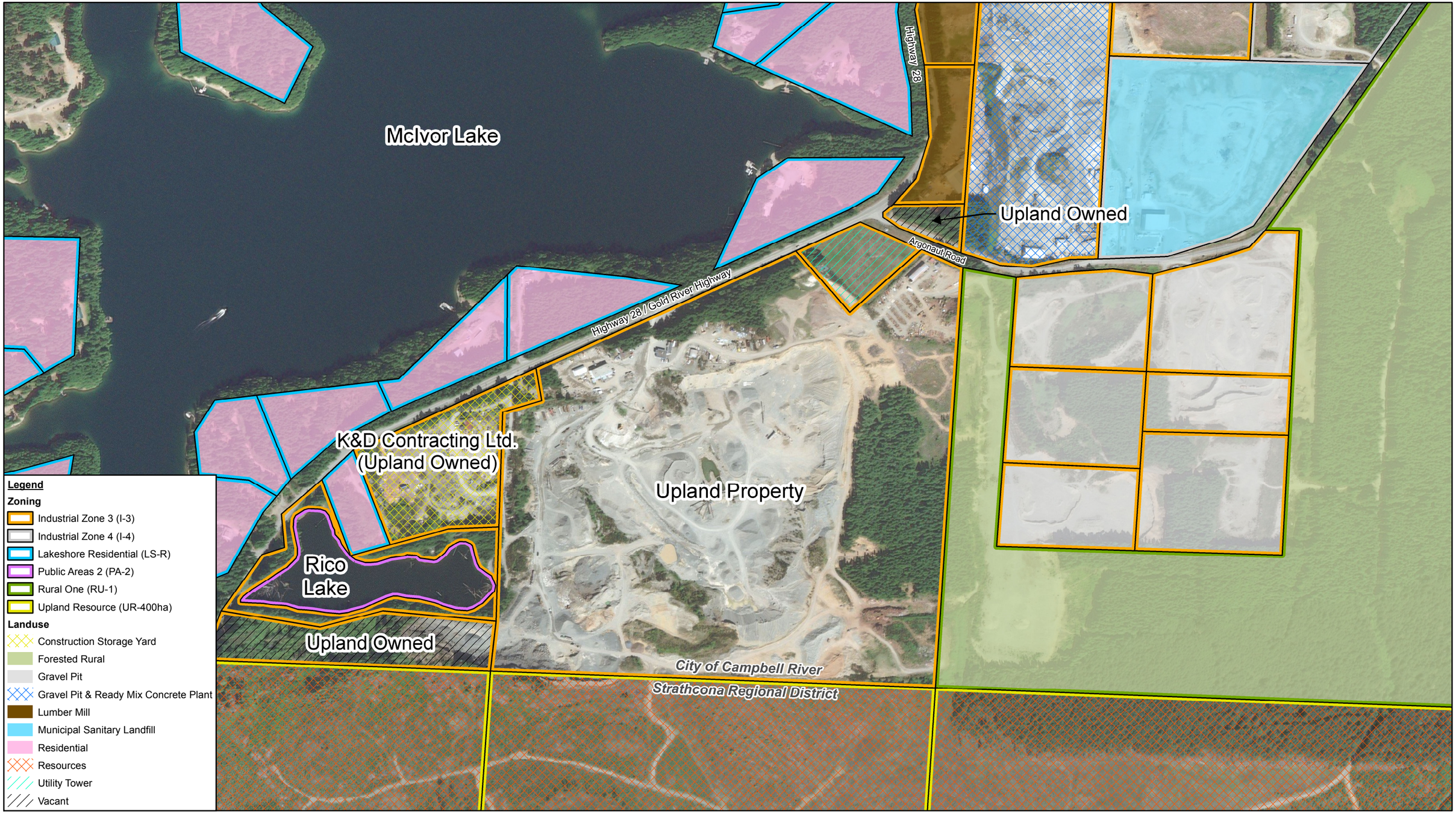
88877-03

May 23, 2017

SITE PLAN

FIGURE 1.1

CAD File: 88877-03(009)GN-WA003.DWG



Sources: CanVec Edition 1.1 © Department of Natural Resources Canada, all rights reserved; National Road Network 2.0 GeoBase; Property Parcels - City of Campbel River; Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation.

0 60 120 180
Meters

Coordinate System:
NAD 1983 UTM Zone 10N

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UPLANDS EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

088877-03
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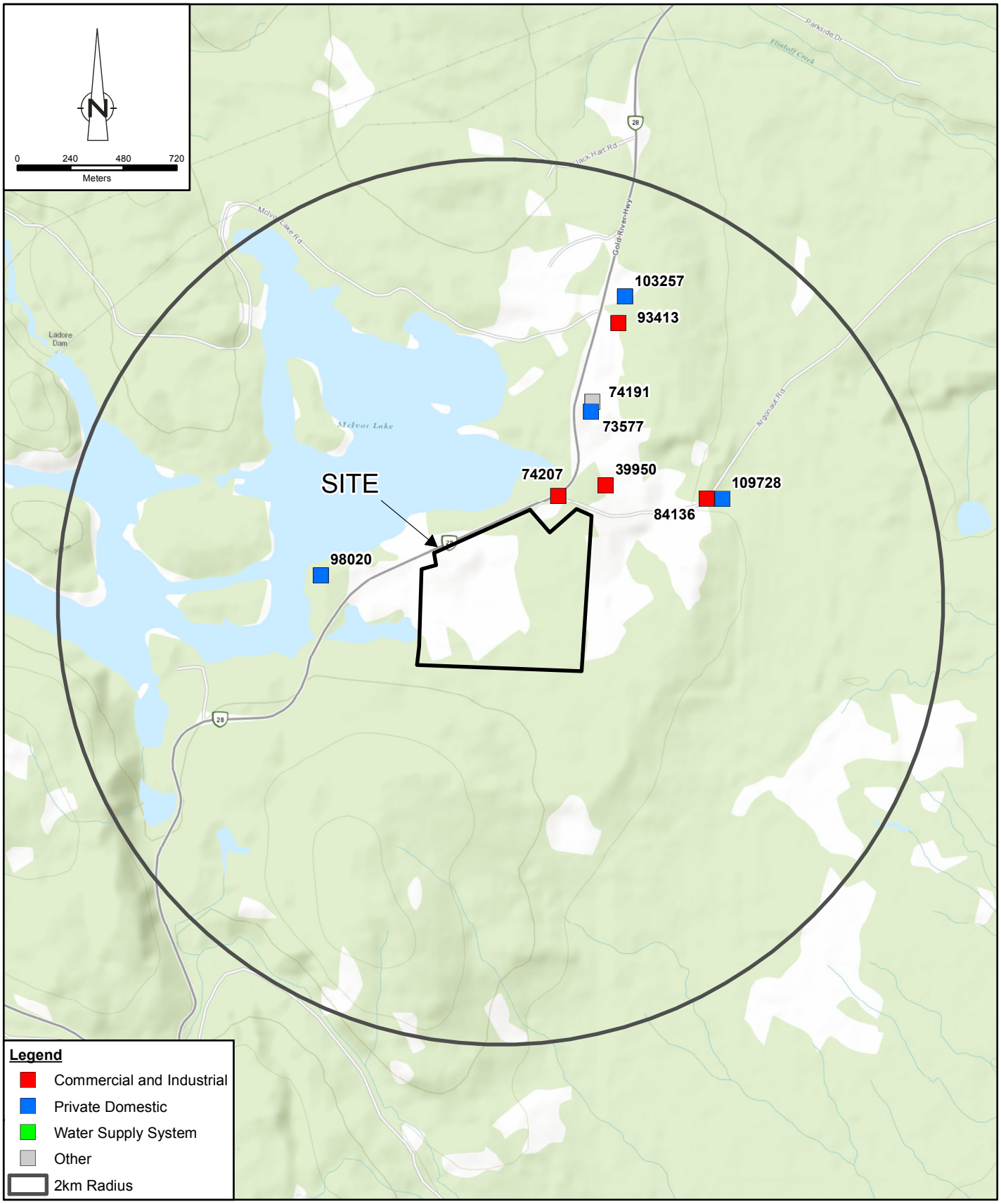
ADJACENT LAND USES

FIGURE 1.2

GIS File: Q:\GIS\PROJECTS\88000s\88877\Layouts\009\88877-03(009)GIS-OT007.mxd



Source: ESRI Topographic Basemap, Accessed 2017; British Columbia Ministry of Environment, Water Protection and Sustainability Branch, September 11, 2014
Coordinate System: NAD 1983 UTM Zone 10N

UPLANDS EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

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May 23, 2017

WELL LOCATION MAP

FIGURE 1.3

GIS File: Q:\GIS\PROJECTS\88000s\88877\Layouts\009\88877-03(009)GIS-OT003.mxd

LEGEND

- 165.00 — EXISTING MAJOR CONTOURS (m AMSL)
- EXISTING MINOR CONTOUR (m AMSL)
- UPLAND EXCAVATING LTD. PROPERTY LINE
- EXISTING LAKE
- EXISTING ACCESS ROADWAY
- LIMIT OF EXCAVATION FOR PROPOSED LANDFILL
- LIMIT OF WASTE FOR PROPOSED LANDFILL
- MW6-17 — EXISTING MONITORING WELL
- RW-98020 — RESIDENTIAL WELL
- BH1-16 — EXISTING BOREHOLE
- BH5-15 — ABANDONED BOREHOLE
- TP1-17 — TEST PIT LOCATION
- SW15-01 — SURFACE WATER SAMPLE LOCATION
- RICO GAUGE — SURFACE WATER GAUGE

McIVOR LAKE

SW15-01 (APPROXIMATELY 1 KM NORTH)

LOT A PLAN 42515

LOT 6 PLAN 31913

ARGONAUT ROAD

2047-R

112 OIP

137m 136-50-24

GOLD RIVER HIGHWAY

301.764m 65-58-15

236.236m 65-58-15

104 OIP

MW9-17

LOT A PLAN 30709

OFFICE

WEIGH SCALE

SHED

SHOP

MW8-17

MW1-14

CONCRETE STOCKPILE

ASPHALT STOCKPILE

2015-2017 PRODUCTION AREA

MW6-17

RW-98020

STRATA LOT 1 PLAN VIS6756

MW7-17

TP1-17

TP2-17

K&D CONTRACTING LTD.

LOT C PLAN 42515

TP3-17

244.553m 2-22-42

SW16-03 WASH PLANT

MW4A-15

MW4B-15

MW2-14

MW2A-16

PROPOSED AERATION POND

BH1-16

PROPOSED INFILTRATION POND

110 OIP

TP6-17

SW15-02 RICO GAUGE

TP4-17

TP7-17

243.443m 2-22-42

RICO LAKE

BH2-16

EXPLOSIVES SHELTER

EXPLOSIVES SHELTER

MW3-14

MW10-17

TP5-17

TP8-17

2015 - 2018 PRODUCTION AREA

TP9-17

EXPLOSIVES SHELTER

EXPLOSIVES SHELTER

MW5A-15

MW5B-15

BH5-15

50.0m BUFFER ZONE

APPROXIMATE LOCATION OF PERMITTED BURN AREA

832m 2-35-48

231.223m 271-28-27

105 OPP BCLS724

524.777m 271-28-27

113 OPP

NE 1/4 SEC.32 TP.2

W 1/2 OF NW 1/4 SEC. 33 TP. 2

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
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

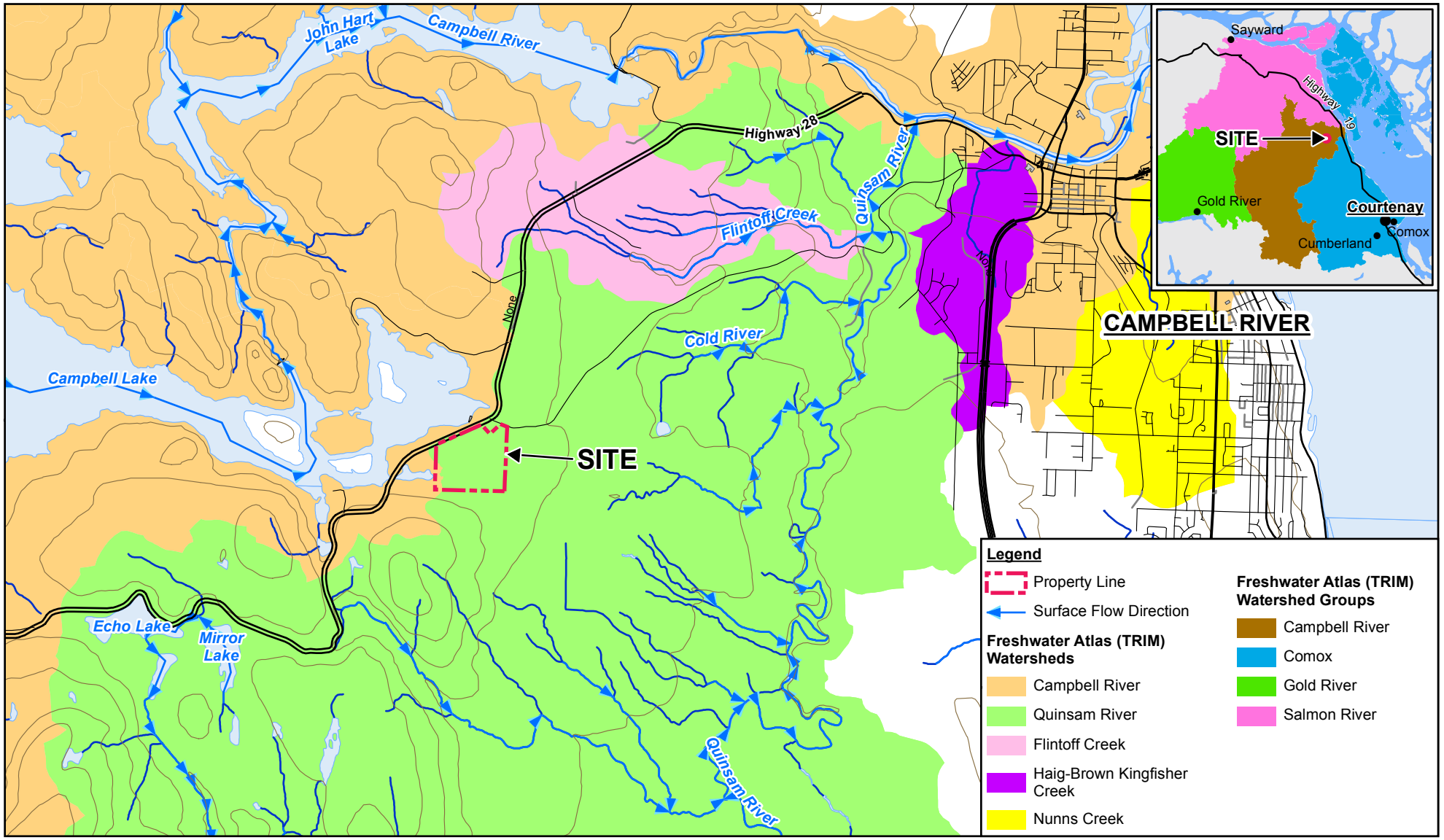
88877-03

May 23, 2017

MONITORING LOCATIONS

FIGURE 1.4

CAD File: 88877-03(009)GN-WA004.DWG



Sources: CanVec Edition 1.1 © Department of Natural Resources Canada, all rights reserved. National Road Network 2.0 GeoBase. ESRI Base Data, 2008.
Surface Flow Direction, & Watershed Boundaries (Campbell River & Quinsam River) from BC Freshwater Atlas, 2016. Freshwater Atlas derives watershed boundaries from 1:20,000 TRIM elevations. Watershed boundary through and adjacent to property line reflects field observations & on-site aerial survey completed on 2010-11-16.

0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 UTM Zone 10N

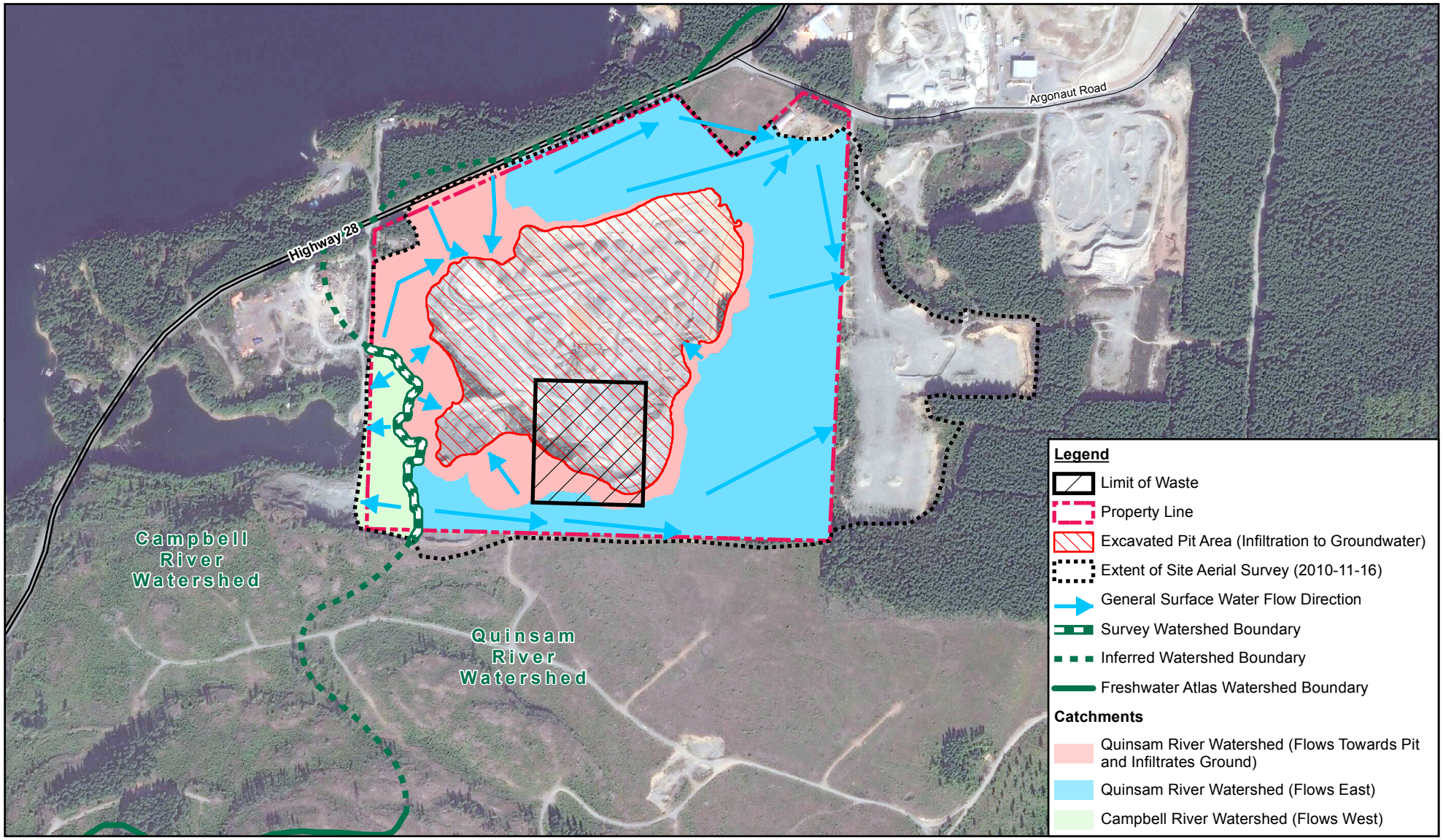
UPLANDS EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

REGIONAL WATERSHED MAP
(FRESHWATER ATLAS - TRIM ELEVATIONS)

88877-03
May 24, 2017

FIGURE 2.0A

GIS File: Q:\GIS\PROJECTS\88000s\88877\Layouts\009\88877-03(009)GIS-WA001.mxd



Sources: CanVec Edition 1.1 © Department of Natural Resources Canada, all rights reserved. National Road Network 2.0 GeoBase. Air photo: © TerraServer, captured September 12th 2014.
Watershed Boundaries (Campbell River & Quinsam River) from BC Freshwater Atlas, 2016. Freshwater Atlas derives watershed boundaries from 1:20,000 TRIM elevations. Watershed boundary through and adjacent to property line reflects field observations & on-site aerial survey completed on 2010-11-16.

0 100 200 300
Meters

Coordinate System:
NAD 1983 UTM Zone 10N

N

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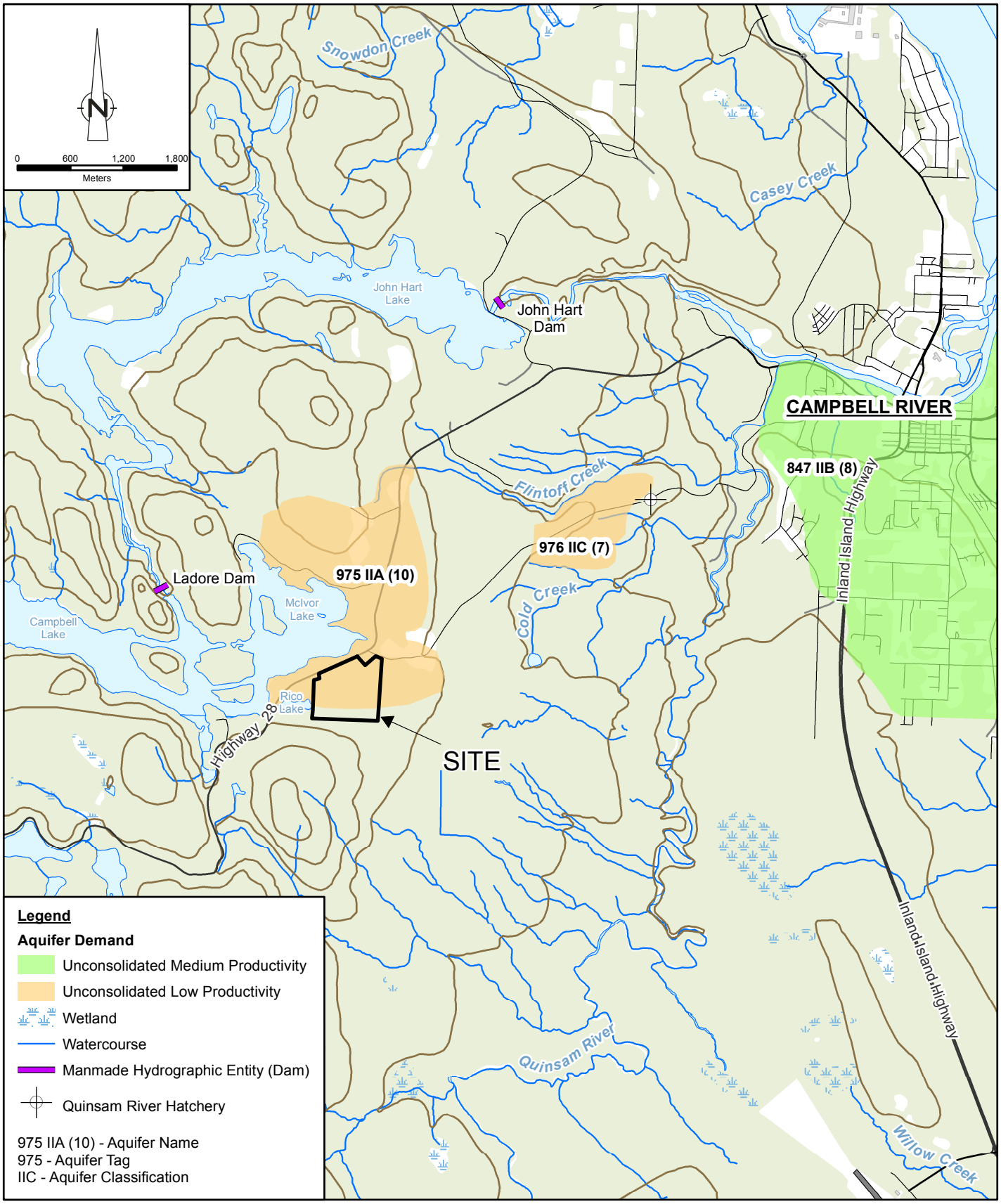
UPLANDS EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

LOCAL WATERSHED MAP (ACCORDING TO AERIAL SITE SURVEY ELEVATIONS)

88877-03
May 24, 2017

FIGURE 2.0B

GIS File: Q:\GIS\PROJECTS\88000s\88877\Layouts\009\88877-03(009)GIS-WA003.mxd



Source: CanVec Edition 1.1 © Department of Natural Resources Canada. All rights reserved. National Road Network 2.0 GeoBase
Coordinate System: NAD 1983 UTM Zone 10N

UPLANDS EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

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May 23, 2017

DRAINAGE MAP

FIGURE 2.1

GIS File: Q:\GIS\PROJECTS\88000s\88877\Layouts\009\88877-03(009)GIS-OT006.mxd

LEGEND

- 165.00 — EXISTING MAJOR CONTOURS (m AMSL)
- EXISTING MINOR CONTOUR (m AMSL)
- UPLAND EXCAVATING LTD. PROPERTY LINE
- EXISTING LAKE
- EXISTING ACCESS ROADWAY
- LIMIT OF EXCAVATION FOR PROPOSED LANDFILL
- LIMIT OF WASTE FOR PROPOSED LANDFILL
- MW6-17 — EXISTING MONITORING WELL
- RW-98020 — RESIDENTIAL WELL
- BH1-16 — EXISTING BOREHOLE
- BH5-15 — ABANDONED BOREHOLE
- SW15-01 — SURFACE WATER SAMPLE LOCATION
- RICO GAUGE — SURFACE WATER GAUGE

McIVOR LAKE

SW15-01 (APPROXIMATELY 1 KM NORTH)

LOT A
PLAN 42515

LOT 6
PLAN 31913

ARGONAUT ROAD

2047-R

112 OIP

137m 136-50-24

GOLD RIVER HIGHWAY

301.764m 65-58-15

236.230m 65-58-15

104 OIP

MW9-17

LOT A
PLAN 30709

OFFICE

WEIGH SCALE

SHED

SHOP

MW8-17

MW6-17

RW-98020

STRATA LOT 1
PLAN VIS6756

MW7-17

K&D CONTRACTING LTD.

LOT C
PLAN 42515

CONCRETE STOCKPILE

MW1-14

ASPHALT STOCKPILE

2015-2017 PRODUCTION AREA

244.553m 2-22-42

SW16-03
WASH PLANT

MW4A-15

MW4B-15

MW2-14

MW2A-16

BH1-16

PROPOSED AERATION POND

PROPOSED INFILTRATION POND

STRATA LOT 2
PLAN VIS6756

110 OIP

SW15-02

RICO GAUGE

RICO LAKE

243.443m 2-22-42

BH2-16

MW3-14

MW10-17

EXPLOSIVES SHELTER

EXPLOSIVES SHELTER

EXPLOSIVES SHELTER

EXPLOSIVES SHELTER

2015 - 2018
PRODUCTION AREA

MW5A-15

MW5B-15

BH5-15

50.0m BUFFER ZONE

APPROXIMATE LOCATION OF PERMITTED BURN AREA

832m 2-35-48

231.223m 271-28-27

105 OPP BCLS724

524.771m 271-28-27

113 OPP

NE 1/4 SEC.32 TP.2

W 1/2 OF NW 1/4 SEC. 33 TP. 2

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
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

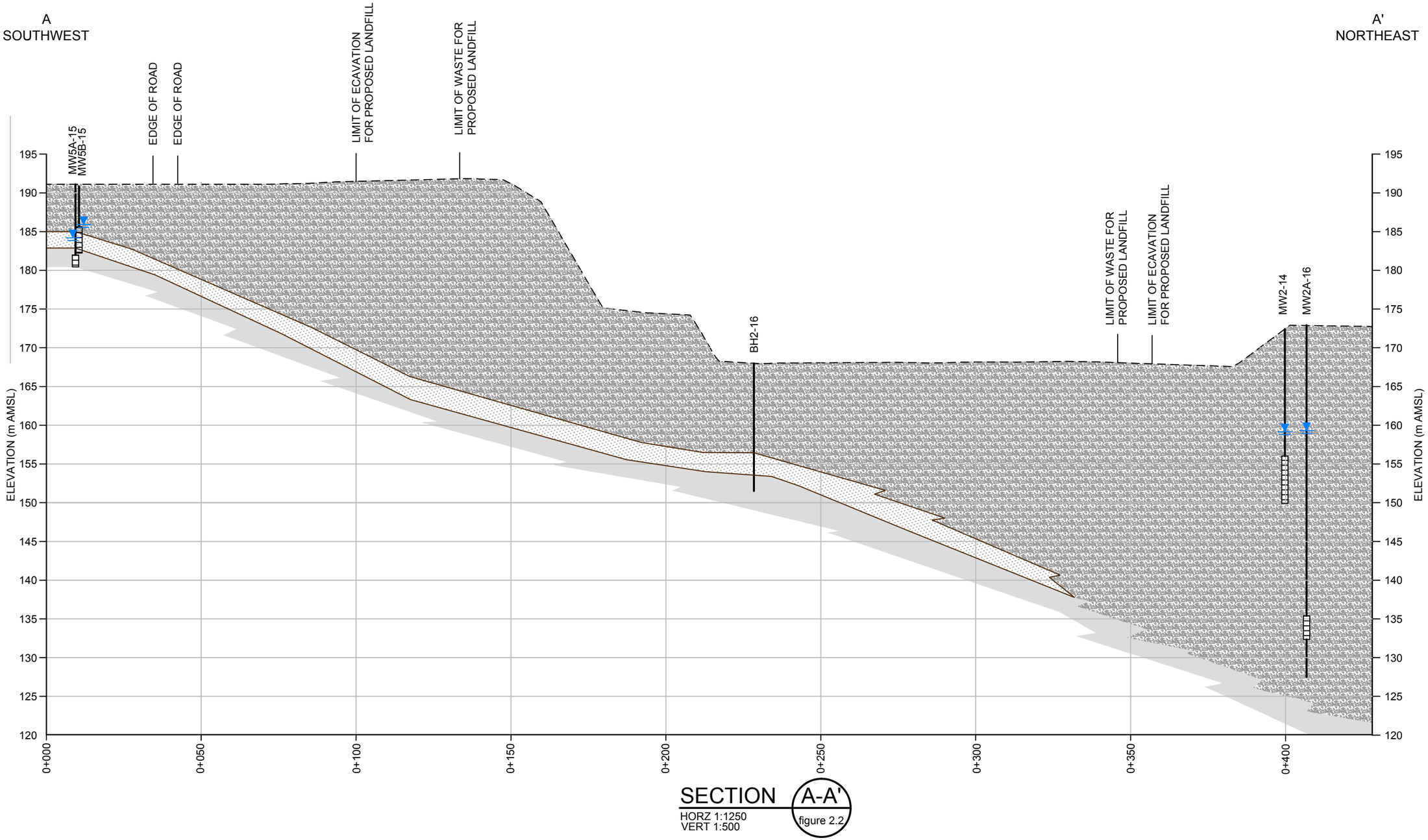
88877-03

May 23, 2017

CROSS-SECTION PLAN

FIGURE 2.2

CAD File: 88877-03(009)GN-WA005.DWG



SECTION A-A'
HORZ 1:1250
VERT 1:500
figure 2.2

LEGEND

- SAND AND GRAVEL
- SANDY SILT
- BEDROCK (BASALT)
- SCREEN INTERVAL
- WATER LEVEL (m AMSL) (APRIL 6, 2017)

UPLAND EXCVAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

88877-03
May 23, 2017

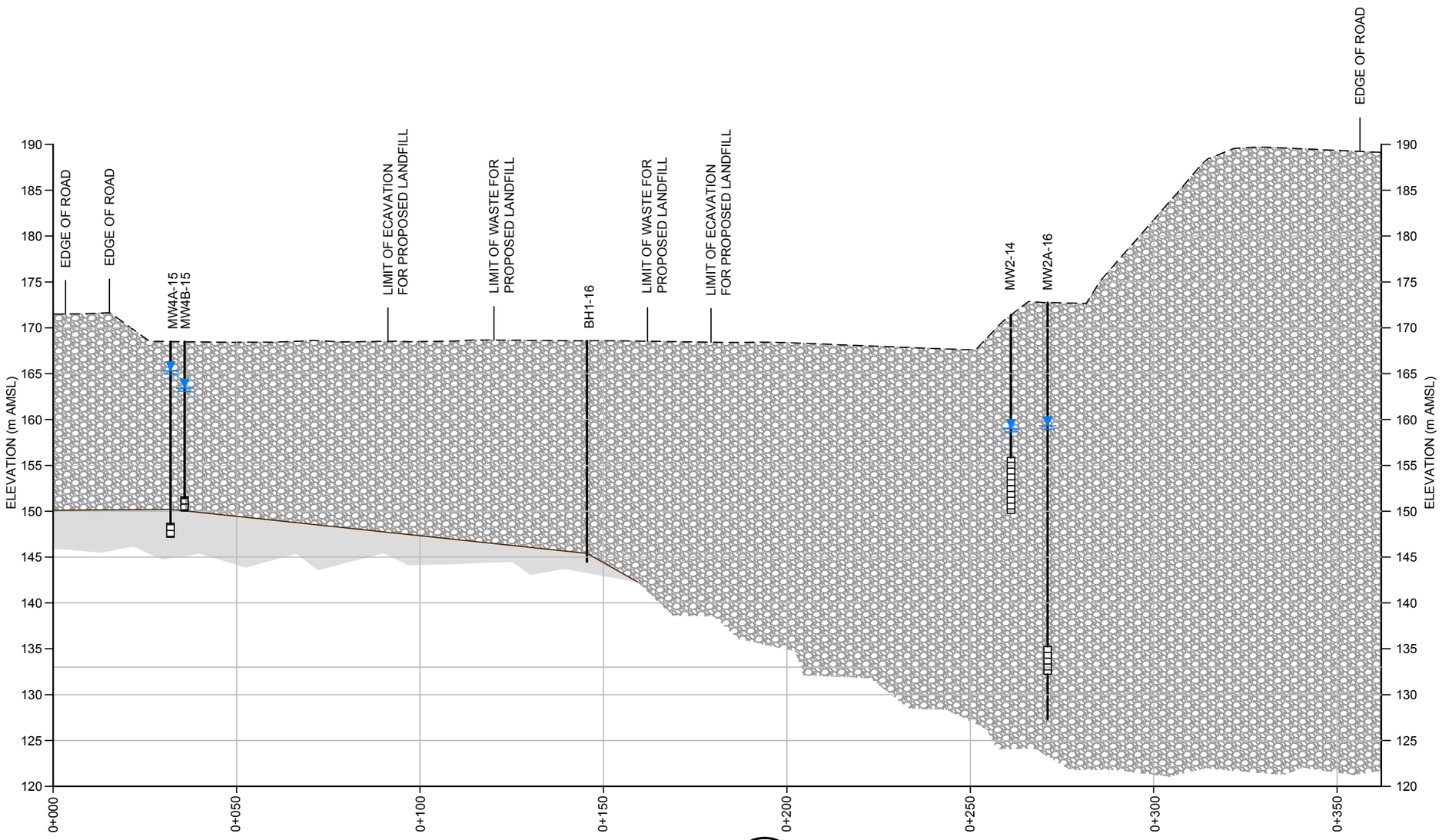
CROSS-SECTION A-A'

FIGURE 2.3

CAD File: P:\drawings\88000s\88877\88877 - REPORTS\88877-03(009)\88877-03(009)GN\88877-03(009)GN-WA006.DWG

B
WEST

B'
EAST



SECTION B-B'
HORZ 1:1250
VERT 1:500
figure 2.2

LEGEND

- SAND AND GRAVEL
- SANDY SILT
- BEDROCK (BASALT)
- SCREEN INTERVAL
- WATER LEVEL (m AMSL) (APRIL 6, 2017)

UPLAND EXCVAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

88877-03
May 23, 2017

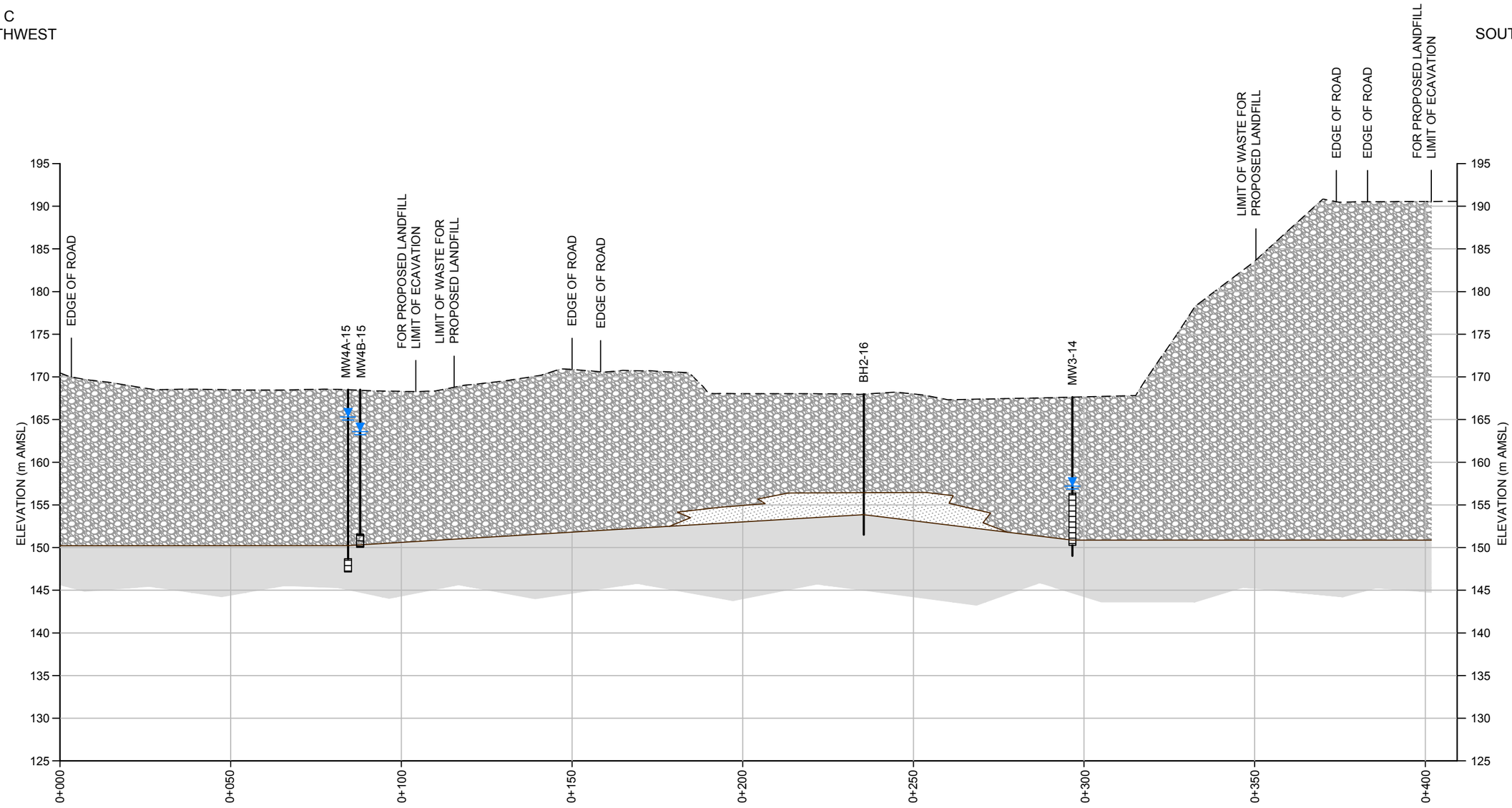
CROSS-SECTION B-B'

FIGURE 2.4

CAD File: P:\drawings\88000s\88877\88877 - REPORTS\88877-03(009)\88877-03(009)GN\88877-03(009)GN-WA006.DWG

C
NORTHWEST

C'
SOUTHEAST



SECTION C-C'

HORZ 1:1250
VERT 1:500

figure 2.2

LEGEND

- SAND AND GRAVEL
- SANDY SILT
- BEDROCK (BASALT)
- SCREEN INTERVAL
- WATER LEVEL (m AMSL) (APRIL 6, 2017)

GHD

UPLAND EXCVAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

88877-03
May 23, 2017

CROSS-SECTION C-C'

FIGURE 2.5

CAD File: P:\drawings\88000s\88877\88877 - REPORTS\88877-03(009)\88877-03(009)GN\88877-03(009)GN-WA006.DWG

D
NORTHWEST

D'
SOUTHEAST

McIVOR LAKE
GOLD RIVER HIGHWAY
MW6-17
PROPERTY BOUNDARY
EDGE OF ROAD
EDGE OF ROAD
EDGE OF ROAD
EDGE OF ROAD
MW4A-15
MW4B-15
LIMIT OF ECAVATION FOR PROPOSED LANDFILL
LIMIT OF WASTE FOR PROPOSED LANDFILL
EDGE OF ROAD
EDGE OF ROAD
BH2-16
MW3-14
LIMIT OF WASTE FOR PROPOSED LANDFILL
LIMIT OF ECAVATION FOR PROPOSED LANDFILL
EDGE OF ROAD
EDGE OF ROAD
MW10-17

ELEVATION (m AMSL)

195 190 185 180 175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100

0+000 0+050 0+100 0+150 0+200 0+250 0+300 0+350 0+400 0+450 0+500 0+550 0+600 0+650 0+700 0+750 0+800 0+850 0+900 0+950 0+1000 0+1050

SECTION D-D'

HORZ 1:3000
VERT 1:750

figure 2.2

LEGEND

- SAND AND GRAVEL
- SANDY SILT
- BEDROCK (BASALT)
- SCREEN INTERVAL
- WATER LEVEL (m AMSL) (APRIL 6, 2017)

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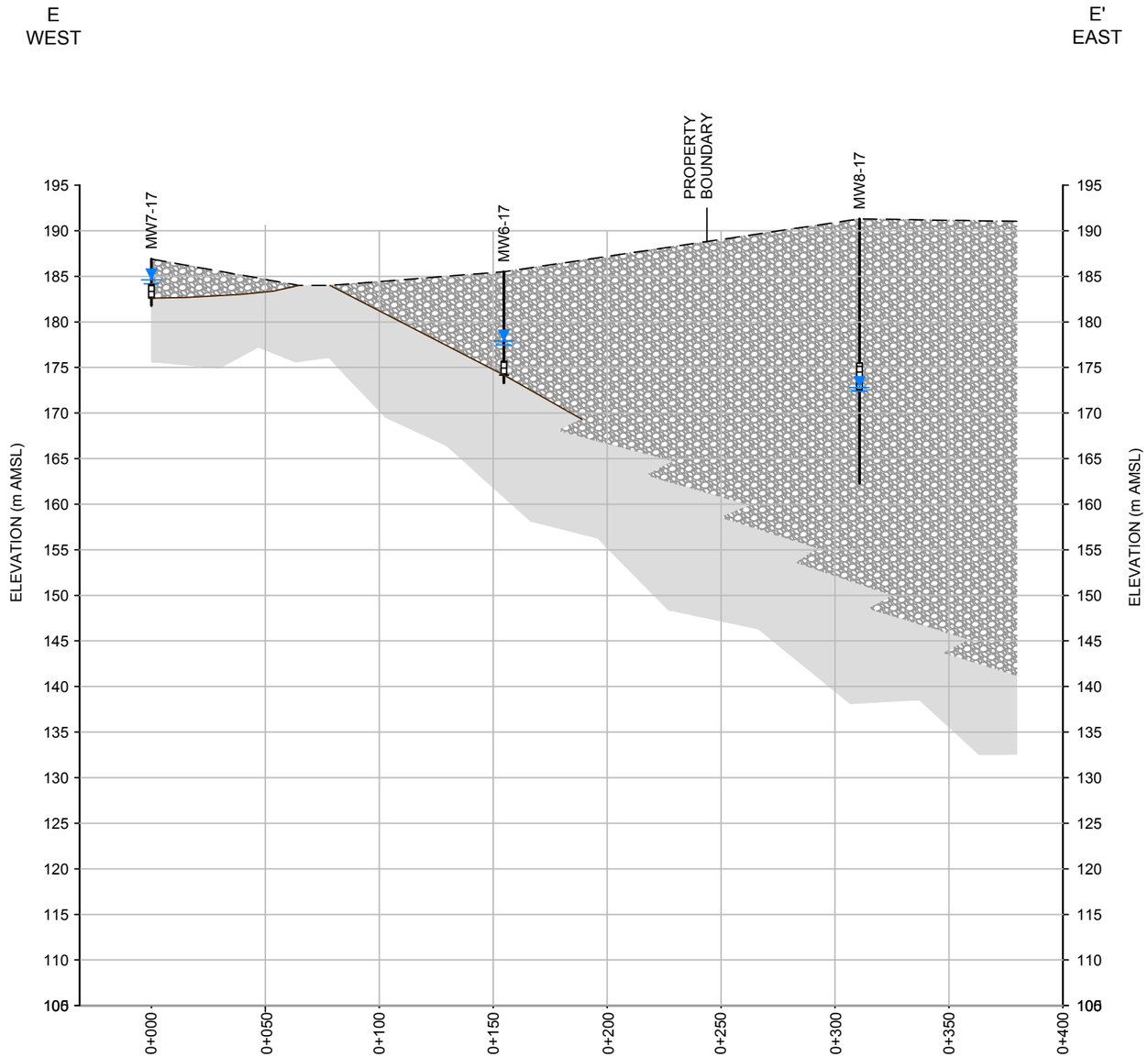
UPLAND EXCVAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

88877-03
May 23, 2017

CROSS-SECTION D-D'

FIGURE 2.6

CAD File: P:\drawings\88000s\88877\88877 - REPORTS\88877-03(009)\88877-03(009)GN\88877-03(009)GN-WA006.DWG



SECTION E-E'
HORZ 1:2400
VERT 1:600
figure 2.2

LEGEND

- SAND AND GRAVEL
- SANDY SILT
- BEDROCK (BASALT)
- SCREEN INTERVAL
- WATER LEVEL (m AMSL) (APRIL 6, 2017)

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UPLAND EXCVAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

88877-03
May 23, 2017

CROSS-SECTION E-E'

FIGURE 2.7

CAD File: P:\drawings\88000s\88877\88877 - REPORTS\88877-03(009)\88877-03(009)GN\88877-03(009)GN-WA006.DWG

LEGEND

165.00	EXISTING MAJOR CONTOURS (m AMSL)
	EXISTING MINOR CONTOUR (m AMSL)
	UPLAND EXCAVATING LTD. PROPERTY LINE
	EXISTING LAKE
	EXISTING ACCESS ROADWAY
	LIMIT OF EXCAVATION FOR PROPOSED LANDFILL
	LIMIT OF WASTE FOR PROPOSED LANDFILL
MW3-14	EXISTING MONITORING WELL
RW-98020	RESIDENTIAL WELL
BH1-16	EXISTING BOREHOLE
BH5-15	ABANDONED BOREHOLE
TP1-17	TEST PIT LOCATION
	BEDROCK OUTCROP
183.07	BEDROCK ELEVATION (m AMSL)
170	BEDROCK CONTOUR (m AMSL)
170	INFERRED BEDROCK CONTOUR (m AMSL)
*	BEDROCK NOT ENCOUNTERED DURING DRILLING. TERMINATION DEPTH USED AS MAXIMUM POSSIBLE BEDROCK ELEVATION
	APPROXIMATE LIMITS OF THE BEDROCK RIDGE

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.

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

0 40 80 120m

UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

88877-03
May 23, 2017

BEDROCK CONTOURS

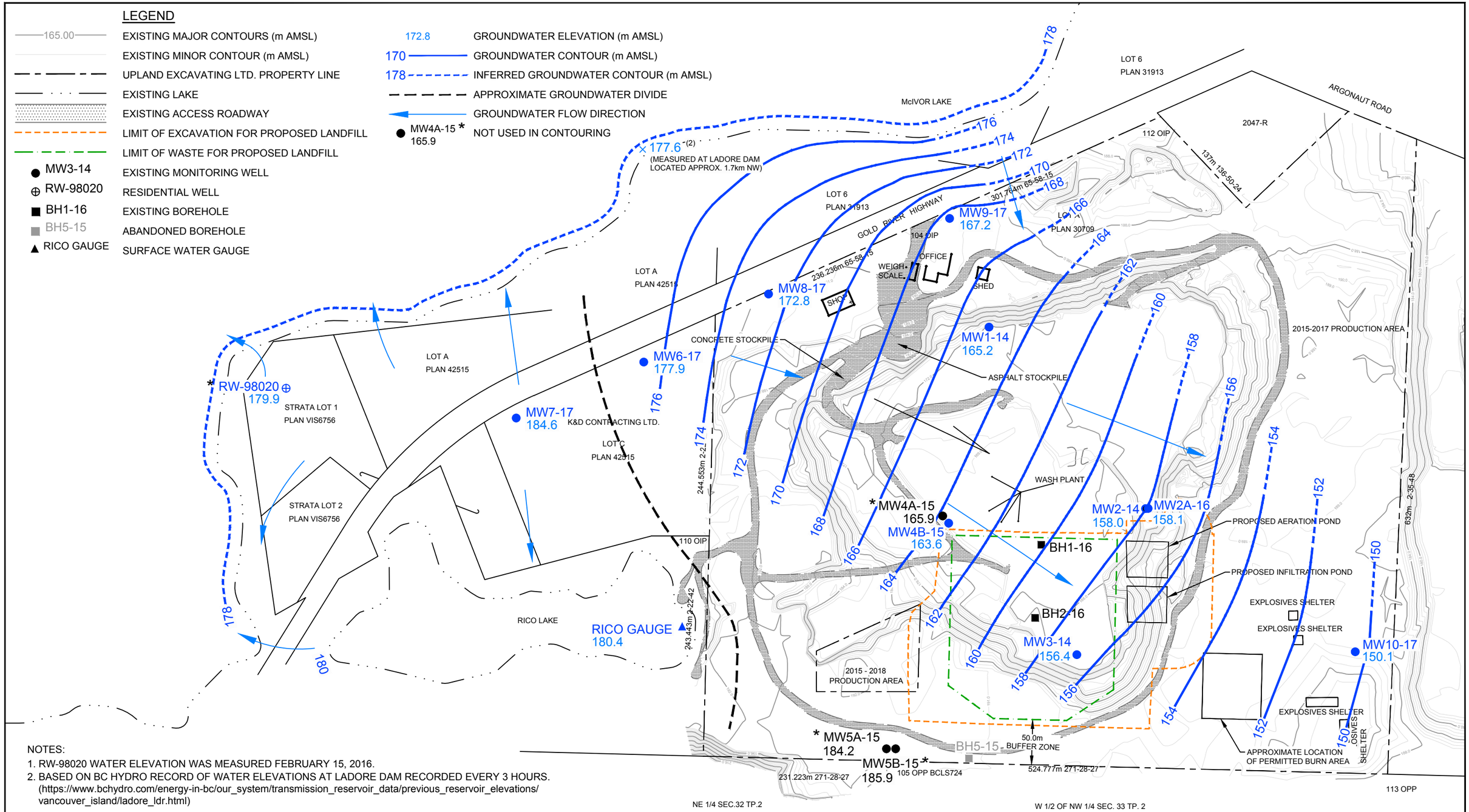
FIGURE 2.8

CAD File: 88877-03(009)GN-WA002.DWG

LEGEND

- 165.00 — EXISTING MAJOR CONTOURS (m AMSL)
- EXISTING MINOR CONTOUR (m AMSL)
- UPLAND EXCAVATING LTD. PROPERTY LINE
- EXISTING LAKE
- EXISTING ACCESS ROADWAY
- LIMIT OF EXCAVATION FOR PROPOSED LANDFILL
- LIMIT OF WASTE FOR PROPOSED LANDFILL
- MW3-14 — EXISTING MONITORING WELL
- RW-98020 — RESIDENTIAL WELL
- BH1-16 — EXISTING BOREHOLE
- BH5-15 — ABANDONED BOREHOLE
- RICO GAUGE — SURFACE WATER GAUGE

- 172.8 — GROUNDWATER ELEVATION (m AMSL)
- 170 — GROUNDWATER CONTOUR (m AMSL)
- 178 — INFERRED GROUNDWATER CONTOUR (m AMSL)
- APPROXIMATE GROUNDWATER DIVIDE
- GROUNDWATER FLOW DIRECTION
- MW4A-15 * 165.9 — NOT USED IN CONTOURING



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)

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
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

GROUNDWATER ELEVATION CONTOURS SAND & GRAVEL AQUIFER - APRIL 6, 2017

88877-03

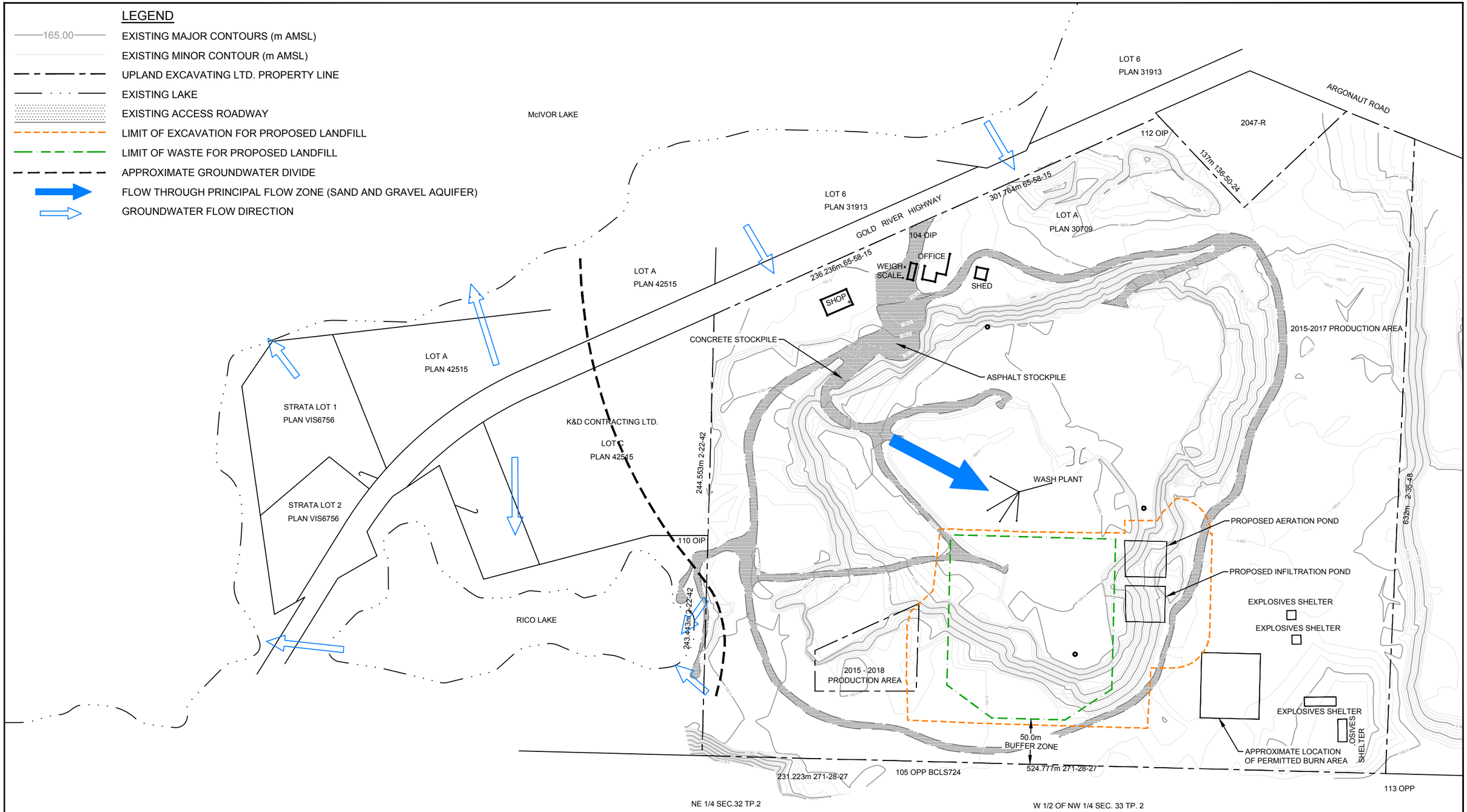
May 23, 2017

FIGURE 2.9

CAD File: 88877-03(009)GN-WA001.DWG

LEGEND

- 165.00 — EXISTING MAJOR CONTOURS (m AMSL)
- EXISTING MINOR CONTOUR (m AMSL)
- UPLAND EXCAVATING LTD. PROPERTY LINE
- EXISTING LAKE
- EXISTING ACCESS ROADWAY
- LIMIT OF EXCAVATION FOR PROPOSED LANDFILL
- LIMIT OF WASTE FOR PROPOSED LANDFILL
- APPROXIMATE GROUNDWATER DIVIDE
- FLOW THROUGH PRINCIPAL FLOW ZONE (SAND AND GRAVEL AQUIFER)
- GROUNDWATER FLOW DIRECTION



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

0 40 80 120m

UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

CONCEPTUAL GROUNDWATER FLOW MODEL - PLAN VIEW

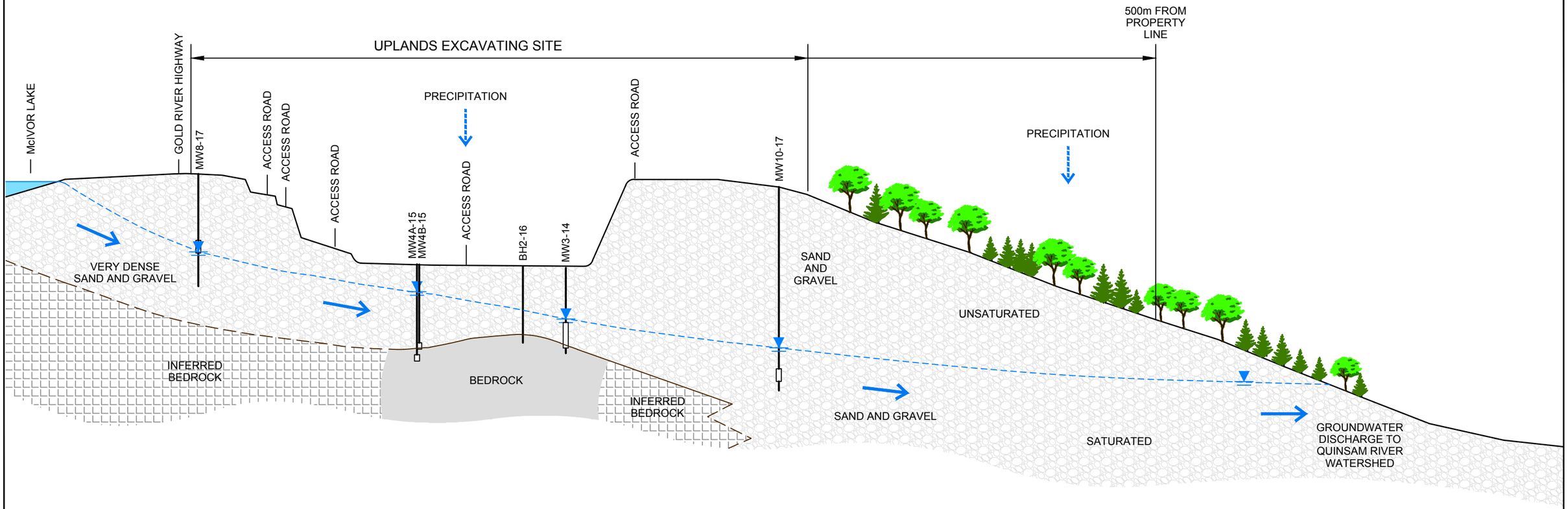
88877-03
May 24, 2017

FIGURE 3.0A

CAD File: 88877-03(009)GN-WA007.DWG

NORTH

SOUTHEAST



NOT TO SCALE

NOTES:
1. ONSITE TOPOGRAPHY IS BASED ON THE TOPOGRAPHICAL SURVEY CONDUCTED BY McELHANNEY ASSOCIATE LAND SURVEYING LTD., NOVEMBER 21, 2016.
2. OFFSITE TOPOGRAPHY HAS BEEN ESTIMATED USING ESRI TOPOGRAPHIC BASEMAP, ACCESSED 2017; BRITISH COLUMBIA MINISTRY OF ENVIRONMENT, WATER PROTECTION AND SUSTAINABILITY BRANCH, SEPTEMBER 11, 2014.
3. ALL LOCATIONS ARE APPROXIMATE AND MEANT TO DEMONSTRATE CONCEPTUAL FLOW DIRECTION.

LEGEND

- SAND AND GRAVEL
- BEDROCK
- INFERRED BEDROCK
- SURFACE WATER
- SCREEN INTERVAL
- WATER LEVEL
- FLOW DIRECTION

GHD

UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

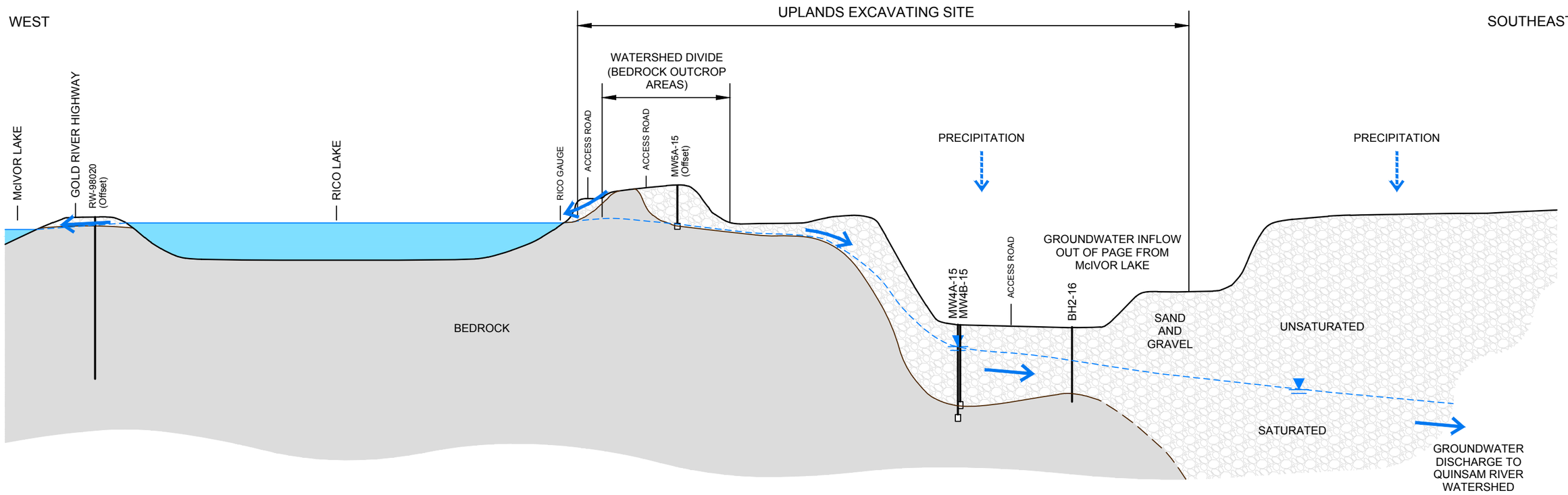
CONCEPTUAL FLOW MODEL - SCHEMATIC CROSS-SECTION - NORTH-SOUTHEAST

88877-03

May 23, 2017

FIGURE 3.0B

CAD File: 88877-03(009)GN-WA008.DWG



NOT TO SCALE

NOTES:
1. ONSITE TOPOGRAPHY IS BASED ON THE TOPOGRAPHICAL SURVEY CONDUCTED BY McELHANNEY ASSOCIATE LAND SURVEYING LTD., NOVEMBER 21, 2016.
2. OFFSITE TOPOGRAPHY HAS BEEN ESTIMATED USING ESRI TOPOGRAPHIC BASEMAP, ACCESSED 2017; BRITISH COLUMBIA MINISTRY OF ENVIRONMENT, WATER PROTECTION AND SUSTAINABILITY BRANCH, SEPTEMBER 11, 2014.
3. RICO LAKE IS APPROXIMATELY 12 M DEEP (LAKE BOTTOM IS AT 168 mAMSL) - MEASURED BY CAMPBELL RIVER ENVIRONMENTAL COMMITTEE.
4. ALL LOCATIONS ARE APPROXIMATE AND MEANT TO DEMONSTRATE CONCEPTUAL FLOW DIRECTION.

LEGEND

SAND AND GRAVEL
BEDROCK
SURFACE WATER
SCREEN INTERVAL
WATER LEVEL
FLOW DIRECTION

UPLAND EXCAVATING LTD.
PROPOSED UPLAND LANDFILL
HYDROGEOLOGIC AND HYDROLOGY CHARACTERIZATION REPORT

CONCEPTUAL FLOW MODEL - SCHEMATIC CROSS-SECTION - WEST-SOUTHEAST

88877-03
May 23, 2017

FIGURE 3.0C

CAD File: 88877-03(009)GN-WA008.DWG

Tables

Table 1.0

Well, Borehole and Test Pit Completion Details
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Monitoring ID	Installation Date	Completed By	Borehole Depth (mBGS)	Easting	Northing	2015 Reference Elevation Ground Surface (mAMSL)[2]	2015 Reference Elevation TOR (mAMSL)[2]	2017 Reference Elevation Ground Surface (mAMSL)[1]	2017 Reference Elevation TOR (mAMSL)[1]	Stick-up (m)	Screened Interval (mBGS)		Screen Interval (mAMSL)		Screen Length (m)	Well Diameter (mm)	Primary Constituent of Completed Unit
Date:																	
MW1-14	12/4/2014	RWD	10.97	330788.539	5541791.638	171.8	172.9	-	-	1.1	11.0	4.9	160.8	166.9	6.1	50.8	Sand/gravel
MW2-14	12/4/2014	RWD	21.64	330961.402	5541591.181	173.1	173.8	-	-	0.8	21.6	15.5	151.4	157.5	6.1	50.8	Sand/gravel
MW2A-16	1/27/2016	Drillwell	45.42	330964.560	5541591.419	173.1	173.9	173.1	173.9	0.8	40.5	37.5	132.6	135.6	6.1	50.8	Sand
MW3-14	12/4/2014	RWD	18.59	330885.439	5541429.793	167.6	168.6	-	-	1.0	17.4	11.3	150.2	156.3	6.1	50.8	Sand/gravel
MW4A-15	8/5/2015	Blue Max	21.33	330737.351	5541583.042	168.5	169.3	-	-	0.8	21.4	19.8	147.2	148.7	1.5	50.8	Bedrock
MW4B-15	8/5/2015	Blue Max	18.28	330743.926	5541575.024	168.4	169.3	-	-	0.9	18.3	15.2	150.1	153.2	3.0	50.8	Sand
MW5A-15	8/7/2015	Blue Max	10.66	330675.167	5541325.831	191.3	191.9	-	-	0.6	10.7	9.1	180.6	182.1	1.5	50.8	Bedrock
MW5B-15	8/7/2015	Blue Max	8.23	330685.323	5541325.831	191.3	192.0	-	-	1.7	7.9	4.9	182.4	186.4	3.0	50.8	Sand/Silt with clay
MW6-17	3/22/2017	Drillwell	11.89	330407.086	5541753.092	-	-	185.5	185.4	-0.1	11.3	9.8	174.2	175.7	1.5	50.8	Sand
MW7-17	3/14/2017	Drillwell	5.03	330266.457	5541691.359	-	-	186.9	187.5	0.7	4.3	2.7	182.6	184.1	1.5	50.8	Gravel
MW8-17	2/22/2017	Blue Max	28.96	330544.895	5541828.138	-	-	191.3	192.5	1.2	18.8	15.8	172.5	175.5	3.0	50.8	Gravel
MW9-17	3/14/2017	Drillwell	33.53	330744.892	5541911.675	-	-	190.9	191.7	0.8	33.5	30.5	157.3	160.4	3.0	50.8	Sand/gravel
MW10-17	3/27/2017	Drillwell	47.87	331208.625	5541441.665	-	-	188.2	189.1	0.8	46.3	43.2	142.0	145.0	3.0	50.8	Sand
RW-98020	5/13/2008	RWD	60.96	330012.000	5541724.000	195.6	196.9	-	-	1.3	61.0	1.8	134.7	193.8	59.1	152.4	Bedrock
BH1-16	1/27/2016	Drillwell	24.08	330846.010	5541551.180	168.41	-	-	-	-	-	-	-	-	-	-	Bedrock
BH2-16	1/28/2016	Drillwell	16.46	330839.010	5541470.180	167.83	-	-	-	-	-	-	-	-	-	-	Bedrock
BH5-15	8/6/2015	Blue Max	24.38	330765.701	5541327.331	ns	-	-	-	-	-	-	-	-	-	-	Sand/gravel
TP1-17	3/23/2017	Upland	4.57	330375.872	5541665.807	-	-	182.14	-	-	-	-	-	-	-	-	Sand with gravel
TP2-17	3/23/2017	Upland	2.44	330340.223	5541649.458	-	-	182.78	-	-	-	-	-	-	-	-	Bedrock
TP3-17	3/23/2017	Upland	5.49	330445.9487	5541608.703	-	-	182.61	-	-	-	-	-	-	-	-	Bedrock
TP4-17	3/23/2017	Upland	4.11	330476.717	5541473.401	-	-	191.23	-	-	-	-	-	-	-	-	Sand with gravel
TP5-17	3/23/2017	Upland	5.64	330467.1592	5541418.59	-	-	189.44	-	-	-	-	-	-	-	-	Silty Sand
TP6-17	3/24/2017	Upland	5.79	330407.0856	5541753.092	-	-	191.89	-	-	-	-	-	-	-	-	Sand with gravel
TP7-17	3/24/2017	Upland	6.40	330509.0192	5541457.215	-	-	191.82	-	-	-	-	-	-	-	-	Sand with gravel
TP8-17	3/24/2017	Upland	3.35	330492.9906	5541417.832	-	-	192.15	-	-	-	-	-	-	-	-	Bedrock
TP9-17	3/24/2017	Upland	0.61	330535.6659	5541369.794	-	-	191.99	-	-	-	-	-	-	-	-	Bedrock

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.
mBGS - metres below ground surface
mAMSL - metres above mean sea level
TOR - top of riser
ns - not surveyed
RWD - Red Williams Well Drilling Ltd.
Upland - Upland Excavating Ltd.
Drillwell - Drillwell Enterprises Ltd.
Blue Max - Blue Max Drilling Inc.

Table 2.0

Hydraulic Monitoring Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Monitoring ID	Borehole Depth (m BGS)	2015/2016 Reference Elevation TOR (m AMSL)[2]	2017 Reference Elevation TOR (m AMSL)[1]	Depth to Water (m BTOR)								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**	**15-Mar-17**	**6-Apr-17**	**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**		**Primary Constituent**
MW1-14	10.97	172.9	-	5.6	6.3	6.1	6.0	-	-	-	8.1	7.7	167.3	166.6	166.9	166.9	-	-	-	-	164.8	165.2	-	Sand/gravel (S&G Aquifer)
MW2-14	21.64	173.8	-	14.5	14.7	15.2	14.7	-	14.6	-	15.9	15.8	159.4	159.1	158.6	159.1	-	159.3	-	-	158.0	158.0	-	Sand/gravel (S&G Aquifer)
MW2A-16	45.42	173.9	173.9	-	-	-	14.5	-	14.5	-	15.9	15.8	-	-	-	159.3	-	159.3	-	-	158.0	158.1	-	Sand (S&G Aquifer)
MW3-14	18.59	168.6	-	12.8	12.7	12.8	11.3	-		-	12.1	12.1	155.8	155.9	155.8	157.2	-	-	-	-	156.5	156.4	-	Sand/gravel (S&G Aquifer)
MW4A-15	21.33	169.3	-	3.9	4.3	4.9	4.0	-	-	-	5.7	3.4	165.4	165.0	164.4	165.3	-	-	-	-	163.6	165.9	2.2×10^{-2}	Bedrock (S&G Aquifer)
MW4B-15	18.28	169.3	-	4.1	4.5	5.1	4.2	-	-	-	5.9	5.7	165.2	164.8	164.1	165.0	-	-	-	-	163.3	163.6	2.0×10^{-2}	Sand (S&G Aquifer)
MW5A-15	10.66	191.9	-	9.0	9.0	8.3	7.3	-	-	-	8.1	7.7	182.9	182.9	183.6	184.6	-	-	-	-	183.8	184.2	1.4×10^{-5}	Bedrock Ridge (Shallow Aquifer)
MW5B-15	8.22	192.0	-	7.1	7.2	7.0	5.4	-	-	-	7.1	6.1	184.9	184.9	185.0	186.6	-	-	-	-	184.9	185.9	-	Sand/Silt with clay (Shallow Aquifer)
MW6-17	11.28	-	185.4	-	-	-	-	-	-	-	-	7.5	-	-	-	-	-	-	-	-	-	177.9	-	Sand (S&G Aquifer)
MW7-17	4.29	-	187.5	-	-	-	-	-	-	-	3.3	2.9	-	-	-	-	-	-	-	-	184.2	184.6	-	Gravel (Shallow Aquifer)
MW8-17	18.80	-	192.5	-	-	-	-	-	-	-	19.7	19.7	-	-	-	-	-	-	-	-	172.8	172.8	-	Gravel (S&G Aquifer)
MW9-17	33.54	-	191.7	-	-	-	-	-	-	-	24.8	24.4	-	-	-	-	-	-	-	-	166.8	167.2	-	Sand/gravel (S&G Aquifer)
MW10-17	46.25	-	189.1	-	-	-	-	-	-	-	-	39.0	-	-	-	-	-	-	-	-	-	150.1	-	Sand (S&G Aquifer)
RW-98020	60.96	196.9	-	-	-	-	-	-	17.1	-	-	-	-	-	-	-	-	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*		-	-	-	-	0.88	-	0.91	0.06	0.09	-	-	-	-	181.2	-	181.2[2]	180.8[2]	180.4	180.4	-	-

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 4.0A
Groundwater Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:				MW1-14	MW1-14	MW1-14	MW2-14	MW2-14	MW2-14	MW2-14	MW2-14	MW2A-16	MW2A-16	MW3-14	MW3-14	MW3-14	MW4A-15	MW4A-15	MW4A-15	MW4A-15	MW4B-15	MW4B-15	MW4B-15
Sample ID:				W-88877-091715-TDF-07	WG-88877-05102015-TE-01	WG-88877-060417-JS-03	W-88877-091715-TDF-05	W-88877-091715-TDF-06	WG-88877-05102015-TE-02	WG-88877-150216-JS-03	WG-88877-060417-JS-04	WG-88877-150216-JS-02	WG-88877-070417-JS-09	W-88877-091715-TDF-04	WG-88877-05102015-TE-03	WG-88877-070417-JS-10	W-88877-091715-TDF-01	WG-88877-06102015-TE-08	WG-88877-06102015-TE-09	WG-88877-070417-JS-12	W-88877-091715-TDF-02	WG-88877-06102015-TE-07	WG-88877-070417-JS-11
Sample Date:		BC CSR[2] Schedule 6 DW d	BC CSR[2] Schedule 10 DW e	9/17/2015	10/5/2015	4/6/2017	9/17/2015	9/17/2015 Duplicate	10/5/2015	2/15/2016	4/6/2017	2/15/2016	4/7/2017	9/17/2015	10/5/2015	4/7/2017	9/17/2015	10/6/2015	10/6/2015 Duplicate	4/7/2017	9/17/2015	10/6/2015	4/7/2017
Parameters	**Units**																						
Field Parameters																							
Conductivity, field	mS/cm	-	-	0.101	0.099	0.103	0.18	0.18	0.163	0.181	0.143	0.092	0.072	0.251	0.157	0.104	0.221	0.323	0.323	0.436	0.238	0.283	0.402
Dissolved oxygen (DO), field	mg/L	-	-	10.5	-	9.45	10.15	10.15	-	-	8.11	-	8.42	10.04	-	9.74	2.1	0	0	6.84	1.8	0	8.99
Oxidation reduction potential (ORP), field	millivolts	-	-	234	226	217	222	222	222	192	233	140	233	194	231	255	131	89	89	285	174	92	287
pH, field	s.u.	-	-	7.45	6.79	7.47	7.52	7.52	7.05	6.86	7.34	7.39	7.39	7.4	7.06	7.21	7.97	7.7	7.7	6.33	7.83	6.95	6.35
Temperature, field	Deg C	-	-	13.75	15.68	12.95	12.5	12.5	15.74	12.31	11.63	12.42	10.99	12.98	14.34	7.65	17.61	11.5	11.5	7.95	15.52	11.92	8.02
Total dissolved solids, field (TDS)	ugL	-	-	-	0.064	0.067	-	-	0.105	0.119	0.093	0.061	0.047	-	0.101	0.068	-	0.21	0.21	0.283	-	0.184	0.262
Turbidity, field	NTU	-	-	250	91	101	NM	NM	561	OOR	71.4	OOR	63	NM	OOR	72.5	8.1	2.6	2.6	4	7.4	2.5	8.6
General Chemistry																							
%difference/ion balance	none	-	-	0.99	1	-	1	1	1.1	-	-	0.96	-	1	1.1	-	1	1	1.1	-	1.1	1.1	-
Alkalinity (as CaCO3 pH=8.3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Alkalinity, total (as CaCO3)	mg/L	-	-	39.1	40.8	41.7	76.2	77.9	71.1	-	59.4	38	34.2	37.8	40.5	40.8	91.4	72 J	102 J	81.7	66.4	15.4	79.4
Bicarbonate (as CaCO3)	mg/L	-	-	47.7	49.8	50.9	93	95	86.7	-	72.5	46.3	41.7	46.1	49.4	49.7	112	87.9 J	124 J	99.7	80.9	18.8	96.8
Biochemical oxygen demand (BOD)	mg/L	-	-	ND (6.0)	ND (6.0)	ND (6.0)	6.7	7.8	ND (6.0)	-	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)
Carbonate (as CaCO3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Chemical oxygen demand (COD)	mg/L	-	-	25	19	10	60	65	18	-	ND (10)	25	21	21	66	29	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	12	ND (10)
Chloride (dissolved)	mg/L	250	-	1.9	3.7	3.2	3.5	3	2.1	-	4.5	0.83	0.89	5.3	9.6	3.7	24	27	26	50	24	6.2	55
Conductivity	uS/cm	-	-	91.2	100	95.5	178	180	162	-	141	85.7	72.1	111	121	100	283	251 J	309 J	379	240	55.5	397
Cyanide (total)	mg/L	-	-	ND (0.00054)	-	-	ND (0.00057)	ND (0.00056)	-	-	-	ND (0.00054)	-	ND (0.00091)	-	-	0.00078	-	-	-	ND (0.00080)	-	-
Cyanide, weak acid dissociable	mg/L	-	-	-	ND (0.00050)	-	-	-	ND (0.00050)	-	-	-	-	-	ND (0.00050)	-	-	ND (0.00050)	ND (0.00050)	-	-	ND (0.00050)	-
Hardness (dissolved)	mg/L	-	-	38.7	43.3	40.8	81.1	80.5	77	-	57.9	34.9	31.8	47.6	56.1	38.2	43	23.5 J	52.2 J	54.7	21.2	16.8	54.3
Hydrogen sulfide	mg/L	0.05	-	-	0.007	ND (0.0020)	-	-	0.01	-	ND (0.0020)	-	ND (0.0020)	-	0.029	ND (0.0020)	-	ND (0.0019)	ND (0.0019)	ND (0.0020)	-	ND (0.0019)	ND (0.0020)
Hydroxide (as CaCO3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Oil and grease	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ND (1.0)	-	-	-	ND (1.0)	-	-
pH	s.u.	-	-	7.65 J	7.85 J	7.79 J	8.01 J	7.96 J	7.98 J	-	7.83 J	7.85 J	7.78 J	7.83 J	7.73 J	7.5 J	8.12 J	8 J	8.16 J	7.76 J	7.8 J	7.48 J	7.78 J
Phenolics (total)	mg/L	-	-	-	-	ND (0.0010)	-	-	-	-	ND (0.0010)	-	ND (0.0010)	-	-	ND (0.0010)	ND (0.0010)	-	-	ND (0.0010)	ND (0.0010)	-	ND (0.0010)
Phosphorus	mg/L	-	-	0.337	0.675	-	0.275 J	0.387 J	0.15	-	-	0.121	-	0.123	1.47	-	0.0162	0.0184 J	0.0108 J	-	0.02	ND (0.0050)	-
Sulfate (dissolved)	mg/L	500	-	3.17	2.31	3.42	8.22	7.72	7.24	-	7.12	4.52	3.9	5.78	5.62	3.75	6.3	6.26	6.84	13.5	5.68	ND (0.50)	14.2
Sulfide	mg/L	-	-	ND (0.0050)	0.0062	ND (0.0019)	ND (0.0050)	ND (0.0075)	0.0093	-	ND (0.0019)	ND (0.0019)	ND (0.0019)	ND (0.0050)	0.027	ND (0.0019)	ND (0.0078)	ND (0.0019)	ND (0.0019)	ND (0.0019)	ND (0.0058)	ND (0.0019)	ND (0.0019)
Total dissolved solids (TDS)	mg/L	-	-	52 J	ND (72)	52	108 J	100 J	94	-	76	60	44	78 J	ND (82)	62	146 J	158 J	204 J	206	162	ND (58)	224
Total suspended solids (TSS)	mg/L	-	-	212	717	-	330	362	174	-	-	139	-	59	882	-	ND (4.0)	ND (4.0)	ND (4.0)	-	ND (4.0)	ND (4.0)	-
Nutrients																							
Ammonia-N	mg/L	-	-	0.021	0.012	0.018	0.058 J	0.034 J	0.2	-	0.043	ND (0.0050)	0.022	0.017	0.15	0.035	0.018	0.02	0.017	0.024	0.015	0.012	0.014
Nitrate (as N)	mg/L	10	-	0.15	0.26	0.291	0.26	0.24	0.14	-	0.288	ND (0.10) J	0.053	0.49	0.54	0.748	0.9	0.77 J	1.11 J	3.52	0.9	ND (0.10)	3.5
Nitrite (as N)	mg/L	3.2	-	ND (0.10)	ND (0.10)	ND (0.0050)	ND (0.10)	ND (0.10)	ND (0.10)	-	ND (0.0050)	ND (0.10) J	ND (0.0050)	ND (0.10)	0.11	ND (0.0050)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.0050)	ND (0.10)	ND (0.10)	ND (0.0050)
Nitrite/Nitrate	mg/L	10	-	0.15	0.26	0.291	0.26	0.24	0.14	-	0.288	ND (0.10) J	0.053	0.49	0.65	0.748	0.9	0.77 J	1.11 J	3.52	0.9	ND (0.10)	3.5
Nitrogen	mg/L	-	-	0.185	0.303	0.334	0.507	0.446	0.211	-	0.324	0.095	0.101	0.584	1.18	0.723	0.928	0.99 J	1.31 J	3.37	0.95	0.154	3.3
Orthophosphate	mg/L	-	-	ND (0.10) J	ND (0.10)	0.0084	ND (0.10) J	ND (0.10) J	ND (0.10)	-	0.0273	ND (0.10) J	0.0268	ND (0.10) J	ND (0.10)	0.005	ND (0.10) J	ND (0.10)	ND (0.10)	0.0125	ND (0.10) J	ND (0.10)	0.0226
Total kjeldahl nitrogen (TKN)	mg/L	-	-	ND (0.10)	ND (0.10)	0.043	0.25	0.21	ND (0.10)	-	0.037	ND (0.10)	0.048	ND (0.10)	0.54	ND (0.020)	ND (0.10)	0.22	0.2	ND (0.10)	ND (0.10)	0.15	ND (0.10)
Dissolved Metals																							
Aluminum (dissolved)	ug/L	9500	-	9 J	6.6	6.2	9.6 J	9.8 J	6.1	-	ND (3.0)	24.2	15.9	127 J	9.4	ND (3.0)	10.6 J	16.6 J	8.5 J	ND (3.0)	9.9 J	18.4	ND (3.0)
Antimony (dissolved)	ug/L	6	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Arsenic (dissolved)	ug/L	10	-	0.13	0.15	0.14	0.18	0.18	0.17	-	0.13	0.83	0.97	0.17	ND (0.10)	ND (0.10)	0.56	0.26 J	0.42 J	0.13	0.21	0.15	ND (0.10)
Barium (dissolved)	ug/L	1000	-	ND (1.0)	ND (1.0)	ND (1.0)	1.7	1.7	1.9	-	1.6	2.8	6.3	2.9	1.7	1.1	12.4	2.1 J	15.5 J	7.2	2.8	2.1	3.3
Beryllium (dissolved)	ug/L	-	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)
Bismuth (dissolved)	ug/L	-	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Boron (dissolved)	ug/L	5000	-	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	-	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Cadmium (dissolved)	ug/L	5	-	ND (0.010)	ND (0.010)	ND (0.010)	0.014	0.011	0.017	-	ND (0.010)	ND (0.010)	ND (0.010)	0.016	0.012	ND (0.010)	0.01	0.019	0.025	ND (0.010)	0.019	0.011	0.013
Calcium (dissolved)	ug/L	-	-	12600	14200	13300	25500	25100	24300	-	18000	11100	10500	13700	16500	11000	14500	7280 J	17900 J	16800	6660	4770	16100
Chromium (dissolved)	ug/L	50	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	-	1.8	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Cobalt (dissolved)	ug/L	-	-	ND (0.50)	ND (0.50)	ND (0.20)	ND (0.50)	ND (0.50)	ND (0.50)	-	ND (0.20)	ND (0.50)	ND (0.20)	ND (0.50)	ND (0.50)	ND (0.20)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.20)	ND (0.50)	ND (0.50)	ND (0.20)
Copper (dissolved)	ug/L	1000	-	0.33	0.44	1.07	0.72	0.85	0.99	-	0.5	ND (0.20)	0.28	1.59	0.3	0.36	0.36	0.54	0.43	3.25	1.26	1.02	0.34
Iron (dissolved)	ug/L	6500	-	53.9	7.5	ND (5.0)	ND (5.0)	5.1	9.5	-	ND (5.0)	ND (5.0)	7.3	305	10.1	ND (5.0)	5.9	17.5 J	6.1 J	ND (5.0)	9.9	162	ND (5.0)
Lead (dissolved)	ug/L	10	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	0.2	ND (0.20)	ND (0.20)	ND (0.20)
Lithium (dissolved)	ug/L	-	730	ND (5.0)	ND (5.0)	ND (2.0)	ND (5.0)	ND (5.0)	ND (5.0)	-	ND (2.0)	ND (5.0)	ND (2.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (2.0)	ND (5.0)	ND (5.0)	ND (2.0)
Magnesium (dissolved)	ug/L	100000	-	1740	1870	1820	4250	4300	3920	-	3140	1730	1340	3230	3620	2590	1630	1300 J	1820 J	3080	1120	1190	3410
Manganese (dissolved)	ug/L	550	550	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	-	ND (1.0)	16.2	ND (1.0)	20	ND (1.0)	ND (1.0)	42.4	1.8 J	19.8 J	ND (1.0)	7.1	24	ND (1.0)
Mercury (dissolved)	ug/L	1	-	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	-	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Molybdenum (dissolved)	ug/L	250	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	-	ND (1.0)	8.7	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	1	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Nickel (dissolved)	ug/L	-	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	2.2	ND (1.0)
Phosphorus (dissolved)	ug/L	-	-	-	-	14	-	-	-	-	12	17	27	-	-	ND (10)	-	-	-	ND(10)	-	-	10
Potassium (dissolved)	ug/L	-	-	181	176	215	291	292	254	-	269	541	314	212	190	191	435	288 J	476 J	425	237	187	408
Selenium (dissolved)	ug/L	10	-	0.18	ND (0.10)	ND (0.10)	0.18	0.18	0.11	-	0.15	0.2	0.1	0.22	0.24	0.17	0.38	0.46	0.56	1.09	0.47	ND (0.10)	1.07
Silicon (dissolved)	ug/L	-	-	5310	5500	5670	6250	6500	6530	-	6480	4540	4350	7700	8240	6010	8010	8810	8730	8770	7940	1480	8390
Silver (dissolved)	ug/L	-	-	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	-	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Sodium (dissolved)	ug/L	200000	-	2850	2620	3550	4720	4630	4370	-	5240	2830	1040	2910	5150	5210	44200	45000	49100	57500	44800	4700	59700
Strontium (dissolved)	ug/L	-	-	21.7	23	22.9	36.6	37.8	34.7	-	29.8	23.7	14.4	22.6	31	20.6	40.5	42.3	50.8	98.7	36.3	15.1	115
Sulfur (dissolved)	ug/L	-	-	ND (3000)	ND (3000)	ND (3000)	ND (3000)	ND (3000)	ND (3000)	-	ND (3000)	5500	ND (3000)	ND (3000)	ND (3000)	ND (3000)	ND (3000)	4500	4600	4200	ND (3000)	3600	4800
Thallium (dissolved)	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.010)	ND (0.050)	ND (0.050)	ND (0.050)	-	ND (0.010)	ND (0.050)	ND (0.010)	ND (0.050)	ND (0.050)	ND (0.010)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.010)	ND (0.050)	ND (0.050)	ND (0.010)
Tin (dissolved)	ug/L	-	22000	ND (5.0)	ND (5.0)	ND (5.0)	5	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Titanium (dissolved)	ug/L	-	-	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	ND (5.0)	9.7	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Uranium (dissolved)	ug/L	20	20	ND (0.10)	0.13	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	0.12	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)
Vanadium (dissolved)	ug/L	-	-	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	6.1	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Zinc (dissolved)	ug/L	5000	-	ND (5.0)	8.7	ND (5.0)	ND (5.0)	ND (5.0)	5	-	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	7.7	ND (5.0)	ND (5.0)
Zirconium (dissolved)	ug/L	-	-	ND (0.50)	ND (0.50) J	ND (0.10)	ND (0.50)	ND (0.50)	ND (0.50) J	-	ND (0.10)	ND (0.50)	ND (0.10)	ND (0.50)	ND (0.50) J	ND (0.10)	ND (0.50)	ND (0.50) J	ND (0.50) J	ND (0.10)	ND (0.50)	ND (0.50) J	ND (0.10)

Notes:

[2]	British Columbia Contaminated Sites Regulation (CSR)
d	Exceeds BC CSR Schedule 6 Drinking Water (DW) Guideline.
e	Exceeds BC CSR Schedule 10 Drinking Water (DW) Guideline.
23.9	Exceeds guideline.
ND	Not detected at the associated reportin
NM	Not measured.
OOR	Out of range.
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.
-	Currently no Standard/Guideline.

Table 4.0A
Groundwater Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:				MW5A-15	MW5A-15	MW5A-15	MW5A-15	MW10-17	MW5B-15	MW5B-15	MW6-17	MW9-17	RW-98020
Sample ID:				W-88877-091715-TDF-03	WG-88877-05102015-TE-05	WG-88877-060417-JS-06	WG-88877-060417-JS-07 Duplicate	WG-88877-060417-JS-01	WG-88877-05102015-TE-04	WG-88877-060417-JS-08	WG-88877-060417-JS-05	WG-88877-060417-JS-02	WG-88877-150216-JS-01
Sample Date:		BC CSR[(2)] Schedule 6 DW d	BC CSR[(2)] Schedule 10 DW e	9/17/2015	10/5/2015	4/6/2017	4/6/2017	4/6/2017	10/5/2015	4/6/2017	4/6/2017	4/6/2017	2/15/2016
Parameters	**Units**												
Field Parameters													
Conductivity, field	mS/cm	-	-	0.459	0.329	0.599	0.599	0.131	0.404	0.285	0.543	0.06	0.135
Dissolved oxygen (DO), field	mg/L	-	-	6.61	-	3.09	3.09	9.97	-	7.55	5.91	9.71	6.61
Oxidation reduction potential (ORP), field	millivolts	-	-	162	177	212	212	214	229	229	235	192	333
pH, field	s.u.	-	-	7.92	7.98	7.36	7.36	7.74	7	7.16	7.16	7.84	6.58
Temperature, field	Deg C	-	-	14.12	16.61	9.26	9.26	10.39	16.99	8.61	8.66	8.21	8.05
Total dissolved solids, field (TDS)	ugL	-	-	-	0.216	0.383	0.383	0.085	0.264	0.185	0.347	0.039	0.088
Turbidity, field	NTU	-	-	500	92	630	630	24.3	36.1	950	ND ()	4.8	6.2
General Chemistry													
%difference/ion balance	none	-	-	1	1	-	-	-	0.94	-	-	-	0.98
Alkalinity (as CaCO3 pH=8.3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Alkalinity, total (as CaCO3)	mg/L	-	-	117	121	97.7	96.7	49.7	160	42	119	28.6	58.6
Bicarbonate (as CaCO3)	mg/L	-	-	143	148	119	118	60.7	195	51.3	146	34.9	71.4
Biochemical oxygen demand (BOD)	mg/L	-	-	6.5	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)
Carbonate (as CaCO3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Chemical oxygen demand (COD)	mg/L	-	-	163	26	56 J	41 J	ND (10)	ND (10)	50	94	ND (10)	ND (10)
Chloride (dissolved)	mg/L	250	-	20	15	4.6	4.6	7.3	3	2.2	88	1	2.4
Conductivity	uS/cm	-	-	487	342	589	579	128	338	280	535	59	124
Cyanide (total)	mg/L	-	-	ND (0.00119)	-	-	-	-	-	-	-	-	ND (0.00057)
Cyanide, weak acid dissociable	mg/L	-	-	-	ND (0.00050)	-	-	-	ND (0.00050)	-	-	-	-
Hardness (dissolved)	mg/L	-	-	135	126	226	228	51.9	141	101	200	26.6	53.3
Hydrogen sulfide	mg/L	0.05	-	-	0.011	0.011 J	0.007 J	ND (0.0020)	ND (0.0019)	0.013	0.01	ND (0.0020)	-
Hydroxide (as CaCO3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Oil and grease	mg/L	-	-	-	ND (1.0)	-	-	-	ND (1.0)	-	-	-	-
pH	s.u.	-	-	8.15 J	8.13 J	8.01 J	8 J	7.93 J	8.03 J	7.21 J	8.06 J	7.69 J	7.14 J
Phenolics (total)	mg/L	-	-	-	ND (0.0010)	0.0012	ND (0.0010)	ND (0.0010)	ND (0.0010)	ND (0.0010)	ND (0.0010)	ND (0.0010)	-
Phosphorus	mg/L	-	-	2.64	0.0746	-	-	-	ND (0.0050)	-	-	-	0.013
Sulfate (dissolved)	mg/L	500	-	87.5	31.4	5.79	5.85	5.19	3.32	79.7	8.47	2.75	3.72
Sulfide	mg/L	-	-	ND (0.0050)	0.01	0.01 J	0.0064 J	ND (0.0019)	ND (0.0019)	0.012	0.0093	ND (0.0019)	ND (0.0019)
Total dissolved solids (TDS)	mg/L	-	-	292 J	222	420	414	74	186	166	354	28	58
Total suspended solids (TSS)	mg/L	-	-	4540	280	-	-	-	30.5	-	-	-	13.8
Nutrients													
Ammonia-N	mg/L	-	-	0.026	0.019	0.05	0.048	0.037	0.021	0.065	0.017	0.034	ND (0.0050)
Nitrate (as N)	mg/L	10	-	ND (0.10)	0.29	47[d]	46.9[d]	0.081	1.33	1.93	0.193	ND (0.020)	0.15 J
Nitrite (as N)	mg/L	3.2	-	ND (0.10)	ND (0.10)	0.341	0.344	ND (0.0050)	ND (0.10)	ND (0.0050)	0.0457	ND (0.0050)	ND (0.10) J
Nitrite/Nitrate	mg/L	10	-	ND (0.10)	0.29	47.4[d]	47.2[d]	0.081	1.33	1.93	0.239	ND (0.020)	0.15 J
Nitrogen	mg/L	-	-	1.26	0.388	54.7	45.7	0.146	1.75	2.65	0.441	0.042	0.155
Orthophosphate	mg/L	-	-	ND (0.10) J	ND (0.10)	0.0104	0.0108	0.0335	ND (0.10)	ND (0.0050)	0.0058	0.0059	ND (0.10) J
Total kjeldahl nitrogen (TKN)	mg/L	-	-	1.26	ND (0.10)	7.3 J	ND (2.0) J	0.065	0.41	0.713	0.202	0.042	ND (0.10)
Dissolved Metals													
Aluminum (dissolved)	ug/L	9500	-	17.2 J	12	11.4 J	3.5 J	9.8	16.3	30.8	5.1	8.8	10.6
Antimony (dissolved)	ug/L	6	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Arsenic (dissolved)	ug/L	10	-	0.91	0.89	0.4	0.43	0.61	0.22	ND (0.10)	0.74	0.24	1.1
Barium (dissolved)	ug/L	1000	-	16	12.2	50.3	48.8	10.8	23.2	8.8	30.3	4.3	4.4
Beryllium (dissolved)	ug/L	-	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)
Bismuth (dissolved)	ug/L	-	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Boron (dissolved)	ug/L	5000	-	78	90	100	97	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Cadmium (dissolved)	ug/L	5	-	0.027	0.029	0.012	0.013	ND (0.010)	0.059	0.013	0.012	ND (0.010)	ND (0.010)
Calcium (dissolved)	ug/L	-	-	40000	36600	62500	63500	16500	49700	34700	56200	8980	16000
Chromium (dissolved)	ug/L	50	-	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	1.4
Cobalt (dissolved)	ug/L	-	-	0.5	ND (0.50)	0.55	0.54	ND (0.20)	0.67	0.29	0.25	ND (0.20)	ND (0.50)
Copper (dissolved)	ug/L	1000	-	1	1.59	0.79 J	0.32 J	0.43	0.97	1.14	0.85	0.39	1.71
Iron (dissolved)	ug/L	6500	-	8.2	14.7	17 J	ND (5.0) J	ND (5.0)	ND (5.0)	20.5	ND (5.0)	ND (5.0)	20.1
Lead (dissolved)	ug/L	10	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
Lithium (dissolved)	ug/L	-	730	ND (5.0)	ND (5.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (5.0)	ND (2.0)	2.4	ND (2.0)	ND (5.0)
Magnesium (dissolved)	ug/L	100000	-	8570	8480	17000	17000	2620	4010	3400	14400	1010	3230
Manganese (dissolved)	ug/L	550	550	167	163	94.9	93.1	12.5	226	9.6	151	1.9	8.5
Mercury (dissolved)	ug/L	1	-	ND (0.010)	ND (0.010)	0.061	0.066	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Molybdenum (dissolved)	ug/L	250	-	6	2.8	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	3.1	ND (1.0)	ND (1.0)
Nickel (dissolved)	ug/L	-	-	2.4	1.8	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Phosphorus (dissolved)	ug/L	-	-	-	-	15	14	15	-	ND (10)	ND (10)	ND (10)	ND (10)
Potassium (dissolved)	ug/L	-	-	1670	1280	936	928	491	489	240	1970	241	132
Selenium (dissolved)	ug/L	10	-	1.07	0.53	0.26	0.25	0.2	0.23	2.6	0.24	ND (0.10)	0.68
Silicon (dissolved)	ug/L	-	-	5010	6810	7480	7460	6300	4720	3290	10900	3110	6480
Silver (dissolved)	ug/L	-	-	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Sodium (dissolved)	ug/L	200000	-	46000	23200	15600	15400	4320	9350	11500	18000	820	5130
Strontium (dissolved)	ug/L	-	-	125	101	208	207	26.2	67.2	59.5	163	12.2	73
Sulfur (dissolved)	ug/L	-	-	24500	12500	ND (3000)	ND (3000)	ND (3000)	3000	27700	3100	ND (3000)	5500
Thallium (dissolved)	ug/L	-	-	ND (0.050)	ND (0.050)	0.013	0.012	ND (0.010)	ND (0.050)	ND (0.010)	0.014	ND (0.010)	ND (0.050)
Tin (dissolved)	ug/L	-	22000	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Titanium (dissolved)	ug/L	-	-	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Uranium (dissolved)	ug/L	20	20	1.8	0.77	0.19	0.19	ND (0.10)	0.16	ND (0.10)	0.82	ND (0.10)	ND (0.10)
Vanadium (dissolved)	ug/L	-	-	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Zinc (dissolved)	ug/L	5000	-	ND (5.0)	10.7	ND (5.0)	ND (5.0)	ND (5.0)	6.5	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Zirconium (dissolved)	ug/L	-	-	ND (0.50)	ND (0.50) J	ND (0.10)	ND (0.10)	ND (0.10)	3.67 J	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.50)

Notes:

(2)	British Columbia Contaminated Sites Regulation (CSR)
d	Exceeds BC CSR Schedule 6 Drinking Water (DW) Guideline.
e	Exceeds BC CSR Schedule 10 Drinking Water (DW) Guideline.
23.9	Exceeds guideline.
ND	Not detected at the associated reportin
NM	Not measured.
OOR	Out of range.
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.
-	Currently no Standard/Guideline.

Table 4.0B
Groundwater Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:				MW4A-15	MW4B-15	MW5A-15	MW5B-15
Sample ID:				W-88877-091715-TDF-01	W-88877-091715-TDF-02	WG-88877-05102015-TE-	WG-88877-05102015-TE-
Sample Date:		BC CSR[(2)] Schedule 6 DW [d]	BC CSR[(2)] Schedule 10 DW [e]	9/17/2015	9/17/2015	10/5/2015	10/5/2015
Parameters	**Units**						
PAH							
2-Methylnaphthalene	ug/L	-	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)
Acenaphthene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Acenaphthylene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Acridine	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Anthracene	ug/L	-	-	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Benzo(a)anthracene	ug/L	-	-	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Benzo(a)pyrene	ug/L	0.01	-	ND (0.0090)	ND (0.0090)	ND (0.0090)	ND (0.0090)
Benzo(b)fluoranthene/Benzo(j)fluoranthene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Benzo(b)pyridine (Quinoline)	ug/L	-	-	ND (0.24)	ND (0.24)	ND (0.24)	ND (0.24)
Benzo(g,h,i)perylene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Benzo(k)fluoranthene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Chrysene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Dibenz(a,h)anthracene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Fluoranthene	ug/L	-	-	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Fluorene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Indeno(1,2,3-cd)pyrene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Naphthalene	ug/L	-	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)
PAH high molecular weight	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
PAH low molecular weight	ug/L	-	-	ND (0.24)	ND (0.24)	ND (0.24)	ND (0.24)
Phenanthrene	ug/L	-	-	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)
Pyrene	ug/L	-	-	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Total PAH	ug/L	-	-	ND (0.24)	ND (0.24)	ND (0.24)	ND (0.24)
Petroleum Products							
Extractable Petroleum Hydrocarbons (C10-C19)	mg/L	5	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
Extractable Petroleum Hydrocarbons (C19-C32)	mg/L	-	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
HEPH (C19-C32 less PAH)	mg/L	-	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
LEPH (C10-C19 less PAH)	mg/L	-	-	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
Total Petroleum Hydrocarbons VPH (C6-C10)LessBTE)	mg/L	-	-	ND (0.3)	ND (0.3)	-	-
Total Petroleum Hydrocarbons VH (C6-C10)	mg/L	15	-	ND (0.3)	ND (0.3)	-	-
Volatile Organic Compounds							
1,1,1,2-Tetrachloroethane	ug/L	-	26	ND (0.50)	ND (0.50)	-	-
1,1,1-Trichloroethane	ug/L	-	10000	ND (0.50)	ND (0.50)	-	-
1,1,2,2-Tetrachloroethane	ug/L	-	3.4	ND (0.50)	ND (0.50)	-	-
1,1,2-Trichloroethane	ug/L	-	12	ND (0.50)	ND (0.50)	-	-
1,1-Dichloroethane	ug/L	-	3700	ND (0.50)	ND (0.50)	-	-
1,1-Dichloroethene	ug/L	14	-	ND (0.50)	ND (0.50)	-	-
1,2,3-Trichlorobenzene	ug/L	-	-	ND (2.0)	ND (2.0)	-	-
1,2,4-Trichlorobenzene	ug/L	-	-	ND (2.0)	ND (2.0)	-	-
1,2-Dibromoethane (Ethylene dibromide)	ug/L	-	0.34	ND (0.20)	ND (0.20)	-	-
1,2-Dichlorobenzene	ug/L	3	-	ND (0.50)	ND (0.50)	-	-
1,2-Dichloroethane	ug/L	5	-	ND (0.50)	ND (0.50)	-	-
1,2-Dichloropropane	ug/L	-	9.9	ND (0.50)	ND (0.50)	-	-
1,3-Butadiene	ug/L	-	6.1	ND (5.0)	ND (5.0)	-	-
1,3-Dichlorobenzene	ug/L	-	-	ND (0.50)	ND (0.50)	-	-
1,4-Dichlorobenzene	ug/L	1	-	ND (0.50)	ND (0.50)	-	-
Benzene	ug/L	5	-	ND (0.40)	ND (0.40)	-	-
Bromobenzene	ug/L	-	730	ND (2.0)	ND (2.0)	-	-
Bromodichloromethane	ug/L	16	16	ND (1.0)	ND (1.0)	-	-
Bromoform	ug/L	100	100	ND (1.0)	ND (1.0)	-	-
Bromomethane (Methyl bromide)	ug/L	-	51	ND (1.0)	ND (1.0)	-	-
Carbon tetrachloride	ug/L	5	-	ND (0.50)	ND (0.50)	-	-
Chlorobenzene	ug/L	30	-	ND (0.50)	ND (0.50)	-	-
Chloroethane	ug/L	-	46	ND (1.0)	ND (1.0)	-	-
Chloroform (Trichloromethane)	ug/L	100	-	ND (1.0)	ND (1.0)	-	-
Chloromethane (Methyl chloride)	ug/L	-	950	ND (1.0)	ND (1.0)	-	-
cis-1,2-Dichloroethene	ug/L	-	370	ND (1.0)	ND (1.0)	-	-
cis-1,3-Dichloropropene	ug/L	-	-	ND (1.0)	ND (1.0)	-	-
Dibromochloromethane	ug/L	100	100	ND (1.0)	ND (1.0)	-	-
Dibromomethane	ug/L	-	370	ND (0.90)	ND (0.90)	-	-
Dichlorodifluoromethane (CFC-12)	ug/L	-	7300	ND (2.0)	ND (2.0)	-	-
Ethylbenzene	ug/L	2.4	-	ND (0.40)	ND (0.40)	-	-
Hexachlorobutadiene	ug/L	-	8.6	ND (0.50)	ND (0.50)	-	-
m&p-Xylenes	ug/L	-	-	ND (0.40)	ND (0.40)	-	-
Methyl tert butyl ether (MTBE)	ug/L	15	15	ND (4.0)	ND (4.0)	-	-
Methylene chloride	ug/L	50	-	ND (2.0)	ND (2.0)	-	-
o-Xylene	ug/L	-	-	ND (0.40)	ND (0.40)	-	-
Styrene	ug/L	-	-	ND (0.50)	ND (0.50)	-	-
Tetrachloroethene	ug/L	30	-	ND (0.50)	ND (0.50)	-	-
Toluene	ug/L	24	-	ND (0.40)	ND (0.40)	-	-
trans-1,2-Dichloroethene	ug/L	-	730	ND (1.0)	ND (1.0)	-	-
trans-1,3-Dichloropropene	ug/L	-	-	ND (1.0)	ND (1.0)	-	-
Trichloroethene	ug/L	5	-	ND (0.50)	ND (0.50)	-	-
Trichlorofluoromethane (CFC-11)	ug/L	-	11000	ND (4.0)	ND (4.0)	-	-
Trifluorotrichloroethane (CFC-113)	ug/L	-	1000000	ND (2.0)	ND (2.0)	-	-
Vinyl chloride	ug/L	2	2	ND (0.50)	ND (0.50)	-	-
Xylenes (total)	ug/L	300	-	ND (0.40)	ND (0.40)	-	-

Notes:

[(2)]	Bristish Columbia Contaminated Sites Regulation (CSR)
[d]	Exceeds BC CSR Schedule 6 Drinking Water (DW) Guideline.
[e]	Exceeds BC CSR Schedule 10 Drinking Water (DW) Guideline.
23.9	Exceeds guideline.
ND	Not detected at the associated reporting limit.
NM	Not measured.
OOR	Out of range.
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.
-	Currently no Standard/Guideline.

Table 4.0C
Groundwater Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:				**RW-98020**
Sample ID:				**WG-88877-150216-JS-01**
Sample Date:		**BC WQG[(1)]**	**BC WQG[(1)]**	**2/15/2016**
Parameters	**Units**	**FWAL a**	**DW b**	
Field Parameters				
Conductivity, field	mS/cm	-	-	0.135
Dissolved oxygen (DO), field	mg/L	>5	-	6.61
Oxidation reduction potential (ORP), field	millivolts	-	-	333
pH, field	s.u.	6.5-9.0	6.5-8.5	6.58
Temperature, field	Deg C	18 (12 spring/fall) (c)	15	8.05
Total dissolved solids, field (TDS)	ugL	-	-	0.088
Turbidity, field	NTU	(c)	(c)	6.2
General Chemistry				
%difference/ion balance	none	-	-	0.98
Alkalinity (as CaCO3 pH=8.3)	mg/L	-	-	ND (0.50)
Alkalinity, total (as CaCO3)	mg/L	-	-	58.6
Bicarbonate (as CaCO3)	mg/L	-	-	71.4
Biochemical oxygen demand (BOD)	mg/L	-	-	ND (6.0)
Carbonate (as CaCO3)	mg/L	-	-	ND (0.50)
Chemical oxygen demand (COD)	mg/L	-	-	ND (10)
Chloride (dissolved)	mg/L	150	250	2.4
Conductivity	uS/cm	-	-	124
Cyanide (total)	mg/L	-	-	ND (0.00057)
Cyanide, weak acid dissociable	mg/L	0.005	-	-
Hardness (dissolved)	mg/L	-	-	53.3
Hydrogen sulfide	mg/L	-	-	-
Hydroxide (as CaCO3)	mg/L	-	-	ND (0.50)
Oil and grease	mg/L	-	-	-
pH	s.u.	6.5-9.0	6.5-8.5	7.14 J
Phenolics (total)	mg/L	0.002	-	-
Phosphorus	mg/L	-	-	0.013
Sulfate (dissolved)	mg/L	[b]	500	3.72
Hardness < 30	mg/L	128	-	3.72
Hardness > 30 - 75	mg/L	218	-	-
Hardness > 75 - 180	mg/L	309	-	-
Hardness > 250	mg/L	[b] TBD	-	-
Sulfide	mg/L	0.002 w	-	ND (0.0019)
Total dissolved solids (TDS)	mg/L	-	500 (*)	58
Total suspended solids (TSS)	mg/L	(c)	-	13.8
Nutrients				
Ammonia-N	mg/L	[d]	-	ND (0.0050)
Varies with pH and Temperature	mg/L	-	-	-
pH < 7.0	mg/L	-	-	ND (0.0050)
pH 7.0 - < 7.5	mg/L	-	-	-
pH 7.5 - < 8.0	mg/L	-	-	-
Nitrate (as N)	mg/L	3	10	0.15 J
Nitrite (as N)	mg/L	[c]	1	ND (0.10) J
Chloride < 2 mg/L	mg/L	0.02	-	-
Chloride 2 - < 4 mg/L	mg/L	0.04	-	ND (0.10) J
Chloride 4 - < 6 mg/L	mg/L	0.06	-	-
Choride 6 - < 8 mg/L	mg/L	0.08	-	-
Chloride 8 - < 10 mg/L	mg/L	0.10	-	-
Chloride >= 10 mg/L	mg/L	0.20	-	-
Nitrite/Nitrate	mg/L	-	-	0.15 J
Nitrogen	mg/L	-	-	0.155
Orthophosphate	mg/L	-	-	ND (0.10) J
Total kjeldahl nitrogen (TKN)	mg/L	-	-	ND (0.10)
Dissolved Metals				
Aluminum (dissolved)	ug/L	[a]	200	10.6
Antimony (dissolved)	ug/L	2 w	14 w	ND (0.50)
Arsenic (dissolved)	ug/L	5	25	1.1
Barium (dissolved)	ug/L	1000 w	1000	4.4
Beryllium (dissolved)	ug/L	0.13 w	4 w	ND (0.10)
Bismuth (dissolved)	ug/L	-	-	ND (1.0)
Boron (dissolved)	ug/L	1200	5000	ND (50)
Cadmium (dissolved)	ug/L	[b]	5	ND (0.010)
Hardness < = 30	ug/L	-	-	-
Hardness 3.4 - 285 (calculated[b])	ug/L	[b]	-	ND (0.010)
Hardness 30 - < 90	ug/L	-	-	ND (0.010)
Hardness 90 - < 150	ug/L	-	-	-
Hardness 450 - < 500 [bx]	ug/L	-	-	-
Calcium (dissolved)	ug/L	-	-	16000
Chromium (dissolved)	ug/L	-	50	1.4
Cobalt (dissolved)	ug/L	4	-	ND (0.50)
Copper (dissolved)	ug/L	[b]	500	1.71
Hardness < 50	ug/L	2	-	-
Hardness 50 - < 75	ug/L	-	-	1.71
Hardness 75 - < 100	ug/L	-	-	-
Hardness 125 - < 150	ug/L	-	-	-
Hardness >= 50 (calculated[c])	ug/L	[b]	-	-
Hardness >= 200	ug/L	-	-	-
Iron (dissolved)	ug/L	350	-	20.1
Lead (dissolved)	ug/L	[b]	50	ND (0.20)
Hardness < 50	ug/L	-	-	-
Hardness 50 - < 100	ug/L	-	-	ND (0.20)
Hardness 100 - < 200	ug/L	-	-	-
Hardness dependent (calculated[d])	ug/L	[b]	-	-
Hardness >= 300	ug/L	-	-	-
Lithium (dissolved)	ug/L	14 w	-	ND (5.0)
Magnesium (dissolved)	ug/L	-	-	3230
Manganese (dissolved)	ug/L	-	-	8.5
Hardness dependent (calculated[e])	ug/L	[b]	50 (*)	8.5
Mercury (dissolved)	ug/L	0.02	1	ND (0.010)
Molybdenum (dissolved)	ug/L	1000	250	ND (1.0)
Nickel (dissolved)	ug/L	[b]	-	ND (1.0)
Hardness < 60	ug/L	25	-	ND (1.0)
Hardness 60 - < 120	ug/L	65	-	-
Hardness 120 - < 180	ug/L	110	-	-
Hardness >= 180	ug/L	150	-	-
Phosphorus (dissolved)	ug/L	-	-	ND (10)
Potassium (dissolved)	ug/L	-	-	132
Selenium (dissolved)	ug/L	2	10	0.68
Silicon (dissolved)	ug/L	-	-	6480
Silver (dissolved)	ug/L	[b]	-	ND (0.020)
Hardness < 100	ug/L	0.05	-	ND (0.020)
Hardness >= 100	ug/L	1.5	-	-
Sodium (dissolved)	ug/L	-	200000	5130
Strontium (dissolved)	ug/L	-	-	73
Sulfur (dissolved)	ug/L	-	-	5500
Thallium (dissolved)	ug/L	0.8 w	2 w	ND (0.050)
Tin (dissolved)	ug/L	-	-	ND (5.0)
Titanium (dissolved)	ug/L	2000 w	-	ND (5.0)
Uranium (dissolved)	ug/L	8.5 w	20	ND (0.10)
Vanadium (dissolved)	ug/L	-	-	ND (5.0)
Zinc (dissolved)	ug/L	[b]	5000	ND (5.0)
Hardness < 90	ug/L	7.5	-	ND (5.0)
Hardness 100 - < 200	ug/L	-	-	-
Hardness 400 - < 500 [bx]	ug/L	-	-	-
Hardness >= 90 (calculated[f])	ug/L	[b]	-	-
Zirconium (dissolved)	ug/L	-	-	ND (0.50)

Notes:

(1)	British Columbia Approved Water Quality Guidelines (WQG), 2006 Edition or Canadian Drinking Guidelines unless otherwise stated.
a	Exceeds BC WQG Freshwater Aquatic Life (FWAL) Guideline.
b	Exceeds BC WQG Drinking Water (DW) Guideline.
[a]	Limit varies with pH.
[b]	Limit varies with Hardness.
[bx]	Limit varies with Hardness. Limit as per Protocol 10 - Hardness Dependent Site-Specific Freshwater Water Quality Standards for Cadmium and Zinc.
[b] TBD	Limit varies with Hardness. Determined on a site-specific basis.
[c]	Limit varies with Chloride (mg/L).
[d]	Limit varies with pH and Temperature.
[e]	Background dependent. Not evaluated until background limits established.
23.9	Exceeds guideline.
ND	Not detected at the associated reporting limit.
OOR	Out of range.
(c)	Background dependant. Background location not established.
w	Values reported from BC MOE - Working Water Quality Guidelines for British Columbia (2015).
*	Aesthetic objective
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.
calculation[a]	Exp(1.6-3.327*pH+0.402*pH^2)
calculation[b]	(10^((0.86*LOG(HARDNESS))-3.2))/1000
calculation[c]	(0.04* hardness)/1000
calculation[d]	3.31 + e(1.273 ln (mean hardness) - 4.704)
calculation[e]	0.01102*hardness+0.54
calculation[f]	7.5 + 0.75 x (hardness -90)
calculation[g]	((-51.73)+(92.57*(LOG(hardness)/LOG(10))))*0.01
-	Currently no Standard/Guideline.

Table 4.1A
Surface Water Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:				SW15-01	SW15-01	SW15-01	SW15-01	SW15-02	SW15-02	SW15-02	SW15-02
Sample ID:				W-88877-091815-TDF-08	WS-88877-06102015-TE-10/6/2015	WS-88877-06102015-TE-10/6/2015 Duplicate	WS-88877-060417-JS-03	W-88877-091815-TDF-09	W-88877-091815-TDF-10	WS-88877-05102015-TE-10/5/2015	WS-88877-060417-JS-02
Sample Date:		BC WQG[(1)]	BC WQG[(1)]	9/18/2015	10/6/2015		4/6/2017	9/18/2015	9/18/2015 Duplicate		4/6/2017
Parameters	**Units**	**FWAL a**	**DW b**								
Field Parameters											
Conductivity, field	mS/cm	-	-	0.071	0.073	0.073	0.048	0.069	0.069	0.056	0.058
Dissolved oxygen (DO), field	mg/L	>5	-	10	8.09	8.09	12.4	6.6	6.6	2.58[a]	9.05
Oxidation reduction potential (ORP), field	millivolts	-	-	219	262	262	228	231	231	220	222
pH, field	s.u.	6.5-9.0	6.5-8.5	7.73	6.82	6.82	7.47	7.52	7.52	6.96	7.5
Temperature, field	Deg C	18 (12 spring/fall) (c)	15	18.11[ab]	15.09[b]	15.09[b]	5.65	16.38[b]	16.38[b]	19.9[ab]	7.56
Total dissolved solids, field (TDS)	ugL	-	-	-	0.046	0.046	0.031	-	-	0.037	0.038
Turbidity, field	NTU	(c)	(c)	11.8	0	0	0	2.1	2.1	3	1.8
General Chemistry											
%difference/ion balance	none	-	-	-	0.92	-	-	-	-	1	-
Alkalinity (as CaCO3 pH=8.3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Alkalinity, total (as CaCO3)	mg/L	-	-	22.5	22	21.2	21.9	14.9	14.7	105	14.5
Bicarbonate (as CaCO3)	mg/L	-	-	27.5	26.8	25.9	26.7	18.2	17.9	128	17.7
Biochemical oxygen demand (BOD)	mg/L	-	-	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)	ND (6.0)
Carbonate (as CaCO3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Chemical oxygen demand (COD)	mg/L	-	-	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Chloride (dissolved)	mg/L	150	250	1	1.6	0.9	0.65	5.8	5.6	25	6.7
Conductivity	uS/cm	-	-	53.1	47.1	47.8	47.8	55.3	56.5	317	59.7
Cyanide (total)	mg/L	-	-	ND (0.00062)	-	-	-	ND (0.00050)	-	-	-
Cyanide, weak acid dissociable	mg/L	0.005	-	-	ND (0.00050)	-	-	-	-	ND (0.00050)	-
Hardness	mg/L	-	-	24.8	24.5	-	22.2	16.3	-	51.6	16.9
Hardness (dissolved)	mg/L	-	-	-	22.4	-	21.8	-	-	48.3	16.3
Hydrogen sulfide	mg/L	-	-	-	ND (0.0019)	-	ND (0.0020)	-	-	ND (0.0019)	ND (0.0020)
Hydroxide (as CaCO3)	mg/L	-	-	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)	ND (0.50)
Oil and grease	mg/L	-	-	ND (1.0)	-	-	-	ND (1.0)	-	-	-
pH	s.u.	6.5-9.0	6.5-8.5	7.52 J	7.54 J	7.46 J	7.56 J	7.45 J	7.33 J	8.18 J	7.25 J
Phenolics (total)	mg/L	0.002	-	ND (0.0010)	-	-	ND (0.0010)	ND (0.0010)	-	-	ND (0.0010)
Phosphorus	mg/L	-	-	ND (0.0050)	ND (0.0050)	-	-	0.0056	0.0053	0.0098	-
Sulfate (dissolved)	mg/L	[b]	500	3.04	2.22	3.02	2.79	0.75	1.12	8.51	1.52
Hardness < 30	mg/L	128		3.04	2.22	3.02	2.79	0.75	1.12		1.52
Hardness > 30 - 75	mg/L	218								8.51	
Sulfide	mg/L	0.002 w	-	0.0068[a]	ND (0.0019)	-	ND (0.0019)	0.0085[a]	-	ND (0.0019)	ND (0.0019)
Total dissolved solids (TDS)	mg/L	-	500 (*)	26	ND (51)	ND (51)	18	32 J	44 J	192	32
Total suspended solids (TSS)	mg/L	(c)	-	ND (4.0)	ND (4.0) J	ND (4.0) J	ND (4.0)	ND (4.0)	ND (4.0)	ND (4.0)	ND (4.0)
Nutrients											
Ammonia-N	mg/L	[d]	-	0.016	0.02	-	0.019	0.019	0.017	0.018	0.022
Varies with pH and Temperature	mg/L	[d]		0.016	0.02		0.019	0.019	0.017	0.018	0.022
pH < 7.0	mg/L				0.02					0.018	
pH 7.0 - < 7.5	mg/L						0.019				
pH 7.5 - < 8.0	mg/L			0.016				0.019	0.017		0.022
Nitrate (as N)	mg/L	3	10	ND (0.10)	ND (0.10)	ND (0.10)	0.031	ND (0.10)	ND (0.10)	1.16	0.045
Nitrite (as N)	mg/L	[c]	1	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.0050)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.0050)
Chloride < 2 mg/L	mg/L	0.02		ND (0.10)	ND (0.10)	ND (0.10)	ND (0.0050)				
Chloride 4 - < 6 mg/L	mg/L	0.06						ND (0.10)	ND (0.10)		
Choride 6 - < 8 mg/L	mg/L	0.08									ND (0.0050)
Chloride >= 10 mg/L	mg/L	0.20								ND (0.10)	
Nitrite/Nitrate	mg/L	-	-	ND (0.10)	ND (0.10)	ND (0.10)	0.031	ND (0.10)	ND (0.10)	1.16	0.045
Nitrogen	mg/L	-	-	0.107	0.074	-	0.097	0.159	0.175	1.41	0.193
Orthophosphate	mg/L	-	-	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.0050)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.0050)
Total kjeldahl nitrogen (TKN)	mg/L	-	-	0.11	ND (0.10)	-	0.066	0.16	0.17	0.25	0.148
Total Metals											
Aluminum	ug/L	[a]	200	18.8	20.4	-	18	15.6	-	ND (9.5)	24.5
pH >= 6.5	ug/L	50		18.8	20.4		18	15.6		ND (9.5)	24.5
Antimony	ug/L	20 w	14 w	ND (0.50)	ND (0.50)	-	ND (0.50)	ND (0.50)	-	ND (0.50)	ND (0.50)
Arsenic	ug/L	5	25	0.12	ND (0.10)	-	ND (0.10)	0.11	-	0.37	ND (0.10)
Barium	ug/L	1000 w	1000	2.9	2.8	-	2.5	2.2	-	13.6	2.6
Beryllium	ug/L	0.13 w	4 w	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)
Bismuth	ug/L	-	-	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)
Boron	ug/L	1200	5000	ND (50)	ND (50)	-	ND (50)	ND (50)	-	ND (50)	ND (50)
Cadmium	ug/L	[b]	5	ND (0.010)	ND (0.010)	-	ND (0.010)	ND (0.010)	-	ND (0.010)	ND (0.010)
Hardness < = 30	ug/L			ND (0.010)	ND (0.010)		ND (0.010)	ND (0.010)			ND (0.010)
Hardness 3.4 - 285 (calculated[b])	ug/L	[b]		ND (0.010)	ND (0.010)		ND (0.010)	ND (0.010)		ND (0.010)	ND (0.010)
Hardness 30 - < 90	ug/L									ND (0.010)	
Calcium	ug/L	-	-	8490	8460	-	7490	4600	-	18000	4930
Chromium	ug/L	-	50	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)
Cobalt	ug/L	4	-	ND (0.50)	ND (0.50)	-	ND (0.20)	ND (0.50)	-	ND (0.50)	ND (0.20)
Copper	ug/L	[b]	500	0.51	0.67 J	-	0.94	0.92	-	0.53 J	0.9
Hardness < 50	ug/L	2		0.51	0.67 J		0.94	0.92			0.9
Hardness < 50	ug/L	2		0.51	0.67 J		0.94	0.92			0.9
Hardness 50 - < 75	ug/L									0.53 J	
Hardness >= 50 (calculated[c])	ug/L	[b]								0.53 J	
Iron	ug/L	1000	-	20	ND (29)	-	14	86	-	ND (10)	255
Lead	ug/L	[b]	50	ND (0.20)	ND (0.20)	-	0.31	ND (0.20)	-	ND (0.20)	ND (0.20)
Hardness < 50	ug/L			ND (0.20)	ND (0.20)		0.31	ND (0.20)			ND (0.20)
Hardness 50 - < 100	ug/L									ND (0.20)	
Hardness dependent (calculated[d])	ug/L	[b]		ND (0.20)	ND (0.20)		0.31	ND (0.20)		ND (0.20)	ND (0.20)
Lithium	ug/L	14 w	-	ND (5.0)	ND (5.0)	-	ND (2.0)	ND (5.0)	-	ND (5.0)	ND (2.0)
Magnesium	ug/L	-	-	868	825	-	842	1180	-	1600	1130
Manganese	ug/L	[b]	50 (*)	2.5	2.5	-	1.8	25.1	-	17.7	19.5
Hardness dependent (calculated[e])	ug/L	[b]		2.5	2.5		1.8	25.1		17.7	19.5
Mercury	ug/L	0.02	1	ND (0.010)	ND (0.010)	-	ND (0.010)	ND (0.010)	-	ND (0.010)	ND (0.010)
Molybdenum	ug/L	1000	250	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)
Nickel	ug/L	[b]	-	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)	-	ND (1.0)	ND (1.0)
Hardness < 60	ug/L	25		ND (1.0)	ND (1.0)		ND (1.0)	ND (1.0)		ND (1.0)	ND (1.0)
Phosphorus	ug/L	-	-	-	-	-	ND (10)	-	-	-	ND (10)
Potassium	ug/L	-	-	87	78	-	76	198	-	457	178
Selenium	ug/L	2	10	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)	-	0.45	ND (0.10)
Silicon	ug/L	-	-	1740	1770	-	2040	1450	-	8800	2190
Silver	ug/L	[b]	-	ND (0.020)	ND (0.020)	-	ND (0.020)	ND (0.020)	-	ND (0.020)	ND (0.020)
Hardness < 100	ug/L	0.05		ND (0.020)	ND (0.020)		ND (0.020)	ND (0.020)		ND (0.020)	ND (0.020)
Sodium	ug/L	-	200000 (*)	800	895	-	885	4510	-	42400	5320
Strontium	ug/L	-	-	12.2	10.4	-	10.4	15.4	-	42.1	14.9
Sulfur	ug/L	-	-	ND (3000)	ND (3000)	-	ND (3000)	ND (3000)	-	ND (3000)	ND (3000)
Thallium	ug/L	0.8 w	2 w	ND (0.050)	ND (0.050)	-	ND (0.010)	ND (0.050)	-	ND (0.050)	ND (0.010)
Tin	ug/L	-	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)
Titanium	ug/L	2000 w	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)
Uranium	ug/L	8.5 w	20	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)	-	ND (0.10)	ND (0.10)
Vanadium	ug/L	-	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)
Zinc	ug/L	[b]	5000	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)	-	ND (5.0)	ND (5.0)
Hardness < 90	ug/L	7.5		ND (5.0)	ND (5.0)		ND (5.0)	ND (5.0)		ND (5.0)	ND (5.0)
Zirconium	ug/L	-	-	ND (0.50)	ND (0.50)	-	ND (0.10)	ND (0.50)	-	ND (0.50)	ND (0.10)

Notes:

(1)	British Columbia Approved Water Quality Guidelines (WQG), 2006 Edition or Canadian Drinking Guidelines unless otherwise stated.
a	Exceeds BC WQG Freshwater Aquatic Life (FWAL) Guideline.
b	Exceeds BC WQG Drinking Water (DW) Guideline.
[a]	Limit varies with pH.
[b]	Limit varies with Hardness.
[bx]	Limit varies with Hardness. Limit as per Protocol 10 - Hardness Dependent Site-Specific Freshwater Water Quality Standards for Cadmium and Zinc.
[b] TBD	Limit varies with Hardness. Determined on a site-specific basis.
[c]	Limit varies with Chloride (mg/L).
[d]	Limit varies with pH and Temperature.
[e]	Background dependent. Not evaluated until background limits established.
23.9	Exceeds guideline.
ND	Not detected at the associated reporting limit.
OOR	Out of range.
(c)	Background dependant. Background location not established.
w	Values reported from BC MOE - Working Water Quality Guidelines for British Columbia (2015).
*	Aesthetic objective
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.
calculation[a]	Exp(1.6-3.327*pH+0.402*pH^2)
calculation[b]	(10^((0.86*LOG(HARDNESS))-3.2))/1000
calculation[c]	(0.04* hardness)/1000
calculation[d]	3.31 + e(1.273 ln (mean hardness) - 4.704)
calculation[e]	0.01102*hardness+0.54
calculation[f]	7.5 + 0.75 x (hardness -90)
calculation[g]	((-51.73)+(92.57*(LOG(hardness)/LOG(10))))*0.01
-	Currently no Standard/Guideline.

Table 4.1B
Surface Water Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:				SW15-01	SW15-02
Sample ID:				W-88877-091815-TDF-	W-88877-091815-TDF-
Sample Date:		BC WQG[1]	BC WQG[1]	9/18/2015	9/18/2015
Parameters	**Units**	**FWAL a**	**DW b**		
PAH					
2-Methylnaphthalene	ug/L	-	-	ND (0.10)	ND (0.10)
Acenaphthene	ug/L	6	-	ND (0.050)	ND (0.050)
Acenaphthylene	ug/L	-	-	ND (0.050)	ND (0.050)
Acridine	ug/L	3	-	ND (0.050)	ND (0.050)
Anthracene	ug/L	4	-	ND (0.010)	ND (0.010)
Benzo(a)anthracene	ug/L	0.1	-	ND (0.010)	ND (0.010)
Benzo(a)pyrene	ug/L	0.01	0.01	ND (0.0090)	ND (0.0090)
Benzo(b)fluoranthene/Benzo(j)fluoranthene	ug/L	-	-	ND (0.050)	ND (0.050)
Benzo(b)pyridine (Quinoline)	ug/L	3.4 w	-	ND (0.24)	ND (0.24)
Benzo(g,h,i)perylene	ug/L	-	-	ND (0.050)	ND (0.050)
Benzo(k)fluoranthene	ug/L	-	-	ND (0.050)	ND (0.050)
Chrysene	ug/L	-	-	ND (0.050)	ND (0.050)
Dibenz(a,h)anthracene	ug/L	-	-	ND (0.050)	ND (0.050)
Fluoranthene	ug/L	4	-	ND (0.020)	ND (0.020)
Fluorene	ug/L	12	-	ND (0.050)	ND (0.050)
Indeno(1,2,3-cd)pyrene	ug/L	-	-	ND (0.050)	ND (0.050)
Naphthalene	ug/L	1	-	ND (0.10)	ND (0.10)
PAH high molecular weight	ug/L	-	-	ND (0.050)	ND (0.050)
PAH low molecular weight	ug/L	-	-	ND (0.24)	ND (0.24)
Phenanthrene	ug/L	0.3	-	ND (0.050)	ND (0.050)
Pyrene	ug/L	0.02	-	ND (0.020)	ND (0.020)
Total PAH	ug/L	-	-	ND (0.24)	ND (0.24)
Petroleum Products					
Extractable Petroleum Hydrocarbons (C10-C19)	mg/L	-	-	ND (0.20)	ND (0.20)
Extractable Petroleum Hydrocarbons (C19-C32)	mg/L	-	-	ND (0.20)	ND (0.20)
HEPH (C19-C32 less PAH)	mg/L	-	-	ND (0.20)	ND (0.20)
LEPH (C10-C19 less PAH)	mg/L	-	-	ND (0.20)	ND (0.20)
Total Petroleum Hydrocarbons VPH (C6-C10)LessBTEX	mg/L	-	-	ND (0.3)	ND (0.3)
Total Petroleum Hydrocarbons VH (C6-C10)	mg/L	-	-	ND (0.3)	ND (0.3)
Volatile Organic Compounds					
1,1,1,2-Tetrachloroethane	ug/L	-	-	ND (0.50)	ND (0.50)
1,1,1-Trichloroethane	ug/L	11100	200	ND (0.50)	ND (0.50)
1,1,2,2-Tetrachloroethane	ug/L	-	-	ND (0.50)	ND (0.50)
1,1,2-Trichloroethane	ug/L	-	-	ND (0.50)	ND (0.50)
1,1-Dichloroethane	ug/L	-	-	ND (0.50)	ND (0.50)
1,1-Dichloroethene	ug/L	-	-	ND (0.50)	ND (0.50)
1,2,3-Trichlorobenzene	ug/L	-	-	ND (2.0)	ND (2.0)
1,2,4-Trichlorobenzene	ug/L	-	-	ND (2.0)	ND (2.0)
1,2-Dibromoethane (Ethylene dibromide)	ug/L	-	-	ND (0.20)	ND (0.20)
1,2-Dichlorobenzene	ug/L	0.7 w	3 (*), 200	ND (0.50)	ND (0.50)
1,2-Dichloroethane	ug/L	100 w	5	ND (0.50)	ND (0.50)
1,2-Dichloropropane	ug/L	-	-	ND (0.50)	ND (0.50)
1,3-Butadiene	ug/L	-	-	ND (5.0)	ND (5.0)
1,3-Dichlorobenzene	ug/L	150 w	-	ND (0.50)	ND (0.50)
1,4-Dichlorobenzene	ug/L	26 w	1 (*), 5	ND (0.50)	ND (0.50)
Benzene	ug/L	40	5	ND (0.40)	ND (0.40)
Bromobenzene	ug/L	-	-	ND (2.0)	ND (2.0)
Bromodichloromethane	ug/L	-	16	ND (1.0)	ND (1.0)
Bromoform	ug/L	-	-	ND (1.0)	ND (1.0)
Bromomethane (Methyl bromide)	ug/L	-	-	ND (1.0)	ND (1.0)
Carbon tetrachloride	ug/L	13.3 w	5	ND (0.50)	ND (0.50)
Chlorobenzene	ug/L	1.3 w	30 (*), 80	ND (0.50)	ND (0.50)
Chloroethane	ug/L	-	-	ND (1.0)	ND (1.0)
Chloroform (Trichloromethane)	ug/L	1.8 w	-	ND (1.0)	ND (1.0)
Chloromethane (Methyl chloride)	ug/L	-	-	ND (1.0)	ND (1.0)
cis-1,2-Dichloroethene	ug/L	-	-	ND (1.0)	ND (1.0)
cis-1,3-Dichloropropene	ug/L	-	-	ND (1.0)	ND (1.0)
Dibromochloromethane	ug/L	-	-	ND (1.0)	ND (1.0)
Dibromomethane	ug/L	-	-	ND (0.90)	ND (0.90)
Dichlorodifluoromethane (CFC-12)	ug/L	-	-	ND (2.0)	ND (2.0)
Ethylbenzene	ug/L	200	2.4 (*)	ND (0.40)	ND (0.40)
Hexachlorobutadiene	ug/L	-	-	ND (0.50)	ND (0.50)
m&p-Xylenes	ug/L	30	300 (*)	ND (0.40)	ND (0.40)
Methyl tert butyl ether (MTBE)	ug/L	3400	20 (*)	ND (4.0)	ND (4.0)
Methylene chloride	ug/L	98.1 w	-	ND (2.0)	ND (2.0)
o-Xylene	ug/L	30	300 (*)	ND (0.40)	ND (0.40)
Styrene	ug/L	72 w	-	ND (0.50)	ND (0.50)
Tetrachloroethene	ug/L	111 w	-	ND (0.50)	ND (0.50)
Toluene	ug/L	0.5	24 (*)	ND (0.40)	ND (0.40)
trans-1,2-Dichloroethene	ug/L	-	-	ND (1.0)	ND (1.0)
trans-1,3-Dichloropropene	ug/L	-	-	ND (1.0)	ND (1.0) J
Trichloroethene	ug/L	21 w	-	ND (0.50)	ND (0.50)
Trichlorofluoromethane (CFC-11)	ug/L	-	-	ND (4.0)	ND (4.0)
Trifluorotrichloroethane (CFC-113)	ug/L	-	-	ND (2.0)	ND (2.0)
Vinyl chloride	ug/L	-	-	ND (0.50)	ND (0.50)
Xylenes (total)	ug/L	30	300 (*)	ND (0.40)	ND (0.40)

Notes:

[1]	British Columbia Approved Water Quality Guidelines (WQG), 2006 Edition or Canadian Drinking Guidelines unless otherwise stated.
a	Exceeds BC WQG Freshwater Aquatic Life (FWAL) Guideline.
b	Exceeds BC WQG Drinking Water (DW) Guideline.
23.9	Exceeds guideline.
ND	Not detected at the associated reporting limit.
OOR	Out of range.
w	Values reported from BC MOE - Working Water Quality Guidelines for British Columbia (2015).
*	Aesthetic objective
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.

Table 4.2
Wash Plant Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:						SW16-03	SW16-03
Sample ID:						SW-88877-290116-JS-01	WS-88877-060417-JS-01
Sample Date:		BC WQG[1]	BC WQG[1]	BC CSR[2] Schedule 6	BC CSR[2] Schedule 10	1/29/2016	4/6/2017
Parameters	**Units**	**FWAL a**	**DW b**	**DW d**	**DW e**		
Field Parameters							
Conductivity, field	mS/cm	-	-	-	-	0.072	0.09
Dissolved oxygen (DO), field	mg/L	>5	-	-	-	13.8	12.81
Oxidation reduction potential (ORP), field	millivolts	-	-	-	-	182	197
pH, field	s.u.	6.5-9.0	6.5-8.5	-	-	8.35	7.65
Temperature, field	Deg C	18 (12 spring/fall) (c)	15	-	-	5.58	8.95
Total dissolved solids, field (TDS)	ugL	-	-	-	-	0.847	0.059
Turbidity, field	NTU	(c)	(c)	-	-	OOR	26
General Chemistry							
%difference/ion balance	none	-	-	-	-	1	-
Alkalinity (as CaCO3 pH=8.3)	mg/L	-	-	-	-	ND (0.50)	ND (0.50)
Alkalinity, total (as CaCO3)	mg/L	-	-	-	-	23.6	33.7
Bicarbonate (as CaCO3)	mg/L	-	-	-	-	28.8	41.1
Biochemical oxygen demand (BOD)	mg/L	-	-	-	-	ND (6.0)	ND (6.0)
Carbonate (as CaCO3)	mg/L	-	-	-	-	ND (0.50)	ND (0.50)
Chemical oxygen demand (COD)	mg/L	-	-	-	-	ND (10)	ND (10)
Chloride (dissolved)	mg/L	150	250	250	-	3.6	5.5
Conductivity	uS/cm	-	-	-	-	65.5	89.3
Hardness	mg/L	-	-	-	-	-	34.9
Hardness (dissolved)	mg/L	-	-	-	-	26.8	37.8
Hydrogen sulfide	mg/L	-	-	0.05	-	0.008 J	0.002
Hydroxide (as CaCO3)	mg/L	-	-	-	-	ND (0.50)	ND (0.50)
pH	s.u.	6.5-9.0	6.5-8.5	-	-	7.63 J	7.78 J
Phenolics (total)	mg/L	0.002	-	-	-	-	ND (0.0010)
Phosphorus	mg/L	-	-	-	-	0.0738	-
Sulfate (dissolved)	mg/L	[b]	500	500	-	4.94	3.57
Hardness < 30	mg/L	128				4.94	
Hardness > 30 - 75	mg/L	218					3.57
Sulfide	mg/L	0.002 w	-	-	-	**0.0078 J[a]**	0.002
Total dissolved solids (TDS)	mg/L	-	500 (*)	-	-	32	42
Total suspended solids (TSS)	mg/L	(c)	-	-	-	20	13.5
Nutrients							
Ammonia-N	mg/L	[d]	-	-	-	0.016	0.028
Varies with pH and Temperature	mg/L	[d]				0.016	0.028
Nitrate (as N)	mg/L	3	10	10	-	ND (0.10)	ND (0.020)
Nitrite (as N)	mg/L	[c]	1	3.2	-	ND (0.10)	ND (0.0050)
Chloride 2 - < 4 mg/L	mg/L	0.04				ND (0.10)	
Chloride 4 - < 6 mg/L	mg/L	0.06					ND (0.0050)
Nitrite/Nitrate	mg/L	-	-	10	-	ND (0.10)	ND (0.020)
Nitrogen	mg/L	-	-	-	-	0.19	0.099
Orthophosphate	mg/L	-	-	-	-	ND (0.10)	0.0492
Total kjeldahl nitrogen (TKN)	mg/L	-	-	-	-	0.19	0.099
Dissolved Metals							
Aluminum (dissolved)	ug/L	[a]	200	9500	-	53.2	-
pH >= 6.5	ug/L	50				**53.2[a]**	
Antimony (dissolved)	ug/L	20 w	14 w	6	-	ND (0.50)	-
Arsenic (dissolved)	ug/L	5	25	10	-	0.18	-
Barium (dissolved)	ug/L	1000 w	1000	1000	-	2	-
Beryllium (dissolved)	ug/L	0.13 w	4 w	-	-	ND (0.10)	-
Bismuth (dissolved)	ug/L	-	-	-	-	ND (1.0)	-
Boron (dissolved)	ug/L	1200	5000	5000	-	ND (50)	-
Cadmium (dissolved)	ug/L	[b]	5	5	-	ND (0.010)	-
Hardness 3.4 - 285 (calculated[b])	ug/L	[b]				ND (0.010)	
Calcium (dissolved)	ug/L	-	-	-	-	8130	-
Chromium (dissolved)	ug/L	-	50	50	-	ND (1.0)	-
Cobalt (dissolved)	ug/L	4	-	-	-	ND (0.50)	-
Copper (dissolved)	ug/L	[b]	500	1000	-	0.38	-
Hardness < 50	ug/L	2				0.38	
Iron (dissolved)	ug/L	350	-	6500	-	11.8	-
Lead (dissolved)	ug/L	[b]	50	10	-	ND (0.20)	-
Hardness dependent (calculated[d])	ug/L	[b]				ND (0.20)	
Lithium (dissolved)	ug/L	14 w	-	-	730	ND (5.0)	-
Magnesium (dissolved)	ug/L	-	-	100000	-	1580	-
Manganese (dissolved)	ug/L	[b]	50 (*)	550	550	20.9	-
Hardness dependent (calculated[e])	ug/L	[b]				20.9	
Mercury (dissolved)	ug/L	0.02	1	1	-	ND (0.010)	-
Molybdenum (dissolved)	ug/L	1000	250	250	-	ND (1.0)	-
Nickel (dissolved)	ug/L	[b]	-	-	-	ND (1.0)	-
Hardness < 60	ug/L	25				ND (1.0)	
Potassium (dissolved)	ug/L	-	-	-	-	231	-
Selenium (dissolved)	ug/L	2	10	10	-	0.12	-
Silicon (dissolved)	ug/L	-	-	-	-	1110	-
Silver (dissolved)	ug/L	[b]	-	-	-	ND (0.020)	-
Hardness < 100	ug/L	0.05				ND (0.020)	

Table 4.2
Wash Plant Analytical Results
Hydrogeology and Hydrology Characterization Report
Upland Landfill
Campbell River, British Columbia

Sample Location:						SW16-03	SW16-03
Sample ID:						SW-88877-290116-JS-01	WS-88877-060417-JS-01
Sample Date:		BC WQG[1]	BC WQG[1]	BC CSR[2] Schedule 6	BC CSR[2] Schedule 10	1/29/2016	4/6/2017
Parameters	**Units**	**FWAL a**	**DW b**	**DW d**	**DW e**		
Sodium (dissolved)	ug/L	-	200000	200000	-	3100	-
Strontium (dissolved)	ug/L	-	-	-	-	18.7	-
Sulfur (dissolved)	ug/L	-	-	-	-	ND (3000)	-
Thallium (dissolved)	ug/L	0.8 w	2 w	-	-	ND (0.050)	-
Tin (dissolved)	ug/L	-	-	-	22000	ND (5.0)	-
Titanium (dissolved)	ug/L	2000 w	-	-	-	ND (5.0)	-
Uranium (dissolved)	ug/L	8.5 w	20	20	20	ND (0.10)	-
Vanadium (dissolved)	ug/L	-	-	-	-	ND (5.0)	-
Zinc (dissolved)	ug/L	[b]	5000	5000	-	ND (5.0)	-
Hardness < 90	ug/L	7.5				ND (5.0)	
Zirconium (dissolved)	ug/L	-	-	-	-	ND (0.50)	-
Total Metals							
Aluminum	ug/L	[a]	200	9500	-	-	**1170[b]**
pH >= 6.5	ug/L	50					**1170[a]**
Antimony	ug/L	20 w	14 w	6	-	-	ND (0.50)
Arsenic	ug/L	5	25	10	-	-	0.52
Barium	ug/L	1000 w	1000	1000	-	-	8.6
Beryllium	ug/L	0.13 w	4 w	-	-	-	ND (0.10)
Bismuth	ug/L	-	-	-	-	-	ND (1.0)
Boron	ug/L	1200	5000	5000	-	-	ND (50)
Cadmium	ug/L	[b]	5	5	-	-	0.029
Hardness 3.4 - 285 (calculated[b])	ug/L	[b]					0.029
Calcium	ug/L	-	-	-	-	-	10100
Chromium	ug/L	-	50	50	-	-	ND (1.0)
Cobalt	ug/L	4	-	-	-	-	0.89
Copper	ug/L	[b]	500	1000	-	-	14.9
Hardness < 50	ug/L	2					**14.9[a]**
Iron	ug/L	1000	-	6500	-	-	**1190[a]**
Lead	ug/L	[b]	50	10	-	-	ND (0.20)
Hardness dependent (calculated[d])	ug/L	[b]					ND (0.20)
Lithium	ug/L	14 w	-	-	730	-	ND (2.0)
Magnesium	ug/L	-	-	100000	-	-	2340
Manganese	ug/L	[b]	50 (*)	550	550	-	46.3
Hardness dependent (calculated[e])	ug/L	[b]					46.3
Mercury	ug/L	0.02	1	1	-	-	ND (0.010)
Molybdenum	ug/L	1000	250	250	-	-	ND (1.0)
Nickel	ug/L	[b]	-	-	-	-	1.2
Hardness < 60	ug/L	25					1.2
Phosphorus	ug/L	-	-	-	-	-	51
Potassium	ug/L	-	-	-	-	-	262
Selenium	ug/L	2	10	10	-	-	0.1
Silicon	ug/L	-	-	-	-	-	3510
Silver	ug/L	[b]	-	-	-	-	ND (0.020)
Hardness < 100	ug/L	0.05					ND (0.020)
Sodium	ug/L	-	200000 (*)	200000	-	-	2840
Strontium	ug/L	-	-	-	-	-	23.4
Sulfur	ug/L	-	-	-	-	-	ND (3000)
Thallium	ug/L	0.8 w	2 w	-	-	-	ND (0.010)
Tin	ug/L	-	-	-	22000	-	ND (5.0)
Titanium	ug/L	2000 w	-	-	-	-	56.7
Uranium	ug/L	8.5 w	20	20	20	-	ND (0.10)
Vanadium	ug/L	-	-	-	-	-	ND (5.0)
Zinc	ug/L	[b]	5000	5000	-	-	5.9
Hardness < 90	ug/L	7.5					5.9
Zirconium	ug/L	-	-	-	-	-	ND (0.10)

Notes:

[1]	British Columbia Approved Water Quality Guidelines (WQG), 2006 Edition or Canadian Drinking Guidelines unless otherwise stated.
[2]	Bristish Columbia Contaminated Sites Regulation (CSR)
a	Exceeds BC WQG Freshwater Aquatic Life (FWAL) Guideline.
b	Exceeds BC WQG Drinking Water (DW) Guideline.
d	Exceeds BC CSR Schedule 6 Drinking Water (DW) Guideline.
e	Exceeds BC CSR Schedule 10 Drinking Water (DW) Guideline.
[a]	Limit varies with pH.
[b]	Limit varies with Hardness.
[bx]	Limit varies with Hardness. Limit as per Protocol 10 - Hardness Dependent Site-Specific Freshwater Water Quality Standards for Cadmium and Zinc.
[b] TBD	Limit varies with Hardness. Determined on a site-specific basis.
[c]	Limit varies with Chloride (mg/L).
[d]	Limit varies with pH and Temperature.
23.9	Exceeds guideline.
ND	Not detected at the associated reporting limit.
OOR	Out of range.
(c)	Background dependant. Background location not established.
w	Values reported from BC MOE - Working Water Quality Guidelines for British Columbia (2015).
*	Aesthetic objective
J	The analyte was positively identified; the associated numerical value is the estimated concentration of the analyte in the sample.
calculation[a]	Exp(1.6-3.327*pH+0.402*pH^2)
calculation[b]	(10^((0.86*LOG(HARDNESS))-3.2))/1000
-	Currently no Standard/Guideline.

Appendices

Appendix A
Permit **PR-10487**

Province of
British Columbia

Ministry of Environment,
Lands and Parks

BC Environment

Vancouver Island Region 1
Regional Headquarters
2569 Kenworth Road
Nanaimo
British Columbia
V9T 4P7
Telephone: (604) 751-3100

JUN 01 1992

File: PR-10807

REGISTERED MAIL

Upland Excavating Ltd.
480 - 10th Avenue
Campbell River, British Columbia
V9W 4E3

Gentlemen:

Enclosed is a copy of Permit No. PR-10807 issued under the provisions of the Waste Management Act, in the name of Upland Excavating Ltd. Your attention is respectfully directed to the terms and conditions outlined in the Permit.

The administration of this Permit will be carried out by staff from our Regional Office located at 2569 Kenworth Road, Nanaimo, British Columbia, V9T 4P7 (telephone 751-3100). Plans, data and reports pertinent to the Permit are to be submitted to the Regional Waste Manager at this address.

Yours truly,

G.E. Oldham

G.E. Oldham, P. Eng.
Regional Waste Manager

Enclosure

Printed on Recycled Paper

British Columbia
Handle with care

PROVINCE OF
BRITISH COLUMBIA

ENVIRONMENTAL PROTECTION
2569 Kenworth Road
Nanaimo, British Columbia
V9T 4P7
Telephone:(604) 751-3100

MINISTRY OF ENVIRONMENT,
LANDS AND PARKS

PERMIT

Under the Provisions of the Waste Management Act

Upland Excavating Ltd.

480 - 10th Avenue

Campbell River, British Columbia

V9W 4E3

is authorized to discharge refuse from Campbell River and the surrounding area to the land and air contaminants from a regulated open burning operation.

An annual fee will be determined on the basis of your industrial code and capacity in accordance with the Waste Management Fees Regulation.

This Permit does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority shall rest with the Permittee.

G. E. Oldham, P. Eng.
Regional Waste Manager

Date issued: JUN 01 1992

Date amended:
(most recent)

Permit No. PR-10807

1. AUTHORIZED DISCHARGES AND RELATED REQUIREMENTS

1.1 Refuse

1.1.1 The maximum rate at which refuse may be discharged is 3200 m^3/year.

1.1.2 The type of refuse which may be discharged is inert municipal.

1.1.3 The components of the refuse which may be discharged are stumps, trees, land clearing waste, selected building demolition debris, and residue of combustion from the open burning of woodwaste.

1.1.4 The works authorized are a landfill operation as directed, located approximately as shown on the attached Appendix A-1.

1.1.5 The works authorized must be complete and in operation on and from the date of this permit.

1.2 Emissions

1.2.1 The works authorized are a regulated open burning operation, as directed, located approximately as shown on the attached Appendix A-1.

1.2.2 The works authorized must be complete and in operation on and from the date of this permit.

2. LOCATION OF THE FACILITIES

Lot A, District Lot 85, Plan 30709, Sayward District.

G. E. Oldham

G. E. Oldham, P. Eng.
Regional Waste Manager

Date issued: JUN 01 1992

Date amended:
(most recent)

Permit No. PR-10807

3. LANDFILL OPERATION

The Permittee shall maintain the landfill as a Level E operation in accordance with the Pollution Control Objectives for Municipal Type Waste Discharges in British Columbia, dated September 1975, which, in normal conditions, requires that cover material be applied once per forty days of operation and at least once every two months. The Regional Waste Manager may vary the frequency of covering when freezing conditions or other circumstances affect normal operation.

4. SITE PREPARATION AND RESTORATION

Provision of fencing, site access, vehicle safety barriers, surface water diversionary works, firebreaks and site restoration as required, shall be carried out to the satisfaction of the Regional Waste Manager.

5. PUTRESCIBLE WASTE

No putrescible wastes shall be discharged at this site.

6. OPERATIONAL REQUIREMENTS FOR REGULATED OPEN BURNING

(a) Area

The operation shall be restricted to an area on the site which is satisfactory to the Regional Waste Manager. If required, this area shall be fenced to restrict access to the burn area stockpile.

G. E. Oldham

G. E. Oldham, P. Eng.
Regional Waste Manager

Date issued: JUN 01 1992

Date amended:
(most recent)

Permit No. PR-10807

(b) Quantity and Frequency

The maximum quantity of wastes to be treated is 750 m^3 per burn at a frequency not to exceed four burns per year. Each burn shall comprise one continuous period necessary to reduce the stockpiled waste to ashes, and shall not exceed 48 hours.

(c) Nature of Wastes

Generally, no waste shall be burned which is unacceptable to the Regional Waste Manager. Acceptable materials may include stumps, trees and similar items, but exclude nuisance causing combustibles such as rubber, plastics, tars, insulation, etc. Demolition debris, excepting wood products, shall not be burned at this site. Burning of any antisapstain treated wood products is prohibited.

(d) Timing

Burning shall take place only when an attendant is on duty and when conditions promote rapid combustion and dispersion of combustion products with a wind direction that conveys the resulting gases away from McIvor Lake and Highway #28 (Gold River Highway). Burning shall take place only when the ventilation index for the Campbell River area is forecasted to exceed 33 for the period of the burn. The ventilation index is issued by the Pacific Weather Centre, Environment Canada, Vancouver, telephone 664-9032. Materials shall be charged to the facility in a manner to promote best combustion and restrict the uplift of lighter constituents. No burning shall take place during periods of fire hazard or when burning is prohibited by other government agencies.

G. E. Oldham, P. Eng.
Regional Waste Manager

Date issued: JUN 01 1992

Date amended:
(most recent)

Permit No. PR-10807

(e) Fire Control

Suitable approved devices shall be available for extinguishing fires to prevent them from spreading to surrounding areas. Such devices may include a pressurized water supply, chemical type fire extinguishers, or an earth stockpile. If an earth stockpile is contemplated for fire control, earth moving equipment shall be available at the site during burning. A fireguard shall be cleared and maintained free of combustible materials.

(f) Residue of Combustion

As soon as the residue of combustion has cooled to ambient temperature, it shall be incorporated into the adjacent landfill.

(g) Other Requirements

The Ministry of Environment, Lands and Parks has established a Smoke Management Steering Committee to review the present practice of burning wood residue. A need for additional controls, such as auxiliary forced air, or other requirements, may result from the recommendations of the Steering Committee or following the observation of any burning episode, and the Permittee shall install such equipment or take measures as may be required by the Regional Waste Manager.

The Ministry is also in the process of revising the existing pollution control objectives for municipal landfills. Based on the provisions of the new criteria, the Permittee may be required to terminate open burning at this site.

7. GROUNDWATER MONITORING WELLS

The Permittee shall install not more than two groundwater monitoring wells. The number, locations and structural details of these facilities are subject to the approval of the Regional Waste Manager.

G. E. Oldham, P. Eng.
Regional Waste Manager

Date issued: JUN 01 1992

Date amended:
(most recent)

8. WASTE REDUCTION

The Ministry of Environment, Lands and Parks has developed a policy to reduce, recycle and reuse solid wastes. The Permittee is encouraged to segregate for recycling and reuse, where possible, materials destined for disposal at this site.

In certain landfill environments, some construction and demolition debris, may create air and water quality concerns. If problems arise at this site that are attributable to specific wastes, the Regional Waste Manager may require that alternate disposal procedures be implemented.

9. WASTE MANAGEMENT PLANNING

The Permittee is advised that the Regional District of Comox-Strathcona is developing a Solid Waste Management Plan which may have an impact on the discharge authorized by this Permit.

G. E. Oldham, P. Eng.
Regional Waste Manager

Date issued: JUN 01 1992

Date amended:
(most recent)

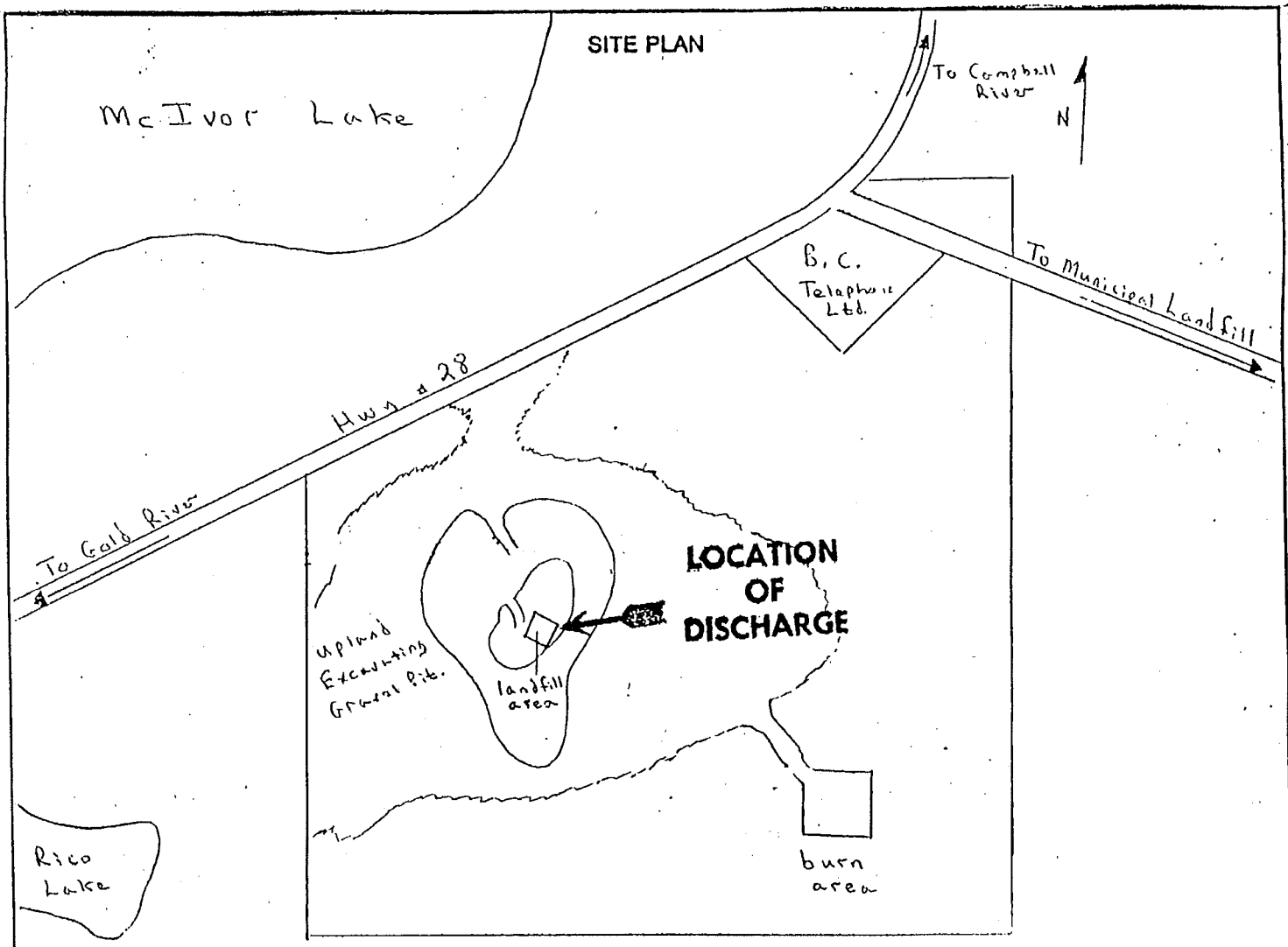
Permit No. PR-10807

Province of British Columbia

Ministry of Environment Lands and Parks

ENVIRONMENTAL PROTECTION

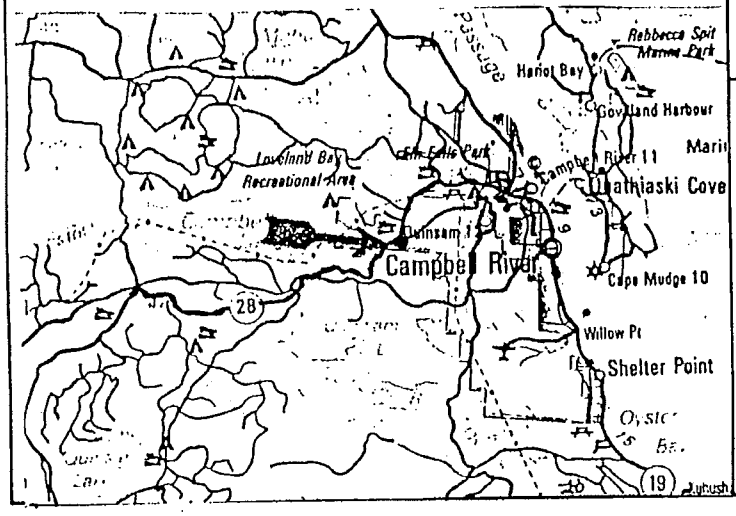
SITE PLAN



SCALE: ≃ 1 : 8,500

LEGAL DESCRIPTION: Lot A, District Lot 85, Plan 30709, Sayward District

LOCATION MAP



Upland Excavating Ltd.

Name of Permittee

Appendix A-1 to Permit No. PR-10807

Approval No. _____

Date Issued JUN 01 1992

Date Amended _____

Regional Waste Manager _____

Appendix B Detailed **Water Supply** Well Records

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 39950	Construction Date: 1978-06-26 00:00:00
Owner: ISLAND READY MIX	Driller: Drillwell Enterprises
	Well Identification Plate Number:
Address: GOLD RIVER HIGHWAY NEAR DUMP	Plate Attached By:
	Where Plate Attached:
Area: CAMPBELL RIVER	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 0 (Driller's Estimate)
SAYWARD Land District	Development Method:
District Lot: Plan: Lot:	Pump Test Info Flag:
Township: Section: 85 Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 7 feet
Island: VANCOUVER	
BCGS Number (NAD 83): 092K004112 Well: 1	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag:
Well Use: Commercial and Industrial	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 10.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:

Well Depth: 55 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag:
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag:	Depth (ft):
File Info Flag:	Thickness (in):
Sieve Info Flag:	
Screen Info Flag:	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

From	0 to	10 Ft.	silty gravel
From	10 to	55 Ft.	sand & gravel
From	55 to	55 Ft.	sand

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 73577	Construction Date: 1981-03-09 00:00:00
Owner: FR FRANZEN CONSTUCTI	Driller: Anderson Well Drilling
	Well Identification Plate Number:
Address:	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 0 (Driller's Estimate)
SAYWARD Land District	Development Method:
District Lot: Plan: 31913 Lot: 7	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 120 feet
Island:	
BCGS Number (NAD 83): 092K004112 Well:	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Private Domestic	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 0.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:

Well Depth: 149 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	
Screen Info Flag: N	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
STEEL CASING, CONTINUOUS,

LITHOLOGY INFORMATION:

From	0	to	117	Ft. BLUE GRAVEL
From	117	to	132	Ft. BLUE WATER BEARING SAND
From	142	to	149	Ft. WATER BEARING SAND & GRAVEL
From	138	to	142	Ft. WHITE WATER BEARING SAND
From	132	to	138	Ft. BLUE WATER BEARING GRAVEL

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 74191	Construction Date: 1991-10-23 00:00:00
Owner: AL & SONS BACKHOE &	Driller: Anderson Air Drilling
	Well Identification Plate Number:
Address: GOLD RIVER HIGHWAY	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 100 (Driller's Estimate) U.S. Gallons per Minute
SAYWARD Land District	Development Method:
District Lot: 85 Plan: 47695 Lot: 2	Pump Test Info Flag: Y
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 80 feet
Island: VANCOUVER ISLAND	
BCGS Number (NAD 83): 092K004112 Well: 3	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Other	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 6.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:
Well Depth: 123 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	
Screen Info Flag: N	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:

		Details of Closure:		
Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
STEEL CASING,0.0 TO 123.2,.250 THICK,A53 LBS, CONTINUOUS,STAINLESS STEEL,PUMP TEST RATE 100 USGM,80 FT AFTER 24 HRS

LITHOLOGY INFORMATION:

From 0 to 20 Ft. GREY SAND & GRAVEL

From 20 to 50 Ft. GREY SAND & GRAVEL

From 50 to 75 Ft. BROWN SAND & GRAVEL

From 122 to 124 Ft. WATER BEARING SAND & GRAVEL

From 85 to 100 Ft. WATER BEARING SAND & GRAVEL

From 100 to 125 Ft. WATERBEARING SAND & GRAVEL

From 115 to 122 Ft. ROCKS & SAND

From 75 to 85 Ft. BROWN SAND & GRAVEL

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 74207	Construction Date: 1987-05-01 00:00:00
Owner: M & S FOREST PRODUCT	Driller: Anderson Well Drilling
	Well Identification Plate Number:
Address: GOLD RIVER HIGHWAY	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 20 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
SAYWARD Land District	Development Method:
District Lot: 85 Plan: Lot:	Pump Test Info Flag: Y
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 85 feet
Island: VANCOUVER ISLAND	
BCGS Number (NAD 83): 092K004112 Well: 2	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Commercial and Industrial	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 7.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:
Well Depth: 138 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	
Screen Info Flag: N	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:

Other Info Details:	Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
STEEL CASING,0.0 TO 129.0,.250 THICK,53 LBS, CONTINUOUS,STAINLESS STEEL,PUMP TEST RATE 20 USGM,5 FT AFTER 2 HRS

LITHOLOGY INFORMATION:

From 0 to 93 Ft. BROWN SAND & GRAVEL

From 100 to 138 Ft. WB SAND

From 93 to 100 Ft. BROWN WB SAND & GRAVEL

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 84136	Construction Date: 2004-07-05 00:00:00
Owner: CAMPBELL RIVER LANDFILL	Driller: Drillwell Enterprises
	Well Identification Plate Number:
Address: 6700 ARGONAUT RD	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 75 (Driller's Estimate) U.S. Gallons per Minute
Land District	Development Method:
District Lot: Plan: Lot:	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level:
Island:	
BCGS Number (NAD 83): 092K004121 Well:	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Commercial and Industrial	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 6.00 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:
Well Depth: 215 feet	
Elevation: feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: Y	Depth (ft):
File Info Flag: N	Thickness (in):

Sieve Info Flag: N	
Screen Info Flag: Y	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size
206.3	215		200

Casing from	to feet	Diameter	Material	Drive Shoe
null	null	null	null	null

GENERAL REMARKS:
CHLORINE & WELDED LID

LITHOLOGY INFORMATION:

From	0	to	13 Ft.	COARSE GRAVEL
From	13	to	36 Ft.	COARSE SAND & GRAVEL
From	36	to	42 Ft.	COARSE GRAVEL
From	42	to	87 Ft.	BROWN SAND
From	87	to	130 Ft.	BROWN SILTY SAND & SOME GRAVEL
From	130	to	142 Ft.	CLEAN BROWN COARSE SAND
From	142	to	150 Ft.	SLIGHTLY SILTY SAND & GRAVEL
From	150	to	220 Ft.	COARSE SAND & GRAVEL (WB)
From	220	to	224 Ft.	MORE SAND & SILTYER BROWN WATER

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 93413	Construction Date: 2005-12-15 00:00:00
Owner: EMCON (MINISTRY OF HIGHWAYS)	Driller: Drillwell Enterprises
	Well Identification Plate Number: 12472
Address: 7025 GOLD RIVER HIGHWAY	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 10 (Driller's Estimate) U.S. Gallons per Minute
RENFREW Land District	Development Method: Bailing
District Lot: 85 Plan: Lot:	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 159 feet
Island:	
BCGS Number (NAD 83): 092K004114 Well: 2	WATER QUALITY:
	Character:
Class of Well: Water supply	Colour:
Subclass of Well: Non-domestic	Odour:
Orientation of Well: Vertical	Well Disinfected: N
Status of Well: Alteration	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Commercial and Industrial	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method:	Water Utility:
Diameter: inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:
Well Depth: 180 feet	
Elevation: feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: 24 inches	Flag: N
Well Cap Type: PITLESS UNIT & CAP	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	Liner from To: feet

Screen Info Flag: N	
	WELL CLOSURE INFORMATION:
Site Info Details:	Reason For Closure:
Other Info Flag:	Method of Closure:
Other Info Details:	Closure Sealant Material:
	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size
180	182		null
182	186		12

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
MEASUREMENTS FROM GROUND LEVEL. RECOMMENDED PUMPING RATE: 10 USGPM.

LITHOLOGY INFORMATION:

From 160 to 178 Ft. GRAVEL

From 178 to 184 Ft. FINER & SANDIER AS GOING DEEPER

From 184 to 187 Ft. brown

From 187 to 188 Ft. VERY SILTY brown

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 103257	Construction Date: 2010-08-18 00:00:00
Owner: CAMPBELL RIVER MOTOCROSS ASSOCIATION	Driller: Red William's Drilling
	Well Identification Plate Number: 34915
Address: GOLD RIVER HIGHWAY	Plate Attached By: THOMAS WILLIAMS
	Where Plate Attached: TOP OF CASING
Area: CAMPBELL RIVER	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 50 (Driller's Estimate) U.S. Gallons per Minute
Land District	Development Method: Air lifting
District Lot: Plan: Lot:	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 158 feet
Island:	
BCGS Number (NAD 83): 092K004114 Well:	WATER QUALITY:
	Character:
Class of Well: Water supply	Colour:
Subclass of Well: Domestic	Odour:
Orientation of Well: Vertical	Well Disinfected: Y
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Private Domestic	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method:	Water Utility:
Diameter: inches	Water Supply System Name:
Casing drive shoe: Y	Water Supply System Well Name:
Well Depth: 239 feet	
Elevation: 599 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: 30 inches	Flag: N
Well Cap Type: SIMPLE	Material: Bentonite clay and cement mixture
Bedrock Depth: feet	Method: Poured
Lithology Info Flag: N	Depth (ft): 15 feet
File Info Flag: N	Thickness (in): 1 inches
Sieve Info Flag: N	Liner from To: feet
Screen Info Flag: N	

Site Info Details:	WELL CLOSURE INFORMATION:
Other Info Flag:	Reason For Closure:
Other Info Details:	Method of Closure:
	Closure Sealant Material:
	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size
230.17	null		null
230.17	234.58		20
234.58	239		15

Casing from	to feet	Diameter	Material	Drive Shoe
0	231.17	6	Steel	Y

GENERAL REMARKS:
SCREEN BOTTOM: BLANK. BAILED 10 GPM DREW 1' - DRAWDOWN AVAILABLE 90'.

LITHOLOGY INFORMATION:

From 0 to 170 Ft. SAND & GRAVEL brown

From 170 to 185 Ft. brown

From 185 to 240 Ft. WATER-BEARING MEDIUM GRAINED SAND brown

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 109728	Construction Date: 2015-01-14 00:00:00
Owner: AL+SONS EXCAVATING	Driller: Drillwell Enterprises
	Well Identification Plate Number: 42401
Address: 6700 ARGONAUT ROAD	Plate Attached By: Driller
	Where Plate Attached: ON WELL CASING
Area: CAMPBELL RIVER	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 50 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
SAYWARD Land District	Development Method: Air lifting
District Lot: Plan: Lot: 85	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block: B	Artesian Pressure (ft):
Quarter:	Static Level: 110 feet
Island:	
BCGS Number (NAD 83): 092K004121 Well:	WATER QUALITY:
	Character:
Class of Well: Water supply	Colour:
Subclass of Well: Domestic	Odour:
Orientation of Well: Vertical	Well Disinfected: Y
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Private Domestic	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method:	Water Utility:
Diameter: 6 inches	Water Supply System Name:
Casing drive shoe: N Y	Water Supply System Well Name:
Well Depth: 208 feet	
Elevation: 520 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: 20 inches	Flag: Y
Well Cap Type: WELDED LID	Material: Bentonite clay
Bedrock Depth: feet	Method: Poured
Lithology Info Flag: Y	Depth (ft): 16 feet
File Info Flag: N	Thickness (in): 2 inches
Sieve Info Flag: N	Liner from To: feet
Screen Info Flag: Y	
	WELL CLOSURE INFORMATION:
Site Info Details:	Reason For Closure:
Other Info Flag:	Method of Closure:

Other Info Details:	Closure Sealant Material: Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size
197	199		null
199	203.6		15
203.6	208		12

Casing from	to feet	Diameter	Material	Drive Shoe
0	216	6	Steel	Y
0	16	10	null	N

GENERAL REMARKS:
EWELLS SUBMISSION

LITHOLOGY INFORMATION:

From 0 to 8 Ft. Medium GRAVEL AND SILTY SANDY brown

From 8 to 14 Ft. Medium GRAVEL ZONE WOOD brown

From 14 to 72 Ft. Medium GRAVEL, SANDY LOOSE brown

From 72 to 110 Ft. Medium SAND,SILTY. SILT LAYERS AND GRAVEL LAYERS brown

From 110 to 144 Ft. Medium SAND CLEAN, LOOSE brown

From 144 to 156 Ft. Medium GRAVEL WB,COARSE CLEAN brown

From 156 to 209 Ft. Medium SAND MED FINE WB,CLEAN brown

From 209 to 216 Ft. Medium SAND,SILTY WB,FINE brown

- Return to Main
- Return to Search Options
- Return to Search Criteria

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☒ Well Construction Report ☐ Well Closure Report ☐ Well Alteration Report

RED WILLIAMS WELL DRILLING LTD 980 PRATT ROAD QUALICUM BEACH BC. V9K 1W5 250-248-5552

Ministry Well ID Plate Number: 26019
Ministry Well Tag Number: _____
☐ Confirmation/alternative specs. attached
☐ Original well construction report attached

Red lettering indicates minimum mandatory information. **See reverse for notes & definitions of abbreviations.**

Owner name: BRIAN TONER
Mailing address: P.O. BOX 624 Town CAMPBELL RIVER Prov. BC Postal Code V9W 5T
Well Location: Address: Street no. 8050 Street name GOLD RIVER HIGHWAY Town CAMPBELL RIVER
(or) Legal description: PROPOSED STRATA Lot 1 Plan _____ D.L. _____ Block _____ Sec. _____ Twp. _____ Rg. _____ Land District _____
(or) PID: _____ (and) Description of well location (attach sketch, if nec.): _____

NAD 83: Zone: 10 (see note 2) (and) UTM Easting: 330012 m UTM Northing: 5541724 m (or) Latitude (see note 3): _____ Longitude: _____

Method of drilling: ☒ air rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ excavating ☐ other (specify): _____
Orientation of well: ☒ vertical ☐ horizontal Ground elevation: 652 ft (asl) Method (see note 4): GPS · ACCURACY 27'
Class of well (see note 5): WATER SUPPLY Sub-class of well: DOMESTIC.
Water supply wells: indicate intended water use: ☒ private domestic ☐ water supply system ☐ irrigation ☐ commercial or industrial ☐ other (specify): _____

Lithologic description (see notes 7-14) or closure description (see notes 15 and 16)

From ft (bgl)	To ft (bgl)	Relative Hardness	Colour	Material Description (Use recommended terms on reverse. List in order of decreasing amount, if applicable)	Water-bearing Estimated Flow (USgpm)	Observations (e.g., fractured, weathered, well sorted, silty wash), closure details
0	3		BROWN	FILL		
3	5		BROWN	ORGANIC		
5	6		BROWN	SILT AND GRAVEL		
6	200			GRANITE		
				FRACTURE @ 150' - 1GPM		
				FRACTORE @ 160' - 1.5 GPM		
				FRACTURE @ 180' - 1.5 GPM		
				FRACTURE @ 200' - 2.0 GPM		
				ESTIMATED YIELD 6.0 AT TIME OF DRILLING		

Casing details

From ft (bgl)	To ft (bgl)	Dia in	Casing Material / Open Hole	Wall Thickness in	Drive Shoe
+2	16	6	STEEL	219	NO

Screen details

From ft (bgl)	To ft (bgl)	Dia in	Type (see note 18)	Slot Size

Surface seal: Type: BENSEAL CLAY GROUT Depth: 16 ft
Method of installation: ☒ Poured ☐ Pumped Thickness: _____ in
Backfill: Type: _____ Depth: _____ ft
Liner: ☐ PVC ☐ Other (specify): _____
Diameter: _____ in Thickness: _____ in
From: ____ ft (bgl) To: ____ ft (bgl) Perforated: From: ____ ft (bgl) To: ____ ft (bgl)

Intake: ☐ Screen ☐ Open bottom ☐ Uncased hole
Screen type: ☐ Telescope ☐ Pipe size
Screen material: ☐ Stainless steel ☐ Plastic ☐ Other (specify): _____
Screen opening: ☐ Continuous slot ☐ Slotted ☐ Perforated pipe
Screen bottom: ☐ Bail ☐ Plug ☐ Plate ☐ Other (specify): _____
Filter pack: From: ____ ft To: ____ ft Thickness: _____ in
Type and size of material: _____

Developed by:

☐ Air lifting ☐ Surging ☐ Jetting ☐ Pumping ☒ Bailing
☐ Other (specify): _____ Total duration: 1.0 hrs
Notes: _____

Well yield estimated by:

☒ Pumping ☐ Air lifting ☐ Bailing ☐ Other (specify): _____
Rate: 7.0 USgpm Duration: _____ hrs
SWL before test: _____ ft (btoc) Pumping water level: _____ ft (btoc)

Obvious water quality characteristics:

☐ Fresh ☐ Salty ☒ Clear ☐ Cloudy ☐ Sediment ☐ Gas
Colour/odour: _____ Water sample collected: ☐

Well driller (print clearly):

Name (first, last) (see note 19): THOMAS WILLIAMS
Registration no. (see note 20): WD 06102703
Consultant (if applicable; name and company): _____

DECLARATION: Well construction, well alteration or well closure, as the case may be, has been done in accordance with the requirements in the *Water Act* and the Ground Water Protection Regulation.
Signature of Driller Responsible per Thomas Williams

Final well completion data:

Total depth drilled: 200 ft Finished well depth: 200 ft (bgl)
Final stick up: 24 in Depth to bedrock: _____ ft (bgl)
SWL: _____ ft (btoc) Estimated well yield: 7.0 USgpm
Artesian flow: _____ USgpm, or Artesian pressure: _____ ft
Type of well cap: SIMPLE Well disinfected: ☒ Yes ☐ No
Where well ID plate is attached: TOP OF CASING

Well closure information:

Reason for closure: _____
Method of closure: ☐ Poured ☐ Pumped
Sealant material: _____ Backfill material: _____
Details of closure (see note 17): _____

POSTED

Date of work (YYYY/MM/DD):

Started: 2008/05/13 Completed: 2008/05/13
Comments: _____

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction, alteration or closure, as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works, which may change over time.

white: Customer copy
canary: Driller copy
pink: Ministry copy

BRITISH COLUMBIA

Report 1 - Detailed Well Record

	Construction Date: 2008-05-13 00:00:00
Well Tag Number: 98020	
	Driller: Red William's Drilling
Owner: TONER	Well Identification Plate Number: 26019
	Plate Attached By: THOMAS WILLIAMS
Address: 8050 GOLD RIVER HIGHWAY	Where Plate Attached: TOP OF CASING
Area: CAMPBELL RIVER	PRODUCTION DATA AT TIME OF DRILLING:
	Well Yield: 7 (Driller's Estimate) U.S. Gallons per Minute
WELL LOCATION:	Development Method: Air lifting
Land District	Pump Test Info Flag: N
District Lot: Plan: Lot:	Artesian Flow:
Township: Section: Range:	Artesian Pressure (ft):
Indian Reserve: Meridian: Block:	Static Level:
Quarter:	
Island: VANCOUVER ISLAND	WATER QUALITY:
BCGS Number (NAD 83): 092K004112 Well:	Character:
	Colour:
Class of Well: Water supply	Odour:
Subclass of Well: Domestic	Well Disinfected: Y
Orientation of Well: Vertical	EMS ID:
Status of Well: New	Water Chemistry Info Flag: N
Licence General Status: UNLICENSED	Field Chemistry Info Flag:
Well Use: Private Domestic	Site Info (SEAM):
Observation Well Number:	
Observation Well Status:	Water Utility:
Construction Method:	Water Supply System Name:
Diameter: inches	Water Supply System Well Name:
Casing drive shoe: N	
Well Depth: 200 feet	SURFACE SEAL:
Elevation: 652 feet (ASL)	Flag: Y
Final Casing Stick Up: 24 inches	Material: Bentonite clay and cement mixture
Well Cap Type: SIMPLE	Method: Poured
Bedrock Depth: feet	Depth (ft): 16 feet
Lithology Info Flag: Y	Thickness (in):
File Info Flag: N	Liner from To: feet
Sieve Info Flag: N	
Screen Info Flag: N	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe
0	16	6	Steel	N

GENERAL REMARKS:
GPS ACCURACY 27 FEET. ESTIMATED YIELD 6 AT TIME OF DRILLING.

LITHOLOGY INFORMATION:

From 0 to 3 Ft. FILL brown

From	3	to	5	Ft.	ORGANIC	brown
From	5	to	6	Ft.	SILT & GRAVEL	brown
From	6	to	200	Ft.	1 Gallons per Minute (U.S./Imperial) FRACTURES AT 150' - 1 GPM, 160' - 1.5 GPM, 180' - 1.5 GPM, 200' - 2.0 GPM.	

- Return to Main
- Return to Search Options
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Appendix C
GHD Field Investigations

Appendix C GHD Field Investigations

This appendix presents an overview of the field investigation activities completed as part of the Updated Hydrogeology and Hydrology Characterization Report (Main Report).

Hydrogeologic field investigations, completed at the Site between August 2015 and April 2017, included a biological assessment of the area south and east of Site, test pitting, borehole advancement, monitoring well installation, monitoring well development, single well response testing (SWRT), hydraulic monitoring, and water quality sampling.

Field investigations were completed in accordance with the BC MOE "Field Sampling Manual for Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples (2013)" and GHD's standard operating procedures (SOPs) included in Appendix D of the Main Report.

Borehole Advancement

In 2014, prior to GHD beginning investigation activities at the Site, a series of boreholes and monitoring wells were completed by Red Williams Well Drilling Ltd. (Red Williams). Using air rotary drilling techniques, Red Williams advanced three boreholes on Site to depths ranging from 10.97 to 21.63 metres (m) below ground surface (BGS). Each of the boreholes was completed as a monitoring well (MW1-14, MW2-14, and MW3-14).

Drilling services during the GHD field investigations were provided by Blue Max Environmental Drilling Inc. of Vancouver, BC (Blue Max) in 2015 and 2017 and by Drillwell of Vancouver Island, BC (Drillwell) in 2016 and 2017.

Under the direction of GHD, Blue Max provided drilling services using a sonic drill rig for the advancement of five boreholes between August 5 and August 7, 2015. The 2015-series boreholes ranged in depths from 8.23 to 28.96 mBGS. BH5-15 was abandoned prior to encountering groundwater or bedrock due to equipment limitations. The remaining four boreholes were completed as two monitoring well nests (MW4A/B-15 and MW5A/B-15).

Blue Max provided drilling services using a combination of hollow stem auger and odex drill rigs for the advancement of one borehole on February 22, 2017. The borehole was advanced to a depth of 18.80 mBGS and was completed as a single monitoring well (MW8-17).

Under the direction of GHD, Drillwell provided drilling services using a sonic drill rig for the advancement of three boreholes on January 27 and 28, 2016 (BH1-16, BH2-16, and MW2A-16) and three boreholes on March 14, 15 and 22, 2017 (MW6-17, MW7-17, and MW9-17). Drillwell provided drilling services using a combination of sonic and air rotary drills for the advancement of one borehole between March 23 and 27, 2017 (MW10-17). Boreholes were advanced to depths ranging from 5.03 to 47.85 mBGS. Of the seven total boreholes advanced by Drillwell, two were completed as boreholes (BH1-16 and BH2-16) while the remaining five were completed as monitoring wells (MW2A-16, MW6-17, MW7-17, MW9-17 and MW10-17).

Soil samples from the 2015, 2016, and 2017 boreholes were collected using sonic sample tubes or split spoons with the exception of MW10-17. MW10-17 was drilled using a sonic drill rig and collecting sonic sample tubes to a depth of 36.59 mBGS. Due to difficult drilling conditions the remaining depth to 47.85 mBGS was drilled using an air rotary rig and stratigraphy was logged based on resurfaced cuttings.

Samples were classified and described by a GHD geologist and were used to generate stratigraphic and instrumentation logs for each drill location.

During the 2016 borehole advancement work, five soil samples were collected between the three locations for grain size analysis. Three samples were collected from MW2A-16 and single samples were collected from BH1-16 and BH2-16. The results are discussed in the overburden geology section of the main report).

The locations of each of the boreholes and monitoring wells advanced as part of the Site characterization are shown on Figure 1.4. Monitoring well completion details are summarized in Table 1.0. Details of the stratigraphy encountered during borehole advancement are presented on the Stratigraphic and Instrumentation Logs included as Appendix F of the Main Report.

Test Pit Excavation

On March 23 and 24, 2017, nine test pits were excavated by Upland with GHD oversight along the western Site boundary and on the adjoining K&D site (located immediately west of Site). Test pits were excavated to depths ranging between 0.61 and 6.40 mBGS. Each of the test pits were excavated with the intent of confirming the thickness of overburden materials and, where possible, confirming the depth to the bedrock surface. Bedrock was encountered in four of the nine test pits at depths ranging from 0.61 to 5.49 mBGS. Samples were collected and classified by a GHD geologist and were used to generate stratigraphic logs for each test pit location.

The locations of the test pits are shown on Figure 2.8. Details of the stratigraphy encountered during test pit excavation are presented on the Stratigraphic and Instrumentation Logs included as Appendix F of the Main Report.

Monitoring Well Installations

Monitoring wells (MW2A-16, MW4A-15, MW4B-15, MW5A-15, MW5B-15, MW6-17, MW7-17, MW8-17, MW9-17 and MW10-17) 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 with at least 1 m of hydrated granular bentonite to create an impermeable seal above the well screen. The remaining annular space was filled with a mix of cuttings and bentonite powder to a depth of 1 to 2 mBGS where a surface seal of hydrated bentonite chips was placed to 0.5 mBGS. The monitoring wells were completed with above ground steel protective casings that were concreted in place.

Well completion details and locations are provided in Table 1.0 and Figure 1.4 respectively.

Well Development

Monitoring well development was completed on September 11, 2015 at MW1-14, MW2-14, MW3-14, MW4A/B-15 and MW5A/5B-15, on January 28, 2016 at MW2A-16, on March 15, 2017 at MW7-17 and MW9-17, and on April 3, 2017 at MW6-17 and MW10-17. Monitoring well development was completed using dedicated Waterra tubing, footvalves, and surge blocks. During well development, the footvalve and surge block were positioned at different intervals in the screen to ensure that the entire length of the screen was properly surged. Well development continued until groundwater was considered stabilized (6 to 10 well volumes removed) and discharge was relatively free of suspended materials. The monitoring

wells that went dry during development (MW5A/B-15, MW6-17, and MW7-17) were pumped dry for a second time prior to sample collection.

Single Well Response Tests

On September 18, 2015, GHD performed hydraulic conductivity testing in three monitoring wells to determine the characteristics of the sand and gravel within the primary flow zone and fractured bedrock unit (the hydrogeologic units are described in more detail in Section 3.0 of the Main Report). GHD completed single well response tests (SWRTs or slug tests) on monitoring wells MW4A/B-15 and MW5A-15. SWRTs were completed in accordance with GHD's SOPs, which are described in Appendix D of the Main Report.

Prior to each SWRT, GHD measured and recorded static water levels, removed all dedicated sampling equipment (tubing etc.), and installed a Solinst Levelogger pressure transducer. GHD field staff then used a slug constructed from a solid cylinder of PVC to displace the static water level within the monitoring well. Following this near instantaneous change in static water level, measurements of the recovery of water levels to near static levels (at least 90 percent of the total initial displacement) were recorded by the pressure transducer. Manual water level measurements were also recorded with an electronic water level tape to validate the pressure transducer measurements.

GHD analyzed the results of the SWRTs using the computer based software, AQTESOLV© (v. 4.01) and the Bouwer-Rice rising head test solution (Bouwer-Rice, 1976). The Bouwer-Rice method provides a solution for determining the hydraulic conductivity of an unconfined aquifer.

Based on the results of these tests, the hydraulic conductivity of the sand and gravel unit within the primary flow zone is estimated to be 2.0×10^{-2} cm/sec (measured at MW4B-15) and the hydraulic conductivity of the fractured bedrock unit is estimated to be 2.2×10^{-2} cm/sec at MW4A-15. Hydraulic conductivity of the bedrock at MW5A-15 is estimated to be 1.4×10^{-5} cm/sec.

A large difference in hydraulic conductivity is noted when comparing the results of the SWRTs at MW4A-15 and MW5A-15. This difference is interpreted to be due to a difference in rock quality or the degree of fracturing in the rock at these locations. MW5A-15 is located on the eastern flank of a ridge of competent bedrock while MW4A-15 is located in the central portion of the Pit (discussed in more detail in the Main Report).

Both wells were completed within the upper shallow bedrock; however, less fracturing was noted in the bedrock at MW5A-15 at the time of drilling. Several fractures and a low rock quality designation (RQD) were noted by GHD field staff in the bottom of MW4A-15 (see Appendix F of the Main Report). The increased fracturing at MW4A-15 results in a higher hydraulic conductivity in the shallow bedrock aquifer in the vicinity of MW4A-15.

The calculated hydraulic conductivities for each monitoring well are included in Table 2.0. Single well response plots generated by AQTESOLV are provided in Appendix G of the Main Report.

Hydraulic Monitoring

Groundwater

GHD measured depth to groundwater at all existing groundwater locations on September 11, September 17, October 5, 2015, January 25, 2016 and March 15, and April 6, 2017. In addition, water levels at the private domestic well 98020, MW2-14 and MW2A-16 were monitored on February 15, 2016.

All depth to groundwater levels were measured using electronic water level tapes. The depth to water levels and calculated groundwater elevations are summarized in Table 2.0.

Surface Water

McIvor Lake surface water elevations are based on records made by BC Hydro at Ladore Dam located approximately 1.9 km northwest of the Site.

In order to provide the most accurate snapshot of hydraulic conditions at the Site, the BC Hydro records from the closest time period (date and time of day) were used to compare against the groundwater and Rico Lake hydraulic monitoring results. It is important to note that McIvor Lake is fed by a number of large freshwater lakes which results in generally consistent surface water elevations. The generally consistent water levels are shown on Table 2.0 which includes McIvor Lake elevations recorded on January 29, 2016, March 15, 2017 and April 6, 2017.

Rico Lake water elevations are based on surface water gauge readings. GHD installed a surface water gauge on the east side of Rico Lake and surveyed the reference elevation using laser level survey equipment on January 29, 2016. Rico Lake gauge readings were recorded on January 29, 2016, March 15, 2017 and April 6, 2017.

For additional verification, both McIvor Lake and Rico Lake water levels were directly surveyed by Upland on March 8, 2016 and April 6, 2016. Results of this survey verification were consistent with McIvor Lake water elevations from BC Hydro and Rico Lake gauge measurements.

All surface water elevations are summarized in Table 2.0. The results of the hydraulic monitoring program were used to determine the groundwater flow direction, vertical and horizontal hydraulic gradients, and the hydraulic relationship between the groundwater and surface water in the vicinity of the Site.

Surveying

Groundwater Monitoring Well Surveying

Monitoring wells installed in 2014, 2015 and 2016 were surveyed on January 29, 2015, March 8, 2016 and April 6, 2016 by Upland, as indicated on Table 1.0.

The surveys noted above were conducted to a Site specific vertical datum. In order to compare the on-Site surface features to off-Site surface features surveyed by others, such as McIvor Lake and the Quinsam River, a datum adjustment was required. McElhanney was retained by Upland to complete a comparison survey of the Site specific datum to the Canadian Geodetic Vertical Datum of 1928. This survey was completed on April 6, 2016. Using the McElhanney survey data, a vertical adjustment of 17.3 metres was applied to the Site specific datum. The updated elevation data which is included in this report is the Canadian Geodetic Vertical Datum of 1928 (CGVD28). The horizontal datum used for all surveys is the North American Datum of 1983 (NAD83) and the coordinates are UTM Zone 10 North

Monitoring wells installed in 2017 were surveyed on March 16 and 31, 2017 by McElhanney. To ensure consistency with previous surveys, elevations reference the CGVD28, and coordinates reference the NAD83 horizontal datum.

Surface Water Surveying

McIvor Lake and Rico Lake water levels were directly surveyed to verify the accuracy of the gauge readings (Rico Lake) and BC Hydro data (McIvor Lake). Water levels of McIvor Lake and Rico Lake were

surveyed on March 8, 2016 and April 6, 2016 by Upland and were consistent with gauge readings and BC Hydro data.

Test Pit Surveying

All nine test pits along the western property boundary and on the adjoining K&D property immediately west of Site were surveyed by McElhanney on March 31, 2017.

Topographic Survey

McElhanney was retained by Upland to complete a topographic survey of the Site on November 21, 2016. The updated topographic survey information was used to create the Site Plan, Figure 1.1 of the Main Report, and subsequent figures presented in this updated Report.

Groundwater and Surface Water Sampling

Groundwater and surface water samples were collected from the existing monitoring network on September 17 and 18, 2015, October 5 and 6, 2015 and April 6 and 7, 2017. Select monitoring locations were sampled on January 29, 2016 (wash plant) and February 15, 2016 (MW2-14, MW2A-16 and private domestic well RW-98020)

Groundwater Sample Collection

Purging and sampling groundwater was completed using low-flow techniques during the September 2015 monitoring event at MW4A-15 and MW4B-15, and during the October 2015 monitoring event at MW4A-15, MW4B-15, MW5A-15, and MW5B-15. Low-flow techniques utilizing a peristaltic pump and dedicated tubing were necessary at these groundwater monitoring locations because sample analysis included polycyclic aromatic hydrocarbons (PAHs), volatile organic carbons (VOCs) and hydrocarbons which require low turbidity values for analysis. All other monitoring locations were purged and sampled with inertial sampling techniques using dedicated Waterra tubing and a footvalve.

Prior to groundwater sample collection, GHD purged the monitoring wells until field parameters stabilized indicating that the groundwater in the monitoring well was representative of the groundwater in the aquifer within the screened portion of the well. Field parameters were measured using a Horiba water quality multi-meter. Groundwater monitoring locations that went dry during purging were purged dry and a sample was collected the following day. Wells that characteristically purge dry are MW5A-15, MW5B-15, and MW6-17.

Groundwater samples collected for dissolved metals analysis were field filtered using dedicated filters. All samples were collected using laboratory-supplied bottles which were provided with the appropriate preservative(s) for each type of sample. All samples were given unique sample identification, packaged in an ice-chilled cooler, and submitted under chain-of-custody protocol for analytical testing.

Surface Water Sample Collection

Surface water samples were collected from McIvor Lake, Rico Lake and the third settling pond of the on-Site wash plant (chosen to represent wash plant surface water quality). Surface water samples were collected by directly dipping laboratory supplied sampling containers approximately 0.15 m below the water surface with the sample bottles completely submerged when possible to eliminate the collection of floating debris.

Field parameter measurements were recorded using a Horiba water quality multi-meter. The meter was submerged directly in the surface water body and allowed to stabilize prior to recording the field

parameters. In order to avoid disturbing any sediment, field readings were collected after water quality sample collection was complete.

Surface water samples designated for dissolved parameters that could not be field filtered were collected unfiltered and delivered to the laboratory as soon as possible for filtration prior to analysis. All surface water samples were given unique sample identification, packaged in an ice-chilled cooler, and submitted to the analytical laboratory under chain-of-custody protocol for analytical testing.

Sample Analysis

Analytical services were provided by Maxxam Analytics (Maxxam), located in Burnaby, BC. Maxxam is accredited by the Canadian Association for Laboratory Accreditation (CALA) to perform the analytical tests required for this assessment. Analytical results were sent directly to GHD. Laboratory reports generated for each of the monitoring events are included in Appendix H of the Main Report.

Quality Assurance/Quality Control

In order to ensure adequate quality control for water monitoring samples, the following quality assurance/quality control (QA/QC) practices were employed:

- Field QA/QC samples were collected and analyzed to facilitate data validation. A groundwater duplicate and surface water duplicate were collected per sampling event and analyzed as part of the sampling program.
- Data validation was completed by a GHD chemist to assess laboratory and field QA/QC and determine if the data exhibited acceptable levels of accuracy and precision.

Data Quality Assessment and Validation results are presented in Appendix I of the Main Report. Validation of the data was based on information obtained from the chain-of-custody forms, field sample keys, analytical data, field duplicate analytical data, and recovery data for laboratory control samples and surrogate spikes.

Overall the data have acceptable levels of accuracy and precision and are suitable for their intended use with the noted qualifiers.

References

BC MOE (formally Ministry of Water, Land and Air Protection -Water, Air and Climate Change Branch), 2013. Field Sampling Manual for Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples.

Bouwer, H. and R.C. Rice, 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells.

Appendix D
GHD Standard Operating Procedures

Appendix D GHD Standard Operating Procedures

Table of Contents

1. Overview of Drilling Program Standard Operating Procedures 5

1.1 Introduction 5

1.2 Background 5

1.3 Planning and Preparation 6

1.4 Safety and Health 6

1.5 Quality Assurance/Quality Control 7

1.6 Equipment Decontamination 7

1.7 Location and Marking of drilling locations/Final Visual Check 8

1.8 Drilling Methods 9

2. Soil Sampling Standard Operating Procedures 11

2.1 Introduction 11

2.2 Sampling Methods 11

2.2.1 Surficial Soil Sampling 11

2.2.2 Borehole Installation and Sampling 12

2.2.3 Test Pit Excavation and Sampling 12

2.2.4 Grab Versus Composite Samples 13

2.3 Planning and Preparation 13

2.4 Safety and Health 14

2.5 Quality Assurance/Quality Control 15

2.6 Equipment Decontamination 15

2.7 Procedures for Soil Classification 16

2.7.1 Coarse Grained Soils 18

2.7.2 Fine-Grained Soil 19

2.8 Procedures for Surficial Soil Sampling 21

2.8.1 Background 21

2.8.2 Random, Biased, and Grid-Based Sampling 22

2.8.3 Sample Interval 22

2.8.4 Procedures for Surficial Sampling 22

2.9 Procedures for Borehole Installation and Sampling 25

2.9.1 Location and Marking of Drill Sites/Final Visual Check 25

2.9.2 Sample Collection 26

2.9.2.1 Split-Spoon Samplers 28
2.9.2.2 Split-Spoon Samples 30
2.9.3 Communication of Field Findings 31
2.9.4 Borehole Abandonment 31
2.9.5 Borehole Tie-In/Surveying 32
2.9.6 Field Notes 32
2.10 Procedures for Test Pit Excavation and Sampling 33
2.10.1 Location and Marking of Test Pits/Final Visual Check 33
2.10.2 Test Pit Location Setup 34
2.10.3 Sample Collection 34
2.10.4 Sample Description and Logging of Test Pits 35
2.10.5 Documentation 36
2.10.6 Test Pit Abandonment 36
2.10.7 Restoration 36
3. Monitoring Well Design and Construction Standard Operating Procedures 36
3.1 Introduction 36
3.2 Background 37
3.3 Planning and Preparation 38
3.4 Safety and Health 39
3.5 Quality Assurance/Quality Control 40
3.6 Equipment Decontamination 40
3.7 Location and Marking of Well Installation Sites/Final Visual Check 41
3.8 Drilling Methods 41
3.9 Well Design Considerations 43
3.9.1 Well Materials 43
3.9.1.1 PVC Well Materials 43
3.9.1.2 Metallic Well Materials 44
3.9.2 Well Diameter 44
3.9.3 Screen Length and Placement 44
3.9.4 Well Slot Size 45
3.9.5 Sand Pack Sizing 45
3.9.6 Well Sealing 45
3.10 Field Procedures for Well Installations 46
3.10.1 Installation Requirements 46
3.10.2 Annular Space 46
3.10.3 Instrumentation Details 46
3.10.4 Filter Pack Placement 47
3.10.5 Bentonite Seal 48
3.10.6 Grouting 48
3.10.7 Protective Casings 49

3.10.8 Protective Posts 50
3.11 Well Construction Techniques 50
3.11.1 Well Installation 50
3.11.2 Bedrock Wells 52
3.12 Well Installation Documentation 53
3.13 Well Development 54
3.13.1 Waterra™ (Surge Block) 54
3.13.2 Surge Block 54
3.13.3 Pumping/Overpumping/Backwashing 55
3.13.4 Bailing 55
3.13.5 Airlifting 55
3.14 Well Development Documentation 55
4. Water Sampling
(Groundwater, Residential, and Surface Water)
Standard Operating Procedures 56
4.1 Introduction 56
4.2 Background figure57
4.3 Planning and Preparation 58
4.4 Safety and Health 59
4.5 Quality Assurance/Quality Control 60
4.6 Equipment Decontamination 60
4.6.1 Purge Water and Decontamination Fluid Disposal 61
4.7 Field Procedures for Groundwater Sampling 62
4.7.1 Well Identification and Inspection 62
4.7.2 Water Level Monitoring/Well Depth Sounding 63
4.7.3 Well Volume Calculation 64
4.7.4 Well Purging and Stabilization Monitoring 65
4.7.4.1 Typical Method 65
4.7.4.2 Purging Entire Water Column 66
4.7.4.3 Low-Flow Purging (LFP) Technique 66
4.7.4.4 Sampling Techniques 68
4.7.4.5 Order of Sample Collection 68
4.7.5 Sample Acquisition and Transfer 69
4.7.5.1 Sample Labels/Sample Identification 69
4.7.6 Purging/Sampling Equipment 70
4.7.6.1 Peristaltic Pumps 70
4.7.6.2 Inertia Pumps 71
4.7.6.3 Bailers 71
4.7.7 Filtering of Groundwater Samples 72

4.8 Field Procedures for Residential Sampling 72
4.8.1 General 72
4.8.2 Field Procedures 72
4.8.3 Field Notes for Residential Sampling 74
4.9 Field Procedures for Surface Water Sampling 74
4.9.1 General 74
4.9.2 Surface Water Sample Location Selection 74
4.9.2.1 Lakes, Ponds, and Impoundments 75
4.9.3 Sampling Equipment and Techniques 75
4.9.4 Field Notes for Surface Water Sampling 76
5. Fluid Level Monitoring Standard Operating Procedures 78
5.1 Introduction 78
5.2 Background 79
5.3 Planning and Preparation 80
5.4 Safety and Health 81
5.5 Quality Assurance/Quality Control 81
5.6 Equipment Decontamination 82
5.6.1 Decontamination Fluid Disposal 82
5.7 Field Procedures for Groundwater/Residential/Leachate Fluid Level Monitoring 83
5.7.1 Well Identification and Inspection 83
5.7.2 Reference Point 84
5.7.3 Water Level Monitoring/Well Depth Sounding 84
5.7.3.1 Electrical Water Level Indicators 85
5.7.3.2 Tape/Plopper 86
5.7.3.3 Interface Probe 86
5.8 Field Procedures for Surface Water Fluid Level Monitoring 87
5.8.1 Surface Water Location Identification and Inspection 87
5.8.2 Reference Point 87
5.8.3 Surface Water Level Monitoring 88
6. Aquifer Hydraulic Testing Standard Operating Procedures 88
6.1 Introduction 88
6.2 Safety and Health 89
6.3 Quality Assurance/Quality Control 89
6.4 Equipment Decontamination 90
6.5 Single-Well Response Tests Standard Operating Procedures 90
6.5.1 Background 90
6.5.2 Prior Planning and Preparation 92
6.5.3 Field Procedure 93

1. Overview of Drilling Program Standard Operating Procedures

1.1 Introduction

Drilling programs are conducted to characterize geologic and hydrogeologic conditions at a site. Standard Operating Procedures (SOPs) are presented herein for completing a variety of drilling activities.

This guideline is not intended to provide the basis for a drilling program, but instead assumes that a scope of work for the completion of a drilling program has been designed, a site-specific Work Plan has been established, and that a GHD representative is preparing to mobilize to the site.

Drilling programs vary from project to project due to different geologic and hydrogeological conditions, chemicals of concern, different guidance provided by the state/province where the site is located, and the specific objectives of the project (i.e., soil sampling, hydraulic monitoring, groundwater sampling, aquifer testing). It is essential that all drilling activities conform to local, provincial/state, and federal regulations. Therefore, it is essential that the GHD representative carefully review the Work Plan requirements. The primary goal of a drilling program is the advancement of boreholes in a variety of geologic and hydrogeologic conditions, to complete the specific objectives of the project. It is imperative that appropriate drilling techniques are chosen. There are advantages and disadvantages to each drilling method discussed herein.

The remainder of this section is organized as follows:

- Section 4.2 Background
- Section 4.3 Planning and Preparation
- Section 4.4 Safety and Health
- Section 4.5 Quality Assurance/Quality Control
- Section 4.6 Equipment Decontamination
- Section 4.7 Location and Marking of Well Sites/Final Visual Check
- Section 4.8 Drilling Methods
- Section 4.9 Drilling Program Follow-up Activities
- Section 4.10 References

1.2 Background

A significant portion of GHD's field activities relates to sampling and investigative activities that involve subsurface drilling. This typically requires GHD to contract or subcontract with a drilling firm to penetrate the ground for sample collection or well installation using a variety of drilling methods. Drilling methods selected are based on the geologic conditions at the site, scope of drilling program, and cost effectiveness of the drilling method.

All drilling programs require that geologic conditions be documented accurately at each site. Therefore, all GHD employees involved in drilling activities shall have specific training in the following Field Training SOPS:

1. Soil Sampling SOPs (Section 5.0).
2. Monitoring Well Design and Construction SOPs (Section 6.0).

3. Bedrock Drilling and Rock Description SOPs (Section 9.0) (required for bedrock drilling).

1.3 Planning and Preparation

Preparation for a drilling program requires that a number of setup and logistical activities be completed:

1. A fully approved drilling contractor from GHD's Approved Vendor List (QSL-004) should be used to complete all drilling program activities. If a drilling contractor is not listed or is only technically approved on QSL-004, then the Vendor must submit a completed QSF-030 (Canada) or QSF-031 (U.S.) to the Regional Safety and Health Manager for approval prior to mobilization to the site. A Vendor Evaluation Form (QSF-012) must be filled out and filed in the Project file for any Vendors that do not have full approval status or are not listed on QSL-004.
2. Initiate a Property Access Utility Clearance Sheet (QSF-019) to ensure utility clearance and property access have been granted.
3. Complete a Field Equipment Requisition Form (QSF-014) and assemble all equipment, materials, log books, and forms.
4. If necessary, contact GHD's Chemistry group to arrange/determine:
    - SSOW (Simplified Scope of Work)
    - glassware/sample jars
    - cooler
    - shipping details
    - start date
    - laboratory
    - expected sampling duration

1.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.

- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently, and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

1.5 Quality Assurance/Quality Control

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 3.9.

1.6 Equipment Decontamination

Prior to use and between each drilling location, drilling and sampling equipment must be decontaminated in accordance with the Work Plan, the Quality Assurance Project Plan (QAPP), or at a minimum, the methods presented in the following section.

The minimum wash procedures for decontamination of drilling or excavating equipment are:

1. High pressure hot water wash (brushing as necessary to remove particulate matter).
2. Potable, hot water, high pressure rinse.

Cover the clean augers with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where no contaminants are present, it is sufficient to clean the drilling or excavating equipment simply by removing the excess soils.

On environmental sites, soil sampling equipment (e.g., split spoons, trowel, spoons, shovels, bowls) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.

2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

In addition, the following steps may be added when sampling for volatile organic compounds (VOCs) and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (e.g., pesticide grade isopropanol, methanol, acetone, hexane).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap equipment in aluminum foil to prevent contamination.

> Caution: Confirm the cleaning protocol from the QAPP. The use of an incorrect cleaning protocol can invalidate chemical data.

1.7 Location and Marking of drilling locations/Final Visual Check

The proposed drilling locations marked on the site plan are located and staked in the field. On most sites, this should be completed several days prior to the drill rig arriving on site. Drilling locations are required for the completion of utility locates. Generally, drilling locations are strategically placed to assess site geologic and hydrogeologic conditions.

Once the final drilling location has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds to confirm the locations of adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

When possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. This is particularly important in limited space sites where wells are being installed close to buried utilities. Alternatively, a Hydrovac truck (air knife) can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

> Caution: Do not assume that site plan details regarding pipe alignment/position are correct. Visually inspect pipe alignment when advancing boreholes near sewers. Be prepared to find additional piping if outdated plans are being used. If possible confirm pipe locations with on-site employees or a client representative.

Drilling locations are selected primarily to provide a good geographical distribution across the site. Most often, the drilling locations specified in the Work Plan are not pre-verified to confirm clearance from underground or overhead utilities, nor to consider the site's specific characteristics (e.g., traffic patterns, drainage patterns). Consequently, it is the Field Supervisor's responsibility to perform the following:

1. Select the exact location of each drilling location with the site and project requirements.
2. If drilling must be relocated, confirm the new location's suitability with the Project Coordinator.
3. Ensure all utilities have been cleared prior to initiating any drilling activities.

To the extent practical, drilling locations should be located adjacent to permanent structures (e.g., fences, buildings) that offer some form of protection and a reference point for future identification. Drilling in high traffic areas or road allowances or low-lying wet areas are undesirable, but may be unavoidable.

> Field tie-ins must be completed to accurately identify each drilling location. These will ensure that the drilling locations are properly identified on plans and for future identification in the field.

1.8 Drilling Methods

The following drilling methods are listed in order of preference. However, final selection will based on site geologic and hydrogeologic conditions. During drilling activities, it is required that detailed descriptions of the site geologic conditions be documented. Therefore, GHD personnel shall have completed all required SOPs related to drilling programs as indicated in Sections 4.2.

Hollow-Stem Augering

Continuous flight hollow-stem augering (HSA) is the most frequently used method of borehole advancement. Its primary advantages are:

1. Generally, no additional drilling fluids are introduced into the formation.
2. Representative geologic samples can be obtained easily using split-spoon samplers in conjunction with the standard penetration test (SPT) and HSA.
3. A monitoring well can be installed through the auger, eliminating the need for a temporary borehole casing.

Information regarding split-spoon sampling is discussed in Section 5.0.

HSAs are available with an inside diameter of 2.5, 3.25, 4.25, 6.25, 8.25, and 10.25 inches (6.4, 8.3, 10.8, 15.9, and 26.0 cm). Some drilling contractors have inside diameter HSAs as large as 16.25 inches (41.3 cm). The most commonly used inside diameter is 4.25 inch for the installation of a 2-inch (5 cm) diameter monitoring well. Larger diameter HSAs, including 6.25, 8.25, and 10.25 inch (10.8, 15.9, 26.0 cm), are used for large diameter monitoring or extraction wells ranging in size from 4 to 8 inches (10 to 20 cm). Boreholes can usually be advanced to depths of about 100 feet (30 m) with an HSA in unconsolidated clays, silts, and sands. However, HSAs cannot typically advance far into consolidated bedrock.

Installation of a well through a HSA is a simple process, but precautions need to be taken to ensure that well construction, particular sealing, is properly completed.

Removing a HSA from flowing sand may be difficult since the auger has to be removed without rotation, if at all possible. A bottom plug or pilot bit assembly should be used to keep out soils and water that have a tendency to fill the bottom of the HSA during drilling. If flowing sands are encountered, potable water

(analyzed for contaminants of concern) may be added into the HSA to equalize the hydrostatic pressure, which will keep the formation materials and water from flowing into the HSA once the plug or pilot bit is removed. As well, all introduced water must be removed prior to groundwater sampling from a monitoring well, typically three times the introduced volume should be removed.

Direct-Push Drilling

Direct-push refers to the sampler being 'pushed' into the soil material without the use of drilling to remove the soil. This method relies on the drill unit static weight, combined with rapid hammer percussion, to advance the tool string. Discrete soil samples are continuously obtained. The direct-push method is popular due to the limited cuttings produced and the speed of the sampling process, which can be much faster than the sample description and sample preparation process.

Groundwater and vapor samples can also be collected utilizing this method and appropriate tooling. Subsurface investigations typically sample to depths of 30 feet (9.1 m) or more; however, depth will vary based on the site-specific geology.

This method is used extensively for initial site screening to establish site geology and delineate vertical and horizontal plume presence. Small diameter wells (3/4 inch or 1 inch [2 cm or 2.5 cm])can be installed using direct-push methods, however the installation of these wells may be regulated or disallowed by state, provincial, or local installation regulations.

SPT values cannot be obtained when sampling with a direct-push discrete soil sampler.

Discrete continuous soil samples are collected in tube samplers typically 4 or 5 feet long (1.2 to 1.5 m) affixed with a cutting shoe and internal liner (PVC, Teflon, or acetate are available). The soil sampler may be operated in "open-mode" (when borehole collapse is not a concern), or in "closed-mode" (when minimization of sample "slough" is desired). Closed-mode operation involves placement of a temporary drill-point in the cutting shoe and driving the assembled sampler to depth. At the required depth, the temporary drill–point is released (via internal threading) and the sampler is driven to the desired soil interval. The drill-point slides inside the sample liner, riding above the collected soil column. Once driven to depth, the sampler is retrieved to the ground surface and the sample liner, with soil, is removed for examination.

Rotosonic Drilling

This method consists of a combination of rotation and high frequency vibration to advance a core barrel to the desired depth. Once the vibration is stopped, an outer casing is advanced to the same depth and the core barrel is retrieved and the sample is vibrated or hydraulically extracted into a plastic sleeve or sample tray. The well is installed through an outer casing. Rotosonic drilling generally requires less time than more traditional methods and continuous, relatively undisturbed samples can be obtained through virtually any formation. Conventional sampling tools can be employed as attachments (e.g., hydropunch, split spoon, Shelby tube). No mud, air, water, or other circulating medium is required, although limited amounts of water are usually introduced to lubricate the drill string. The main limitation of this method is the availability of equipment.

Rotary Method

This method consists of a drill rod attached to a drill bit (for soils, a tricone or drag bit; for rock, a button studded or diamond studded bit) that rotates and cuts through the soils and rock. The cuttings produced are forced to the surface between the borehole wall and the drill rod by drilling fluids that generally consist of water or drilling mud, or air. The drilling fluid or air not only forces the cuttings to the surface but also

keeps the drilling bit cool. Using the rotary method can be difficult as it requires several steps to complete the installation. First, the borehole is drilled, then temporarily cased, then the well is installed, and then the temporary casing is removed. In some cases, the borehole may remain open without installing a casing (e.g., cohesive soils or bedrock).

Air Rotary (typically used in rock)

When using the air rotary method, the air compressor must have an in-line oil filter system assembly to filter the compressor oil mixed with the air coming from the compressor. This helps eliminate the introduction of contaminants into the formation. The oil filter system needs to be regularly inspected. An air compressor with no in-line oil filter system is not acceptable for air rotary drilling. A cyclone velocity dissipater or similar air containment system must also be used to funnel the cuttings to one location rather than allowing them to blow uncontrolled out of the borehole. Air rotary may not be an acceptable method for well installation where certain contaminants are present in the formation. Alternatively, it may be necessary to provide treatment for the air being exhausted from the borehole during the installation process.

2. Soil Sampling Standard Operating Procedures

2.1 Introduction

Soil sampling is conducted to characterize the physical and/or chemical conditions at a site. Standard Operating Procedures (SOPs) are presented herein for obtaining a variety of soil samples for physical and chemical analyses, including:

- Surficial soil samples (soil between ground surface and 6 to 12 inches (15 to 30 cm) below ground surface)
- Subsurface samples that require borehole installation
- Test pit excavations

This guideline is not intended to provide the basis for designing a soil sampling program, but instead assumes that a soil sampling program has been designed, a Work Plan has been established, and the sampling team is preparing to mobilize to the field.

Soil sampling procedures vary from project to project due to different parameters of concern, different guidance provided by the state/province where the site is located, or the specific objectives for the project. Therefore, it is essential that the sampling team members carefully review the Work Plan. The primary goal of surface soil sampling is to collect representative samples for examination and chemical analysis (if required).

2.2 Sampling Methods

2.2.1 Surficial Soil Sampling

Surficial soil sampling is less frequently used than subsurface soil sampling (which involves borehole installation). Typically, surficial soil sampling is used when a large site is being assessed and the extent of contamination is unknown. In this case, surficial sampling is helpful in identifying the location of surface releases (e.g., historical spills of hydrocarbons) that may have contributed to subsurface contamination. A

surficial soil sampling program is also recommended for sites with suspected atmospheric deposition of contaminants (e.g., stacks), areas of surface spills, or recent spills.

Surficial soil sampling is used when contamination is known to be restricted to the surficial region of the soil stratum. Thus, surficial sampling can be useful at brownfield sites, where it is necessary to determine if soils are contaminated with specific contaminants of concern (e.g., metals) as part of a purchaser's due diligence. Surficial soil sampling can also be required when obtaining data in order to perform a site-specific risk assessment.

For the purposes of this section, the surficial soil is considered to be the 0- to 6-inch (0 to 15 cm) soil horizon.

Samples are collected from areas where surficial soil contamination is known or suspected. Samples from a particular depth increment must not be mixed with soil from other depths. Soil horizons displaying different properties should be sampled separately, since they may behave very differently with respect to contaminant accumulation and movement.

2.2.2 Borehole Installation and Sampling

A significant portion of GHD's field activities involve borehole installation.

Several manual methods are available for the collection of shallow subsurface soil samples (e.g., hand augers, post-hole augers). However, the most common methods used by GHD to advance boreholes are a drill rig equipped with continuous flight hollow-stem augers (HSAs) and split-spoon samplers, or a direct-push drilling unit equipped with solid tube soil samplers.

2.2.3 Test Pit Excavation and Sampling

Test pits are typically excavated to explore and define geologic conditions (or buried waste/debris) and to allow the collection of subsurface soil samples for geotechnical or chemical analysis. Test pits give a more complete view of the subsurface soil conditions than soil borings. Test pits are excavated using either a rubber-tired backhoe or track-mounted excavator, and can extend 10 to 15 feet (3.0 to 4.6 m) below ground surface.

The use of test pits for investigation is determined on a site-specific basis. Experience from past projects has identified the following issues:

1. The nature and extent of contamination which may be encountered may be unknown. The Site-specific Health and Safety Plan (HASP) and Job Safety Analysis (JSA) must be specific to the level of Personal Protective Equipment (PPE); this may be Level A or B.
2. Waste materials, including drums, may be encountered. A plan must be in place specifying how this material will be handled.
3. Air emissions of some compounds may occur. A plan must be in place to ensure that employees and the public are adequately protected.
4. Community relations concerns may exist (e.g., workers in chemically protective "moon suits"). A notification plan may be required.
5. All underground utilities must be located utilizing documentation using the GHD Subsurface Clearance Protocol.

2.2.4 Grab Versus Composite Samples

A grab sample is collected to identify and quantify compounds at a specific location or interval. The sample is comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample analyses. Composite samples are a mixture of a given number of sub-samples and are collected to characterize the average composition in a given surface area.

Samples to be analyzed for volatile organic compounds (VOCs) are always collected as grab samples. Mixing of soil samples to create a composite is not performed. Mixing of soil samples results in partial volatilization of VOCs from the soil, and thus compromises the integrity of the composite soil sample.

2.3 Planning and Preparation

The following activities are required prior to undertaking a soil sampling program:

1. Review the Work Plan, project documents, and health and safety requirements with the Project Coordinator.
2. Complete a Field Equipment Requisition Form (QSF-014) and assemble all equipment, materials, log books, and forms. Form SP-02 (Project Planning, Completion, and Follow-Up Checklist) should be used for guidance throughout the project. Borehole Installation/Soil Sampling Equipment and Supply Checklist (Form SP-12) provides a summary of the typical equipment/materials required for soil sampling. Drilling/Well Construction Checklist (Form SP-13) provides a listing of pre-planning and site activities that is designed as an aid to preparing and completing the project.
3. Obtain a site plan and any previous stratigraphic logs. Determine the exact number, location, and depths of samples to be collected.
4. Complete a Vendor Evaluation Form (QSF-012) and file in the project file for any vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work; QSF-031 for U.S. work) is necessary for all vendors who complete field services. Prior to mobilization on site, the vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
5. Contact GHD's Chemistry Group to arrange/determine:
    - SSOW (simplified Scope of Work)
    - Glassware/sample jars
    - Cooler
    - Shipping details
    - Start date
    - Laboratory
    - Expected sampling duration
6. Initiate a Property Access/Utility Clearance Data Sheet (QSF-019), if necessary. In most instances, surface sampling activities do not require utility clearances.
7. Determine notification needs with the Project Coordinator. Have the regulatory groups, client, landowner, GHD personnel, and laboratory been informed of the sampling event?

8. Determine the methods for handling and disposal of wash waters and spent decontamination fluids.

In addition to the above, the following may be required when conducting a borehole or test pit program:

1. Establish a water source for drilling and decontamination activities. Pre-plan the methods for handling and disposal of drill cuttings, wash waters, and spent decontamination fluids.
2. Arrange with driller to provide paraffin wax, melting pot, and heat source (if required).

2.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule implications.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the HASP is specific to the job and approved by a Regional Safety and Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A JSA for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety and Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure the equipment is in good working order.
- Maintain all required PPE, safety equipment, and instrumentation necessary to perform the work effectively, efficiently, and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the client's) safety requirements.

2.5 Quality Assurance/Quality Control

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 3.9.

2.6 Equipment Decontamination

Borehole Installation and Sampling

Prior to use and between each borehole location at an environmental site, the drilling and sampling equipment must be decontaminated in accordance with the Work Plan or the methods presented in this section.

The minimum wash procedures for decontamination of drilling or excavating equipment are:

1. High pressure hot water detergent wash (brushing as necessary to remove particulate matter).
2. Potable, hot water, high pressure rinse.

Cover the clean augers with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where contaminants are not present, it is sufficient to clean the drilling or excavating equipment simply by removing the excess soils.

On environmental sites, the soil sampler equipment (split spoons, trowel, spoons, shovels, bowls) are typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

In addition, the following steps may be added when sampling for VOCs and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap split-spoon samplers in aluminum foil to prevent contamination.

Caution: Check the Quality Assurance Project Plan (QAPP) to confirm the cleaning protocol. Use of incorrect cleaning protocol could invalidate chemical data.

2.7 Procedures for Soil Classification

This SOP for Soil Classification is not intended to provide complete training in soil classification. Soil Classification will require additional training and experience.

Criteria and procedures for soil classification and description include:

1. A standard method of describing the soil by name and group symbol.
2. Standard field identification methods based on visual examination and manual tests on representative soil samples by a qualified GHD representative for interpretation of subsurface conditions at the site.
3. Verifying field description descriptions through the inspection.
4. Confirming descriptive information by laboratory determination of selected soil characteristics if required in the Work Plan.
5. Factual overburden stratigraphic logs completed by GHD personnel responsible for interpreting the subsurface conditions at the site and review/confirmation of soil descriptions by the Project Coordinator.

The overburden stratigraphic log is the factual description of the soil at each borehole location and will be relied on to interpret soil characteristics at the site. The overburden stratigraphic log will also be used to interpret the soil characteristics' influence and significance on the subsurface environment. GHD personnel responsible for interpreting the subsurface conditions at the site will also verify overburden stratigraphic log accuracy. If practical, the Project Coordinator, Geologist, or Geotechnical Engineer should confirm the soil descriptions and examine representative soil samples.

Describing and classifying soils is a skill that is learned through experience and by systematic training using laboratory results of soil composition in comparison to field descriptions.

Attendance at a soil identification course provided by GHD is mandatory.

Descriptions for natural undisturbed soils are recorded on a Stratigraphy Log (Overburden) (Form SP-14).

Soil descriptions are completed in the following order:

1. Unified Soil Classification System (USCS) group symbol(s) (e.g., SM) of primary soil components or dual or borderline symbols.
2. Name and adjective description of primary, secondary, and minor grain size components.
3. Relative density for non-cohesive soils or consistency for cohesive soils.
4. Gradation and soil structure for non-cohesive soils or structure and plasticity for cohesive soils.
5. Color.
6. Moisture content.
7. Other physical observations including presence of staining and or odors.

When describing observed odors, be as specific as possible to classify general odor category and strength of odor. Odors are generally chemical, petroleum, or septic related, varying from slight to moderate to strong. Identification of specific chemical compounds (i.e., benzene, gasoline) is not necessary and is often inaccurate as detailed chemistry commonly shows an array of chemicals present.

When describing vegetative matter presence in soils, do not use the term organic. The use of the term organic often leads to confusion regarding the presence of organic chemicals (i.e., VOCs, semi-volatile organic compounds [SVOCs]). Similarly, as noted above, use more specific terms for odors than organic.

The description of fill soils is similar to those used to describe native undisturbed soils. Fill soils will be identified as fill (i.e., SP/GP-Sand and Gravel [Fill]). To determine if soils are fill, look for evidence that the soil has been artificially placed (e.g., brick fragments, slag, glass, wood fragments). Relative or inconsistent soil density can also assist in determining if soils are fill, along with irregular soil structure.

Soils are identified and grouped consistently to determine subsurface pattern or changes and non-conformities in the soil stratigraphy. The stratigraphy of each soil boring or test pit is compared to ensure that patterns or changes in soil stratigraphy are noted and that consistent terminology is used.

Visual examination, physical observation, and manual tests (based on ASTM D2488, Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]) are used to aid in classifying and grouping soil samples in the field. These procedures are described in the following subsection. ASTM D2488 should be reviewed for detailed explanations of the procedures. (Note that the related ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System] uses slightly different percentages of soil components.) Visual-manual procedures used to aid in soil identification and classification include:

1. Visual determination of grain size, soil gradation, and percentage of various soil components to the nearest 5 percent (i.e., gravel, sand, silt, and clay).
2. Dry strength, dilatancy, toughness, and plasticity tests (i.e., thread or ribbon test) for identification of inorganic fine-grained soils (e.g., CL or CH [clays], and ML or MH [silts]).
3. Soil compressive strength and consistency estimates based on thumb indent and or pocket penetrometer (preferred) methods.

The three main soil divisions are:

1. Coarse-grained soils (e.g., sand and gravel)
2. Fine-grained soils (e.g., silts and clays)
3. Soils with high natural organic and vegetative matter content (e.g., peat, marl)

These soil divisions are presented in the table of USCS classifications below.

Major Division			Group Symbol	Typical Description
Coarse grained soils more than 50% retained on No. 200 sieve	Gravel more than 50% of coarse fraction retained on No. 4 sieve	clean gravel <5% fines	GW	well graded gravel, gravel-sand mixtures
			GP	poorly graded gravel, gravel-sand mixtures
		gravel with >15% fines	GM	silty gravel, gravel-sand-silt mixtures

Major Division			Group Symbol	Typical Description
			GC	clayey gravel, gravel-sand-clay mixtures
	Sand more than 50% of coarse fraction passes No. 4 sieve	clean sand <5% fines	SW	well graded sand, fine to coarse sand, gravelly sand
			SP	poorly graded sand
		sand with >15% fines	SM	silty sand, sand-silt mixtures
			SC	clayey sand, sand-clay mixtures
Fine grained soils more than 50% passes No. 200 sieve	Silt and Clay liquid limit <50, low plasticity	inorganic	ML	Inorganic silt
			CL	Inorganic clay
		organic	OL	organic silt, organic clay
				silt of high plasticity, elastic silt
	Silt and Clay liquid limit ≥50, high plasticity	inorganic	MH	clay of high plasticity, fat clay
			CH	organic clay, organic silt, low plasticity
		organic	OL	organic clay, organic silt, high plasticity
			OH	
Highly organic soils			Pt	peat

2.7.1 Coarse Grained Soils

The USCS symbols for coarse-grained soil are primarily based on grain size, grain size distribution (gradation), and percent of fines (silt and clay content).

Grain size classification used for describing soils is in terms of particle size and sieve size (e.g., gravelly sand, trace silt). Coarse-grained soil is composed of more than 50 percent by weight, sand size, or larger (75 μm diameter, No. 200 sieve size). Note that there are other definitions for coarse-grained or coarse textured soil and for sand and for sand size as soil having greater than 70 percent particles equal to or greater than 50 μm diameter (after "Guidelines for Contaminated Sites in Ontario") or 60 μm diameter ("Canadian Foundation Manual").

The percentage descriptors for soil components are different for coarse-grained versus fine-grained soils. The following are the percentage component descriptors for coarse-grained soils:

Noun (e.g., sand, gravel)	Major Component
Adjective (e.g., silty, clayey, sandy, gravelly)	Greater than 15%
With (e.g., with silt, with clay, with sand, with gravel)	5% to 15%
Trace (e.g., trace silt, trace clay, trace sand, trace gravel)	<5%

Grain size distribution of coarse-grained soils includes:

- Poorly graded (i.e., soil having a uniform or predominantly one grain size, SP and GP)
- Well graded (i.e., poorly sorted soils with a wide range of particle sizes with substantial percentage of intermediate sizes, SW and GW)

- Dirty (i.e., soil having greater than 15 percent fines, SM, SC, GM, and GC)

Coarse-grained soils are further classified based on the percentage of fine-grained soils (e.g., silts and clays) they contain. Coarse-grained soils containing greater than 15 percent fine-grained soils are described with an adjective (e.g., silty [SM, GM], clayey [SC, GC]). This description is attributed to soil particles that adhere when the soil sample is rubbed between the hands or adhere to the sides of sample jars after shaking, or rolling in the jar. The jar shake test will also result in the segregation of sand and gravel particles and can be used as a visual aid in determining sand and gravel content percentages.

Examples of the group symbol, name, and adjectives used to describe the primary, secondary, and minor components of soil are:

- GW - Sandy Gravel (e.g., 70 percent gravel and 30 percent sand, well graded)
- GW - Sandy Gravel-trace silt (less than 5 percent silt, well graded)
- SP - Sand (a uniform sand, predominantly one sand grain size)
- SM - Silty Sand, with clay (sand with greater than 15 percent silt, and 5 to 15 percent clay)

Relative density is important in establishing the engineering properties and behavior of coarse-grained soils. Relative density of non-cohesive (coarse-grained) soils is determined using the standard penetration test (SPT) blow counts (N-values) in accordance with ASTM D1586. A detailed discussion of the SPT and N values can be found in Section 5.9.2.1.

The SPT provides reliable indications of the relative density of sand and fine gravel. N-values in coarse-grained soil are influenced by a number of factors that result in overestimated relative densities. For example, in coarse-grained gravel, dilatent silty fine sands, sand below the water table and uniform coarse sand, N-values tend to be conservative and under estimate the relative density. The Project Geotechnical Engineer will assess these effects, if required.

Other methods, such as modified SPT and cone penetration tests, are used on occasion to supplement or replace the SPT method for certain site-specific conditions. All modifications to the SPT or substitute methods must be recorded as required to interpret test results and correlate relative density.

2.7.2 Fine-Grained Soil

A fine-grained soil is made up of more than 50 percent silt and clay (i.e., fines greater than 50 percent by weight passing the 75 μm (No. 200) sieve size). Description of visual-manual field methods and criteria to further characterize and group fine-grained soil (e.g., CL, CH, ML, and MH) are discussed in ASTM D2488.

The percentage descriptors for components is different for fine-grained versus coarse-grained soils. The following are the percentage component descriptors for fine-grained soils:

Noun (e.g., silt, clay)	Major Component
Adjective (e.g., sandy, gravelly, silty, clayey)	Greater than 30%
With (e.g., with sand, with gravel, with silt, with clay)	15% to 30%
Few (e.g., few sand, few gravel, few silt, few clay)	5% to 15%
Trace (e.g., trace silt, trace clay, trace sand, trace gravel)	<5%

Further soil characterization tests include dry strength, dilatency, toughness, and plasticity (thread or ribbon test).

Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen crumbles into powder with finger pressure; specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in small wetted specimen when rapidly shaken in palm of hand.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing or stretching.

Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit; the thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit; the thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit; the thread and the lump have very high stiffness.

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit; the thread cannot be re-rolled after reaching the plastic limit; the lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit; the thread can be re-rolled several times after reaching the plastic limit; the lump can be formed without crumbling when drier than the plastic limit.

Examples of group symbol identification based on visual-manual procedures and criteria for describing fine grained soil are:

Group Symbol	Dry Strength	Dilatancy	Toughness	Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed	Slight
CL	Medium to high	None to slow	Medium	Low
MH	Low to medium	None to slow	Low to medium	Low
CH	High to very high	None	High	High

Positive classification by USCS group symbols as described in ASTM D2487, is through laboratory determination of particle size characteristics, liquid limit, and plasticity index. The need for laboratory testing will be determined by the Project Hydrogeologist, Geologist, or Geotechnical Engineer and will be detailed in the Work Plan. If no laboratory testing is performed to confirm soil classification, a statement of qualification (method used) is required for group symbols.

Examples of terminology that accompany the group symbols are:

- ML - Sandy Silt (e.g., 30 percent sand)
- CL - Clay (lean) with sand (e.g., 15 to 29 percent sand)

The USCS group symbols require the use of lean clay (CL) and fat clay (CH). The use of these symbols is dependent on the plasticity of the soil. Classification such as silty clay can only be used for a very narrow set of conditions, and will only be used if Atterberg Limit results are available. The lean and fat clay designations are not universally used, but adherence to the USCS requires that these symbols be used.

Correlation of N-values and consistency for clays is unreliable. Consistency determinations will be performed using more appropriate static test methods, especially for very soft to stiff clays. N-values are more reliable in hard clays.

Estimates of unconfined compressive strength (Su) can be obtained by a pocket penetrometer test. To estimate consistency and compressive strength with a pocket penetrometer, cut a minimum 4-inch (10 cm) soil core perpendicular to the soil core length. Hold the core with moderate confining pressure so as not to deform the soil core. Slowly insert the pocket penetrometer tip into the perpendicular face of the soil core until the pocket penetrometer indents the soil core to the mark indicated on the piston of the penetrometer. The pocket penetrometer estimate of the soil compressive strength (Su) is the direct reading of the value mark on the graduated shaft indicated by the shaft ring marker, or by the graduated piston reading at the shaft body. For average estimates, complete this procedure several times on the ends and middle of the soil core. For Shelby tube samples (or thin wall samplers), perform the pocket penetrometer test at several locations on the exposed ends of the sample.

In situ shear vane tests or other test methods provide better compressive strength estimates for very soft to stiff consistency clay soil.

Describing soil consistency is an important component in evaluating the engineering properties and strength characteristics of fine-grained cohesive soil. Consistency terms like soft and hard are based on the unconfined compressive strength (Su) and shear strength or cohesion (cu) of the soil.

Patterns of soil gas and groundwater movement in fine-grained soil are influenced by natural soil structure. Soil structure is dependent on the depositional method and to a lesser extent climate. The identification of fill soil is equally important in determining soil characteristics in fine-grained soils.

2.8 Procedures for Surficial Soil Sampling

This section provides a limited discussion on considerations for the design of a soil sampling program in order to provide the sampling team members with a basic understanding of those considerations.

2.8.1 Background

Soil sampling locations are selected in order to obtain representative soils with the minimum number of samples. Prior to conducting an investigation, a site inspection may eliminate many uncertainties with respect to site characteristics and result in a more complete soil sampling study. The site inspection

should identify pertinent features (e.g., rock outcrops, drainage patterns, surface runoff, surface cover characteristics (e.g., grass, gravel, concrete), wet areas, and fill areas) and evaluate the relationship between those features and potential sources of contaminants. An understanding of these relationships and conditions is important in developing a sampling plan.

2.8.2 Random, Biased, and Grid-Based Sampling

Unless there is a strong indication of contaminant presence, such as staining, soil sample locations may be randomly selected from several areas within the site, such as near obvious potential sources of current or historic contamination. Potential sources include large transformers, aboveground storage tanks (ASTs), mandoors, outdoor storage racks, and drainage swales.

If an area shows evidence of contamination, such as staining or vegetative stress, biased samples are collected from the area to characterize the contamination. Background and control samples are also biased, since they are collected in locations typical of non-site-impacted conditions.

When a soil sampling investigation involves a large area, grid-based soil sampling is performed. There is no single grid size that is appropriate for all sites. Common grid sizes are developed on 50- and 100-foot (15 to 30 m) centers. It is acceptable to integrate several different grid sizes in a single investigation.

For a surficial soil sampling program, it is also important to consider the presence of structures and drainage pathways that might affect contaminant migration. It is sometimes desirable to select sampling locations in low-lying areas which are capable of retaining some surface water flow since these areas could provide samples which are representative of historic site conditions (worst-case scenario if surface water flow is a concern).

2.8.3 Sample Interval

Surficial soil is generally considered to be soil between ground surface and 6 to 12 inches (15 to 30 cm) below ground surface. However, for risk assessment purposes, regulatory authorities often consider soil from ground surface to 2 feet (0.6 m) below ground surface to be surficial soil.

> Ontario regulations state that surficial soils are 0 to 6 inches (0 to 15 cm) below ground surface.

The exact interval to be considered as surficial soil is often a matter of discussion with the regulatory authorities that review the Work Plan. The sample interval is important to the sample collection method and to the manner in which the data are ultimately interpreted. Another important factor is the type of soil. If there are different types of soil present at the site, this may have a bearing on the sample interval. For example, it may be important to separately sample a layer of material with high organic carbon content which overlies a layer of fine-grained soil.

2.8.4 Procedures for Surficial Sampling

Soil sampling methods are dependent upon the sample interval of interest, the type of soil material to be sampled, and the requirements for handling the sample after retrieval. The most common method for collection of surficial soil samples is the use of a stainless steel trowel. Soil samples may also be collected with spoons and push tubes. Often a shovel is required to open a trench such that sampling can be conducted. Soil that has come in contact with the shovel cannot be used as sample material.

In all cases, the sampling device must be constructed of an inert material with smooth surfaces which can be easily decontaminated. The decontamination protocol employs a sequence of cleaning agents and

water designed to remove surface contaminants (refer to Section 5.6). All sampling equipment is cleaned between sample locations. A typical surficial soil sampling protocol is outlined below:

1. Collect surficial soil samples using a precleaned stainless steel trowel or other appropriate tool. Each sample consists of soil from the surface (or other starting depth) to the depth specified in the Work Plan. Sample in ditches only when there is no water present.
2. Use a new pair of disposable gloves at each sample location.
3. Prior to use, at each sample location, decontaminate all sampling tools as specified in the Work Plan or as described in Section 5.5.
4. Use a precleaned sampling tool to remove the sample from the layer of exposed soil. Place the collected soil directly into a clean, prelabeled sample jar and seal with a Teflon-lined cap. If a sample is to be split for duplicate analyses, first homogenize the soil in a precleaned stainless steel bowl.
5. After collection, place the samples on ice or cooler packs in a laboratory-supplied cooler.

Surficial debris (e.g., grass cover) should be removed from the area where the sample is to be collected using a separate precleaned device.

In the event that soil conditions are not as described in the Work Plan, or if there are unexpected distinct layers of soil present (e.g., a layer of high organic carbon content overlying a layer of fine-grained soil), sampling personnel should immediately report the conditions to the Project Coordinator for direction. Similarly, if a sampling location is in a gravel or paved area, sampling personnel should confirm with the Project Coordinator whether the surface samples are to be collected from the gravel/pavement subbase material or from the first layer of soil beneath these layers.

Also, sampling team members should immediately report any conditions to the Project Coordinator that they believe may have a negative effect on the quality of the results.

It is generally inadvisable to collect samples containing excessive amounts of large particles such as gravel. Gravel presents difficulties for the laboratory in terms of sample preparation and the results may not be truly representative of contaminant concentrations in nearby soil.

All conditions at the time of sample collection are properly documented in a field log book. This includes a thorough description of the sample characteristics including grain size, color, and general appearance; date/time of sampling; and labeling information. The location of the sampling point is described in words, and three measurements are taken from adjacent permanent structures so that, if necessary, the sample location can be readily identified in the field at a future date. It is often advisable to have a licensed land surveyor accurately survey the locations.

Soil samples are homogenized in a stainless steel bowl prior to filling sample containers. This step can be bypassed if only one sample container is required to be filled, as long as the laboratory will homogenize the sample upon receipt. It is important that soil samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample interval. When using a round bowl, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Fill the sample container completely, leaving no headspace.

Do not mix soil for samples for VOC analyses as this promotes the partial volatilization of compounds from the soil.

In 1997, EPA adopted new methods for sampling soils for VOC analysis. Method 5035 calls for collecting soil using a coring device (EnCore). For analysis of low level VOCs (typically 1 to 200 μg/kg), soil is sealed in a specially prepared vial with a solution of sodium bisulfate. For higher levels of VOCs, the soil is placed in a vial with a volume of methanol. This method increases the complexity of collecting soils and makes it imperative that the sampler and laboratory work closely together. For some soil sampling programs, multiple EnCores are required for each sample interval. The number of EnCores required per sample interval should be ascertained during the prior planning and preparation stage.

Discrete Grab Sampling Methodology for Surficial Soils

Discrete grab sampling is employed when the sampling location is considered to be a small area (approximately 1 square foot [0.1 square meter]) that has both a consistent soil type and a consistent level of contaminant impact.

When collecting a discrete grab surficial soil sample, use the following procedure:

1. Using the sampling device (e.g., trowel, spoon, Oakfield sampler) scoop soil from the top 2 inches (5 cm) into the sample container. If the sample is being collected for VOC analyses, perform this step as quickly as possible in order to minimize the loss of volatile compounds from the soil.
2. Collect a field screening sample from the same sampling location as the discrete grab sample and at the same time. Scoop soil into a zip-loc bag until it is no more than one quarter full.
3. Do not mix the soil for samples collected for VOC analyses (for sample homogenization purposes) as this will promote the loss of volatile compounds from the soil. The laboratory will obtain a representative sample from the container by using coring techniques before the laboratory analysis is performed.

Composite Sampling Methodology for Surficial Soils

A composite sample can be obtained directly from the soil surface by combining a number of discrete grab samples from a number of sampling locations on the soil surface. For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different sampling locations should have (by visual observation) similar contaminant concentrations.

When collecting a composite surface soil sample, use the following procedure:

1. Choose a number of discrete sampling locations that will give a representative sample of the defined composite area at each sampling location.
2. Using the sampling device (e.g., trowel, spoon), scoop the soil from the top 2 inches (5 cm) into the sample container. As much as practical, try to put approximately the same volume of soil from each sampling location into the container.
3. Move to the next sampling location and repeat steps 1 and 2.
4. Collect a maximum of five surface samples (to avoid the complete dilution of any hot spots).
5. When the last location has been sampled, ensure the sample container is filled with soil, leaving no headspace.
6. Since composite samples are used for semi-volatile organic compounds (SVOCs) and inorganic parameters, minimizing the sample collection time is not as important as when discrete samples for VOC analyses are being collected. However, the preferred practice is that the sampler take no longer than necessary to obtain the sample.

7. Collect a field screening sample from the same sampling location as the composite sample and at the same time. As much as practical, try to put approximately the same volume of soil from each discrete grab sampling location into a zip-loc bag. The zip-loc bag should be no more than one quarter full after all the sub-samples have been added.

Since composite samples are not analyzed for VOCs, there is no reason to avoid mixing the sub-samples from the various sampling locations in the sample container (homogenization). However, since the laboratory will use coring techniques to ensure that a sample is representative of the entire container, there is no need to perform field homogenization of the soil within the sample container.

During the sampling program, the sampling team leader will stay in contact with the GHD chemist assigned to the project such that the GHD chemist can properly inform the contract laboratory of the progress of the work. This includes submitting sample summaries and/or copies of completed chain-of-custody forms to the GHD chemist.

Finally, some GHD QAPPs require a designation of a QA/QC officer for field activities. The sampling team leader may be required to conduct certain field audit activities and, at minimum, should be familiar with and responsible for completion of all QA/QC sample activities.

2.9 Procedures for Borehole Installation and Sampling

Once the prior planning and preparation activities are completed, the drilling program can proceed. The typical series of events that takes place is:

1. Locating and marking boring locations.
2. Initiation of a Property Access/Utility Clearance Data Sheet (QSF-019), including obtaining appropriate signoffs by the client representative and drilling subcontractor representative.
3. Contractor mobilization; equipment and material check.
4. Site selection of decontamination pad and drum staging area (if applicable); final visual examination of proposed drilling area for utility conflicts.
5. Decontamination of sampling and drilling equipment prior to use in accordance with the Work Plan or as described in Section 5.6.
6. Borehole advancement utilizing the approved method as outlined in the Work Plan.
7. Soil sample collection; descriptions of the soil samples in accordance with GHD protocol.
8. Monitoring well installation (if applicable).
9. Sample preparation and packaging.
10. Abandonment of boreholes or installation of monitoring wells.
11. Collection of groundwater samples (if monitoring wells are installed).
12. Surveying of borehole location and elevations.
13. Field note completion and review.

2.9.1 Location and Marking of Drill Sites/Final Visual Check

The proposed borehole locations marked on the site plan are located in the field and staked. On most sites, this will likely be done several days in advance of the drill rig arriving on site. Unless boreholes are

to be installed on a fixed grid, the proposed locations are usually strategically placed to assess site conditions.

> Any borehole (and all the records thereof) which is completed with casing as a temporary or permanent monitoring well, will be designated by the monitoring well number only (i.e., MW1-yy). Boreholes drilled strictly as soil test borings in which no casing is set (even if an open-hole groundwater sample is collected) will be designated by the boring number only (i.e., BH1-yy).

Once the final location for the proposed boring has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds. This should confirm the locations of any adjacent utilities (subsurface or overhead) and verification of adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

If possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. Alternatively, a Hydrovac truck can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

> Caution: Do not assume site plan details regarding pipe alignments/position are correct. Visually check pipe position when drilling near sewers. Personnel should also be alert to additional piping presence if the plans are outdated.

If it is necessary to relocate a proposed borehole due to terrain, utilities, access, etc., the Project Coordinator must be notified and an alternate location will be selected.

2.9.2 Sample Collection

A boring is advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the Project Coordinator or Work Plan. Typically, the depth interval for sampling is 2.5 to 5 feet (0.75 to 1.5 m), or less in homogeneous strata, with at least one test and sampling location at every change of stratum. In some cases samples are taken continuously (i.e., 2-foot (0.6 m) long samples at 2-foot (0.6 m) intervals).

Collected soil samples are described in the field using the USCS (visual-manual procedure). The soil description is recorded on a Stratigraphic Log (Overburden) (Form SP-14) or field book in the following order:

1. USCS Soil Symbol of major component
2. Native or fill
3. Secondary and minor soil components
4. Relative densities/consistency
5. Grain-size/plasticity
6. Gradation/structure
7. Color
8. Moisture content

9. Observations of odor or visual chemical presence (i.e., non-aqueous phase liquid [NAPL])
10. Additional descriptions

For environmental sampling, always change gloves between collecting subsequent soil samples to prevent cross-contamination. Decontaminate all tools (e.g., samplers, spatulas) prior to use on each sample to prevent cross-contamination in accordance with the Work Plan or as described in Section 5.6.

Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler, and assures that the standard penetration test (SPT) or other sampling technique is performed on essentially undisturbed soil, is acceptable. The drilling method is selected based on the subsurface conditions. Each of the following methods has proven to be acceptable for specific subsurface conditions:

- HSA with inside diameter between 2.5 and 6.25 inches (5.7 to 15.9 cm)
- Solid stem auger (SSA) with auger diameter between 2.5 and 6.25 inches (5.7 to 15.9 cm)
- Direct-push (dual tube systems, discrete soil sample systems)
- Open-hole rotary drilling
- Wash boring

Several drilling methods are not acceptable. These include:

- Jetting through an open tube sampler and then sampling when the desired depth is reached.
- SSA use below the groundwater table in non-cohesive soils.
- Casing driven below the sampling depth prior to sampling.
- Advancing a borehole with bottom discharge bits.
- Advancing a boring for subsequent insertion of the sampler solely by means of previous sampling when performing SPT (the open hole must be larger in diameter than the split-spoon sampler).

Discrete Grab Sampling Methodology for Boreholes

When borehole drilling, the split-spoon sample retrieved from the borehole is considered a discrete grab sample that has been taken from one sampling location, as long as both the stratigraphy of the entire sample and the level of contamination are consistent over the length of the split-spoon sample. If a single split-spoon sample contains soils from two different stratigraphic units, the soils from each of these stratigraphic units are considered separate discrete grab samples.

If a single split-spoon sample contains soils from a single stratigraphic unit, but visual observation indicated that some of the soil was heavily impacted with contaminants, while the rest of the soil was only lightly impacted, then the soils representing each of the two levels of contamination are considered two separate discrete grab samples.

Composite Sampling Methodology for Boreholes

A composite sample is obtained by combining a number of discrete grab samples from the same borehole. For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different split-spoon samples should be from a single stratigraphic unit and have (by visual observation) similar contaminant concentrations (or be physically similar for geotechnical testing purposes).

Use the following methodology for preparing a composite sample from these discrete grab split-spoon samples:

1. Prior to collecting a sample of the soil for field vapor screening or chemical analysis, if smearing of soil is apparent on the outside of the soil core, scrape away the outer layer of the soil using a decontaminated putty knife, stainless steel spoon, or similar implement. This should only be performed if the soil core sample is consolidated. Do not use this procedure for unconsolidated soil samples.
2. Split the sample longitudinally along the length of the split-spoon sampler. Use one half of the core sample to prepare a composite sample to be used in soil headspace vapor screening measurements, and the other half to prepare a composite sample to be submitted to the laboratory for chemical analysis or geotechnical testing.
3. Place sub-samples from various sampling locations (i.e., split-spoon samples) into a zip-loc bag for field screening. As much as practical, attempt to place approximately the same volume of soil from each sampling location into the zip-loc bag.
4. For samples where labo , ratory analysis is also desired, place sub-samples from various sampling locations into the appropriate soil sample containers. As much as practical, attempt to place approximately the same volume of soil from each sampling location into the sample container.

The following subsections describe specific protocols for split-spoon sampling, Shelby tube sampling, and methods for collecting soil samples using a direct-push rig.

2.9.2.1 Split-Spoon Samplers

This method is used to obtain representative samples of subsurface soil materials and to determine a measure of the in situ relative density of the subsurface soils. The test methods described below must be followed to obtain representative samples.

SPT involves the use of split-barrel samplers (also known as split spoons). Split-spoon sampling is performed in accordance with ASTM D1586. The split-spoon sampler consists of an 18- or 24-inch (45 or 60 cm) long, 2-inch (5 cm) outside diameter tube, which comes apart lengthwise into two halves. An example of a split-spoon sampler is presented on Figure 5.1.

> A typical 2-inch (5 cm) outside diameter split-spoon is 1 3/8-inch (3.5 cm) diameter at the drive shoe and 1 1/2-inch (3.8 cm)diameter within the barrel of the split spoon. The volume of the soil in a completely filled 24-inch (61 cm) long split-spoon is approximately 19.8 oz (586 mL), thus the sample volume requirements are important if multiple types of parameters requiring differing analytical techniques are required (i.e., VOCs, SVOCs, metals, petroleum hydrocarbon compounds [PHC]). Soil recovery in a split spoon is often less than 24 inches (61 cm), resulting in less available volume.

Once the borehole is advanced to the target depth and cleared of cuttings, representative soil samples are collected in the following manner:

1. The split-spoon sampler is inspected to ensure it is properly cleaned and decontaminated. The driving shoe (tip) should be relatively sharp and free of severe dents and distortions.
2. The cleaned split-spoon sampler is attached to the drill rods and lowered into the borehole. Do not allow the sampler to drop onto the soil in the bottom of the borehole.

3. After the sampler has been lowered to the bottom of the hole, it is given a single blow to seat it and make sure that it is in undisturbed soil. If there still appears to be excessive cuttings in the bottom of the borehole, remove the sampler from the borehole and remove the cuttings.
4. Mark the drill rods in three or four successive 6-inch (15 cm) increments, depending on sampler length, so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-inch (15 cm) increment.

The sampler is then driven continuously for either 18 or 24 inches (45 or 60 cm) by use of a 140-pound (63.5 kg) hammer. The hammer may be lifted and dropped by either the cathead and rope method, or by using a trip, automatic, or semi-automatic drop system. The hammer should free-fall a distance of 30 inches (±1 inch) (75 cm, ±25 mm) per blow. Measure the drop at least daily to ensure that the drop is correct. To ensure a free-falling hammer, no more than 2 1/4 turns of the rope may be wound around the cathead (see ASTM D1586). The number of blows applied in each 6-inch (15 cm) increment is counted until one of the following occurs:

1. A total of 50 blows have been applied during any one of the 6-inch (15 cm) increments described above.
2. A total of 100 blows have been applied.
3. There is no advancement of the sampler during the application of ten successive blows of the hammer (i.e., the spoon is 'bouncing' on a stone or bedrock).
4. The sampler has advanced the complete 18 or 24 inches (45 or 60 cm) without the limiting blow counts occurring as described above.

In some cases where the limiting number of blow counts has been exceeded, GHD may direct the driller to attempt to drive the sampler more if collection of a greater sample length is essential, as long as the sampler is still being advanced.

On the field form, record the number of blows required to drive each 6-inch (15 cm) increment of penetration. The first 6 inches (15 cm) is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches (15 cm) of penetration is termed the "standard penetration resistance" or the "N-value".

If the borehole has sloughed and there is caved material in the bottom, the split spoon may push through this under its own weight, but now the spoon is partially 'pre-filled'. When the spoon is driven the 18 or 24 inches (45 or 60 cm) representing its supposedly empty length, the spoon fills completely before the end of the drive interval. Three problems arise:

1. The top part of the sample is not representative of the in-place soil at that depth.
2. The SPT value will be artificially higher toward the bottom of the drive interval since the spoon was packed full. These conditions should be noted on the field log.
3. The available sample volume is significantly reduced.

The sampler is then removed from the borehole and unthreaded from the drill rods. The open shoe (cutting end) and head of the sampler are partially unthreaded by the drill crew and the sampler is transferred to the geologist/engineer work surface.

A table made out of two sawhorses and a piece of plywood is appropriate, or a drum, both covered with plastic sheeting.

The open shoe and head are removed by hand by the drill crew or GHD representative, and the sampler is tapped so that the tube separates.

Handle each split spoon with clean disposable gloves if environmental samples are being collected from that split-spoon sample.

Measure and record the length of sample recovered making sure to discount any sloughed material that is present on top of the sample core.

Caution must be used when conducting split-spoon sampling below the groundwater table, particularly in sand or silt. These soils tend to heave or "blow back" into the HSA due to the difference in hydraulic pressures between the inside of the HSA and the undisturbed soil. To equalize the hydraulic pressure, it may be necessary to fill the inside of the HSA with potable water from a reliable and pre-tested source. Drilling mud is uncommonly used and presents problems for sample collection and well development. The water level within the boring or HSA needs to be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling. Since heave or blow back is not always obvious to the driller, it is essential that the water level in the borehole always be maintained at or above the groundwater level. Split-spoon sampling below the water table in sands and silt occasionally results in non-representative samples being collected due to the heaving effect disturbing the soil. This is particularly important if the water level in the hole has not been maintained at the in situ water level.

Heaving conditions and the volume of potable water used should be noted on a Stratigraphic Log (Overburden) (Form SP-14). The volume of water added must be removed during well development prior to groundwater sampling. This practice may not be acceptable if environmental samples are to be collected.

Suspected low N-values should be noted on the field logs. If it is critical to have accurate N-values below the water table, other methods can be employed, such as conducting a dynamic cone penetration test. This quick and easy test involves attaching a cone shaped tip to the end of the drill rods, and driving the tip into the ground similar to the split-spoon method, except that the borehole is not pre-augered. Cones may be driven 20 to 40 feet (6.1 to 12.2 m) through a formation without augering. Blow counts are recorded for each 1 foot (0.3 m) of advancement. Consult the Project Manager if such conditions are unexpectedly encountered.

A 3-inch (7.5 cm) outside diameter split spoon is available in order to obtain larger sample volumes. However, the SPT values from driving this sampler are typically much higher than those for the 2-inch (5 cm) split spoon.

2.9.2.2 Split-Spoon Samples

1. Following completion of PID screening of the split spoon, remove and dispose of soil at the top of the sample that is obviously sloughed material not representative of the soil at the sampled depth.
2. Measure the length of the sample and record as the recovered length.
3. If cohesive, perform a pocket penetrometer reading and describe the soil.

4. Carefully transfer the sample onto a sheet of aluminum or tin foil, taking care to maintain structure and bedding of the soil sample as much as possible. This may not be possible with non-cohesive soils with low silt or clay contents. The sample may need to be packaged in three 6- to 8-inch (15 to 20 cm) segments.
5. Roll the sample in the tin foil and fold over the ends to seal. Wrap in a second layer of tin foil.
6. Identify the top, middle, and bottom segments with a T, M, and B using an indelible marker.
7. For each segment record the "up" direction with an arrow.
8. Place the foil wrapped sample in a plastic bag and write the sample identification on the bag using an indelible marker. Storing the sample in foil, as opposed to a jar, has the advantage of retaining the soil's in-place structure and preventing loss of moisture.
9. If the soils are sandy and it is not possible to retain the soils structure by rolling it in tin foil, packaging the sample in a jar or zip-loc bag is also acceptable, provided the jar or zip-loc bag is filled to eliminate air space which could result in the soil sample drying out.

A split-barrel sample is approximately 4 inches (10 cm) in diameter and requires different handling than a split-spoon or Shelby tube sample. For a cohesive core sample, the section of drill core is wrapped in several layers of cheesecloth, coated with paraffin wax, and the process repeated until the entire sample is sealed adequately. These samples are usually utilized for specific bench-scale tests.

2.9.3 Communication of Field Findings

Field findings should be communicated frequently with the office technical staff responsible for the program. This communication allows the office staff to: confirm that the investigation meets the intent of the Work Plan; alter procedures and sampling protocol if soil conditions are markedly different from those assumed; and assist in determining screening intervals for piezometers or monitoring wells.

Call office staff no later than the completion of the first borehole, and sooner if possible. Be prepared to discuss the results by faxing the field logs beforehand (wherever possible) and by having a copy of the field log in hand when on the telephone. Call after each borehole and call before leaving the site.

2.9.4 Borehole Abandonment

Following completion of the borehole it must be properly abandoned in accordance with the project documents. Some jurisdictions have requirements or standards of practice that require filling the borehole with bentonite or cement grout.

> The integrity of any underlying confining layer must be restored to prevent chemical cross-contamination or hydraulic cross-connection. This is true for all sites, regardless of the known presence or absence of contaminants. This normally requires grouting of the borehole within the zone of the confining layer.

Whenever possible, the cuttings are returned to the borehole to within 1 foot (0.3 m) of the ground surface. The remainder of the borehole is topped off with material consistent with the surrounding ground surface. Excess cuttings are usually collected in drums or a lugger box or spread on the surrounding ground surface consistent with the protocols specified in the Work Plan and as required by federal, state, provincial, and local regulations.

Check with the Project Coordinator to determine the method for handling drill cuttings.

Always include the method of abandonment in the field log book or on a Stratigraphic Log (Overburden) (Form SP-14)

2.9.5 Borehole Tie-In/Surveying

Recording the locations of boreholes on the site plan is extremely important, and may be accomplished by manual measurement (i.e., swing ties) and surveying. Manual measurements for each borehole must be tied into three permanent features (e.g., buildings, utility poles, hydrants). Include diagrams with measurements in the field book.

In addition to manual measurements, surveying with respect to a geodetic benchmark and a site coordinate system is often completed at larger sites for horizontal and vertical control.

Manual field measurements are always necessary regardless of whether a survey is completed.
Manual measurements in field notes allow future identification of the sample/drill site without the need for a survey crew to locate positions using a grid system. This becomes important when trying to locate flushmount wells buried by snow or soils.

2.9.6 Field Notes

Field notes must document all the events, equipment used, calibration activities, and measurements collected during the sampling activities. The field notes must be legible and concise such that the entire borehole installation and soil sampling event can be reconstructed for future reference.

Field notes documenting events, equipment used, and related items are typically recorded in a standard GHD field book, while soil descriptions and PID readings are recorded on a Stratigraphic Log (Overburden) (Form SP-14). Standard GHD field books are available from all GHD equipment administrators. Form SP-14 is available as a printable linked document in this file or as a bound pad from each office.

Use a Stratigraphic Log (Overburden) for recording all soil descriptions and related notes unless otherwise approved by the Project Coordinator/Manager.

Field book/form entries are made in black ink and any changes/corrections are stroked out with a single line, initialed, and dated to indicate when and by whom the correction was made.

The field notes should document the following for each borehole completed:

1. Identification of borehole
2. Depth
3. Static water level depth and measurement technique
4. Time started and completed
5. Measured field parameters
6. Sample appearance
7. Sample odors (if respiratory protection is not required)
8. Types of sample containers and sample identification numbers

9. Parameters requested for analysis
10. Field analysis data and method(s)
11. Sample distribution and transporter
12. Laboratory shipped to
13. Chain-of-custody number for shipment to laboratory
14. Field observations on sampling event
15. Name of collector(s)
16. Climatic conditions including air temperature
17. Problems encountered and any deviations made from the established sampling protocol

2.10 Procedures for Test Pit Excavation and Sampling

Once the prior planning and preparation activities are completed, the test pit excavation and subsurface soil sampling program can proceed. The typical series of events which takes place is:

1. Location and marking of test pit locations
2. Final visual examination of proposed excavation area for utility conflicts
3. Excavation of test pits and collection of the soil samples
4. Field screening of soil sample with specific air monitoring equipment (e.g., PID, LEL meter)
5. Description of soil sample and test pit
6. Completion of Test Pit Stratigraphy Log (Form SP-03)
7. Documentation, including photographs and/or videotape, as required
8. Chemical sample preparation and packaging
9. Backfilling of test pit excavation
10. Surveying of test pit locations
11. Field note completion and review.

2.10.1 Location and Marking of Test Pits/Final Visual Check

Proposed test pit locations marked on the site plan are located in the field and staked. The proposed test pit locations are usually strategically placed to assess site conditions, former facilities, waste areas, etc.

Once the final location for the proposed test pit has been selected and utility clearances are complete, one last check of the immediate area is performed before excavation proceeds to confirm the locations of any adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers are opened and the conduit/sewer alignments confirmed.

> Caution: Do not assume site plan details regarding pipe alignments/position are correct. Visually check pipe position when excavating near sewers. Personnel should also be alert to the presence of additional piping, especially if the plans are outdated.

If it is necessary to relocate a proposed test pit due to terrain, utilities, access etc., the Project Coordinator must be notified and an alternate location will be selected.

2.10.2 Test Pit Location Setup

The test pit location is set up as follows:

1. The excavator is positioned such that the excavation spoils are deposited by the excavator downwind of all staff.
2. A sheet of polyethylene is placed downwind of the test pit location to accept spoils, if required by the Work Plan.
3. To the extent practicable, the investigation area is set up such that water or liquids that may be excavated, freely drain back into the excavation.
4. The excavation begins at one location with the excavator backing up (as required) to extend the pit.

2.10.3 Sample Collection

Soil samples can be collected from the backhoe/excavator bucket or from the test pit excavation face. Samples which require a discrete depth interval are collected from the excavator bucket following excavation of all or a portion of the test pit. Samples are collected using a cleaned steel trowel, shovel, or stainless steel spoon. Samples are placed in a stainless steel bowl and mixed (except VOCs). **Do not enter the test pit**. (Confined Space Entry requirements apply and proper shoring of the excavation walls may be necessary.)

> Caution: Personnel observing or sampling test pit operations must never stand within the "turning radius" or "reach-zone" of the excavation equipment. Operator error or equipment failure could result in severe injury or death if struck by the backhoe bucket or the backhoe itself. Stand opposite the backhoe well beyond the far end of the trench for communication.
> Personnel should also be alert to test pit side wall conditions which typically undermine the ground surface and create unstable soils surrounding the test pit area.

Discrete Grab Sampling From Test Pits

When taking discrete grab samples from a test pit using an excavator bucket, the sampling location is considered a volume of soil in the bucket that has both a consistent soil type and a consistent level of contaminant impact. When sampling using an excavator bucket, the operator will dig to the desired depth and then provide a small volume of soil from a discrete position and depth in the test pit.

When collecting a discrete grab sample from the excavator bucket, use the following procedure:

1. Scrape off the top 2 inches (5 cm) of soil at the sampling location in the excavator bucket.
2. Using the sampling device (e.g., trowel, spoon) scoop the freshly exposed soil into the sample container. Ensure that the samples taken were not in contact with the excavator bucket to avoid the potential for cross-contamination.
3. Pushing the sample container into the soil in order to fill the container is not recommended. This could result in breaking the sample container and potential injury to field personnel (e.g., cutting hands on broken glass).

4. If the sample is being collected for VOC analyses, perform this step as quickly as possible in order to minimize the loss of volatile compounds from the soil.
5. Collect a field screening sample from the same sampling location as the discrete grab sample and at the same time. Scoop soil into a zip-loc bag until it is no more than one quarter full.
6. Do not mix the soil for samples collected for VOC analyses (for sample homogenization purposes) as this will promote the loss of volatile compounds from the soil. The laboratory will obtain a representative sample from the container by using coring techniques before the laboratory analysis is performed.

2.10.4 Sample Description and Logging of Test Pits

During the excavation of a test pit, samples may be collected to provide a geologic record, to assist the geologist/engineer in completing or characterizing the stratigraphic units, and to allow for physical or chemical testing.

Soil samples collected are described in the field using the USCS. The soil descriptions are recorded on the field form or field book in the following order:

1. USCS Soil Symbol of major component
2. Native or fill
3. Secondary and minor soil components
4. Relative densities/consistency
5. Grain size/plasticity
6. Gradation/structure
7. Color
8. Moisture content
9. Observations of odor or visual chemical presence (i.e., NAPL)

In addition to describing the soil properties, enter the following information into a Test Pit Stratigraphy Log (Form SP-03):

1. Presence of groundwater and the rate of seepage (if groundwater is encountered).
2. Thickness of each stratigraphic unit.
3. Description of bedding plane features (e.g., continuous, discontinuous, graded, wavy bedding).
4. Description of joints, fractures and faults, if bedrock is encountered (number and orientation).
5. Any appearance of weathering.
6. Description of fill and waste materials.

When describing observed odors, be specific in terms of general odor category and strength of odor noted. Odors may typically be chemical, petroleum, or septic related, varying from slight, to moderate, to strong. Identification of specific chemical compounds (i.e., TCE or C-56 odor) is usually unnecessary and often inaccurate as a detailed analysis commonly shows an array of chemistry present.

When describing the presence of vegetative matter in the soil sample, do not use the term "organic" as this often leads to confusion with regards to the presence of organic chemicals (i.e., NAPL).

When describing the soil samples and the stratigraphy observed in the test pit, it is imperative that the sampler use consistent terms from one test pit to the next. As test pits are installed, compare the stratigraphy of completed test pits to the stratigraphy of the test pit you are currently excavating. Be aware of patterns and confirm all inconsistencies at the time the test pit is being excavated. Since soil stratigraphy is so important to understanding site conditions, soil samples are collected from each stratigraphic unit, and described in full.

2.10.5 Documentation

In addition to completing all field logs and books, it will generally be necessary for test pits to be documented with photographs and/or video tape. This requirement should be fully ascertained and coordinated in advance of field activities.

2.10.6 Test Pit Abandonment

Following completion of the test pit, backfill the excavation using the soil excavated from the pit. To the extent practicable, replace materials in the test pit in the same intervals from which they were extracted.

It should be noted that the material will tend to "bulk" after excavation. As a result, the excavator operator must be informed to compact the materials as they are replaced within the excavation.

2.10.7 Restoration

The test pit location must be fully restored. Ensure that restoration activities are properly designed and incorporated within the scope of services for the test pit contractor.

Restoration could include:

- Landscaping
- Paving
- Concrete

3. Monitoring Well Design and Construction Standard Operating Procedures

3.1 Introduction

Monitoring well design and construction is conducted to characterize the hydraulic and groundwater quality at a site. Standard Operating Procedures (SOPs) are presented herein for obtaining a variety of hydraulic and groundwater quality results, including:

- Groundwater elevation data
- Performance of aquifer testing
- Collection of groundwater samples for groundwater quality analysis

This guideline is not intended to provide the basis for designing a groundwater monitoring network, but instead assumes that a groundwater monitoring network has been designed, a site-specific Work Plan has been established, and that a GHD representative is preparing to mobilize to the site.

Monitoring well design and construction procedures vary from project to project due to different chemicals of concern, different guidance provided by the state/province where the site is located, and the specific objectives of the project (i.e., hydraulic monitoring, groundwater sampling, aquifer testing). It is essential that all monitoring well design and construction activities conform to local, provincial/state, and federal regulations. Therefore, it is essential that the GHD representative carefully review the Work Plan requirements. The primary goal of monitoring well design and construction is the appropriate placement of monitoring wells in various geologic and groundwater environments. It is imperative appropriate monitoring well installation and construction techniques are chosen.

The remainder of this section is organized as follows:

- Section 6.2 Background
- Section 6.3 Planning and Preparation
- Section 6.4 Safety and Health
- Section 6.5 Quality Assurance/Quality Control
- Section 6.6 Equipment Decontamination
- Section 6.7 Location and Marking of Well Sites/Final Visual Check
- Section 6.8 Drilling Methods
- Section 6.9 Well Design Considerations
- Section 6.10 Field Procedures for Well Installations
- Section 6.11 Well Construction Techniques
- Section 6.12 Well Installation Documentation
- Section 6.13 Well Installation Follow-up Activities
- Section 6.14 Well Development
- Section 6.15 Well Development Documentation
- Section 6.16 Well Development Follow-up Activities
- Section 6.17 References

3.2 Background

The design and installation of monitoring and extraction wells involves drilling boreholes into various types of geologic formations. Designing and installing monitoring wells may require several different drilling methods and installation procedures.

It is important that the drilling method used minimizes the disturbance of subsurface materials.

The drilling method should not contaminate the subsurface soils and groundwater. It is extremely important that drilling does not create a hydraulic link or conduit between different hydrostratigraphic units. Groundwater in monitoring and extraction wells must not be contaminated by drilling fluids or the borehole advancement process. Drilling equipment is decontaminated before use and between well locations to

prevent cross-contamination between well locations and sites. Drilling equipment is decontaminated between all well locations regardless of whether or not contaminants are suspected. The Work Plan or Quality Assurance Project Plan (QAPP) will specify the required decontamination procedures for the site. At a minimum, decontamination procedures detailed in Section 6.6 should be used during monitoring well design and construction. The only time decontamination is not required is when boreholes are advanced on known clean sites for the purpose of collecting geologic information.

Finally, precleaned monitoring well construction materials are used in order to prevent the potential introduction of contaminants into a hydrostratigraphic unit.

> Caution: If using threaded low carbon steel (BIP) well materials, ensure that materials are thoroughly decontaminated. Threaded low carbon steel will have cutting oil on threads and on the inside and outside of the pipe. The outside of low carbon steel may also have a wax type coating which needs to be removed prior to installation.

3.3 Planning and Preparation

Prior to undertaking monitoring well design and construction:

1. Review the Work Plan and Site-Specific Health and Safety Plan (HASP), project documents, all available geologic and hydrogeologic mapping and reports, water well records, and historic site reports to become familiar with the geologic and hydrogeologic framework of the site and surrounding area. Review and become familiar with the health and safety requirements, and discuss the work activities with the Project Coordinator.
2. Complete a Field Equipment Requisition Form (QSF-014) and assemble all required equipment, materials, log books, and forms. Project Planning, Completion, and Follow-Up Checklist (Form SP-02) should be used for guidance throughout the project.
3. Obtain a site plan and previous stratigraphic logs. Determine the exact number, location, and depth of wells to be installed.
4. If not performed as part of borehole advancement, complete a Property Access/Utility Clearance Data Sheet (QSF-019). In most instances, the utility clearances and property access will have been completed as part of the well drilling and advancements.
5. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status on or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work; QSF-031 for U.S. work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
6. Determine notification requirements with the Project Coordinator. Have all regulatory groups, the client, landowner, drilling contractor, and GHD personnel been informed of the well design and installation program?
7. Determine the methods for handling and disposal of well installation and decontamination fluids. Generally, this is dealt with as part of the well advancement activities.

In addition to the above, the following may be required when conducting monitoring well design and installation activities:

8. Establish a water source for well installation and decontamination. Pre-plan the methods of handling and disposal of well installation and decontamination fluids.
9. Arrange with the drilling contractor/client to provide a means of containment and disposal of fluids.

3.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

10. Assure the HASP is specific to the job and approved by a Regional Safety & Health Manager.
11. Confirm that all HASP elements have been implemented for the job.
12. A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
13. Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
14. Review and implement applicable sections of the GHD Safety & Health Policy Manual.
15. Confirm that all site personnel have the required training and medical surveillance as defined in the HASP.
16. Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
17. Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
18. Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, vehicle incident, and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a job hazard analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's and the client's safety requirements.

3.5 Quality Assurance/Quality Control

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 3.9.

3.6 Equipment Decontamination

Borehole Installation and Sampling

Prior to use and between each borehole location, drilling and sampling equipment must be decontaminated in accordance with the Work Plan, the QAPP, or the methods presented in the following section.

The minimum wash procedures for decontamination of drilling or excavating equipment are:

19. High pressure hot water detergent wash (brushing as necessary to remove particulate matter)
20. Potable, hot water, high pressure rinse

Cover the clean augers with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where no contaminants are present, it is sufficient to clean the drilling or excavating equipment simply by removing the excess soils.

On environmental sites, soil sampling equipment (e.g., split spoons, trowel, spoons, shovels, bowls) is typically cleaned as follows:

21. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
22. Rinse with tap water.
23. Rinse with deionized water.
24. Air dry for as long as possible.

In addition, the following steps may be added when sampling for volatile organic compounds (VOCs) and metals:

25. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
26. Rinse with deionized water.
27. Rinse with appropriate solvent (e.g., pesticide grade isopropanol, methanol, acetone, hexane).
28. Rinse again with deionized water.
29. Air dry for as long as possible.
30. Wrap equipment in aluminum foil to prevent contamination.

Caution: Confirm the cleaning protocol from the QAPP. The use of an incorrect cleaning protocol can invalidate chemical data.

3.7 Location and Marking of Well Installation Sites/Final Visual Check

The proposed well locations marked on the site plan are located and staked in the field. On most sites, this should be completed several days prior to the drill rig arriving on site. Well locations are required for the completion of utility locates. Generally, well locations are strategically placed to assess site hydrogeologic conditions.

Once the final well location has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds to confirm the locations of adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

When possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. This is particularly important in limited space sites where wells are being installed close to buried utilities. Alternatively, a Hydrovac truck can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

Caution: Do not assume that site plan details regarding pipe alignment/position are correct. Visually inspect pipe alignment when advancing boreholes near sewers. Be prepared to find additional piping if outdated plans are being used. If possible confirm pipe locations with on-site employees or a client representative.

Well locations are selected primarily to provide a good geographical distribution across the site. Most often, the well locations specified in the Work Plan are not pre-verified to confirm clearance from underground or overhead utilities, nor to consider the site's specific characteristics (e.g., traffic patterns, drainage patterns). Consequently, it is the Field Supervisor's responsibility to perform the following:

31. Select the exact location of each well consistent with the site and project requirements.
32. If a well must be relocated more than 20 feet (5.7 m) from the initially identified location, confirm the new location's suitability with the Project Coordinator.
33. Ensure all utilities have been cleared prior to initiating borehole advancement activities.

To the extent practical, wells should be located adjacent to permanent structures (e.g., fences, buildings) that offer some form of protection and a reference point for future identification. Wells located in high traffic areas or road allowances or low-lying wet areas are undesirable, but may be unavoidable.

Field tie-ins must be completed to accurately identify each well location. These will ensure that the wells are properly identified on plans and for future identification in the field.

3.8 Drilling Methods

The following drilling methods are listed in order of preference. However, final selection will be based on site geologic and hydrogeologic conditions. The drilling methods outlined below are discussed in detail in Section 4.0.

Hollow-Stem Augering

Continuous flight hollow-stem augering (HSA) is the most frequently used method of borehole advancement. Its primary advantages are:

34. Generally, no additional drilling fluids are introduced into the formation.
35. Representative geologic samples can be obtained easily using split-spoon samplers in conjunction with the standard penetration test (SPT) and HSA.
36. A monitoring well can be installed through the auger, eliminating the need for a temporary borehole casing.

Information regarding split-spoon sampling is discussed in Section 5.0.

HSAs are available with an inside diameter of 2.5, 3.25, 4.25, 6.25, 8.25, and 10.25 inches (6.4, 8.3, 10.8, 15.9, and 26.0 cm). Some drilling contractors have inside diameter HSAs as large as 16.25 inches (41.3 cm). The most commonly used inside diameter is 4.25 inch for the installation of a 2-inch (5 cm) diameter monitoring well. Larger diameter HSAs, including 6.25, 8.25, and 10.25 inch (10.8, 15.9, 26.0 cm), are used for large diameter monitoring or extraction wells ranging in size from 4 to 8 inches (10 to 20 cm). Boreholes can usually be advanced to depths of about 100 feet (30 m) with an HSA in unconsolidated clays, silts, and sands.

Installation of a well through a HSA is a simple process, but precautions need to be taken to ensure that well construction, particular sealing, is properly completed.

Removing a HSA from flowing sand may be difficult since the auger has to be removed without rotation, if at all possible. A bottom plug or pilot bit assembly should be used to keep out soils and water that have a tendency to fill the bottom of the HSA during drilling. If flowing sands are encountered, potable water (analyzed for contaminants of concern) may be poured into the HSA to equalize the hydrostatic pressure, which will keep the formation materials and water from flowing into the HSA once the plug or pilot bit is removed.

Dual-Wall Reverse Circulation Air Drilling

This method consists of two concentric strings of drill pipe (an outer casing and a slightly smaller inner casing). Compressed air is continually forced down the annulus between the inner casing carrying the drill cuttings and groundwater. At the surface, the inner casing is connected to a cyclone hopper where the drill cuttings and groundwater fall out from the bottom of the hopper, and air is disbursed from the top. The dual wall provides a fully cased borehole in which to install a well. The only soil or groundwater materials exposed at any time are those at the drill bit, so the potential for carrying contamination from one stratum to another is minimal. Depth-specific groundwater samples can be collected during drilling; however, since the groundwater is aerated, analysis for volatile organic compounds (VOCs) may not be valid.

Rotosonic Drilling

This method consists of a combination of rotation and high frequency vibration to advance a core barrel to the desired depth. Once the vibration is stopped, the core barrel is retrieved and the sample is vibrated or hydraulically extracted into a plastic sleeve or sample tray. The well is installed through an outer casing. Rotosonic drilling generally requires less time than more traditional methods and continuous, relatively undisturbed samples can be obtained through virtually any formation. Conventional sampling tools can be employed as attachments (e.g., hydropunch, split spoon, Shelby tube). No mud, air, water, or other circulating medium is required. The main limitation of this method is the availability of equipment.

Rotary Method

This method consists of a drill rod attached to a drill bit (for soils, a tricone or drag bit; for rock, a button studded or diamond studded bit) that rotates and cuts through the soils and rock. The cuttings produced are forced to the surface between the borehole wall and the drill rod by drilling fluids that generally consist of water or drilling mud, or air. The drilling fluid or air not only forces the cuttings to the surface but also keeps the drilling bit cool. Using the rotary method can be difficult as it requires several steps to complete the installation. First, the borehole is drilled, then temporarily cased, then the well is installed, and then the temporary casing is removed. In some cases, the borehole may remain open without installing a casing (e.g., cohesive soils).

Air Rotary (typically used in rock)

When using the air rotary method, the air compressor must have an in-line oil filter system assembly to filter the oil mixed with the air coming from the compressor. This helps eliminate the introduction of contaminants into the formation. The oil filter system needs to be regularly inspected. An air compressor with no in-line oil filter system is not acceptable for air rotary drilling. A cyclone velocity dissipater or similar air containment system must also be used to funnel the cuttings to one location rather than allowing them to blow uncontrolled out of the borehole. Air rotary may not be an acceptable method for well installation where certain contaminants are present in the formation. Alternatively, it may be necessary to provide treatment for the air being exhausted from the borehole during the installation process.

3.9 Well Design Considerations

Well design must be completed prior to initiating well installation activities.

The compatibility of the well construction materials with the groundwater environment should be verified. Certain materials are not compatible in a corrosive environment or where groundwater has high solvent concentrations. In deeper well applications, well material strength should be considered. Finally, the overall cost of the well materials should be considered.

3.9.1 Well Materials

The following well materials are commonly used:

- PVC well screen and riser pipe
- Stainless steel well screen and riser pipe
- Stainless steel screen and black iron (low carbon steel) riser pipe
- Stainless steel screen and PVC riser pipe

3.9.1.1 PVC Well Materials

PVC is generally either Schedule 40 or Schedule 80. Schedule 80 PVC is thicker and provides more strength than Schedule 40. Schedule 80 PVC is more resistant to heat caused by the placement and setting of grout. Because of the higher strength and greater heat resistance, Schedule 80 is preferred for well applications greater than 100 feet (30 m).

PVC is available in a variety of diameters, from 0.5 inch (1.5 cm) to 8 inch (20 cm). PVC is relatively inexpensive and readily supplied by drilling contractors well material suppliers. PVC is light and generally comes pre-cleaned and bagged.

PVC is resistant to corrosion, most acids, oxidizing agents, salt, alkaline, and oils and fuels. However, it may break down in environments with high solvent concentrations. PVC can become brittle over time and is not as strong as metal.

PVC installations may be difficult in deep applications through a large water column because of its buoyancy.

PVC wells should not be constructed using solvent cement.

Threaded PVC well materials should be used where possible.

PVC well materials should meet the National Sanitation Foundation (NSF) Standard 14.

3.9.1.2 Metallic Well Materials

Metallic materials include stainless steel, black iron (low carbon steel), and galvanized steel. Metallic well materials are less commonly used than PVC.

Metallic materials are suitable for deep well applications because of their high strength and resistance to the heat produced during grout and cement grout curing.

Black iron pipe (BIP) is susceptible to corrosive environments. Stainless steel well materials are generally pre-cleaned and bagged. Threaded BIP must be decontaminated prior to use to remove all waxes on the exterior of the pipe and to remove cutting oil from threads and the interior and exterior of the pipe.

Metallic well materials cost more than PVC.

3.9.2 Well Diameter

The diameter of a well is primarily dictated by the purpose of the well. Generally, wells installed for groundwater and hydraulic monitoring should be between 1 and 2 inches (2.5 and 5 cm) in diameter. The diameter is also dependent on the drilling method being used.

Small diameter wells allow for the installation of bladder pumps as well as small diameter tubing and bailers. Wells smaller than 1 inch (2.5 cm) should only be used for hydraulic monitoring. Due to the small diameter, sampling equipment cannot be used in wells smaller than 1 inch (2.5 cm) in diameter. The cost saving for wells smaller than 1 inch (2.5 cm) is negligible.

For groundwater extraction, 4- to 6-inch (10 to 15 cm) diameter wells are sufficient. Wells greater than 6 inches (15 cm) in diameter are generally installed for water supply and are project specific.

3.9.3 Screen Length and Placement

Screen lengths for wells can vary depending on a variety of factors including:

- Formation thickness
- Seasonal groundwater fluctuations
- Extraction/water supply

Screen length should be consistent with the hydrogeologic conditions and the desired monitored interval. A 10-foot (3.0 m) long screen is suitable for groundwater table wells when the screen is completely submerged and a specific monitoring interval is required.

If monitoring for light non-aqueous phase liquids (LNAPL), the screen length is generally 10 feet (3.0 m). A longer screen length can be installed to accommodate seasonal groundwater fluctuations. A 5- to 10-foot (1.5 to 3.0 m) screen length is adequate where the hydrostratigraphic formation is low and allows for the water level to be drawn down during sampling through the filter pack into the screened interval.

If monitoring for dense non-aqueous phase liquids (DNAPL), the screen needs to be placed at the bottom, or sumped slightly into the confining unit. In general, a 5-foot (1.5 m) long screen is suitable for wells designated for DNAPL monitoring. However, it is acceptable to use a 10-foot (3.0 m) long screen if the formation has sufficient saturated thickness.

> Caution: Do not penetrate the confining unit during advancement, especially if DNAPL is suspected.

Monitoring wells installed in confined aquifer conditions can be installed using 5-foot (1.5 m) long screens.

> Note: Well installations are not able to straddle a confined potentiometric surface.

3.9.4 Well Slot Size

Well slot sizes are described in thousandths of an inch. For most monitoring wells, a No. 10 slot (0.01-inch [0.25 mm]) well screen is adequate in most hydrostratigraphic units. PVC wells screens are typically available in No. 10 (0.01-inch [0.25 mm]) or No. 20 (0.02-inch [0.51 mm]) slot sizes. Stainless steel screens are available in a wider range of slot sizes. Typically, stainless steel screens must be specially ordered and require additional delivery time. Wells screens can be slotted, continuous slot, or louvered. Well points come in very limited slot sizes.

Some state/provincial and federal regulators require design of monitoring well screen slot sizing. The design of the slot size is based upon grain size results from the desired monitored interval.

Pre-pack screens are an effective screening method for deep installations or where flowing sands exist. A pre-pack screen consists of two screens with filter pack placed between the screens. Pre-pack screens are most commonly constructed of PVC and are available in No. 10 (0.01-inch [0.25 mm]) or No. 20 (0.02-inch [0.51 mm]) slot sizes.

Filter socks or cloths are for use in fine-grained soils. Filter socks or cloths should not be used when monitoring for the presence of LNAPL or DNAPL. An alternative to using filter socks or cloths is to install well points.

3.9.5 Sand Pack Sizing

The silica sand pack placed around the well screen should be no finer than the slot size of the screen. Some companies supply different sieve size ranges for the same sand size number. Grain size curves should be obtained from the driller or well materials supplier to ensure proper sand size prior to placement.

In some instances, generally in situations with flowing sands, a natural sand pack may be required. A natural sand pack is not desired because of the increase in development time.

3.9.6 Well Sealing

All wells must be properly sealed. A seal is placed over the silica sand pack. Cuttings must never be used to seal a well.

Certain well applications require specific well seals including:

- bentonite gravel or chips
- bentonite grout
- cement/bentonite grout
- cement grout

Prior to initiating well installation activities, confirm sealing requirements with local, state/provincial, or federal regulations.

3.10 Field Procedures for Well Installations

The following presents the field procedure and techniques for installing a well in overburden and bedrock. Typical overburden well installation details are provided on Figure 6.1. Typical bedrock well installation details are provided on Figure 6.2.

3.10.1 Installation Requirements

Well installation requires the following components:

37. Annular space
38. Instrumentation details
39. Filter pack placement
40. Bentonite seal
41. Grouting
42. Protective casings and well caps
43. Surface seal
44. Protective posts (if required)

3.10.2 Annular Space

The annular space is the space between the outside of the riser pipe or casing and the inside of the HSA, casing, or borehole wall.

The borehole diameter must be sufficient to allow well construction to proceed without difficulty. Check with local, state/provincial, or federal regulations to insure that the borehole annular space meets regulations. To assure adequate size, a minimum 2-inch (5 cm) annular space is required to allow a minimum 1.5-inch (4 cm) tremie line for placing filter pack, seal, and grout at the specific intervals. An annular space of less than 2 inches (5 cm) is not acceptable.

3.10.3 Instrumentation Details

Prior to installation through the auger or into the borehole, the well assembly (i.e., well screen and riser components) and the length of each component must be measured and recorded. The borehole must be measured to ensure installation at the desired interval to be monitored.

Note: Well screen and riser should only be handled using clean nitrile gloves.

Once the depth of the borehole has been confirmed and the length of the well assembly is known, well construction can proceed. Placement problems are easily identified by measuring the amount of riser stickup during installation and comparing to the measured depth of the borehole.

3.10.4 Filter Pack Placement

Primary Filter Pack (see ASTM D5092)

The primary filter pack is composed of graded washed silica sand. The silica sand size should be no finer than the screen size opening. The primary sand pack size may have to be designed based on the well screen slot size and the grain size of the hydrostratigraphic formation.

The primary filter pack is placed as follows:

45. The primary filter pack is placed using the tremie line method.
46. A minimum 6 inches (15 cm) of the primary filter pack material is placed under the bottom of the well screen. This interval of primary filter pack provides a firm footing for the well.
47. Where DNAPL is present, or is being monitored for, the well may be sumped into a confining unit. In this case, no primary filter pack is placed under the bottom of the well screen.
48. The top of the primary filter pack is determined in the field based on the geologic and hydrogeologic conditions encountered during borehole advancement.
49. The primary filter pack should extend a minimum of 2 feet (0.6 m) above the top of the well screen.
50. For shallow overburden wells it is common to extend the primary filter pack to about 2 feet (0.6 m) above the water table to account for anticipated seasonal groundwater fluctuations.
51. In shallow overburden wells the sand pack should not be extended across a native and fill unit. For deeper overburden wells, it is common to select a specific hydrogeologic unit to monitor.
52. The primary filter pack should never extend through a confining unit causing two or more permeable units to become connected.

Placing the primary filter pack by pouring may be acceptable if measurements are taken to ensure that the filter pack is reaching the assigned depth.

The primary filter pack must be carefully placed concurrent with the removal of the HSA or temporary casing when collapsing borehole conditions exists. The primary filter pack must be maintained in the HSA or temporary casing to ensure proper filter pack placement around the well screen.

Placement of the primary filter pack is typically a delicate and time-consuming operation. It requires a balance between placement of too much sand and "locking" the well components in the auger or temporary casing, or placing too little sand, which allows the formation materials to collapse around the well screen. A good well installation will involve constantly checking the primary filter pack level as the auger or temporary casing is extracted from the borehole. Constant measurement of the primary filter pack will allow for adjustment of the rate and amount of filter pack placement.

In certain situations it may be necessary to add potable water within the HSA or temporary casing to maintain a positive hydrostatic pressure on the formation materials. This will help stop the flow of formation materials into the HSA or temporary casing. This generally occurs in sandy/silty soils below the

water table. If potable water is added, the volume of water added must be recorded and additional purging volumes will be required to remove the volume of potable water added.

Secondary Filter Pack (see ASTM D5097 and D5092)

The secondary filter pack is finer than the primary filter pack. The first secondary filter pack prevents the intrusion of grout from reaching the primary filter pack. The final secondary filter pack limits the migration of grout material into the bentonite seal. Generally, a bentonite seal over the primary filter pack is sufficient to stop grout from reaching the primary filter pack.

The secondary filter pack is a layer of fine-grained silica sand placed in the annular space between the primary filter pack and bentonite seal, and between the bentonite seal and grout seal. The secondary filter pack must be uniformly graded fine silica sand with 100 percent by weight passing the No. 30 U.S. Standard sieve, and less than 2 percent by weight passing the No. 200 U.S. Standard sieve. Blasting sand or "sugar" sand is typically used as a secondary filter pack.

3.10.5 Bentonite Seal

A bentonite seal is placed on top of the filter pack. This seal consists of high solids, pure bentonite material. Bentonite in either pellet or granular form is acceptable. Check with local, state/provincial, and federal regulations concerning bentonite seal material requirements.

Generally, 3/8-inch (1 cm) bentonite chips are used, but larger 3/4-inch (1.9 cm) bentonite chips may be used in larger annular spaces. Bentonite pellets have a machined surface and are good for deep well applications, or for adding bentonite seals through a long water column.

When placing a bentonite seal:

53. A tremie line is the preferred method. Pouring the bentonite seal is acceptable in shallow applications (less than 50 feet [15 m]) where the annular space is large enough to prevent bridging.
54. Take continuous measurements to ensure that the bentonite seal is being placed in the proper interval, and that bridging is not occurring.
55. Place the bentonite seal above the filter pack to a minimum of 2 feet (0.6 m) thick.
56. Allow the bentonite to hydrate before grouting.
57. If the water table is temporarily below the bentonite seal interval, use potable water to hydrate the bentonite.

3.10.6 Grouting

The annular space between the well casing and borehole wall must be filled with neat cement grout, cement/bentonite grout, or bentonite grout. Check required local, state/provincial, and federal regulations regarding well sealing requirements.

Bentonite grout does not crack or harden and is generally self-healing. Cement/bentonite grout may crack, but bentonite will typically seal any cracks. Cement/bentonite grout must contain at least 5 percent bentonite volume by weight. Neat cement will crack and may pull away from riser pipe or borehole wall.

When placing grout:

58. Prepare the grout in accordance with the manufacturer’s specifications.

59. Using a tremie line, place the grout into the borehole, over the bentonite seal.

60. Place the grout from the top of the bentonite seal to within 2 feet (0.6 m) of the ground surface or, if possible, below the frost line.

61. Allow the grout to set for a minimum of 24 hours before installing a concrete surface seal. Grout will generally settle due to infiltration into medium- and coarse-grained soils. Check grout levels and, if required, add additional grout to the borehole to bring the grout level to the required depth.

62. When grouting on contaminated sites, collect and contain displaced fluids for future disposal.

When a concrete surface seal is not required, the grout is brought to within 0.5 to 1 foot (0.15 to 0.30 m) below ground surface. The remaining annular space is backfilled to match the surrounding ground surface conditions (e.g., asphalt, topsoil). This method will reduce surface water infiltration and well lifting due to frost.

3.10.7 Protective Casings

A protective casing is installed over the completed well and sealed in place. Once installed and grouted, the casing should extend about 2.5 feet (0.75 m) above ground surface. The outer protective casing is made of steel and has a locking cap that is hinged, waterproof, and resistant to vandalism. The protective casing should have sufficient clearance around the inner well casing so that no contact is made with the outer protective casing. A concrete surface seal is installed flush to promote drainage away from the outer protective casing at a depth below the frost line to deter frost heaving. Check local, state/provincial, and federal regulations pertaining to requirements for concrete surface seals.

Typically, a concrete form (sonatube) is used to provide a collar for the concrete around the protective casing. The concrete surface seal is placed as follows:

63. The concrete surface seal is sloped to promote surface drainage away from the well.

64. The protective casing is installed with two weep holes for drainage. The weep holes should be 1/4 inch (0.6 cm) in diameter and drilled into the protective casing slightly above the top of the concrete surface seal. The weep holes will prevent standing water from accumulating inside the protective casing and allow internal air pressure to be in equilibrium with atmospheric conditions.

65. Bentonite chips or pellets are placed in the annular space below ground level in the protective casing.

66. Silica sand is placed in the annular space above the bentonite chips or pellets and above the weep hole to prevent insect infestation.

Sometimes a well must be completed in a high traffic area. In this situation, the well is completed as a flush-mount installation. A waterproof protective casing is essential to ensure the integrity of the screened hydrostratigraphic unit. The protective casing is grouted in place and is fitted with bolts and a rubber gasket to deter surface water infiltration. For a flush-mount installation, the well top is generally fitted with a locking expandable cap with watertight screw-on connections (as referenced in ASTM F480). For a flush-mount installation, the well cap must have a lock to deter vandalism. The preferred cap is manufactured by OPW of Cincinnati, Ohio (OPW 634 TTM-7087). For above-grade installations, the well cap or well casing must be properly vented to allow air pressure to be in equilibrium with atmospheric conditions.

Flush-mount installations are typically more problematic and maintenance intensive. If possible, avoid the use of flush-mount installations.

A typical protective casing installation is shown on Figure 6.3.

Once all well installation activities are complete, wells are labeled with the appropriate well identification in at least two locations. Check for local, state/provincial, or federal regulations that may require that wells be assigned a specific well identification number. A well tag may be required on the well casing or embedded in the concrete surface seal.

Note: Lock all wells to prevent vandalism.

3.10.8 Protective Posts

When required, protective posts (bollards) can be constructed of 4-inch (10 cm) diameter Schedule 40 PVC; or low carbon steel pipe filled with concrete; or 4- by 4-inch (10 cm by 10 cm) wooden posts, and installed as follows:

67. Install the posts at least 3 to 4 feet (0.9 to 1.2 m) above ground surface. As many as four posts may be installed for each well location.
68. Set each post at least 2 feet (0.6 m) into the ground and install in a separate concrete seal.
69. Place the posts at the corners of the well concrete surface seal, 4 feet (1.2 m) radially from the center of the well at 90-degree increments.

If a well is installed in a heavily forested or vegetated area, identify the well location using a high visibility marker to allow for future identification.

3.11 Well Construction Techniques

3.11.1 Well Installation

Boreholes for well installations should be drilled as close to vertical as possible. Slanted boreholes are not acceptable unless specified in the well design or Work Plan. Well casings and screens should be installed plumb in the boreholes. Where critical, especially on installations deeper than 50 feet (15 m), centralizers may be used to help keep the screen as close as possible to the center of the borehole. An alternative method to setting a well casing and well assembly is to suspend the casing or assembly from the wireline on the drill rig.

Petroleum-based lubricating oils or grease should not be used on casing threads. Teflon tape can be used to ensure a watertight seal. No glue of any kind should be used to secure casing joints. For some steel casings, welded joint construction is acceptable.

The well is installed as follows:

70. Before placing the well assembly at the bottom of the borehole, place at least 6 inches (0.15 m) of filter pack at the bottom of the borehole to serve as a footing.
71. If monitoring for DNAPL, the well assembly may be set directly on the bottom of the borehole. Place the well into the borehole plumb.
72. On a well installed to a depth greater than 50 feet (5 m), centralizers are required. Place the centralizers on the well casing or well assembly above the proposed bentonite seal interval. Place the centralizers so as not to interfere with the placement of the filter pack, bentonite

seal, and annular grout. (Generally, wells less than 50 feet (15 m) deep will not require centralizers unless required by local, state/provincial, or federal regulations, or the Work Plan.)

73. During well installation through a HSA, slowly pull back the auger as the filter pack, bentonite seal, and annular grout are tremied or poured in place.
74. When the well has been lowered into the borehole, place the filter pack around and above the top of the screen, as required.
75. When the filter pack has been installed, place a minimum 2-foot (0.6 m) thick bentonite seal directly on top of the filter pack.
76. Allow the bentonite seal to hydrate for a reasonable amount of time (generally, 30 minutes is sufficient).
77. When the bentonite seal has hydrated sufficiently, seal the remaining borehole annular space grout placed with a tremie line using positive displacement methods. Generally, the grout will be brought to 2 feet (0.6 m) below ground surface or below the frost line, whichever is greater. In situations where no concrete seal is being placed, the grout can be brought to 0.5 to 1 foot (0.15 to 0.3 m) below ground surface.
78. During grout placement, ensure the end of the tremie line is always submerged in the grout to ensure positive displacement.
79. During grout placement on contaminated sites, containerize all fluids for future disposal.
80. Allow the grout to set for about 24 hours before installing the concrete surface seal. If the grout level has subsided, top off the borehole annular space with grout or bentonite pellets to the required depth.
81. Install protective casings in a minimum 2-foot (0.6 m) thick concrete surface seal graded to divert surface water away from the monitoring well. Check local, state/provincial, and federal regulations for concrete surface seal requirements. Some agencies require that concrete pads be constructed around the wells.
82. When installation is complete, label the well in at least two locations for future identification.

For well installation in a high traffic area (i.e., parking lot, residential yard, road allowances) it may be necessary to install a flush-mount protective casing. It is important that the flush-mount protective casing be watertight to protect the screened hydrostratigraphic unit. Flush-mount protective casings are designed to extend from ground surface down into the concrete surface seal. Elevate the areas in the immediate vicinity of a flush-mount well to the extent possible to promote surface water drainage away from the flush-mount protective casing. Be aware of possible trip hazards associated with a flush-mount protective casing in areas of pedestrian traffic need. It is also important to avoid installing a well in a low-lying area that is susceptible to surface water accumulation and ponding.

Typical overburden well installation details are shown on Figure 6.1. Typical protective casing installations are shown on Figure 6.3.

3.11.2 Bedrock Wells

Bedrock well installations may be accomplished using two methods.

Method 1

83. Advance a pilot borehole through the overburden and into upper bedrock.
84. Install an outer casing into the borehole and grout in place using the grouting methods described in Section 6.10.6.

After the grout has properly set, further borehole advancement can occur through the grout seal into the underlying bedrock. Bedrock is typically advanced using rock coring techniques. Bedrock coring makes a smooth, round hole through the seal and into the underlying bedrock minimizing the possibilities of shattering or cracking the outer surface casing seal. Roller cone bits are also commonly used in soft bedrock formations. However, this method can produce excessive water and pressures that may cause the seal to crack, shatter, or wash away. Coring is preferred because it provides a continuous bedrock core. The bedrock cores can be logged for lithology, structure, and fracture presence and orientation. Bedrock cores can be kept at the site for geologic record. When drilling is completed to the required depth, the finished well consists of an open corehole from the bottom of the outer casing to the bottom of the well. There is no inner casing installed with this bedrock installation type. The open rock interval is the desired monitoring interval. The outer casing installed into the upper bedrock can be extended to above ground surface to serve as the protective casing, or typical above-grade or flush-mount protective casings can be installed. If the outer casing becomes cracked or is broken off, the well is open to contamination from the ground surface. If this occurs, the well must be immediately repaired or abandoned. It may be desirable to install a protective casing over the outer casing as an extra precaution.

For wells installed to monitor bedrock units below the uppermost layers or below a suspected confining unit in the bedrock, a second casing is installed to the top of the desired monitored interval. The borehole is then extended through the seal and second casing into the bedrock interval selected for monitoring.

Method 2

85. Install an outer casing and advance the borehole into the bedrock.
86. Install an inner casing and well screen to the selected monitoring interval in the bedrock.
87. Place a filter pack around and above the well screen.
88. Place a minimum 2-foot (0.6 m) thick bentonite seal over the filter pack.
89. Seal the remaining annular space with grout placed using a tremie line and positive displacement methods.

This installation method enables isolation of the bedrock monitoring interval. This method is also used in cases of poor bedrock quality, where the corehole continually collapses.

Typical bedrock well installation details are shown on Figure 6.2. Typical protective casing installations are shown on Figure 6.3.

3.12 Well Installation Documentation

Details of each overburden well installation are recorded on a Stratigraphy Log (Overburden) (Form SP-14) and also in the field book. Well installation details, comprised of the following, are recorded on a Well Instrumentation Log (Form SP-15):

90. Drilling method
91. Borehole diameter
92. Borehole depth
93. Well screen length
94. Well screen depth
95. Well screen and riser diameter
96. Outer casing diameter if present
97. Filter pack interval
98. Filter pack material
99. Seal/plug interval
100. Seal material
101. Grout interval
102. Grout material
103. Stickup/flush-mount detail
104. Surface seal detail
105. Protective type detail
106. Date installed

Overburden stratigraphic details are recorded in detail, in accordance with the soil classification methods detailed in Section 5.0, on a Stratigraphic Log (Overburden) (Form SP-14). Bedrock lithology and descriptions are recorded on a Bedrock Coring and Drilling Stratigraphic Log (Form SP-16).

Details of a bedrock well installation are typically recorded and sketched in a GHD standard field book. A Bedrock Coring and Drilling Stratigraphic Log (Form SP-16) are used to log lithology and structure for bedrock cores and bedrock boreholes.

The field book records and sketches of bedrock well installations must include:

107. Corehole diameter
108. Corehole depth
109. Overburden depth
110. Outer casing depth
111. Grout depths
112. Grout material
113. Surface cap details

114. Date of installation

Each well must be marked in at least two locations to identify the well designation for future reference.

> Field tie-ins must be completed to accurately identify each well location upon completion of installation. These will ensure that the wells are properly identified on plans and for future identification in the field.

3.13 Well Development

Monitoring well development is the process of obtaining hydraulic stabilization of a monitoring well. To ensure hydraulic stabilization of a well, it is recommended to remove five to ten well volumes. The removal of well volumes will aid in achieving a sand-free condition with the lowest possible turbidity.

The most suitable methods of well development are:

115. Waterra™ (surge block)
116. Surge block
117. Pumping/overpumping/backwashing
118. Bailing
119. Airlifting
120. A combination of the above five methods

> Note: Ensure the development method chosen conforms to local, state/provincial, and federal regulations.

3.13.1 Waterra™ (Surge Block)

Waterra™ is an inertial foot valve attached to flexible or rigid tubing. For well depths greater than 50 feet (15 m) rigid tubing is used. The inertia pump may be pumped by hand or with a power pump. As the inertia pump is moved up and down in the well, water is lifted to the surface. Surge blocks can be attached to the inertia pump so that surging and purging is performed simultaneously.

This development method is cost effective and works well for shallow and small diameter wells. However, this method can be labor intensive.

3.13.2 Surge Block

When used effectively, surge blocks can destroy the bridging of fine-grained particles from the formation. Surging creates the agitation necessary in the proper development of a well. A surge block is generally used alternately with either bailing or pumping so that purging removes all agitated and loosened particulate in the well. The surge block assembly must be of sufficient weight to freefall through the water column and create a vigorous outward surge. Surging begins at the top of the screen so that sand or silt loosened by the initial surging action will not cascade down on the surge block and "lock" or "bind" the surge block in the well. Surging is initially gentle, and the energy of the action is increased throughout the development process. Surging and pumping continue until the water is free of suspended particulate in the purge water.

3.13.3 Pumping/Overpumping/Backwashing

The least expensive and most commonly used well development technique is pumping.

Overpumping causes an increase in the flow velocity of water through the well screen. This creates a rapid and effective migration of particulate toward and through the well screen.

With no backflow prevention valve (check valve) installed on a pump, the pump can be alternately started and stopped. This backwashing creates a surging action in the well and generally loosens the bridging of fine particles in the formation. Backwashing must only be used with dedicated pumps and hoses or pumps that have been thoroughly decontaminated between well locations. Pumps commonly used for well development include BK pump, submersible pumps, and jet pumps.

> Note: Particulate wears out submersible pumps. A 2-inch (5.0 cm) Grundfos™ pump should not be used for well development.

All of the above techniques are designed to remove the drilling effects from the monitored interval and restore the formation to its previous condition. The above techniques avoid the introduction of fluids, including air, into the monitored interval during development. This minimizes adverse effects on the water quality and restricts available development options.

3.13.4 Bailing

In a relatively clean permeable formation, bailing is an effective development technique. The bailer is allowed to freefall down the well until it strikes the water surface. That contact creates a strong outward surge of water through the screen into the formation. This action tends to break bridging that has occurred in the formation from the borehole advancement process. As the bailer fills and is rapidly removed from the water column, particulate matter outside the well intake flows through the well screen. Subsequent bailing will remove all accumulated particulate from inside the well. Bailing is continued until the water is free from suspended particulate matter.

3.13.5 Airlifting

Airlifting is an effective development technique that is generally used in larger diameter wells. Airlifting is commonly performed using the drill rig that advanced the borehole. Air is injected through small diameter drill rods or pipe to the bottom of the well. The air loosens particulate from the formation and is carried with the water into the well. The particulate is then extracted along with water to the ground surface. Airlifting provides good development for the sand pack and formation. It is an excellent well rehabilitation tool. This development method can produce large volumes of water which can create some difficulties for containment.

3.14 Well Development Documentation

A well is developed after installation to ensure hydraulic stabilization.

Details of well development are recorded on a Well Development, Purging, and Sampling Form (SP-06) or in a standard GHD field book, and must include:

1. Well identification number
2. Date of development
3. Development method

4. Well type including diameter and construction
5. Measuring point location and elevation (if known)
6. Measured water level
7. Measured bottom depth
8. Water column length
9. Screened interval
10. Well volume
11. Volumes purged
12. All field measurements

4. Water Sampling (Groundwater, Residential, and Surface Water) Standard Operating Procedures

4.1 Introduction

Groundwater, residential, and surface water sampling are conducted in order to characterize the groundwater and surface water quality at a site. Standard Operating Procedures (SOPs) are presented herein for the collection of groundwater and surface water samples from:

- Monitoring wells
- Residential wells
- Surface water bodies

This guideline is not intended to provide the basis for designing a groundwater or surface water monitoring program, but instead assumes that a groundwater and/or surface water monitoring program has already been designed. It is also assumed that a site-specific Work Plan has been established and that a GHD representative is preparing to mobilize to the site.

Groundwater and surface water sampling procedures vary from project to project due to:

- Different chemicals of concern.
- Different guidance provided by local, provincial/state, and/or federal regulatory agencies with jurisdiction at the site.
- The specific objectives of the project.

It is essential that all groundwater, residential, and surface water sampling activities conform to local, state/provincial, and federal regulations. Therefore, it is essential that the GHD representative carefully reviews the Work Plan requirements. The primary goal of groundwater, residential, and surface water sampling is the collection of samples representative of the hydrostratigraphic unit and/or surface water body. It is necessary to use appropriate sampling techniques to collect representative samples that provide reliable and reproducible results in accordance with the Work Plan and all relevant regulations.

The remainder of this section is organized as follows:

- Section 7.2 Background
- Section 7.3 Planning and Preparation
- Section 7.4 Safety and Health
- Section 7.5 Quality Assurance/Quality Control
- Section 7.6 Equipment Decontamination
- Section 7.7 Field Procedures for Groundwater Sampling
- Section 7.8 Field Procedures for Residential Sampling
- Section 7.9 Field Procedures for Surface Water Sampling
- Section 7.10 Follow-Up Activities
- Section 7.11 References

4.2 Background

The objective of a groundwater and residential monitoring program is to obtain samples that are representative of existing groundwater conditions, or samples that retain the physical and chemical properties of groundwater in the hydrostratigraphic unit. Surface water sampling is performed to collect samples that are representative of physical and chemical properties of surface water bodies. Improper sampling and transport practices will cause compounds of interest to be removed or added to a sample prior to analysis. The importance of proper and consistent field sampling methods cannot be over emphasized. It is equally important that proper documentation occurs throughout the sampling program.

The most important aspect of groundwater sampling is the collection of groundwater samples that are free of suspended silt, sediment, or other fine-grained material. Fine-grained material has a variety of chemical compounds sorbed to the particles or has the ability to sorb chemicals from the aqueous phase. This causes a bias in the subsequent analytical results. Reproducible and reliable analytical data are invaluable to a groundwater monitoring program. GHD frequently criticizes the sampling activities completed by others due to the collection and analyses of turbid samples. This SOP discusses sampling protocols that typically achieve sediment-free samples.

When sampling for monitored natural attenuation (MNA) parameters, more stringent protocols are followed to ensure sediment-free samples that are representative of the total mobile load (i.e., dissolved and naturally suspended particles). Low-flow purging (LFP) techniques are strongly recommended, if not mandated, when collecting groundwater samples for MNA parameters. The LFP techniques detailed in Section 7.7.5.3 are in accordance with United States Environmental Protection Agency (USEPA) LFP procedures (Puls and Barcelona, 1996).

Groundwater sampling is required for various reasons, including:

- Investigating potable or industrial water supplies
- Tracking contaminant plumes
- Investigating a site with suspected groundwater contamination

Groundwater is usually sampled from in-place wells, installed either temporarily or permanently. Municipal, industrial, or residential wells may also be sampled during an investigation. When completing residential well sampling it is important that representative samples are collected. Poor or incorrect

sampling techniques will result in erroneous results. Incorrect results disclosed to the public will create a false impression, making it difficult to change the perception when correct results are reported.

Groundwater and residential sample collection are performed from non-impacted to most impacted locations. This eliminates the potential for cross-contamination. A review of all historical analytical data is performed to ensure the exact sampling sequence.

Surface water sampling locations are selected based on many factors including:

- The study objectives
- The location of point source discharges
- The location of no-point source discharges and tributaries
- The presence of structures (e.g., bridges, dams)
- Accessibility

Surface water sampling should be performed from downstream to upstream locations. This ensures that surface water sampling activities do not cause suspended sediments to bias samples collected downstream.

4.3 Planning and Preparation

Prior to groundwater, residential, and surface water sampling:

121. Review the Work Plan, project documents, and Site-Specific Health and Safety Plan (HASP) with the Project Manager/Coordinator.
122. Review the Quality Assurance Project Plan (QAPP) with the Project Coordinator and Project Chemist to determine Quality Assurance/Quality Control (QA/QC) and decontamination requirements.
123. Complete a Field Equipment Requisition Form (QSF-014). Assemble all sampling equipment and supplies required per the Groundwater Sampling Equipment and Supply Checklist (Form SP-05). The Project Planning, Completion, and Follow-Up Checklist (Form SP-02) should be used for guidance throughout the project.
124. Assemble the site plan, well logs, and previous sampling/purging data required for the sampling event. Determine the exact number and locations of wells to be sampled.
125. Obtain all forms to record purging and sampling activities (Forms SP-06, SP-08, and SP-09).
126. Confirm with the Project Manager/Coordinator that a Property Access/Utility Clearance Data Sheet (QSF-019) has been completed. For residential sampling, ensure that homeowners have been notified of the intended sampling event. Confirm the presence of any dogs on site, modify the site-specific Job Safety Analysis, if there is a dog.
127. Arrange access to the site. Obtain all well and site keys. Consider site access conditions (e.g., snow).
128. For surface water sampling consider if hazards exist due to deep/fast moving water, difficult access, and if additional GHD personnel are required for safety and health reasons.
129. For residential sampling contact homeowners to make arrangements for a site visit, arrange for site dog to be removed from all areas where a GHD employee will be working. The client of another party may be responsible for making arrangements.

130. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work; QSF-031 for U.S. work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).

131. Contact the GHD Chemistry group to arrange:

    - SSOW (Simplified Scope of Work)
    - Laboratory
    - Sample containers delivery
    - Preservatives if required
    - Filtration information if required
    - Coolers
    - Shipping details
    - Sample starting date
    - Expected duration of sampling program

132. If several sampling events are planned, evaluate with the client the benefit of purchasing and installing dedicated sampling equipment. Dedicated purging and sampling equipment reduces potential cross-contamination and reduces decontamination requirements. At a minimum, sample tubing is dedicated to each well and is left secured in the well for future use. For LFP it is recommended that each well is dedicated with a bladder pump and tubing to eliminate well disturbance.

133. Evaluate sample notification needs with the Project Coordinator. Have the regulatory groups, client, landowner, GHD personnel, and laboratory been notified of the sampling activities?

134. Evaluate containment and disposal requirements for purge waters.

135. Plan sampling activities to ensure that wells that historically go dry or have poor recharge fit into the sampling program. This will reduce the time required for sample collection.

136. Plan the sequence of sampling activities to reduce the potential for cross-contamination. For groundwater sampling, start with clean wells and progress to impacted wells. For surface water sampling, start downstream and progress upstream.

4.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule implications.

Field personnel are required to implement the Safety Means Responsibility Awareness Teamwork (SMART) program as follows:

- Assure the HASP is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.

- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions, and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently, and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all involving injury/illness, property damage, vehicle incident, and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

4.5 Quality Assurance/Quality Control

A well-designed QA/QC program will:

- Ensure that data of sufficient quality are obtained, for proper site management decisions or remediation design.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

It is important to note that a QA/QC program should be developed on a site-specific basis. QA/QC requirements are discussed in Section 3.9.

4.6 Equipment Decontamination

Equipment decontamination procedures for a groundwater, residential, or surface water monitoring program will be described in detail in the site-specific Work Plan or in the QAPP.

Equipment is decontaminated between sampling locations and prior to leaving the site. Upon completion of the sampling program, all equipment is decontaminated at the site and then returned clean to the appropriate field equipment manager.

For most groundwater, residential, and surface water sampling programs, sampling equipment (e.g., pumps, bailers, water level indicators) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

If required, the following steps may be added when sampling for Volatile Organic Compounds (VOCs) and metals:

5. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
6. Rinse with deionized water.
7. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
8. Rinse again with deionized water.
9. Air dry for as long as possible.
10. Wrap samplers in aluminum foil to prevent contamination.

> Caution: Check the QAPP to confirm the cleaning protocol. Use of incorrect cleaning protocol could invalidate chemical data.

4.6.1 Purge Water and Decontamination Fluid Disposal

Project-specific disposal methods for purged groundwater and decontamination fluids are determined by the Project Manager during the sampling program's planning and preparation stage (see Section 7.3), but may include:

11. Off-site treatment at private treatment/disposal facility or publicly owned treatment facilities (sanitary sewer).
12. On-site treatment at a client-operated facility.
13. Direct discharge to the surrounding ground surface, allowing infiltration to the underlying subsurface.
14. Direct discharge to an impervious pavement surface allowing for evaporation.

Options 3 and 4 are permitted only after careful review of these practices and the anticipated site conditions. Under no circumstances shall GHD personnel aggravate an existing condition or spread contamination into clean areas.

Decontamination fluids (specifically cleaning solvents/acids) are segregated and collected separately from wash water and purge water. Often small volumes of solvents used during the course of a groundwater, residential, or surface water sampling program will evaporate if left in an open pail. If evaporation is not possible, off-site disposal need to be arranged.

4.7 Field Procedures for Groundwater Sampling

The typical series of events that takes place for a groundwater sampling program is:

15. Well identification and inspection
16. Air monitoring
17. Water level monitoring
18. Well depth sounding
19. Well volume calculation
20. Purging and sampling equipment installation
21. Well purging and stabilization monitoring
22. Sample collection, sample preparation, completion of chain-of-custody, (COC) sample packaging
23. Final water level monitoring (if required), purging, sampling equipment removal, secure the well
24. Equipment decontamination
25. Field note completion and review
26. Sample shipment and COC distribution
27. Purged groundwater and decontamination fluid disposal
28. Sample record documentation, equipment return
29. Completion and distribution of appropriate forms

It is recommended that new plastic sheeting be placed on the ground around the well to prevent contamination of purging and sampling equipment and accessories (e.g., pumps, hoses, rope.).

4.7.1 Well Identification and Inspection

At sites with numerous wells or wells nests, misidentification of wells has occurred. The GHD representative must be alert to the possibility of potential cap switching, mislabeled wells, or unlabeled well locations.

Determine proper well location and identification by comparing the well log details to the measured well depths (i.e., total well depth, casing diameter, casing stick-up, or stick-down distances), field tie-ins, and site plan.

Once well identification has been established, complete a thorough well inspection:

30. Determine if the well cap and lock are secure, and check for vandalism.
31. If no lock is present, dedicate a new lock to the well location.
32. Examine the integrity of the surface seal.
33. Check for cracks, evidence of frost heave, or subsidence in the vicinity of the well.
34. Examine the integrity of the protective casing. Ensure that the casing can be closed and locked.

35. If required, re-label the well to assist in future identification.

36. If the well is installed with dedicated sampling equipment, check for cracks or leaks in tubing, and worn or frayed rope.

37. Record all the well inspection details in the field book to document well conditions and suitability for groundwater sampling activities.

38. Forward the well inspection results to the Project Coordinator, especially if repairs are required.

4.7.2 Water Level Monitoring/Well Depth Sounding

Prior to commencing well purging and groundwater sampling, the water level is measured for hydraulic monitoring and to determine the well volume. Typically, a complete round of water level measurements is taken at a site to establish groundwater conditions prior to initiating well purging or groundwater sampling activities.

A watertight cap provides an airtight seal on the casing and the water level positioned in the casing area. The cap creates a vacuum or pressurized condition in the casing section which can support or depress the water column in the well casing. This can produce an artificially high or low water level in the well casing. This effect can cause a few inches or feet of error in the static water level. Once the cap is removed, allow the pressure to stabilize for about a half hour. Measure the water level frequently to ensure that stabilization of the water level has occurred. Once the water level has stabilized (i.e., is static) the correct water level may be measured.

A number of instruments are available to measure groundwater levels. GHD typically uses:

- Battery-operated water level indicators (i.e., audible and/or visual identification of water level)
- Battery-operated oil/water interface probes (i.e., audible and/or visual identification of water levels and presence of NAPL)
- Electronic transducers (numerous manufacturers) and recording devices for long-term hydraulic monitoring
- Stevens™ recorders (both float and electronic instrumentation) for long-term hydraulic monitoring

Section 8.0 describes in detail the equipment and monitoring techniques for water level measurements.

Well depth sounding is often required to confirm well identification, evaluate the accumulation of sediment in the well bottom, or assist in determining the standing well volume. Sounding is performed using a water level indicator or a measuring tape with a weighted end. The water level indicator or weighted tape is lowered to the bottom of the well and a comparison is made of the installed well depth versus the measured well depth. The presence of excessive sediment or drill cuttings may warrant redevelopment of the well prior to well purging and groundwater sampling activities.

The total well depth is compared to the original installed total well depth. If the well screen is more than 50 percent blocked by accumulated sediment, the well is redeveloped prior to the next groundwater sampling event. Report all wells requiring redevelopment to the Project Coordinator. Well depth sounding is performed on an annual or biannual basis if the well is equipped with a dedicated pump.

For LFP, well depth measurement is performed to ensure proper pump intake placement. The used of a wide-based probe, such as a weighted tape, is necessary to minimize penetration and disturbance of

accumulated sediment. The measuring device is lowered slowly through the water column to the well bottom to minimize mixing of the stagnant well casing water and disturbance of sediment.

> Don't forget that decontamination procedures apply to the water level monitoring equipment as well as the groundwater sampling equipment. If well sounding is performed, the entire measuring device must be thoroughly decontaminated prior to re-use. Measuring the well depth with certain water level indicators may damage the probe seal. Therefore, a tape with a weighted end should be used to measure well depth.

4.7.3 Well Volume Calculation

Prior to commencing well purging, the volume of water in the well must be known to determine the volume of groundwater to be removed. A well volume is defined as the volume of water contained in the well screen and casing (and in the case of an open bedrock hole, the volume of water in the open corehole and possibly in the well casing). To determine the standing water volume in a well:

39. Calculate the distance from the bottom of the well to the static water level.
40. Measure the inside diameter of the well or casing. Obtain the volume of standing water in the well using the following formula:

    V = $\pi r^2 h$ (7.48 U.S. gallons/cubic feet) (1 liter/1,000 cubic centimeters)

    Where:

    V = volume of water in gallons or liters

    π = 3.142

    r = radius of well casing (feet or meters)

    h = depth of water column in the well (feet or meters)

Typical 1 - Foot Casing Volumes	
Diameter (inches)	Gallons (U.S.) of Water Per Foot of Casing
1.5	0.09
2	0.16
3	0.37
4	0.65
6	1.47

Typical 1 Meter Casing Volumes		
Diameter		Litres per Meter of Casing
(inches)	6 (cm)	
1.5	3	1.14
2	5	2.02
3	8	4.56
4	10	8.11
6	15	18.24

4.7.4 Well Purging and Stabilization Monitoring

4.7.4.1 Typical Method

Prior to initiating groundwater sample collection, the wells is purged of the standing stagnant groundwater volume. This volume is not representative of the groundwater in the hydrostratigraphic unit. Purging is performed until the water in the well is representative of the actual conditions in the hydrostratigraphic unit. Stabilization is usually achieved by the removal of three to five times the volume of standing water in the well (USEPA convention). Purging is considered complete once purged groundwater is free of sediment and field parameters including specific conductance, temperature, and turbidity are stable. Stabilization is achieved when field measurements for specific conductance and temperature are within a range of plus or minus 10 percent of the average for the last three readings. Field measurement for pH should be within a range of plus or minus 0.1 pH unit of the average for the last three readings, and groundwater turbidity values should be less than 5 nephelometric turbidity units (NTU) (guidance value only). Once the number of well volumes required to achieve stabilization is established, the volume required to reach stabilization for future sampling events is reduced or eliminated. Extended purging of a well will generally result in achieving sediment-free groundwater conditions.

During purging, if stabilization has not occurred after removal of five well volumes, purging is continued until ten well volumes have been removed. If stabilization still has not been achieved, stabilization may be dropped as a pre-condition to groundwater sampling. The Project Coordinator should be notified that stabilization has not occurred after the removal of ten well volumes.

At high yielding wells, removing three to five well volumes is usually sufficient prior to initiating groundwater sampling. For low yield wells (i.e., wells that pump dry after one well volume) it is necessary to purge the well dry on three successive days, unless the well recovers to full static conditions in a shorter time. If the recharge is relatively high, groundwater sampling will be initiated once the well has fully recovered to static groundwater conditions, or to a level that is sufficient to collect the necessary groundwater sample volume.

> Purging of dry wells should be scheduled to begin on Monday or Tuesday, to reduce weekend requirements.

Turbidity of purged groundwater is evaluated by a visual examination for sediment/silt presence or by using a nephelometer which physically measures groundwater turbidity in NTUs. Generally, a turbidity value of 50 NTU or less is acceptable, although some regulatory agencies have established lower criteria (i.e., less than 5 NTU). If 50 NTU is not achieved, filtration of samples may be required. LFP can generally result in turbidity values less than 5 NTU.

> Agitation of the water column within the well will increase turbidity. Therefore, bailers and inertia pumps (Waterra™) are of limited use for collecting sediment-free samples. The tubing of peristaltic pumps must be secured to prevent movement of the tubing within the water column which would disturb sediment. The best method to reduce sediment disturbance is low-volume non-agitation pumping (i.e., bladder pump).

Well purging is accomplished using dedicated equipment or by using either peristaltic, bladder, or other approved purging methods. Purging and sampling equipment are dependent on the total well depth. Bailing can be used for well purging but this method stirs up sediment and increases the purging effort required before stabilization is achieved. Equipment available for well purging is discussed in

Section 7.7.7. Monitoring equipment used during well purging includes a water level indicator, pH meter, thermometer, conductivity meter, and turbidity meter.

4.7.4.2 Purging Entire Water Column

The purging equipment is lowered into the top of the standing water column. Well purging is completed from as close to the top of the water column as possible, not from the well bottom, unless poor well recovery occurs. Purging from the top of the water column moves water from the formation through the well screen of the well and into the well casing. This allows for the entire static volume to be removed. Purging at depth in the water column does not remove water above the pump intake and results in the collection of unrepresentative samples.

If required, the pump intake can be adjusted. If the recovery rate is greater than the pumping rate, the pump should remain suspended until the required purged volume has been removed. If the recovery rate is less than the pumping rate, the pump should be lowered to ensure the removal of the required well volume.

4.7.4.3 Low-Flow Purging (LFP) Technique

LFP purging results in minimal drawdown during well purging, so less purging is required before formation water is removed. The volume required for purging using LFP is significantly reduced. LFP results in less agitation and mobilization of sediments compared to traditional sampling techniques.

A pre-cleaned stainless steel bladder pump equipped with a Teflon™ bladder is strongly recommended for LFP. The discharge line should be polyethylene or Teflon™ lined tubing with an inside diameter of 1/4 or 3/8 inch (6 or 10 mm). Check the Work Plan or QAPP to ascertain the proper bladder and discharge tubing. Smaller discharge tubing ensures that the tubing remains filled with water and reduces air bubbles at low purging rates. The airline to the pump is generally 1/4-inch (6 mm) inside diameter polyethylene tubing. The pump is secured to nylon rope and positioned in the well so that the pump intake is set at the mid-point of the well screen, or a minimum of 2 feet (0.6 m) above the bottom of the well or accumulated sediment level. It is important that the rope, airline, and discharge tubing are measured prior to installation in the well. The bladder pump and tubing are lowered very slowly through the water column to minimize mixing of the stagnant well casing water and to minimize the agitation of sediment into suspension, which would increase the purging time. It is recommended, and in some instances regulated, that pump installation occurs at least 24 hours prior to initiating LFP. It is recommended that a bladder pump be dedicated to the well for regular monitoring events.

During LFP, the pumping rate should be between 100 and 500 milliliters per minute (mL/min). It is recommended that initial pumping be conducted at a lower rate to limit drawdown in the well. During purging, groundwater levels are measured to maintain a maximum 0.4 foot (0.1 m) of drawdown. The pumping rate can be gradually increased during LFP. Pumping rate increases will be dependent on the drawdown and the stabilization of field parameters discussed below. Pumping rate adjustments should occur in the first 15 minutes of purging. After this time the pumping rate should remain constant and flow rate adjustments should be avoided. During purging, the pumping rate and groundwater level should be measured at least every 10 minutes. It is recommended that water level measurements occur at 5-minute intervals.

During LFP, stabilization of the purged groundwater is required to ensure the collection of representative groundwater samples from the formation and not from the stagnant water in the well casing. Field parameters including pH, temperature, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity should monitored during LFP. The measurement of these field

parameters is used to evaluate if stabilization of the purged groundwater has occurred prior to the collection of groundwater samples. The field measurements should be measured and recorded at 5-minute intervals. Groundwater stabilization is considered achieved when three consecutive readings for each of the field parameters, taken at 5-minute intervals, are within the following limits:

pH	±0.1 pH units of the average value of the three readings
Temperature	±3 percent of the average value of the three readings
Conductivity	±0.005 milliSiemen per centimeter (mS/cm) of the average value of the three readings for conductivity <1 mS/cm and ±0.01 mS/cm of the average value of the three readings for conductivity >1 mS/cm
ORP	±10 millivolts (mV) of the average value of the three readings
DO	±10 percent of the average value of the three readings
Turbidity	±10 percent of the average value of the three readings, or a final value of less than 5 NTU

During LFP, field parameters are measured using a flow-through cell apparatus. At the start of LFP the purge water is visually inspected for clarity prior to connecting to the flow-through cell. If the purge water is turbid, LFP continues until the purge water is visually less turbid prior to connecting to the flow-through cell. Field parameters may be obtained using individual meters or a multiple meter unit; however, the use of a flow-through cell is highly recommended. All meters must be calibrated daily in accordance with the manufacturer's and GHD's calibration instructions, and a calibration record maintained in a standard GHD field book.

During LFP the meter readings are monitored for evidence of meter malfunction. The following are common indicators of meter malfunctions:

- DO above solubility (e.g., oxygen solubility is approximately 11 milligrams per liter (mg/L) at 10°C) may indicate a DO meter malfunction.
- Negative ORP and DO less than 1 to 2 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have positive ORP and DO less than 1 to 2 mg/L under oxidizing conditions).
- Positive ORP and DO less than 1 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have a negative ORP and DO less than 1 mg/L under reducing conditions).

Meter calibration fluids should be available for meter recalibration in the field. Spare meters should also be available for meter replacement if necessary.

DO levels exceeding the solubility of oxygen in water are erroneous and are indicative of meter malfunction or poor sampling techniques causing turbulence and aeration. DO concentrations cannot exceed:

9 mg/L at 20°C 10 mg/L at 15°C 11 mg/L at 10°C 14 mg/L at 1°C

Stabilization will be considered complete when the field parameters have stabilized as indicated in the above table. Purging will continue if stabilization does not occur, until a maximum of 20 screen volumes has been removed. LFP causes groundwater to be drawn from a significant distance above or below the pump intake. Therefore, the screen volume is based on a 5-foot (1.5 m) screen length. After the removal of 20 screen volumes, purging will continue if the purged water remains visually turbid and appears to be clearing. Also purging will continue if the field parameters vary only slightly outside of the stabilization criteria and appear to be approaching stabilization.

If the recharge to the well is insufficient to conduct LFP, the well should be pumped dry and allowed to recharge sufficiently for the collection of the groundwater sample volume. Wells purged dry are required to meet the stabilization criteria detailed above.

4.7.4.4 Sampling Techniques

Upon completion of purging, with groundwater stabilization and clarity meeting the applicable protocol described above, groundwater sample collection can proceed. Generally the field parameters of pH, temperature, and specific conductance are monitored first, then any other required field measurements.

Samples are collected directly from the purging pump, when possible, or an alternate device (i.e., pump or bailer) may be installed or used. If new sampling equipment is installed, the first few bails or discharge volumes should be discarded to allow acclimation of the sampling equipment with the groundwater.

Samples are typically collected from the pump or bailer with the discharged groundwater collected directly in the appropriate sample containers. The interior of the bottle or cap must not be touched or handled in anyway. New gloves (i.e., disposable nitrile gloves or equivalent) should be worn for the collection of each sample. Caps from sample bottles must not be placed on the ground or in pockets to eliminate the possibility of cross-contamination.

Descriptions of the various equipment and sampling methods for the collection of groundwater samples are contained in Section 7.7.7.

The following describes the main activities involved in the collection of groundwater samples.

4.7.4.5 Order of Sample Collection

Groundwater samples are collected and containerized in the order following volatilization sensitivity:

41. VOCs
42. Semi-volatile organic compounds (SVOCs)
43. Total organic carbon
44. Total organic halides
45. Extractable organics
46. Total metals
47. Dissolved metals
48. Phenols
49. Cyanide
50. Sulfate and chloride
51. Nitrate and ammonia
52. Microbiological parameters
53. Radionuclides

QA/QC requirements for groundwater sampling are described in detail in Section 3.9.

4.7.5 Sample Acquisition and Transfer

If groundwater sample collection is performed using a pump, the flow rate must not exceed 100 mL/min during the collection of groundwater samples for VOCs. The low flow rate will reduce the possibility of degassing samples. During the collection of groundwater into the sample container or filtration device, minimize agitation and aeration of the sample. Groundwater samples are transferred directly into the sample container for submittal to the laboratory. Groundwater samples should not be collected in larger containers and subsequently transferred to smaller sample containers; however, on occasion this will be required for filtration or sample composting. During VOC sample collection, samples must not be collected, handled, or containerized near or in the vicinity of a running motor or exhaust which may contaminate the samples.

Groundwater samples for VOCs are collected in laboratory supplied 40 mL glass vials. The vials are filled to the top until a meniscus is formed, then topped with a Teflon™-lined cap. To prevent the loss of volatiles, it is important that no air bubbles or headspace are present in the sample container. Inverting and tapping the vial will check for the presence of air bubbles. If air bubbles are present, the sample should be topped off again and resealed. This process may only be performed a maximum of twice, at which time the sample must be discarded and the sample retaken. If preservatives were present in the bottle from the laboratory, a new sample vial must be used.

> Gas bubbles that appear in VOC containers after sample collection may be a result of degassing or reaction with preservative. If this occurs, note this occurrence on the chain-of-custody. Re-sampling is not required in most cases.

During sample collection ensure groundwater samples are preserved according to laboratory requirements. If required and supplied by the laboratory, preserve the samples in accordance with the QAPP. Some laboratories pre-preserve bottles so that once the groundwater sample is added the preservation is completed. In either case, it is advisable to check sample preservation using litmus paper. Using litmus paper ensures that groundwater sample preservation has been completed to the proper pH as required by the QAPP. If preservation of a sample does not meet the requirements of the QAPP, it may be necessary to add additional preservative, or note on the chain-of-custody that incomplete sample preservation has occurred.

Once sample collection is complete, samples are placed in a cooler on ice to maintain a sample temperature no more than 4°C.

4.7.5.1 Sample Labels/Sample Identification

Label all groundwater samples with the following, written in indelible ink:

54. A unique sample number (see Section 3.9 for guidance)
55. Date and time
56. Parameters to be analyzed
57. Job number
58. Sampler's initial

Secure the label to the bottle. It is recommended that bottle labels be covered with wide clear tape to protect the label during sample packing and shipment. Pack glassware in appropriate packing material to

deter breakage during sample packing and shipment. Sample labels can be prepared in advance in GHD offices that have label-generating programs.

An example of a groundwater sample log entry is provided on Figure 3.8.

Section 3.9 details sample labeling requirements for environmental sampling programs. Section 3.9 also details COC requirements and sample shipment requirements.

4.7.6 Purging/Sampling Equipment

GHD maintains a wide variety of purging and sampling equipment for well purging and groundwater sample collection. The groundwater sampler should be familiar with purging and sampling equipment and understand equipment limitations and proper use. Some equipment is very useful for well purging (i.e., high flow rates) but is not permissible for LFP or for sampling sensitive parameters (e.g., VOCs cannot be collected with a submersible (turbine) or suction pump). If the groundwater sampler understands the various equipment operation and limitations, the proper selection of purging and sampling equipment is made, which will minimize the purging and sampling duration and maximize productivity.

> Caution: Gas powered equipment requires special attention to ensure that staff hauling these units do not cause equipment or sample contamination. Frequent changes of disposable glove as well strict separation of sampling crew tasks (i.e., those handling pumps and hoses do not contact generator or are involved in any refueling activities) are required.

The following subsections describe the equipment available for groundwater sampling, the equipment use, approximate flow rates, and advantages and disadvantages of the equipment.

4.7.6.1 Peristaltic Pumps

A peristaltic pump is acceptable for purging wells and for most groundwater sample analytes. The groundwater sampler must ensure that a peristaltic pump is acceptable to regulatory agencies with local jurisdiction for VOC and SVOC sample collection. The QAPP will provide sampling requirements.

A peristaltic pump is capable of lifting water from a maximum depth of 25 feet (7.6 m) below ground surface or the pump, whichever is greater. A peristaltic pump is a self-priming, low volume, suction pump which consists of a rotor with ball bearing rollers. Flexible silicon tubing is inserted around or in the pump rotor and squeezed in place by the heads as they revolve in a circular pattern. The section of silicon tubing must not exceed 3 feet (0.9 m) in length. Additional rigid polyethylene or Teflon™ tubing is attached to the flexible tubing and placed in the well. Another piece of rigid tubing is attached to the discharge end of the flexible silicon tubing to facilitate sample collection. The entire length of rigid and flexible silicon tubing is dedicated to the well for future use. The tubing is typically tied and suspended in the well. The flexible or rigid tubing is not reused in other wells because cross-contamination will occur.

> Often a length of tubing is accidentally dropped into a well and can be difficult to retrieve. Retrieval can be accomplished by sending another piece of tubing down the well overlapping the lost section of tubing. Once in place, rotate the tubing, essentially wrapping or corkscrewing the lost tubing and new tubing together. After a number of turns are completed pull the tubing, hopefully with the lost section wound around the new piece. Repeat the procedure until successful.

Liquid is pulled into the tubing by the peristaltic pump through the creation of a vacuum as the rotor head turns. An advantage of using a peristaltic pump is that no pump parts come in direct contact with the sample. A peristaltic pump is capable of providing low flow sampling rates (i.e., typically less than 500 mL/min) with less agitation than other suction pumps. However, it is important that the tubing is secured during pumping to prevent the tubing from moving and causing agitation. A peristaltic pump also allows for regulation of the flow rate by increasing or decreasing the rotor head speed.

Peristaltic pumps are small and easily mobilized to remote sample locations. They require minimal setup, and do not require decontamination between sample locations. The disadvantages of a peristaltic pump are its limited lift and flow capabilities and the limited ability to collect VOC and SVOC samples. If VOC or SVOC sampling, check the QAPP to see if sampling with a peristaltic pump is allowed. Also check with regulatory agencies with local jurisdiction to see if the use of a peristaltic pump for collection of VOC and SVOC samples is acceptable. If using a peristaltic pump for purging, and the collection of VOCs and SVOC samples with the peristaltic pump is not acceptable, it is common to collect the initial VOC and SVOC analytes with a stainless steel bottom loading bailer. The peristaltic pump can then be used to collect the remaining sample analytes.

Peristaltic pumps are becoming more popular for LFP. However, it should be noted that a peristaltic pump may cause degassing, pH modification, and possible VOC loss.

4.7.6.2 Inertia Pumps

An Inertia pump or Waterra™ pump is a manually operated or mechanically driven pump which uses only a foot valve on the sample/purge tubing. "Jerking" the sample/purge tubing with the attached foot valve removes groundwater from the well. The rapid lifting and lowering action of the tubing imparts an inertia to the water column within the sample/purge tubing. This causes the water column to rise to ground surface and discharge from the end of the sample/purge tubing. The foot valve holds the water column in the tubing during the lifting process and allows groundwater to enter the sample/purge tubing during the lowering, or down stroke.

GHD owns both manual and mechanical gas-powered inertia systems. Flow rates with inertia pumps are variable and are dependent on cycle speed, tubing size, foot valve size, well depth, and depth to groundwater. The inertia pump is a useful method for purging and for collection of most groundwater sample analytes. Acceptability of VOC and SVOC sampling with inertia pumps is gaining approval in selected areas. Prior to using an inertia pump as a sampling device, check the sampling requirements in the QAPP, or obtain approval from the Project Coordinator.

Inertia pumps are useful for the extraction of dense non-aqueous phase liquids (DNAPL). The only equipment that is exposed to the gross contamination is the foot valve and a small section of the sample/purge tubing. On most projects, the foot valve and sample/purge tubing are dedicated to the well.

Inertia pumps tend to cause extensive disturbance to the water column. The vigorous lifting and lowering of the inertia pump tends to make it difficult to collect sediment-free groundwater samples. Therefore, inertia pumps are not suitable for LFP.

4.7.6.3 Bailers

A bailer is a manual sampling device consisting generally of a hollow tube (e.g., Teflon™, PVC, or stainless steel) with a lower check ball that permits water entry and prevents water loss. The bailer is lowered slowly into the well. This allows water to enter the bailer through the bottom, and the weight of the water inside the bailer closes the check ball when the bailer is retrieved from the well. A rope or cable is

affixed to the bailer to allow the lowering and retrieval of the bailer from the well. Bailing tends to be disruptive to the water column and formation. Obtaining sediment-free groundwater samples using a bailer tends to be difficult, if not impossible. VOCs and SVOCs, as well as other analytes can be collected using a bailer, but it is important that these analytes be as sediment-free as possible. The compatibility of the bailer material and groundwater analytes should be reviewed and approved prior to using a bailer for the collection of groundwater samples. Generally, Teflon™ bailers are acceptable for the collection of most analytes.

Power winches with overhead tripods are available to assist in purging and sampling deep or large volume wells.

Flow rates attained using a bailer is a function of the bailer size and retrieval frequency. Retrieval frequency is dependent on well depth, water depth, and well recharge rate. Bailing is not practical for deep wells or for the removal of large well volumes.

A bailer is a useful tool for well development as the surging action from the bailer insertion and removal from the well promotes sediment suspension and subsequent removal. However, obtaining completely sediment-free samples, or samples below 50 NTU, is difficult if not impossible using a bailer.

A bailer provides representative samples once the well has been adequately developed and purged. A bailer is not suitable for LFP. Rope used for bailing must be kept off the ground and free of other contaminating material that could be introduced to the well. Rope can either be dedicated to the well for future use or discarded.

4.7.7 Filtering of Groundwater Samples

Filtering is an important process to remove suspended particulate that affect sample results. Filtration of groundwater samples is generally limited to metals analysis.

Filtering can be completed in the field using in-line filters or a vacuum filter kit. Filtering of samples can also be completed by the laboratory, in which case the samples must not be preserved and must be at the laboratory in at least 24 hours of sample collection.

4.8 Field Procedures for Residential Sampling

4.8.1 General

When sampling potable water supply wells it is important to ensure that the samples collected are representative of the aquifer being sampled. Poor or incorrect sampling techniques will result in erroneous sample results that can be disclosed to the public. Incorrect sample results may make any changes in the public perception hard to accomplish when correct results are reported.

4.8.2 Field Procedures

The requirements of a residential well sampling program should be reviewed with the Project Coordinator prior to initiating sampling activities. While similar field procedures used in groundwater sampling (including documentation, sample identification, date, time, etc.) are required in residential well sampling, additional procedures are also required.

Prior to collection of groundwater samples from a residential well, the well must be purged to ensure that samples collected are representative of the formation. Purging removes standing water from the well casing, pipes, and pressure or holding tank. Purging of a residential well requires the removal of one well

volume. If access to the well is not available to determine the well volume, purging for a period of 15 to 30 minutes is generally sufficient. Field measurements for pH, conductivity, and temperature are recorded during purging activities until the readings indicate that stabilization has occurred.

Sampling of residential wells is generally performed using the existing pumping system. However, GHD purging and sampling equipment can be used. It is important that only designated **clean** purging and sampling equipment be used for residential well sampling. The use of the existing pumping system is preferred, as this is more representative of the water quality provided to the residence. Using the existing pumping system also minimizes the possibility of damaging the well and existing pumping system when installing additional purging and sampling equipment.

If GHD equipment is used for residential well sampling, it must be cleaned prior to and between use with a bleach and deionized water solution wash followed by a thorough deionized water rinse.

> In addition to the special technical procedures noted, GHD personnel must be aware of this unique situation of conducting sampling at private residences. Special care must be taken to be polite and courteous at all times. Offer only necessary information and maintain a clean work area that is returned to pre-sampling conditions. Personnel should have proper identification available, and only remain in areas long enough to complete the required tasks.

Taps selected for residential well sampling should be located as close to the well as possible. Locate the taps before any treatment systems and, if possible, the pressure tank. It is important to note, if possible, all water treatment devices in operation at the residence including:

- Water softeners
- Filtration units
- Ultraviolet light
- Reverse osmosis
- Distillers
- Chlorinators

Leaking taps that allow water to flow from the stem of the valve handle and around the tap should not be used as sampling locations. Aerators, strainers, and hose attachments should be removed prior to sampling. Maintain a steady flow of water during sampling activities to avoid pressure fluctuations that may cause sheets of microbial growth lodged in the pipes to break loose. Open the cold water tap for a period of 15 to 30 minutes to allow for the complete purging of the pumping system. Maintain a smooth-flaring water stream at a low to moderate pressure without splashing. Do not change the flow rate. Changes in the flow could dislodge particles in the pipes or faucet.

When sampling for microbiological parameters, the end of the faucet must be flame sterilized. During residential well sample, never place caps from sample containers on the ground or in a pocket. Instead, hold the sample container in one hand and the sample container cap in the other. Be very careful not to touch the inside of the sample container cap. Wear new disposable gloves at each sampling location and following contact with a potential contaminant source. The inside of the sample bottle must not be touched with bare hands or allowed to contact the surface of the faucet.

4.8.3 Field Notes for Residential Sampling

Full documentation of each residential well is required and includes:

59. Well depth
60. Casing construction and diameter
61. Well installation date if known
62. Pumping system configuration
63. Piping system construction (e.g., copper, lead-joint, ABS)
64. Presence of treatment devices

Obtain the name and exact mailing address for all residence or well owners, as well as home and work telephone numbers. This information is required to inform the residence or well owner of the results of the sampling activities.

Document residential well sampling activities in a standard GHD field book. Figure 3.8 provides typical residential well sampling field note requirements. Note that additional documentation of well details, treatment devices, piping system, and special circumstances are required in the field book in addition to the sample log entry.

4.9 Field Procedures for Surface Water Sampling

4.9.1 General

Surface water sampling is performed to obtain samples for surface water bodies that are representative of existing surface water conditions.

Surface water sampling locations for surface water quality and groundwater interaction studies are selected based on the following:

65. Study objectives
66. Location of point surface discharges
67. Non-point source discharges and tributaries
68. Presence of structures (e.g., bridge, dam)
69. Accessibility

During surface water sampling it is important to obtain samples that are not impacted by the re-suspension of sediment produced because of improper or poor surface water sampling techniques.

4.9.2 Surface Water Sample Location Selection

Prior to conducting surface water sampling activities, the first requirement is the consideration and development of surface water sampling locations. It is important that all surface water sampling locations be selected in accordance with the Work Plan and described to and discussed with the Project Coordinator.

Bridges and piers are good locations for surface water sampling locations since they provide easy access and permit water sampling across the entire width of the surface water body. The JSA for sampling from bridges must include a traffic management plan to assure the employee has considered using a spotter,

signage, cones, and flags to warn car traffic of the work adjacent to the roadway. Wading for surface water samples increases the chances of disturbance of sediments from the floor of the surface water body.

When wading for surface water samples in lakes, ponds, streams, and slow moving rivers be aware of potential safety and health risks. A life vest and safety line must be worn at all times where footing is unstable or when sampling in fast moving or more than 3 feet (0.9 m) deep. A two-person team is required for most surface water sampling activities, a Project Manager must approve a one person sampling team. If the site conditions require the use of the life vest and safety line, the two people involved in the sampling must be competent swimmers.

Surface water samples must be collected with no suspended sediments. Surface water samples are collected commencing with the furthest downstream location to avoid sediment interference with upstream locations.

4.9.2.1 Lakes, Ponds, and Impoundments

The surface water in lakes, ponds, and impoundments has a greater tendency to be stratified than water in rivers and streams. Lack of mixing in these surface water bodies may require additional surface water sample collection. Extreme turbidity variances may occur where highly turbid surface water courses enter a lake or pond. Therefore, each layer of the stratified surface water column may need to be considered separately. Stratification is generally a result of water temperature differences, with cooler heavier water being trapped below warmer water.

Surface water sample locations for lakes, ponds, and impoundments should adequately represent the conditions of the surface water body. All intakes and outflows that may provide biased surface water representation should be identified and documented. Surface water sample locations with adjacent structures (e.g., banks, piers) may also provide biased samples, as the potential for boundary flow and eddies exists.

The number of surface water sample locations on lakes, ponds, or impoundments will vary depending on the purpose of the investigation, as well as the size and shape of the surface water body. In ponds and small impoundments a single surface water sample should be collected at the deepest point. In naturally formed ponds, the deepest point is usually near the center of the surface water body. In impoundments the point is usually near the dam.

In lakes and larger impoundments, several sub-samples should be taken to form a single composite sample. These vertical surface water sampling locations are collected along a pre-determined grid.

In irregular shaped lakes with several bays and covers that are protected from the wind, additional surface water samples are required to properly represent surface water quality at various locations in the lake. Additional surface water samples should be taken at discharges, tributaries, and other factors or sources that are suspected of affecting the surface water quality.

In all instances, properly document all surface water sampling locations in a standard GHD field book. Documentation may include photographs and tie-ins to known structures.

4.9.3 Sampling Equipment and Techniques

When collecting surface water samples, direct dipping of the sample container into the stream or water is acceptable unless the sample container contains preservatives. If preserved, a pre-cleaned unpreserved sample container should be used to collect the surface water sample. The surface water sample is then

transferred to the appropriate preserved sample container. When collecting surface water samples, submerse the inverted bottle to the desired sample depth and tilt the opening of the sample container upstream to fill. During surface water sample collection, wading or movement may cause sediment deposits to be re-suspended and can result in biased samples. Wading is acceptable if the stream has a noticeable current and the samples are collected directly in the sample container when faced upstream. If the stream is too deep to wade in or if addition samples must be collected at various depths, additional sampling equipment will be required. Surface water samples should be collected about 6 inches (15 cm) below the surface, with the sample bottles being completely submerged. Taking the surface water sample at this depth eliminates the collection of floating debris in the sample container.

Surface water sample collection where the flow depth is less than 1 inch (<2.5 cm) requires the use of special equipment to eliminate sediment disturbance. Surface water sampling may be conducted with a container then transferred to the appropriate sample container, or collection may be performed using a peristaltic pump. A small excavation in the stream bed to create a sump for sample collection can also be considered but should be prepared in advance to allow all the sediment to settle prior to surface water sampling activities.

Teflon™ bailers can be used for surface water sampling if it is not necessary to collect surface water samples at specific depths. A bottom loading bailer with a check ball is sufficient. When the bailer is lowered through the water, the water is continually displaced through the bailer until the desired depth is reached. The bailer is retrieved and the check ball prohibits the release of the collected surface water sample. Bailers are not suitable in surface water bodies with strong currents, or where depth-specific sampling is required.

For discrete and specified depth surface water sampling, and the parameters to be monitored do not require a Teflon™ coated sampling device, a standard Kemmerer or Van Dorn sampler can be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the sampler ends open while the sampler is being lowered. The sampler is lowered in a vertical position to allow water to pass through. The Van Dorn sampler is plastic and is lowered in a horizontal position. For both samplers, a messenger is sent down a rope when the sampler has reached the required depth. The messenger causes the stopper on the sampler to close. The sampler is then retrieved and the surface water sample can be collected through a valve. DO sample bottles can be filled by allowing overflow using a rubber tube attached to the valve. During depth-specific surface water sampling, take care not to disturb bottom sediments.

Glass beakers or stainless steel cups may also be used to collect surface water samples if parameter interference does not occur. The beaker or cup must be rinsed at least three times with the surface water sample prior to sample collection.

All equipment must be thoroughly decontaminated as outlined in Section 7.6.

4.9.4 Field Notes for Surface Water Sampling

Use a standard GHD field book to record daily surface sampling activities, describe surface water sampling locations, sampling techniques, and, if applicable, provide a description of photographs taken. Visual observations are important and provide valuable information when interpreting surface water quality results. Observations include:

70. Weather conditions
71. Stream flow directions
72. Stream physical conditions (width, depth, etc.)

73. Tributaries
74. Effluent discharges
75. Impoundments
76. Bridges
77. Railway trestles
78. Oil sheens
79. Odors
80. Buried debris
81. Vegetation
82. Algae
83. Fish and other aquatic life
84. Surrounding industrial areas

The following factors should be considered for surface water sampling:

85. Predominant Surrounding Land Use: Observe the prevalent land use type in the vicinity and note any other land uses in the area which, although not dominant, may potentially affect surface water quality.
86. Local Watershed Erosion: Note the existing or potential erosion of soil in the local watershed and its movement into the stream. Erosion can be rated through visual observation of watershed stream characteristics including increases or decreases in turbidity.
87. Local Watershed Non-Point Source Pollution: This refers to problems or potential problems other than erosion and sedimentation. Nonpoint source pollution can be diffuse agricultural and urban runoff. Other factors may include feed lots, wetlands, septic systems, dams, impoundments, and mine seepage.
88. Estimated Stream Width: The estimated distance from shore at a transect representative of the stream width in the area.
89. Estimated Stream Depth: Riffle (rocky area), run (steady flow area), and pool (still area). Estimate the vertical distance from the water surface to the bottom of the surface water body at a representative depth at three locations.
90. High Water Mark: Estimate the vertical distance from the bank of the surface water body to the peak overflow level, as indicated by debris hanging in bank or flood plain vegetation, and deposition of silt. In instances where bank flow is rare, high water marks may not be evident.
91. Velocity: Record or measure the stream velocity in a representative run area.
92. Dam Present: Indicate the presence or absence of a dam upstream or downstream of the surface water sampling location. If a dam is present, include specific information detailing the alteration of the surface water flow.
93. Channelized: Indicate if the area surrounding the surface water sampling location is channelized.

94. Canopy Cover: Note the general proportion of open to shaded areas which best describes the amount of cover at the surface water sampling location.

5. Fluid Level Monitoring Standard Operating Procedures

5.1 Introduction

Fluid level monitoring within groundwater monitoring wells, residential wells, and surface water bodies are conducted in order to characterize the groundwater and surface water flow characteristics and interactions at a site. Standard Operating Procedures (SOPs) are presented herein for the collection of fluid levels from:

- Monitoring wells
- Residential wells
- Surface water bodies

This guideline is not intended to provide the basis for designing a fluid level monitoring program, but instead assumes that a groundwater and/or surface water monitoring program has already been designed. It is also assumed that a site-specific Work Plan has been established and that a GHD representative is preparing to mobilize to the site.

Groundwater and surface water monitoring procedures vary from project to project due to:

- Different chemicals of concern.
- Different guidance provided by local, provincial/state, and/or federal regulatory agencies with jurisdiction at the site.
- The specific objectives of the project.

It is essential that all groundwater, residential, and surface water fluid level monitoring activities are completed properly. Therefore, the GHD representative must carefully review the Work Plan requirements. The primary goal of groundwater, residential, and surface water fluid level monitoring is the collection of fluid level data representative of the hydrostratigraphic unit and/or surface water body. It is necessary to use appropriate monitoring techniques to collect representative data that provide reliable and reproducible results in accordance with the Work Plan and all relevant regulations.

The remainder of this section is organized as follows:

- Section 8.2 Background
- Section 8.3 Planning and Preparation
- Section 8.4 Safety and Health
- Section 8.5 Quality Assurance/Quality Control
- Section 8.6 Equipment Decontamination
- Section 8.7 Field Procedures for Groundwater/Residential/Leachate Fluid Level Monitoring
- Section 8.8 Field Procedures for Surface Water Fluid Level Monitoring
- Section 8.9 Follow-Up Activities

- Section 8.10 References

5.2 Background

The measurement of fluid levels (groundwater or phase-separated compounds) in monitoring wells, piezometers, extraction wells, and/or boreholes is required in geotechnical, hydrogeologic, and waste management investigations to determine the presence and condition of the groundwater, or the presence and thickness of phase-separated compounds. Water level measurements (hydraulic head) are used to determine: hydraulic gradients and the direction of groundwater flow; the effectiveness of groundwater extraction systems; and the volume of water required for well purging prior to groundwater sampling. The measurement of the thickness of phase-separated compounds provides a qualitative (not quantitative) monitoring of this severe form of contamination.

In order to provide reliable data, water levels must be collected over as short a period of time as possible. Barometric pressure can affect groundwater levels and, therefore, observation of significant weather changes during the period of water level measurements must be noted. Tidal fluctuations, navigation controls on rivers, rainfall events and groundwater pumping can also affect groundwater and surface water levels. Personnel collecting water level data must note if any of these controls are in effect during the groundwater level collection period. Due to possible changes during the groundwater level collection period, it is imperative that the time of data collection at each station be accurately recorded.

In conjunction with groundwater level measurements, surface water (e.g., ponds, lakes, rivers, and lagoons) must also be monitored. This information is critical to understanding the hydrogeologic setting of the site and, most importantly, how contaminants may move beneath the site.

A number of devices are used by GHD to collect water level measurements. Typical devices used are:

- Calibrated electronic water level indicator (e.g., Solinst, Heron, or Slope Indicator)
- Measuring tape/plopper
- Pressure transducer and datalogger (generally for pumping tests and long-term monitoring)

Devices typically used by GHD to measure phase-separated compounds are:

- Oil/water interface probe
- Clear "bottom loading" bailer
- Weighted cotton string or cord

The pressure transducers and oil/water interface probes have manuals which describe their use. This SOP will focus on an overview of the use of this equipment and other methods which have more widespread use in fluid level measurement.

Since many decisions concerning the distribution, transport, and remediation of groundwater contamination will be made on the basis of the fluid level monitoring, the accuracy of the measurements made at an appropriate level of precision is very important. Typically, the precision required is ±0.01 foot (±1 mm) and the majority of GHD's measuring devices are calibrated to this precision level. To ensure accuracy, double check all fluid level readings; it is very easy to misread a tape or transpose figures when recording data.

5.3 Planning and Preparation

Prior to measuring fluid levels:

95. Review the Work Plan, project documents, and Site-Specific Health and Safety Plan (HASP) with the Project Coordinator.

96. Review the Quality Assurance Project Plan (QAPP) with the Project Coordinator and Project Chemist to determine Quality Assurance/Quality Control (QA/QC) and decontamination requirements.

97. Complete a Field Equipment Requisition Form (QSF-014). Assemble all equipment and supplies required in accordance with the Water Level Measurement Equipment and Supply Checklist (Form SP-10). A Project Planning Completion and Follow-Up Checklist (Form SP-02) should be used for guidance throughout the project.

98. Assemble the site plan, well depths, and previous measurements. Determine the exact number of points (wells and surface water levels to be measured).

99. Obtain all forms required to record fluid levels such as Water Level Record (Form SP-11) or site field book.

100. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status or not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian Work; QSF-031 for U.S. Work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).

101. Confirm with the Project Manager and Project Coordinator that a Property Access/Utility Clearance Data Sheet (QSF-019) has been completed. For residential monitoring, ensure that homeowners have been notified of the intended monitoring event. Confirm the presence of any dogs on site, modify the site specific Job Safety Analysis if there is a dog.

102. Arrange access to the site. Obtain all well and site keys. Consider site access and well conditions (e.g., snow, insects, bee hives, wasp nests).

103. For surface water monitoring consider whether hazards exist due to deep/fast moving water, difficult access, and if additional GHD personnel are required for safety and health reasons.

104. For residential sampling, contact homeowners to make arrangements for a site visit, arrange for site dog to be removed from all areas where a GHD employee will be working. The client or other party may be responsible for making arrangements.

105. Determine measurement notification needs with the Project Coordinator. Have the client, regulatory agency, landowner been notified?

106. Evaluate monitoring notification needs with the Project Coordinator. Have the regulatory groups, client, landowner, and GHD personnel been notified of the activities?

107. Plan the sequence of monitoring activities to reduce the potential for cross-contamination. For groundwater monitoring, start with clean wells and progress to impacted wells. For surface water monitoring, start downstream and progress upstream.

5.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule implications.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

5.5 Quality Assurance/Quality Control

A well-designed QA/QC program will:

- Ensure that data of sufficient quality are obtained, for proper site management decisions or remediation design.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

It is important to note that a QA/QC program should be developed on a site-specific basis. QA/QC requirements are discussed in Section 3.9.

5.6 Equipment Decontamination

Equipment decontamination procedures for a fluid level monitoring program will typically be described in detail in the site-specific Work Plan or in the QAPP.

Equipment is decontaminated between monitoring locations and prior to leaving the site. Upon completion of the monitoring program, all equipment is decontaminated at the site and then returned clean to the appropriate field equipment manager.

For most groundwater, residential, and surface water fluid level monitoring programs, monitoring equipment (e.g., water level indicators, oil/water interface probes, weighted tapes) is typically cleaned as follows:

108. Wash with clean potable water and laboratory detergent.
109. Rinse with tap water.
110. Rinse with deionized water.
111. Air dry for as long as possible.

If required, the following steps may be added under specific monitoring programs when certain chemical compounds are present within the monitored media:

112. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
113. Rinse with deionized water.
114. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
115. Rinse again with deionized water.

Monitoring fluid levels in residential wells also may require the following additional steps:

116. Rinse with tap water.
117. Rinse with a 10 percent or stronger bleach solution before and after fluid level monitoring in each well.
118. Rinse with distilled water.

> Caution: Check the QAPP to confirm the cleaning protocol. Use of incorrect cleaning protocol could invalidate chemical data.

5.6.1 Decontamination Fluid Disposal

Project-specific disposal methods for decontamination fluids are determined by the Project Manager during the monitoring program's planning and preparation stage (see Section 8.3), but may include:

119. Off-site treatment at private treatment/disposal facility or publicly owned treatment facilities (sanitary sewer).
120. On-site treatment at a client-operated facility.

121. Direct discharge to the surrounding ground surface, allowing infiltration to the underlying subsurface.

122. Direct discharge to an impervious pavement surface allowing for evaporation.

Options 3 and 4 are permitted only after careful review of these practices and the anticipated site conditions. Under no circumstances shall GHD personnel aggravate an existing condition or spread contamination into clean areas.

Decontamination fluids (specifically cleaning solvents/acids) are segregated and collected separately from wash water and purge water. Often, small volumes of solvents used during the course of a groundwater, residential, or surface water monitoring program will evaporate if left in an open pail. If evaporation is not possible, off-site disposal needs to be arranged.

5.7 Field Procedures for Groundwater/Residential/Leachate Fluid Level Monitoring

Fluid level monitoring in monitoring wells, residential wells, and leachate wells is very similar. The typical series of events that takes place for a fluid level monitoring program is:

123. Well/monitoring location identification and inspection.

124. Air monitoring.

125. Water level monitoring.

126. Well depth sounding.

127. Equipment decontamination.

128. Field note completion and review.

129. Sample record documentation, equipment return.

130. Completion and distribution of appropriate forms.

5.7.1 Well Identification and Inspection

At sites with numerous wells or wells nests, misidentification of wells can easily occur. The GHD representative must be alert to the possibility of potential cap switching, mislabeled wells, or unlabeled well locations.

Determine proper well location and identification by comparing the well log details to the measured well depths (i.e., total well depth, casing diameter, casing stick-up, or stick-down distances), field tie-ins, and site plan.

Once well identification has been established, perform a thorough well inspection:

131. Determine if the well cap and lock are secure, and check for vandalism.

132. If no lock is present, dedicate a new lock to the well location.

133. Examine the integrity of the surface seal.

134. Check for cracks, evidence of frost heave, or subsidence in the vicinity of the well.

135. Examine the integrity of the protective casing. Ensure that the casing can be closed and locked.

136. If required, re-label the well to assist in future identification.

137. Record all the well inspection details in the field book to document well conditions and suitability for groundwater sampling activities.

138. Forward the well inspection results to the Project Coordinator. If well repairs are required this must be done immediately.

5.7.2 Reference Point

Fluid level measurements are made relative to a surveyed reference point. For groundwater level measurements, the reference point is usually the top of the well riser or casing (the protective casing should not be used as a reference point). The top of the well riser/casing is usually not level and/or square; therefore, the reference point must be clearly marked on the riser and noted in the field book. Clearly marking the reference point will eliminate future measurement errors. Measure and record the distance from the reference point to the ground surface. The elevation of the reference point should be determined to the nearest 0.01 foot (1 mm). Typically, the reference point is the highest point on non-level riser pipes.

5.7.3 Water Level Monitoring/Well Depth Sounding

Prior to commencing well purging and groundwater sampling, the water level is measured for hydraulic monitoring and to determine the well volume. Typically, a complete round of water level measurements is taken at a site to establish groundwater conditions prior to initiating well purging or groundwater sampling activities.

A watertight cap provides an airtight seal on the casing and the water level positioned in the casing area. These caps are most commonly used on flush mount monitoring wells. The cap creates a vacuum or pressurized condition in the casing section which can support or depress the water column in the well casing. This can produce an artificially high or low water level in the well casing. This effect can cause a few inches or feet of error in the static water level. Once the watertight cap is removed, allow the pressure to stabilize for approximately half an hour. Measure the water level frequently to ensure that stabilization of the water level has occurred. Once the water level has stabilized (i.e., is static) the correct water level may be measured. If unsure of whether the water level has stabilized, note this in the field book/water level record form.

A number of instruments are available to measure groundwater levels. GHD typically uses:

- Battery-operated water level indicator (i.e., audible and/or visual identification of water level)
- Battery-operated oil/water interface probe [i.e., audible and/or visual identification of water level and presence of non-aqueous phase liquid (NAPL)]
- Electronic transducer (numerous manufacturers) and recording device for long-term hydraulic monitoring

This section describes in detail the equipment and monitoring techniques for water level measurements.

Well depth sounding is often required to confirm well identification, evaluate the accumulation of sediment in the well bottom, or assist in determining the standing well volume. Sounding is performed using a water level indicator or a measuring tape with a weighted end (plopper). The water level indicator or weighted tape is lowered to the bottom of the well and a comparison is made of the installed well depth versus the measured well depth. The presence of excessive sediment or drill cuttings may warrant redevelopment of the well prior to well purging and groundwater sampling activities.

The total well depth is compared to the original installed total well depth. If the well screen is more than 50 percent blocked by accumulated sediment, the well should be redeveloped prior to the next groundwater sampling event. Report all wells requiring redevelopment to the Project Coordinator. Well depth sounding is performed on an annual or biannual basis if the well is equipped with a dedicated pump.

For low-flow purging (LFP), well depth measurement is performed to ensure proper pump intake placement. The use of a wide-based probe, such as a weighted tape, is necessary to minimize penetration and disturbance of accumulated sediment. The measuring device is lowered slowly through the wat er column to the well bottom to minimize mixing of the stagnant well casing water and disturbance of sediment.

> If well sounding is performed, the entire measuring device must be thoroughly decontaminated prior to re-use. Measuring the well depth with certain water level indicators may damage the probe seal. Therefore, a tape with a weighted end should be used to measure well depth. Make sure to add in the length of the weight below the end of the tape, if used.

The following subsections describe the most common techniques used by GHD to measure fluid levels.

5.7.3.1 Electrical Water Level Indicators

The most common method of obtaining water level measurements is the electronic water level indicator (e.g., Solinst). These meters consist of calibrated cable or tape with a weighted sensing tip at the end. When the tip contacts the water, an electric circuit is completed and the light and/or buzzer signals the contact. The following procedures shall be used with electrical water level meters:

139. Check the proper operation of the meter by inserting the tip into water and noting if the contact is registered clearly (on some meters, the sensor is in the midpoint of the metal tips). Deionized water cannot be used for this check, as it will not conduct an electrical current. Always check to see if the tape has been previously repaired and if a correction of the measurement is required.
140. Dry the tip and then slowly lower the tip into the well until contact with the water is indicated.
141. Slowly raise the tip until the light and/or buzzer just begins to deactivate. This indicates the static water level.
142. Using the thumb and index finger, grasp the tape at the reference point and note the reading to the nearest 0.01 foot (1 mm).
143. The reading should be checked twice more before removing the tape from the well. This helps confirm that the water level is static.
144. Record the water level measurement in the field book and/or water level form. Compare to previous measurements to see if significant changes [i.e., greater than 2 feet (0.6 m)] have occurred. Recheck the water level if a significant difference is measured.
145. Decontaminate the submerged end of the tape in accordance with the Work Plan.

> In cases where water levels will be measured on several occasions, it may be advantageous to set up a separate page within the field book for the water level measurements from each well. This will allow the measurements to be compared to the previous water level events and allow significant differences to be easily identified.

5.7.3.2 Tape/Plopper

A weighted standard surveying tape, typically graduated in increments of 0.01 foot (1 mm) weighted with a sounding device, was for many years the only means used for measuring fluid levels in monitoring wells, boreholes, and pits. It should still be considered as a failsafe backup method (there are no batteries or electrical circuits to fail), or alternative device if an electrical level indicator is not available.

Although the tape can be weighted with any heavy object (e.g., a nut, fishing sinker), the device commonly used by GHD is a hollow-pipe section described as a "plopper". The exact top of the fluid level can be determined by carefully listening for the sound the plopper makes when it contacts the fluid surface. The plopper is hung from the bottom of the tape such that the capped end is up and the open end is down. When the open end of the hollow pipe touches the fluid surface, a hollow plopping sound results. By moving the tape up and down ever so slightly, the fluid level can be determined very precisely.

Since the weight is hanging from the "zero" end of the tape, and since it is the weight touching the fluid level which allows detection of the fluid surface, the length of the weight must be added to the tape reading. It is most convenient (and results in fewer errors) if the weight is purposely designed to be a standard, easily remembered length, say 0.5 foot (15 cm). Thorough field cleaning the hollow "water plopper" is very important due to its shape and the potential for contaminants lingering around the internal area.

5.7.3.3 Interface Probe

Electrical water level indicators are not reliable when light non-aqueous phase liquids (LNAPL) are floating on the water surface, therefore another method to determine fluid levels is required.

Phase-separated liquids may consist of lighter-than-water materials (i.e., petroleum hydrocarbons) which float on the groundwater surface are categorically referred to as LNAPL; or heavier-than-water materials (dense organic chemicals) which are denser than water and will sink until a confining layer or less permeable layer is encountered, and are categorically referred to as dense non-aqueous phase liquids (DNAPL). Interface probes will detect the surface of LNAPL layers and the interface between LNAPL and groundwater or groundwater and DNAPL. Some oil/water interface probes may not detect DNAPL.

The interface probe uses an optical liquid sensor in conjunction with an electric circuit to detect the top of a phase-separated liquid and the interface between the phase layer and water (water level). The procedure for use of this probe is:

146. Lower the probe tip into the well until discontinuous beeping is heard. This indicates the top of the oil has been detected. Grasp the calibrated tape at the reference point and note the reading. Confirm the reading by slowly raising and lowering the probe to the level of the phase layer.
147. Once the top of the phase layer is confirmed, slowly lower the probe until a continuous sound is heard. This indicates that the water level has been encountered. Grasp the tape at the reference point and note the reading. Confirm this water level measurement.
148. Decontaminate the submerged end of the tape and probe prior to the next use in accordance with the Work Plan.

5.8 Field Procedures for Surface Water Fluid Level Monitoring

Fluid level monitoring at surface water level locations is generally completed in the same manner as other fluid level monitoring methods. The typical series of events that takes place for a surface water level monitoring program is:

149. Surface water location identification and inspection.
150. Water level monitoring.
151. Flow measurements.
152. Equipment decontamination.
153. Field note completion and review.
154. Sample record documentation, equipment return.
155. Completion and distribution of appropriate forms.

5.8.1 Surface Water Location Identification and Inspection

At sites with numerous surface water monitoring locations, misidentification of locations has occurred. The GHD representative must be alert to the possibility of potential mislabeled or unlabeled surface water monitoring locations.

Determine proper surface water monitoring location and identification by comparing the physical location of the surface water location to current Site Plan in addition to field tie-ins.

Once the surface water location identification has been established, complete a thorough inspection:

156. Examine the integrity of the staff gauge, or T-bar, and check for vandalism.
157. Inspect for and remove any debris that may have collected around the monitoring location which could potentially impact the reference elevation of the monitoring point.
158. Examine the integrity of the surrounding area to determine safe monitoring conditions.
159. If required, re-label the surface water location to assist in future identification.
160. Record all inspection details in the field book to document the conditions and suitability for surface water sampling.
161. Forward the inspection results to the Project Coordinator. If reinstallation or resurveying is required, this must be done immediately.

5.8.2 Reference Point

Fluid level measurements are made relative to a surveyed reference point. For surface water level measurements, the location of the reference point can vary depending on the surface water monitoring location (e.g., T-bar, staff gauge, piezometer, concrete structures at bridge abutments, and sewer outfalls.). The reference point must be clearly marked at the monitoring location and noted in the field book. Clearly marking the reference point will eliminate future measurement errors. The elevation of the reference point should be determined to the nearest 0.01 foot (1 mm).

During surface water monitoring, if staff gauges are damaged or missing they should be replaced and then resurveyed to establish horizontal and vertical control.

5.8.3 Surface Water Level Monitoring

Surface water level monitoring is commonly completed in conjunction with sampling programs. Careful attention must be paid to ensuring suspended sediments caused by monitoring activities do not impact the surface water samples. Surface water levels should therefore be collected beginning downstream and progressing upstream.

A number of instruments are available to measure groundwater levels. GHD typically uses:

- Battery-operated water level indicator (i.e., audible and/or visual identification of water level)
- Battery-operated oil/water interface probe (i.e., audible and/or visual identification of water levels and presence of NAPL)
- Electronic transducer (numerous manufacturers) and recording device for long-term hydraulic monitoring

The equipment and monitoring techniques for surface water level measurements are similar to groundwater level measurements. Refer to these sections for applicable information.

For staff gauges and T-bars, the depth from the reference point to the water surface is measured. Where practical, the depth to water/sediment interface should also be measured.

6. Aquifer Hydraulic Testing Standard Operating Procedures

6.1 Introduction

Aquifer Testing is conducted to characterize the hydraulic performance of a hydrostratigraphic unit at a site. Standard Operating Procedures (SOPs) are presented herein for completing aquifer testing, including:

- Single Well Response Testing (SWRT)

This guideline is not intended to provide the basis for designing a pumping test, but instead assumes that a monitoring network has been developed, a site specific Work Plan has been established, and that GHD representatives are preparing to mobilize to the site.

Aquifer Tests vary from project to project due to differences in pumping well design, monitoring networks, chemicals of concern, and guidance from local, state/provincial, or federal regulators where the site is located. Also, specific objectives of the project (e.g., groundwater extraction for pump and treat design purposes, water supply studies) will dictate the aquifer test objectives. It is essential that all aquifer test activities conform to local, provincial/state, and federal regulations. Therefore, it is important that the GHD representative carefully reviews the Work Plan requirements and ensures that all permitting issues have been addressed. The primary goal of aquifer tests is to characterize the hydraulic performance of the hydrostratigraphic units at a site. It is necessary to use appropriate aquifer test techniques in accordance with the Work Plan and all relevant regulations.

The remainder of this section is organized as follows:

- Section 10.2 Safety and Health
- Section 10.3 Quality Assurance/Quality Control
- Section 10.4 Equipment Decontamination
- Section 10.5 Pumping Tests Standard Operating Procedures

- Section 10.6 Packer Tests Standard Operating Procedures
- Section 10.7 Single-Well Response Tests (SWRT) Standard Operating Procedures
- Section 10.8 References

6.2 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

6.3 Quality Assurance/Quality Control

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management.

- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 3.9.

6.4 Equipment Decontamination

On all sites, pumping test equipment including pumps, transducers, and manual water level measuring equipment will be decontaminated as follows:

162. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
163. Rinse with tap water.
164. Rinse with deionized water.
165. Air dry for as long as possible.

In addition, the following steps may be added when sampling for Volatile Organic Compound (VOCs) and metals:

166. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
167. Rinse with deionized water.
168. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
169. Rinse again with deionized water.
170. Air dry for as long as possible.
171. Wrap equipment if possible in aluminum foil to prevent contamination.

Caution:	Confirm the cleaning protocol from the QAPP. The use of an incorrect cleaning protocol can invalidate chemical data.

6.5 Single-Well Response Tests Standard Operating Procedures

6.5.1 Background

The purpose of the single-well response test is to obtain an estimate of a formation's hydraulic properties (i.e., hydraulic conductivity and transmissivity). The data available from a single-well response test is insufficient to obtain the well property of specific capacity and the formation property of storage coefficient. Longer-term pumping tests are required to estimate these two properties.

Permeability (k) is a function only of the formation properties and has the dimensions L^2 (e.g., cm^2).

Hydraulic Conductivity (K) is a function of both the formation and the fluid properties described by:

$$K = \frac{k\rho g}{\mu}$$

Where:

ρ = fluid density (M/L^3)

g = gravitational constant (L/t^2)

μ = fluid dynamic viscosity (M/Lt)

Note: by convention M/Lt = 1 Pa•sec = 1,000 centipoise.

K has the dimensions L/t (e.g., cm/sec). Typically, ρ = 1 gm/cm^3 and μ = 1 centipoise for water. Thus the terms permeability and hydraulic conductivity are often interchanged when referenced to water.

Transmissivity (T) - The rate at which water is transmitted through a unit width of formation under a unit hydraulic gradient. Typically expressed as: gallons per minute, through a vertical section of aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 1; or cubic meters per day through a vertical section of 1 meter width, extending the full saturated height of the aquifer under a hydraulic gradient of 1.

There are two types of single-well response tests; the slug test and the recovery test.

The slug test involves causing a sudden change in water level in a well and measuring the water level response within that well. Water level change may be induced by suddenly injecting or removing a known quantity or "slug" of water into or out of the well, emplacement or removal of a solid slug (i.e., stainless steel, polyvinyl chloride [PVC]) into the water column, or a release of pressure in a tightly capped well.

The slug test is advantageous over a pumping test in that it does not require the disposal of large quantities of water that may be produced. This is of special importance when testing a potentially contaminated formation. However, a disadvantage of the slug test is that typically the slug is of small volume and only provides an estimate of the formation hydraulic properties immediately adjacent to the well. In addition, if the static water level is located within the screened interval and surrounding sandpack, the data may be useless, depending on the size of the slug, since the "data" will represent either the saturation or dewatering of the sandpack (which should be more permeable than the formation) and not of the formation.

An alternate single-well response test, which provides estimates of the hydraulic properties of a larger portion of the formation surrounding the monitored interval and which is not as sensitive to impacts from a partially saturated sandpack, is recovery monitoring after the completion of either well development or after sampling. After sample collection, if the well has recovered to a significant extent, it may be necessary to pump some additional water from the well prior to performing the recovery monitoring.

> It is common practice to pre plan the schedule of single well response tests such that the tests progress from "clean" to "dirty" areas in an effort to eliminate the potential for cross contamination. Review previous analytical data (if available) to determine best testing sequence.

Historically, single-well response test water levels have been measured using the manual methods (i.e., electronic water level indicator). Manual methods have generally been replaced with the use of pressure transducers and electronic data recorders which provide the following two advantages:

- The water levels can be recorded at selected short time intervals (e.g., 0.5 sec) to allow evaluation of quickly recovering wells which previously could not be evaluated since the well recovered too quickly to obtain the necessary data by the manual method; and

- The data from the data recorders can be transferred directly to computer programs which calculate the formation properties, without the time consuming manual transposition and evaluation of data.

The use of pressure transducers and recorders is the method preferred by GHD.

In order to provide reliable data, the tests must be performed over as short a period of time as possible. Barometric pressure can affect groundwater levels and therefore, observation of significant weather changes during the period of the tests must be noted. Tidal fluctuations, navigation controls on rivers, rainfall events, and groundwater pumping can also affect groundwater level measurements. Personnel performing the tests must note if any of these controls are in effect during the testing period. Due to possible changes during the testing period, it is imperative that the time of data collection at each location be accurately recorded.

6.5.2 Prior Planning and Preparation

The following shall be considered prior to conducting a single-well response test.

1. Review the Work Plan and HASP with the Project Coordinator.
2. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status or not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian Work; QSF-031 for U.S. Work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
3. Contact the GHD Chemistry group to arrange (if necessary);
    - SSOW (Simplified Scope of Work);
    - Laboratory;
    - Sample containers delivery;
    - Preservatives if required;
    - Coolers;
    - Shipping details;
    - Sample starting date; and
    - Expected duration of sampling program.
4. Complete a Field Equipment Requisition Form (QSF-014). Assemble all equipment and supplies per the Slug and Aquifer Test Equipment and Supply Checklist (Form SP-18). If a recovery test is to be performed after well development or sampling, it is expected that the equipment and supplies obtained pursuant to the Groundwater Sampling Equipment and Supply Checklist (Form SP-05) will be sufficient with the addition of pressure transducers, electronic data recorders, and portable computers. Ensure that the psi range of the pressure transducer is sufficient.
5. Obtain information on each monitoring well to be tested. Information shall consist of inside diameter of the well screen and well casing, borehole diameter, depth of well, static water level, and the length and depth setting of the screen. For slug tests, this information will be used to calculate the volume of the "slug" required. The volume of the slug should be

sufficient to affect a minimum change of 6 inches in the well's water level. If the static water level is within the screened portion of the well, the volume calculation must account for the porosity of the sandpack (a value of 0.3 is generally assumed). For well recovery tests, the volume of water removed during development/purging/sampling must be recorded on the Well Development, Purging, and Sampling Form (Form SP-06).

6. Arrange access to the site. Assemble well keys and site keys. Also consider site conditions (e.g., is snow removal required?).

7. Establish groundwater and spent decontamination fluid handling and disposal methods before testing activities start.

8. Pre-plan the testing sequence to insure "clean" wells are tested before "dirty" wells to reduce the potential for cross-contamination.

9. Determine testing notification requirements with the Project Coordinator. Have the client, landowner, and appropriate regulatory agencies been notified?

6.5.3 Field Procedure

1. SWRT

   The following steps need to be performed for a SWRT, assuming that the well has been previously developed:

   i) Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level monitoring.

   ii) Insert the pressure transducer at a sufficient depth below the water table so that upon insertion of a slug into the water column, the slug will not strike the pressure transducer. Check the operation of the transducer and data recorder.

   iii) Set the slug just above the static level.

   iv) Release the slug instantaneously. It is important that the slug is completely submerged in the water column.

   This is called a "falling-head" test.

   v) Upon 90 percent recovery of the induced change, remove the slug rapidly and completely from the water column being careful not to inadvertently raise the pressure transducer.

   This is called a "rising-head" test.

   vi) Confirm the well has again recovered to 90 percent of the induced change and complete the test by performing steps v) through viii) outlined in 1.a) (After Well Development).

Water levels along with the well data and time shall be recorded on the Single-Well Response Test - Data form (Form SP-19) and in the site field book. Figure 10.3 provides definitions for the parameters listed on Form SP-19.

Under some conditions (i.e., very permeable formations) the slug test can best be conducted by simulating the withdrawal/injection of a slug of water by the release of pressure in a tightly capped well. The following steps need to be performed:

i) Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level monitoring.

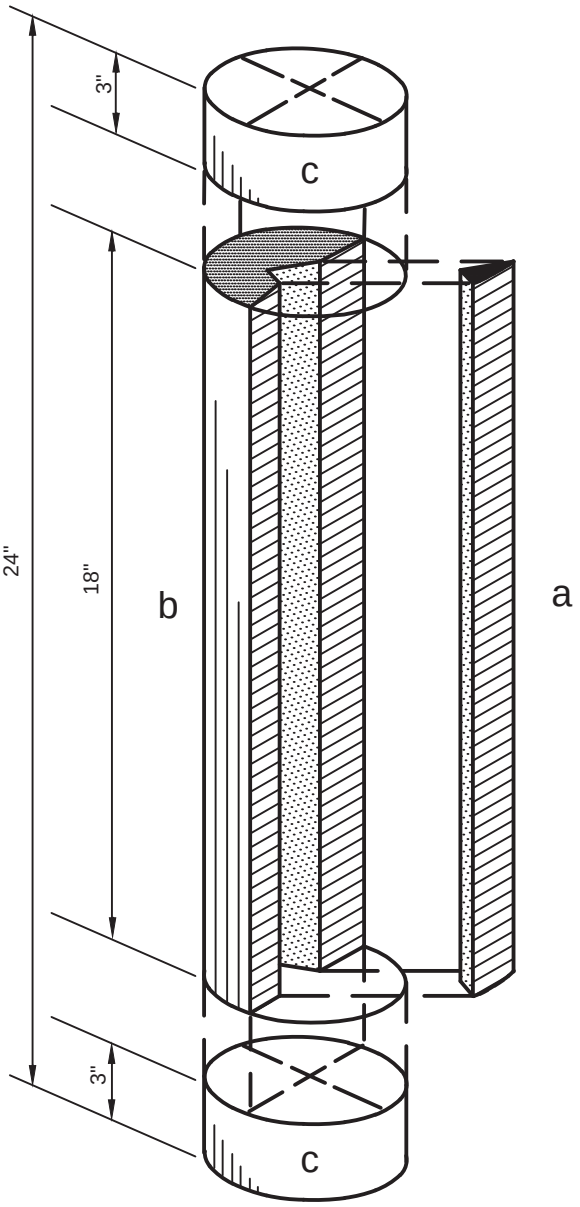
ii) Insert the pressure transducer at a sufficient depth below the water table. Check the operation of the transducer and data recorder.

iii) Install sealed well cap with a pressure cap.

iv) Increase the pressure in the well to lower the water level (usually a bicycle pump is a sufficient source of compressed air).

v) Release the pressure by opening a valve on the well cap and allow well to recover.

vi) Repeat the test three or four times.



TYPICAL SOIL CORE

a

PORTION OF SAMPLE FOR CHEMICAL ANALYSIS

-CONTACT WITH UNSTERILIZED MATERIALS IS NOT ACCEPTABLE

-STORAGE - REFRIGERATED (4°C)

-SHIPPING - ON ICE BY COURIER TO DESIGNATED LAB

b

PORTION OF SAMPLE TO BE RETAINED FOR GEOLOGIC RECORDS

-CONTACT WITH UNSTERILIZED MATERIALS IS NOT A PROBLEM

-CONTAINER: - CLEAN GLASS JAR
- CLEAR GLASS IS SUITABLE

-STORAGE - IN STANDARD SHIPPING CARTON
- NO REFRIGERATION REQUIRED

c

PORTION OF SAMPLE TO BE DISCARDED

-DISCARDED WITHIN 55 GALLON DRUM MAINTAINED ON-SITE

figure 5.1

SPLIT SPOON SAMPLE SELECTION DETAILS

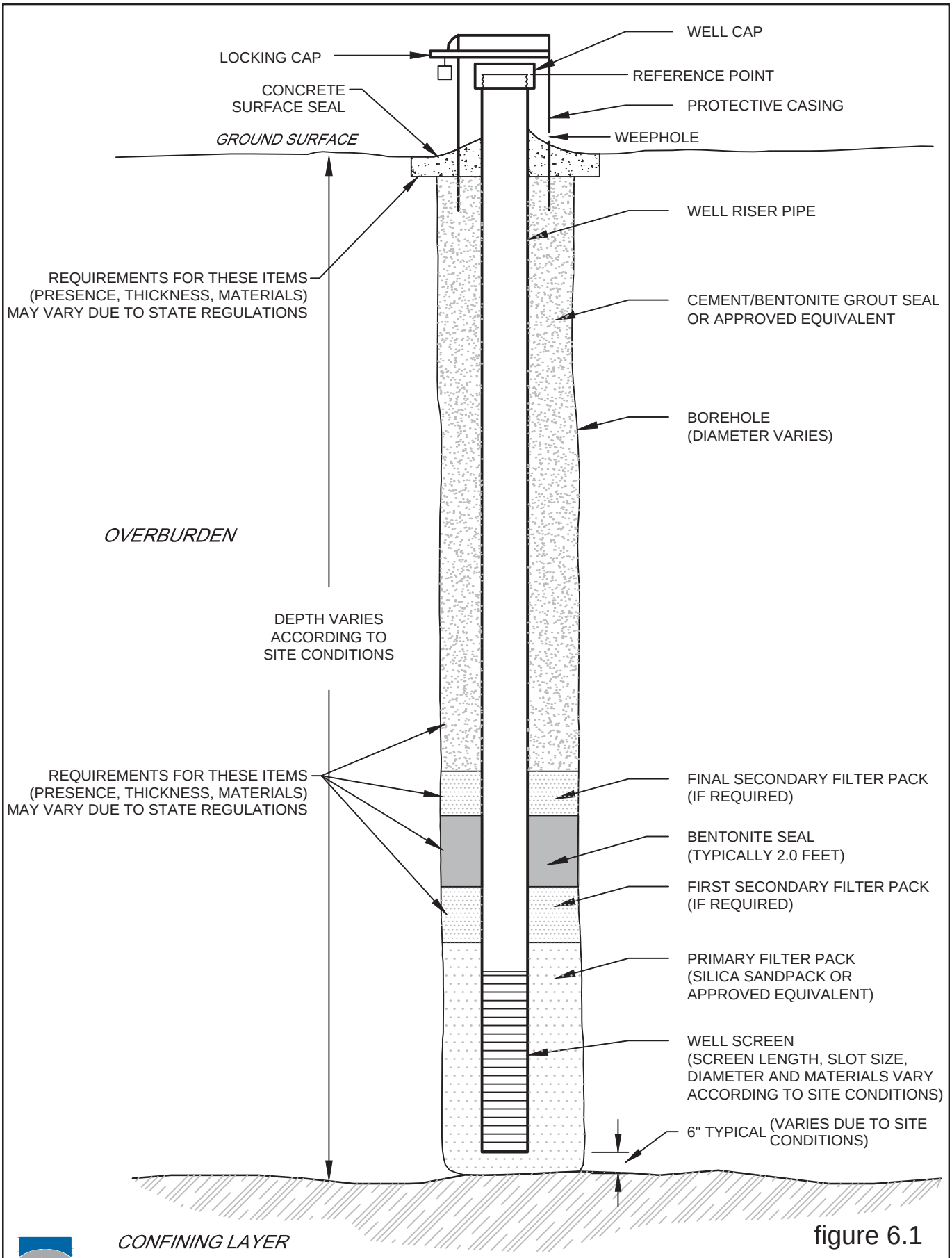


figure 6.1

TYPICAL OVERBURDEN WELL INSTALLATION

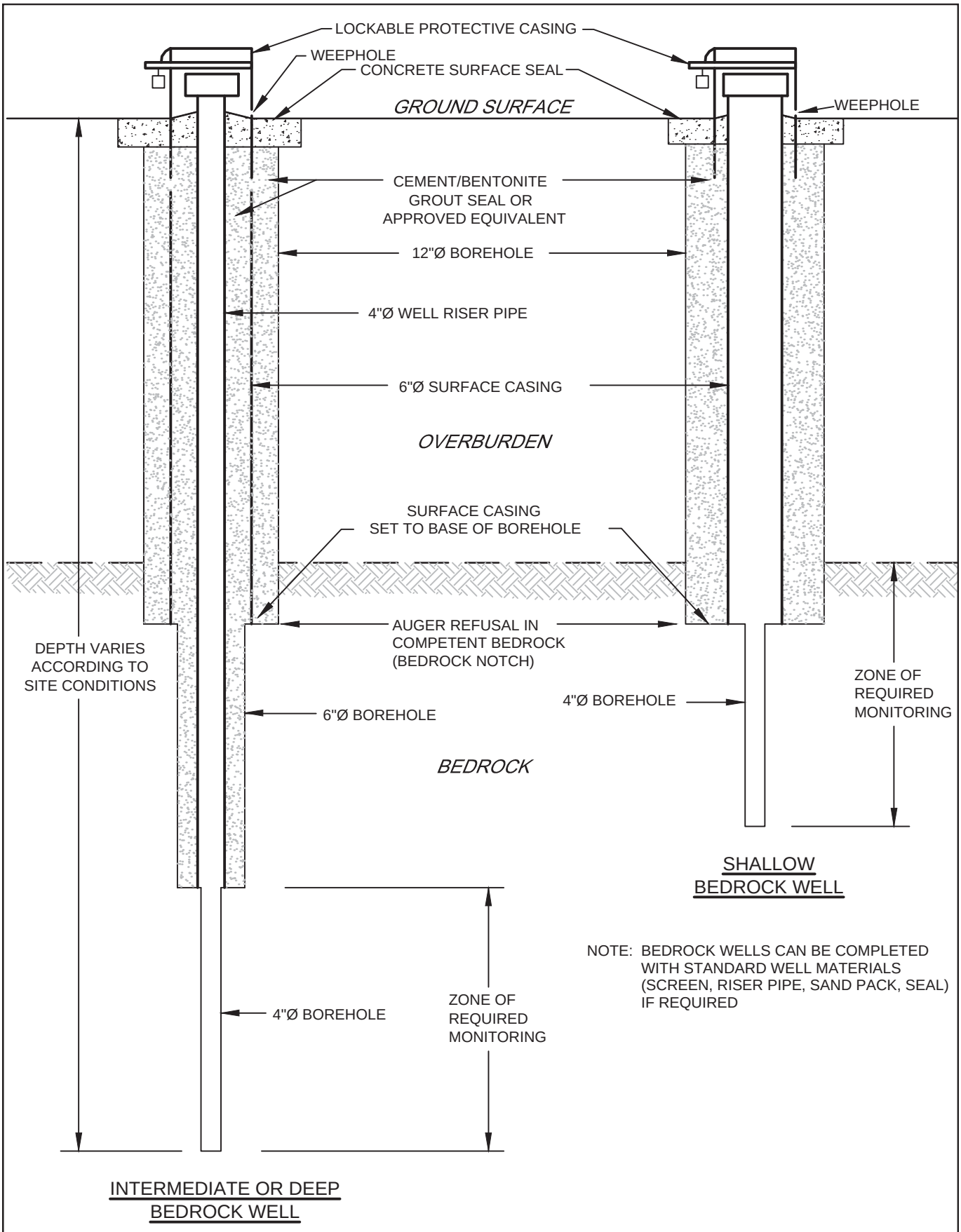
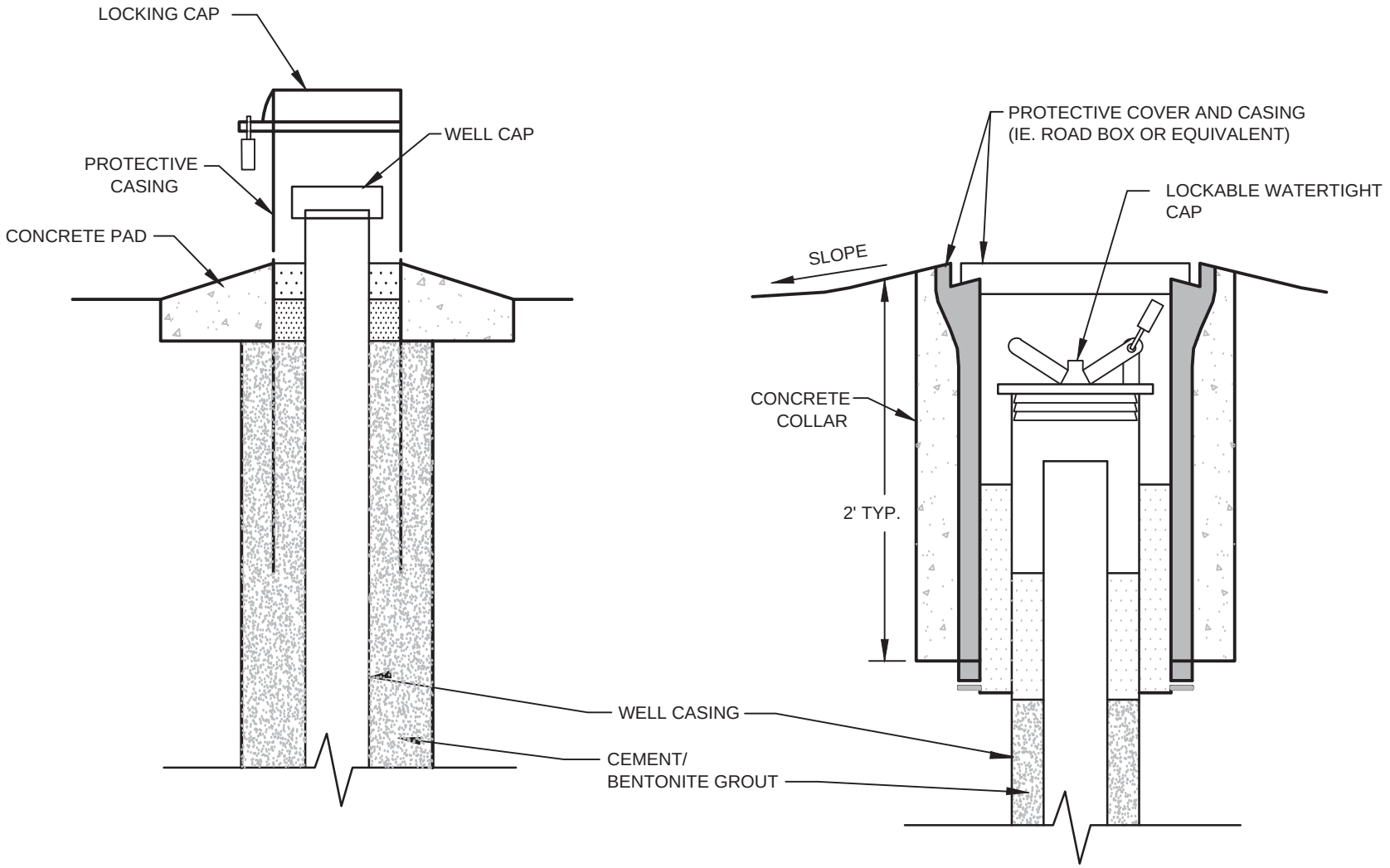


figure 6.2

TYPICAL BEDROCK WELL INSTALLATION



ABOVE-GRADE CASING
N.T.S.

FLUSH MOUNT CASING
N.T.S.

figure 6.3

PROTECTIVE CASING INSTALLATION

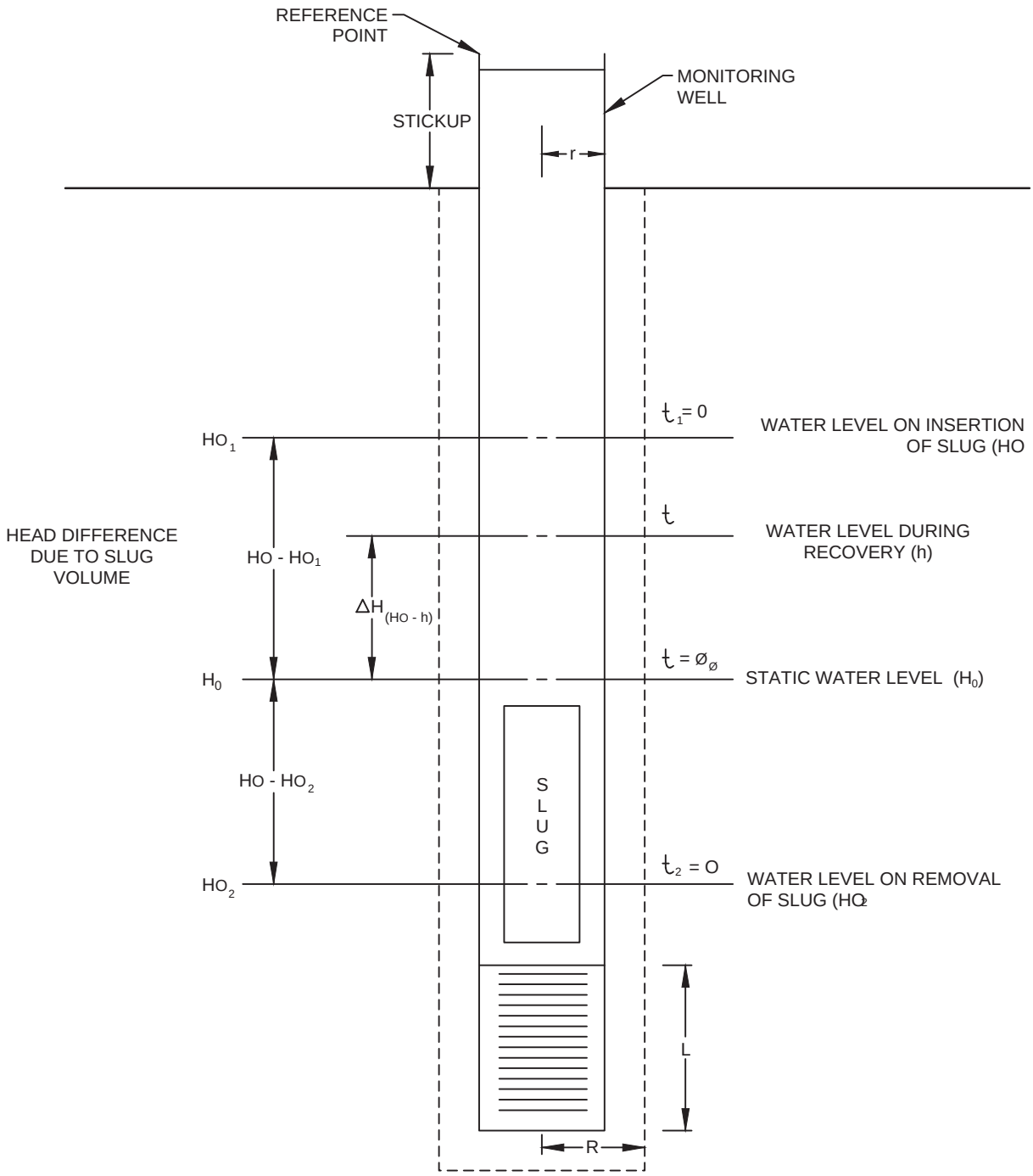


figure 10.3

SINGLE - WELL RESPONSE TEST PARAMETERS

Appendix E Aquatic Life Assessment Memorandum

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558 England Ave
Courtenay, BC V9N 2N3
p: 250.871.1944
w: currentenvironmental.ca

April 20, 2017

GHD
10271 Shellbridge Way
Richmond, BC
V6X 2W8

Attention: Shauna Sturgeon

Subject: Site Assessment – Potential Aquatic Receptors at the Upland Pit – Campbell River, BC.

Shauna,

The Upland Group is planning to broaden the spectrum of materials that may be disposed of at their large pit located at 7295 Gold River Hwy, in Campbell River, BC. To meet this objective, an application under the BC Contaminated Site Regulation (CSR)[1] is required. As part of this application, Current Environmental was retained to complete a ground-level assessment for potential aquatic receptors (aquatic life assessment) within an area outside the pit area delineated by GHD. This area lies between the Upland Pit boundary to a distance of 500 m to the east and south (Figures 1 and 2).

METHODS

The project area of interest (AOI) was surveyed on foot on April 5th and 6th; weather during these two days was inclement with periods of both rain and sun. Generally, the region experienced significant rainfall within the week previous to the assessment. Field data was captured using handheld GPS[2] and imported to GIS platform for visual display purposes.

Generally, field inspection focused on identifying all wetted habitats with the potential to meet the following definition as outlined in the CSR:

"aquatic life water use" *means the use of water as habitat for any component of the freshwater or marine aquatic ecosystem, including phytoplankton, zooplankton, benthos, macrophytes and fish.*

[1] March 18, 2013
[2] Garmin GPSmap 60Cx

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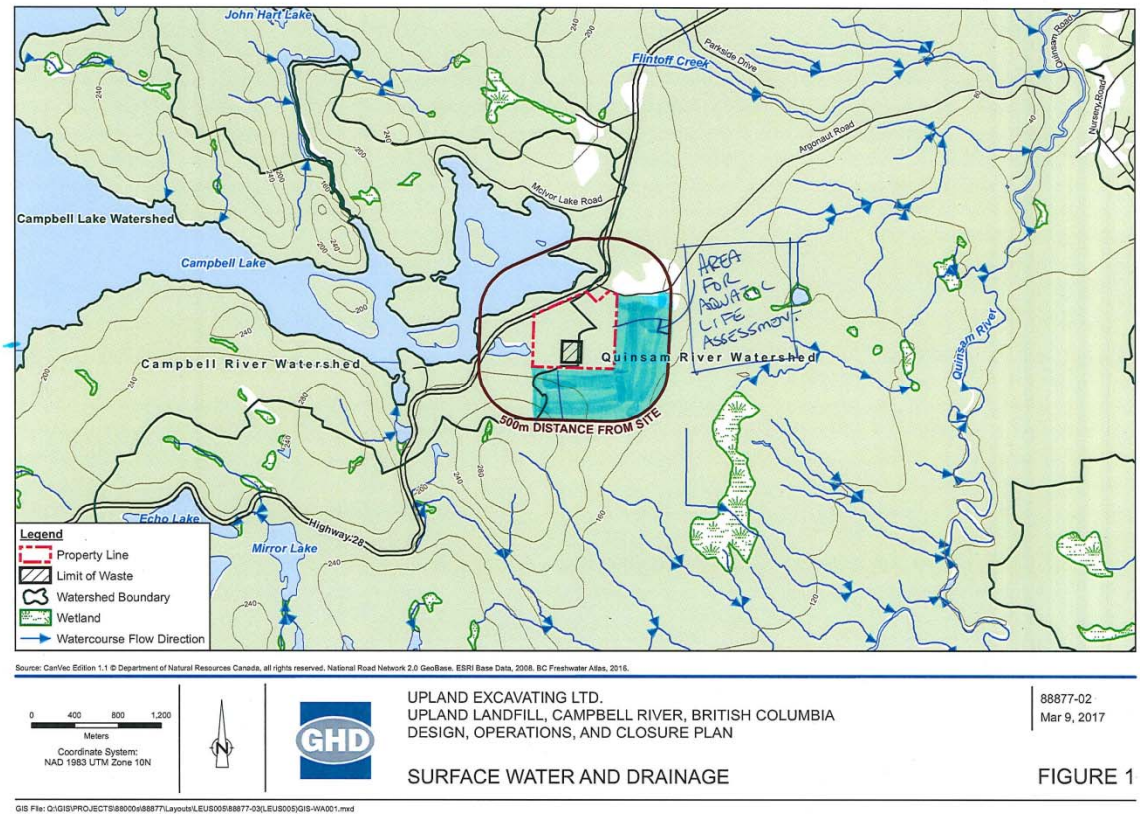

Figure 1. Overview map showing the location of the project area and the AOI. Figure provided by GHD.

RESULTS

During the field assessment work, two candidate watercourse systems were noted (Figure 2). Likely a result of the prevalence of deep gravel deposits in the area, it appears that the vast majority of precipitation and overland flows dissipate into soils. As such, there were no other habitats with the potential to provide aquatic life water use noted within the subject area. The two watercourse systems are discussed in the following subsections.

Watercourse System 1

This small system originates from a small wetland swamp located approximately 70 m outside of the western AOI boundary. The flows originating from the wetland enter the AOI in a small, somewhat naturalized channel (bankfull width ~ 1.3 m) flowing east/northeast approximately 140 m south of the southwestern-most corner of the Upland Pit. This channel bifurcates into several smaller channels that run downslope to the east in skidder trail ruts (Photo 1) to a roadside ditch running north-south. Flows are conveyed through the roadside ditch (Photo 2) for

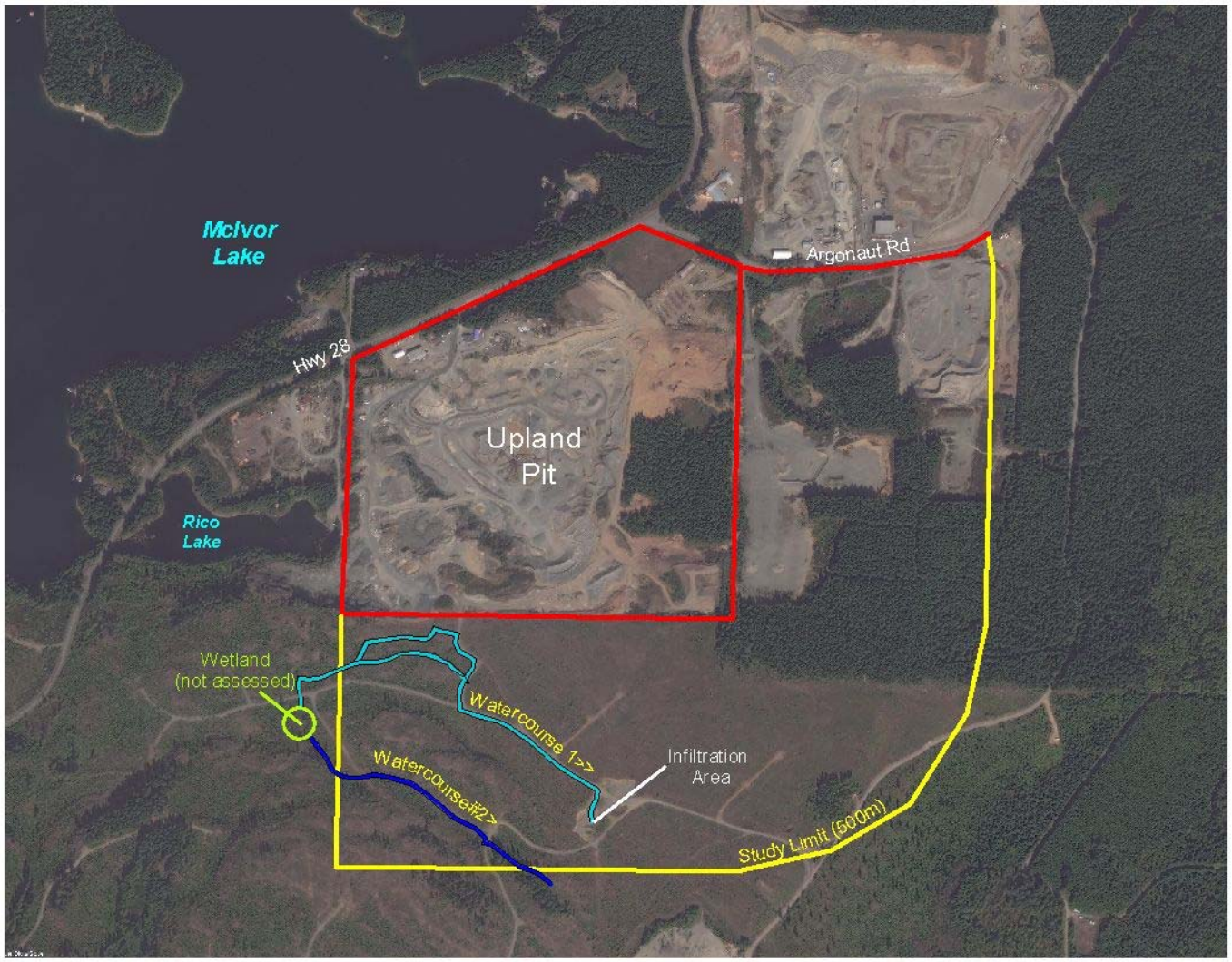

Figure 2. Inventory Results

N

Map created April, 2017.
All linework approximate.
Airphoto ca. Sept. 2014.
No reproduction without consent of author.

500 0 500 1000 Meters

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approximately 500 m (southeast) until dissipating to ground in what appears to be a smaller gravel borrow area (Photo 3).

Watercourse System 2

Interestingly, this system originates from the same natural wetland area as Watercourse System 1. However, flows from this wetland feeding this system flow in a southeasterly direction through a natural channel with an average bankfull width of 1.8 m. The majority of this channel flows through a 277 m section of young (2-4 years) Douglas fir forested area (Photo 4) before entering an more mature forest over a ~90 m length (Photo 5). At this point Watercourse 2 crosses the southern AOI boundary. Beyond this point, the watercourse was not assessed.

Please contact the undersigned with any questions.

Sincerely,

CURRENT ENVIRONMENTAL

WARREN FLEENOR, R.P. BIO. PRINCIPAL

DISCLAIMER

This report was prepared exclusively for GHD and Upland Group by Current Environmental. The quality of information, conclusions and estimates contained herein is consistent with the level of effort expended and is based on: i) information available at the time of preparation; ii) data collected by the authors and/or supplied by outside sources; and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by GHD and Upland Group only, subject to the terms and conditions of its contract or understanding with Current Environmental. Other use or reliance on this report by any third party is at that party's sole risk.

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PHOTOGRAPHS

Photo 1. Water flows through skidder trail ruts – Watercourse system 1.

Photo 2. Roadside ditch conveying flows of Watercourse System 1.

Photo 3. Overland flows from Watercourse System 1 dissipating to ground in a pit area.

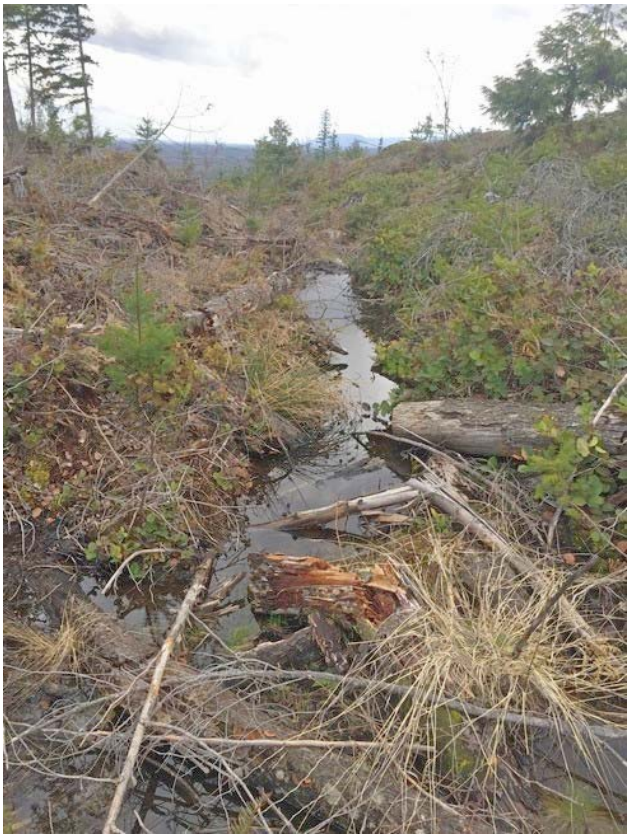


Photo 4. Watercourse 2 – young second growth forested area.

Photo 5. Watercourse 2 – mature forest area.

Appendix F
Stratigraphic and Instrumentation Logs

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: BH1-16
DATE COMPLETED: January 27, 2016
DRILLING METHOD: Rotosonic
FIELD PERSONNEL: S. Foster

NORTHING: 5541551.19
EASTING: 330846.01
GROUND SURFACE ELEV. 168.41 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	SW-GRAVELY SAND, well graded, fine to medium sand, fine to coarse gravel, brown, dry, dense	
2		165.67
	SW/GW-SAND AND GRAVEL, well graded, fine to medium sand, fine gravel, brown, dry, very dense	
4	- with coarse sand at 3.05m BGS	
	- moist at 5.15m BGS	163.23
6	SP-SAND with gravel, fine sand with trace coarse sand and fine gravel, moist, sub-rounded, very dense	162.31
	SW/GW-SAND AND GRAVEL, well graded, fine to coarse sand and gravel, subangular, grey, moist, very dense	
8		
10		158.05
	SP-FINE SAND, trace coarse gravel, grey, moist, dense	157.13
12	SW-SAND with gravel, fine to medium grained sand and gravel, grey, moist, very dense	
	- cobbles at 12.80m BGS	
14		154.39
	SW-SAND, with gravel to trace gravel, fine to medium grained sand and gravel, grey, wet, loose	
16	- heaving sands at 14.94m BGS	
18		150.43
	SP-SAND, fine to medium grained sand, grey, moist	
20		
22		
		145.25
24	BEDROCK, (highly weathered), silty, slight plasticity, soft, grey, wet	144.94
		144.33
26	BEDROCK, Karmutsen, porphyritic basalt, igneous extrusive, black (blueish) with white crystals, phaneritic, moderate iron staining on fractures	
	vertical fracturing, with iron staining on fracture surface, largely non-intact, RQD=0.25	
28	END OF BOREHOLE @ 24.08m BGS	
	Borehole completed to target depth in bedrock	
	No topsoil evident/surface compact sand and	

BOREHOLE: SOIL CUTTINGS; BENONITE GRAVEL; 152 mm Ø BOREHOLE; SOIL CUTTINGS; BENTONITE GRAVEL

WELL DETAILS
Seal:
146.46 to 144.33m AMSL
21.95 to 24.08m BGS
Material: Bentonite Gravel

SAMPLE NUMBER	INTERVAL	REC (m)	'N' VALUE
RS-1		30.48	
SPT-2		24.38	43
RC-2		30.48	
SPT-3		24.38	45
RS-3		30.48	
SPT-4		15.24	85
RS-4		30.48	
SPT-5 GB-2		30.48	87
RS-4		30.48	
SPT-6		15.24	41
RS-5		30.48	
SPT-7 GB-1		15.24	4
RS-7		30.48	
RS-8		30.48	

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

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: BH1-16
DATE COMPLETED: January 27, 2016
DRILLING METHOD: Rotosonic
FIELD PERSONNEL: S. Foster

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	BOREHOLE	SAMPLE				
				NUMBER	INTERVAL	REC (m)	'N' VALUE	
32	gravel Borehole backfilled with soil cuttings and sealed with bentonite Static water level in boring - 11.21 m BGS measured after 14 hours RS - Rotosonic Core Sample SPT - Standard Penetration Test (splitspoon sample) GB - Grab Sample							
34								
36								
38								
40								
42								
44								
46								
48								
50								
52								
54								
56								
58								

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

STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: BH2-16
DATE COMPLETED: January 28, 2016
DRILLING METHOD: Rotosonic
FIELD PERSONNEL: J. Stewart

NORTHING: 5541470.19
EASTING: 330839.07
GROUND SURFACE ELEV. m AMSL: 167.86

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	SW-GRAVELY SAND, with cobbles, well graded, fine to coarse sand and gravel, brown, moist, dense	
4	SW/GW-SAND AND GRAVEL, fine to medium grain sand, dry, compact	164.51
6	SP-SAND, poorly graded, fine sand, brown, dry, very dense	162.68
8	SW/GW-GRAVELY SAND, well graded, grey, moist, dense	159.63
12	ML-SANDY SILT with gravel, slightly cohesive, low plasticity, fine sand and gravel silt till, grey with brown ribbons, moist, compact	156.28
14	BEDROCK, highly weathered (saprolite) surface, silt, crumbly, interbedded grey and brown, moist	153.84 153.53
16	BEDROCK, Karmutsen, porphyritic basalt, igneous extrusive, black (blueish) with white crystals, phaneritic, moderate iron staining on fractures vertical fracturing, with iron staining on fracture surface, largely non-intact, RQD=0	151.40
18	END OF BOREHOLE @ 16.46m BGS	
20	Borehole completed to target depth in bedrock No topsoil evident/surface compact sand and gravel Borehole dry upon completion Borehole backfilled with soil cuttings and sealed with bentonite RS - Rotosonic Core Sample SPT - Standard Penetration Test (splitspoon sample) GB - Grab Sample	
22		
24		
26		
28		

BOREHOLE

WELL DETAILS
Seal:
156.28 to 151.40m AMSL
11.58 to 16.46m BGS
Material: Bentonite Gravel

SAMPLE NUMBER	INTERVAL	REC (m)	'N' VALUE
SPT-1		6.10	48
RS-1		30.48	
SPT-2		6.10	42
RS-2		30.48	
SPT-3		15.24	44
RS-3		30.48	
GB-1			
SPT-4		18.29	21
RS-4		30.48	
SPT-5		15.24	>66
RS-5		30.48	
GB-2			
SPT-6		15.24	37
RS-6		30.48	
GB-3			
STP-7		15.24	13
GB-4			
RS-7		30.48	
GB-5			

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

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: BH5-15
DATE COMPLETED: August 6, 2015
DRILLING METHOD: Sonic
FIELD PERSONNEL: T. Fitzgerald
DRILLER: A. McRea

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	DEPTH m BGS
	GW GRAVEL, with sand, well graded gravel, medium to coarse grained sand, 1.52 m of recovery from 0-3.05 m	
	GW GRAVEL, well graded, up to 7.5 cm	3.05
	GW GRAVEL, with sand, well graded gravel up to 7.5 cm, medium to coarse grained sand	3.66
	SW SAND, with gravel, medium to coarse grained well graded sand, gravel up to 7.5 cm - 0.3 m thick bed of silty sand from 7.01 to 7.32m BGS	4.27
	GW GRAVEL, with sand, well graded gravel, coarse grained sand	9.14
	SW SAND, medium grained	10.36
	SW SAND, with gravel, gravel up to 2 cm	11.28
	GW GRAVEL, with sand, well graded gravel, coarse grained sand	12.19
	SW SAND, medium grained	13.11
	SW SAND, with gravel, gravel up to 2 cm, some cementation but pulverized by coring	13.41
	GW GRAVEL, with sand, gravel up to 10 cm, coarse grained sand	15.24
	SW SAND, with gravel, gravel up to 2 cm, some cementation but pulverized by coring	17.37
	GW GRAVEL, with sand, gravel up to 3 cm, medium to coarse grained sand	18.29
	SW SAND, with gravel, medium to coarse grained sand, gravel up to 6 cm	20.42
	END OF BOREHOLE @ 24.38m BGS Lost 15.24 m of 0.15 m diameter casing down the borehole. Borehole abandoned.	24.38

BOREHOLE: Bentonite Chips; Soil Cuttings

SAMPLE: NUMBER | INTERVAL | REC (m) | 'N' VALUE

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

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: Upland Landfill
PROJECT NUMBER: 088877
CLIENT: Uplands
LOCATION: Campbell River, British Columbia
INSTALLED BY: Red Williams Drilling Ltd

HOLE DESIGNATION: MW1-14
DATE COMPLETED: December 4, 2014
DRILLING METHOD: Air Rotary
FIELD PERSONNEL: Red Williams Drilling Ltd
DRILLER: T Johnson

NORTHING: 5541791.65
EASTING: 100824.35

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
	GROUND SURFACE	171.80	1.2m Stickup				
0	SP/PG-SAND AND GRAVEL		5.08cm Ø PVC Well Casing; Bentonite; 15.24cm Ø Borehole				
2							
4							
6	- wet at 5.49m BGS		5.08cm Ø PVC Well Screen; Sand Pack				
8							
10							
	END OF BOREHOLE @ 10.97m BGS	160.83					
12	Log recreated from notes taken by Red Williams Drilling						
14							
16							
18							
20							
22							
24							
26							
28							

WELL DETAILS
Screened interval:
166.92 to 160.83m AMSL
4.88 to 10.97m BGS
Length: 6.1m
Diameter: 51mm
Material: PVC
Seal:
171.80 to 167.23m AMSL
0.00 to 4.57m BGS
Material: Bentonite
Sand Pack:
167.23 to 160.83m AMSL
4.57 to 10.97m BGS
Material: Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 12/4/14

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: Upland Landfill
PROJECT NUMBER: 088877
CLIENT: Uplands
LOCATION: Campbell River, British Columbia
INSTALLED BY: Red Williams Drilling Ltd

HOLE DESIGNATION: MW2-14
DATE COMPLETED: December 4, 2014
DRILLING METHOD: Air Rotary
FIELD PERSONNEL: Red Williams Drilling Ltd
DRILLER: T Johnson

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
	NORTHING: 5541591.19 EASTING: 100877.04 TOP OF RISER GROUND SURFACE	173.85 173.09	0.8m Stickup				
0	SP/GP-SAND AND GRAVEL		5.08cm Ø PVC Well Casing; Bentonite; 15.24cm Ø Borehole				
6	BOULDERS	166.38					
7	SP/GP-SAND AND GRAVEL	165.77					
16	GP-SANDY GRAVEL, wet	156.02	5.08cm Ø PVC Well Screen; Sand Pack				
22	END OF BOREHOLE @ 21.64m BGS Log recreated from notes taken by Red Williams Drilling	151.45					

WELL DETAILS
Screened interval:
157.54 to 151.45m AMSL
15.54 to 21.64m BGS
Length: 6.1m
Diameter: 51mm
Material: PVC
Seal:
173.09 to 168.52m AMSL
0.00 to 4.57m BGS
Material: Bentonite
Sand Pack:
168.52 to 151.45m AMSL
4.57 to 21.64m BGS
Material: Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 12/4/14

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW2A-16
DATE COMPLETED: January 27, 2016
DRILLING METHOD: Rotosonic
FIELD PERSONNEL: S. Foster

NORTHING: 5541591.43
EASTING: 100878

TOP OF RISER 173.86 m AMSL
GROUND SURFACE 173.10 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	SW/GW-SAND AND GRAVEL, medium to coarse sand ti coarse gravel, well graded, grey, dry, subrounded to rounded, dense	
2	- Compact, brown, dry at 1.22m BGS	
	GW-GRAVEL with sand and cobbles, fine to coarse grain gravel, cobbles, coarse sand, well graded, grey, dry, sub-angular-subrounded, compact	170.36
4	- Cobble rich (7-9 cm diameter) from 5.18 to 6.71m BGS	
	- Sandy silt layer, increase in fines, very dense, grey, moist at 5.49m BGS	167.61
6	SW/GW-SAND AND GRAVEL, medium sand to coarse gravel, with cobbles, grey moist, well rounded to subrounded, very dense	166.70
8	SW/GW-SAND AND GRAVEL, fine to medium sand fine to coarse gravel, grey, dry, very dense	
10		
12	SP-SAND with gravel, poorly graded, fine to medium sand, fine gravel, grey, moist, subangular to subrounded, very dense	160.91
14	- Becoming wet at 13.41m BGS	
16	SP-SAND, trace gravel, poorly graded, fine to medium sand, grey, wet, very dense	156.64
18		
20	- Cobbles at 19.81m BGS	
	SW/GW-SAND AND GRAVEL, fine to coarse sand and gravel to cobble, sand heaving, grey, wet	152.68
22	SP-SAND, fine grain, grey, sand heaving, wet	152.07
24	- Silt rich layer (20 cm) at 24.08m BGS	
26		
28		

MONITORING WELL: STICKUP 0.80 M; BENTONITE GRAVEL; 51 mm Ø PVC RISER PIPE; 152 mm Ø BOREHOLE; SOIL CUTTINGS; BENTONITE GRAVEL; SOIL

SAMPLE NUMBER	INTERVAL	REC (m)	'N' VALUE
SPT-1		7.62	32
RS-1		30.48	
SPT-2		7.62	15
GB-1	G		
RS-2		30.48	
SPT-3		7.62	12
RS-3		30.48	
SPT-4		15.24	12
RS-4		0.00	
RS-5		30.48	
GB-2	G		
SPT-5		7.62	69
RS-6		30.48	
RS-7		30.48	
RS-8		30.48	
SPT-6		15.24	90
RS-9		30.48	
GB-3	G		
SPT-7		6.10	>100
RS-10		30.48	
RS-11		30.48	
RS-12		30.48	
GB-4	G		
SPT-9		15.24	7
RS-13		30.48	
GB-5	G		
RS-14		30.48	
RS-15		30.48	

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

STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW2A-16
DATE COMPLETED: January 27, 2016
DRILLING METHOD: Rotosonic
FIELD PERSONNEL: S. Foster

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
32	- Wood detritus (carbon) 2 cm at 32.92m BGS		CUTTINGS	RS-16		30.48	
34				RS-17		30.48	
36			BENTONITE PELLETS				
38			SILICA SAND	RS-18		30.48	
40			51 mm Ø 10-SLOT PVC SCREEN	BG-6	G		
42				RS-19		30.48	
44				RS-20		30.48	
46	END OF BOREHOLE @ 45.42m BGS	127.68					
48	Borehole terminated at maximum drilling method depth No topsoil evident/surface compact sand and gravel Static Groundwater Elevation - 13.74 m BGS after completion of well RS - Rotosonic Core Sample SPT - Standard Penetration Test (splitspoon sample) GB - Grab Sample						
50							
52							
54							
56							
58							

WELL DETAILS
Screened interval:
135.61 to 132.56m AMSL
37.49 to 40.54m BGS
Length: 3.05m
Diameter: 51mm
Slot Size: 10
Material: SCH. 40 PVC
Seal:
136.22 to 138.05m AMSL
36.88 to 35.05m BGS
Material: Bentonite Pellets
Sand Pack:
132.26 to 136.22m AMSL
40.84 to 36.88m BGS
Material: #2 SILICA SAND

Seal:
169.44 to 151.76m AMSL
3.66 to 21.34m BGS
Material: SOIL CUTTINGS

Seal:
151.76 to 148.72m AMSL
21.34 to 24.38m BGS
Material: BENTONITE CHIPS

Seal:

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

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW2A-16
DATE COMPLETED: January 27, 2016
DRILLING METHOD: Rotosonic
FIELD PERSONNEL: S. Foster

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE				
				NUMBER	INTERVAL	REC (m)	'N' VALUE	
62			148.72 to 138.05m AMSL 24.38 to 35.05m BGS Material: SOIL CUTTINGS					
64								
66								
68								
70								
72								
74								
76								
78								
80								
82								
84								
86								
88								

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

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

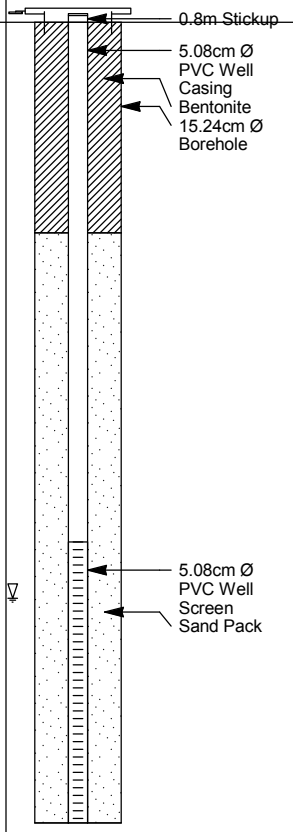
PROJECT NAME: Upland Landfill
PROJECT NUMBER: 088877
CLIENT: Uplands
LOCATION: Campbell River, British Columbia

HOLE DESIGNATION: MW3-14
DATE COMPLETED: December 4, 2014
DRILLING METHOD: Air Rotary
FIELD PERSONNEL: Red Williams Drilling Ltd
DRILLER: T Johnson

NORTHING: 5541429.8
EASTING: 100853.88

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
	TOP OF RISER	168.59
	GROUND SURFACE	167.59
0	SP/GP-SAND AND GRAVEL	
4	GP-SANDY GRAVEL	163.32
8	SP/GP-SAND AND GRAVEL	159.97
12	GP-SANDY GRAVEL, wet	155.09
16	GRANITE BECROCK	150.83
18	END OF BOREHOLE @ 18.59m BGS Log recreated from notes taken by Red Williams Drilling	149.00

MONITORING WELL



WELL DETAILS
Screened interval:
156.31 to 150.22m AMSL
11.28 to 17.37m BGS
Length: 6.1m
Diameter: 51mm
Material: PVC
Seal:
167.59 to 163.02m AMSL
0.00 to 4.57m BGS
Material: Bentonite
Sand Pack:
163.02 to 150.22m AMSL
4.57 to 17.37m BGS
Material: Sand

SAMPLE				
NUMBER	INTERVAL	REC (m)	'N' VALUE	

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 12/4/14

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

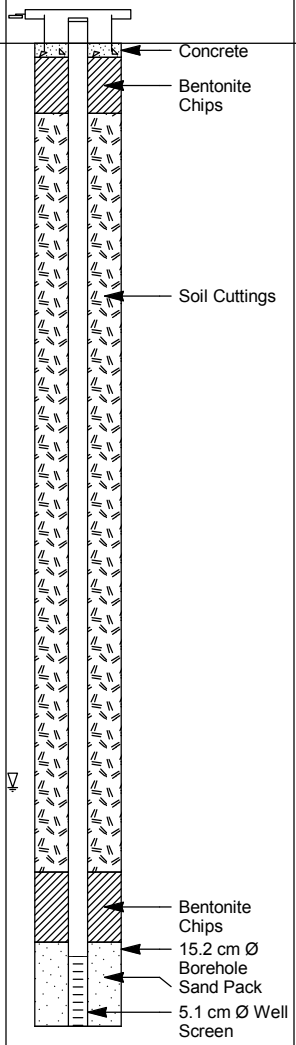
HOLE DESIGNATION: MW4A-15
DATE COMPLETED: August 5, 2015
DRILLING METHOD: Sonic
FIELD PERSONNEL: T. Fitzgerald
DRILLER: A. McRea

NORTHING: 5541583.05
EASTING: 100808.74

TOP OF RISER 169.30 m AMSL
GROUND SURFACE 168.54 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	GW GRAVEL, with sand, subrounded gravel up to 5.1 cm diameter, medium to coarse grained sand	
6	SW SAND, well graded, medium to coarse grained, moist	162.14
10	SW SAND, well graded, fine to medium grained, moist, 1.52 m of recovery	159.09
12	SW SAND, some gravel, well graded sand, medium to coarse grained gravel	156.35
	SP SAND, fine grained	155.74
14	SW SAND, some gravel, medium to coarse grained well graded sand	155.43
	GW GRAVEL, clean, up to 5.1 cm diameter	153.30
16	SW SAND, medium to coarse grained, 1.52 m of recovery - wet at 16.15m BGS	153.00
18	- some gravel from 17.98 to 18.29m BGS	
	BEDROCK	150.25
20	IGNEOUS ROCK, porphyritic, aphanitic, brown; phenocrysts approximately 1-3 mm, reddish brown; no evidence of fractures, rock core broken by vibration of the sonic rig	149.95 149.34
22	IGNEOUS ROCK, fine grained, coarser than above, green; phenocrysts up to 1 cm - horizontal fracture, fine sediment filling at 19.51m BGS	147.20
24	- vertical and oblique fractures at 19.81m BGS - with secondary mineralization from 20.88 to 21.34m BGS	
26	END OF BOREHOLE @ 21.34m BGS	
28		

MONITORING WELL



WELL DETAILS
Screened interval:
148.73 to 147.20m AMSL
19.81 to 21.34m BGS
Length: 1.52m
Diameter: 51mm
Slot Size: 10
Material: PVC
Seal:
150.56 to 149.03m AMSL
17.98 to 19.51m BGS
Material: Bentonite Chips
Sand Pack:
149.03 to 147.20m AMSL
19.51 to 21.34m BGS
Material: Sand

SAMPLE

NUMBER	INTERVAL	REC (m)	'N' VALUE

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 8/5/15

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

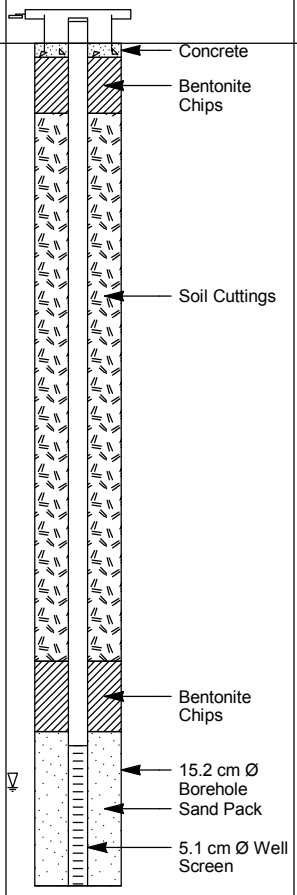
HOLE DESIGNATION: MW4B-15
DATE COMPLETED: August 5, 2015
DRILLING METHOD: Sonic
FIELD PERSONNEL: T. Fitzgerald
DRILLER: A. McRea

NORTHING: 5541575.03
EASTING: 100810.75

TOP OF RISER 169.29 m AMSL
GROUND SURFACE 168.42 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	GW GRAVEL, with sand, subrounded gravel up to 5.1 cm diameter, medium to coarse grained sand	
6	SW SAND, well graded, medium to coarse grained, moist	162.02
10	SW SAND, well graded, fine to medium grained, moist, 1.52 m of recovery	158.97
12	SW SAND, some gravel, well graded sand, medium to coarse grained gravel	156.23
		155.62
	SP SAND, fine grained	155.31
14	SW SAND, some gravel, medium to coarse grained well graded sand	
		153.18
	GW GRAVEL, clean, up to 5.1 cm diameter	152.88
16	SW SAND, medium to coarse grained, 1.52 m of recovery - wet at 16.15m BGS	
18	- some gravel from 17.98 to 18.29m BGS - bedrock at 18.29m BGS	150.13
	END OF BOREHOLE @ 18.29m BGS	

MONITORING WELL



WELL DETAILS
Screened interval:
153.18 to 150.13m AMSL
15.24 to 18.29m BGS
Length: 3.05m
Diameter: 51mm
Slot Size: 10
Material: PVC
Seal:
155.01 to 153.48m AMSL
13.41 to 14.94m BGS
Material: Bentonite Chips
Sand Pack:
153.48 to 150.13m AMSL
14.94 to 18.29m BGS
Material: Sand

SAMPLE

NUMBER	INTERVAL	REC (m)	'N' VALUE

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 8/5/15

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

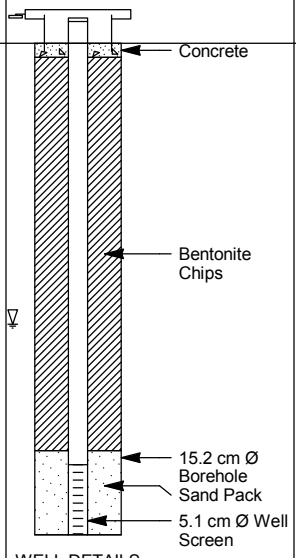
HOLE DESIGNATION: MW5A-15
DATE COMPLETED: August 7, 2015
DRILLING METHOD: Sonic
FIELD PERSONNEL: T. Fitzgerald
DRILLER: A. McRea

NORTHING: 5541325.84
EASTING: 100789.79

TOP OF RISER 191.88 m AMSL
GROUND SURFACE 191.25 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	GW GRAVEL (FILL), with sand, subrounded gravel up to 10 cm, medium to coarse grained sand, 1.52 m of recovery	
2		
	GW GRAVEL, with sand, gravel up to 10 cm, medium to coarse grained sand - wet due to drilling fluids from 3.05 to 5.49 m BGS	188.20
4		
6	SM SAND, silty, fine grained, light brown, wet	185.15
	ML SILT, light brown, dry	184.85 184.54
	MH SILT, with clay, brownish gray, moist	183.93
8	SM SAND, silty, fine grained, gray, wet	183.33 183.02
	MH SILT, with clay, light brown	
10	IGNEOUS ROCK, porphyritic, aphanitic; phenocrysts approximately 1-3 mm; some weathered rock possibly from fracture infilling; rock broken by vibration from sonic rig; reddish brown	180.58
12	- 0.15 m long vertical fracture, rock mostly broken by sonic rig, reddish brown, green phenocrysts up to 5 mm from 9.45 to 9.60m BGS	
14	END OF BOREHOLE @ 10.67m BGS	
16		
18		
20		
22		
24		
26		
28		

MONITORING WELL



WELL DETAILS
Screened interval:
182.11 to 180.58m AMSL
9.14 to 10.67m BGS
Length: 1.52m
Diameter: 51mm
Slot Size: 10
Material: PVC
Seal:
190.34 to 182.41m AMSL
0.91 to 8.84m BGS
Material: Bentonite Chips
Sand Pack:
182.41 to 180.58m AMSL
8.84 to 10.67m BGS
Material: Sand

SAMPLE

NUMBER	INTERVAL	REC (m)	'N' VALUE

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 8/7/15

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

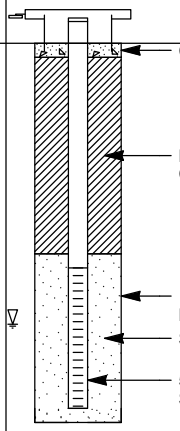
HOLE DESIGNATION: MW5B-15
DATE COMPLETED: August 7, 2015
DRILLING METHOD: Sonic
FIELD PERSONNEL: T. Fitzgerald
DRILLER: A. McRea

NORTHING: 5541325.84
EASTING: 100792.89

TOP OF RISER 192.01 m AMSL
GROUND SURFACE 191.30 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	GW GRAVEL (FILL), with sand, subrounded gravel up to 10 cm, medium to coarse grained sand, 1.52 m of recovery from 0-3.05 m	
2		
		188.25
4	GW GRAVEL, with sand, gravel up to 10 cm, medium to coarse grained sand - wet due to drilling fluids from 3.05 to 5.49 m BGS	
6		185.20
	SM SAND, silty, fine grained, light brown, wet	184.90
	ML SILT, light brown, dry	184.59
	MH SILT, with clay, brownish gray, moist	183.98
8		183.38
	SM SAND, silty, fine grained, gray, wet	183.07
	MH SILT, with clay, light brown - bedrock at 8.23m BGS	
10	END OF BOREHOLE @ 8.23m BGS	
12		
14		
16		
18		
20		
22		
24		
26		
28		

MONITORING WELL



WELL DETAILS
Screened interval:
186.42 to 183.38m AMSL
4.88 to 7.92m BGS
Length: 3.05m
Diameter: 51mm
Slot Size: 10
Material: PVC
Seal:
190.69 to 186.73m AMSL
0.61 to 4.57m BGS
Material: Bentonite Chips
Sand Pack:
186.73 to 183.07m AMSL
4.57 to 8.23m BGS
Material: Sand

SAMPLE

NUMBER	INTERVAL	REC (m)	'N' VALUE

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 8/7/15

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

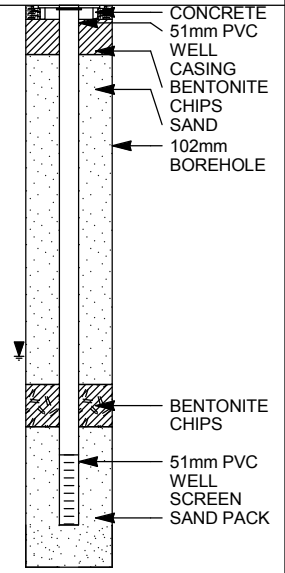
HOLE DESIGNATION: MW6-17
DATE COMPLETED: March 22, 2017
DRILLING METHOD: Sonic
FIELD PERSONNEL: T. Morton

NORTHING: 5541753.1
EASTING: 330407.1

GROUND SURFACE elev. 185.50 m AMSL
TOP OF RISER elev. 185.38 m AMSL

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
0	GP-GRAVEL (FILL), with sand, occasional cobble, trace silt, poorly graded, brown, moist	
	- increase in coarseness at 0.91m BGS	
2		
	SP-SAND, with gravel, medium to coarse grained, poorly graded, grey, moist	183.21
4		
	SP-SAND, with silt to silty sand, fine to very fine grained, grey to brown, moist	180.77
6		
	SP-SAND, with silt and gravel, occasional till-like cobble, grey, moist	179.25
8		
	SP-SAND (FILL), with silt and gravel, occasional cobble, very dense, grey, moist to wet	177.57
10		
		174.22
	TILL/BEDROCK, highly weathered, grey	173.92
12	BEDROCK, granite, pink/red, white inclusions	173.31
	END OF BOREHOLE @ 12.19m BGS	
14		
16		
18		
20		
22		
24		
26		
28		

MONITORING WELL



WELL DETAILS
Screened interval:
175.75 to 174.22m AMSL
9.75 to 11.28m BGS
Length: 1.52m
Diameter: 51mm
Slot Size: 0.020
Material: PVC
Seal:
177.27 to 176.35m AMSL
8.23 to 9.14m BGS
Material: Bentonite Chips
Sand Pack:
176.35 to 173.31m AMSL
9.14 to 12.19m BGS
Material: Sand

SAMPLE NUMBER	INTERVAL	REC (m)	'N' VALUE
1SS			
2SS			
3SS			
4SS			
5SS			
6SS			
7SS			

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
STATIC WATER LEVEL ▼ 3/22/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW7-17
DATE COMPLETED: March 14, 2017
DRILLING METHOD: Sonic
FIELD PERSONNEL: C. Ragan

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
	NORTHING: 5541691.37 EASTING: 100665.22 TOP OF RISER GROUND SURFACE	187.52 186.86					
0	GP-GRAVEL, with fine to coarse sand, with cobble, trace silt, very dense, well graded, dry to moist		CONCRETE; 51mm PVC WELL CASING; BENTONITE; 102mm BOREHOLE; BENTONITE CHIPS; 51mm PVC WELL SCREEN; SAND PACK	1GS			
4	BEDROCK	182.59		1SS		0.00	59
	END OF BOREHOLE @ 5.03m BGS	181.83					

WELL DETAILS
Screened interval:
184.12 to 182.59m AMSL
2.74 to 4.27m BGS
Length: 1.52m
Diameter: 51mm
Slot Size: 0.040
Material: PVC
Seal:
185.18 to 184.57m AMSL
1.68 to 2.29m BGS
Material: Bentonite Chips
Sand Pack:
184.57 to 181.83m AMSL
2.29 to 5.03m BGS
Material: Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
STATIC WATER LEVEL ▼ 3/14/17

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

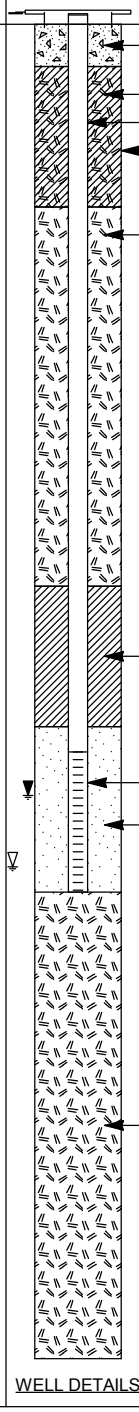
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW8-17
DATE COMPLETED: February 22, 2017
DRILLING METHOD: Hollow Stem Auger/odex
FIELD PERSONNEL: T. Morton/R. Rocca

NORTHING: 5541828.15
EASTING: 100750.08

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
	TOP OF RISER	192.51
	GROUND SURFACE	191.29
0	SP-SAND (FILL), with gravel, trace silt and organic rootlets, well graded, red/brown	190.38
2	GP-GRAVEL, with sand, trace silt, trace to some cobble, dense to very dense, well graded, grey/brown, dry to moist	188.24
4	SP-SAND, with gravel, trace to some cobble, trace silt, dense, grey/brown, dry to moist	
6	- infrequent cobble from 6.10m BGS	
8		
10		
12		
14	BOULDER	178.18
	GP-GRAVEL, with sand, frequent cobble, trace silt, very dense, poorly graded, brown, wet	177.73
16	- SS9: refusal at 15.62m BGS	
	- cobble/boulder from 16.76 to 17.07m BGS	
18	- red from 17.98 to 18.14m BGS	173.15
	SP-SAND, with gravel, very dense, medium to fine grained, poorly graded, grey, wet	172.09
20	GP-GRAVEL, with sand, occasional cobble, compact, poorly graded, grey, wet	
22	SP-SAND, with gravel, very dense, medium to fine grained, poorly graded, grey, wet	169.34
24	- trace gravel, dense below 24.38m BGS	
26		
28		
	END OF BOREHOLE @ 28.96m BGS	162.33



WELL DETAILS

SAMPLE NUMBER	INTERVAL	REC (m)	'N' VALUE
1SS	☒	20.42	70
2SS	☒	16.46	44
3SS	☒	12.80	33
4SS	☒	14.02	41
5SS	☒	15.24	40
6SS	☒	17.68	35
7SS	☒	15.24	38
8SS	☒		40
9SS	☒	6.10	96+
10SS	☒	21.64	64
11SS	☒	12.80	21
12SS	☒	30.48	38

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

WATER FOUND ▽ 2/20/17 STATIC WATER LEVEL ▼ 2/20/17

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW8-17
DATE COMPLETED: February 22, 2017
DRILLING METHOD: Hollow Stem Auger/odex
FIELD PERSONNEL: T. Morton/R. Rocca

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE				
				NUMBER	INTERVAL	REC (m)	'N' VALUE	
32 34 36 38 40 42 44 46 48 50 52 54 56 58			Screened interval: 175.50 to 172.45m AMSL 15.79 to 18.84m BGS Length: 3.05m Diameter: 51mm Slot Size: 0.040 Material: PVC Seal: 179.10 to 176.05m AMSL 12.19 to 15.24m BGS Material: Bentonite Pellets Sand Pack: 176.05 to 172.45m AMSL 15.24 to 18.84m BGS Material: Sand					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 2/20/17 STATIC WATER LEVEL ▼ 2/20/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW9-17
DATE COMPLETED: March 14, 2017
DRILLING METHOD: Sonic
FIELD PERSONNEL: C. Ragan

NORTHING: 5541911.68
EASTING: 100811.04

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL
	TOP OF RISER	191.65
	GROUND SURFACE	190.85
0	SP-SAND (FILL), with gravel, trace silt and organic rootlets, well graded, red/brown, dry to moist	189.94
2	GW-GRAVEL, with sand, with cobble, trace silt, dense to very dense, brown, dry - 0.13m diameter boulder at 1.52m BGS	
4		185.97
6	SP-SAND, with gravel, trace cobble, trace silt, dense to very dense, fine to coarse grained, brown, dry to moist - increase in gravel and cobble content at 7.32m BGS	183.23
8	GP-GRAVEL, with cobble, with medium to coarse sand, with silt, brown, moist	182.62
10	SW/GW-SAND/GRAVEL, trace cobble, trace silt, dense, fine to coarse sand, fine to coarse subrounded gravel, brown, moist	181.10
12	SP-SAND, with medium gravel, some cobble, trace silt, very dense, coarse grained, moist	
14	GW-GRAVEL, with cobble, with medium to coarse sand, very dense, fine to medium grained, dark grey, moist	177.13 176.52
16	SP-SAND, with fine to medium gravel, some cobble, trace silt, dense, medium to coarse grained, brown, moist	175.00 174.39
18	SM-SILTY SAND, with gravel, dense, fine grained, light grey, dry	
20	SW/GW-SAND/GRAVEL, with cobble, with silt, dense, fine to coarse sand, fine to coarse gravel, brown, moist	171.34
22	SM-SILTY SAND, with gravel, very dense, fine grained, poorly graded, light grey, dry to moist	170.12
24	SW/GW-SAND/GRAVEL, with cobble, with silt, very dense, fine to coarse sad, fine to coarse gravel, brown, moist	
26	GW-GRAVEL, with fine to medium sand, some cobble, trace silt, very dense, fine to coarse grained, subrounded, brown/dark grey, wet	166.16
28	GP/SP-SAND/GRAVEL, some coble, trace silt, dense, medium to coarse sand, fine to medium subrounded gravel, clean, brown, wet - increase in cobble up to > 7cm, heaving	163.11

MONITORING WELL: CONCRETE; 51mm PVC WELL CASING; BENTONITE CHIPS/CUTTINGS; 102mm BOREHOLE; BENTONITE CHIPS

SAMPLE

NUMBER	INTERVAL	REC (m)	'N' VALUE
1SS		30.48	58
2SS		9.14	51
3GS			
4SS		0.00	43
5GS			
6SS		9.14	85
7SS		7.62	40
9GS			
8SS		9.14	95
10GS			
11SS		9.14	126
12GS			
13SS		3.05	62
14GS			
15SS		3.05	21
16GS			

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

WATER FOUND ▽ 3/14/17 STATIC WATER LEVEL ▼ 3/14/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW9-17
DATE COMPLETED: March 14, 2017
DRILLING METHOD: Sonic
FIELD PERSONNEL: C. Ragan

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
32	formation approx. 1.22m into casing at 29.57m BGS		51mm PVC WELL SCREEN SAND PACK	17SS		7.62	30
34	SM-SILTY SAND, trace gravel, dense, fine to medium grained, light brown/grey, wet	157.93		18GS			
36	END OF BOREHOLE @ 33.53m BGS	157.32					
38							
40							
42							
44							
46							
48							
50							
52							
54							
56							
58							

WELL DETAILS
Screened interval:
160.37 to 157.32m AMSL
30.48 to 33.53m BGS
Length: 3.05m
Diameter: 51mm
Slot Size: 0.040
Material: PVC
Seal:
161.59 to 160.37m AMSL
29.26 to 30.48m BGS
Material: Bentonite Pellets
Sand Pack:
161.59 to 157.32m AMSL
29.26 to 33.53m BGS
Material: Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 3/14/17 STATIC WATER LEVEL ▼ 3/14/17

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW10-17
DATE COMPLETED: March 27, 2017
DRILLING METHOD: Sonic/air Rotary
FIELD PERSONNEL: T. Morton/C. Ragan

NORTHING: 5541441.67
EASTING: 331208.63

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
	TOP OF RISER	189.07	CONCRETE; 51mm PVC WELL CASING; BENTONITE GROUT; PEA GRAVEL/CUTTINGS; 102mm BOREHOLE				
	GROUND SURFACE	188.24					
0	GP-GRAVEL, with sand, intermixed with organics (rootlets), poorly graded, red/brown	188.09					
	GP/SP-GRAVEL/SAND, with sand to with gravel, trace silt, occasional cobble, poorly graded, grey, dry	187.02		1GS			
2	GP-GRAVEL, with sand, trace silt, occasional cobble, poorly graded, grey, dry	185.19					
	GP-GRAVEL/COBBLE	184.73		2GS			
4	SP-SAND, trace gravel, medium to coarse grained, poorly graded, grey, moist to wet	183.36					
	GW/SW-SAND/GRAVEL, with cobble, trace silt, fine to medium gravel, medium to coarse sand, very dense, brown, moist			3SS		5.18	34
6							
8							
10							
	GW-GRAVEL, with fine to medium sand, with silt, with cobble up to 10cm, fine to coarse gravel, very dense, brown, moist	177.57		4GS			
12							
	GW/SW-SAND/GRAVEL, with cobble, some silt, fine to coarse gravel, fine to coarse sand, very dense, brown, moist	174.52					
14							
	SM-SILTY SAND, with gravel, trace cobble, very dense, fine grained, dark grey	172.39					
16		171.48		5GS			
	SP-SAND, trace silt, trace gravel, dense, medium grained, clean, brown, moist						
18	- with fine gravel at 18.90m BGS						
20							
	GP/SP-GRAVEL/SAND, some cobble, trace silt, fine to coarse gravel, medium sand, brown, moist	167.21		6GS			
22							
	SP-SAND, with fine to medium gravel, trace cobble, trace silt, very dense, medium grained, brown, moist	165.08		7SS		15.24	101
24							
26	- increase in silt content, trace gravel, fine to medium grained at 27.13m BGS						
28				8GS			

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

WATER FOUND ▽ 3/23/17 STATIC WATER LEVEL ▼ 3/27/17

OVERBURDEN LOG 088877-WI.GPJ CRA_CORP.GDT 4/17/17

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

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

HOLE DESIGNATION: MW10-17
DATE COMPLETED: March 27, 2017
DRILLING METHOD: Sonic/air Rotary
FIELD PERSONNEL: T. Morton/C. Ragan

DEPTH m BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. m AMSL	MONITORING WELL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (m)	SAMPLE 'N' VALUE
32				9SS		15.24	87
34	SM-SILTY SAND, very dense, fine grained, some medium grained, dark grey/brown, moist	154.71		10GS			
36				11SS			120
38							
40	SP-SAND, with silt, trace gravel, medium fine to fine grained, moist to wet	148.62					
42			BENTONITE PELLETS				
44			51mm PVC WELL SCREEN				
46			SAND PACK				
48	END OF BOREHOLE @ 47.85m BGS	140.39	SLOUGH				
50							
52							
54							
56							
58							

WELL DETAILS
Screened interval:
145.05 to 142.00m AMSL
43.19 to 46.24m BGS
Length: 3.05m
Diameter: 51mm
Slot Size: 0.020
Material: PVC
Seal:
147.70 to 146.18m AMSL
40.54 to 42.06m BGS
Material: Bentonite Pellets
Sand Pack:
146.18 to 142.00m AMSL
42.06 to 46.24m BGS
Material: Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ 3/23/17 STATIC WATER LEVEL ▼ 3/27/17

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP1-17**
Project No.: 088877-03-07		**Date/Time Started: 3/23/17**
Client: Upland Excavating Ltd.	**Surface Elevation: 182.14 m amsl**	**Date/Time Completed: 3/23/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m) From	Depth (m) At	Depth (m) To	Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)
0		2.44	SP-SAND, with gravel, trace silt, poorly graded, grey, moist	1GS	0.91-1.22m
2.438		2.9	GP-COBBLE/GRAVEL, with sand		
2.896		3.66	SM-SILTY SAND, with gravel, grey, saturated	2GS	3.51-3.66m
3.658		4.57	SP-SAND, with gravel, occasional cobble/boulders, poorly graded, grey, saturated		
	4.57		End of Test Pit		

Location:
Easting: 330375.87160
Northing: 5541665.80676

Geologic Profile

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP2-17**
Project No.: 088877-03-07		**Date/Time Started: 3/23/17**
Client: Upland Excavating Ltd.	**Surface Elevation: 182.78433**	**Date/Time Completed: 3/23/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m) From	At	To	Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)
0		1.07	SP-SAND, with gravel, trace silt, poorly graded, brown, wet		
1.067		2.44	SP-SAND, with gravel, occasional cobble, medium to		
2.896		3.66	SM-SILTY SAND, with gravel, grey, saturated	1GS	1.37-1.52m
2.438		2.44	BEDROCK		
	2.44		End of Test Pit		

Location:
Easting: 330340.22287
Northing: 5541649.45781

Geologic Profile

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP3-17**
Project No.: 088877-03-07		**Date/Time Started: 3/23/17**
Client: Upland Excavating	**Surface Elevation: 182.61 m amsl**	**Date/Time Completed: 3/23/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m)			Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330445.94872 Northing: 5541608.70263
From	At	To				Geologic Profile
0		4.57	SP-SAND, trace gravel and silt, poorly graded, brown, dry to moist	1GS	2.29-2.44m	
	0.91		grey			
	4.57		wet			
4.572		5.49	SM-SILTY SAND, with gravel, occasional cobble/boulders, brown, saturated to wet	2GS	4.88-5.03m	
5.49		5.49	BEDROCK			
	5.49		End of Test Pit			

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP4-17**
Project No.: 088877-03-07		**Date/Time Started: 3/23/17**
Client: Upland Excavating	**Surface Elevation: 191.23 m amsl**	**Date/Time Completed: 3/23/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m) From	Depth (m) At	Depth (m) To	Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330471.17660 Northing: 5541750.68814 / Geologic Profile
0		2.59	FILL, cobble and boulders intermixed with sand, with silt and gravel, grey/brown, moist			
2.591		2.74	TOPSOIL			
2.743		4.11	SP-SAND, with silt and gravel, trace organics, intermixed with cobble and boulders, red/brown, moist, red iron staining	1GS	3.35-3.51m	
	4.11		End of Test Pit (terminated excavation due to sides sloughing too much)			

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP5-17**
Project No.: 088877-03-07		**Date/Time Started: 3/23/17**
Client: Upland Excavating	**Surface Elevation: 189.44 m amsl**	**Date/Time Completed: 3/23/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m)			Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330467.15923 Northing: 5541418.59037 Geologic Profile
From	At	To				
0		0.3	SP-SAND (FILL), with silt and gravel, red/brown			
0.305		0.46	TOPSOIL, with rootlets, brown			
0.457		1.83	SP-SAND, with silt and gravel, red/brown, moist			
1.829		4.88	SP-SAND, with silt, trace gravel, poorly graded, grey			
4.9		5.64	SM-SILTY SAND (till), with gravel, brown			
	5.64		End of Test Pit			

No photo available.

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP6-17**
Project No.: 088877-03-07		**Date/Time Started: 3/24/17**
Client: Upland Excavating	**Surface Elevation: 191.89 m amsl**	**Date/Time Completed: 3/24/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m)			Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330407.08564 Northing: 5541753.09154 Geologic Profile
From	At	To				
0		0.76	SP-SAND (FILL), with gravel, poorly graded, grey			
0.762		4.57	SP-SAND, with gravel and silt, occasional to frequent cobble/boulders, red/brown, moist			
	2.59	2.74	brown			
4.572		5.79	SP-SAND, with gravel, trace silt, occasional cobble, medium grained, brown, moist	1GS	5.49-5.79m	
	5.79		End of Test Pit			
						No photo available.

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP7-17**
Project No.: 088877-03-07		**Date/Time Started: 3/24/17**
Client: Upland Excavating	**Surface Elevation: 191.82 m amsl**	**Date/Time Completed: 3/24/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m) From	Depth (m) At	Depth (m) To	Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330509.01923 Northing: 5541457.21495 / Geologic Profile
0		1.07	SP-SAND (FILL), with gravel, trace construction debris (brick), poorly graded, grey			
1.067		2.29	SP-SAND, with gravel, trace silt, intermixed with frequent to occasional cobble/boulders, poorly graded, red/brown			
2.286		6.40	SP-SAND, with gravel, medium to coarse grained, poorly graded, grey, moist	1GS	3.05-3.35m	
	6.40		End of Test Pit			

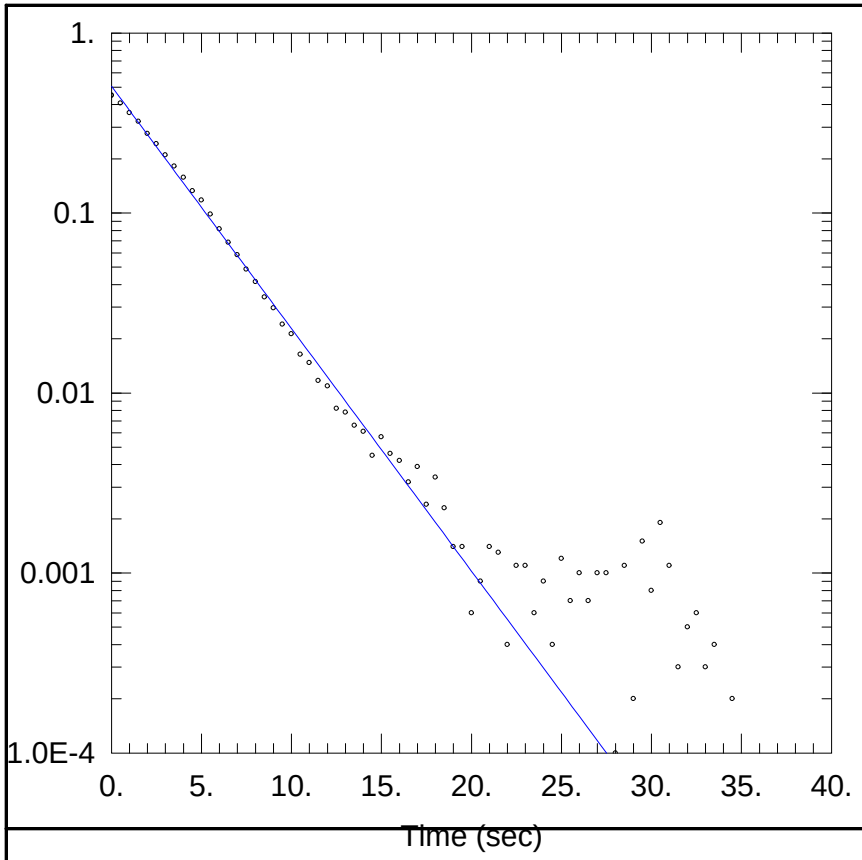
Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP8-17**
Project No.: 088877-03-07		**Date/Time Started: 3/24/17**
Client: Upland Excavating	**Surface Elevation: 192.15 m amsl**	**Date/Time Completed: 3/24/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m) From	Depth (m) At	Depth (m) To	Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330492.99064 Northing: 5541417.83152 — Geologic Profile
0		3.35	GP-GRAVEL, with sand and silt, subrounded, red/brown, moist, more granular with depth	1GS	1.52-1.83m	
3.353		3.35	BEDROCK			
	3.35		End of Test Pit			
			Notes: Bedrock outcrops approximately 3 m south of test pit. Connected test pit to bedrock outcrop. Bedrock slopes down at approx. 80 degrees. No water noted in test pit.			

Project Name: Upland	**Contractor: Upland Excavating Ltd.**	**Test Pit Designation: TP9-17**
Project No.: 088877-03-07		**Date/Time Started: 3/24/17**
Client: Upland Excavating	**Surface Elevation: 191.99 m amsl**	**Date/Time Completed: 3/24/17**
Location: Campbell River, BC	**Test Pit Method: Excavator**	**GHD Supervisor: T. Morton**

Depth (m)			Soil Symbol, Primary Component, Secondary Components, Relative Density/Consistency, Grain Size/Plasticity, Gradation/Structure, Colour, Moisture Content, Supplementary Descriptors	Sample No.	Sample Interval (m bgs)	Location: Easting: 330535.66593 Northing: 5541369.79418 Geologic Profile
From	At	To				
0		0.61	GP-GRAVEL (FILL), with sand, occasional cobble, angular, grey			
0.61		0.61	BEDROCK			
	0.61		End of Test Pit			
			Notes: No water present in test pit.			
						No photo available.

Appendix G
Single Well Response Plots



MW4A-15 RISING HEAD

Data Set: I:\...\88877 MW4A RH.aqt
Date: 04/19/16 Time: 10:01:30

PROJECT INFORMATION

Company: GHD
Client: Uplands
Project: 88877
Location: Uplands
Test Well: MW4A-15
Test Date: 9/18/15

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.02203 cm/sec
y0 = 0.506 m

AQUIFER DATA

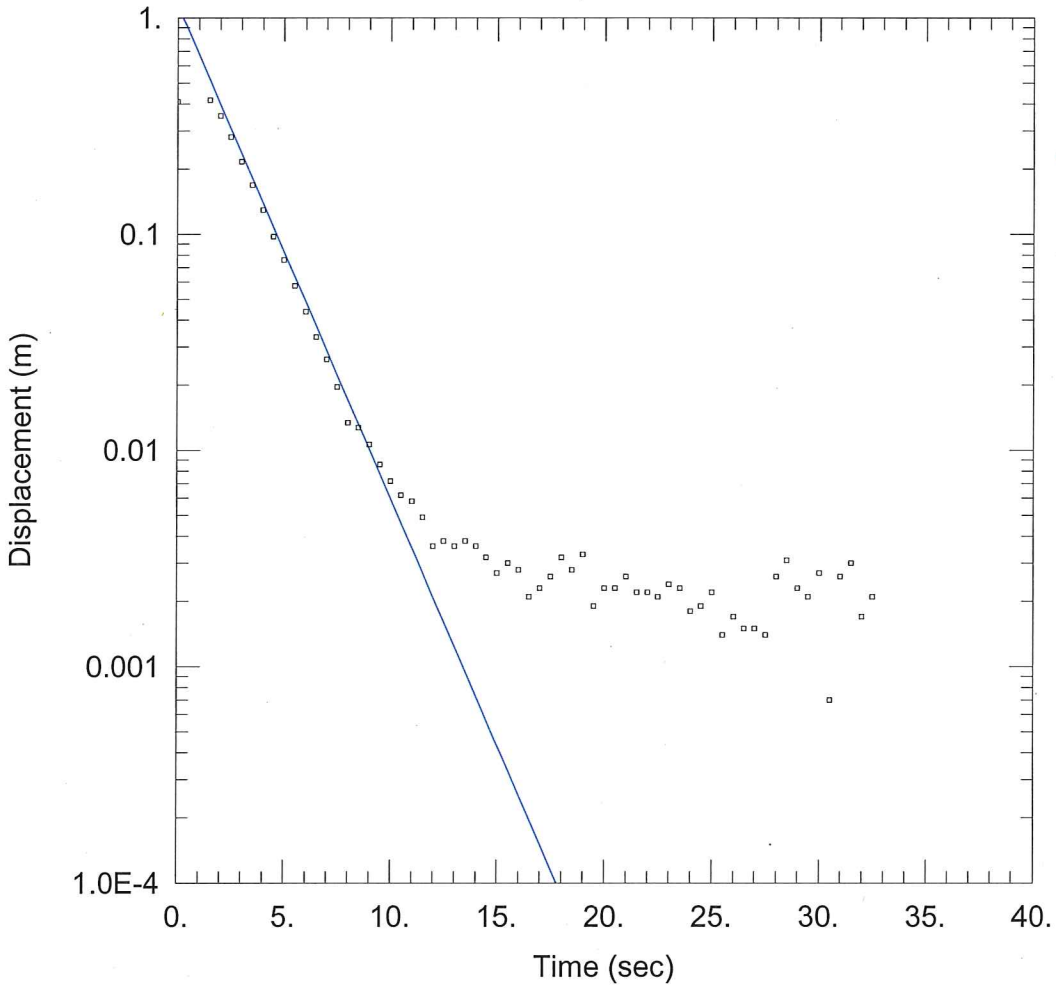
Saturated Thickness: 17.84 m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW4A-15)

Initial Displacement: 0.45 m
Total Well Penetration Depth: 17.81 m
Casing Radius: 0.025 m

Static Water Column Height: 17.84 m
Screen Length: 1.5 m
Well Radius: 0.075 m



MW4B-15 RISING HEAD

Data Set: I:\...\88877 MW4B RH.aqt
Date: 02/12/16 Time: 13:16:42

PROJECT INFORMATION

Company: GHD
Client: Uplands Exc
Project: 88877
Location: Uplands
Test Well: MW4B-15
Test Date: 9/18/15

AQUIFER DATA

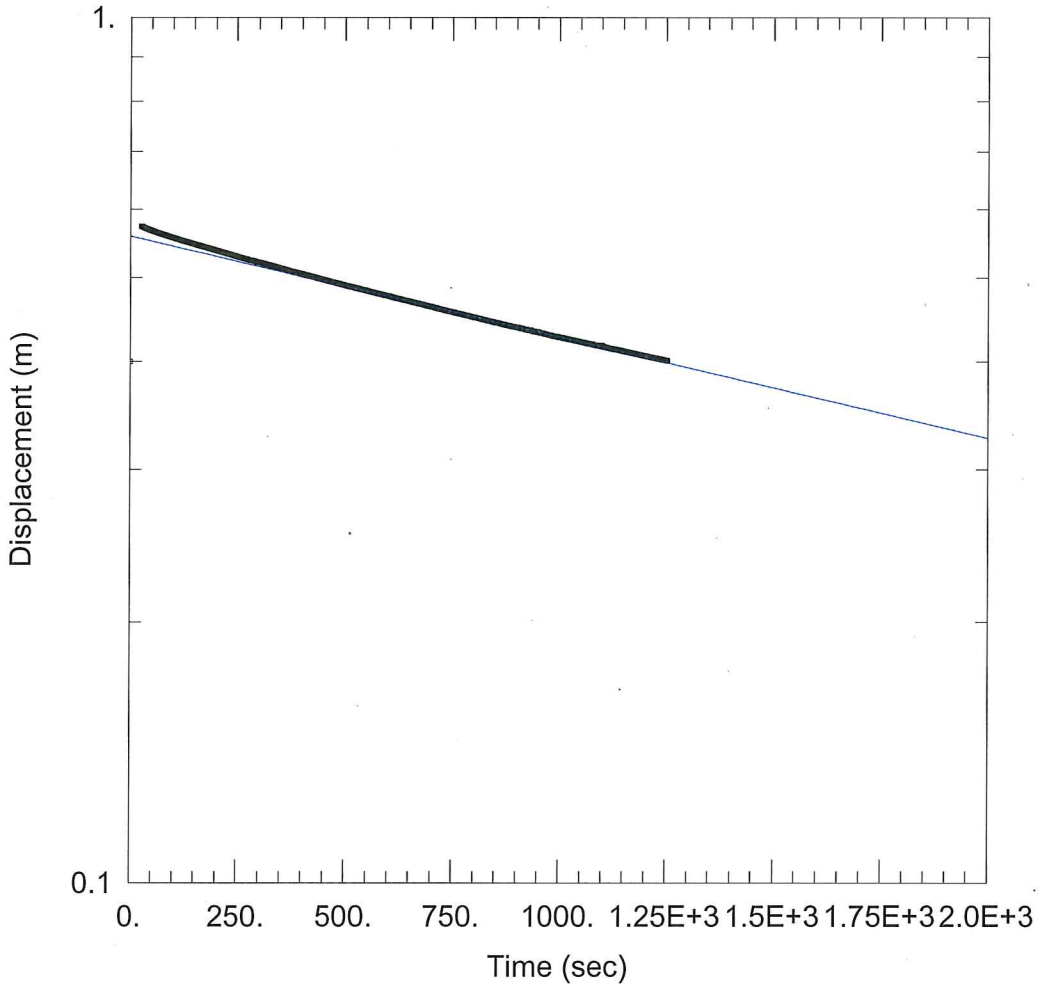
Saturated Thickness: 14.08 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW4B-15)

Initial Displacement: 0.41 m
Total Well Penetration Depth: 13.65 m
Casing Radius: 0.025 m
Static Water Column Height: 14.08 m
Screen Length: 3.05 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.01959 cm/sec
y0 = 1.141 m



MW5A-15 RISING HEAD

Data Set: I:\...\88877 MW5A RH.aqt
Date: 02/12/16 Time: 13:14:14

PROJECT INFORMATION

Company: GHD
Client: Uplands Exc
Project: 88877
Location: Uplands
Test Well: MW5A-15
Test Date: 9/18/15

AQUIFER DATA

Saturated Thickness: 2.41 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 0.4 m
Total Well Penetration Depth: 2.44 m
Casing Radius: 0.025 m
Static Water Column Height: 2.41 m
Screen Length: 1.5 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 1.405E-5 cm/sec
y0 = 0.5589 m

Appendix H
FSK and Laboratory Reports

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name TDF

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code :

SSOW Reference Code :

Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Sample Type	Sample Matrix	Grab or Composite	Parent Sample ID for Field Dups	Footnote(s)	Volume of Water Purged	pH: Field pH	Temperature: Sample Temp.	Temperature: Ambient Temp.	Temperature: Temp Units	Conductivity: Conductivity	Conductivity: Conductivity Units	Turbidity: Turbidity	Turbidity: Turbidity Units	DO: DO	DO: DO Units	Eh / ORP: Eh/ORP	Eh / ORP: Eh/ORP Units
W-88877-091715-TDF-01	MW4A-15	9/17/2015	14:10	N	WG	grab			7	7.97	17.61	NM	C	0.221	mS	8.1	ntu	-	mg/L	131	mV
W-88877-091715-TDF-02	MW4B-15	9/17/2015	14:55	N	WG	grab			5	7.83	15.52	NM	C	0.238	mS	7.4	ntu	-	mg/L	174	mV
W-88877-091715-TDF-03	MW5A-15	9/17/2015	15:45	N	WG	grab			4	7.92	14.12	NM	C	0.459	mS	500	ntu	-	mg/L	162	mV
W-88877-091715-TDF-04	MW3-14	9/17/2015	16:30	N	WG	grab		1	30	7.4	12.98	NM	C	0.251	mS	OOR	ntu	-	mg/L	194	mV
W-88877-091715-TDF-05	MW2-14	9/17/2015	17:00	N	WG	grab		1	30	7.52	12.5	NM	C	0.18	mS	OOR	ntu	-	mg/L	222	mV
W-88877-091715-TDF-06	MW2-14	9/17/2015	17:10	FD	WG	grab	Duplicate of W-88877-091715-TDF-05	1	30	7.52	12.5	NM	C	0.18	mS	OOR	ntu	-	mg/L	222	mV
W-88877-091715-TDF-07	MW1-14	9/17/2015	17:50	N	WG	grab			36	7.45	13.75	NM	C	0.101	mS	250	ntu	-	mg/L	234	mV
W-88877-091815-TDF-08	SW15-01	9/18/2015	6:50	N	WS	grab			na	7.73	18.11	NM	C	0.071	mS	11.8	ntu	-	mg/L	219	mV
W-88877-091815-TDF-09	SW15-02	9/18/2015	7:40	N	WS	grab			na	7.52	16.38	NM	C	0.069	mS	2.1	ntu	-	mg/L	231	mV
W-88877-091815-TDF-10	SW15-02	9/18/2015	7:50	N	WS	grab	Duplicate of W-88877-091815-TDF-09		na	7.52	16.38	NM	C	0.069	mS	2.1	ntu	-	mg/L	231	mV

Footnotes

1. OOR - out of range (>800 NTU)
2.
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

Your P.O. #: 73500976
Your Project #: 088877-02-01
Site Location: UPLANDS
Your C.O.C. #: 476602-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2015/09/28
Report #: R2048939
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B582021
Received: 2015/09/19, 10:15

Sample Matrix: Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	10	2015/09/22	2015/09/22	BBY6SOP-00026	SM 22 2320 B m
Biochemical Oxygen Demand	10	2015/09/19	2015/09/19	BBY6SOP-00045	SM 22 5210 B m
Chloride by Automated Colourimetry	7	N/A	2015/09/21	BBY6SOP-00011	SM 22 4500-Cl- G m
Chloride by Automated Colourimetry	3	N/A	2015/09/22	BBY6SOP-00011	SM 22 4500-Cl- G m
Cyanide SAD (strong acid dissociable)	1	N/A	2015/09/21	BBY6SOP-00004	SM 22 4500-CN O m
Cyanide SAD (strong acid dissociable)	8	N/A	2015/09/23	BBY6SOP-00004	SM 22 4500-CN O m
COD by Colorimeter	10	2015/09/22	2015/09/23	BBY6SOP-00024	SM 22 5220 D m
Conductance - water	10	N/A	2015/09/22	BBY6SOP-00026	SM 22 2510 B m
Hardness Total (calculated as CaCO3)	2	N/A	2015/09/24	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	7	N/A	2015/09/25	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	7	N/A	2015/09/25	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Total) by CVAF	2	2015/09/25	2015/09/25	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Ion Balance	7	N/A	2015/09/25	BBY WI-00033	SM 22 1030E
EPH in Water when PAH required	3	2015/09/23	2015/09/23	BBY8SOP-00029	BCMOE EPH w 12/00 m
EPH in Water when PAH required	1	2015/09/24	2015/09/24	BBY8SOP-00029	BCMOE EPH w 12/00 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	7	N/A	2015/09/25	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	7	N/A	2015/09/25	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	2	2015/09/19	2015/09/24	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	2	2015/09/21	2015/09/23	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	10	2015/09/23	2015/09/24	BBY6SOP-00016	SM 22 4500-N C m
Ammonia-N (Preserved)	10	N/A	2015/09/23	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N) (highlevel)	10	N/A	2015/09/19	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA (highlevel)	10	N/A	2015/09/19	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	10	N/A	2015/09/22	BBY6SOP-00010	SM 22 4500-NO3 I m
PAH in Water by GC/MS (SIM)	3	2015/09/23	2015/09/23	BBY8SOP-00021	EPA 8270d R4 m
PAH in Water by GC/MS (SIM)	1	2015/09/24	2015/09/24	BBY8SOP-00021	EPA 8270d R4 m
Total LMW, HMW, Total PAH Calc	3	N/A	2015/09/24	BBY WI-00033	Auto Calc
Total LMW, HMW, Total PAH Calc	1	N/A	2015/09/25	BBY WI-00033	Auto Calc
Filter and HNO3 Preserve for Metals	7	N/A	2015/09/25	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (1)	10	N/A	2015/09/22	BBY6SOP-00026	SM 22 4500-H+ B m

Your P.O. #: 73500976
Your Project #: 088877-02-01
Site Location: UPLANDS
Your C.O.C. #: 476602-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2015/09/28
Report #: R2048939
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B582021
Received: 2015/09/19, 10:15

Sample Matrix: Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Phenols (4-AAP)	4	N/A	2015/09/24	BBY6SOP-00008	SM 22 5530 D m
Orthophosphate by Konelab (highlevel)	10	N/A	2015/09/21	BBY6SOP-00013	SM 22 4500-P E m
Sulphate by Automated Colourimetry	9	N/A	2015/09/21	BBY6SOP-00017	SM 22 4500-SO42- E m
Sulphate by Automated Colourimetry	1	N/A	2015/09/22	BBY6SOP-00017	SM 22 4500-SO42- E m
Sulphide	7	N/A	2015/09/23	BBY6SOP-00006	SM 22 4500-S2- D m
Sulphide	2	N/A	2015/09/25	BBY6SOP-00006	SM 22 4500-S2- D m
Total Dissolved Solids (Filt. Residue)	1	2015/09/23	2015/09/24	BBY6SOP-00033	SM 22 2540 C m
Total Dissolved Solids (Filt. Residue)	1	2015/09/24	2015/09/26	BBY6SOP-00033	SM 22 2540 C m
Total Dissolved Solids (Filt. Residue)	8	2015/09/25	2015/09/26	BBY6SOP-00033	SM 22 2540 C m
EPH less PAH in Water by GC/FID	3	N/A	2015/09/24	BBY WI-00033	Auto Calc
EPH less PAH in Water by GC/FID	1	N/A	2015/09/25	BBY WI-00033	Auto Calc
TKN (Calc. TN, N/N) total	10	N/A	2015/09/25	BBY WI-00033	Calculation
Total Oil and Grease	4	N/A	2015/09/23	BBY8SOP-00004	BCMOE BCLM Sep2011 m
Total Phosphorus	10	N/A	2015/09/21	BBY6SOP-00013	SM 22 4500-P E m
Total Suspended Solids	10	N/A	2015/09/24	BBY6SOP-00034	SM 22 2540 D
VOCs, VH, F1, LH in Water by HS GC/MS	3	2015/09/21	2015/09/22	BBY8SOP-00009	EPA 8260c R3 m
VOCs, VH, F1, LH in Water by HS GC/MS	1	2015/09/22	2015/09/23	BBY8SOP-00009	EPA 8260c R3 m
Volatile HC-BTEX	3	N/A	2015/09/22	BBY WI-00033	Auto Calc
Volatile HC-BTEX	1	N/A	2015/09/23	BBY WI-00033	Auto Calc

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Your P.O. #: 73500976
Your Project #: 088877-02-01
Site Location: UPLANDS
Your C.O.C. #: 476602-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2015/09/28
Report #: R2048939
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B582021
Received: 2015/09/19, 10:15

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Tabitha Rudkin, AScT, Burnaby Project Manager
Email: TRudkin@maxxam.ca
Phone# (604)638-2639
==========

This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NE0803		NE0804		
Sampling Date		2015/09/17 14:10		2015/09/17 14:55		
COC Number		476602-01-01		476602-01-01		
	UNITS	W-88877-091715-TDF-01	QC Batch	W-88877-091715-TDF-02	RDL	QC Batch
Calculated Parameters						
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Ion Balance	N/A	1.0	8043882	1.1	0.010	8043882
Demand Parameters						
Biochemical Oxygen Demand	mg/L	<6.0	8043714	<6.0	6.0	8043714
Chemical Oxygen Demand	mg/L	<10	8046135	<10	10	8046135
Misc. Inorganics						
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00078	8045121	0.00080	0.00050	8047923
Alkalinity (Total as CaCO3)	mg/L	91.4	8047763	66.4	0.50	8047763
Alkalinity (PP as CaCO3)	mg/L	<0.50	8047763	<0.50	0.50	8047763
Bicarbonate (HCO3)	mg/L	112	8047763	80.9	0.50	8047763
Carbonate (CO3)	mg/L	<0.50	8047763	<0.50	0.50	8047763
Hydroxide (OH)	mg/L	<0.50	8047763	<0.50	0.50	8047763
Nutrients						
Total Ammonia (N)	mg/L	0.018	8048220	0.015	0.0050	8048221
Total Phosphorus (P)	mg/L	0.0162	8045579	0.0200	0.0050	8045579
OIL & GREASE						
Total Oil and grease	mg/L	<1.0	8047224	<1.0	1.0	8047224
Misc. Organics						
Phenols	mg/L	<0.0010	8049283	<0.0010	0.0010	8049283
Physical Properties						
Conductivity	uS/cm	283	8047768	240	1.0	8047768
pH	pH	8.12	8047769	7.80	N/A	8047769
Physical Properties						
Total Suspended Solids	mg/L	<4.0	8047646	<4.0	4.0	8047646
Total Dissolved Solids	mg/L	146 (1)	8049095	162	10	8046946

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Sample analysed past recommended hold time.

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NE0804			NE0805		
Sampling Date		2015/09/17 14:55			2015/09/17 15:45		
COC Number		476602-01-01			476602-01-01		
	UNITS	W-88877-091715-TDF-02 Lab-Dup	RDL	QC Batch	W-88877-091715-TDF-03	RDL	QC Batch
Calculated Parameters							
Filter and HNO3 Preservation	N/A	N/A	N/A	ONSITE	FIELD	N/A	ONSITE
Ion Balance	N/A	N/A	0.010	8043882	1.0	0.010	8043882
Demand Parameters							
Biochemical Oxygen Demand	mg/L	N/A	6.0	8043714	6.5	6.0	8043714
Chemical Oxygen Demand	mg/L	N/A	10	8046135	163	10	8046135
Misc. Inorganics							
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00081	0.00050	8047923	0.00119	0.00050	8047923
Alkalinity (Total as CaCO3)	mg/L	N/A	0.50	8047763	117	0.50	8047763
Alkalinity (PP as CaCO3)	mg/L	N/A	0.50	8047763	<0.50	0.50	8047763
Bicarbonate (HCO3)	mg/L	N/A	0.50	8047763	143	0.50	8047763
Carbonate (CO3)	mg/L	N/A	0.50	8047763	<0.50	0.50	8047763
Hydroxide (OH)	mg/L	N/A	0.50	8047763	<0.50	0.50	8047763
Nutrients							
Total Ammonia (N)	mg/L	0.014	0.0050	8048221	0.026	0.0050	8048221
Total Phosphorus (P)	mg/L	N/A	0.0050	8045579	2.64	0.050	8045579
Physical Properties							
Conductivity	uS/cm	N/A	1.0	8047768	487	1.0	8047768
pH	pH	N/A	N/A	8047769	8.15	N/A	8047769
Physical Properties							
Total Suspended Solids	mg/L	N/A	4.0	8047646	4540 (1)	32	8047646
Total Dissolved Solids	mg/L	N/A	10	8046946	292 (2)	10	8049095

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) RDL raised due to high concentration of solids in the sample.
(2) Sample analysed past recommended hold time.

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Maxxam Job #: B582021
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GHD Limited
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Your P.O. #: 73500976
Sampler Initials: DF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NE0806		NE0807	NE0807		
Sampling Date		2015/09/17 16:30		2015/09/17 17:00	2015/09/17 17:00		
COC Number		476602-01-01		476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-04	RDL	W-88877-091715-TDF-05	W-88877-091715-TDF-05 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Filter and HNO3 Preservation	N/A	FIELD	N/A	FIELD	N/A	N/A	ONSITE
Ion Balance	N/A	1.0	0.010	1.0	N/A	0.010	8043882
Demand Parameters							
Biochemical Oxygen Demand	mg/L	<6.0	6.0	6.7	N/A	6.0	8043714
Chemical Oxygen Demand	mg/L	21	10	60	N/A	10	8046135
Misc. Inorganics							
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00091	0.00050	0.00057	N/A	0.00050	8047923
Alkalinity (Total as CaCO3)	mg/L	37.8	0.50	76.2	N/A	0.50	8047763
Alkalinity (PP as CaCO3)	mg/L	<0.50	0.50	<0.50	N/A	0.50	8047763
Bicarbonate (HCO3)	mg/L	46.1	0.50	93.0	N/A	0.50	8047763
Carbonate (CO3)	mg/L	<0.50	0.50	<0.50	N/A	0.50	8047763
Hydroxide (OH)	mg/L	<0.50	0.50	<0.50	N/A	0.50	8047763
Nutrients							
Total Ammonia (N)	mg/L	0.017	0.0050	0.058	N/A	0.0050	8048221
Total Phosphorus (P)	mg/L	0.123	0.0050	0.275	0.283	0.0050	8045579
Physical Properties							
Conductivity	uS/cm	111	1.0	178	N/A	1.0	8047768
pH	pH	7.83	N/A	8.01	N/A	N/A	8047769
Physical Properties							
Total Suspended Solids	mg/L	59.0	4.0	330 (1)	N/A	32	8047646
Total Dissolved Solids	mg/L	78 (2)	10	108 (2)	N/A	10	8049095

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) RDL raised due to high concentration of solids in the sample.
(2) Sample analysed past recommended hold time.

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
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Your P.O. #: 73500976
Sampler Initials: DF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NE0808	NE0808		NE0809		
Sampling Date		2015/09/17 17:10	2015/09/17 17:10		2015/09/17 17:50		
COC Number		476602-01-01	476602-01-01		476602-01-01		
	UNITS	W-88877-091715-TDF-06	W-88877-091715-TDF-06 Lab-Dup	RDL	W-88877-091715-TDF-07	RDL	QC Batch
Calculated Parameters							
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	FIELD	N/A	ONSITE
Ion Balance	N/A	1.0	N/A	0.010	0.99	0.010	8043882
Demand Parameters							
Biochemical Oxygen Demand	mg/L	7.8	N/A	6.0	<6.0	6.0	8043714
Chemical Oxygen Demand	mg/L	65	N/A	10	25	10	8046135
Misc. Inorganics							
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00056	N/A	0.00050	0.00054	0.00050	8047923
Alkalinity (Total as CaCO3)	mg/L	77.9	78.2	0.50	39.1	0.50	8047725
Alkalinity (PP as CaCO3)	mg/L	<0.50	<0.50	0.50	<0.50	0.50	8047725
Bicarbonate (HCO3)	mg/L	95.0	95.4	0.50	47.7	0.50	8047725
Carbonate (CO3)	mg/L	<0.50	<0.50	0.50	<0.50	0.50	8047725
Hydroxide (OH)	mg/L	<0.50	<0.50	0.50	<0.50	0.50	8047725
Nutrients							
Total Ammonia (N)	mg/L	0.034	N/A	0.0050	0.021	0.0050	8048220
Total Phosphorus (P)	mg/L	0.387	N/A	0.0050	0.337	0.0050	8045579
Physical Properties							
Conductivity	uS/cm	180	179	1.0	91.2	1.0	8047724
pH	pH	7.96	8.03	N/A	7.65	N/A	8047717
Physical Properties							
Total Suspended Solids	mg/L	362 (1)	N/A	32	212 (1)	8.0	8047646
Total Dissolved Solids	mg/L	100 (2)	N/A	10	52 (2)	10	8049095

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) RDL raised due to high concentration of solids in the sample.
(2) Sample analysed past recommended hold time.

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
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Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NE0810	NE0811		
Sampling Date		2015/09/18 06:50	2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01		
	UNITS	W-88877-091815-TDF-08	W-88877-091815-TDF-09	RDL	QC Batch
Demand Parameters					
Biochemical Oxygen Demand	mg/L	<6.0	<6.0	6.0	8043714
Chemical Oxygen Demand	mg/L	<10	<10	10	8046135
Misc. Inorganics					
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00062	<0.00050	0.00050	8047923
Alkalinity (Total as CaCO3)	mg/L	22.5	14.9	0.50	8047725
Alkalinity (PP as CaCO3)	mg/L	<0.50	<0.50	0.50	8047725
Bicarbonate (HCO3)	mg/L	27.5	18.2	0.50	8047725
Carbonate (CO3)	mg/L	<0.50	<0.50	0.50	8047725
Hydroxide (OH)	mg/L	<0.50	<0.50	0.50	8047725
Nutrients					
Total Ammonia (N)	mg/L	0.016	0.019	0.0050	8048220
Total Phosphorus (P)	mg/L	<0.0050	0.0056	0.0050	8045579
OIL & GREASE					
Total Oil and grease	mg/L	<1.0	<1.0	1.0	8047224
Misc. Organics					
Phenols	mg/L	<0.0010	<0.0010	0.0010	8049283
Physical Properties					
Conductivity	uS/cm	53.1	55.3	1.0	8047724
pH	pH	7.52	7.45	N/A	8047717
Physical Properties					
Total Suspended Solids	mg/L	<4.0	<4.0	4.0	8047646
Total Dissolved Solids	mg/L	26	32	10	8049095

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NE0812	NE0812		
Sampling Date		2015/09/18 07:40	2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01		
	UNITS	W-88877-091815-TDF-10	W-88877-091815-TDF-10 Lab-Dup	RDL	QC Batch
Demand Parameters					
Biochemical Oxygen Demand	mg/L	<6.0	N/A	6.0	8043714
Chemical Oxygen Demand	mg/L	<10	12	10	8046138
Misc. Inorganics					
Alkalinity (Total as CaCO3)	mg/L	14.7	N/A	0.50	8047725
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	8047725
Bicarbonate (HCO3)	mg/L	17.9	N/A	0.50	8047725
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	8047725
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	8047725
Nutrients					
Total Ammonia (N)	mg/L	0.017	N/A	0.0050	8048220
Total Phosphorus (P)	mg/L	0.0053	N/A	0.0050	8045579
Physical Properties					
Conductivity	uS/cm	56.5	N/A	1.0	8047724
pH	pH	7.33	N/A	N/A	8047717
Physical Properties					
Total Suspended Solids	mg/L	<4.0	N/A	4.0	8047646
Total Dissolved Solids	mg/L	44	N/A	10	8049124

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

MISCELLANEOUS (WATER)

Maxxam ID		NE0803	NE0804	NE0805		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/17 15:45		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091715-TDF-03	RDL	QC Batch
MISCELLANEOUS						
Sulphide	mg/L	0.0078	0.0058	<0.0050	0.0050	8047784
RDL = Reportable Detection Limit						

Maxxam ID		NE0806	NE0807	NE0808		
Sampling Date		2015/09/17 16:30	2015/09/17 17:00	2015/09/17 17:10		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-04	W-88877-091715-TDF-05	W-88877-091715-TDF-06	RDL	QC Batch
MISCELLANEOUS						
Sulphide	mg/L	<0.0050	<0.0050	0.0075	0.0050	8047784
RDL = Reportable Detection Limit						

Maxxam ID		NE0809		NE0810	NE0810		
Sampling Date		2015/09/17 17:50		2015/09/18 06:50	2015/09/18 06:50		
COC Number		476602-01-01		476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-07	QC Batch	W-88877-091815-TDF-08	W-88877-091815-TDF-08 Lab-Dup	RDL	QC Batch
MISCELLANEOUS							
Sulphide	mg/L	<0.0050	8047784	0.0068	0.0071	0.0050	8050357
RDL = Reportable Detection Limit Lab-Dup = Laboratory Initiated Duplicate							

Maxxam ID		NE0811		
Sampling Date		2015/09/18 07:40		
COC Number		476602-01-01		
	UNITS	W-88877-091815-TDF-09	RDL	QC Batch
MISCELLANEOUS				
Sulphide	mg/L	0.0085	0.0050	8050357
RDL = Reportable Detection Limit				

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		NE0803		NE0804		
Sampling Date		2015/09/17 14:10		2015/09/17 14:55		
COC Number		476602-01-01		476602-01-01		
	UNITS	W-88877-091715-TDF-01	QC Batch	W-88877-091715-TDF-02	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.10	8046982	<0.10	0.10	8046982
Calculated Parameters						
Nitrate (N)	mg/L	0.90	8043755	0.90	0.10	8043755
Anions						
Dissolved Sulphate (SO4)	mg/L	6.30	8046021	5.68	0.50	8046014
Dissolved Chloride (Cl)	mg/L	24	8046016	24	0.50	8046006
Nutrients						
Orthophosphate (P)	mg/L	<0.10 (1)	8045491	<0.10 (1)	0.10	8045491
Nitrate plus Nitrite (N)	mg/L	0.90	8046981	0.90	0.10	8046981

RDL = Reportable Detection Limit
(1) Sample analysed past recommended hold time.

Maxxam ID		NE0805	NE0806	NE0807		
Sampling Date		2015/09/17 15:45	2015/09/17 16:30	2015/09/17 17:00		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-03	W-88877-091715-TDF-04	W-88877-091715-TDF-05	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.10	<0.10	<0.10	0.10	8046982
Calculated Parameters						
Nitrate (N)	mg/L	<0.10	0.49	0.26	0.10	8043755
Anions						
Dissolved Sulphate (SO4)	mg/L	87.5	5.78	8.22	0.50	8046021
Dissolved Chloride (Cl)	mg/L	20	5.3	3.5	0.50	8046016
Nutrients						
Orthophosphate (P)	mg/L	<0.10 (1)	<0.10 (1)	<0.10 (1)	0.10	8045491
Nitrate plus Nitrite (N)	mg/L	<0.10	0.49	0.26	0.10	8046981

RDL = Reportable Detection Limit
(1) Sample analysed past recommended hold time.

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
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Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		NE0808		NE0809		
Sampling Date		2015/09/17 17:10		2015/09/17 17:50		
COC Number		476602-01-01		476602-01-01		
	UNITS	W-88877-091715-TDF-06	QC Batch	W-88877-091715-TDF-07	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.10	8046982	<0.10	0.10	8046982
Calculated Parameters						
Nitrate (N)	mg/L	0.24	8043755	0.15	0.10	8043755
Anions						
Dissolved Sulphate (SO4)	mg/L	7.72	8046014	3.17	0.50	8046014
Dissolved Chloride (Cl)	mg/L	3.0	8046006	1.9	0.50	8047341
Nutrients						
Orthophosphate (P)	mg/L	<0.10 (1)	8045491	<0.10 (1)	0.10	8045491
Nitrate plus Nitrite (N)	mg/L	0.24	8046981	0.15	0.10	8046981

RDL = Reportable Detection Limit
(1) Sample analysed past recommended hold time.

Maxxam ID		NE0810	NE0810		NE0811		
Sampling Date		2015/09/18 06:50	2015/09/18 06:50		2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01		476602-01-01		
	UNITS	W-88877-091815-TDF-08	W-88877-091815-TDF-08 Lab-Dup	QC Batch	W-88877-091815-TDF-09	RDL	QC Batch
ANIONS							
Nitrite (N)	mg/L	<0.10	N/A	8046982	<0.10	0.10	8046982
Calculated Parameters							
Nitrate (N)	mg/L	<0.10	N/A	8043755	<0.10	0.10	8043755
Anions							
Dissolved Sulphate (SO4)	mg/L	3.04	2.99	8047350	0.75	0.50	8046014
Dissolved Chloride (Cl)	mg/L	1.0	1.0	8047341	5.8	0.50	8046006
Nutrients							
Orthophosphate (P)	mg/L	<0.10	N/A	8045491	<0.10	0.10	8045491
Nitrate plus Nitrite (N)	mg/L	<0.10	N/A	8046981	<0.10	0.10	8046981

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
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Sampler Initials: DF

HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		NE0812	NE0812		
Sampling Date		2015/09/18 07:40	2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01		
	UNITS	W-88877-091815-TDF-10	W-88877-091815-TDF-10 Lab-Dup	RDL	QC Batch
ANIONS					
Nitrite (N)	mg/L	<0.10	<0.10	0.10	8046982
Calculated Parameters					
Nitrate (N)	mg/L	<0.10	N/A	0.10	8043755
Anions					
Dissolved Sulphate (SO4)	mg/L	1.12	N/A	0.50	8046014
Dissolved Chloride (Cl)	mg/L	5.6	N/A	0.50	8047341
Nutrients					
Orthophosphate (P)	mg/L	<0.10	<0.10	0.10	8045491
Nitrate plus Nitrite (N)	mg/L	<0.10	<0.10	0.10	8046981

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Your P.O. #: 73500976
Sampler Initials: DF

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		NE0803	NE0804	NE0810		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/18 06:50		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091815-TDF-08	RDL	QC Batch
Polycyclic Aromatics						
Low Molecular Weight PAH`s	ug/L	<0.24	<0.24	<0.24	0.24	8043693
High Molecular Weight PAH`s	ug/L	<0.050	<0.050	<0.050	0.050	8043693
Total PAH	ug/L	<0.24	<0.24	<0.24	0.24	8043693
Naphthalene	ug/L	<0.10	<0.10	<0.10	0.10	8047638
2-Methylnaphthalene	ug/L	<0.10	<0.10	<0.10	0.10	8047638
Quinoline	ug/L	<0.24	<0.24	<0.24	0.24	8047638
Acenaphthylene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Acenaphthene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Fluorene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Phenanthrene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Anthracene	ug/L	<0.010	<0.010	<0.010	0.010	8047638
Acridine	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Fluoranthene	ug/L	<0.020	<0.020	<0.020	0.020	8047638
Pyrene	ug/L	<0.020	<0.020	<0.020	0.020	8047638
Benzo(a)anthracene	ug/L	<0.010	<0.010	<0.010	0.010	8047638
Chrysene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Benzo(b&j)fluoranthene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Benzo(k)fluoranthene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Benzo(a)pyrene	ug/L	<0.0090	<0.0090	<0.0090	0.0090	8047638
Indeno(1,2,3-cd)pyrene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Dibenz(a,h)anthracene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	0.050	8047638
Calculated Parameters						
LEPH (C10-C19 less PAH)	mg/L	<0.20	<0.20	<0.20	0.20	8043776
HEPH (C19-C32 less PAH)	mg/L	<0.20	<0.20	<0.20	0.20	8043776
Ext. Pet. Hydrocarbon						
EPH (C10-C19)	mg/L	<0.20	<0.20	<0.20	0.20	8047645
EPH (C19-C32)	mg/L	<0.20	<0.20	<0.20	0.20	8047645
Surrogate Recovery (%)						
O-TERPHENYL (sur.)	%	97	98	98	N/A	8047645
D10-ANTHRACENE (sur.)	%	98	102	107	N/A	8047638
D8-ACENAPHTHYLENE (sur.)	%	100	100	102	N/A	8047638
D8-NAPHTHALENE (sur.)	%	101	100	102	N/A	8047638

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		NE0803	NE0804	NE0810		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/18 06:50		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091815-TDF-08	RDL	QC Batch
D9-Acridine	%	95	98	102	N/A	8047638
TERPHENYL-D14 (sur.)	%	95	100	105	N/A	8047638

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		NE0811		
Sampling Date		2015/09/18 07:40		
COC Number		476602-01-01		
	UNITS	W-88877-091815-TDF-09	RDL	QC Batch
Polycyclic Aromatics				
Low Molecular Weight PAH`s	ug/L	<0.24	0.24	8043693
High Molecular Weight PAH`s	ug/L	<0.050	0.050	8043693
Total PAH	ug/L	<0.24	0.24	8043693
Naphthalene	ug/L	<0.10	0.10	8049027
2-Methylnaphthalene	ug/L	<0.10	0.10	8049027
Quinoline	ug/L	<0.24	0.24	8049027
Acenaphthylene	ug/L	<0.050	0.050	8049027
Acenaphthene	ug/L	<0.050	0.050	8049027
Fluorene	ug/L	<0.050	0.050	8049027
Phenanthrene	ug/L	<0.050	0.050	8049027
Anthracene	ug/L	<0.010	0.010	8049027
Acridine	ug/L	<0.050	0.050	8049027
Fluoranthene	ug/L	<0.020	0.020	8049027
Pyrene	ug/L	<0.020	0.020	8049027
Benzo(a)anthracene	ug/L	<0.010	0.010	8049027
Chrysene	ug/L	<0.050	0.050	8049027
Benzo(b&j)fluoranthene	ug/L	<0.050	0.050	8049027
Benzo(k)fluoranthene	ug/L	<0.050	0.050	8049027
Benzo(a)pyrene	ug/L	<0.0090	0.0090	8049027
Indeno(1,2,3-cd)pyrene	ug/L	<0.050	0.050	8049027
Dibenz(a,h)anthracene	ug/L	<0.050	0.050	8049027
Benzo(g,h,i)perylene	ug/L	<0.050	0.050	8049027
Calculated Parameters				
LEPH (C10-C19 less PAH)	mg/L	<0.20	0.20	8043776
HEPH (C19-C32 less PAH)	mg/L	<0.20	0.20	8043776
Ext. Pet. Hydrocarbon				
EPH (C10-C19)	mg/L	<0.20	0.20	8049033
EPH (C19-C32)	mg/L	<0.20	0.20	8049033
Surrogate Recovery (%)				
O-TERPHENYL (sur.)	%	98	N/A	8049033
D10-ANTHRACENE (sur.)	%	73	N/A	8049027
D8-ACENAPHTHYLENE (sur.)	%	81	N/A	8049027
D8-NAPHTHALENE (sur.)	%	85	N/A	8049027

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		NE0811		
Sampling Date		2015/09/18 07:40		
COC Number		476602-01-01		
	UNITS	**W-88877-091815-TDF-09**	**RDL**	**QC Batch**
D9-Acridine	%	69	N/A	8049027
TERPHENYL-D14 (sur.)	%	80	N/A	8049027

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0803	NE0804	NE0805		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/17 15:45		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091715-TDF-03	RDL	QC Batch
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	43.0	21.2	135	0.50	8043769
Elements						
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	0.010	8050464
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	10.6	9.9	17.2	3.0	8046218
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	0.50	8046218
Dissolved Arsenic (As)	ug/L	0.56	0.21	0.91	0.10	8046218
Dissolved Barium (Ba)	ug/L	12.4	2.8	16.0	1.0	8046218
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	0.10	8046218
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	1.0	8046218
Dissolved Boron (B)	ug/L	<50	<50	78	50	8046218
Dissolved Cadmium (Cd)	ug/L	0.010	0.019	0.027	0.010	8046218
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	1.0	8046218
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	0.50	8046218
Dissolved Copper (Cu)	ug/L	0.36	1.26	1.00	0.20	8046218
Dissolved Iron (Fe)	ug/L	5.9	9.9	8.2	5.0	8046218
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	<0.20	0.20	8046218
Dissolved Lithium (Li)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Manganese (Mn)	ug/L	42.4	7.1	167	1.0	8046218
Dissolved Molybdenum (Mo)	ug/L	1.0	<1.0	6.0	1.0	8046218
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	2.4	1.0	8046218
Dissolved Selenium (Se)	ug/L	0.38	0.47	1.07	0.10	8046218
Dissolved Silicon (Si)	ug/L	8010	7940	5010	100	8046218
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	<0.020	0.020	8046218
Dissolved Strontium (Sr)	ug/L	40.5	36.3	125	1.0	8046218
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	0.050	8046218
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Uranium (U)	ug/L	0.12	<0.10	1.80	0.10	8046218
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Zinc (Zn)	ug/L	<5.0	7.7	<5.0	5.0	8046218
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50	0.50	8046218
Dissolved Calcium (Ca)	mg/L	14.5	6.66	40.0	0.050	8043796
Dissolved Magnesium (Mg)	mg/L	1.63	1.12	8.57	0.050	8043796
RDL = Reportable Detection Limit						

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0803	NE0804	NE0805		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/17 15:45		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	**W-88877-091715-TDF-01**	**W-88877-091715-TDF-02**	**W-88877-091715-TDF-03**	**RDL**	**QC Batch**
Dissolved Potassium (K)	mg/L	0.435	0.237	1.67	0.050	8043796
Dissolved Sodium (Na)	mg/L	44.2	44.8	46.0	0.050	8043796
Dissolved Sulphur (S)	mg/L	<3.0	<3.0	24.5	3.0	8043796
RDL = Reportable Detection Limit						

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0806	NE0807	NE0808		
Sampling Date		2015/09/17 16:30	2015/09/17 17:00	2015/09/17 17:10		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-04	W-88877-091715-TDF-05	W-88877-091715-TDF-06	RDL	QC Batch
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	47.6	81.1	80.5	0.50	8043769
Elements						
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	0.010	8050464
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	127	9.6	9.8	3.0	8046218
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	0.50	8046218
Dissolved Arsenic (As)	ug/L	0.17	0.18	0.18	0.10	8046218
Dissolved Barium (Ba)	ug/L	2.9	1.7	1.7	1.0	8046218
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	0.10	8046218
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	1.0	8046218
Dissolved Boron (B)	ug/L	<50	<50	<50	50	8046218
Dissolved Cadmium (Cd)	ug/L	0.016	0.014	0.011	0.010	8046218
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	1.0	8046218
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	<0.50	0.50	8046218
Dissolved Copper (Cu)	ug/L	1.59	0.72	0.85	0.20	8046218
Dissolved Iron (Fe)	ug/L	305	<5.0	5.1	5.0	8046218
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	<0.20	0.20	8046218
Dissolved Lithium (Li)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Manganese (Mn)	ug/L	20.0	<1.0	<1.0	1.0	8046218
Dissolved Molybdenum (Mo)	ug/L	<1.0	<1.0	<1.0	1.0	8046218
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	<1.0	1.0	8046218
Dissolved Selenium (Se)	ug/L	0.22	0.18	0.18	0.10	8046218
Dissolved Silicon (Si)	ug/L	7700	6250	6500	100	8046218
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	<0.020	0.020	8046218
Dissolved Strontium (Sr)	ug/L	22.6	36.6	37.8	1.0	8046218
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	0.050	8046218
Dissolved Tin (Sn)	ug/L	<5.0	5.0	<5.0	5.0	8046218
Dissolved Titanium (Ti)	ug/L	9.7	<5.0	<5.0	5.0	8046218
Dissolved Uranium (U)	ug/L	<0.10	<0.10	<0.10	0.10	8046218
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	<5.0	5.0	8046218
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50	0.50	8046218
Dissolved Calcium (Ca)	mg/L	13.7	25.5	25.1	0.050	8043796
Dissolved Magnesium (Mg)	mg/L	3.23	4.25	4.30	0.050	8043796
RDL = Reportable Detection Limit						

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0806	NE0807	NE0808		
Sampling Date		2015/09/17 16:30	2015/09/17 17:00	2015/09/17 17:10		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-04	W-88877-091715-TDF-05	W-88877-091715-TDF-06	RDL	QC Batch
Dissolved Potassium (K)	mg/L	0.212	0.291	0.292	0.050	8043796
Dissolved Sodium (Na)	mg/L	2.91	4.72	4.63	0.050	8043796
Dissolved Sulphur (S)	mg/L	<3.0	<3.0	<3.0	3.0	8043796
RDL = Reportable Detection Limit						

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0809	NE0809		
Sampling Date		2015/09/17 17:50	2015/09/17 17:50		
COC Number		476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-07	W-88877-091715-TDF-07 Lab-Dup	RDL	QC Batch
Misc. Inorganics					
Dissolved Hardness (CaCO3)	mg/L	38.7	N/A	0.50	8043769
Elements					
Dissolved Mercury (Hg)	ug/L	<0.010	N/A	0.010	8050464
Dissolved Metals by ICPMS					
Dissolved Aluminum (Al)	ug/L	9.0	12.7	3.0	8046218
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	8046218
Dissolved Arsenic (As)	ug/L	0.13	0.13	0.10	8046218
Dissolved Barium (Ba)	ug/L	<1.0	<1.0	1.0	8046218
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	0.10	8046218
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	1.0	8046218
Dissolved Boron (B)	ug/L	<50	<50	50	8046218
Dissolved Cadmium (Cd)	ug/L	<0.010	<0.010	0.010	8046218
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	1.0	8046218
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	8046218
Dissolved Copper (Cu)	ug/L	0.33	0.35	0.20	8046218
Dissolved Iron (Fe)	ug/L	53.9	51.4	5.0	8046218
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	0.20	8046218
Dissolved Lithium (Li)	ug/L	<5.0	<5.0	5.0	8046218
Dissolved Manganese (Mn)	ug/L	<1.0	<1.0	1.0	8046218
Dissolved Molybdenum (Mo)	ug/L	<1.0	<1.0	1.0	8046218
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	1.0	8046218
Dissolved Selenium (Se)	ug/L	0.18	0.15	0.10	8046218
Dissolved Silicon (Si)	ug/L	5310	5750	100	8046218
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	0.020	8046218
Dissolved Strontium (Sr)	ug/L	21.7	21.7	1.0	8046218
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	8046218
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	5.0	8046218
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	5.0	8046218
Dissolved Uranium (U)	ug/L	<0.10	<0.10	0.10	8046218
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	5.0	8046218
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	5.0	8046218
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	0.50	8046218

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0809	NE0809		
Sampling Date		2015/09/17 17:50	2015/09/17 17:50		
COC Number		476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-07	W-88877-091715-TDF-07 Lab-Dup	RDL	QC Batch
Dissolved Calcium (Ca)	mg/L	12.6	N/A	0.050	8043796
Dissolved Magnesium (Mg)	mg/L	1.74	N/A	0.050	8043796
Dissolved Potassium (K)	mg/L	0.181	N/A	0.050	8043796
Dissolved Sodium (Na)	mg/L	2.85	N/A	0.050	8043796
Dissolved Sulphur (S)	mg/L	<3.0	N/A	3.0	8043796

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0810	NE0810	NE0811		
Sampling Date		2015/09/18 06:50	2015/09/18 06:50	2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091815-TDF-08	W-88877-091815-TDF-08 Lab-Dup	W-88877-091815-TDF-09	RDL	QC Batch
Calculated Parameters						
Total Hardness (CaCO3)	mg/L	24.8	N/A	16.3	0.50	8043691
Elements						
Total Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	0.010	8050474
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	18.8	N/A	15.6	3.0	8045645
Total Antimony (Sb)	ug/L	<0.50	N/A	<0.50	0.50	8045645
Total Arsenic (As)	ug/L	0.12	N/A	0.11	0.10	8045645
Total Barium (Ba)	ug/L	2.9	N/A	2.2	1.0	8045645
Total Beryllium (Be)	ug/L	<0.10	N/A	<0.10	0.10	8045645
Total Bismuth (Bi)	ug/L	<1.0	N/A	<1.0	1.0	8045645
Total Boron (B)	ug/L	<50	N/A	<50	50	8045645
Total Cadmium (Cd)	ug/L	<0.010	N/A	<0.010	0.010	8045645
Total Chromium (Cr)	ug/L	<1.0	N/A	<1.0	1.0	8045645
Total Cobalt (Co)	ug/L	<0.50	N/A	<0.50	0.50	8045645
Total Copper (Cu)	ug/L	0.51	N/A	0.92	0.50	8045645
Total Iron (Fe)	ug/L	20	N/A	86	10	8045645
Total Lead (Pb)	ug/L	<0.20	N/A	<0.20	0.20	8045645
Total Lithium (Li)	ug/L	<5.0	N/A	<5.0	5.0	8045645
Total Manganese (Mn)	ug/L	2.5	N/A	25.1	1.0	8045645
Total Molybdenum (Mo)	ug/L	<1.0	N/A	<1.0	1.0	8045645
Total Nickel (Ni)	ug/L	<1.0	N/A	<1.0	1.0	8045645
Total Selenium (Se)	ug/L	<0.10	N/A	<0.10	0.10	8045645
Total Silicon (Si)	ug/L	1740	N/A	1450	100	8045645
Total Silver (Ag)	ug/L	<0.020	N/A	<0.020	0.020	8045645
Total Strontium (Sr)	ug/L	12.2	N/A	15.4	1.0	8045645
Total Thallium (Tl)	ug/L	<0.050	N/A	<0.050	0.050	8045645
Total Tin (Sn)	ug/L	<5.0	N/A	<5.0	5.0	8045645
Total Titanium (Ti)	ug/L	<5.0	N/A	<5.0	5.0	8045645
Total Uranium (U)	ug/L	<0.10	N/A	<0.10	0.10	8045645
Total Vanadium (V)	ug/L	<5.0	N/A	<5.0	5.0	8045645
Total Zinc (Zn)	ug/L	<5.0	N/A	<5.0	5.0	8045645
Total Zirconium (Zr)	ug/L	<0.50	N/A	<0.50	0.50	8045645

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NE0810	NE0810	NE0811		
Sampling Date		2015/09/18 06:50	2015/09/18 06:50	2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091815-TDF-08	W-88877-091815-TDF-08 Lab-Dup	W-88877-091815-TDF-09	RDL	QC Batch
Total Calcium (Ca)	mg/L	8.49	N/A	4.60	0.050	8043692
Total Magnesium (Mg)	mg/L	0.868	N/A	1.18	0.050	8043692
Total Potassium (K)	mg/L	0.087	N/A	0.198	0.050	8043692
Total Sodium (Na)	mg/L	0.800	N/A	4.51	0.050	8043692
Total Sulphur (S)	mg/L	<3.0	N/A	<3.0	3.0	8043692

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

TOTAL TKN IN WATER (WATER)

Maxxam ID		NE0803	NE0804	NE0805		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/17 15:45		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091715-TDF-03	RDL	QC Batch
Nutrients						
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	<0.10	1.26	0.10	8043883
Total Nitrogen (N)	mg/L	0.928	0.950	1.26	0.020	8048559
RDL = Reportable Detection Limit						

Maxxam ID		NE0806	NE0807	NE0808		
Sampling Date		2015/09/17 16:30	2015/09/17 17:00	2015/09/17 17:10		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-04	W-88877-091715-TDF-05	W-88877-091715-TDF-06	RDL	QC Batch
Nutrients						
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	0.25	0.21	0.10	8043883
Total Nitrogen (N)	mg/L	0.584	0.507	0.446	0.020	8048559
RDL = Reportable Detection Limit						

Maxxam ID		NE0809	NE0810	NE0811		
Sampling Date		2015/09/17 17:50	2015/09/18 06:50	2015/09/18 07:40		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-07	W-88877-091815-TDF-08	W-88877-091815-TDF-09	RDL	QC Batch
Nutrients						
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	0.11	0.16	0.10	8043883
Total Nitrogen (N)	mg/L	0.185	0.107	0.159	0.020	8048559
RDL = Reportable Detection Limit						

Maxxam ID		NE0812		
Sampling Date		2015/09/18 07:40		
COC Number		476602-01-01		
	UNITS	W-88877-091815-TDF-10	RDL	QC Batch
Nutrients				
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.17	0.10	8043883
Total Nitrogen (N)	mg/L	0.175	0.020	8048559
RDL = Reportable Detection Limit				

Maxxam Job #: B582021
Report Date: 2015/09/28

GHD Limited
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Your P.O. #: 73500976
Sampler Initials: DF

CSR VOC + VPH IN WATER (WATER)

Maxxam ID		NE0803	NE0804	NE0810		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/18 06:50		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091815-TDF-08	RDL	QC Batch
Volatiles						
VPH (VHW6 to 10 - BTEX)	ug/L	<300	<300	<300	300	8043541
Chloromethane	ug/L	<1.0	<1.0	<1.0	1.0	8044829
Vinyl chloride	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Chloroethane	ug/L	<1.0	<1.0	<1.0	1.0	8044829
Trichlorofluoromethane	ug/L	<4.0	<4.0	<4.0	4.0	8044829
1,1,2Trichloro-1,2,2Trifluoroethane	ug/L	<2.0	<2.0	<2.0	2.0	8044829
Dichlorodifluoromethane	ug/L	<2.0	<2.0	<2.0	2.0	8044829
1,1-dichloroethene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Dichloromethane	ug/L	<2.0	<2.0	<2.0	2.0	8044829
trans-1,2-dichloroethene	ug/L	<1.0	<1.0	<1.0	1.0	8044829
1,1-dichloroethane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
cis-1,2-dichloroethene	ug/L	<1.0	<1.0	<1.0	1.0	8044829
Chloroform	ug/L	<1.0	<1.0	<1.0	1.0	8044829
1,1,1-trichloroethane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
1,2-dichloroethane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Carbon tetrachloride	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Benzene	ug/L	<0.40	<0.40	<0.40	0.40	8044829
Methyl-tert-butylether (MTBE)	ug/L	<4.0	<4.0	<4.0	4.0	8044829
1,2-dichloropropane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
cis-1,3-dichloropropene	ug/L	<1.0	<1.0	<1.0	1.0	8044829
trans-1,3-dichloropropene	ug/L	<1.0	<1.0	<1.0	1.0	8044829
Bromomethane	ug/L	<1.0	<1.0	<1.0	1.0	8044829
1,1,2-trichloroethane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Trichloroethene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Chlorodibromomethane	ug/L	<1.0	<1.0	<1.0	1.0	8044829
1,2-dibromoethane	ug/L	<0.20	<0.20	<0.20	0.20	8044829
1,3-Butadiene	ug/L	<5.0	<5.0	<5.0	5.0	8044829
Tetrachloroethene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Bromodichloromethane	ug/L	<1.0	<1.0	<1.0	1.0	8044829
Toluene	ug/L	<0.40	<0.40	<0.40	0.40	8044829
Ethylbenzene	ug/L	<0.40	<0.40	<0.40	0.40	8044829
m & p-Xylene	ug/L	<0.40	<0.40	<0.40	0.40	8044829
Bromoform	ug/L	<1.0	<1.0	<1.0	1.0	8044829
Styrene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
RDL = Reportable Detection Limit						

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GHD Limited
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Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

CSR VOC + VPH IN WATER (WATER)

Maxxam ID		NE0803	NE0804	NE0810		
Sampling Date		2015/09/17 14:10	2015/09/17 14:55	2015/09/18 06:50		
COC Number		476602-01-01	476602-01-01	476602-01-01		
	UNITS	W-88877-091715-TDF-01	W-88877-091715-TDF-02	W-88877-091815-TDF-08	RDL	QC Batch
o-Xylene	ug/L	<0.40	<0.40	<0.40	0.40	8044829
Xylenes (Total)	ug/L	<0.40	<0.40	<0.40	0.40	8044829
1,1,1,2-tetrachloroethane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
1,1,2,2-tetrachloroethane	ug/L	<0.50	<0.50	<0.50	0.50	8044829
1,2-dichlorobenzene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
1,3-dichlorobenzene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
1,4-dichlorobenzene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Chlorobenzene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
Dibromomethane	ug/L	<0.90	<0.90	<0.90	0.90	8044829
Bromobenzene	ug/L	<2.0	<2.0	<2.0	2.0	8044829
1,2,3-trichlorobenzene	ug/L	<2.0	<2.0	<2.0	2.0	8044829
1,2,4-trichlorobenzene	ug/L	<2.0	<2.0	<2.0	2.0	8044829
Hexachlorobutadiene	ug/L	<0.50	<0.50	<0.50	0.50	8044829
VH C6-C10	ug/L	<300	<300	<300	300	8044829
Surrogate Recovery (%)						
1,4-Difluorobenzene (sur.)	%	98	99	99	N/A	8044829
4-Bromofluorobenzene (sur.)	%	73	73	73	N/A	8044829
D4-1,2-Dichloroethane (sur.)	%	90	90	89	N/A	8044829

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N/A = Not Applicable

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Maxxam Job #: B582021
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CSR VOC + VPH IN WATER (WATER)

Maxxam ID		NE0811		
Sampling Date		2015/09/18 07:40		
COC Number		476602-01-01		
	UNITS	W-88877-091815-TDF-09	RDL	QC Batch
Volatiles				
VPH (VHW6 to 10 - BTEX)	ug/L	<300	300	8043541
Chloromethane	ug/L	<1.0	1.0	8046486
Vinyl chloride	ug/L	<0.50	0.50	8046486
Chloroethane	ug/L	<1.0	1.0	8046486
Trichlorofluoromethane	ug/L	<4.0	4.0	8046486
1,1,2Trichloro-1,2,2Trifluoroethane	ug/L	<2.0	2.0	8046486
Dichlorodifluoromethane	ug/L	<2.0	2.0	8046486
1,1-dichloroethene	ug/L	<0.50	0.50	8046486
Dichloromethane	ug/L	<2.0	2.0	8046486
trans-1,2-dichloroethene	ug/L	<1.0	1.0	8046486
1,1-dichloroethane	ug/L	<0.50	0.50	8046486
cis-1,2-dichloroethene	ug/L	<1.0	1.0	8046486
Chloroform	ug/L	<1.0	1.0	8046486
1,1,1-trichloroethane	ug/L	<0.50	0.50	8046486
1,2-dichloroethane	ug/L	<0.50	0.50	8046486
Carbon tetrachloride	ug/L	<0.50	0.50	8046486
Benzene	ug/L	<0.40	0.40	8046486
Methyl-tert-butylether (MTBE)	ug/L	<4.0	4.0	8046486
1,2-dichloropropane	ug/L	<0.50	0.50	8046486
cis-1,3-dichloropropene	ug/L	<1.0	1.0	8046486
trans-1,3-dichloropropene	ug/L	<1.0	1.0	8046486
Bromomethane	ug/L	<1.0	1.0	8046486
1,1,2-trichloroethane	ug/L	<0.50	0.50	8046486
Trichloroethene	ug/L	<0.50	0.50	8046486
Chlorodibromomethane	ug/L	<1.0	1.0	8046486
1,2-dibromoethane	ug/L	<0.20	0.20	8046486
1,3-Butadiene	ug/L	<5.0	5.0	8046486
Tetrachloroethene	ug/L	<0.50	0.50	8046486
Bromodichloromethane	ug/L	<1.0	1.0	8046486
Toluene	ug/L	<0.40	0.40	8046486
Ethylbenzene	ug/L	<0.40	0.40	8046486
m & p-Xylene	ug/L	<0.40	0.40	8046486
Bromoform	ug/L	<1.0	1.0	8046486
Styrene	ug/L	<0.50	0.50	8046486
RDL = Reportable Detection Limit				

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CSR VOC + VPH IN WATER (WATER)

Maxxam ID		NE0811		
Sampling Date		2015/09/18 07:40		
COC Number		476602-01-01		
	UNITS	W-88877-091815-TDF-09	RDL	QC Batch
o-Xylene	ug/L	<0.40	0.40	8046486
Xylenes (Total)	ug/L	<0.40	0.40	8046486
1,1,1,2-tetrachloroethane	ug/L	<0.50	0.50	8046486
1,1,2,2-tetrachloroethane	ug/L	<0.50	0.50	8046486
1,2-dichlorobenzene	ug/L	<0.50	0.50	8046486
1,3-dichlorobenzene	ug/L	<0.50	0.50	8046486
1,4-dichlorobenzene	ug/L	<0.50	0.50	8046486
Chlorobenzene	ug/L	<0.50	0.50	8046486
Dibromomethane	ug/L	<0.90	0.90	8046486
Bromobenzene	ug/L	<2.0	2.0	8046486
1,2,3-trichlorobenzene	ug/L	<2.0	2.0	8046486
1,2,4-trichlorobenzene	ug/L	<2.0	2.0	8046486
Hexachlorobutadiene	ug/L	<0.50	0.50	8046486
VH C6-C10	ug/L	<300	300	8046486
Surrogate Recovery (%)				
1,4-Difluorobenzene (sur.)	%	101	N/A	8046486
4-Bromofluorobenzene (sur.)	%	86	N/A	8046486
D4-1,2-Dichloroethane (sur.)	%	93	N/A	8046486

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GENERAL COMMENTS

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8044829	1,4-Difluorobenzene (sur.)	2015/09/22	98	70 - 130	101	70 - 130	100	%		
8044829	4-Bromofluorobenzene (sur.)	2015/09/22	85	70 - 130	98	70 - 130	78	%		
8044829	D4-1,2-Dichloroethane (sur.)	2015/09/22	92	70 - 130	112	70 - 130	87	%		
8046486	1,4-Difluorobenzene (sur.)	2015/09/23	100	70 - 130	100	70 - 130	101	%		
8046486	4-Bromofluorobenzene (sur.)	2015/09/23	99	70 - 130	100	70 - 130	88	%		
8046486	D4-1,2-Dichloroethane (sur.)	2015/09/23	94	70 - 130	94	70 - 130	91	%		
8047638	D10-ANTHRACENE (sur.)	2015/09/23	105	60 - 130	109	60 - 130	106	%		
8047638	D8-ACENAPHTHYLENE (sur.)	2015/09/23	103	50 - 130	104	50 - 130	104	%		
8047638	D8-NAPHTHALENE (sur.)	2015/09/23	102	50 - 130	101	50 - 130	106	%		
8047638	D9-Acridine	2015/09/23	101	50 - 130	104	50 - 130	100	%		
8047638	TERPHENYL-D14 (sur.)	2015/09/23	104	60 - 130	99	60 - 130	107	%		
8047645	O-TERPHENYL (sur.)	2015/09/23	108	50 - 130	107	50 - 130	99	%		
8049027	D10-ANTHRACENE (sur.)	2015/09/24	78	60 - 130	82	60 - 130	86	%		
8049027	D8-ACENAPHTHYLENE (sur.)	2015/09/24	79	50 - 130	80	50 - 130	80	%		
8049027	D8-NAPHTHALENE (sur.)	2015/09/24	78	50 - 130	79	50 - 130	82	%		
8049027	D9-Acridine	2015/09/24	83	50 - 130	83	50 - 130	80	%		
8049027	TERPHENYL-D14 (sur.)	2015/09/24	62	60 - 130	84	60 - 130	86	%		
8049033	O-TERPHENYL (sur.)	2015/09/24	102	50 - 130	101	50 - 130	102	%		
8043714	Biochemical Oxygen Demand	2015/09/19			97	85 - 115	<6.0	mg/L	13 (1)	20
8044829	1,1,1,2-tetrachloroethane	2015/09/22	79	70 - 130	84	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,1,1-trichloroethane	2015/09/22	81	70 - 130	89	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,1,2,2-tetrachloroethane	2015/09/22	89	70 - 130	91	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,1,2Trichloro-1,2,2Trifluoroethane	2015/09/22					<2.0	ug/L	NC (1)	30
8044829	1,1,2-trichloroethane	2015/09/22	79	70 - 130	84	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,1-dichloroethane	2015/09/22	82	70 - 130	89	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,1-dichloroethene	2015/09/22	83	70 - 130	89	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,2,3-trichlorobenzene	2015/09/22	75	70 - 130	78	70 - 130	<2.0	ug/L	NC (1)	30
8044829	1,2,4-trichlorobenzene	2015/09/22	76	70 - 130	79	70 - 130	<2.0	ug/L	NC (1)	30
8044829	1,2-dibromoethane	2015/09/22	75	70 - 130	79	70 - 130	<0.20	ug/L	NC (1)	30
8044829	1,2-dichlorobenzene	2015/09/22	85	70 - 130	89	70 - 130	<0.50	ug/L	NC (1)	30

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8044829	1,2-dichloroethane	2015/09/22	78	70 - 130	82	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,2-dichloropropane	2015/09/22	84	70 - 130	90	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,3-Butadiene	2015/09/22					<5.0	ug/L		
8044829	1,3-dichlorobenzene	2015/09/22	87	70 - 130	92	70 - 130	<0.50	ug/L	NC (1)	30
8044829	1,4-dichlorobenzene	2015/09/22	85	70 - 130	89	70 - 130	<0.50	ug/L	NC (1)	30
8044829	Benzene	2015/09/22	82	70 - 130	88	70 - 130	<0.40	ug/L	NC (1)	30
8044829	Bromobenzene	2015/09/22	81	70 - 130	84	70 - 130	<2.0	ug/L		
8044829	Bromodichloromethane	2015/09/22	79	70 - 130	85	70 - 130	<1.0	ug/L	NC (1)	30
8044829	Bromoform	2015/09/22	82	70 - 130	84	70 - 130	<1.0	ug/L	NC (1)	30
8044829	Bromomethane	2015/09/22	70	60 - 140	85	60 - 140	<1.0	ug/L	NC (1)	30
8044829	Carbon tetrachloride	2015/09/22	81	70 - 130	88	70 - 130	<0.50	ug/L	NC (1)	30
8044829	Chlorobenzene	2015/09/22	79	70 - 130	83	70 - 130	<0.50	ug/L	NC (1)	30
8044829	Chlorodibromomethane	2015/09/22	78	70 - 130	82	70 - 130	<1.0	ug/L	NC (1)	30
8044829	Chloroethane	2015/09/22	84	60 - 140	91	60 - 140	<1.0	ug/L	NC (1)	30
8044829	Chloroform	2015/09/22	82	70 - 130	89	70 - 130	<1.0	ug/L	NC (1)	30
8044829	Chloromethane	2015/09/22	109	60 - 140	116	60 - 140	<1.0	ug/L	NC (1)	30
8044829	cis-1,2-dichloroethene	2015/09/22	84	70 - 130	91	70 - 130	<1.0	ug/L	NC (1)	30
8044829	cis-1,3-dichloropropene	2015/09/22	75	70 - 130	82	70 - 130	<1.0	ug/L	NC (1)	30
8044829	Dibromomethane	2015/09/22	77	70 - 130	81	70 - 130	<0.90	ug/L		
8044829	Dichlorodifluoromethane	2015/09/22	129	60 - 140	134	60 - 140	<2.0	ug/L	NC (1)	30
8044829	Dichloromethane	2015/09/22	84	70 - 130	91	70 - 130	<2.0	ug/L	NC (1)	30
8044829	Ethylbenzene	2015/09/22	70	70 - 130	76	70 - 130	<0.40	ug/L	NC (1)	30
8044829	Hexachlorobutadiene	2015/09/22	86	70 - 130	91	70 - 130	<0.50	ug/L	NC (1)	30
8044829	m & p-Xylene	2015/09/22	72	70 - 130	79	70 - 130	<0.40	ug/L	NC (1)	30
8044829	Methyl-tert-butylether (MTBE)	2015/09/22	76	70 - 130	82	70 - 130	<4.0	ug/L	NC (1)	30
8044829	o-Xylene	2015/09/22	71	70 - 130	76	70 - 130	<0.40	ug/L	NC (1)	30
8044829	Styrene	2015/09/22	65 (2)	70 - 130	70	70 - 130	<0.50	ug/L		
8044829	Tetrachloroethene	2015/09/22	78	70 - 130	84	70 - 130	<0.50	ug/L	NC (1)	30
8044829	Toluene	2015/09/22	71	70 - 130	77	70 - 130	<0.40	ug/L	NC (1)	30
8044829	trans-1,2-dichloroethene	2015/09/22	77	70 - 130	83	70 - 130	<1.0	ug/L	NC (1)	30

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8044829	trans-1,3-dichloropropene	2015/09/22	69 (2)	70 - 130	75	70 - 130	<1.0	ug/L	NC (1)	30
8044829	Trichloroethene	2015/09/22	78	70 - 130	85	70 - 130	<0.50	ug/L	NC (1)	30
8044829	Trichlorofluoromethane	2015/09/22	101	60 - 140	109	60 - 140	<4.0	ug/L	NC (1)	30
8044829	VH C6-C10	2015/09/22			93	70 - 130	<300	ug/L		
8044829	Vinyl chloride	2015/09/22	109	60 - 140	119	60 - 140	<0.50	ug/L	NC (1)	30
8044829	Xylenes (Total)	2015/09/22					<0.40	ug/L	NC (1)	30
8045121	Strong Acid Dissoc. Cyanide (CN)	2015/09/21	94	80 - 120	102	80 - 120	<0.00050	mg/L	NC (1)	20
8045491	Orthophosphate (P)	2015/09/21	97 (3)	80 - 120	91	80 - 120	<0.10	mg/L	NC (4)	20
8045579	Total Phosphorus (P)	2015/09/21	NC (5)	80 - 120	99	80 - 120	<0.0050	mg/L	2.7 (6)	20
8045645	Total Aluminum (Al)	2015/09/23	104	80 - 120	109	80 - 120	<3.0	ug/L		
8045645	Total Antimony (Sb)	2015/09/23	107	80 - 120	107	80 - 120	<0.50	ug/L		
8045645	Total Arsenic (As)	2015/09/23	105	80 - 120	105	80 - 120	<0.10	ug/L		
8045645	Total Barium (Ba)	2015/09/23	NC	80 - 120	104	80 - 120	<1.0	ug/L		
8045645	Total Beryllium (Be)	2015/09/23	108	80 - 120	105	80 - 120	<0.10	ug/L		
8045645	Total Bismuth (Bi)	2015/09/23	100	80 - 120	103	80 - 120	<1.0	ug/L		
8045645	Total Boron (B)	2015/09/23					<50	ug/L		
8045645	Total Cadmium (Cd)	2015/09/23	102	80 - 120	100	80 - 120	<0.010	ug/L		
8045645	Total Chromium (Cr)	2015/09/23	100	80 - 120	99	80 - 120	<1.0	ug/L		
8045645	Total Cobalt (Co)	2015/09/23	99	80 - 120	99	80 - 120	<0.50	ug/L		
8045645	Total Copper (Cu)	2015/09/23	97	80 - 120	100	80 - 120	<0.50	ug/L		
8045645	Total Iron (Fe)	2015/09/23	113	80 - 120	114	80 - 120	<10	ug/L		
8045645	Total Lead (Pb)	2015/09/23	100	80 - 120	102	80 - 120	<0.20	ug/L		
8045645	Total Lithium (Li)	2015/09/23	103	80 - 120	104	80 - 120	<5.0	ug/L		
8045645	Total Manganese (Mn)	2015/09/23	101	80 - 120	101	80 - 120	<1.0	ug/L		
8045645	Total Molybdenum (Mo)	2015/09/23	108	80 - 120	99	80 - 120	<1.0	ug/L		
8045645	Total Nickel (Ni)	2015/09/23	98	80 - 120	98	80 - 120	<1.0	ug/L		
8045645	Total Selenium (Se)	2015/09/23	99	80 - 120	96	80 - 120	<0.10	ug/L		
8045645	Total Silicon (Si)	2015/09/23					<100	ug/L		
8045645	Total Silver (Ag)	2015/09/23	102	80 - 120	100	80 - 120	<0.020	ug/L		
8045645	Total Strontium (Sr)	2015/09/23	NC	80 - 120	103	80 - 120	<1.0	ug/L		

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8045645	Total Thallium (Tl)	2015/09/23	106	80 - 120	92	80 - 120	<0.050	ug/L		
8045645	Total Tin (Sn)	2015/09/23	103	80 - 120	105	80 - 120	<5.0	ug/L		
8045645	Total Titanium (Ti)	2015/09/23	112	80 - 120	96	80 - 120	<5.0	ug/L		
8045645	Total Uranium (U)	2015/09/23	101	80 - 120	99	80 - 120	<0.10	ug/L		
8045645	Total Vanadium (V)	2015/09/23	101	80 - 120	100	80 - 120	<5.0	ug/L		
8045645	Total Zinc (Zn)	2015/09/23	103	80 - 120	102	80 - 120	<5.0	ug/L		
8045645	Total Zirconium (Zr)	2015/09/23					<0.50	ug/L		
8046006	Dissolved Chloride (Cl)	2015/09/21	NC	80 - 120	105	80 - 120	<0.50	mg/L	1.4 (1)	20
8046014	Dissolved Sulphate (SO4)	2015/09/21			97	80 - 120	<0.50	mg/L		
8046016	Dissolved Chloride (Cl)	2015/09/21			96	80 - 120	<0.50	mg/L	NC (1)	20
8046021	Dissolved Sulphate (SO4)	2015/09/21			95	80 - 120	<0.50	mg/L	0.099 (1)	20
8046135	Chemical Oxygen Demand	2015/09/23	95	80 - 120	98	80 - 120	<10	mg/L	NC (1)	20
8046138	Chemical Oxygen Demand	2015/09/23	99 (7)	80 - 120	101	80 - 120	<10	mg/L	NC (8)	20
8046218	Dissolved Aluminum (Al)	2015/09/25	106 (9)	80 - 120	111	80 - 120	<3.0	ug/L	NC (10)	20
8046218	Dissolved Antimony (Sb)	2015/09/25	105 (9)	80 - 120	102	80 - 120	<0.50	ug/L	NC (10)	20
8046218	Dissolved Arsenic (As)	2015/09/25	96 (9)	80 - 120	101	80 - 120	<0.10	ug/L	NC (10)	20
8046218	Dissolved Barium (Ba)	2015/09/25	96 (9)	80 - 120	101	80 - 120	<1.0	ug/L	NC (10)	20
8046218	Dissolved Beryllium (Be)	2015/09/25	102 (9)	80 - 120	103	80 - 120	<0.10	ug/L	NC (10)	20
8046218	Dissolved Bismuth (Bi)	2015/09/25	97 (9)	80 - 120	101	80 - 120	<1.0	ug/L	NC (10)	20
8046218	Dissolved Boron (B)	2015/09/25					<50	ug/L	NC (10)	20
8046218	Dissolved Cadmium (Cd)	2015/09/25	97 (9)	80 - 120	99	80 - 120	<0.010	ug/L	NC (10)	20
8046218	Dissolved Chromium (Cr)	2015/09/25	98 (9)	80 - 120	102	80 - 120	<1.0	ug/L	NC (10)	20
8046218	Dissolved Cobalt (Co)	2015/09/25	102 (9)	80 - 120	104	80 - 120	<0.50	ug/L	NC (10)	20
8046218	Dissolved Copper (Cu)	2015/09/25	102 (9)	80 - 120	104	80 - 120	<0.20	ug/L	NC (10)	20
8046218	Dissolved Iron (Fe)	2015/09/25	NC (9)	80 - 120	107	80 - 120	<5.0	ug/L	4.7 (10)	20
8046218	Dissolved Lead (Pb)	2015/09/25	96 (9)	80 - 120	99	80 - 120	<0.20	ug/L	NC (10)	20
8046218	Dissolved Lithium (Li)	2015/09/25	102 (9)	80 - 120	100	80 - 120	<5.0	ug/L	NC (10)	20
8046218	Dissolved Manganese (Mn)	2015/09/25	96 (9)	80 - 120	100	80 - 120	<1.0	ug/L	NC (10)	20
8046218	Dissolved Molybdenum (Mo)	2015/09/25	102 (9)	80 - 120	100	80 - 120	<1.0	ug/L	NC (10)	20
8046218	Dissolved Nickel (Ni)	2015/09/25	102 (9)	80 - 120	106	80 - 120	<1.0	ug/L	NC (10)	20

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8046218	Dissolved Selenium (Se)	2015/09/25	102 (9)	80 - 120	99	80 - 120	<0.10	ug/L	NC (10)	20
8046218	Dissolved Silicon (Si)	2015/09/25					<100	ug/L	7.8 (10)	20
8046218	Dissolved Silver (Ag)	2015/09/25	102 (9)	80 - 120	99	80 - 120	<0.020	ug/L	NC (10)	20
8046218	Dissolved Strontium (Sr)	2015/09/25	NC (9)	80 - 120	96	80 - 120	<1.0	ug/L	0.11 (10)	20
8046218	Dissolved Thallium (Tl)	2015/09/25	92 (9)	80 - 120	98	80 - 120	<0.050	ug/L	NC (10)	20
8046218	Dissolved Tin (Sn)	2015/09/25	90 (9)	80 - 120	99	80 - 120	<5.0	ug/L	NC (10)	20
8046218	Dissolved Titanium (Ti)	2015/09/25	86 (9)	80 - 120	95	80 - 120	<5.0	ug/L	NC (10)	20
8046218	Dissolved Uranium (U)	2015/09/25	94 (9)	80 - 120	98	80 - 120	<0.10	ug/L	NC (10)	20
8046218	Dissolved Vanadium (V)	2015/09/25	95 (9)	80 - 120	101	80 - 120	<5.0	ug/L	NC (10)	20
8046218	Dissolved Zinc (Zn)	2015/09/25	101 (9)	80 - 120	108	80 - 120	<5.0	ug/L	NC (10)	20
8046218	Dissolved Zirconium (Zr)	2015/09/25					<0.50	ug/L	NC (10)	20
8046486	1,1,1,2-tetrachloroethane	2015/09/23	93	70 - 130	88	70 - 130	<0.50	ug/L		
8046486	1,1,1-trichloroethane	2015/09/24	94	70 - 130	90	70 - 130	<0.50	ug/L	NC (1)	30
8046486	1,1,2,2-tetrachloroethane	2015/09/23	97	70 - 130	92	70 - 130	<0.50	ug/L		
8046486	1,1,2Trichloro-1,2,2Trifluoroethane	2015/09/23					<2.0	ug/L		
8046486	1,1,2-trichloroethane	2015/09/23	92	70 - 130	88	70 - 130	<0.50	ug/L		
8046486	1,1-dichloroethane	2015/09/24	92	70 - 130	89	70 - 130	<0.50	ug/L	NC (1)	30
8046486	1,1-dichloroethene	2015/09/24	98	70 - 130	93	70 - 130	<0.50	ug/L	NC (1)	30
8046486	1,2,3-trichlorobenzene	2015/09/23	106	70 - 130	97	70 - 130	<2.0	ug/L		
8046486	1,2,4-trichlorobenzene	2015/09/23	106	70 - 130	99	70 - 130	<2.0	ug/L		
8046486	1,2-dibromoethane	2015/09/23	89	70 - 130	86	70 - 130	<0.20	ug/L		
8046486	1,2-dichlorobenzene	2015/09/23	105	70 - 130	100	70 - 130	<0.50	ug/L		
8046486	1,2-dichloroethane	2015/09/23	88	70 - 130	88	70 - 130	<0.50	ug/L		
8046486	1,2-dichloropropane	2015/09/23	95	70 - 130	92	70 - 130	<0.50	ug/L		
8046486	1,3-Butadiene	2015/09/23					<5.0	ug/L		
8046486	1,3-dichlorobenzene	2015/09/23	107	70 - 130	100	70 - 130	<0.50	ug/L		
8046486	1,4-dichlorobenzene	2015/09/23	104	70 - 130	98	70 - 130	<0.50	ug/L		
8046486	Benzene	2015/09/23	95	70 - 130	91	70 - 130	<0.40	ug/L		
8046486	Bromobenzene	2015/09/23	98	70 - 130	94	70 - 130	<2.0	ug/L		
8046486	Bromodichloromethane	2015/09/23	92	70 - 130	89	70 - 130	<1.0	ug/L		

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8046486	Bromoform	2015/09/23	91	70 - 130	88	70 - 130	<1.0	ug/L		
8046486	Bromomethane	2015/09/23	90	60 - 140	83	60 - 140	<1.0	ug/L		
8046486	Carbon tetrachloride	2015/09/23	95	70 - 130	90	70 - 130	<0.50	ug/L		
8046486	Chlorobenzene	2015/09/23	95	70 - 130	92	70 - 130	<0.50	ug/L		
8046486	Chlorodibromomethane	2015/09/23	90	70 - 130	87	70 - 130	<1.0	ug/L		
8046486	Chloroethane	2015/09/24	91	60 - 140	89	60 - 140	<1.0	ug/L	NC (1)	30
8046486	Chloroform	2015/09/23	93	70 - 130	89	70 - 130	<1.0	ug/L		
8046486	Chloromethane	2015/09/24	105	60 - 140	98	60 - 140	<1.0	ug/L	NC (1)	30
8046486	cis-1,2-dichloroethene	2015/09/24	98	70 - 130	93	70 - 130	<1.0	ug/L	NC (1)	30
8046486	cis-1,3-dichloropropene	2015/09/23	78	70 - 130	74	70 - 130	<1.0	ug/L		
8046486	Dibromomethane	2015/09/23	89	70 - 130	86	70 - 130	<0.90	ug/L		
8046486	Dichlorodifluoromethane	2015/09/23	138	60 - 140	134	60 - 140	<2.0	ug/L		
8046486	Dichloromethane	2015/09/24	102	70 - 130	96	70 - 130	<2.0	ug/L	NC (1)	30
8046486	Ethylbenzene	2015/09/23	92	70 - 130	91	70 - 130	<0.40	ug/L		
8046486	Hexachlorobutadiene	2015/09/23	106	70 - 130	99	70 - 130	<0.50	ug/L		
8046486	m & p-Xylene	2015/09/23	98	70 - 130	95	70 - 130	<0.40	ug/L		
8046486	Methyl-tert-butylether (MTBE)	2015/09/23	93	70 - 130	91	70 - 130	<4.0	ug/L		
8046486	o-Xylene	2015/09/23	97	70 - 130	94	70 - 130	<0.40	ug/L		
8046486	Styrene	2015/09/23	85	70 - 130	84	70 - 130	<0.50	ug/L		
8046486	Tetrachloroethene	2015/09/24	95	70 - 130	90	70 - 130	<0.50	ug/L	NC (1)	30
8046486	Toluene	2015/09/23	91	70 - 130	89	70 - 130	<0.40	ug/L		
8046486	trans-1,2-dichloroethene	2015/09/24	87	70 - 130	82	70 - 130	<1.0	ug/L	NC (1)	30
8046486	trans-1,3-dichloropropene	2015/09/23	69 (2)	70 - 130	66 (2)	70 - 130	<1.0	ug/L		
8046486	Trichloroethene	2015/09/24	94	70 - 130	90	70 - 130	<0.50	ug/L	NC (1)	30
8046486	Trichlorofluoromethane	2015/09/23	124	60 - 140	116	60 - 140	<4.0	ug/L		
8046486	VH C6-C10	2015/09/23			97	70 - 130	<300	ug/L		
8046486	Vinyl chloride	2015/09/24	112	60 - 140	105	60 - 140	<0.50	ug/L	NC (1)	30
8046486	Xylenes (Total)	2015/09/23					<0.40	ug/L		
8046946	Total Dissolved Solids	2015/09/24	97 (11)	80 - 120	106	80 - 120	<10	mg/L	3.5 (1)	20
8046981	Nitrate plus Nitrite (N)	2015/09/19	107 (3)	80 - 120	105	80 - 120	<0.10	mg/L	NC (4)	25

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8046982	Nitrite (N)	2015/09/19	103 (3)	80 - 120	103	80 - 120	<0.10	mg/L	NC (4)	20
8047224	Total Oil and grease	2015/09/23			93	70 - 130	<1.0	mg/L		
8047341	Dissolved Chloride (Cl)	2015/09/22	118	80 - 120	102	80 - 120	<0.50	mg/L	NC (1)	20
8047350	Dissolved Sulphate (SO4)	2015/09/22	NC	80 - 120	97	80 - 120	<0.50	mg/L	0.81 (1)	20
8047638	2-Methylnaphthalene	2015/09/23	100	50 - 130	99	50 - 130	<0.10	ug/L	6.9 (1)	40
8047638	Acenaphthene	2015/09/23	101	50 - 130	101	50 - 130	<0.050	ug/L	NC (13,1)	40
8047638	Acenaphthylene	2015/09/23	98	50 - 130	98	50 - 130	<0.050	ug/L	NC (13,1)	40
8047638	Acridine	2015/09/23	107	50 - 130	108	50 - 130	<0.050	ug/L	NC (1)	40
8047638	Anthracene	2015/09/23	102	60 - 130	104	60 - 130	<0.010	ug/L	NC (13,1)	40
8047638	Benzo(a)anthracene	2015/09/23	96	60 - 130	90	60 - 130	<0.010	ug/L	NC (1)	40
8047638	Benzo(a)pyrene	2015/09/23	103	60 - 130	96	60 - 130	<0.0090	ug/L	NC (1)	40
8047638	Benzo(b&j)fluoranthene	2015/09/23	105	60 - 130	93	60 - 130	<0.050	ug/L	NC (1)	40
8047638	Benzo(g,h,i)perylene	2015/09/23	98	60 - 130	90	60 - 130	<0.050	ug/L	NC (1)	40
8047638	Benzo(k)fluoranthene	2015/09/23	93	60 - 130	92	60 - 130	<0.050	ug/L	NC (1)	40
8047638	Chrysene	2015/09/23	93	60 - 130	86	60 - 130	<0.050	ug/L	NC (1)	40
8047638	Dibenz(a,h)anthracene	2015/09/23	95	60 - 130	92	60 - 130	<0.050	ug/L	NC (1)	40
8047638	Fluoranthene	2015/09/23	91	60 - 130	92	60 - 130	<0.020	ug/L	NC (1)	40
8047638	Fluorene	2015/09/23	88	50 - 130	88	50 - 130	<0.050	ug/L	5.8 (1)	40
8047638	Indeno(1,2,3-cd)pyrene	2015/09/23	103	60 - 130	94	60 - 130	<0.050	ug/L	NC (1)	40
8047638	Naphthalene	2015/09/23	99	50 - 130	99	50 - 130	<0.10	ug/L	NC (13,1)	40
8047638	Phenanthrene	2015/09/23	95	60 - 130	95	60 - 130	<0.050	ug/L	12 (1)	40
8047638	Pyrene	2015/09/23	95	60 - 130	96	60 - 130	<0.020	ug/L	NC (1)	40
8047638	Quinoline	2015/09/23	104	50 - 130	103	50 - 130	<0.24	ug/L	NC (13,1)	40
8047645	EPH (C10-C19)	2015/09/23	NC	50 - 130	82	50 - 130	<0.20	mg/L	13 (1)	30
8047645	EPH (C19-C32)	2015/09/23	100	50 - 130	104	50 - 130	<0.20	mg/L	NC (1)	30
8047646	Total Suspended Solids	2015/09/24	110	80 - 120	102	80 - 120	<4.0	mg/L	0 (1)	20
8047717	pH	2015/09/22			102	97 - 103			0.88 (14)	N/A
8047724	Conductivity	2015/09/22			98	80 - 120	1.0, RDL=1.0	uS/cm	0.17 (14)	20
8047725	Alkalinity (PP as CaCO3)	2015/09/22					<0.50	mg/L	NC (14)	20
8047725	Alkalinity (Total as CaCO3)	2015/09/22	NC (15)	80 - 120	95	80 - 120	0.61, RDL=0.50	mg/L	0.37 (14)	20

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Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8047725	Bicarbonate (HCO3)	2015/09/22					0.74, RDL=0.50	mg/L	0.37 (14)	20
8047725	Carbonate (CO3)	2015/09/22					<0.50	mg/L	NC (14)	20
8047725	Hydroxide (OH)	2015/09/22					<0.50	mg/L	NC (14)	20
8047763	Alkalinity (PP as CaCO3)	2015/09/22					<0.50	mg/L	NC (1)	20
8047763	Alkalinity (Total as CaCO3)	2015/09/22	95	80 - 120	90	80 - 120	0.93, RDL=0.50	mg/L	0.35 (1)	20
8047763	Bicarbonate (HCO3)	2015/09/22					1.13, RDL=0.50	mg/L	0.35 (1)	20
8047763	Carbonate (CO3)	2015/09/22					<0.50	mg/L	NC (1)	20
8047763	Hydroxide (OH)	2015/09/22					<0.50	mg/L	NC (1)	20
8047768	Conductivity	2015/09/22			99	80 - 120	1.0, RDL=1.0	uS/cm	0.36 (1)	20
8047769	pH	2015/09/22			102	97 - 103				
8047784	Sulphide	2015/09/23	NC	80 - 120	99	80 - 120	0.0054, RDL=0.0050	mg/L	5.6 (1)	20
8047923	Strong Acid Dissoc. Cyanide (CN)	2015/09/23	103 (16)	80 - 120	103	80 - 120	0.00052, RDL=0.00050	mg/L	NC (17)	20
8048220	Total Ammonia (N)	2015/09/23	101	80 - 120	97	80 - 120	<0.0050	mg/L	NC (1)	20
8048221	Total Ammonia (N)	2015/09/23	104 (18)	80 - 120	100	80 - 120	<0.0050	mg/L	NC (19)	20
8048559	Total Nitrogen (N)	2015/09/24	NC	80 - 120	94	80 - 120	<0.020	mg/L	3.9 (1)	20
8049027	2-Methylnaphthalene	2015/09/24	82	50 - 130	97	50 - 130	<0.10	ug/L	NC (1)	40
8049027	Acenaphthene	2015/09/24	83	50 - 130	96	50 - 130	<0.050	ug/L	NC (1)	40
8049027	Acenaphthylene	2015/09/24	82	50 - 130	96	50 - 130	<0.050	ug/L	NC (1)	40
8049027	Acridine	2015/09/24	87	50 - 130	78	50 - 130	<0.050	ug/L	NC (1)	40
8049027	Anthracene	2015/09/24	83	60 - 130	84	60 - 130	<0.010	ug/L	NC (1)	40
8049027	Benzo(a)anthracene	2015/09/24	77	60 - 130	93	60 - 130	<0.010	ug/L	NC (1)	40
8049027	Benzo(a)pyrene	2015/09/24	80	60 - 130	96	60 - 130	<0.0090	ug/L	NC (1)	40
8049027	Benzo(b&j)fluoranthene	2015/09/24	80	60 - 130	85	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Benzo(g,h,i)perylene	2015/09/24	72	60 - 130	100	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Benzo(k)fluoranthene	2015/09/24	79	60 - 130	101	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Chrysene	2015/09/24	67	60 - 130	102	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Dibenz(a,h)anthracene	2015/09/24	82	60 - 130	90	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Fluoranthene	2015/09/24	74	60 - 130	84	60 - 130	<0.020	ug/L	NC (1)	40

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Maxxam Job #: B582021
Report Date: 2015/09/28

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8049027	Fluorene	2015/09/24	71	50 - 130	94	50 - 130	<0.050	ug/L	NC (1)	40
8049027	Indeno(1,2,3-cd)pyrene	2015/09/24	82	60 - 130	91	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Naphthalene	2015/09/24	NC	50 - 130	95	50 - 130	<0.10	ug/L	NC (1)	40
8049027	Phenanthrene	2015/09/24	77	60 - 130	85	60 - 130	<0.050	ug/L	NC (1)	40
8049027	Pyrene	2015/09/24	77	60 - 130	85	60 - 130	<0.020	ug/L	NC (1)	40
8049027	Quinoline	2015/09/24	112	50 - 130	98	50 - 130	<0.24	ug/L	NC (1)	40
8049033	EPH (C10-C19)	2015/09/24	82	50 - 130	87	50 - 130	<0.20	mg/L	NC (1)	30
8049033	EPH (C19-C32)	2015/09/24	103	50 - 130	112	50 - 130	<0.20	mg/L	NC (1)	30
8049095	Total Dissolved Solids	2015/09/25	103	80 - 120	102	80 - 120	<10	mg/L	11 (1)	20
8049124	Total Dissolved Solids	2015/09/26	101	80 - 120	98	80 - 120	<10	mg/L	1.3 (1)	20
8049283	Phenols	2015/09/24	100	80 - 120	95	80 - 120	<0.0010	mg/L	NC (1)	20
8050357	Sulphide	2015/09/25	83 (20)	80 - 120	95	80 - 120	0.0070, RDL=0.0050	mg/L	NC (21)	20
8050464	Dissolved Mercury (Hg)	2015/09/25	86	80 - 120	94	80 - 120	<0.010	ug/L	NC (1)	20
8050474	Total Mercury (Hg)	2015/09/25	85 (22)	80 - 120	96	80 - 120	<0.010	ug/L	NC (23)	20

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Duplicate Parent ID

(2) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(3) Matrix Spike Parent ID [NE0812-02]

(4) Duplicate Parent ID [NE0812-02]

(5) Matrix Spike Parent ID [NE0807-06]

(6) Duplicate Parent ID [NE0807-06]

(7) Matrix Spike Parent ID [NE0812-05]

(8) Duplicate Parent ID [NE0812-05]

(9) Matrix Spike Parent ID [NE0809-04]

(10) Duplicate Parent ID [NE0809-04]

(11) Matrix Spike Parent ID [NE0804-04]

(12) Duplicate Parent ID [NE0810-04]

(13) Detection limits raised due to matrix interference.

(14) Duplicate Parent ID [NE0808-02]

(15) Matrix Spike Parent ID [NE0808-02]

(16) Matrix Spike Parent ID [NE0804-10]

(17) Duplicate Parent ID [NE0804-10]

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
(18) Matrix Spike Parent ID [NE0804-08]										
(19) Duplicate Parent ID [NE0804-08]										
(20) Matrix Spike Parent ID [NE0811-11]										
(21) Duplicate Parent ID [NE0810-11]										
(22) Matrix Spike Parent ID [NE0810-07]										
(23) Duplicate Parent ID [NE0810-07]										

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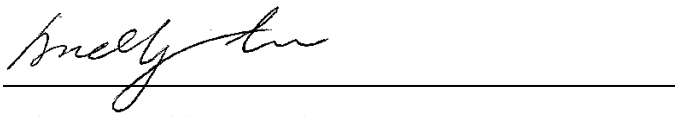
GHD Limited
Client Project #: 088877-02-01
Site Location: UPLANDS
Your P.O. #: 73500976
Sampler Initials: DF

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Andy Lu, Data Validation Coordinator

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Maxxam Analytics International Corporation o/a Maxxam Analytics
4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-Free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#163 GHD Limited	Company Name	#27087 GHD Limited	Quotation #	B31426	Maxxam Job #	Bottle Order #:
Contact Name	Airesse MacPhee	Contact Name	Airesse MacPhee	P.O. #			476602
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address	179 Colonnade Road, Suite 400 Ottawa ON K2E 7J4	Project #	088877-02-01	Chain Of Custody Record	Project Manager
Phone	(519) 884-0510 Fax (519) 725-1394	Phone	(613) 727-0510 Fax	Project Name	Upkeeb	C#476602-01-01	Tabitha Rudkin
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email	amacphee@CRAworld.com	Site #			
				Sampled By	Danny Fitzgerald		

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other

Special Instructions

B582021

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: (will be applied if Rush TAT is not specified) — X

Standard TAT = 5-7 Working days for most tests.

Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)

1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: ☐

Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, Ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	Cyanide SAD, Sulphide	CSR Dissolved Metals in Water with CV Hg	CSR Total Metals in Water with CV Hg	VOC/VPH, LEPH/HEPH/PAH, TOG	Phenols (4-AAP)	LAB I.D.	# of Bottles	Comments
1	SID#135075	W-88877-091715-TDF-01	9/17/15	1410	GW	Y	X	X	X	X	X	X	X	X	NE0803	14	dissolved metals only
2	SID#135076	W-88877-091715-TDF-02	9/17/15	1455	GW	Y	X	X	X	X	X	X	X	X	NE0804	14	
3	SID#135077	W-88877-091715-TDF-03	9/17/15	1545	GW	Y	X	X	X	X	X	X		X	NE0805	9	
4	SID#135078	W-88877-091715-TDF-04	9/17/15	1630	GW	Y	X	X	X	X	X	X		X	NE0806	9	
5	SID#135079	W-88877-091715-TDF-05	9/17/15	1700	GW	Y	X	X	X	X	X	X		X	NE0807	9	
6	SID#135080	W-88877-091715-TDF-06	9/17/15	1710	GW	Y	X	X	X	X	X	X		X	NE0808	9	
7	SID#135081	W-88877-091715-TDF-07	9/17/15	1750	GW	Y	X	X	X	X	X	X		X	NE0809	9	
8	SID#135082	W-88877-091815-TDF-08	09/18/15	0650	SW	Y	X	X	X	X	X	X	X	X	NE0810		Total metals only
9	SID#135083	W-88877-091815-TDF-09	9/18/15	0740	SW	Y	X	X	X	X	X	X	X	X	NE0811		
10	SID#135084	W-88877-091815-TDF-10	9/18/15	0740	SW	Y	X	X	X						NE0812		

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
	15/09/19	1015	SAMANTHA TAKHAR	2015/09/19	10:15		☐	2.2-1/1.1-2 3.4-3	N/A ☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

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4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-Free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

Chain Of Custody Record

INVOICE TO:

Company Name: #163 GHD Limited
Contact Name: Airesse MacPhee
Address: 651 COLBY DRIVE
WATERLOO ON N2V 1C2
Phone: (519) 884-0510 Fax: (519) 725-1394
Email: airesse.macphee@ghd.com; NationalEDDSupport@ma

Report Information

Company Name: #27087 GHD Limited
Contact Name: Airesse MacPhee
Address: 179 Colonnade Road, Suite 400
Ottawa ON K2E 7J4
Phone: (613) 727-0510 Fax:
Email: amacphee@CRAworld.com

Project Information

Quotation #: B31426
P.O. #:
Project #: 088877-02-01
Project Name: Uplands
Site #:
Sampled By: Danny Fitzgerald

Laboratory Use Only

Maxxam Job #:
Bottle Order #: 476602
Chain Of Custody Record: C#476602-01-01
Project Manager: Tabitha Rudkin

Regulatory Criteria:
- [ ] CSR
- [ ] CCME
- [ ] BC Water Quality
- [ ] Other

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests..
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY [ ] 2 Day [ ] 3 Day [ ] Date Required: ____
Rush Confirmation Number: ____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	Cyanide SAD, Sulphide	CSR Dissolved Metals in Water with CV Hg	CSR Total Metals in Water with CV Hg	VOC/VPH, LEPH/HEPH/PAH, TOG	Phenols (4-AAP)	# of Bottles	Comments
1	SID#135075	W-88877-091715-TDF-01	9/17/15	1410	GW	Y	X	X	X	X	X	X	X	X	14	
2	SID#135076	W-88877-091715-TDF-02	9/17/15	1455	GW	Y	X	X	X	X	X	X	X	X	14	dissolved metals only
3	SID#135077	W-88877-091715-TDF-03	9/17/15	1545	GW	Y	X	X	X	X	X	X		X	9	
4	SID#135078	W-88877-091715-TDF-04	9/17/15	1630	GW	Y	X	X	X	X	X	X		X	9	Do not analyze
5	SID#135079	W-88877-091715-TDF-05	9/17/15	1700	GW	Y	X	X	X	X	X	X		X	9	samples TDF-03 Through TDF-07
6	SID#135080	W-88877-091715-TDF-06	9/17/15	1710	GW	Y	X	X	X	X	X	X		X	9	for phenols
7	SID#135081	W-88877-091715-TDF-07	9/17/15	1750	GW	Y	X	X	X	X	X	X		X	9	
8	SID#135082	W-88877-18 091715-TDF-08	09/18/15	0650	SW	Y	X	X	X	X	X	X	X	X		
9	SID#135083	W-88877-091815-TDF-09	9/18/15	0740	SW	Y	X	X	X	X	X	X	X	X		Total metals only
10	SID#135084	W-88877-091815-TDF-10	9/18/15	0740	SW	Y	X	X	X							

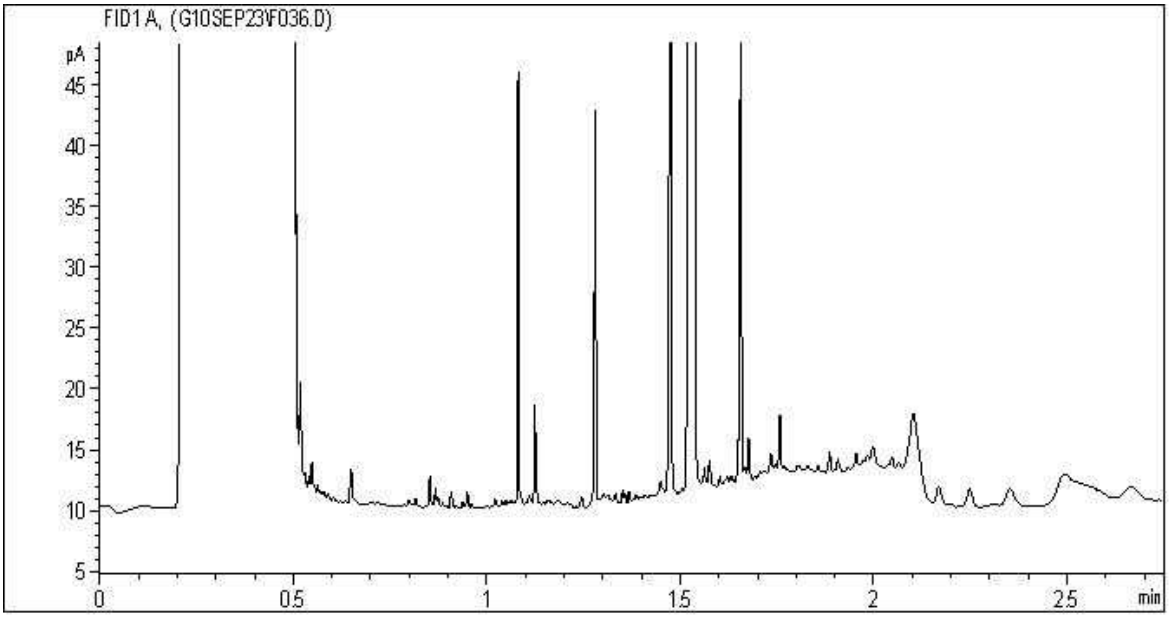
* * RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
DF	15/09/19	1015	SAMANTHA TAKTAK	2015/09/19	10:15	

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

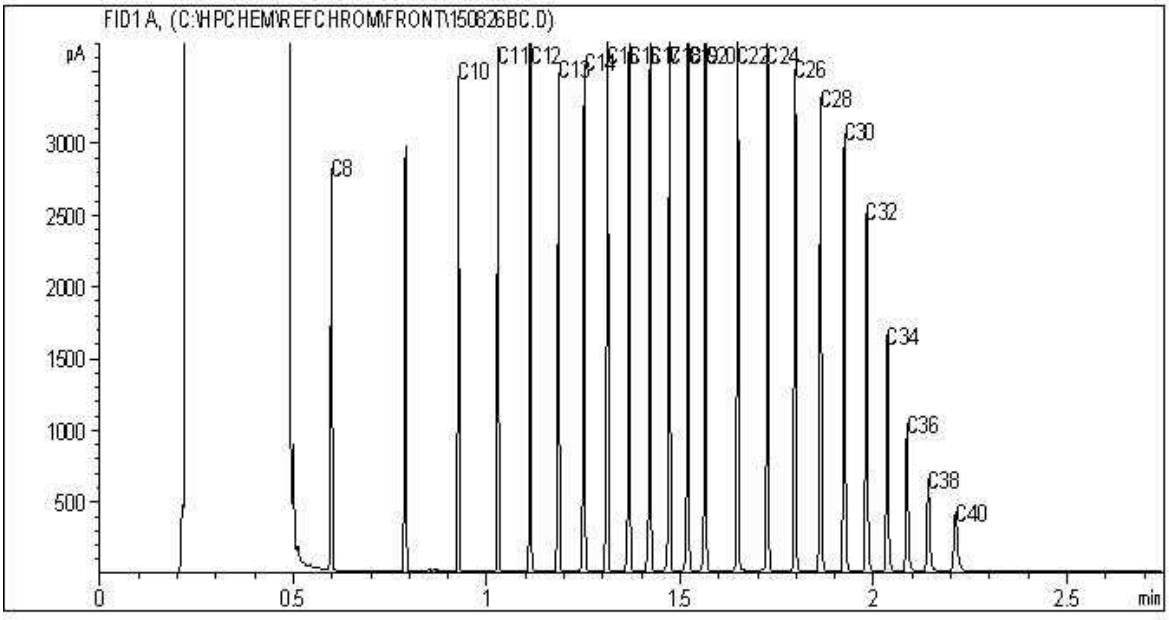
Lab Use Only

Time Sensitive [ ]
Temperature (°C) on Receipt: 2.2 / 1.1 / 3.4
Custody Seal Intact on Cooler? N/A [ ] Yes [ ] No

EPH in Water when PAH required Chromatogram



Carbon Range Distribution - Reference Chromatogram

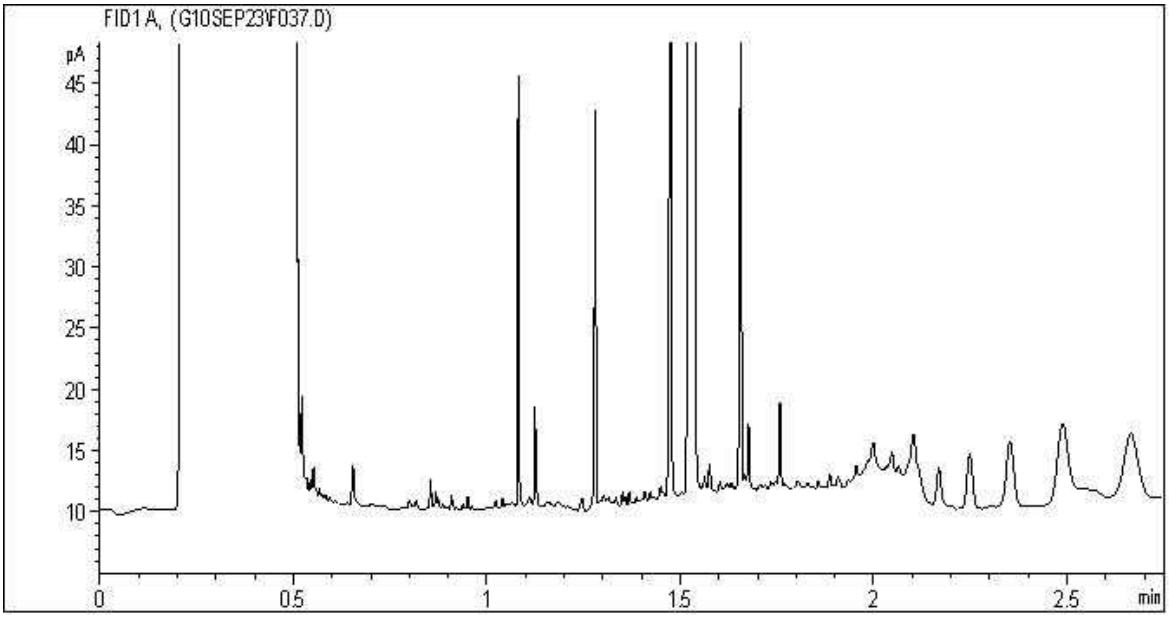


TYPICAL PRODUCT CARBON NUMBER RANGES

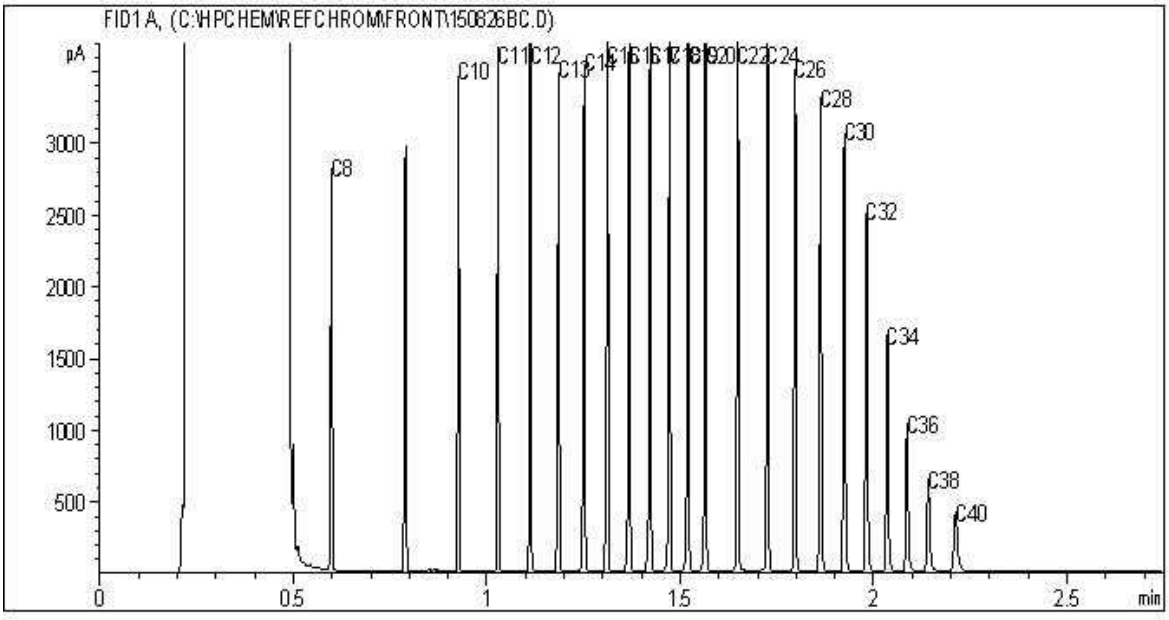
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

EPH in Water when PAH required Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

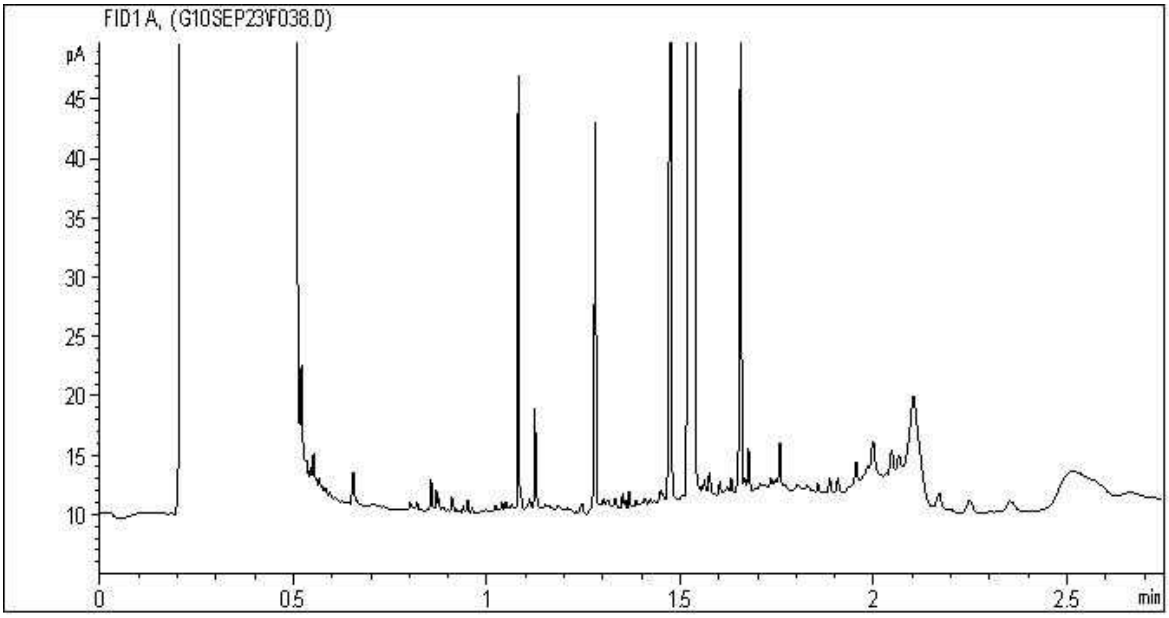
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

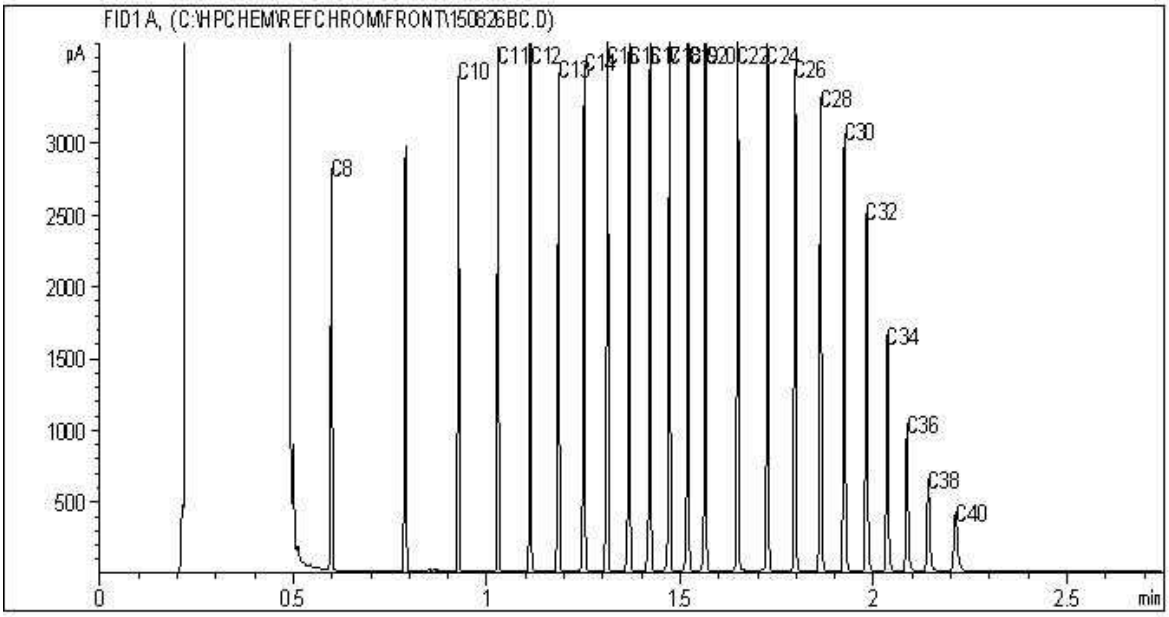
Maxxam Job #: B582021
Report Date: 2015/09/28
Maxxam Sample: NE0810

GHD Limited
Client Project #: 088877-02-01
Site Reference: UPLANDS
Client ID: W-88877-091815-TDF-08

EPH in Water when PAH required Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

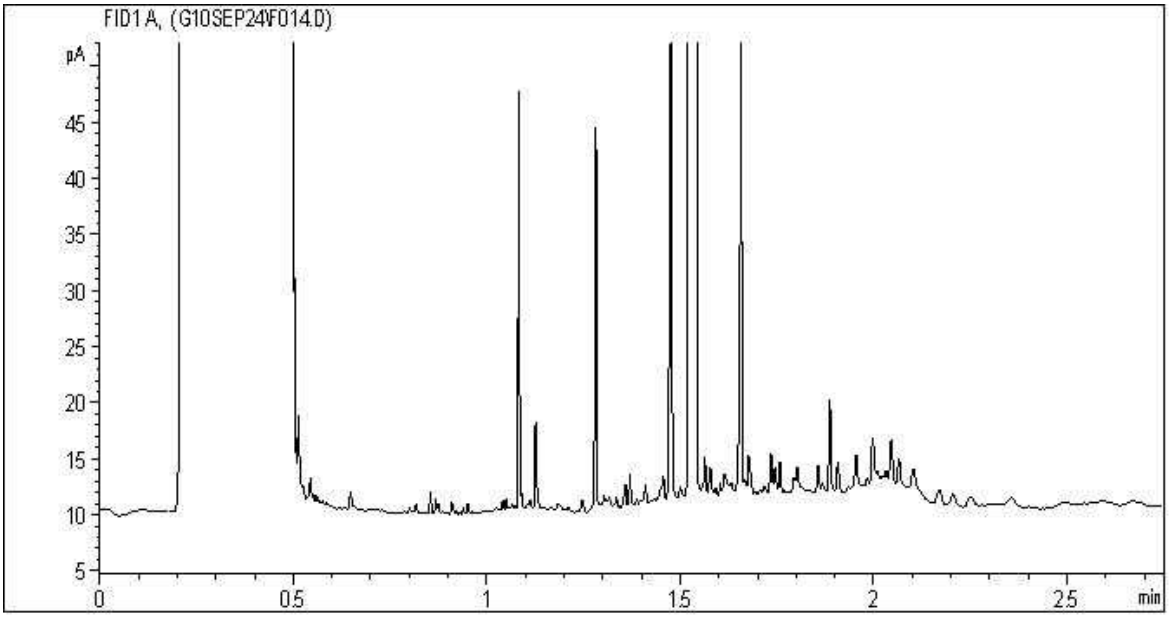
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

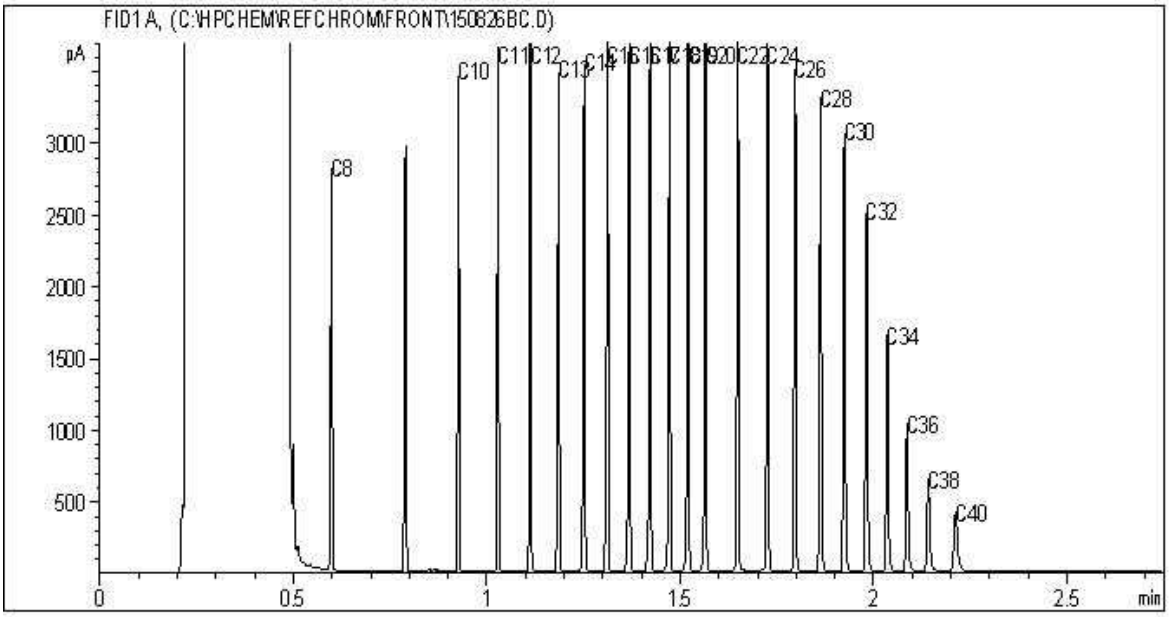
Maxxam Job #: B582021
Report Date: 2015/09/28
Maxxam Sample: NE0811

GHD Limited
Client Project #: 088877-02-01
Site Reference: UPLANDS
Client ID: W-88877-091815-TDF-09

EPH in Water when PAH required Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name Thomas Elliott/James Stewart

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code : 73500976

Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Sample Type	Sample Matrix	Grab or Composite	Start Depth (ft bgs)	End Depth (ft bgs)	Parent Sample ID for Field Dups	Footnote(s)
WG-88877-05102015-TE-01	MW1-14	10/5/2015	11:30	N	WG	grab	-	-	-	1
WG-88877-05102015-TE-02	MW2-14	10/5/2015	12:30	N	WG	grab	-	-	-	1
WG-88877-05102015-TE-03	MW3-14	10/5/2015	13:45	N	WG	grab	-	-	-	1
WG-88877-05102015-TE-04	MW5B-15	10/5/2015	15:00	N	WG	grab	-	-	-	2
WG-88877-05102015-TE-05	MW5A-15	10/5/2015	16:30	N	WG	grab	-	-	-	2
WS-88877-05102015-TE-06	SW15-02	10/6/2015	16:00	N	WS	grab	-	-	-	
WG-88877-06102015-TE-07	MW4B-15	10/5/2015	16:00	N	WG	grab	-	-	-	2
WG-88877-06102015-TE-08	MW4A-15	10/6/2015	8:30	N	WG	grab	-	-	-	2
WG-88877-06102015-TE-09	MW4A-15	10/6/2015	9:00	FD	WGQ	grab	-	-	Duplicate of WG-88877-06102015-TE-08	2
WS-88877-06102015-TE-10	SW15-01	10/6/2015	11:45	N	WS	grab	-	-	-	
WS-88877-06102015-TE-11	SW15-01	10/6/2015	12:00	FD	WSQ	grab	-	-	Duplicate of WS-88877-06102015-TE-10	

Footnotes

1. Sampled using high flow methodology
2. Sampled using low flow methodolgy
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name Thomas Elliott/James Stewart

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code : 73500976

					pH	Temperature			Conductivity		Turbidity		TDS				Eh / ORP	
Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Volume of Water Purged	Field pH	Sample Temp.	Ambient Temp.	Temp Units	Conductivity	Conductivity Units	Turbidity	Turbidity Units	TDS	Units	DO	Units	Eh/ORP	Eh/ORP Units
WG-88877-05102015-TE-01	MW1-14	10/5/2015	11:30	48	6.79	15.68	NM	C	0.099	mS	91	ntu	0.064	g/L	-	mg/L	226	mV
WG-88877-05102015-TE-02	MW2-14	10/5/2015	12:30	42	7.05	15.74	NM	C	0.163	mS	561	ntu	0.105	g/L	-	mg/L	222	mV
WG-88877-05102015-TE-03	MW3-14	10/5/2015	13:45	36	7.06	14.34	NM	C	0.157	mS	OOR	ntu	0.101	g/L	-	mg/L	231	mV
WG-88877-05102015-TE-04	MW5B-15	10/5/2015	15:00	1.5	7.00	16.99	NM	C	0.404	mS	36.1	ntu	0.264	g/L	-	mg/L	229	mV
WG-88877-05102015-TE-05	MW5A-15	10/5/2015	16:30	1.5	7.98	16.61	NM	C	0.329	mS	92	ntu	0.216	g/L	0.05	mg/L	177	mV
WS-88877-05102015-TE-06	SW15-02	10/6/2015	16:00	-	6.96	19.9	NM	C	0.056	mS	3.0	ntu	0.037	g/L	2.58	mg/L	220	mV
WG-88877-06102015-TE-07	MW4B-15	10/5/2015	16:00	2.5	6.95	11.92	NM	C	0.283	mS	2.5	ntu	0.184	g/L	0.00	mg/L	92	mV
WG-88877-06102015-TE-08	MW4A-15	10/6/2015	8:30	3.75	7.70	11.50	NM	C	0.323	mS	2.6	ntu	0.210	g/L	0.00	mg/L	89	mV
WG-88877-06102015-TE-09	MW4A-15	10/6/2015	9:00	3.75	7.70	11.50	NM	C	0.323	mS	2.6	ntu	0.210	g/L	0.00	mg/L	89	mV
WS-88877-06102015-TE-10	SW15-01	10/6/2015	11:45	-	6.82	15.09	NM	C	0.073	mS	0.0	ntu	0.046	g/L	8.09	mg/L	262	mV
WS-88877-06102015-TE-11	SW15-01	10/6/2015	12:00	-	6.82	15.09	NM	C	0.073	mS	0.0	ntu	0.046	g/L	8.09	mg/L	262	mV

Footnotes

1. Sampled using high flow methodology
2. Sampled using low flow methodolgy
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your P.O. #: 73500976-1
Your Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your C.O.C. #: 478427-01-01, 478427-02-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2015/10/19
Report #: R2060072
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B588841
Received: 2015/10/08, 09:40

Sample Matrix: Water
Samples Received: 11

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	1	2015/10/09	2015/10/10	BBY6SOP-00026	SM 22 2320 B m
Alkalinity - Water	10	2015/10/10	2015/10/10	BBY6SOP-00026	SM 22 2320 B m
Biochemical Oxygen Demand	11	2015/10/08	2015/10/08	BBY6SOP-00045	SM 22 5210 B m
Chloride by Automated Colourimetry	9	N/A	2015/10/08	BBY6SOP-00011	SM 22 4500-Cl- G m
Chloride by Automated Colourimetry	2	N/A	2015/10/09	BBY6SOP-00011	SM 22 4500-Cl- G m
Cyanide WAD (weak acid dissociable)	10	N/A	2015/10/16	BBY6SOP-00004	SM 22 4500-CN O
COD by Colorimeter	5	2015/10/08	2015/10/09	BBY6SOP-00024	SM 22 5220 D m
COD by Colorimeter	6	2015/10/09	2015/10/10	BBY6SOP-00024	SM 22 5220 D m
Conductance - water	11	N/A	2015/10/10	BBY6SOP-00026	SM 22 2510 B m
Sulphide (as H2S)	10	N/A	2015/10/13	BBY6SOP-00006	SM 22 4500-S2-D m
Hardness Total (calculated as CaCO3)	2	N/A	2015/10/16	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	8	N/A	2015/10/14	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	2	N/A	2015/10/15	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	5	N/A	2015/10/16	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Dissolved) by CVAF	3	N/A	2015/10/18	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Total) by CVAF	2	2015/10/16	2015/10/18	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Ion Balance	10	N/A	2015/10/15	BBY WI-00033	SM 22 1030E
EPH in Water when PAH required	2	2015/10/09	2015/10/11	BBY8SOP-00029	BCMOE EPH w 12/00 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	8	N/A	2015/10/14	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	8	N/A	2015/10/13	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	2	2015/10/08	2015/10/16	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	2	2015/10/14	2015/10/16	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	10	2015/10/09	2015/10/13	BBY6SOP-00016	SM 22 4500-N C m
Ammonia-N (Preserved)	10	N/A	2015/10/14	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N) (highlevel)	11	N/A	2015/10/08	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA (highlevel)	11	N/A	2015/10/08	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	11	N/A	2015/10/09	BBY6SOP-00010	SM 22 4500-NO3 I m
PAH in Water by GC/MS (SIM)	2	2015/10/09	2015/10/10	BBY8SOP-00021	EPA 8270d R4 m
Total LMW, HMW, Total PAH Calc	2	N/A	2015/10/13	BBY WI-00033	Auto Calc
Filter and HNO3 Preserve for Metals	10	N/A	2015/10/09	BBY7 WI-00004	BCMOE Reqs 08/14

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your P.O. #: 73500976-1
Your Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your C.O.C. #: 478427-01-01, 478427-02-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2015/10/19
Report #: R2060072
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B588841
Received: 2015/10/08, 09:40

Sample Matrix: Water
Samples Received: 11

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
pH Water (2)	11	N/A	2015/10/10	BBY6SOP-00026	SM 22 4500-H+ B m
Phenols (4-AAP)	2	N/A	2015/10/16	BBY6SOP-00008	SM 22 5530 D m
Orthophosphate by Konelab (highlevel)	11	N/A	2015/10/08	BBY6SOP-00013	SM 22 4500-P E m
Sulphide (1)	10	N/A	2015/10/10	EENVSOP-00096	SM 22 4500-S2 D m
Sulphate by Automated Colourimetry	9	N/A	2015/10/08	BBY6SOP-00017	SM 22 4500-SO42- E m
Sulphate by Automated Colourimetry	2	N/A	2015/10/09	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	7	2015/10/10	2015/10/14	BBY6SOP-00033	SM 22 2540 C m
Total Dissolved Solids (Filt. Residue)	4	2015/10/13	2015/10/14	BBY6SOP-00033	SM 22 2540 C m
EPH less PAH in Water by GC/FID	2	N/A	2015/10/13	BBY WI-00033	Auto Calc
TKN (Calc. TN, N/N) total	10	N/A	2015/10/13	BBY WI-00033	Calculation
Total Oil and Grease	2	N/A	2015/10/09	BBY8SOP-00004	BCMOE BCLM Sep2011 m
Total Phosphorus	10	N/A	2015/10/09	BBY6SOP-00013	SM 22 4500-P E m
Total Suspended Solids	6	N/A	2015/10/13	BBY6SOP-00034	SM 22 2540 D
Total Suspended Solids	3	N/A	2015/10/14	BBY6SOP-00034	SM 22 2540 D
Total Suspended Solids	2	N/A	2015/10/16	BBY6SOP-00034	SM 22 2540 D

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Edmonton Environmental
(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Tabitha Rudkin, AScT, Burnaby Project Manager
Email: TRudkin@maxxam.ca
Phone# (604)638-2639

==========

This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NI3984	NI3984		NI3985	NI3985		
Sampling Date		2015/10/05 11:30	2015/10/05 11:30		2015/10/05 12:30	2015/10/05 12:30		
COC Number		478427-01-01	478427-01-01		478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-01	WG-88877-051 02015-TE-01 Lab-Dup	RDL	WG-88877-051 02015-TE-02	WG-88877-051 02015-TE-02 Lab-Dup	RDL	QC Batch
Calculated Parameters								
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	FIELD	N/A	N/A	ONSITE
Hydrogen Sulphide (H2S)	mg/L	0.0070	N/A	0.0019	0.010	N/A	0.0019	8071889
Ion Balance	N/A	1.0	N/A	0.010	1.1	N/A	0.010	8066661
Demand Parameters								
Biochemical Oxygen Demand	mg/L	<6.0	N/A	6.0	<6.0	N/A	6.0	8067243
Chemical Oxygen Demand	mg/L	19	N/A	10	18	N/A	10	8066984
Misc. Inorganics								
Weak Acid Dissoc. Cyanide (CN)	mg/L	<0.00050	N/A	0.00050	<0.00050	N/A	0.00050	8077103
Alkalinity (Total as CaCO3)	mg/L	40.8	N/A	0.50	71.1	63.0	0.50	8075072
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	<0.50	<0.50	0.50	8075072
Bicarbonate (HCO3)	mg/L	49.8	N/A	0.50	86.7	76.8	0.50	8075072
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	<0.50	<0.50	0.50	8075072
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	<0.50	<0.50	0.50	8075072
Anions								
Sulphide	mg/L	0.0062	N/A	0.0019	0.0093	N/A	0.0019	8070663
Nutrients								
Total Ammonia (N)	mg/L	0.012	N/A	0.0050	0.20	N/A	0.0050	8074137
Total Phosphorus (P)	mg/L	0.675	N/A	0.050	0.150	N/A	0.0050	8067890
Physical Properties								
Conductivity	uS/cm	100	N/A	1.0	162	148	1.0	8075078
pH	pH	7.85	N/A	N/A	7.98	8.01	N/A	8075077
Physical Properties								
Total Suspended Solids	mg/L	717 (1)	N/A	16	174 (1)	N/A	16	8070271
Total Dissolved Solids	mg/L	72	62	10	94	N/A	10	8070333

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) RDL raised due to high concentration of solids in the sample.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NI3986		NI3987		NI3988	NI3988		
Sampling Date		2015/10/05 13:45		2015/10/05 15:00		2015/10/05 16:30	2015/10/05 16:30		
COC Number		478427-01-01		478427-01-01		478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-03	RDL	WG-88877-051 02015-TE-04	RDL	WG-88877-051 02015-TE-05	WG-88877-051 02015-TE-05 Lab-Dup	RDL	QC Batch
Calculated Parameters									
Filter and HNO3 Preservation	N/A	FIELD	N/A	FIELD	N/A	FIELD	N/A	N/A	ONSITE
Hydrogen Sulphide (H2S)	mg/L	0.029	0.0019	<0.0019	0.0019	0.011	N/A	0.0019	8071889
Ion Balance	N/A	1.1	0.010	0.94	0.010	1.0	N/A	0.010	8066661
Demand Parameters									
Biochemical Oxygen Demand	mg/L	<6.0	6.0	<6.0	6.0	<6.0	N/A	6.0	8067243
Chemical Oxygen Demand	mg/L	66	10	<10	10	26	N/A	10	8066984
Misc. Inorganics									
Weak Acid Dissoc. Cyanide (CN)	mg/L	<0.00050	0.00050	<0.00050	0.00050	<0.00050	N/A	0.00050	8077103
Alkalinity (Total as CaCO3)	mg/L	40.5	0.50	160	0.50	121	109	0.50	8075072
Alkalinity (PP as CaCO3)	mg/L	<0.50	0.50	<0.50	0.50	<0.50	<0.50	0.50	8075072
Bicarbonate (HCO3)	mg/L	49.4	0.50	195	0.50	148	134	0.50	8075072
Carbonate (CO3)	mg/L	<0.50	0.50	<0.50	0.50	<0.50	<0.50	0.50	8075072
Hydroxide (OH)	mg/L	<0.50	0.50	<0.50	0.50	<0.50	<0.50	0.50	8075072
Anions									
Sulphide	mg/L	0.027	0.0019	<0.0019	0.0019	0.010	N/A	0.0019	8070663
Nutrients									
Total Ammonia (N)	mg/L	0.15	0.0050	0.021	0.0050	0.019	N/A	0.0050	8074137
Total Phosphorus (P)	mg/L	1.47	0.050	<0.0050	0.0050	0.0746	N/A	0.0050	8067890
OIL & GREASE									
Total Oil and grease	mg/L	N/A	N/A	<1.0	1.0	<1.0	N/A	1.0	8068696
Misc. Organics									
Phenols	mg/L	N/A	N/A	<0.0010	0.0010	<0.0010	N/A	0.0010	8077145
Physical Properties									
Conductivity	uS/cm	121	1.0	338	1.0	342	312	1.0	8075078
pH	pH	7.73	N/A	8.03	N/A	8.13	8.16	N/A	8075077
Physical Properties									
Total Suspended Solids	mg/L	882 (1)	32	30.5	4.0	280 (1)	N/A	32	8070271
Total Dissolved Solids	mg/L	82	10	186	10	222	N/A	10	8070333

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) RDL raised due to high concentration of solids in the sample.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NI3989	NI3989	NI3990		NI3991		
Sampling Date		2015/10/06 08:30	2015/10/06 08:30	2015/10/06 09:00		2015/10/06 09:05		
COC Number		478427-01-01	478427-01-01	478427-01-01		478427-01-01		
	UNITS	WG-88877-061 02015-TE-07	WG-88877-061 02015-TE-07 Lab-Dup	WG-88877-061 02015-TE-08	QC Batch	WG-88877-061 02015-TE-09	RDL	QC Batch
Calculated Parameters								
Filter and HNO3 Preservation	N/A	FIELD	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Hydrogen Sulphide (H2S)	mg/L	<0.0019	N/A	<0.0019	8071889	<0.0019	0.0019	8071889
Ion Balance	N/A	1.1	N/A	1.0	8066661	1.1	0.010	8066661
Demand Parameters								
Biochemical Oxygen Demand	mg/L	<6.0	N/A	<6.0	8067243	<6.0	6.0	8067243
Chemical Oxygen Demand	mg/L	12	<10	<10	8069011	<10	10	8069011
Misc. Inorganics								
Weak Acid Dissoc. Cyanide (CN)	mg/L	<0.00050	N/A	<0.00050	8077103	<0.00050	0.00050	8077103
Alkalinity (Total as CaCO3)	mg/L	15.4	N/A	72.0	8075072	102	0.50	8075072
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	<0.50	8075072	<0.50	0.50	8075072
Bicarbonate (HCO3)	mg/L	18.8	N/A	87.9	8075072	124	0.50	8075072
Carbonate (CO3)	mg/L	<0.50	N/A	<0.50	8075072	<0.50	0.50	8075072
Hydroxide (OH)	mg/L	<0.50	N/A	<0.50	8075072	<0.50	0.50	8075072
Anions								
Sulphide	mg/L	<0.0019	N/A	<0.0019	8070663	<0.0019	0.0019	8070663
Nutrients								
Total Ammonia (N)	mg/L	0.012	N/A	0.020	8074137	0.017	0.0050	8074137
Total Phosphorus (P)	mg/L	<0.0050	N/A	0.0184	8067890	0.0108	0.0050	8067890
Physical Properties								
Conductivity	uS/cm	55.5	N/A	251	8075078	309	1.0	8075078
pH	pH	7.48	N/A	8.00	8075077	8.16	N/A	8075077
Physical Properties								
Total Suspended Solids	mg/L	<4.0	N/A	<4.0	8071670	<4.0	4.0	8071670
Total Dissolved Solids	mg/L	58	N/A	158	8071654	204	10	8070333

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		NI3999		NI4000	NI4001		
Sampling Date		2015/10/05 16:00		2015/10/06 11:45	2015/10/06 12:00		
COC Number		478427-02-01		478427-02-01	478427-02-01		
	UNITS	WS-88877-051 02015-TE-06	QC Batch	WS-88877-061 02015-TE-10	WS-88877-061 02015-TE-11	RDL	QC Batch
Calculated Parameters							
Filter and HNO3 Preservation	N/A	LAB	8068985	LAB	N/A	N/A	8068985
Hydrogen Sulphide (H2S)	mg/L	<0.0019	8071889	<0.0019	N/A	0.0019	8071889
Ion Balance	N/A	1.0	8066661	0.92	N/A	0.010	8066661
Demand Parameters							
Biochemical Oxygen Demand	mg/L	<6.0	8067243	<6.0	<6.0	6.0	8067726
Chemical Oxygen Demand	mg/L	<10	8069011	<10	<10	10	8069011
Misc. Inorganics							
Weak Acid Dissoc. Cyanide (CN)	mg/L	<0.00050	8077103	<0.00050	N/A	0.00050	8077103
Alkalinity (Total as CaCO3)	mg/L	105	8070054	22.0	21.2	0.50	8075072
Alkalinity (PP as CaCO3)	mg/L	<0.50	8070054	<0.50	<0.50	0.50	8075072
Bicarbonate (HCO3)	mg/L	128	8070054	26.8	25.9	0.50	8075072
Carbonate (CO3)	mg/L	<0.50	8070054	<0.50	<0.50	0.50	8075072
Hydroxide (OH)	mg/L	<0.50	8070054	<0.50	<0.50	0.50	8075072
Anions							
Sulphide	mg/L	<0.0019	8070663	<0.0019	N/A	0.0019	8070663
Nutrients							
Total Ammonia (N)	mg/L	0.018	8074137	0.020	N/A	0.0050	8074137
Total Phosphorus (P)	mg/L	0.0098	8067890	<0.0050	N/A	0.0050	8067890
Physical Properties							
Conductivity	uS/cm	317	8070059	47.1	47.8	1.0	8075078
pH	pH	8.18	8070057	7.54	7.46	N/A	8075077
Physical Properties							
Total Suspended Solids	mg/L	<4.0	8070271	<4.0 (1)	<4.0 (1)	4.0	8071672
Total Dissolved Solids	mg/L	192	8070333	51	51	10	8071654

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Sample analysed past recommended hold time.

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Maxxam Job #: B588841
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GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		NI3984	NI3985	NI3986	NI3986	NI3987		
Sampling Date		2015/10/05 11:30	2015/10/05 12:30	2015/10/05 13:45	2015/10/05 13:45	2015/10/05 15:00		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-01	WG-88877-051 02015-TE-02	WG-88877-051 02015-TE-03	WG-88877-051 02015-TE-03 Lab-Dup	WG-88877-051 02015-TE-04	RDL	QC Batch
ANIONS								
Nitrite (N)	mg/L	<0.10	<0.10	0.11	N/A	<0.10	0.10	8068005
Calculated Parameters								
Nitrate (N)	mg/L	0.26	0.14	0.54	N/A	1.33	0.10	8066502
Anions								
Dissolved Sulphate (SO4)	mg/L	2.31	7.24	5.62	5.80	3.32	0.50	8068167
Dissolved Chloride (Cl)	mg/L	3.7	2.1	9.6	9.5	3.0	0.50	8068165
Nutrients								
Orthophosphate (P)	mg/L	<0.10	<0.10	<0.10	N/A	<0.10	0.10	8068060
Nitrate plus Nitrite (N)	mg/L	0.26	0.14	0.65	N/A	1.33	0.10	8068004

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Maxxam ID		NI3988	NI3989	NI3990	NI3991		NI3999		
Sampling Date		2015/10/05 16:30	2015/10/06 08:30	2015/10/06 09:00	2015/10/06 09:05		2015/10/05 16:00		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01		478427-02-01		
	UNITS	WG-88877-051 02015-TE-05	WG-88877-061 02015-TE-07	WG-88877-061 02015-TE-08	WG-88877-061 02015-TE-09	QC Batch	WS-88877-051 02015-TE-06	RDL	QC Batch
ANIONS									
Nitrite (N)	mg/L	<0.10	<0.10	<0.10	<0.10	8068005	<0.10	0.10	8068005
Calculated Parameters									
Nitrate (N)	mg/L	0.29	<0.10	0.77	1.11	8066502	1.16	0.10	8066502
Anions									
Dissolved Sulphate (SO4)	mg/L	31.4	<0.50	6.26	6.84	8068167	8.51	0.50	8069967
Dissolved Chloride (Cl)	mg/L	15	6.2	27	26	8068165	25	0.50	8069965
Nutrients									
Orthophosphate (P)	mg/L	<0.10	<0.10	<0.10	<0.10	8068060	<0.10	0.10	8068060
Nitrate plus Nitrite (N)	mg/L	0.29	<0.10	0.77	1.11	8068004	1.16	0.10	8068004

RDL = Reportable Detection Limit

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Maxxam Job #: B588841
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GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		NI4000	NI4000		NI4001	NI4001		
Sampling Date		2015/10/06 11:45	2015/10/06 11:45		2015/10/06 12:00	2015/10/06 12:00		
COC Number		478427-02-01	478427-02-01		478427-02-01	478427-02-01		
	UNITS	**WS-88877-061 02015-TE-10**	**WS-88877-061 02015-TE-10 Lab-Dup**	**QC Batch**	**WS-88877-061 02015-TE-11**	**WS-88877-061 02015-TE-11 Lab-Dup**	**RDL**	**QC Batch**
ANIONS								
Nitrite (N)	mg/L	<0.10	N/A	8068005	<0.10	<0.10	0.10	8068005
Calculated Parameters								
Nitrate (N)	mg/L	<0.10	N/A	8066502	<0.10	N/A	0.10	8066502
Anions								
Dissolved Sulphate (SO4)	mg/L	2.22	2.06	8068167	3.02	N/A	0.50	8071651
Dissolved Chloride (Cl)	mg/L	1.6	1.2	8068165	0.90	N/A	0.50	8071637
Nutrients								
Orthophosphate (P)	mg/L	<0.10	N/A	8068060	<0.10	<0.10	0.10	8068060
Nitrate plus Nitrite (N)	mg/L	<0.10	N/A	8068004	<0.10	<0.10	0.10	8068004

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		NI3987	NI3988		
Sampling Date		2015/10/05 15:00	2015/10/05 16:30		
COC Number		478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-04	WG-88877-051 02015-TE-05	RDL	QC Batch
Polycyclic Aromatics					
Low Molecular Weight PAH`s	ug/L	<0.24	<0.24	0.24	8066842
High Molecular Weight PAH`s	ug/L	<0.050	<0.050	0.050	8066842
Total PAH	ug/L	<0.24	<0.24	0.24	8066842
Naphthalene	ug/L	<0.10	<0.10	0.10	8069794
2-Methylnaphthalene	ug/L	<0.10	<0.10	0.10	8069794
Quinoline	ug/L	<0.24	<0.24	0.24	8069794
Acenaphthylene	ug/L	<0.050	<0.050	0.050	8069794
Acenaphthene	ug/L	<0.050	<0.050	0.050	8069794
Fluorene	ug/L	<0.050	<0.050	0.050	8069794
Phenanthrene	ug/L	<0.050	<0.050	0.050	8069794
Anthracene	ug/L	<0.010	<0.010	0.010	8069794
Acridine	ug/L	<0.050	<0.050	0.050	8069794
Fluoranthene	ug/L	<0.020	<0.020	0.020	8069794
Pyrene	ug/L	<0.020	<0.020	0.020	8069794
Benzo(a)anthracene	ug/L	<0.010	<0.010	0.010	8069794
Chrysene	ug/L	<0.050	<0.050	0.050	8069794
Benzo(b&j)fluoranthene	ug/L	<0.050	<0.050	0.050	8069794
Benzo(k)fluoranthene	ug/L	<0.050	<0.050	0.050	8069794
Benzo(a)pyrene	ug/L	<0.0090	<0.0090	0.0090	8069794
Indeno(1,2,3-cd)pyrene	ug/L	<0.050	<0.050	0.050	8069794
Dibenz(a,h)anthracene	ug/L	<0.050	<0.050	0.050	8069794
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	0.050	8069794
Calculated Parameters					
LEPH (C10-C19 less PAH)	mg/L	<0.20	<0.20	0.20	8066845
HEPH (C19-C32 less PAH)	mg/L	<0.20	<0.20	0.20	8066845
Ext. Pet. Hydrocarbon					
EPH (C10-C19)	mg/L	<0.20	<0.20	0.20	8069797
EPH (C19-C32)	mg/L	<0.20	<0.20	0.20	8069797
Surrogate Recovery (%)					
O-TERPHENYL (sur.)	%	108	110	N/A	8069797
D10-ANTHRACENE (sur.)	%	99	99	N/A	8069794
D8-ACENAPHTHYLENE (sur.)	%	102	101	N/A	8069794

RDL = Reportable Detection Limit
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Maxxam Job #: B588841
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GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		NI3987	NI3988		
Sampling Date		2015/10/05 15:00	2015/10/05 16:30		
COC Number		478427-01-01	478427-01-01		
	UNITS	**WG-88877-051 02015-TE-04**	**WG-88877-051 02015-TE-05**	**RDL**	**QC Batch**
D8-NAPHTHALENE (sur.)	%	100	98	N/A	8069794
D9-Acridine	%	102	101	N/A	8069794
TERPHENYL-D14 (sur.)	%	90	91	N/A	8069794

RDL = Reportable Detection Limit
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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

CSR DISSOLVED METALS IN WATER (WATER)

Maxxam ID		NI3999	NI4000		
Sampling Date		2015/10/05 16:00	2015/10/06 11:45		
COC Number		478427-02-01	478427-02-01		
	UNITS	WS-88877-051 02015-TE-06	WS-88877-061 02015-TE-10	RDL	QC Batch
Misc. Inorganics					
Dissolved Hardness (CaCO3)	mg/L	48.3	22.4	0.50	8067792
RDL = Reportable Detection Limit					

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Maxxam Job #: B588841
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GHD Limited
Client Project #: 088877-02-01
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Your P.O. #: 73500976-1
Sampler Initials: TE

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3984	NI3984	NI3985	NI3986		
Sampling Date		2015/10/05 11:30	2015/10/05 11:30	2015/10/05 12:30	2015/10/05 13:45		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-01	WG-88877-051 02015-TE-01 Lab-Dup	WG-88877-051 02015-TE-02	WG-88877-051 02015-TE-03	RDL	QC Batch
Misc. Inorganics							
Dissolved Hardness (CaCO3)	mg/L	43.3	N/A	77.0	56.1	0.50	8067173
Elements							
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	<0.010	0.010	8078653
Dissolved Metals by ICPMS							
Dissolved Aluminum (Al)	ug/L	6.6	N/A	6.1	9.4	3.0	8068823
Dissolved Antimony (Sb)	ug/L	<0.50	N/A	<0.50	<0.50	0.50	8068823
Dissolved Arsenic (As)	ug/L	0.15	N/A	0.17	<0.10	0.10	8068823
Dissolved Barium (Ba)	ug/L	<1.0	N/A	1.9	1.7	1.0	8068823
Dissolved Beryllium (Be)	ug/L	<0.10	N/A	<0.10	<0.10	0.10	8068823
Dissolved Bismuth (Bi)	ug/L	<1.0	N/A	<1.0	<1.0	1.0	8068823
Dissolved Boron (B)	ug/L	<50	N/A	<50	<50	50	8068823
Dissolved Cadmium (Cd)	ug/L	<0.010	N/A	0.017	0.012	0.010	8068823
Dissolved Chromium (Cr)	ug/L	<1.0	N/A	<1.0	<1.0	1.0	8068823
Dissolved Cobalt (Co)	ug/L	<0.50	N/A	<0.50	<0.50	0.50	8068823
Dissolved Copper (Cu)	ug/L	0.44	N/A	0.99	0.30	0.20	8068823
Dissolved Iron (Fe)	ug/L	7.5	N/A	9.5	10.1	5.0	8068823
Dissolved Lead (Pb)	ug/L	<0.20	N/A	<0.20	<0.20	0.20	8068823
Dissolved Lithium (Li)	ug/L	<5.0	N/A	<5.0	<5.0	5.0	8068823
Dissolved Manganese (Mn)	ug/L	<1.0	N/A	<1.0	<1.0	1.0	8068823
Dissolved Molybdenum (Mo)	ug/L	<1.0	N/A	<1.0	<1.0	1.0	8068823
Dissolved Nickel (Ni)	ug/L	<1.0	N/A	<1.0	<1.0	1.0	8068823
Dissolved Selenium (Se)	ug/L	<0.10	N/A	0.11	0.24	0.10	8068823
Dissolved Silicon (Si)	ug/L	5500	N/A	6530	8240	100	8068823
Dissolved Silver (Ag)	ug/L	<0.020	N/A	<0.020	<0.020	0.020	8068823
Dissolved Strontium (Sr)	ug/L	23.0	N/A	34.7	31.0	1.0	8068823
Dissolved Thallium (Tl)	ug/L	<0.050	N/A	<0.050	<0.050	0.050	8068823
Dissolved Tin (Sn)	ug/L	<5.0	N/A	<5.0	<5.0	5.0	8068823
Dissolved Titanium (Ti)	ug/L	<5.0	N/A	<5.0	<5.0	5.0	8068823
Dissolved Uranium (U)	ug/L	0.13	N/A	<0.10	<0.10	0.10	8068823
Dissolved Vanadium (V)	ug/L	<5.0	N/A	<5.0	<5.0	5.0	8068823
Dissolved Zinc (Zn)	ug/L	8.7	N/A	5.0	<5.0	5.0	8068823

RDL = Reportable Detection Limit
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N/A = Not Applicable

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Maxxam Job #: B588841
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GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3984	NI3984	NI3985	NI3986		
Sampling Date		2015/10/05 11:30	2015/10/05 11:30	2015/10/05 12:30	2015/10/05 13:45		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01		
	UNITS	**WG-88877-051 02015-TE-01**	**WG-88877-051 02015-TE-01 Lab-Dup**	**WG-88877-051 02015-TE-02**	**WG-88877-051 02015-TE-03**	**RDL**	**QC Batch**
Dissolved Zirconium (Zr)	ug/L	<0.50	N/A	<0.50	<0.50	0.50	8068823
Dissolved Calcium (Ca)	mg/L	14.2	N/A	24.3	16.5	0.050	8066734
Dissolved Magnesium (Mg)	mg/L	1.87	N/A	3.92	3.62	0.050	8066734
Dissolved Potassium (K)	mg/L	0.176	N/A	0.254	0.190	0.050	8066734
Dissolved Sodium (Na)	mg/L	2.62	N/A	4.37	5.15	0.050	8066734
Dissolved Sulphur (S)	mg/L	<3.0	N/A	3.8	<3.0	3.0	8066734

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3987	NI3988	NI3989	NI3990	NI3991		
Sampling Date		2015/10/05 15:00	2015/10/05 16:30	2015/10/06 08:30	2015/10/06 09:00	2015/10/06 09:05		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-04	WG-88877-051 02015-TE-05	WG-88877-061 02015-TE-07	WG-88877-061 02015-TE-08	WG-88877-061 02015-TE-09	RDL	QC Batch
Misc. Inorganics								
Dissolved Hardness (CaCO3)	mg/L	141	126	16.8	23.5	52.2	0.50	8067173
Elements								
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	8076419
Dissolved Metals by ICPMS								
Dissolved Aluminum (Al)	ug/L	16.3	12.0	18.4	16.6	8.5	3.0	8068823
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	8068823
Dissolved Arsenic (As)	ug/L	0.22	0.89	0.15	0.26	0.42	0.10	8068823
Dissolved Barium (Ba)	ug/L	23.2	12.2	2.1	2.1	15.5	1.0	8068823
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	8068823
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	8068823
Dissolved Boron (B)	ug/L	<50	90	<50	<50	<50	50	8068823
Dissolved Cadmium (Cd)	ug/L	0.059	0.029	0.011	0.019	0.025	0.010	8068823
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	8068823
Dissolved Cobalt (Co)	ug/L	0.67	<0.50	<0.50	<0.50	<0.50	0.50	8068823
Dissolved Copper (Cu)	ug/L	0.97	1.59	1.02	0.54	0.43	0.20	8068823
Dissolved Iron (Fe)	ug/L	<5.0	14.7	162	17.5	6.1	5.0	8068823
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	8068823
Dissolved Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	8068823
Dissolved Manganese (Mn)	ug/L	226	163	24.0	1.8	19.8	1.0	8068823
Dissolved Molybdenum (Mo)	ug/L	<1.0	2.8	<1.0	<1.0	<1.0	1.0	8068823
Dissolved Nickel (Ni)	ug/L	<1.0	1.8	2.2	<1.0	<1.0	1.0	8068823
Dissolved Selenium (Se)	ug/L	0.23	0.53	<0.10	0.46	0.56	0.10	8068823
Dissolved Silicon (Si)	ug/L	4720	6810	1480	8810	8730	100	8068823
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	0.020	8068823
Dissolved Strontium (Sr)	ug/L	67.2	101	15.1	42.3	50.8	1.0	8068823
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	8068823
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	8068823
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	8068823
Dissolved Uranium (U)	ug/L	0.16	0.77	<0.10	<0.10	<0.10	0.10	8068823
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	8068823
Dissolved Zinc (Zn)	ug/L	6.5	10.7	<5.0	<5.0	<5.0	5.0	8068823
Dissolved Zirconium (Zr)	ug/L	3.67	<0.50	<0.50	<0.50	<0.50	0.50	8068823
Dissolved Calcium (Ca)	mg/L	49.7	36.6	4.77	7.28	17.9	0.050	8066734

RDL = Reportable Detection Limit

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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3987	NI3988	NI3989	NI3990	NI3991		
Sampling Date		2015/10/05 15:00	2015/10/05 16:30	2015/10/06 08:30	2015/10/06 09:00	2015/10/06 09:05		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-04	WG-88877-051 02015-TE-05	WG-88877-061 02015-TE-07	WG-88877-061 02015-TE-08	WG-88877-061 02015-TE-09	RDL	QC Batch
Dissolved Magnesium (Mg)	mg/L	4.01	8.48	1.19	1.30	1.82	0.050	8066734
Dissolved Potassium (K)	mg/L	0.489	1.28	0.187	0.288	0.476	0.050	8066734
Dissolved Sodium (Na)	mg/L	9.35	23.2	4.70	45.0	49.1	0.050	8066734
Dissolved Sulphur (S)	mg/L	3.0	12.5	3.6	4.5	4.6	3.0	8066734
RDL = Reportable Detection Limit								

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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
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Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3991		
Sampling Date		2015/10/06 09:05		
COC Number		478427-01-01		
	UNITS	WG-88877-061 02015-TE-09 Lab-Dup	RDL	QC Batch
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	7.3	3.0	8068823
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	8068823
Dissolved Arsenic (As)	ug/L	0.44	0.10	8068823
Dissolved Barium (Ba)	ug/L	14.8	1.0	8068823
Dissolved Beryllium (Be)	ug/L	<0.10	0.10	8068823
Dissolved Bismuth (Bi)	ug/L	<1.0	1.0	8068823
Dissolved Boron (B)	ug/L	<50	50	8068823
Dissolved Cadmium (Cd)	ug/L	0.023	0.010	8068823
Dissolved Chromium (Cr)	ug/L	<1.0	1.0	8068823
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	8068823
Dissolved Copper (Cu)	ug/L	0.53	0.20	8068823
Dissolved Iron (Fe)	ug/L	5.6	5.0	8068823
Dissolved Lead (Pb)	ug/L	<0.20	0.20	8068823
Dissolved Lithium (Li)	ug/L	<5.0	5.0	8068823
Dissolved Manganese (Mn)	ug/L	20.0	1.0	8068823
Dissolved Molybdenum (Mo)	ug/L	<1.0	1.0	8068823
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	8068823
Dissolved Selenium (Se)	ug/L	0.59	0.10	8068823
Dissolved Silicon (Si)	ug/L	8680	100	8068823
Dissolved Silver (Ag)	ug/L	<0.020	0.020	8068823
Dissolved Strontium (Sr)	ug/L	48.6	1.0	8068823
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	8068823
Dissolved Tin (Sn)	ug/L	<5.0	5.0	8068823
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	8068823
Dissolved Uranium (U)	ug/L	<0.10	0.10	8068823
Dissolved Vanadium (V)	ug/L	<5.0	5.0	8068823
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	8068823
Dissolved Zirconium (Zr)	ug/L	2.27	0.50	8068823

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate

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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3999	NI3999	NI4000		
Sampling Date		2015/10/05 16:00	2015/10/05 16:00	2015/10/06 11:45		
COC Number		478427-02-01	478427-02-01	478427-02-01		
	UNITS	WS-88877-051 02015-TE-06	WS-88877-051 02015-TE-06 Lab-Dup	WS-88877-061 02015-TE-10	RDL	QC Batch
Calculated Parameters						
Total Hardness (CaCO3)	mg/L	51.6	N/A	24.5	0.50	8066659
Elements						
Total Mercury (Hg)	ug/L	<0.010	N/A	<0.010	0.010	8076829
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	9.5	9.5	20.4	3.0	8073701
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	0.50	8073701
Total Arsenic (As)	ug/L	0.37	0.35	<0.10	0.10	8073701
Total Barium (Ba)	ug/L	13.6	14.9	2.8	1.0	8073701
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	0.10	8073701
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	1.0	8073701
Total Boron (B)	ug/L	<50	<50	<50	50	8073701
Total Cadmium (Cd)	ug/L	<0.010	<0.010	<0.010	0.010	8073701
Total Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	1.0	8073701
Total Cobalt (Co)	ug/L	<0.50	<0.50	<0.50	0.50	8073701
Total Copper (Cu)	ug/L	0.53	1.10	0.67	0.50	8073701
Total Iron (Fe)	ug/L	<10	<10	29	10	8073701
Total Lead (Pb)	ug/L	<0.20	<0.20	<0.20	0.20	8073701
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	5.0	8073701
Total Manganese (Mn)	ug/L	17.7	18.8	2.5	1.0	8073701
Total Molybdenum (Mo)	ug/L	<1.0	<1.0	<1.0	1.0	8073701
Total Nickel (Ni)	ug/L	<1.0	<1.0	<1.0	1.0	8073701
Total Selenium (Se)	ug/L	0.45	0.46	<0.10	0.10	8073701
Total Silicon (Si)	ug/L	8800	8620	1770	100	8073701
Total Silver (Ag)	ug/L	<0.020	<0.020	<0.020	0.020	8073701
Total Strontium (Sr)	ug/L	42.1	45.2	10.4	1.0	8073701
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	0.050	8073701
Total Tin (Sn)	ug/L	<5.0	<5.0	<5.0	5.0	8073701
Total Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	5.0	8073701
Total Uranium (U)	ug/L	<0.10	<0.10	<0.10	0.10	8073701
Total Vanadium (V)	ug/L	<5.0	<5.0	<5.0	5.0	8073701
Total Zinc (Zn)	ug/L	<5.0	<5.0	<5.0	5.0	8073701

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B588841
Report Date: 2015/10/19

GHD Limited
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Your P.O. #: 73500976-1
Sampler Initials: TE

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID		NI3999	NI3999	NI4000		
Sampling Date		2015/10/05 16:00	2015/10/05 16:00	2015/10/06 11:45		
COC Number		478427-02-01	478427-02-01	478427-02-01		
	UNITS	WS-88877-051 02015-TE-06	WS-88877-051 02015-TE-06 Lab-Dup	WS-88877-061 02015-TE-10	RDL	QC Batch
Total Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50	0.50	8073701
Total Calcium (Ca)	mg/L	18.0	N/A	8.46	0.050	8066941
Total Magnesium (Mg)	mg/L	1.60	N/A	0.825	0.050	8066941
Total Potassium (K)	mg/L	0.457	N/A	0.078	0.050	8066941
Total Sodium (Na)	mg/L	42.4	N/A	0.895	0.050	8066941
Total Sulphur (S)	mg/L	<3.0	N/A	<3.0	3.0	8066941

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B588841
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GHD Limited
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Sampler Initials: TE

TOTAL TKN IN WATER (WATER)

Maxxam ID		NI3984		NI3985	NI3986		NI3987		
Sampling Date		2015/10/05 11:30		2015/10/05 12:30	2015/10/05 13:45		2015/10/05 15:00		
COC Number		478427-01-01		478427-01-01	478427-01-01		478427-01-01		
	UNITS	WG-88877-051 02015-TE-01	QC Batch	WG-88877-051 02015-TE-02	WG-88877-051 02015-TE-03	QC Batch	WG-88877-051 02015-TE-04	RDL	QC Batch
Nutrients									
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	8067348	<0.10	0.54	8067348	0.41	0.10	8067348
Total Nitrogen (N)	mg/L	0.303	8069742	0.211	1.18	8069744	1.75	0.020	8069742
RDL = Reportable Detection Limit									

Maxxam ID		NI3988	NI3989	NI3990	NI3991	NI3991		
Sampling Date		2015/10/05 16:30	2015/10/06 08:30	2015/10/06 09:00	2015/10/06 09:05	2015/10/06 09:05		
COC Number		478427-01-01	478427-01-01	478427-01-01	478427-01-01	478427-01-01		
	UNITS	WG-88877-051 02015-TE-05	WG-88877-061 02015-TE-07	WG-88877-061 02015-TE-08	WG-88877-061 02015-TE-09	WG-88877-061 02015-TE-09 Lab-Dup	RDL	QC Batch
Nutrients								
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	0.15	0.22	0.20	N/A	0.10	8067348
Total Nitrogen (N)	mg/L	0.388	0.154	0.990	1.31	1.34	0.020	8069742
RDL = Reportable Detection Limit								
Lab-Dup = Laboratory Initiated Duplicate								
N/A = Not Applicable								

Maxxam ID		NI3999	NI4000		
Sampling Date		2015/10/05 16:00	2015/10/06 11:45		
COC Number		478427-02-01	478427-02-01		
	UNITS	WS-88877-051 02015-TE-06	WS-88877-061 02015-TE-10	RDL	QC Batch
Nutrients					
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.25	<0.10	0.10	8067348
Total Nitrogen (N)	mg/L	1.41	0.074	0.020	8069742
RDL = Reportable Detection Limit					

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GHD Limited
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GENERAL COMMENTS

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8069794	D10-ANTHRACENE (sur.)	2015/10/10	91	60 - 130	96	60 - 130	103	%		
8069794	D8-ACENAPHTHYLENE (sur.)	2015/10/10	96	50 - 130	100	50 - 130	107	%		
8069794	D8-NAPHTHALENE (sur.)	2015/10/10	97	50 - 130	99	50 - 130	109	%		
8069794	D9-Acridine	2015/10/10	98	50 - 130	100	50 - 130	107	%		
8069794	TERPHENYL-D14 (sur.)	2015/10/10	84	60 - 130	94	60 - 130	103	%		
8069797	O-TERPHENYL (sur.)	2015/10/11	117	50 - 130	114	50 - 130	108	%		
8066984	Chemical Oxygen Demand	2015/10/09	97	80 - 120	99	80 - 120	<10	mg/L	NC (1)	20
8067243	Biochemical Oxygen Demand	2015/10/08			99	85 - 115	<6.0	mg/L	18 (1)	20
8067726	Biochemical Oxygen Demand	2015/10/08			99	85 - 115	<6.0	mg/L	2.6 (1)	20
8067890	Total Phosphorus (P)	2015/10/09	NC (2)	80 - 120	99	80 - 120	<0.0050	mg/L	0.76 (1)	20
8068004	Nitrate plus Nitrite (N)	2015/10/08	108 (3)	80 - 120	99	80 - 120	<0.10	mg/L	NC (4)	25
8068005	Nitrite (N)	2015/10/08	104 (3)	80 - 120	97	80 - 120	<0.10	mg/L	NC (4)	20
8068060	Orthophosphate (P)	2015/10/08	92 (3)	80 - 120	89	80 - 120	<0.10	mg/L	NC (4)	20
8068165	Dissolved Chloride (Cl)	2015/10/08	102 (5)	80 - 120	101	80 - 120	<0.50	mg/L	NC (7)	20
8068167	Dissolved Sulphate (SO4)	2015/10/08	98 (5)	80 - 120	91	80 - 120	<0.50	mg/L	NC (7)	20
8068696	Total Oil and grease	2015/10/09			98	70 - 130	<1.0	mg/L		
8068823	Dissolved Aluminum (Al)	2015/10/14	105 (8)	80 - 120	105	80 - 120	<3.0	ug/L	NC (9)	20
8068823	Dissolved Antimony (Sb)	2015/10/14	110 (8)	80 - 120	102	80 - 120	<0.50	ug/L	NC (9)	20
8068823	Dissolved Arsenic (As)	2015/10/14	103 (8)	80 - 120	101	80 - 120	<0.10	ug/L	NC (9)	20
8068823	Dissolved Barium (Ba)	2015/10/14	NC (8)	80 - 120	98	80 - 120	<1.0	ug/L	4.9 (9)	20
8068823	Dissolved Beryllium (Be)	2015/10/14	110 (8)	80 - 120	103	80 - 120	<0.10	ug/L	NC (9)	20
8068823	Dissolved Bismuth (Bi)	2015/10/14	103 (8)	80 - 120	102	80 - 120	<1.0	ug/L	NC (9)	20
8068823	Dissolved Boron (B)	2015/10/14					<50	ug/L	NC (9)	20
8068823	Dissolved Cadmium (Cd)	2015/10/14	101 (8)	80 - 120	98	80 - 120	<0.010	ug/L	NC (9)	20
8068823	Dissolved Chromium (Cr)	2015/10/14	100 (8)	80 - 120	102	80 - 120	<1.0	ug/L	NC (9)	20
8068823	Dissolved Cobalt (Co)	2015/10/14	101 (8)	80 - 120	101	80 - 120	<0.50	ug/L	NC (9)	20
8068823	Dissolved Copper (Cu)	2015/10/14	106 (8)	80 - 120	102	80 - 120	<0.20	ug/L	NC (9)	20
8068823	Dissolved Iron (Fe)	2015/10/14	107 (8)	80 - 120	115	80 - 120	<5.0	ug/L	NC (9)	20
8068823	Dissolved Lead (Pb)	2015/10/14	108 (8)	80 - 120	104	80 - 120	<0.20	ug/L	NC (9)	20
8068823	Dissolved Lithium (Li)	2015/10/14	104 (8)	80 - 120	101	80 - 120	<5.0	ug/L	NC (9)	20

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Maxxam Job #: B588841
Report Date: 2015/10/19

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8068823	Dissolved Manganese (Mn)	2015/10/14	NC (8)	80 - 120	102	80 - 120	<1.0	ug/L	0.84 (9)	20
8068823	Dissolved Molybdenum (Mo)	2015/10/14	NC (8)	80 - 120	98	80 - 120	<1.0	ug/L	NC (9)	20
8068823	Dissolved Nickel (Ni)	2015/10/14	100 (8)	80 - 120	103	80 - 120	<1.0	ug/L	NC (9)	20
8068823	Dissolved Selenium (Se)	2015/10/14	101 (8)	80 - 120	98	80 - 120	<0.10	ug/L	5.9 (9)	20
8068823	Dissolved Silicon (Si)	2015/10/14					<100	ug/L	0.61 (9)	20
8068823	Dissolved Silver (Ag)	2015/10/14	113 (8)	80 - 120	93	80 - 120	<0.020	ug/L	NC (9)	20
8068823	Dissolved Strontium (Sr)	2015/10/14	NC (8)	80 - 120	100	80 - 120	<1.0	ug/L	4.5 (9)	20
8068823	Dissolved Thallium (Tl)	2015/10/14	91 (8)	80 - 120	92	80 - 120	<0.050	ug/L	NC (9)	20
8068823	Dissolved Tin (Sn)	2015/10/14	103 (8)	80 - 120	100	80 - 120	<5.0	ug/L	NC (9)	20
8068823	Dissolved Titanium (Ti)	2015/10/14	94 (8)	80 - 120	101	80 - 120	<5.0	ug/L	NC (9)	20
8068823	Dissolved Uranium (U)	2015/10/14	108 (8)	80 - 120	103	80 - 120	<0.10	ug/L	NC (9)	20
8068823	Dissolved Vanadium (V)	2015/10/14	101 (8)	80 - 120	98	80 - 120	<5.0	ug/L	NC (9)	20
8068823	Dissolved Zinc (Zn)	2015/10/14	107 (8)	80 - 120	104	80 - 120	<5.0	ug/L	NC (9)	20
8068823	Dissolved Zirconium (Zr)	2015/10/14					<0.50	ug/L	NC (9)	20
8069011	Chemical Oxygen Demand	2015/10/10	97 (10)	80 - 120	98	80 - 120	<10	mg/L	NC (11)	20
8069742	Total Nitrogen (N)	2015/10/13	NC (12)	80 - 120	94	80 - 120	<0.020	mg/L	2.2 (13)	20
8069744	Total Nitrogen (N)	2015/10/13	NC	80 - 120	95	80 - 120	<0.020	mg/L	2.3 (1)	20
8069794	2-Methylnaphthalene	2015/10/10	90	50 - 130	86	50 - 130	<0.10	ug/L	NC (1)	40
8069794	Acenaphthene	2015/10/10	NC	50 - 130	89	50 - 130	<0.050	ug/L	NC (1)	40
8069794	Acenaphthylene	2015/10/10	91	50 - 130	91	50 - 130	<0.050	ug/L	NC (1)	40
8069794	Acridine	2015/10/10	95	50 - 130	93	50 - 130	<0.050	ug/L	NC (1)	40
8069794	Anthracene	2015/10/10	84	60 - 130	87	60 - 130	<0.010	ug/L	NC (1)	40
8069794	Benzo(a)anthracene	2015/10/10	86	60 - 130	88	60 - 130	<0.010	ug/L	NC (1)	40
8069794	Benzo(a)pyrene	2015/10/10	86	60 - 130	90	60 - 130	<0.0090	ug/L	NC (1)	40
8069794	Benzo(b&j)fluoranthene	2015/10/10	85	60 - 130	88	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Benzo(g,h,i)perylene	2015/10/10	80	60 - 130	91	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Benzo(k)fluoranthene	2015/10/10	82	60 - 130	86	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Chrysene	2015/10/10	90	60 - 130	91	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Dibenz(a,h)anthracene	2015/10/10	81	60 - 130	91	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Fluoranthene	2015/10/10	80	60 - 130	79	60 - 130	<0.020	ug/L	NC (1)	40

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Maxxam Job #: B588841
Report Date: 2015/10/19

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8069794	Fluorene	2015/10/10	81	50 - 130	80	50 - 130	<0.050	ug/L	NC (1)	40
8069794	Indeno(1,2,3-cd)pyrene	2015/10/10	82	60 - 130	92	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Naphthalene	2015/10/10	85	50 - 130	87	50 - 130	<0.10	ug/L	NC (1)	40
8069794	Phenanthrene	2015/10/10	88	60 - 130	86	60 - 130	<0.050	ug/L	NC (1)	40
8069794	Pyrene	2015/10/10	82	60 - 130	82	60 - 130	<0.020	ug/L	NC (1)	40
8069794	Quinoline	2015/10/10	92	50 - 130	106	50 - 130	<0.24	ug/L	NC (1)	40
8069797	EPH (C10-C19)	2015/10/11	101	50 - 130	93	50 - 130	<0.20	mg/L	NC (1)	30
8069797	EPH (C19-C32)	2015/10/11	119	50 - 130	111	50 - 130	<0.20	mg/L	NC (1)	30
8069965	Dissolved Chloride (Cl)	2015/10/09	99	80 - 120	101	80 - 120	<0.50	mg/L	0.57 (1)	20
8069967	Dissolved Sulphate (SO4)	2015/10/09	NC	80 - 120	98	80 - 120	<0.50	mg/L	4.5 (1)	20
8070054	Alkalinity (PP as CaCO3)	2015/10/10					<0.50	mg/L	NC (1)	20
8070054	Alkalinity (Total as CaCO3)	2015/10/10	NC	80 - 120	97	80 - 120	<0.50	mg/L	8.3 (1)	20
8070054	Bicarbonate (HCO3)	2015/10/10					<0.50	mg/L	8.3 (1)	20
8070054	Carbonate (CO3)	2015/10/10					<0.50	mg/L	NC (1)	20
8070054	Hydroxide (OH)	2015/10/10					<0.50	mg/L	NC (1)	20
8070057	pH	2015/10/10			101	97 - 103			0.12 (1)	N/A
8070059	Conductivity	2015/10/10			101	80 - 120	<1.0	uS/cm	8.4 (1)	20
8070271	Total Suspended Solids	2015/10/13	105	80 - 120	99	80 - 120	<4.0	mg/L	NC (1)	20
8070333	Total Dissolved Solids	2015/10/14	98 (14)	80 - 120	98	80 - 120	18, RDL=10	mg/L	15 (15)	20
8070663	Sulphide	2015/10/10			81	80 - 120	<0.0019	mg/L	NC (1)	20
8071637	Dissolved Chloride (Cl)	2015/10/09			102	80 - 120	<0.50	mg/L	1.1 (1)	20
8071651	Dissolved Sulphate (SO4)	2015/10/09	116	80 - 120	98	80 - 120	<0.50	mg/L	14 (1)	20
8071654	Total Dissolved Solids	2015/10/14	NC	80 - 120	116	80 - 120	16, RDL=10	mg/L	5.8 (1)	20
8071670	Total Suspended Solids	2015/10/14	110	80 - 120	101	80 - 120	<4.0	mg/L	NC (1)	20
8071672	Total Suspended Solids	2015/10/16	109	80 - 120	103	80 - 120	<4.0	mg/L	NC (1)	20
8073701	Total Aluminum (Al)	2015/10/16	101 (16)	80 - 120	100	80 - 120	3.2, RDL=3.0	ug/L	NC (17)	20
8073701	Total Antimony (Sb)	2015/10/16	107 (16)	80 - 120	100	80 - 120	<0.50	ug/L	NC (17)	20
8073701	Total Arsenic (As)	2015/10/16	99 (16)	80 - 120	104	80 - 120	<0.10	ug/L	NC (17)	20
8073701	Total Barium (Ba)	2015/10/16	NC (16)	80 - 120	106	80 - 120	<1.0	ug/L	9.4 (17)	20
8073701	Total Beryllium (Be)	2015/10/16	104 (16)	80 - 120	103	80 - 120	<0.10	ug/L	NC (17)	20

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Maxxam Job #: B588841
Report Date: 2015/10/19

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8073701	Total Bismuth (Bi)	2015/10/16	93 (16)	80 - 120	88	80 - 120	<1.0	ug/L	NC (17)	20
8073701	Total Boron (B)	2015/10/16					<50	ug/L	NC (17)	20
8073701	Total Cadmium (Cd)	2015/10/16	98 (16)	80 - 120	94	80 - 120	<0.010	ug/L	NC (17)	20
8073701	Total Chromium (Cr)	2015/10/16	98 (16)	80 - 120	99	80 - 120	<1.0	ug/L	NC (17)	20
8073701	Total Cobalt (Co)	2015/10/16	98 (16)	80 - 120	97	80 - 120	<0.50	ug/L	NC (17)	20
8073701	Total Copper (Cu)	2015/10/16	93 (16)	80 - 120	100	80 - 120	<0.50	ug/L	NC (17)	20
8073701	Total Iron (Fe)	2015/10/16	102 (16)	80 - 120	111	80 - 120	12, RDL=10	ug/L	NC (17)	20
8073701	Total Lead (Pb)	2015/10/16	94 (16)	80 - 120	92	80 - 120	<0.20	ug/L	NC (17)	20
8073701	Total Lithium (Li)	2015/10/16	95 (16)	80 - 120	95	80 - 120	<5.0	ug/L	NC (17)	20
8073701	Total Manganese (Mn)	2015/10/16	NC (16)	80 - 120	101	80 - 120	<1.0	ug/L	6.1 (17)	20
8073701	Total Molybdenum (Mo)	2015/10/16	NC (16)	80 - 120	86	80 - 120	<1.0	ug/L	NC (17)	20
8073701	Total Nickel (Ni)	2015/10/16	94 (16)	80 - 120	98	80 - 120	<1.0	ug/L	NC (17)	20
8073701	Total Selenium (Se)	2015/10/16	88 (16)	80 - 120	93	80 - 120	<0.10	ug/L	NC (17)	20
8073701	Total Silicon (Si)	2015/10/16					<100	ug/L	2.0 (17)	20
8073701	Total Silver (Ag)	2015/10/16	94 (16)	80 - 120	100	80 - 120	<0.020	ug/L	NC (17)	20
8073701	Total Strontium (Sr)	2015/10/16	NC (16)	80 - 120	94	80 - 120	<1.0	ug/L	7.0 (17)	20
8073701	Total Thallium (Tl)	2015/10/16	96 (16)	80 - 120	86	80 - 120	<0.050	ug/L	NC (17)	20
8073701	Total Tin (Sn)	2015/10/16	NC (16)	80 - 120	110	80 - 120	<5.0	ug/L	NC (17)	20
8073701	Total Titanium (Ti)	2015/10/16	104 (16)	80 - 120	105	80 - 120	<5.0	ug/L	NC (17)	20
8073701	Total Uranium (U)	2015/10/16	94 (16)	80 - 120	90	80 - 120	<0.10	ug/L	NC (17)	20
8073701	Total Vanadium (V)	2015/10/16	100 (16)	80 - 120	97	80 - 120	<5.0	ug/L	NC (17)	20
8073701	Total Zinc (Zn)	2015/10/16	85 (16)	80 - 120	114	80 - 120	<5.0	ug/L	NC (17)	20
8073701	Total Zirconium (Zr)	2015/10/16					<0.50	ug/L	NC (17)	20
8074137	Total Ammonia (N)	2015/10/14	101	80 - 120	103	80 - 120	<0.0050	mg/L	NC (1)	20
8075072	Alkalinity (PP as CaCO3)	2015/10/10					<0.50	mg/L	NC (1)	20
8075072	Alkalinity (Total as CaCO3)	2015/10/10	107	80 - 120	94	80 - 120	0.58, RDL=0.50	mg/L	NC (1)	20
8075072	Bicarbonate (HCO3)	2015/10/10					0.71, RDL=0.50	mg/L	NC (1)	20
8075072	Carbonate (CO3)	2015/10/10					<0.50	mg/L	NC (1)	20
8075072	Hydroxide (OH)	2015/10/10					<0.50	mg/L	NC (1)	20
8075077	pH	2015/10/10			101	97 - 103			0.37 (19)	N/A

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Report Date: 2015/10/19

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8075078	Conductivity	2015/10/10			100	80 - 120	<1.0	uS/cm	8.9 (19)	20
8076419	Dissolved Mercury (Hg)	2015/10/16	83	80 - 120	97	80 - 120	<0.010	ug/L	NC (1)	20
8076829	Total Mercury (Hg)	2015/10/18	90	80 - 120	93	80 - 120	<0.010	ug/L	NC (1)	20
8077103	Weak Acid Dissoc. Cyanide (CN)	2015/10/16	99	80 - 120	98	80 - 120	<0.00050	mg/L	NC (1)	20
8077145	Phenols	2015/10/16	99	80 - 120	98	80 - 120	<0.0010	mg/L	NC (1)	20
8078653	Dissolved Mercury (Hg)	2015/10/18	85 (20)	80 - 120	87	80 - 120	<0.010	ug/L	NC (21)	20

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Duplicate Parent ID

(2) Matrix Spike Parent ID [NI3985-06]

(3) Matrix Spike Parent ID [NI4001-02]

(4) Duplicate Parent ID [NI4001-02]

(5) Matrix Spike Parent ID [NI4000-02]

(6) Duplicate Parent ID [NI3986-02]

(7) Duplicate Parent ID [NI4000-02]

(8) Matrix Spike Parent ID [NI3991-04]

(9) Duplicate Parent ID [NI3991-04]

(10) Matrix Spike Parent ID [NI3989-06]

(11) Duplicate Parent ID [NI3989-06]

(12) Matrix Spike Parent ID [NI3991-06]

(13) Duplicate Parent ID [NI3991-06]

(14) Matrix Spike Parent ID [NI3991-02]

(15) Duplicate Parent ID [NI3984-02]

(16) Matrix Spike Parent ID [NI3999-04]

(17) Duplicate Parent ID [NI3999-04]

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
(18) Duplicate Parent ID [NI3985-02]										
(19) Duplicate Parent ID [NI3988-04]										
(20) Matrix Spike Parent ID [NI3984-05]										
(21) Duplicate Parent ID [NI3984-05]										

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GHD Limited
Client Project #: 088877-02-01
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: TE

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Data Validation Coordinator

Winnie Au, B.Sc., Supervisor - Water Lab

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Maxxam Analytics International Corporation o/a Maxxam Analytics
4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-Free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#163 GHD Limited	Company Name	#27087 GHD Limited	Quotation #	B31426	Maxxam Job #	Bottle Order #:
Contact Name	Airesse MacPhee	Contact Name	Airesse MacPhee	P.O. #		B588841	478427
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address	179 Colonnade Road, Suite 400 Ottawa ON K2E 7J4	Project #	088877-02-01	Chain Of Custody Record	Project Manager
Phone	(519) 884-0510 Fax: (519) 725-1394	Phone	(613) 727-0510 Fax:	Project Name		C#478427-01-01	Tabitha Rudkin
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email	amacphee@CRAworld.com	Site #			
				Sampled By			

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other _____

Special Instructions

SAMPLES MUST BE KEPT COOL (10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: _____ ☐
Rush Confirmation Number: _____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	Cyanide SAD, Sulphide-LL	CSR Dissolved Metals in Water with CV Hg	CSR Total Metals in Water with CV Hg	Phenols (4-AAP)	LEPH/HEPH/PAH,TOG	Total oil & grease	# of Bottles	Comments
1	N13984	WG-88877-05102015-TE-01	5/10/15	1130	W	Y	X	X	X	X	X					8	
2	N13985	-02		1230			X	X	X	X	X					8	
3	N13986	-03		1345			X	X	X	X	X					8	
4	N13987	-04		1500			X	X	X	X	X			X	X	11	
5	N13988	-05		1630			X	X	X	X	X			X	X	11	
6	N13989	WG-88877-06102015-TE-07	6/10/15	830			X	X	X	X	X					8	
7	N13990	-08		900			X	X	X	X	X					8	
8	N13991	-09		905			X	X	X	X	X					8	1x 1L bottle filled for Gen Chem instead of 250 mL
9																	
10																	

B588841

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)*	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Present on Cooler?
Jamie Stewart	15/10/06	1200		2015/10/08	09:40		☐	6,6 / 4,5,6	☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam Analytics International Corporation o/a Maxxam Analytics
4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-Free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

Chain Of Custody Record

Page 2 of 2

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#163 GHD Limited	Company Name	#27087 GHD Limited	Quotation #	B31426	Maxxam Job #	Bottle Order #:
Contact Name	Airesse MacPhee	Contact Name	Airesse MacPhee	P.O. #		B588841	478427
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address	179 Colonnade Road, Suite 400 Ottawa ON K2E 7J4	Project #	088877-02-01	Chain Of Custody Record	Project Manager
Phone	(519) 884-0510 Fax: (519) 725-1394	Phone	(613) 727-0510 Fax:	Project Name		C#478427-02-01	Tabitha Rudkin
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email	amacphee@CRAworld.com	Site #			
				Sampled By			

Regulatory Criteria:
- ☐ CSR
- ☐ CCME
- ☐ BC Water Quality
- ☐ Other _____

Special Instructions

SAMPLES MUST BE KEPT COOL (≤ 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: _____
Rush Confirmation Number: _____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	Cyanide SAD, Sulphide-LL	CSR Dissolved Metals in Water with CV Hg	CSR Total Metals in Water with CV Hg	Phenols (4-AAP)	LEPH/HEPH/PAH,TOG			# of Bottles	Comments
1	N13999	WS-88877-0510205-TE-06	5/10/15	1600	W	N	X	X	X	X		X					8	
2	N14000	WS-88877-0610205-TE-10	6/10/15	1145	↓	↓	X	X	X	X		X					~~9~~ 8	2 x 120 mL used for Gen Chem. instead of 1 x 250 mL
3	N14001	-11	↓	1200	↓	↓	X	X	X	X		X					9	↓
4																		
5																		
6																		
7																		
8																		
9																		
10																		

B588841

* * RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
Jamie Stewart	15/10/06	12:00	[illegible]	2015/10/08	09:40		☐	6.6 / 4.5	☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

III changes made by Rose Marie Rocca [illegible] on Oct 9 2015

Maxxam Analytics International Corporation o/a Maxxam Analytics
8800 Glenlyon Way, Burnaby, British Columbia Canada V5J 5K5 Tel (604) 734 7276 Toll Free 800 665 8566 Fax (604) 731 2386 www.maxxam.ca

Chain Of Custody Record

Page 1 of 2

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#163 GHD Limited	Company Name	#27067 GHD Limited	Quotation #	B31426	Maxxam Job #	Bottle Order #
Contact Name	Alexsse MacPhee	Contact Name	Alexsse MacPhee	P.O. #		B588841	470427
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address	179 Colonnade Road, Suite 400 Ottawa ON K2E 7J4	Project #	088877-02-01	Chain Of Custody Record	Project Manager
Phone	(519) 884-0510 Fax (519) 725-1394	Phone	(613) 727-0618 Fax	Project Name	Uplands	C#470427-01-01	Tabitha Burton
Email	alexsse.macphee@ghd.com; NationalEDDSupport@ma	Email	amacphee@CRAworld.com	Site #			
				Sampled By	Thomas Elliott		

Regulatory Criteria: ☐ CWR ☐ CCME ☒ MTVWater Quality ☐ Other _____

Special Instructions

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required

Please provide advance notice for rush projects

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests
Please note: Standard TAT for certain tests such as BOD and Dissolved Metals are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission): 1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: _____ ☐
Rush Confirmation Number: _____
Total (40 for 8)

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

	Sample Barcode Label	Sample Location Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	Cyanide SAD, Sulphide-LL	CSR Dissolved Metals in Water with CV Hg	CSR Total Metals in Water with CV Hg	Phenols (4-AAP)	LEPH/HEPH/PAH, TOG	Total oil & grease	Ref. Bottles	Comments
1	NI 3984	WG-88877-05102015-TE-01	5/10/15	1130	W	Y	X	X	X	X	X					8	
2	NI 3985	-02		1230			X	X	X	X	X					8	
3	NI 3986	-03		1345			X	X	X	X	X					8	
4	NI 3987	-04		1500			X	X	X	X	X		X	X	X	11	
5	NI 3988	-05		1630			X	X	X	X	X		X	X	X	11	
6	NI 3989	WG-88877-06102015-TE-07	6/10/15	830			X	X	X	X	X					8	
7	NI 3990	-08		900			X	X	X	X	X					8	
8	NI 3991	-09		905			X	X	X	X	X					8	Gen Chem instead of 250 mL
9																	
10																	

B588841

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only
[signature] Jessie Stewart	15/10/06	1200	[signature]	06/10/08	09:40		Time Sensitive ☐ Temperature (°C) on Receipt 6.6 / 4.6 Custody Seal Present on Cooler? ☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

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III changes made by Rose Marie Rocca Kent on Oct 9 2015

MAXXAM — Maxxam Analytics International Corporation o/a Maxxam Analytics
8909 Canada Way, Burnaby, British Columbia Canada V5G 1K6 Tel (604) 734 7276 Toll Free 800-663-6266 Fax (604) 731 2386

Chain Of Custody Record Page 1 of 2

INVOICE TO:
Company Name: #163 GHD Limited
Contact Name: Airesse MacPhee
Address: 651 COLBY DRIVE, WATERLOO ON N2V 1C2
Phone: (519) 884-0510 Fax: (519) 725-1394
Email: airesse.macphee@ghd.com; NationalEDDSupport@ma

Report Information:
Company Name: #27087 GHD Limited
Contact Name: Airesse MacPhee
Address: 179 Colonnade Road, Suite 400, Ottawa ON K2E 7J4
Phone: (613) 727-0510 Fax:
Email: amacphee@CRAworld.com

Project Information:
Quotation #: B31426
P.O. #:
Project #: 088877-02-01
Project Name: Uplands
Site #:
Sampled By: Thomas Elliott

Laboratory Use Only:
Maxxam Job #: B588841
Bottle Order #:
Chain Of Custody Record:
Project Manager:
Turnaround Time (TAT) Required: Regular (Standard) TAT:

Regulatory Criteria: ☐ CSR ☐ CCME ☒ BC Water Quality ☐ Other

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

	Sample Bottle Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered? (Y/N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, Ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	Cyanide SAD, Sulphide-LL	CSR Dissolved Metals in Water with CV Hg	CSR Total Metals in Water with CV Hg	Phenols (4-AAP)	LEPH/HEPH/PAH/TOG	COP	# of Bottles	Comments
1	N13999	WS-88877-05102015-TE-06	5/10/15	1600	W	N	X	X	X	X		X				8	
2	N14000	WS-88877-06102015-TE-10	6/10/15	1145	↓	↓	X	X	X	X		X				8 9	2 x 120 mL used for Gen Chem. instead of 1 x 250 mL
3	N14001	↓ -11	↓	1200	↓	↓	X	X							X	9	↓
4																	
5																	
6																	
7																	
8																	
9																	
10																	

B588841

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	* RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
Jamie Stewart	15/10/06	12:00		15/10/08	09:40		6.6 / 4.5	☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

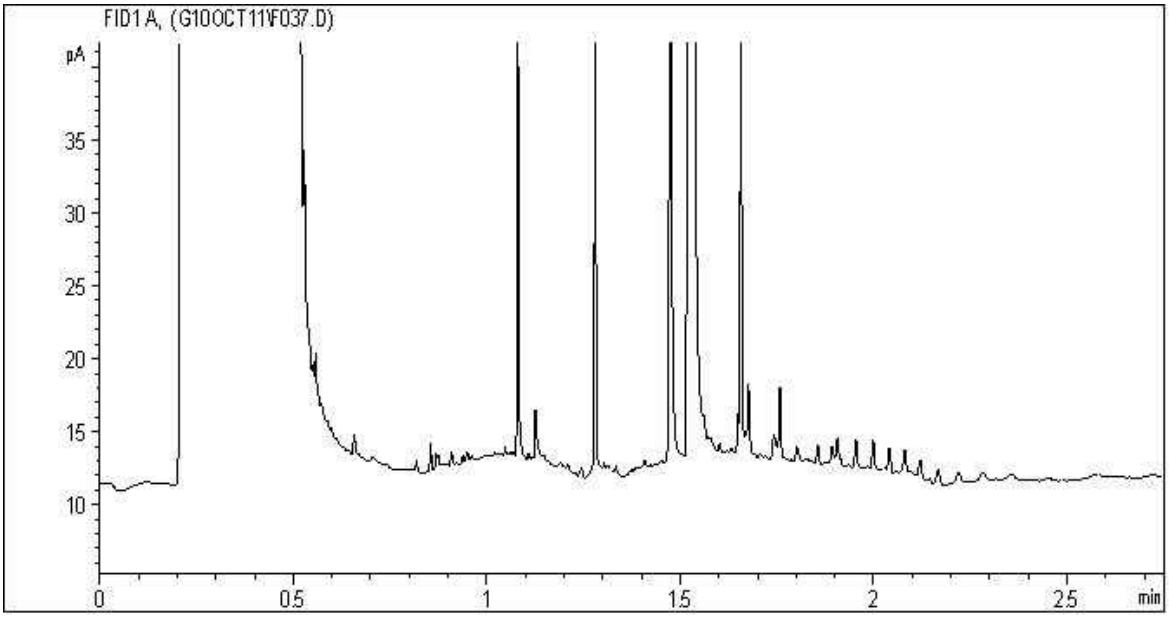
Maxxam Analytics International Corporation o/a Maxxam Analytics

SAMANTHA FREGIEN, BSc
Project Manager

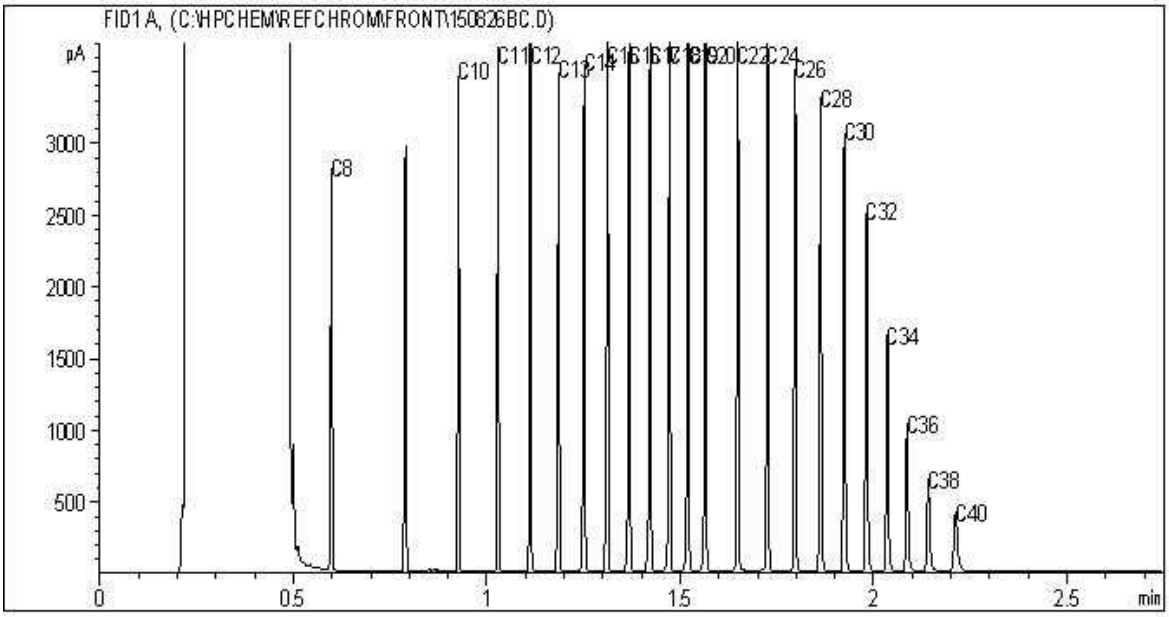
Maxxam Job #: B588841
Report Date: 2015/10/19
Maxxam Sample: NI3987

GHD Limited
Client Project #: 088877-02-01
Site Reference: UPLAND LANDFILL
Client ID: WG-88877-05102015-TE-04

EPH in Water when PAH required Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

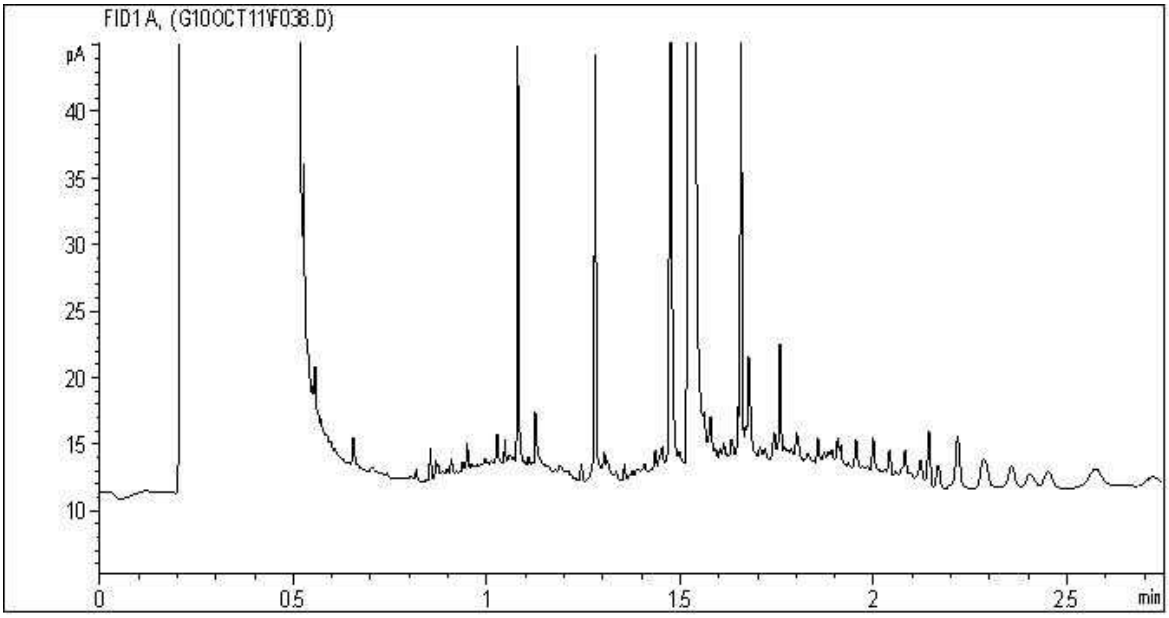
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

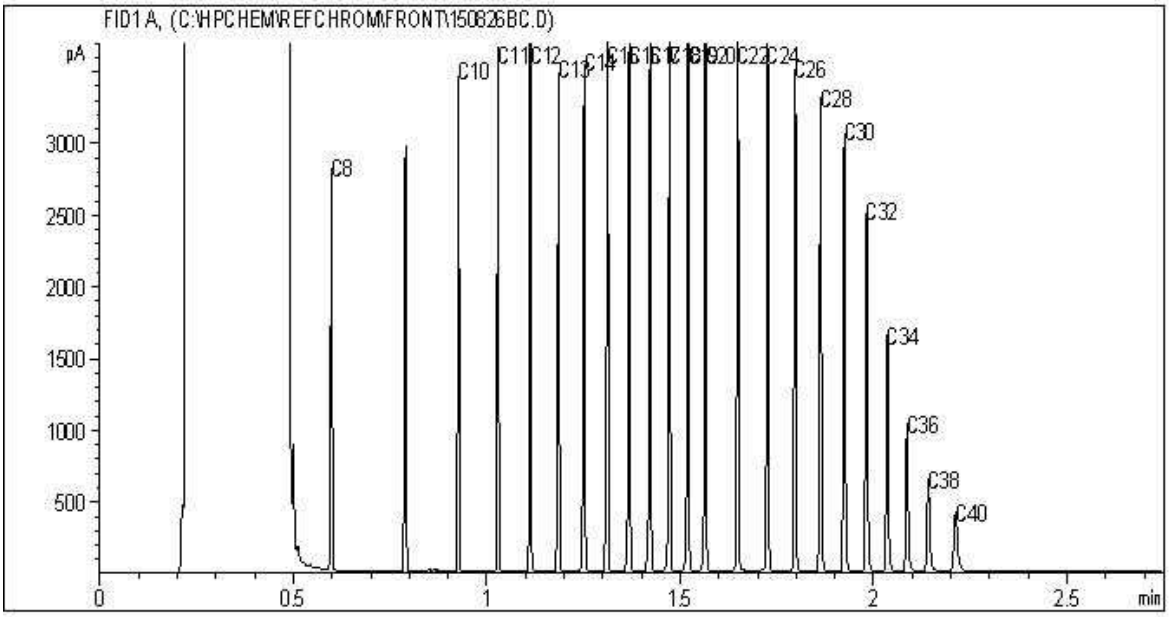
Maxxam Job #: B588841
Report Date: 2015/10/19
Maxxam Sample: NI3988

GHD Limited
Client Project #: 088877-02-01
Site Reference: UPLAND LANDFILL
Client ID: WG-88877-05102015-TE-05

EPH in Water when PAH required Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name Simon Foster/James Stewart

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code : C#486392-01-01

Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Sample Type	Sample Matrix	Grab or Composite	Start Depth (ft bgs)	End Depth (ft bgs)	Parent Sample ID for Field Dups	Footnote(s)
SW-88877-290116-JS-01	Wash Plant	1/29/2016	9:30	SW		Grab				

Footnotes

1. Sampled using high flow methodology
2. Sampled using low flow methodolgy
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name Simon Foster/James Stewart

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code : C#486392-01-01

					pH	Temperature			Conductivity		Turbidity		TDS				Eh / ORP	
Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Volume of Water Purged	Field pH	Sample Temp.	Ambient Temp.	Temp Units	Conductivity	Conductivity Units	Turbidity	Turbidity Units	TDS	Units	DO	Units	Eh/ORP	Eh/ORP Units
SW-88877-290116-JS-01	Wash Plant	1/29/2016	9:30		8.35	5.58		C	0.072	uS	OOR	ntu	0.847	mg/L	13.8	mg/L	182	mV

Footnotes

1. Sampled using high flow methodology
2. Sampled using low flow methodolgy
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your P.O. #: 73500976-1
Your Project #: 088877
Site Location: UPLAND LANDFILL
Your C.O.C. #: 486392-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2016/02/09
Report #: R2127940
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B607136
Received: 2016/01/30, 14:56

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	1	2016/02/01	2016/02/01	BBY6SOP-00026	SM 22 2320 B m
Biochemical Oxygen Demand	1	2016/02/01	2016/02/01	BBY6SOP-00045	SM 22 5210 B m
Chloride by Automated Colourimetry	1	N/A	2016/02/01	BBY6SOP-00011	SM 22 4500-Cl- G m
COD by Colorimeter	1	2016/02/02	2016/02/03	BBY6SOP-00024	SM 22 5220 D m
Conductance - water	1	N/A	2016/02/01	BBY6SOP-00026	SM 22 2510 B m
Sulphide (as H2S) (1)	1	N/A	2016/02/08	AB WI-00065	Auto Calc
Hardness (calculated as CaCO3)	1	N/A	2016/02/02	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	1	N/A	2016/02/03	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Ion Balance	1	N/A	2016/02/02	BBY WI-00033	SM 22 1030E
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	1	N/A	2016/02/02	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	1	N/A	2016/02/01	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	1	2016/02/02	2016/02/03	BBY6SOP-00016	SM 22 4500-N C m
Ammonia-N (Preserved)	1	N/A	2016/02/02	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N) (highlevel)	1	N/A	2016/01/30	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA (highlevel)	1	N/A	2016/01/30	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	1	N/A	2016/02/02	BBY6SOP-00010	SM 22 4500-NO3 I m
Filter and HNO3 Preserve for Metals	1	N/A	2016/02/03	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (2)	1	N/A	2016/02/01	BBY6SOP-00026	SM 22 4500-H+ B m
Orthophosphate by Konelab (highlevel)	1	N/A	2016/01/30	BBY6SOP-00013	SM 22 4500-P E m
Sulphide (1)	1	N/A	2016/02/08	EENVSOP-00096	SM 22 4500-S2 D m
Sulphate by Automated Colourimetry	1	N/A	2016/02/01	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	1	2016/02/02	2016/02/03	BBY6SOP-00033	SM 22 2540 C m
TKN (Calc. TN, N/N) total	1	N/A	2016/02/03	BBY WI-00033	Calculation
Total Phosphorus	1	N/A	2016/02/02	BBY6SOP-00013	SM 22 4500-P E m
Total Suspended Solids	1	N/A	2016/02/03	BBY6SOP-00034	SM 22 2540 D

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Edmonton Environmental

(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your P.O. #: 73500976-1
Your Project #: 088877
Site Location: UPLAND LANDFILL
Your C.O.C. #: 486392-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2016/02/09
Report #: R2127940
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B607136
Received: 2016/01/30, 14:56

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Tabitha Rudkin, AScT, Burnaby Project Manager
Email: TRudkin@maxxam.ca
Phone# (604)638-2639

==========

This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B607136
Report Date: 2016/02/09

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		OA7684		
Sampling Date		2016/01/29 09:30		
COC Number		486392-01-01		
	UNITS	SW-88877-290116-JS-01	RDL	QC Batch
Calculated Parameters				
Ion Balance	N/A	1.0	0.010	8179563
Sulphide (as H2S)	mg/L	0.0080	0.0020	8186073
Demand Parameters				
Biochemical Oxygen Demand	mg/L	<6.0	6.0	8180164
Chemical Oxygen Demand	mg/L	<10	10	8181224
Misc. Inorganics				
Alkalinity (Total as CaCO3)	mg/L	23.6	0.50	8180424
Alkalinity (PP as CaCO3)	mg/L	<0.50	0.50	8180424
Bicarbonate (HCO3)	mg/L	28.8	0.50	8180424
Carbonate (CO3)	mg/L	<0.50	0.50	8180424
Hydroxide (OH)	mg/L	<0.50	0.50	8180424
Anions				
Sulphide	mg/L	0.0078 (1)	0.0019	8186189
Nutrients				
Total Ammonia (N)	mg/L	0.016	0.0050	8181543
Total Phosphorus (P)	mg/L	0.0738	0.0050	8182316
Physical Properties				
Conductivity	uS/cm	65.5	1.0	8180426
pH	pH	7.63	N/A	8180425
Physical Properties				
Total Suspended Solids	mg/L	20.0	4.0	8180947
Total Dissolved Solids	mg/L	32	10	8180757

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Sample was analyzed after holding time expired.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B607136
Report Date: 2016/02/09

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		OA7684	OA7684		
Sampling Date		2016/01/29 09:30	2016/01/29 09:30		
COC Number		486392-01-01	486392-01-01		
	UNITS	**SW-88877-290116-JS-01**	**SW-88877-290116-JS-01 Lab-Dup**	**RDL**	**QC Batch**
ANIONS					
Nitrite (N)	mg/L	<0.10	<0.10	0.10	8180972
Calculated Parameters					
Nitrate (N)	mg/L	<0.10	N/A	0.10	8179513
Anions					
Dissolved Sulphate (SO4)	mg/L	4.94	N/A	0.50	8180386
Dissolved Chloride (Cl)	mg/L	3.6	N/A	0.50	8180385
Nutrients					
Orthophosphate (P)	mg/L	<0.10	<0.10	0.10	8180161
Nitrate plus Nitrite (N)	mg/L	<0.10	<0.10	0.10	8180971

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B607136
Report Date: 2016/02/09

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		OA7684		
Sampling Date		2016/01/29 09:30		
COC Number		486392-01-01		
	UNITS	SW-88877-290116-JS-01	RDL	QC Batch
Calculated Parameters				
Filter and HNO3 Preservation	N/A	FIELD	N/A	ONSITE
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	26.8	0.50	8179312
Elements				
Dissolved Mercury (Hg)	ug/L	<0.010	0.010	8182207
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	53.2	3.0	8180047
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	8180047
Dissolved Arsenic (As)	ug/L	0.18	0.10	8180047
Dissolved Barium (Ba)	ug/L	2.0	1.0	8180047
Dissolved Beryllium (Be)	ug/L	<0.10	0.10	8180047
Dissolved Bismuth (Bi)	ug/L	<1.0	1.0	8180047
Dissolved Boron (B)	ug/L	<50	50	8180047
Dissolved Cadmium (Cd)	ug/L	<0.010	0.010	8180047
Dissolved Chromium (Cr)	ug/L	<1.0	1.0	8180047
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	8180047
Dissolved Copper (Cu)	ug/L	0.38	0.20	8180047
Dissolved Iron (Fe)	ug/L	11.8	5.0	8180047
Dissolved Lead (Pb)	ug/L	<0.20	0.20	8180047
Dissolved Lithium (Li)	ug/L	<5.0	5.0	8180047
Dissolved Manganese (Mn)	ug/L	20.9	1.0	8180047
Dissolved Molybdenum (Mo)	ug/L	<1.0	1.0	8180047
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	8180047
Dissolved Selenium (Se)	ug/L	0.12	0.10	8180047
Dissolved Silicon (Si)	ug/L	1110	100	8180047
Dissolved Silver (Ag)	ug/L	<0.020	0.020	8180047
Dissolved Strontium (Sr)	ug/L	18.7	1.0	8180047
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	8180047
Dissolved Tin (Sn)	ug/L	<5.0	5.0	8180047
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	8180047
Dissolved Uranium (U)	ug/L	<0.10	0.10	8180047
Dissolved Vanadium (V)	ug/L	<5.0	5.0	8180047
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	8180047

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B607136
Report Date: 2016/02/09

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		OA7684		
Sampling Date		2016/01/29 09:30		
COC Number		486392-01-01		
	UNITS	**SW-88877-290116-JS-01**	**RDL**	**QC Batch**
Dissolved Zirconium (Zr)	ug/L	<0.50	0.50	8180047
Dissolved Calcium (Ca)	mg/L	8.13	0.050	8179313
Dissolved Magnesium (Mg)	mg/L	1.58	0.050	8179313
Dissolved Potassium (K)	mg/L	0.231	0.050	8179313
Dissolved Sodium (Na)	mg/L	3.10	0.050	8179313
Dissolved Sulphur (S)	mg/L	<3.0	3.0	8179313
RDL = Reportable Detection Limit				

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Report Date: 2016/02/09

GHD Limited
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Sampler Initials: JS

TOTAL TKN IN WATER (WATER)

Maxxam ID		OA7684		
Sampling Date		2016/01/29 09:30		
COC Number		486392-01-01		
	UNITS	SW-88877-290116-JS-01	RDL	QC Batch
Nutrients				
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.19	0.10	8179587
Total Nitrogen (N)	mg/L	0.190	0.020	8181606
RDL = Reportable Detection Limit				

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Maxxam Job #: B607136
Report Date: 2016/02/09

GHD Limited
Client Project #: 088877
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GENERAL COMMENTS

Results relate only to the items tested.

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Maxxam Job #: B607136
Report Date: 2016/02/09

QUALITY ASSURANCE REPORT

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8180047	Dissolved Aluminum (Al)	2016/02/01	106	80 - 120	109	80 - 120	<3.0	ug/L	10 (1)	20
8180047	Dissolved Antimony (Sb)	2016/02/01	106	80 - 120	110	80 - 120	<0.50	ug/L	NC (1)	20
8180047	Dissolved Arsenic (As)	2016/02/01	NC	80 - 120	105	80 - 120	<0.10	ug/L	1.3 (1)	20
8180047	Dissolved Barium (Ba)	2016/02/01	NC	80 - 120	103	80 - 120	<1.0	ug/L	0.92 (1)	20
8180047	Dissolved Beryllium (Be)	2016/02/01	99	80 - 120	98	80 - 120	<0.10	ug/L	NC (1)	20
8180047	Dissolved Bismuth (Bi)	2016/02/01	99	80 - 120	105	80 - 120	<1.0	ug/L	NC (1)	20
8180047	Dissolved Boron (B)	2016/02/01	NC	80 - 120	93	80 - 120	<50	ug/L	NC (1)	20
8180047	Dissolved Cadmium (Cd)	2016/02/01	106	80 - 120	109	80 - 120	<0.010	ug/L	NC (1)	20
8180047	Dissolved Chromium (Cr)	2016/02/01	104	80 - 120	108	80 - 120	<1.0	ug/L	NC (1)	20
8180047	Dissolved Cobalt (Co)	2016/02/01	100	80 - 120	106	80 - 120	<0.50	ug/L	NC (1)	20
8180047	Dissolved Copper (Cu)	2016/02/01	97	80 - 120	103	80 - 120	<0.20	ug/L	NC (1)	20
8180047	Dissolved Iron (Fe)	2016/02/01	NC	80 - 120	120	80 - 120	<5.0	ug/L	0.91 (1)	20
8180047	Dissolved Lead (Pb)	2016/02/01	113	80 - 120	113	80 - 120	<0.20	ug/L	NC (1)	20
8180047	Dissolved Lithium (Li)	2016/02/01	NC	80 - 120	105	80 - 120	<5.0	ug/L	1.9 (1)	20
8180047	Dissolved Manganese (Mn)	2016/02/01	NC	80 - 120	106	80 - 120	<1.0	ug/L	1.1 (1)	20
8180047	Dissolved Molybdenum (Mo)	2016/02/01	NC	80 - 120	111	80 - 120	<1.0	ug/L	1.6 (1)	20
8180047	Dissolved Nickel (Ni)	2016/02/01	99	80 - 120	104	80 - 120	<1.0	ug/L	NC (1)	20
8180047	Dissolved Selenium (Se)	2016/02/01	103	80 - 120	105	80 - 120	<0.10	ug/L	NC (1)	20
8180047	Dissolved Silicon (Si)	2016/02/01					<100	ug/L	0.040 (1)	20
8180047	Dissolved Silver (Ag)	2016/02/01	106	80 - 120	103	80 - 120	<0.020	ug/L	NC (1)	20
8180047	Dissolved Strontium (Sr)	2016/02/01	NC	80 - 120	115	80 - 120	<1.0	ug/L	1.2 (1)	20
8180047	Dissolved Thallium (Tl)	2016/02/01	103	80 - 120	110	80 - 120	<0.050	ug/L	NC (1)	20
8180047	Dissolved Tin (Sn)	2016/02/01	113	80 - 120	109	80 - 120	<5.0	ug/L	NC (1)	20
8180047	Dissolved Titanium (Ti)	2016/02/01	108	80 - 120	104	80 - 120	<5.0	ug/L	NC (1)	20
8180047	Dissolved Uranium (U)	2016/02/01	110	80 - 120	111	80 - 120	<0.10	ug/L	NC (1)	20
8180047	Dissolved Vanadium (V)	2016/02/01	103	80 - 120	106	80 - 120	<5.0	ug/L	NC (1)	20
8180047	Dissolved Zinc (Zn)	2016/02/01	108	80 - 120	119	80 - 120	<5.0	ug/L	NC (1)	20
8180047	Dissolved Zirconium (Zr)	2016/02/01					<0.50	ug/L	NC (1)	20
8180161	Orthophosphate (P)	2016/01/30	94 (2)	80 - 120	91	80 - 120	<0.10	mg/L	NC (3)	20
8180164	Biochemical Oxygen Demand	2016/02/01			102	85 - 115	<6.0	mg/L	NC (1)	20

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Maxxam Job #: B607136
Report Date: 2016/02/09

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8180385	Dissolved Chloride (Cl)	2016/02/01	101	80 - 120	100	80 - 120	0.51, RDL=0.50	mg/L	0.57 (1)	20
8180386	Dissolved Sulphate (SO4)	2016/02/01	NC	80 - 120	94	80 - 120	0.59, RDL=0.50	mg/L	0.035 (1)	20
8180424	Alkalinity (PP as CaCO3)	2016/02/01					<0.50	mg/L	NC (1)	20
8180424	Alkalinity (Total as CaCO3)	2016/02/01	NC	80 - 120	98	80 - 120	<0.50	mg/L	0.11 (1)	20
8180424	Bicarbonate (HCO3)	2016/02/01					<0.50	mg/L	0.11 (1)	20
8180424	Carbonate (CO3)	2016/02/01					<0.50	mg/L	NC (1)	20
8180424	Hydroxide (OH)	2016/02/01					<0.50	mg/L	NC (1)	20
8180425	pH	2016/02/01			101	97 - 103			0 (1)	N/A
8180426	Conductivity	2016/02/01			100	80 - 120	<1.0	uS/cm	0.17 (1)	20
8180757	Total Dissolved Solids	2016/02/03	102	80 - 120	98	80 - 120	<10	mg/L	5.7 (1)	20
8180947	Total Suspended Solids	2016/02/03	117	80 - 120	104	80 - 120	<4.0	mg/L	NC (1)	20
8180971	Nitrate plus Nitrite (N)	2016/01/30	117 (2)	80 - 120	106	80 - 120	<0.10	mg/L	NC (3)	25
8180972	Nitrite (N)	2016/01/30	107 (2)	80 - 120	100	80 - 120	<0.10	mg/L	NC (3)	20
8181224	Chemical Oxygen Demand	2016/02/03	103	80 - 120	107	80 - 120	<10	mg/L	NC (1)	20
8181543	Total Ammonia (N)	2016/02/02	NC	80 - 120	114	80 - 120	<0.0050	mg/L		
8181606	Total Nitrogen (N)	2016/02/03	NC	80 - 120	87	80 - 120	<0.020	mg/L	6.1 (1)	20
8182207	Dissolved Mercury (Hg)	2016/02/03	96	80 - 120	95	80 - 120	<0.010	ug/L	NC (1)	20
8182316	Total Phosphorus (P)	2016/02/02			97	80 - 120	<0.0050	mg/L		

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Maxxam Job #: B607136
Report Date: 2016/02/09

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8186189	Sulphide	2016/02/08			90	80 - 120	<0.0019	mg/L	NC (1)	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Duplicate Parent ID

(2) Matrix Spike Parent ID [OA7684-02]

(3) Duplicate Parent ID [OA7684-02]

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Maxxam Job #: B607136
Report Date: 2016/02/09

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Data Validation Coordinator

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-Free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

Chain Of Custody Record

Page 1 of 1

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#163 GHD Limited	Company Name	#27087 GHD Limited	Quotation #	B31426	Maxxam Job #	Bottle Order #:
Contact Name	Airesse MacPhee	Contact Name	Airesse MacPhee	P.O. #	73500976-1	B607136	486392
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address	179 Colonnade Road, Suite 400 Ottawa ON K2E 7J4	Project #	088877	Chain Of Custody Record	Project Manager
Phone	(519) 884-0510 Fax: (519) 725-1394	Phone	(613) 727-0510 Fax:	Project Name		C#486392-01-01	Tabitha Rudkin
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email	amacphee@CRAworld.com	Site #			
				Sampled By			

Regulatory Criteria:
- ☐ CSR
- ☐ CCME
- ☐ BC Water Quality
- ☐ Other _____

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests..
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: _____ ☐
Rush Confirmation Number: _____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity, pH, EC, Cl, SO4, NO2, NO3, PO4, ion bal, TDS	BOD, TSS	COD, NH4, TKN, T-Phos	~~Cyanide~~, Sulphide-LL	CSR Dissolved Metals in Water with CV Hg	Phenols (4-AAP)	LEPH/HEPH/PAH,TOG	CSR VOC + VPH in Water	pH, conductivity, ion balance		# of Bottles	Comments
1	OA 7684	SW-88877-290116-JS-01	29/01/16	9:30	W	Y	X	X	X	X	X				X		6	
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

B607136_COC

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
Jamie Steward	16/01/30	9:30	KEVIN CHOW	2016/01/31	14:56	N/A	☑	1, 1, 1	☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

N/A

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name Thomas Elliot/James Stewart

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code : C#487576-02-01

Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Sample Type	Sample Matrix	Grab or Composite	Start Depth (ft bgs)	End Depth (ft bgs)	Parent Sample ID for Field Dups	Footnote(s)
WG-88877-150216-JS-02	MW2A-16	2/15/2016	12:45		WG	grab				
WG-88877-150216-JS-01	RW-98020	2/15/2016	13:30		WG	grab				
WG-88877-150216-JS-03	MW2-14	2/15/2016	13:30		WG	grab			Put on hold at lab	

Footnotes

1. Sampled using high flow methodology
2. Sampled using low flow methodolgy
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

GHD Field Sample Key (FSK)

Site Uplands Excavating

Sample Reason hydro/geo investigation

Sampler Name Thomas Elliot/James Stewart

Sampling Company GHD

Laboratory(s) Maxxam

SSOW Reference Code : C#487576-02-01

					pH	Temperature			Conductivity		Turbidity		TDS				Eh / ORP	
Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Volume of Water Purged	Field pH	Sample Temp.	Ambient Temp.	Temp Units	Conductivity	Conductivity Units	Turbidity	Turbidity Units	TDS	Units	DO	Units	Eh/ORP	Eh/ORP Units
WG-88877-150216-JS-02	MW2A-16	2/15/2016	12:45		7.39	12.42		C	0.092	uS	OOR	ntu	0.061	g/L			140	mV
WG-88877-150216-JS-01	RW-98020	2/15/2016	13:30		6.58	8.05		C	0.135	uS	6.2	ntu	0.088	g/L	6.61	mg/L	333	mV
WG-88877-150216-JS-03	MW2-14	2/15/2016	13:30		6.86	12.31		C	0.181	uS	OOR	ntu	0.119	g/L			192	mV

Footnotes

1. Sampled using high flow methodology
2. Sampled using low flow methodolgy
3.
4.
5.
6.

Key

- Required Field
- Populate When Appropriate
- Field Data

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your P.O. #: 73500976-1
Your Project #: 088877
Site#: UPLANDS
Site Location: UPLAND LANDFILL
Your C.O.C. #: 487576-02-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2016/04/19
Report #: R2159059
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B612278
Received: 2016/02/17, 09:00

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	1	2016/02/19	2016/02/19	BBY6SOP-00026	SM 22 2320 B m
Alkalinity - Water	1	2016/02/19	2016/02/20	BBY6SOP-00026	SM 22 2320 B m
Biochemical Oxygen Demand	2	2016/02/19	2016/02/19	BBY6SOP-00045	SM 22 5210 B m
Chloride by Automated Colourimetry	2	N/A	2016/02/19	BBY6SOP-00011	SM 22 4500-Cl- G m
Cyanide SAD (strong acid dissociable)	2	N/A	2016/02/22	BBY6SOP-00004	SM 22 4500-CN O m
COD by Colorimeter	2	2016/02/19	2016/02/19	BBY6SOP-00024	SM 22 5220 D m
Conductance - water	1	N/A	2016/02/19	BBY6SOP-00026	SM 22 2510 B m
Conductance - water	1	N/A	2016/02/20	BBY6SOP-00026	SM 22 2510 B m
Hardness (calculated as CaCO3)	2	N/A	2016/02/22	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	2	N/A	2016/02/22	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Ion Balance	2	N/A	2016/02/22	BBY WI-00033	SM 22 1030E
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	2	N/A	2016/02/22	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	2	N/A	2016/02/19	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	2	2016/02/23	2016/02/24	BBY6SOP-00016	SM 22 4500-N C m
Ammonia-N (Unpreserved)	2	N/A	2016/02/19	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N) (highlevel)	2	N/A	2016/02/19	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA (highlevel)	2	N/A	2016/02/19	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	2	N/A	2016/02/20	BBY6SOP-00010	SM 22 4500-NO3 I m
Filter and HNO3 Preserve for Metals	2	N/A	2016/02/22	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (2)	1	N/A	2016/02/19	BBY6SOP-00026	SM 22 4500-H+ B m
pH Water (2)	1	N/A	2016/02/20	BBY6SOP-00026	SM 22 4500-H+ B m
Orthophosphate by Konelab (highlevel)	2	N/A	2016/02/23	BBY6SOP-00013	SM 22 4500-P E m
Sulphide (1)	2	N/A	2016/02/22	CAL SOP-00062	SM 22 4500 S2-D m
Sulphate by Automated Colourimetry	2	N/A	2016/02/19	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	2	2016/02/23	2016/02/24	BBY6SOP-00033	SM 22 2540 C m
TKN (Calc. TN, N/N) total	2	N/A	2016/02/24	BBY WI-00033	Calculation
Total Phosphorus	2	N/A	2016/02/20	BBY6SOP-00013	SM 22 4500-P E m
Total Suspended Solids	2	2016/02/22	2016/02/23	BBY6SOP-00034	SM 22 2540 D

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your P.O. #: 73500976-1
Your Project #: 088877
Site#: UPLANDS
Site Location: UPLAND LANDFILL
Your C.O.C. #: 487576-02-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2016/04/19
Report #: R2159059
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B612278

Received: 2016/02/17, 09:00

(1) This test was performed by Maxxam Calgary Environmental
(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Tabitha Rudkin, AScT, Burnaby Project Manager
Email: TRudkin@maxxam.ca
Phone# (604)638-2639

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B612278
Report Date: 2016/04/19

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		OD3412	OD3412		
Sampling Date		2016/02/15 13:30	2016/02/15 13:30		
COC Number		487576-02-01	487576-02-01		
	UNITS	WG-88877-150216-JS-01	WG-88877-150216-JS-01 Lab-Dup	RDL	QC Batch
Calculated Parameters					
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	ONSITE
Ion Balance	N/A	0.98	N/A	0.010	8195244
Demand Parameters					
Biochemical Oxygen Demand	mg/L	<6.0 (1)	N/A	6.0	8196084
Chemical Oxygen Demand	mg/L	<10	N/A	10	8194905
Misc. Inorganics					
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00057	N/A	0.00050	8197879
Alkalinity (Total as CaCO3)	mg/L	58.6	N/A	0.50	8196009
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	8196009
Bicarbonate (HCO3)	mg/L	71.4	N/A	0.50	8196009
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	8196009
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	8196009
Anions					
Sulphide	mg/L	<0.0019	N/A	0.0019	8197671
Nutrients					
Total Ammonia (N)	mg/L	<0.0050	<0.0050	0.0050	8197824
Total Phosphorus (P)	mg/L	0.0130	N/A	0.0050	8197866
Physical Properties					
Conductivity	uS/cm	124	N/A	1.0	8196008
pH	pH	7.14	N/A	N/A	8196005
Physical Properties					
Total Suspended Solids	mg/L	13.8	15.3	4.0	8197579
Total Dissolved Solids	mg/L	58 (1)	N/A	10	8198475

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Sample analysed past recommended hold time.

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RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		OD3413	OD3413		
Sampling Date		2016/02/15 12:45	2016/02/15 12:45		
COC Number		487576-02-01	487576-02-01		
	UNITS	WG-88877-150216-JS-02	WG-88877-150216-JS-02 Lab-Dup	RDL	QC Batch
Calculated Parameters					
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	ONSITE
Ion Balance	N/A	0.96	N/A	0.010	8195244
Demand Parameters					
Biochemical Oxygen Demand	mg/L	<6.0 (1)	N/A	6.0	8196084
Chemical Oxygen Demand	mg/L	25	N/A	10	8194905
Misc. Inorganics					
Strong Acid Dissoc. Cyanide (CN)	mg/L	0.00054	N/A	0.00050	8197879
Alkalinity (Total as CaCO3)	mg/L	38.0	N/A	0.50	8196024
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	8196024
Bicarbonate (HCO3)	mg/L	46.3	N/A	0.50	8196024
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	8196024
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	8196024
Anions					
Sulphide	mg/L	<0.0019	N/A	0.0019	8197671
Nutrients					
Total Ammonia (N)	mg/L	<0.0050	N/A	0.0050	8197824
Total Phosphorus (P)	mg/L	0.121	0.119	0.0050	8197866
Physical Properties					
Conductivity	uS/cm	85.7	N/A	1.0	8196028
pH	pH	7.85	N/A	N/A	8196029
Physical Properties					
Total Suspended Solids	mg/L	139 (2)	N/A	16	8197579
Total Dissolved Solids	mg/L	60 (1)	N/A	10	8198475

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Sample analysed past recommended hold time.
(2) RDL raised due to high concentration of solids in the sample.

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HIGH LEVEL ANIONS PACKAGE (WATER)

Maxxam ID		OD3412	OD3412	OD3413		
Sampling Date		2016/02/15 13:30	2016/02/15 13:30	2016/02/15 12:45		
COC Number		487576-02-01	487576-02-01	487576-02-01		
	UNITS	WG-88877-150216-JS-01	WG-88877-150216-JS-01 Lab-Dup	WG-88877-150216-JS-02	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.10 (1)	N/A	<0.10 (1)	0.10	8196784
Calculated Parameters						
Nitrate (N)	mg/L	0.15	N/A	<0.10	0.10	8194532
Anions						
Dissolved Sulphate (SO4)	mg/L	3.72	N/A	4.52	0.50	8197488
Dissolved Chloride (Cl)	mg/L	2.4	N/A	0.83	0.50	8197478
Nutrients						
Orthophosphate (P)	mg/L	<0.10 (1)	<0.10	<0.10 (1)	0.10	8197859
Nitrate plus Nitrite (N)	mg/L	0.15 (1)	N/A	<0.10 (1)	0.10	8196778

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Sample analysed past recommended hold time.

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CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		OD3412	OD3413		
Sampling Date		2016/02/15 13:30	2016/02/15 12:45		
COC Number		487576-02-01	487576-02-01		
	UNITS	WG-88877-150216-JS-01	WG-88877-150216-JS-02	RDL	QC Batch
Misc. Inorganics					
Dissolved Hardness (CaCO3)	mg/L	53.3	34.9	0.50	8194515
Elements					
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	0.010	8197841
Dissolved Metals by ICPMS					
Dissolved Aluminum (Al)	ug/L	10.6	24.2	3.0	8195915
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	8195915
Dissolved Arsenic (As)	ug/L	1.10	0.83	0.10	8195915
Dissolved Barium (Ba)	ug/L	4.4	2.8	1.0	8195915
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	0.10	8195915
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	1.0	8195915
Dissolved Boron (B)	ug/L	<50	<50	50	8195915
Dissolved Cadmium (Cd)	ug/L	<0.010	<0.010	0.010	8195915
Dissolved Chromium (Cr)	ug/L	1.4	<1.0	1.0	8195915
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	8195915
Dissolved Copper (Cu)	ug/L	1.71	<0.20	0.20	8195915
Dissolved Iron (Fe)	ug/L	20.1	<5.0	5.0	8195915
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	0.20	8195915
Dissolved Lithium (Li)	ug/L	<5.0	<5.0	5.0	8195915
Dissolved Manganese (Mn)	ug/L	8.5	16.2	1.0	8195915
Dissolved Molybdenum (Mo)	ug/L	<1.0	8.7	1.0	8195915
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	1.0	8195915
Dissolved Phosphorus (P)	ug/L	<10	17	10	8195915
Dissolved Selenium (Se)	ug/L	0.68	0.20	0.10	8195915
Dissolved Silicon (Si)	ug/L	6480	4540	100	8195915
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	0.020	8195915
Dissolved Strontium (Sr)	ug/L	73.0	23.7	1.0	8195915
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	8195915
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	5.0	8195915
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	5.0	8195915
Dissolved Uranium (U)	ug/L	<0.10	<0.10	0.10	8195915
RDL = Reportable Detection Limit					

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Maxxam Job #: B612278
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CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		OD3412	OD3413		
Sampling Date		2016/02/15 13:30	2016/02/15 12:45		
COC Number		487576-02-01	487576-02-01		
	UNITS	WG-88877-150216-JS-01	WG-88877-150216-JS-02	RDL	QC Batch
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	5.0	8195915
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	5.0	8195915
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	0.50	8195915
Dissolved Calcium (Ca)	mg/L	16.0	11.1	0.050	8194530
Dissolved Magnesium (Mg)	mg/L	3.23	1.73	0.050	8194530
Dissolved Potassium (K)	mg/L	0.132	0.541	0.050	8194530
Dissolved Sodium (Na)	mg/L	5.13	2.83	0.050	8194530
Dissolved Sulphur (S)	mg/L	5.5	5.5	3.0	8194530
RDL = Reportable Detection Limit					

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TOTAL TKN IN WATER (WATER)

Maxxam ID		OD3412	OD3413		
Sampling Date		2016/02/15 13:30	2016/02/15 12:45		
COC Number		487576-02-01	487576-02-01		
	UNITS	**WG-88877-150216-JS-01**	**WG-88877-150216-JS-02**	**RDL**	**QC Batch**
Nutrients					
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	<0.10	0.10	8194519
Total Nitrogen (N)	mg/L	0.155	0.095	0.020	8199117
RDL = Reportable Detection Limit					

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GENERAL COMMENTS

Revised Report (Version:2): Report comments have been amended (TWI).

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
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Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8194905	Chemical Oxygen Demand	2016/02/19	NC	80 - 120	100	80 - 120	<10	mg/L	6.3 (1)	20
8195915	Dissolved Aluminum (Al)	2016/02/20	70 (2)	80 - 120	100	80 - 120	<3.0	ug/L		
8195915	Dissolved Antimony (Sb)	2016/02/20	102	80 - 120	106	80 - 120	<0.50	ug/L		
8195915	Dissolved Arsenic (As)	2016/02/22	115	80 - 120	102	80 - 120	<0.10	ug/L	NC (1)	20
8195915	Dissolved Barium (Ba)	2016/02/22	NC	80 - 120	101	80 - 120	<1.0	ug/L	3.1 (1)	20
8195915	Dissolved Beryllium (Be)	2016/02/20	110	80 - 120	91	80 - 120	<0.10	ug/L		
8195915	Dissolved Bismuth (Bi)	2016/02/20	88	80 - 120	104	80 - 120	<1.0	ug/L		
8195915	Dissolved Boron (B)	2016/02/20	NC	80 - 120	96	80 - 120	<50	ug/L		
8195915	Dissolved Cadmium (Cd)	2016/02/22	103	80 - 120	102	80 - 120	<0.010	ug/L	NC (1)	20
8195915	Dissolved Chromium (Cr)	2016/02/22	100	80 - 120	104	80 - 120	<1.0	ug/L	NC (1)	20
8195915	Dissolved Cobalt (Co)	2016/02/20	102	80 - 120	104	80 - 120	<0.50	ug/L		
8195915	Dissolved Copper (Cu)	2016/02/20	74 (2)	80 - 120	108	80 - 120	<0.20	ug/L		
8195915	Dissolved Iron (Fe)	2016/02/22	NC	80 - 120	107	80 - 120	<5.0	ug/L	1.3 (1)	20
8195915	Dissolved Lead (Pb)	2016/02/22	105	80 - 120	94	80 - 120	<0.20	ug/L	NC (1)	20
8195915	Dissolved Lithium (Li)	2016/02/20	NC	80 - 120	88	80 - 120	<5.0	ug/L		
8195915	Dissolved Manganese (Mn)	2016/02/22	NC	80 - 120	102	80 - 120	<1.0	ug/L	1.1 (1)	20
8195915	Dissolved Molybdenum (Mo)	2016/02/20	91	80 - 120	103	80 - 120	<1.0	ug/L		
8195915	Dissolved Nickel (Ni)	2016/02/20	95	80 - 120	107	80 - 120	<1.0	ug/L		
8195915	Dissolved Phosphorus (P)	2016/02/20					<10	ug/L		
8195915	Dissolved Selenium (Se)	2016/02/22	81	80 - 120	101	80 - 120	<0.10	ug/L	NC (1)	20
8195915	Dissolved Silicon (Si)	2016/02/20					<100	ug/L		
8195915	Dissolved Silver (Ag)	2016/02/22	77 (2)	80 - 120	102	80 - 120	<0.020	ug/L	NC (1)	20
8195915	Dissolved Strontium (Sr)	2016/02/20	NC	80 - 120	92	80 - 120	<1.0	ug/L		
8195915	Dissolved Thallium (Tl)	2016/02/20	98	80 - 120	100	80 - 120	<0.050	ug/L		
8195915	Dissolved Tin (Sn)	2016/02/20	117	80 - 120	100	80 - 120	<5.0	ug/L		
8195915	Dissolved Titanium (Ti)	2016/02/20	85	80 - 120	92	80 - 120	<5.0	ug/L		
8195915	Dissolved Uranium (U)	2016/02/20	104	80 - 120	88	80 - 120	<0.10	ug/L		
8195915	Dissolved Vanadium (V)	2016/02/20	101	80 - 120	106	80 - 120	<5.0	ug/L		
8195915	Dissolved Zinc (Zn)	2016/02/22	NC	80 - 120	103	80 - 120	<5.0	ug/L	NC (1)	20
8195915	Dissolved Zirconium (Zr)	2016/02/20					<0.50	ug/L		

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877
Site Location: UPLAND LANDFILL
Your P.O. #: 73500976-1
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8196005	pH	2016/02/19			102	97 - 103			1.9 (1)	N/A
8196008	Conductivity	2016/02/19			100	80 - 120	<1.0	uS/cm	0.45 (1)	20
8196009	Alkalinity (PP as CaCO3)	2016/02/19					<0.50	mg/L	NC (1)	20
8196009	Alkalinity (Total as CaCO3)	2016/02/19	95	80 - 120	95	80 - 120	<0.50	mg/L	0.10 (1)	20
8196009	Bicarbonate (HCO3)	2016/02/19					<0.50	mg/L	0.10 (1)	20
8196009	Carbonate (CO3)	2016/02/19					<0.50	mg/L	NC (1)	20
8196009	Hydroxide (OH)	2016/02/19					<0.50	mg/L	NC (1)	20
8196024	Alkalinity (PP as CaCO3)	2016/02/19					<0.50	mg/L	NC (1)	20
8196024	Alkalinity (Total as CaCO3)	2016/02/19	NC (3)	80 - 120	101	80 - 120	<0.50	mg/L	2.2 (1)	20
8196024	Bicarbonate (HCO3)	2016/02/19					<0.50	mg/L	2.2 (1)	20
8196024	Carbonate (CO3)	2016/02/19					<0.50	mg/L	NC (1)	20
8196024	Hydroxide (OH)	2016/02/19					<0.50	mg/L	NC (1)	20
8196028	Conductivity	2016/02/19			102	80 - 120	<1.0	uS/cm		
8196029	pH	2016/02/19			102	97 - 103			0.14 (1)	N/A
8196084	Biochemical Oxygen Demand	2016/02/19			100	85 - 115	<6.0	mg/L	0.65 (1)	20
8196778	Nitrate plus Nitrite (N)	2016/02/19	105	80 - 120	103	80 - 120	<0.10	mg/L	NC (1)	25
8196784	Nitrite (N)	2016/02/19	98	80 - 120	96	80 - 120	<0.10	mg/L	NC (1)	20
8197478	Dissolved Chloride (Cl)	2016/02/19			98	80 - 120	<0.50	mg/L		
8197488	Dissolved Sulphate (SO4)	2016/02/19			93	80 - 120	<0.50	mg/L		
8197579	Total Suspended Solids	2016/02/23	107	80 - 120	99	80 - 120	<4.0	mg/L	NC (4)	20
8197671	Sulphide	2016/02/22			97	80 - 120	<0.0019	mg/L	NC (1)	20
8197824	Total Ammonia (N)	2016/02/19	105 (5)	80 - 120	96	80 - 120	0.0082, RDL=0.0050	mg/L	NC (6)	20
8197841	Dissolved Mercury (Hg)	2016/02/22	97	80 - 120	99	80 - 120	<0.010	ug/L	NC (1)	20
8197859	Orthophosphate (P)	2016/02/23	98 (7)	80 - 120	104	80 - 120	<0.10	mg/L	NC (8)	20
8197866	Total Phosphorus (P)	2016/02/20			105	80 - 120	<0.0050	mg/L	2.0 (9)	20
8197879	Strong Acid Dissoc. Cyanide (CN)	2016/02/22	102	80 - 120	100	80 - 120	0.00066, RDL=0.00050	mg/L	NC (1)	20
8198475	Total Dissolved Solids	2016/02/24	105	80 - 120	94	80 - 120	<10	mg/L	2.3 (1)	20

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
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Site Location: UPLAND LANDFILL
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			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8199117	Total Nitrogen (N)	2016/02/24	NC	80 - 120	97	80 - 120	<0.020	mg/L	0.61 (1)	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Duplicate Parent ID

(2) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(3) Matrix Spike Parent ID [OD3413-03]

(4) Duplicate Parent ID [OD3412-02]

(5) Matrix Spike Parent ID [OD3412-03]

(6) Duplicate Parent ID [OD3412-03]

(7) Matrix Spike Parent ID [OD3412-04]

(8) Duplicate Parent ID [OD3412-04]

(9) Duplicate Parent ID [OD3413-07]

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VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Ph.D., P.Chem., Scientific Specialist

Harry (Peng) Liang, Senior Analyst

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Analytics International Corporation o/a Maxxam Analytics
4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-Free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#163 GHD Limited	Company Name		Quotation #	B31426	Maxxam Job #	Bottle Order #:
Contact Name	Airesse MacPhee	Contact Name	Airesse MacPhee	P.O. #	73500976-1	B612278	
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address		Project #	088977	Chain Of Custody Record	Project Manager
Phone	(519) 884-0510 Fax: (519) 725-1394	Phone	Fax:	Project Name		C#487576-02-01	Tabitha Ruckin
Email	amacphee@CRAworld.com; NationalEDDSupport@ma	Email	amacphee@CRAworld.com; NationalEDDSupport@ma	Site #	Uplands		
				Sampled By	J. Stewart, T. Elliot		

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other _____

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: _____ ☐
Rush Confirmation Number: _____ (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered (Y/N)	Alk, pH, Conductivity, ion bal-	High-Level Anions (Cl, F, NO2, NO3, SO4)	Ammonia-N (Unpreserved), tot. Phos, COD, Nitrogen, TKN	CSR Dissolved Metals in Water with CV Hg + P	CSR Total Metals in Water with CV Hg	CSR VOC-EPH-HA-Water	TSS, TDS	BOD	LL-Sulphide	Cyanide	# of Bottles	Comments
1		WG-88977-150216-JS-01	15/02/16	13:30	W	Y	X	X	X	X	X		X	X	X	X	9	
2		-88977-02	↓	12:45	↓	↓	X	X	X	X			X	X	X	X	9	
3		-88977-03	↓	13:30	↓	↓	X	X	X	X			X	X	X	X	9	HOLD*
4		-56484-																
5		-56484-																
6		-56484-																
7		-56484-																
8		-56484-																
9		-56484-																
10		-56484-																

B612278_COC

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
Jamie Stewart	16/02/16	10:00		2016/02/17	09:00		☐	1.1	☐ Yes ☐ No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your P.O. #: 73506780
Your Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your C.O.C. #: 520094-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2017/04/21
Report #: R2372387
Version: 3 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B726019
Received: 2017/04/07, 17:30

Sample Matrix: Water
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	3	2017/04/08	2017/04/09	BBY6SOP-00026	SM 22 2320 B m
Biochemical Oxygen Demand	3	2017/04/08	2017/04/13	BBY6SOP-00045	SM 22 5210 B m
Chloride by Automated Colourimetry	3	N/A	2017/04/10	BBY6SOP-00011	SM 22 4500-Cl- E m
COD by Colorimeter	3	2017/04/11	2017/04/12	BBY6SOP-00024	SM 22 5220 D m
Conductance - water	3	N/A	2017/04/09	BBY6SOP-00026	SM 22 2510 B m
Sulphide (as H2S) (1)	3	N/A	2017/04/12	AB WI-00065	Auto Calc
Hardness Total (calculated as CaCO3)	2	N/A	2017/04/13	BBY WI-00033	Auto Calc
Hardness Total (calculated as CaCO3)	1	N/A	2017/04/17	BBY WI-00033	Auto Calc
Hardness (calculated as CaCO3)	3	N/A	2017/04/12	BBY WI-00033	Auto Calc
Mercury (Total) by CVAF	3	2017/04/13	2017/04/13	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	2	2017/04/07	2017/04/13	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	2017/04/07	2017/04/17	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	2	2017/04/12	2017/04/13	BBY7SOP-00003,	BCLM2005,EPA6020bR2m
Elements by CRC ICPMS (total)	1	2017/04/12	2017/04/14	BBY7SOP-00003,	BCLM2005,EPA6020bR2m
Nitrogen (Total)	3	2017/04/11	2017/04/11	BBY6SOP-00016	SM 22 4500-N C m
Ammonia-N (Preserved)	3	N/A	2017/04/10	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N)	3	N/A	2017/04/08	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA	3	N/A	2017/04/08	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	3	N/A	2017/04/12	BBY6SOP-00010	SM 22 4500-NO3 I m
Filter and HNO3 Preserve for Metals	3	N/A	2017/04/10	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (2)	3	N/A	2017/04/09	BBY6SOP-00026	SM 22 4500-H+ B m
Phenols (4-AAP)	3	N/A	2017/04/12	BBY6SOP-00008	SM 22 5530 D m
Orthophosphate by Konelab	3	N/A	2017/04/08	BBY6SOP-00013	SM 22 4500-P E m
Sulphide (1)	3	N/A	2017/04/12	AB SOP-00080	SM 22 4500-S2 D m
Sulphate by Automated Colourimetry	3	N/A	2017/04/10	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	3	2017/04/12	2017/04/13	BBY6SOP-00033	SM 22 2540 C m
TKN (Calc. TN, N/N) total	3	N/A	2017/04/12	BBY WI-00033	Calculation
Total Suspended Solids	3	2017/04/08	2017/04/10	BBY6SOP-00034	SM 22 2540 D

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted,

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your P.O. #: 73506780
Your Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your C.O.C. #: 520094-01-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2017/04/21
Report #: R2372387
Version: 3 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B726019
Received: 2017/04/07, 17:30

procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Edmonton Environmental
(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
VJ Oco, Burnaby Project Manager
Email: VOco@maxxam.ca
Phone# (604)639-8422

==========

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8567	QV8567		QV8568		
Sampling Date		2017/04/06 13:00	2017/04/06 13:00		2017/04/06 13:30		
COC Number		520094-01-01	520094-01-01		520094-01-01		
	UNITS	WS-88877-060417-JS-01	WS-88877-060417-JS-01 Lab-Dup	QC Batch	WS-88877-060417-JS-02	RDL	QC Batch
ANIONS							
Nitrite (N)	mg/L	<0.0050	N/A	8599503	<0.0050	0.0050	8599503
Calculated Parameters							
Filter and HNO3 Preservation	N/A	LAB	N/A	8598180	LAB	N/A	8598180
Nitrate (N)	mg/L	<0.020	N/A	8598442	0.045	0.020	8598442
Sulphide (as H2S)	mg/L	0.0020	N/A	8598256	<0.0020	0.0020	8598256
Demand Parameters							
Biochemical Oxygen Demand	mg/L	<6.0	N/A	8599382	<6.0	6.0	8599382
Chemical Oxygen Demand	mg/L	<10	<10	8601313	<10	10	8601313
Misc. Inorganics							
Dissolved Hardness (CaCO3)	mg/L	37.8	N/A	8598285	16.3	0.50	8598285
Alkalinity (Total as CaCO3)	mg/L	33.7	N/A	8599365	14.5	0.50	8599368
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	8599365	<0.50	0.50	8599368
Bicarbonate (HCO3)	mg/L	41.1	N/A	8599365	17.7	0.50	8599368
Carbonate (CO3)	mg/L	<0.50	N/A	8599365	<0.50	0.50	8599368
Hydroxide (OH)	mg/L	<0.50	N/A	8599365	<0.50	0.50	8599368
Anions							
Dissolved Sulphate (SO4)	mg/L	3.57	N/A	8601048	1.52	0.50	8601048
Total Sulphide	mg/L	0.0020	N/A	8601794	<0.0019	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	5.5	N/A	8601046	6.7	0.50	8601046
Nutrients							
Orthophosphate (P)	mg/L	0.0492	N/A	8599445	<0.0050	0.0050	8599445
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.099	N/A	8598538	0.148	0.020	8598538
Total Ammonia (N)	mg/L	0.028	N/A	8600016	0.022	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	<0.020	N/A	8599502	0.045	0.020	8599502
Total Nitrogen (N)	mg/L	0.099	N/A	8601383	0.193	0.020	8601385
Misc. Organics							
Phenols	mg/L	<0.0010	N/A	8602424	<0.0010	0.0010	8602424
Physical Properties							
Conductivity	uS/cm	89.3	N/A	8599364	59.7	1.0	8599367

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8567	QV8567		QV8568		
Sampling Date		2017/04/06 13:00	2017/04/06 13:00		2017/04/06 13:30		
COC Number		520094-01-01	520094-01-01		520094-01-01		
	UNITS	**WS-88877-060417-JS-01**	**WS-88877-060417-JS-01 Lab-Dup**	**QC Batch**	**WS-88877-060417-JS-02**	**RDL**	**QC Batch**
pH	pH	7.78	N/A	8599362	7.25	N/A	8599366
Physical Properties							
Total Suspended Solids	mg/L	13.5	N/A	8599269	<4.0	4.0	8599269
Total Dissolved Solids	mg/L	42	N/A	8602116	32	10	8602135

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8568		QV8569	QV8569		
Sampling Date		2017/04/06 13:30		2017/04/06 13:45	2017/04/06 13:45		
COC Number		520094-01-01		520094-01-01	520094-01-01		
	UNITS	WS-88877-060417-JS-02 Lab-Dup	QC Batch	WS-88877-060417-JS-03	WS-88877-060417-JS-03 Lab-Dup	RDL	QC Batch
ANIONS							
Nitrite (N)	mg/L	<0.0050	8599503	<0.0050	N/A	0.0050	8599505
Calculated Parameters							
Filter and HNO3 Preservation	N/A	N/A	8598180	LAB	N/A	N/A	8598180
Nitrate (N)	mg/L	N/A	8598442	0.031	N/A	0.020	8598442
Sulphide (as H2S)	mg/L	N/A	8598256	<0.0020	N/A	0.0020	8598256
Demand Parameters							
Biochemical Oxygen Demand	mg/L	N/A	8599382	<6.0	N/A	6.0	8599382
Chemical Oxygen Demand	mg/L	N/A	8601313	<10	N/A	10	8601313
Misc. Inorganics							
Dissolved Hardness (CaCO3)	mg/L	N/A	8598285	21.8	N/A	0.50	8598285
Alkalinity (Total as CaCO3)	mg/L	15.5	8599368	21.9	N/A	0.50	8599368
Alkalinity (PP as CaCO3)	mg/L	<0.50	8599368	<0.50	N/A	0.50	8599368
Bicarbonate (HCO3)	mg/L	18.9	8599368	26.7	N/A	0.50	8599368
Carbonate (CO3)	mg/L	<0.50	8599368	<0.50	N/A	0.50	8599368
Hydroxide (OH)	mg/L	<0.50	8599368	<0.50	N/A	0.50	8599368
Anions							
Dissolved Sulphate (SO4)	mg/L	N/A	8601048	2.79	N/A	0.50	8601061
Total Sulphide	mg/L	N/A	8601794	<0.0019	N/A	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	N/A	8601046	0.65	N/A	0.50	8601058
Nutrients							
Orthophosphate (P)	mg/L	N/A	8599445	<0.0050	N/A	0.0050	8599446
Total Total Kjeldahl Nitrogen (Calc)	mg/L	N/A	8598538	0.066	N/A	0.020	8598538
Total Ammonia (N)	mg/L	N/A	8600016	0.019	N/A	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	0.045	8599502	0.031	N/A	0.020	8599504
Total Nitrogen (N)	mg/L	N/A	8601385	0.097	N/A	0.020	8601383
Misc. Organics							
Phenols	mg/L	N/A	8602424	<0.0010	<0.0010	0.0010	8602424
Physical Properties							
Conductivity	uS/cm	57.9	8599367	47.8	N/A	1.0	8599367

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8568		QV8569	QV8569		
Sampling Date		2017/04/06 13:30		2017/04/06 13:45	2017/04/06 13:45		
COC Number		520094-01-01		520094-01-01	520094-01-01		
	UNITS	**WS-88877-060417-JS-02 Lab-Dup**	**QC Batch**	**WS-88877-060417-JS-03**	**WS-88877-060417-JS-03 Lab-Dup**	**RDL**	**QC Batch**
pH	pH	7.29	8599366	7.56	N/A	N/A	8599366
Physical Properties							
Total Suspended Solids	mg/L	N/A	8599269	<4.0	N/A	4.0	8599269
Total Dissolved Solids	mg/L	N/A	8602135	18	N/A	10	8602135

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8567		QV8568	QV8569		
Sampling Date		2017/04/06 13:00		2017/04/06 13:30	2017/04/06 13:45		
COC Number		520094-01-01		520094-01-01	520094-01-01		
	UNITS	WS-88877-060417-JS-01	QC Batch	WS-88877-060417-JS-02	WS-88877-060417-JS-03	RDL	QC Batch
Calculated Parameters							
Total Hardness (CaCO3)	mg/L	34.9	8599077	16.9	22.2	0.50	8599077
Elements							
Total Mercury (Hg)	ug/L	<0.010	8603155	<0.010	<0.010	0.010	8603155
Total Metals by ICPMS							
Total Aluminum (Al)	ug/L	1170	8602428	24.5	18.0	3.0	8602388
Total Antimony (Sb)	ug/L	<0.50	8602428	<0.50	<0.50	0.50	8602388
Total Arsenic (As)	ug/L	0.52	8602428	<0.10	<0.10	0.10	8602388
Total Barium (Ba)	ug/L	8.6	8602428	2.6	2.5	1.0	8602388
Total Beryllium (Be)	ug/L	<0.10	8602428	<0.10	<0.10	0.10	8602388
Total Bismuth (Bi)	ug/L	<1.0	8602428	<1.0	<1.0	1.0	8602388
Total Boron (B)	ug/L	<50	8602428	<50	<50	50	8602388
Total Cadmium (Cd)	ug/L	0.029	8602428	<0.010	<0.010	0.010	8602388
Total Chromium (Cr)	ug/L	<1.0	8602428	<1.0	<1.0	1.0	8602388
Total Cobalt (Co)	ug/L	0.89	8602428	<0.20	<0.20	0.20	8602388
Total Copper (Cu)	ug/L	14.9	8602428	0.90	0.94	0.50	8602388
Total Iron (Fe)	ug/L	1190	8602428	255	14	10	8602388
Total Lead (Pb)	ug/L	<0.20	8602428	<0.20	0.31	0.20	8602388
Total Lithium (Li)	ug/L	<2.0	8602428	<2.0	<2.0	2.0	8602388
Total Manganese (Mn)	ug/L	46.3	8602428	19.5	1.8	1.0	8602388
Total Molybdenum (Mo)	ug/L	<1.0	8602428	<1.0	<1.0	1.0	8602388
Total Nickel (Ni)	ug/L	1.2	8602428	<1.0	<1.0	1.0	8602388
Total Phosphorus (P)	ug/L	51	8602428	<10	<10	10	8602388
Total Selenium (Se)	ug/L	0.10	8602428	<0.10	<0.10	0.10	8602388
Total Silicon (Si)	ug/L	3510	8602428	2190	2040	100	8602388
Total Silver (Ag)	ug/L	<0.020	8602428	<0.020	<0.020	0.020	8602388
Total Strontium (Sr)	ug/L	23.4	8602428	14.9	10.4	1.0	8602388
Total Thallium (Tl)	ug/L	<0.010	8602428	<0.010	<0.010	0.010	8602388
Total Tin (Sn)	ug/L	<5.0	8602428	<5.0	<5.0	5.0	8602388
Total Titanium (Ti)	ug/L	56.7	8602428	<5.0	<5.0	5.0	8602388
Total Uranium (U)	ug/L	<0.10	8602428	<0.10	<0.10	0.10	8602388

RDL = Reportable Detection Limit

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8567		QV8568	QV8569		
Sampling Date		2017/04/06 13:00		2017/04/06 13:30	2017/04/06 13:45		
COC Number		520094-01-01		520094-01-01	520094-01-01		
	UNITS	**WS-88877-060417-JS-01**	**QC Batch**	**WS-88877-060417-JS-02**	**WS-88877-060417-JS-03**	**RDL**	**QC Batch**
Total Vanadium (V)	ug/L	<5.0	8602428	<5.0	<5.0	5.0	8602388
Total Zinc (Zn)	ug/L	5.9	8602428	<5.0	<5.0	5.0	8602388
Total Zirconium (Zr)	ug/L	<0.10	8602428	<0.10	<0.10	0.10	8602388
Total Calcium (Ca)	mg/L	10.1	8598441	4.93	7.49	0.050	8598441
Total Magnesium (Mg)	mg/L	2.34	8598441	1.13	0.842	0.050	8598441
Total Potassium (K)	mg/L	0.262	8598441	0.178	0.076	0.050	8598441
Total Sodium (Na)	mg/L	2.84	8598441	5.32	0.885	0.050	8598441
Total Sulphur (S)	mg/L	<3.0	8598441	<3.0	<3.0	3.0	8598441
RDL = Reportable Detection Limit							

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Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

GENERAL COMMENTS

Report re-issued with only Dissolved Hardness reported as per COC. April 20, 2017

Results relate only to the items tested.

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Maxxam Job #: B726019
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8599269	Total Suspended Solids	2017/04/10	107	80 - 120	98	80 - 120	<4.0	mg/L	15 (1)	20
8599362	pH	2017/04/09			101	97 - 103			0.37 (1)	N/A
8599364	Conductivity	2017/04/09			99	80 - 120	1.1, RDL=1.0	uS/cm	0.41 (1)	20
8599365	Alkalinity (PP as CaCO3)	2017/04/09					<0.50	mg/L	NC (1)	20
8599365	Alkalinity (Total as CaCO3)	2017/04/09	NC	80 - 120	99	80 - 120	<0.50	mg/L	0.32 (1)	20
8599365	Bicarbonate (HCO3)	2017/04/09					<0.50	mg/L	0.32 (1)	20
8599365	Carbonate (CO3)	2017/04/09					<0.50	mg/L	NC (1)	20
8599365	Hydroxide (OH)	2017/04/09					<0.50	mg/L	NC (1)	20
8599366	pH	2017/04/09			101	97 - 103			0.55 (2)	N/A
8599367	Conductivity	2017/04/09			100	80 - 120	<1.0	uS/cm	3.0 (2)	20
8599368	Alkalinity (PP as CaCO3)	2017/04/09					<0.50	mg/L	NC (2)	20
8599368	Alkalinity (Total as CaCO3)	2017/04/09	NC	80 - 120	101	80 - 120	<0.50	mg/L	6.7 (2)	20
8599368	Bicarbonate (HCO3)	2017/04/09					<0.50	mg/L	6.7 (2)	20
8599368	Carbonate (CO3)	2017/04/09					<0.50	mg/L	NC (2)	20
8599368	Hydroxide (OH)	2017/04/09					<0.50	mg/L	NC (2)	20
8599382	Biochemical Oxygen Demand	2017/04/13			104	85 - 115	<6.0	mg/L	NC (1)	20
8599445	Orthophosphate (P)	2017/04/08	92	80 - 120	94	80 - 120	<0.0050	mg/L	12 (1)	20
8599446	Orthophosphate (P)	2017/04/08	100	80 - 120	80	80 - 120	<0.0050	mg/L	13 (1)	20
8599502	Nitrate plus Nitrite (N)	2017/04/08	102 (3)	80 - 120	105	80 - 120	<0.020	mg/L	0.44 (2)	25
8599503	Nitrite (N)	2017/04/08	96 (3)	80 - 120	101	80 - 120	<0.0050	mg/L	NC (2)	20
8599504	Nitrate plus Nitrite (N)	2017/04/08	NC	80 - 120	105	80 - 120	<0.020	mg/L	0.13 (1)	25
8599505	Nitrite (N)	2017/04/08	98	80 - 120	103	80 - 120	<0.0050	mg/L	NC (1)	20
8600016	Total Ammonia (N)	2017/04/10	100	80 - 120	101	80 - 120	<0.0050	mg/L	1.5 (1)	20
8601046	Dissolved Chloride (Cl)	2017/04/10	111	80 - 120	97	80 - 120	<0.50	mg/L	0.055 (1)	20
8601048	Dissolved Sulphate (SO4)	2017/04/10	NC	80 - 120	93	80 - 120	<0.50	mg/L	1.1 (1)	20
8601058	Dissolved Chloride (Cl)	2017/04/10	106	80 - 120	97	80 - 120	<0.50	mg/L	0.89 (1)	20
8601061	Dissolved Sulphate (SO4)	2017/04/10	110	80 - 120	105	80 - 120	<0.50	mg/L	NC (1)	20
8601313	Chemical Oxygen Demand	2017/04/12	96 (4)	80 - 120	104	80 - 120	<10	mg/L	NC (5)	20
8601383	Total Nitrogen (N)	2017/04/11	100	80 - 120	96	80 - 120	<0.020	mg/L	3.7 (1)	20
8601385	Total Nitrogen (N)	2017/04/11	103	80 - 120	97	80 - 120	<0.020	mg/L	3.5 (1)	20

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Maxxam Job #: B726019
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8601794	Total Sulphide	2017/04/12			92	80 - 120	<0.0019	mg/L	NC (1)	20
8602116	Total Dissolved Solids	2017/04/13	99	80 - 120	86	80 - 120	<10	mg/L	3.6 (1)	20
8602135	Total Dissolved Solids	2017/04/13	99	80 - 120	88	80 - 120	<10	mg/L		
8602388	Total Aluminum (Al)	2017/04/13	110	80 - 120	113	80 - 120	<3.0	ug/L		
8602388	Total Antimony (Sb)	2017/04/13	103	80 - 120	100	80 - 120	<0.50	ug/L		
8602388	Total Arsenic (As)	2017/04/13	102	80 - 120	100	80 - 120	<0.10	ug/L		
8602388	Total Barium (Ba)	2017/04/13	98	80 - 120	99	80 - 120	<1.0	ug/L		
8602388	Total Beryllium (Be)	2017/04/13	100	80 - 120	94	80 - 120	<0.10	ug/L		
8602388	Total Bismuth (Bi)	2017/04/13	97	80 - 120	98	80 - 120	<1.0	ug/L		
8602388	Total Boron (B)	2017/04/13	109	80 - 120	110	80 - 120	<50	ug/L		
8602388	Total Cadmium (Cd)	2017/04/13	101	80 - 120	98	80 - 120	<0.010	ug/L		
8602388	Total Chromium (Cr)	2017/04/13	101	80 - 120	99	80 - 120	<1.0	ug/L		
8602388	Total Cobalt (Co)	2017/04/13	100	80 - 120	99	80 - 120	<0.20	ug/L		
8602388	Total Copper (Cu)	2017/04/13	97	80 - 120	98	80 - 120	<0.50	ug/L	NC (1)	20
8602388	Total Iron (Fe)	2017/04/13	113	80 - 120	113	80 - 120	<10	ug/L		
8602388	Total Lead (Pb)	2017/04/13	97	80 - 120	96	80 - 120	<0.20	ug/L	NC (1)	20
8602388	Total Lithium (Li)	2017/04/13	103	80 - 120	100	80 - 120	<2.0	ug/L		
8602388	Total Manganese (Mn)	2017/04/13	99	80 - 120	98	80 - 120	<1.0	ug/L		
8602388	Total Molybdenum (Mo)	2017/04/13	102	80 - 120	100	80 - 120	<1.0	ug/L		
8602388	Total Nickel (Ni)	2017/04/13	100	80 - 120	99	80 - 120	<1.0	ug/L	NC (1)	20
8602388	Total Phosphorus (P)	2017/04/13					<10	ug/L		
8602388	Total Selenium (Se)	2017/04/13	107	80 - 120	101	80 - 120	<0.10	ug/L		
8602388	Total Silicon (Si)	2017/04/13					<100	ug/L		
8602388	Total Silver (Ag)	2017/04/13	105	80 - 120	101	80 - 120	<0.020	ug/L		
8602388	Total Strontium (Sr)	2017/04/13	99	80 - 120	100	80 - 120	<1.0	ug/L		
8602388	Total Thallium (Tl)	2017/04/13	100	80 - 120	99	80 - 120	<0.010	ug/L		
8602388	Total Tin (Sn)	2017/04/13	103	80 - 120	100	80 - 120	<5.0	ug/L		
8602388	Total Titanium (Ti)	2017/04/13	110	80 - 120	96	80 - 120	<5.0	ug/L		
8602388	Total Uranium (U)	2017/04/13	96	80 - 120	96	80 - 120	<0.10	ug/L		
8602388	Total Vanadium (V)	2017/04/13	99	80 - 120	102	80 - 120	<5.0	ug/L		

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Maxxam Job #: B726019
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8602388	Total Zinc (Zn)	2017/04/13	100	80 - 120	98	80 - 120	<5.0	ug/L	NC (1)	20
8602388	Total Zirconium (Zr)	2017/04/13					<0.10	ug/L		
8602424	Phenols	2017/04/12	95	80 - 120	104	80 - 120	<0.0010	mg/L	NC (6)	20
8602428	Total Aluminum (Al)	2017/04/14	99	80 - 120	105	80 - 120	<3.0	ug/L	9.2 (1)	20
8602428	Total Antimony (Sb)	2017/04/14	99	80 - 120	95	80 - 120	<0.50	ug/L	NC (1)	20
8602428	Total Arsenic (As)	2017/04/14	107	80 - 120	101	80 - 120	<0.10	ug/L	4.5 (1)	20
8602428	Total Barium (Ba)	2017/04/14	NC	80 - 120	98	80 - 120	<1.0	ug/L	5.5 (1)	20
8602428	Total Beryllium (Be)	2017/04/14	106	80 - 120	102	80 - 120	<0.10	ug/L	NC (1)	20
8602428	Total Bismuth (Bi)	2017/04/14	91	80 - 120	94	80 - 120	<1.0	ug/L	NC (1)	20
8602428	Total Boron (B)	2017/04/14	103	80 - 120	95	80 - 120	<50	ug/L	NC (1)	20
8602428	Total Cadmium (Cd)	2017/04/14	102	80 - 120	101	80 - 120	<0.010	ug/L	8.2 (1)	20
8602428	Total Chromium (Cr)	2017/04/14	92	80 - 120	98	80 - 120	<1.0	ug/L	NC (1)	20
8602428	Total Cobalt (Co)	2017/04/14	91	80 - 120	95	80 - 120	<0.20	ug/L	3.5 (1)	20
8602428	Total Copper (Cu)	2017/04/14	91	80 - 120	96	80 - 120	<0.50	ug/L	0.78 (1)	20
8602428	Total Iron (Fe)	2017/04/14	NC	80 - 120	109	80 - 120	<10	ug/L	2.5 (1)	20
8602428	Total Lead (Pb)	2017/04/14	97	80 - 120	97	80 - 120	<0.20	ug/L	4.0 (1)	20
8602428	Total Lithium (Li)	2017/04/14	92	80 - 120	89	80 - 120	<2.0	ug/L	6.6 (1)	20
8602428	Total Manganese (Mn)	2017/04/14	NC	80 - 120	93	80 - 120	<1.0	ug/L	2.2 (1)	20
8602428	Total Molybdenum (Mo)	2017/04/14	NC	80 - 120	95	80 - 120	<1.0	ug/L	1.8 (1)	20
8602428	Total Nickel (Ni)	2017/04/14	NC	80 - 120	98	80 - 120	<1.0	ug/L	0.15 (1)	20
8602428	Total Phosphorus (P)	2017/04/13					<10	ug/L		
8602428	Total Selenium (Se)	2017/04/14	111	80 - 120	104	80 - 120	<0.10	ug/L	2.6 (1)	20
8602428	Total Silicon (Si)	2017/04/14					<100	ug/L	1.5 (1)	20
8602428	Total Silver (Ag)	2017/04/14	100	80 - 120	98	80 - 120	<0.020	ug/L	NC (1)	20
8602428	Total Strontium (Sr)	2017/04/14	NC	80 - 120	101	80 - 120	<1.0	ug/L	1.5 (1)	20
8602428	Total Thallium (Tl)	2017/04/14	94	80 - 120	94	80 - 120	<0.010	ug/L	9.7 (1)	20
8602428	Total Tin (Sn)	2017/04/14	65 (7)	80 - 120	87	80 - 120	<5.0	ug/L	NC (1)	20
8602428	Total Titanium (Ti)	2017/04/14	94	80 - 120	103	80 - 120	<5.0	ug/L	NC (1)	20
8602428	Total Uranium (U)	2017/04/14	96	80 - 120	94	80 - 120	<0.10	ug/L	4.8 (1)	20
8602428	Total Vanadium (V)	2017/04/14	96	80 - 120	98	80 - 120	<5.0	ug/L	NC (1)	20

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Maxxam Job #: B726019
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8602428	Total Zinc (Zn)	2017/04/14	NC	80 - 120	115	80 - 120	<5.0	ug/L	4.8 (1)	20
8602428	Total Zirconium (Zr)	2017/04/14					<0.10	ug/L	NC (1)	20
8603155	Total Mercury (Hg)	2017/04/13	96 (8)	80 - 120	99	80 - 120	<0.010	ug/L	2.1 (1)	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Duplicate Parent ID

(2) Duplicate Parent ID [QV8568-02]

(3) Matrix Spike Parent ID [QV8568-02]

(4) Matrix Spike Parent ID [QV8567-07]

(5) Duplicate Parent ID [QV8567-07]

(6) Duplicate Parent ID [QV8569-07]

(7) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(8) Matrix Spike Parent ID [QV8569-06]

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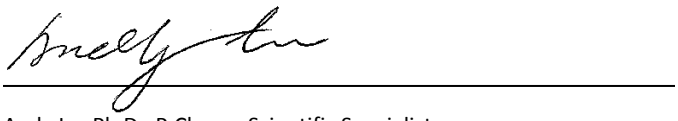
Maxxam Job #: B726019
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Andy Lu, Ph.D., P.Chem., Scientific Specialist

Suwan Fock, B.Sc., QP, Inorganics Senior Analyst

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Page 1 of 2

B726019_COC

C#520094-01-01

Bottle Order #: 520094

Project Manager: VJ Oco

INVOICE TO:		Report Information		Project Information	
Company Name	#163 GHD Limited	Company Name		Quotation #	B61466
Contact Name	Airesse MacPhee	Contact Name		P.O. #	73506780
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address		Project #	088877-02-01
				Project Name	
Phone	(519) 884-0510 x Fax: (519) 725-1394 x	Phone	Fax:	Site #	
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email		Sampled By	J. Stewart

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: ☐
Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity	Biochemical Oxygen Demand	COD	Chloride	Conductivity	Cyanide	pH	Total Phenols	Sulphate	Sulphide (w/ H2S)	# of Bottles	Comments
1		WS-88877-060417-JS-01	06/04/17	1300	W	N	X	X	X	X	X		X	X	X	X	10	
2		-02	↓	1330	W	N	X	X	X	X	X		X	X	X	X	10	
3		-03	↓	1345	W	N	X	X	X	X	X		X	X	X	X	10	
4																		
5																		
6																		
7																		
8																		
9																		
10																		

RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# Jars used and not submitted
J. Stewart	17/04/07	1300	JWAHNNE MOY	2017/04/07	17:30	

Lab Use Only: Time Sensitive ☐ | Temperature (°C) on Receipt: 6,7,7/5,5,7 | Custody Seal Intact on Cooler? ☐ Yes ☐ No

N/A

6,7,5

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam Analytics International Corporation o/a Maxxam Analytics
4606 Canada Way, Burnaby, British Columbia Canada V5G 1K5 Tel:(604) 734 7276 Toll-free:800-563-6266 Fax:(604) 731 2386 www.maxxam.ca

B726019_COC

C#520094-01-03

INVOICE TO:

Company Name: #163 GHD Limited
Contact Name: Airesse MacPhee
Address: 651 COLBY DRIVE, WATERLOO ON N2V 1C2
Phone: (519) 884-0510 x Fax: (519) 725-1394 x
Email: airesse.macphee@ghd.com; NationalEDDSupport@ma

Report Information

Company Name:
Contact Name:
Address:
Phone: Fax:
Email:

Project Information

Quotation #: B61466
P.O. #: 73506780
Project #: 088877-02-01
Project Name:
Site #:
Sampled By: J. Stewart

Lab Use Only

Bottle Order #: 520094
Project Manager: VJ Oco

Regulatory Criteria:
- [ ] CSR
- [ ] CCME
- [ ] BC Water Quality
- [ ] Other

Special Instructions:

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: [ ]
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY [ ] 2 Day [ ] 3 Day [ ] Date Required: [ ]
Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Total Dissolved Solids	Ammonia-N	Nitrite / Nitrate / Nitrogen	Orthophosphate	TKN	Dissolved Metals (inc Phophorus, Hg and Hardness)	LL Sulphide	Total Suspended Solids	Total Metals (inc Phosphorus, Hg and Hardness)	Dissolved Hardness	# of Bottles	Comments
1		WS-88777-060417-JS-01	06/04/17	1300	W	N	X	X	X	X	X		X	X	X	X	10	
2		-02	↓	1330	W	N	X	X	X	X	X		X	X	X	X	10	
3		-03	↓	1345	W	N	X	X	X	X	X		X	X	X	X	10	
4																		
5																		
6																		
7																		
8																		
9																		
10																		

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
J. Stewart	17/04/07	1300	JWAHNNE MOY	2017/04/07	17:30	

Lab Use Only: Time Sensitive [ ] | Temperature (°C) on Receipt: 6.7, 7.5, 5.7 | Custody Seal Intact on Cooler? [ ] Yes [ ] No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

6.7, 5

White: Maxxam Yellow: Client

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your P.O. #: 73506780
Your Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your C.O.C. #: 520094-03-01, 520094-02-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2017/04/21
Report #: R2372389
Version: 3 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B726014
Received: 2017/04/07, 17:30

Sample Matrix: Water
Samples Received: 12

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	1	2017/04/08	2017/04/08	BBY6SOP-00026	SM 22 2320 B m
Alkalinity - Water	11	2017/04/08	2017/04/09	BBY6SOP-00026	SM 22 2320 B m
Biochemical Oxygen Demand	12	2017/04/08	2017/04/13	BBY6SOP-00045	SM 22 5210 B m
Chloride by Automated Colourimetry	12	N/A	2017/04/10	BBY6SOP-00011	SM 22 4500-Cl- E m
COD by Colorimeter	12	2017/04/11	2017/04/12	BBY6SOP-00024	SM 22 5220 D m
Conductance - water	1	N/A	2017/04/08	BBY6SOP-00026	SM 22 2510 B m
Conductance - water	11	N/A	2017/04/09	BBY6SOP-00026	SM 22 2510 B m
Sulphide (as H2S) (1)	12	N/A	2017/04/12	AB WI-00065	Auto Calc
Hardness (calculated as CaCO3)	12	N/A	2017/04/13	BBY WI-00033	Auto Calc
Mercury (Dissolved) by CVAF	12	N/A	2017/04/13	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	12	N/A	2017/04/13	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	12	N/A	2017/04/13	BBY7SOP-00002	EPA 6020B R2 m
Nitrogen (Total)	12	2017/04/11	2017/04/11	BBY6SOP-00016	SM 22 4500-N C m
Ammonia-N (Preserved)	12	N/A	2017/04/10	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N)	12	N/A	2017/04/08	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA	12	N/A	2017/04/08	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	12	N/A	2017/04/12	BBY6SOP-00010	SM 22 4500-NO3 I m
Filter and HNO3 Preserve for Metals	12	N/A	2017/04/12	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (2)	1	N/A	2017/04/08	BBY6SOP-00026	SM 22 4500-H+ B m
pH Water (2)	11	N/A	2017/04/09	BBY6SOP-00026	SM 22 4500-H+ B m
Phenols (4-AAP)	12	N/A	2017/04/12	BBY6SOP-00008	SM 22 5530 D m
Orthophosphate by Konelab	12	N/A	2017/04/08	BBY6SOP-00013	SM 22 4500-P E m
Sulphide (1)	12	N/A	2017/04/12	AB SOP-00080	SM 22 4500-S2 D m
Sulphate by Automated Colourimetry	11	N/A	2017/04/10	BBY6SOP-00017	SM 22 4500-SO42- E m
Sulphate by Automated Colourimetry	1	N/A	2017/04/11	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	12	2017/04/12	2017/04/13	BBY6SOP-00033	SM 22 2540 C m
TKN (Calc. TN, N/N) total	12	N/A	2017/04/12	BBY WI-00033	Calculation

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your P.O. #: 73506780
Your Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your C.O.C. #: 520094-03-01, 520094-02-01

Attention:Airesse MacPhee

GHD Limited
651 COLBY DRIVE
WATERLOO, ON
CANADA N2V 1C2

Report Date: 2017/04/21
Report #: R2372389
Version: 3 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B726014
Received: 2017/04/07, 17:30

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Edmonton Environmental

(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
VJ Oco, Burnaby Project Manager
Email: VOco@maxxam.ca
Phone# (604)639-8422

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8539	QV8539		
Sampling Date		2017/04/06 10:00	2017/04/06 10:00		
COC Number		520094-03-01	520094-03-01		
	UNITS	WG-88877-060417-JS-01	WG-88877-060417-JS-01 Lab-Dup	RDL	QC Batch
ANIONS					
Nitrite (N)	mg/L	<0.0050	N/A	0.0050	8599503
Calculated Parameters					
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	ONSITE
Nitrate (N)	mg/L	0.081	N/A	0.020	8598442
Sulphide (as H2S)	mg/L	<0.0020	N/A	0.0020	8598256
Demand Parameters					
Biochemical Oxygen Demand	mg/L	<6.0	N/A	6.0	8599382
Chemical Oxygen Demand	mg/L	<10	N/A	10	8601312
Misc. Inorganics					
Alkalinity (Total as CaCO3)	mg/L	49.7	N/A	0.50	8599365
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	8599365
Bicarbonate (HCO3)	mg/L	60.7	N/A	0.50	8599365
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	8599365
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	8599365
Anions					
Dissolved Sulphate (SO4)	mg/L	5.19	5.25	0.50	8601048
Total Sulphide	mg/L	<0.0019	N/A	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	7.3	7.3	0.50	8601046
Nutrients					
Orthophosphate (P)	mg/L	0.0335	N/A	0.0050	8599445
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.065	N/A	0.020	8598538
Total Ammonia (N)	mg/L	0.037	N/A	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	0.081	N/A	0.020	8599502
Total Nitrogen (N)	mg/L	0.146	N/A	0.020	8601383
Misc. Organics					
Phenols	mg/L	<0.0010	N/A	0.0010	8602424
Physical Properties					
Conductivity	uS/cm	128	N/A	1.0	8599364
pH	pH	7.93	N/A	N/A	8599362

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8539	QV8539		
Sampling Date		2017/04/06 10:00	2017/04/06 10:00		
COC Number		520094-03-01	520094-03-01		
	UNITS	**WG-88877-060417-JS-01**	**WG-88877-060417-JS-01 Lab-Dup**	**RDL**	**QC Batch**
Physical Properties					
Total Dissolved Solids	mg/L	74	N/A	10	8602116

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8540	QV8540		
Sampling Date		2017/04/06 10:45	2017/04/06 10:45		
COC Number		520094-03-01	520094-03-01		
	UNITS	WG-88877-060417-JS-02	WG-88877-060417-JS-02 Lab-Dup	RDL	QC Batch
ANIONS					
Nitrite (N)	mg/L	<0.0050	N/A	0.0050	8599503
Calculated Parameters					
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	ONSITE
Nitrate (N)	mg/L	<0.020	N/A	0.020	8598442
Sulphide (as H2S)	mg/L	<0.0020	N/A	0.0020	8598256
Demand Parameters					
Biochemical Oxygen Demand	mg/L	<6.0	N/A	6.0	8599382
Chemical Oxygen Demand	mg/L	<10	N/A	10	8601312
Misc. Inorganics					
Alkalinity (Total as CaCO3)	mg/L	28.6	N/A	0.50	8599365
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	8599365
Bicarbonate (HCO3)	mg/L	34.9	N/A	0.50	8599365
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	8599365
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	8599365
Anions					
Dissolved Sulphate (SO4)	mg/L	2.75	N/A	0.50	8601048
Total Sulphide	mg/L	<0.0019	N/A	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	1.0	N/A	0.50	8601046
Nutrients					
Orthophosphate (P)	mg/L	0.0059	N/A	0.0050	8599445
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.042	N/A	0.020	8598538
Total Ammonia (N)	mg/L	0.034	N/A	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	<0.020	N/A	0.020	8599502
Total Nitrogen (N)	mg/L	0.042	0.059	0.020	8601388
Misc. Organics					
Phenols	mg/L	<0.0010	N/A	0.0010	8602424
Physical Properties					
Conductivity	uS/cm	59.0	N/A	1.0	8599364
pH	pH	7.69	N/A	N/A	8599362

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8540	QV8540		
Sampling Date		2017/04/06 10:45	2017/04/06 10:45		
COC Number		520094-03-01	520094-03-01		
	UNITS	**WG-88877-060417-JS-02**	**WG-88877-060417-JS-02 Lab-Dup**	**RDL**	**QC Batch**
Physical Properties					
Total Dissolved Solids	mg/L	28	N/A	10	8602116

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8541		QV8542		
Sampling Date		2017/04/06 11:30		2017/04/06 12:30		
COC Number		520094-03-01		520094-03-01		
	UNITS	WG-88877-060417-JS-03	QC Batch	WG-88877-060417-JS-04	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.0050	8599505	<0.0050	0.0050	8599503
Calculated Parameters						
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	0.291	8598442	0.288	0.020	8598442
Sulphide (as H2S)	mg/L	<0.0020	8598256	<0.0020	0.0020	8598256
Demand Parameters						
Biochemical Oxygen Demand	mg/L	<6.0	8599382	<6.0	6.0	8599382
Chemical Oxygen Demand	mg/L	10	8601312	<10	10	8601312
Misc. Inorganics						
Alkalinity (Total as CaCO3)	mg/L	41.7	8599368	59.4	0.50	8599365
Alkalinity (PP as CaCO3)	mg/L	<0.50	8599368	<0.50	0.50	8599365
Bicarbonate (HCO3)	mg/L	50.9	8599368	72.5	0.50	8599365
Carbonate (CO3)	mg/L	<0.50	8599368	<0.50	0.50	8599365
Hydroxide (OH)	mg/L	<0.50	8599368	<0.50	0.50	8599365
Anions						
Dissolved Sulphate (SO4)	mg/L	3.42	8601061	7.12	0.50	8601048
Total Sulphide	mg/L	<0.0019	8601794	<0.0019	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	3.2	8601058	4.5	0.50	8601046
Nutrients						
Orthophosphate (P)	mg/L	0.0084	8599446	0.0273	0.0050	8599445
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.043	8598538	0.037	0.020	8598538
Total Ammonia (N)	mg/L	0.018	8600016	0.043	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	0.291	8599504	0.288	0.020	8599502
Total Nitrogen (N)	mg/L	0.334	8601383	0.324	0.020	8601383
Misc. Organics						
Phenols	mg/L	<0.0010	8602424	<0.0010	0.0010	8602424
Physical Properties						
Conductivity	uS/cm	95.5	8599367	141	1.0	8599364
pH	pH	7.79	8599366	7.83	N/A	8599362

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8541		QV8542		
Sampling Date		2017/04/06 11:30		2017/04/06 12:30		
COC Number		520094-03-01		520094-03-01		
	UNITS	**WG-88877-060417-JS-03**	**QC Batch**	**WG-88877-060417-JS-04**	**RDL**	**QC Batch**
Physical Properties						
Total Dissolved Solids	mg/L	52	8602116	76	10	8602116
RDL = Reportable Detection Limit						

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Maxxam Job #: B726014
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GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8543			QV8544		
Sampling Date		2017/04/06 14:30			2017/04/06 15:00		
COC Number		520094-03-01			520094-03-01		
	UNITS	WG-88877-060417-JS-05	RDL	QC Batch	WG-88877-060417-JS-06	RDL	QC Batch
ANIONS							
Nitrite (N)	mg/L	0.0457	0.0050	8599503	0.341	0.0050	8599505
Calculated Parameters							
Filter and HNO3 Preservation	N/A	FIELD	N/A	ONSITE	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	0.193	0.020	8598442	47.0	1.0	8598442
Sulphide (as H2S)	mg/L	0.010	0.0020	8598256	0.011	0.0020	8598256
Demand Parameters							
Biochemical Oxygen Demand	mg/L	<6.0	6.0	8599382	<6.0	6.0	8599382
Chemical Oxygen Demand	mg/L	94	10	8601312	56	10	8601312
Misc. Inorganics							
Alkalinity (Total as CaCO3)	mg/L	119	0.50	8599365	97.7	0.50	8599368
Alkalinity (PP as CaCO3)	mg/L	<0.50	0.50	8599365	<0.50	0.50	8599368
Bicarbonate (HCO3)	mg/L	146	0.50	8599365	119	0.50	8599368
Carbonate (CO3)	mg/L	<0.50	0.50	8599365	<0.50	0.50	8599368
Hydroxide (OH)	mg/L	<0.50	0.50	8599365	<0.50	0.50	8599368
Anions							
Dissolved Sulphate (SO4)	mg/L	8.47	0.50	8601048	5.79	0.50	8601061
Total Sulphide	mg/L	0.0093	0.0019	8601794	0.010	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	88	0.50	8601046	4.6	0.50	8601058
Nutrients							
Orthophosphate (P)	mg/L	0.0058	0.0050	8599445	0.0104	0.0050	8599446
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.202	0.020	8598538	7.3	2.0	8598538
Total Ammonia (N)	mg/L	0.017	0.0050	8600016	0.050	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	0.239	0.020	8599502	47.4 (1)	1.0	8599504
Total Nitrogen (N)	mg/L	0.441	0.020	8601383	54.7 (1)	2.0	8601383
Misc. Organics							
Phenols	mg/L	<0.0010	0.0010	8602424	0.0012	0.0010	8602424
Physical Properties							
Conductivity	uS/cm	535	1.0	8599364	589	1.0	8599367
pH	pH	8.06	N/A	8599362	8.01	N/A	8599366

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8543			QV8544		
Sampling Date		2017/04/06 14:30			2017/04/06 15:00		
COC Number		520094-03-01			520094-03-01		
	UNITS	**WG-88877-060417-JS-05**	**RDL**	**QC Batch**	**WG-88877-060417-JS-06**	**RDL**	**QC Batch**
Physical Properties							
Total Dissolved Solids	mg/L	354	10	8602116	420	10	8602116
RDL = Reportable Detection Limit							

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8545	QV8545		QV8546		
Sampling Date		2017/04/06 15:05	2017/04/06 15:05		2017/04/06 15:30		
COC Number		520094-03-01	520094-03-01		520094-03-01		
	UNITS	WG-88877-060417-JS-07	WG-88877-060417-JS-07 Lab-Dup	RDL	WG-88877-060417-JS-08	RDL	QC Batch
ANIONS							
Nitrite (N)	mg/L	0.344	N/A	0.0050	<0.0050	0.0050	8599505
Calculated Parameters							
Filter and HNO3 Preservation	N/A	FIELD	N/A	N/A	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	46.9	N/A	1.0	1.93	0.020	8598442
Sulphide (as H2S)	mg/L	0.0070	N/A	0.0020	0.013	0.0020	8598256
Demand Parameters							
Biochemical Oxygen Demand	mg/L	<6.0	<6.0	6.0	<6.0	6.0	8599382
Chemical Oxygen Demand	mg/L	41	N/A	10	50	10	8601312
Misc. Inorganics							
Alkalinity (Total as CaCO3)	mg/L	96.7	N/A	0.50	42.0	0.50	8599368
Alkalinity (PP as CaCO3)	mg/L	<0.50	N/A	0.50	<0.50	0.50	8599368
Bicarbonate (HCO3)	mg/L	118	N/A	0.50	51.3	0.50	8599368
Carbonate (CO3)	mg/L	<0.50	N/A	0.50	<0.50	0.50	8599368
Hydroxide (OH)	mg/L	<0.50	N/A	0.50	<0.50	0.50	8599368
Anions							
Dissolved Sulphate (SO4)	mg/L	5.85	5.92	0.50	79.7	0.50	8601061
Total Sulphide	mg/L	0.0064	N/A	0.0019	0.012	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	4.6	4.6	0.50	2.2	0.50	8601058
Nutrients							
Orthophosphate (P)	mg/L	0.0108	0.0095	0.0050	<0.0050	0.0050	8599446
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<2.0	N/A	2.0	0.713	0.040	8598538
Total Ammonia (N)	mg/L	0.048	N/A	0.0050	0.065	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	47.2 (1)	N/A	1.0	1.93	0.020	8599504
Total Nitrogen (N)	mg/L	45.7 (1)	N/A	2.0	2.65 (1)	0.040	8601383
Misc. Organics							
Phenols	mg/L	<0.0010	N/A	0.0010	<0.0010	0.0010	8602424
Physical Properties							
Conductivity	uS/cm	579	N/A	1.0	280	1.0	8599367

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8545	QV8545		QV8546		
Sampling Date		2017/04/06 15:05	2017/04/06 15:05		2017/04/06 15:30		
COC Number		520094-03-01	520094-03-01		520094-03-01		
	UNITS	**WG-88877-060417-JS-07**	**WG-88877-060417-JS-07 Lab-Dup**	**RDL**	**WG-88877-060417-JS-08**	**RDL**	**QC Batch**
pH	pH	8.00	N/A	N/A	7.21	N/A	8599366
Physical Properties							
Total Dissolved Solids	mg/L	414	N/A	10	166	10	8602116

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
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Your P.O. #: 73506780
Sampler Initials: JS

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8547		QV8548		
Sampling Date		2017/04/07 09:00		2017/04/07 09:30		
COC Number		520094-03-01		520094-03-01		
	UNITS	WG-88877-070417-JS-09	QC Batch	WG-88877-070417-JS-10	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.0050	8599505	<0.0050	0.0050	8599505
Calculated Parameters						
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	0.053	8598442	0.748	0.020	8598442
Sulphide (as H2S)	mg/L	<0.0020	8598256	<0.0020	0.0020	8598256
Demand Parameters						
Biochemical Oxygen Demand	mg/L	<6.0	8599382	<6.0	6.0	8599382
Chemical Oxygen Demand	mg/L	21	8601313	29	10	8601313
Misc. Inorganics						
Alkalinity (Total as CaCO3)	mg/L	34.2	8599368	40.8	0.50	8599349
Alkalinity (PP as CaCO3)	mg/L	<0.50	8599368	<0.50	0.50	8599349
Bicarbonate (HCO3)	mg/L	41.7	8599368	49.7	0.50	8599349
Carbonate (CO3)	mg/L	<0.50	8599368	<0.50	0.50	8599349
Hydroxide (OH)	mg/L	<0.50	8599368	<0.50	0.50	8599349
Anions						
Dissolved Sulphate (SO4)	mg/L	3.90	8601061	3.75	0.50	8601061
Total Sulphide	mg/L	<0.0019	8601794	<0.0019	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	0.89	8601058	3.7	0.50	8601058
Nutrients						
Orthophosphate (P)	mg/L	0.0268	8599446	0.0050	0.0050	8599446
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.048	8598538	<0.020	0.020	8598538
Total Ammonia (N)	mg/L	0.022	8600016	0.035	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	0.053	8599504	0.748	0.020	8599504
Total Nitrogen (N)	mg/L	0.101	8601383	0.723	0.020	8601383
Misc. Organics						
Phenols	mg/L	<0.0010	8602424	<0.0010	0.0010	8602424
Physical Properties						
Conductivity	uS/cm	72.1	8599367	100	1.0	8599348
pH	pH	7.78	8599366	7.50	N/A	8599347

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B726014
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GHD Limited
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RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8547		QV8548		
Sampling Date		2017/04/07 09:00		2017/04/07 09:30		
COC Number		520094-03-01		520094-03-01		
	UNITS	WG-88877-070417-JS-09	QC Batch	WG-88877-070417-JS-10	RDL	QC Batch
Physical Properties						
Total Dissolved Solids	mg/L	44	8602116	62	10	8602116
RDL = Reportable Detection Limit						

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Maxxam Job #: B726014
Report Date: 2017/04/21

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RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8549		QV8550		
Sampling Date		2017/04/07 10:00		2017/04/07 10:30		
COC Number		520094-02-01		520094-02-01		
	UNITS	WG-88877-070417-JS-11	QC Batch	WG-88877-070417-JS-12	RDL	QC Batch
ANIONS						
Nitrite (N)	mg/L	<0.0050	8599503	<0.0050	0.0050	8599503
Calculated Parameters						
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	3.50	8598442	3.52	0.10	8598442
Sulphide (as H2S)	mg/L	<0.0020	8598256	<0.0020	0.0020	8598256
Demand Parameters						
Biochemical Oxygen Demand	mg/L	<6.0	8599382	<6.0	6.0	8599382
Chemical Oxygen Demand	mg/L	<10	8601313	<10	10	8601313
Misc. Inorganics						
Alkalinity (Total as CaCO3)	mg/L	79.4	8599368	81.7	0.50	8599368
Alkalinity (PP as CaCO3)	mg/L	<0.50	8599368	<0.50	0.50	8599368
Bicarbonate (HCO3)	mg/L	96.8	8599368	99.7	0.50	8599368
Carbonate (CO3)	mg/L	<0.50	8599368	<0.50	0.50	8599368
Hydroxide (OH)	mg/L	<0.50	8599368	<0.50	0.50	8599368
Anions						
Dissolved Sulphate (SO4)	mg/L	14.2	8601957	13.5	0.50	8601048
Total Sulphide	mg/L	<0.0019	8601794	<0.0019	0.0019	8601794
Dissolved Chloride (Cl)	mg/L	55	8601046	50	0.50	8601046
Nutrients						
Orthophosphate (P)	mg/L	0.0226	8599445	0.0125	0.0050	8599445
Total Total Kjeldahl Nitrogen (Calc)	mg/L	<0.10	8598538	<0.10	0.10	8598538
Total Ammonia (N)	mg/L	0.014	8600017	0.024	0.0050	8600016
Nitrate plus Nitrite (N)	mg/L	3.50 (1)	8599502	3.52 (1)	0.10	8599502
Total Nitrogen (N)	mg/L	3.30 (1)	8601385	3.37 (1)	0.10	8601383
Misc. Organics						
Phenols	mg/L	<0.0010	8602424	<0.0010	0.0010	8602424
Physical Properties						
Conductivity	uS/cm	397	8599367	379	1.0	8599367
pH	pH	7.78	8599366	7.76	N/A	8599366

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

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Maxxam Job #: B726014
Report Date: 2017/04/21

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RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		QV8549		QV8550		
Sampling Date		2017/04/07 10:00		2017/04/07 10:30		
COC Number		520094-02-01		520094-02-01		
	UNITS	**WG-88877-070417-JS-11**	**QC Batch**	**WG-88877-070417-JS-12**	**RDL**	**QC Batch**
Physical Properties						
Total Dissolved Solids	mg/L	224	8602135	206	10	8602135
RDL = Reportable Detection Limit						

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
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Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8539	QV8539	QV8540		
Sampling Date		2017/04/06 10:00	2017/04/06 10:00	2017/04/06 10:45		
COC Number		520094-03-01	520094-03-01	520094-03-01		
	UNITS	WG-88877-060417-JS-01	WG-88877-060417-JS-01 Lab-Dup	WG-88877-060417-JS-02	RDL	QC Batch
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	51.9	N/A	26.6	0.50	8598285
Elements						
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	0.010	8603106
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	9.8	N/A	8.8	3.0	8601126
Dissolved Antimony (Sb)	ug/L	<0.50	N/A	<0.50	0.50	8601126
Dissolved Arsenic (As)	ug/L	0.61	N/A	0.24	0.10	8601126
Dissolved Barium (Ba)	ug/L	10.8	N/A	4.3	1.0	8601126
Dissolved Beryllium (Be)	ug/L	<0.10	N/A	<0.10	0.10	8601126
Dissolved Bismuth (Bi)	ug/L	<1.0	N/A	<1.0	1.0	8601126
Dissolved Boron (B)	ug/L	<50	N/A	<50	50	8601126
Dissolved Cadmium (Cd)	ug/L	<0.010	N/A	<0.010	0.010	8601126
Dissolved Chromium (Cr)	ug/L	<1.0	N/A	<1.0	1.0	8601126
Dissolved Cobalt (Co)	ug/L	<0.20	N/A	<0.20	0.20	8601126
Dissolved Copper (Cu)	ug/L	0.43	N/A	0.39	0.20	8601126
Dissolved Iron (Fe)	ug/L	<5.0	N/A	<5.0	5.0	8601126
Dissolved Lead (Pb)	ug/L	<0.20	N/A	<0.20	0.20	8601126
Dissolved Lithium (Li)	ug/L	<2.0	N/A	<2.0	2.0	8601126
Dissolved Manganese (Mn)	ug/L	12.5	N/A	1.9	1.0	8601126
Dissolved Molybdenum (Mo)	ug/L	<1.0	N/A	<1.0	1.0	8601126
Dissolved Nickel (Ni)	ug/L	<1.0	N/A	<1.0	1.0	8601126
Dissolved Phosphorus (P)	ug/L	15	N/A	<10	10	8601126
Dissolved Selenium (Se)	ug/L	0.20	N/A	<0.10	0.10	8601126
Dissolved Silicon (Si)	ug/L	6300	N/A	3110	100	8601126
Dissolved Silver (Ag)	ug/L	<0.020	N/A	<0.020	0.020	8601126
Dissolved Strontium (Sr)	ug/L	26.2	N/A	12.2	1.0	8601126
Dissolved Thallium (Tl)	ug/L	<0.010	N/A	<0.010	0.010	8601126
Dissolved Tin (Sn)	ug/L	<5.0	N/A	<5.0	5.0	8601126
Dissolved Titanium (Ti)	ug/L	<5.0	N/A	<5.0	5.0	8601126

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8539	QV8539	QV8540		
Sampling Date		2017/04/06 10:00	2017/04/06 10:00	2017/04/06 10:45		
COC Number		520094-03-01	520094-03-01	520094-03-01		
	UNITS	WG-88877-060417-JS-01	WG-88877-060417-JS-01 Lab-Dup	WG-88877-060417-JS-02	RDL	QC Batch
Dissolved Uranium (U)	ug/L	<0.10	N/A	<0.10	0.10	8601126
Dissolved Vanadium (V)	ug/L	<5.0	N/A	<5.0	5.0	8601126
Dissolved Zinc (Zn)	ug/L	<5.0	N/A	<5.0	5.0	8601126
Dissolved Zirconium (Zr)	ug/L	<0.10	N/A	<0.10	0.10	8601126
Dissolved Calcium (Ca)	mg/L	16.5	N/A	8.98	0.050	8598535
Dissolved Magnesium (Mg)	mg/L	2.62	N/A	1.01	0.050	8598535
Dissolved Potassium (K)	mg/L	0.491	N/A	0.241	0.050	8598535
Dissolved Sodium (Na)	mg/L	4.32	N/A	0.820	0.050	8598535
Dissolved Sulphur (S)	mg/L	<3.0	N/A	<3.0	3.0	8598535

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
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CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8541	QV8542	QV8543		
Sampling Date		2017/04/06 11:30	2017/04/06 12:30	2017/04/06 14:30		
COC Number		520094-03-01	520094-03-01	520094-03-01		
	UNITS	WG-88877-060417-JS-03	WG-88877-060417-JS-04	WG-88877-060417-JS-05	RDL	QC Batch
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	40.8	57.9	200	0.50	8598285
Elements						
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	0.010	8603106
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	6.2	<3.0	5.1	3.0	8601126
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	0.50	8601126
Dissolved Arsenic (As)	ug/L	0.14	0.13	0.74	0.10	8601126
Dissolved Barium (Ba)	ug/L	<1.0	1.6	30.3	1.0	8601126
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	0.10	8601126
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	1.0	8601126
Dissolved Boron (B)	ug/L	<50	<50	<50	50	8601126
Dissolved Cadmium (Cd)	ug/L	<0.010	<0.010	0.012	0.010	8601126
Dissolved Chromium (Cr)	ug/L	<1.0	1.8	<1.0	1.0	8601126
Dissolved Cobalt (Co)	ug/L	<0.20	<0.20	0.25	0.20	8601126
Dissolved Copper (Cu)	ug/L	1.07	0.50	0.85	0.20	8601126
Dissolved Iron (Fe)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	<0.20	0.20	8601126
Dissolved Lithium (Li)	ug/L	<2.0	<2.0	2.4	2.0	8601126
Dissolved Manganese (Mn)	ug/L	<1.0	<1.0	151	1.0	8601126
Dissolved Molybdenum (Mo)	ug/L	<1.0	<1.0	3.1	1.0	8601126
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	<1.0	1.0	8601126
Dissolved Phosphorus (P)	ug/L	14	12	<10	10	8601126
Dissolved Selenium (Se)	ug/L	<0.10	0.15	0.24	0.10	8601126
Dissolved Silicon (Si)	ug/L	5670	6480	10900	100	8601126
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	<0.020	0.020	8601126
Dissolved Strontium (Sr)	ug/L	22.9	29.8	163	1.0	8601126
Dissolved Thallium (Tl)	ug/L	<0.010	<0.010	0.014	0.010	8601126
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Uranium (U)	ug/L	<0.10	<0.10	0.82	0.10	8601126

RDL = Reportable Detection Limit

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Maxxam Job #: B726014
Report Date: 2017/04/21

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Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8541	QV8542	QV8543		
Sampling Date		2017/04/06 11:30	2017/04/06 12:30	2017/04/06 14:30		
COC Number		520094-03-01	520094-03-01	520094-03-01		
	UNITS	**WG-88877-060417-JS-03**	**WG-88877-060417-JS-04**	**WG-88877-060417-JS-05**	**RDL**	**QC Batch**
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Zirconium (Zr)	ug/L	<0.10	<0.10	<0.10	0.10	8601126
Dissolved Calcium (Ca)	mg/L	13.3	18.0	56.2	0.050	8598535
Dissolved Magnesium (Mg)	mg/L	1.82	3.14	14.4	0.050	8598535
Dissolved Potassium (K)	mg/L	0.215	0.269	1.97	0.050	8598535
Dissolved Sodium (Na)	mg/L	3.55	5.24	18.0	0.050	8598535
Dissolved Sulphur (S)	mg/L	<3.0	<3.0	3.1	3.0	8598535
RDL = Reportable Detection Limit						

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
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CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8544	QV8545	QV8546		
Sampling Date		2017/04/06 15:00	2017/04/06 15:05	2017/04/06 15:30		
COC Number		520094-03-01	520094-03-01	520094-03-01		
	UNITS	WG-88877-060417-JS-06	WG-88877-060417-JS-07	WG-88877-060417-JS-08	RDL	QC Batch
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	226	228	101	0.50	8598285
Elements						
Dissolved Mercury (Hg)	ug/L	0.061	0.066	<0.010	0.010	8603106
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	11.4	3.5	30.8	3.0	8601126
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	0.50	8601126
Dissolved Arsenic (As)	ug/L	0.40	0.43	<0.10	0.10	8601126
Dissolved Barium (Ba)	ug/L	50.3	48.8	8.8	1.0	8601126
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	0.10	8601126
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	1.0	8601126
Dissolved Boron (B)	ug/L	100	97	<50	50	8601126
Dissolved Cadmium (Cd)	ug/L	0.012	0.013	0.013	0.010	8601126
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	1.0	8601126
Dissolved Cobalt (Co)	ug/L	0.55	0.54	0.29	0.20	8601126
Dissolved Copper (Cu)	ug/L	0.79	0.32	1.14	0.20	8601126
Dissolved Iron (Fe)	ug/L	17.0	<5.0	20.5	5.0	8601126
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	<0.20	0.20	8601126
Dissolved Lithium (Li)	ug/L	<2.0	<2.0	<2.0	2.0	8601126
Dissolved Manganese (Mn)	ug/L	94.9	93.1	9.6	1.0	8601126
Dissolved Molybdenum (Mo)	ug/L	<1.0	<1.0	<1.0	1.0	8601126
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	<1.0	1.0	8601126
Dissolved Phosphorus (P)	ug/L	15	14	<10	10	8601126
Dissolved Selenium (Se)	ug/L	0.26	0.25	2.60	0.10	8601126
Dissolved Silicon (Si)	ug/L	7480	7460	3290	100	8601126
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	<0.020	0.020	8601126
Dissolved Strontium (Sr)	ug/L	208	207	59.5	1.0	8601126
Dissolved Thallium (Tl)	ug/L	0.013	0.012	<0.010	0.010	8601126
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Uranium (U)	ug/L	0.19	0.19	<0.10	0.10	8601126

RDL = Reportable Detection Limit

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8544	QV8545	QV8546		
Sampling Date		2017/04/06 15:00	2017/04/06 15:05	2017/04/06 15:30		
COC Number		520094-03-01	520094-03-01	520094-03-01		
	UNITS	**WG-88877-060417-JS-06**	**WG-88877-060417-JS-07**	**WG-88877-060417-JS-08**	**RDL**	**QC Batch**
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	<5.0	5.0	8601126
Dissolved Zirconium (Zr)	ug/L	<0.10	<0.10	<0.10	0.10	8601126
Dissolved Calcium (Ca)	mg/L	62.5	63.5	34.7	0.050	8598535
Dissolved Magnesium (Mg)	mg/L	17.0	17.0	3.40	0.050	8598535
Dissolved Potassium (K)	mg/L	0.936	0.928	0.240	0.050	8598535
Dissolved Sodium (Na)	mg/L	15.6	15.4	11.5	0.050	8598535
Dissolved Sulphur (S)	mg/L	<3.0	<3.0	27.7	3.0	8598535
RDL = Reportable Detection Limit						

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GHD Limited
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Site Location: 7295 GOLD RIVER HIGHWAY
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Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8547	QV8548		QV8549		
Sampling Date		2017/04/07 09:00	2017/04/07 09:30		2017/04/07 10:00		
COC Number		520094-03-01	520094-03-01		520094-02-01		
	UNITS	WG-88877-070417-JS-09	WG-88877-070417-JS-10	QC Batch	WG-88877-070417-JS-11	RDL	QC Batch
Misc. Inorganics							
Dissolved Hardness (CaCO3)	mg/L	31.8	38.2	8598285	54.3	0.50	8598285
Elements							
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	8603106	<0.010	0.010	8603106
Dissolved Metals by ICPMS							
Dissolved Aluminum (Al)	ug/L	15.9	<3.0	8601126	<3.0	3.0	8601429
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	8601126	<0.50	0.50	8601429
Dissolved Arsenic (As)	ug/L	0.97	<0.10	8601126	<0.10	0.10	8601429
Dissolved Barium (Ba)	ug/L	6.3	1.1	8601126	3.3	1.0	8601429
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	8601126	<0.10	0.10	8601429
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	8601126	<1.0	1.0	8601429
Dissolved Boron (B)	ug/L	<50	<50	8601126	<50	50	8601429
Dissolved Cadmium (Cd)	ug/L	<0.010	<0.010	8601126	0.013	0.010	8601429
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	8601126	<1.0	1.0	8601429
Dissolved Cobalt (Co)	ug/L	<0.20	<0.20	8601126	<0.20	0.20	8601429
Dissolved Copper (Cu)	ug/L	0.28	0.36	8601126	0.34	0.20	8601429
Dissolved Iron (Fe)	ug/L	7.3	<5.0	8601126	<5.0	5.0	8601429
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	8601126	<0.20	0.20	8601429
Dissolved Lithium (Li)	ug/L	<2.0	<2.0	8601126	<2.0	2.0	8601429
Dissolved Manganese (Mn)	ug/L	<1.0	<1.0	8601126	<1.0	1.0	8601429
Dissolved Molybdenum (Mo)	ug/L	<1.0	<1.0	8601126	<1.0	1.0	8601429
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	8601126	<1.0	1.0	8601429
Dissolved Phosphorus (P)	ug/L	27	<10	8601126	10	10	8601429
Dissolved Selenium (Se)	ug/L	0.10	0.17	8601126	1.07	0.10	8601429
Dissolved Silicon (Si)	ug/L	4350	6010	8601126	8390	100	8601429
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	8601126	<0.020	0.020	8601429
Dissolved Strontium (Sr)	ug/L	14.4	20.6	8601126	115	1.0	8601429
Dissolved Thallium (Tl)	ug/L	<0.010	<0.010	8601126	<0.010	0.010	8601429
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	8601126	<5.0	5.0	8601429
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	8601126	<5.0	5.0	8601429
Dissolved Uranium (U)	ug/L	<0.10	<0.10	8601126	<0.10	0.10	8601429

RDL = Reportable Detection Limit

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8547	QV8548		QV8549		
Sampling Date		2017/04/07 09:00	2017/04/07 09:30		2017/04/07 10:00		
COC Number		520094-03-01	520094-03-01		520094-02-01		
	UNITS	**WG-88877-070417-JS-09**	**WG-88877-070417-JS-10**	**QC Batch**	**WG-88877-070417-JS-11**	**RDL**	**QC Batch**
Dissolved Vanadium (V)	ug/L	6.1	<5.0	8601126	<5.0	5.0	8601429
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	8601126	<5.0	5.0	8601429
Dissolved Zirconium (Zr)	ug/L	<0.10	<0.10	8601126	<0.10	0.10	8601429
Dissolved Calcium (Ca)	mg/L	10.5	11.0	8598535	16.1	0.050	8598535
Dissolved Magnesium (Mg)	mg/L	1.34	2.59	8598535	3.41	0.050	8598535
Dissolved Potassium (K)	mg/L	0.314	0.191	8598535	0.408	0.050	8598535
Dissolved Sodium (Na)	mg/L	1.04	5.21	8598535	59.7	0.050	8598535
Dissolved Sulphur (S)	mg/L	<3.0	<3.0	8598535	4.8	3.0	8598535
RDL = Reportable Detection Limit							

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Maxxam Job #: B726014
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GHD Limited
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Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8550		
Sampling Date		2017/04/07 10:30		
COC Number		520094-02-01		
	UNITS	WG-88877-070417-JS-12	RDL	QC Batch
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	54.7	0.50	8598285
Elements				
Dissolved Mercury (Hg)	ug/L	<0.010	0.010	8603106
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	<3.0	3.0	8601429
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	8601429
Dissolved Arsenic (As)	ug/L	0.13	0.10	8601429
Dissolved Barium (Ba)	ug/L	7.2	1.0	8601429
Dissolved Beryllium (Be)	ug/L	<0.10	0.10	8601429
Dissolved Bismuth (Bi)	ug/L	<1.0	1.0	8601429
Dissolved Boron (B)	ug/L	<50	50	8601429
Dissolved Cadmium (Cd)	ug/L	<0.010	0.010	8601429
Dissolved Chromium (Cr)	ug/L	<1.0	1.0	8601429
Dissolved Cobalt (Co)	ug/L	<0.20	0.20	8601429
Dissolved Copper (Cu)	ug/L	3.25	0.20	8601429
Dissolved Iron (Fe)	ug/L	<5.0	5.0	8601429
Dissolved Lead (Pb)	ug/L	0.20	0.20	8601429
Dissolved Lithium (Li)	ug/L	<2.0	2.0	8601429
Dissolved Manganese (Mn)	ug/L	<1.0	1.0	8601429
Dissolved Molybdenum (Mo)	ug/L	<1.0	1.0	8601429
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	8601429
Dissolved Phosphorus (P)	ug/L	<10	10	8601429
Dissolved Selenium (Se)	ug/L	1.09	0.10	8601429
Dissolved Silicon (Si)	ug/L	8770	100	8601429
Dissolved Silver (Ag)	ug/L	<0.020	0.020	8601429
Dissolved Strontium (Sr)	ug/L	98.7	1.0	8601429
Dissolved Thallium (Tl)	ug/L	<0.010	0.010	8601429
Dissolved Tin (Sn)	ug/L	<5.0	5.0	8601429
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	8601429
Dissolved Uranium (U)	ug/L	<0.10	0.10	8601429
RDL = Reportable Detection Limit				

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Maxxam Job #: B726014
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GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID		QV8550		
Sampling Date		2017/04/07 10:30		
COC Number		520094-02-01		
	UNITS	**WG-88877-070417-JS-12**	**RDL**	**QC Batch**
Dissolved Vanadium (V)	ug/L	<5.0	5.0	8601429
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	8601429
Dissolved Zirconium (Zr)	ug/L	<0.10	0.10	8601429
Dissolved Calcium (Ca)	mg/L	16.8	0.050	8598535
Dissolved Magnesium (Mg)	mg/L	3.08	0.050	8598535
Dissolved Potassium (K)	mg/L	0.425	0.050	8598535
Dissolved Sodium (Na)	mg/L	57.5	0.050	8598535
Dissolved Sulphur (S)	mg/L	4.2	3.0	8598535
RDL = Reportable Detection Limit				

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
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Sampler Initials: JS

GENERAL COMMENTS

Results relate only to the items tested.

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Maxxam Job #: B726014
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8599347	pH	2017/04/08			101	97 - 103			0.28 (1)	N/A
8599348	Conductivity	2017/04/08			100	80 - 120	<1.0	uS/cm	0 (1)	20
8599349	Alkalinity (PP as CaCO3)	2017/04/08					<0.50	mg/L		
8599349	Alkalinity (Total as CaCO3)	2017/04/08	98	80 - 120	101	80 - 120	<0.50	mg/L		
8599349	Bicarbonate (HCO3)	2017/04/08					<0.50	mg/L		
8599349	Carbonate (CO3)	2017/04/08					<0.50	mg/L		
8599349	Hydroxide (OH)	2017/04/08					<0.50	mg/L		
8599362	pH	2017/04/09			101	97 - 103			0.37 (1)	N/A
8599364	Conductivity	2017/04/09			99	80 - 120	1.1, RDL=1.0	uS/cm	0.41 (1)	20
8599365	Alkalinity (PP as CaCO3)	2017/04/09					<0.50	mg/L	NC (1)	20
8599365	Alkalinity (Total as CaCO3)	2017/04/09	NC	80 - 120	99	80 - 120	<0.50	mg/L	0.32 (1)	20
8599365	Bicarbonate (HCO3)	2017/04/09					<0.50	mg/L	0.32 (1)	20
8599365	Carbonate (CO3)	2017/04/09					<0.50	mg/L	NC (1)	20
8599365	Hydroxide (OH)	2017/04/09					<0.50	mg/L	NC (1)	20
8599366	pH	2017/04/09			101	97 - 103			0.55 (1)	N/A
8599367	Conductivity	2017/04/09			100	80 - 120	<1.0	uS/cm	3.0 (1)	20
8599368	Alkalinity (PP as CaCO3)	2017/04/09					<0.50	mg/L	NC (1)	20
8599368	Alkalinity (Total as CaCO3)	2017/04/09	NC	80 - 120	101	80 - 120	<0.50	mg/L	6.7 (1)	20
8599368	Bicarbonate (HCO3)	2017/04/09					<0.50	mg/L	6.7 (1)	20
8599368	Carbonate (CO3)	2017/04/09					<0.50	mg/L	NC (1)	20
8599368	Hydroxide (OH)	2017/04/09					<0.50	mg/L	NC (1)	20
8599382	Biochemical Oxygen Demand	2017/04/13			104	85 - 115	<6.0	mg/L	NC (2)	20
8599445	Orthophosphate (P)	2017/04/08	92	80 - 120	94	80 - 120	<0.0050	mg/L	12 (1)	20
8599446	Orthophosphate (P)	2017/04/08	100 (3)	80 - 120	80	80 - 120	<0.0050	mg/L	13 (4)	20
8599502	Nitrate plus Nitrite (N)	2017/04/08	102	80 - 120	105	80 - 120	<0.020	mg/L	0.44 (1)	25
8599503	Nitrite (N)	2017/04/08	96	80 - 120	101	80 - 120	<0.0050	mg/L	NC (1)	20
8599504	Nitrate plus Nitrite (N)	2017/04/08	NC	80 - 120	105	80 - 120	<0.020	mg/L	0.13 (1)	25
8599505	Nitrite (N)	2017/04/08	98	80 - 120	103	80 - 120	<0.0050	mg/L	NC (1)	20
8600016	Total Ammonia (N)	2017/04/10	100	80 - 120	101	80 - 120	<0.0050	mg/L	1.5 (1)	20
8600017	Total Ammonia (N)	2017/04/10	101	80 - 120	101	80 - 120	<0.0050	mg/L	NC (1)	20

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Maxxam Job #: B726014
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8601046	Dissolved Chloride (Cl)	2017/04/10	111	80 - 120	97	80 - 120	<0.50	mg/L	0.055 (5)	20
8601048	Dissolved Sulphate (SO4)	2017/04/10	NC	80 - 120	93	80 - 120	<0.50	mg/L	1.1 (5)	20
8601058	Dissolved Chloride (Cl)	2017/04/10	106	80 - 120	97	80 - 120	<0.50	mg/L	0.89 (1)	20
8601061	Dissolved Sulphate (SO4)	2017/04/10	110	80 - 120	105	80 - 120	<0.50	mg/L	NC (1)	20
8601126	Dissolved Aluminum (Al)	2017/04/13	100	80 - 120	100	80 - 120	<3.0	ug/L	NC (1)	20
8601126	Dissolved Antimony (Sb)	2017/04/13	101	80 - 120	99	80 - 120	<0.50	ug/L	NC (1)	20
8601126	Dissolved Arsenic (As)	2017/04/13	102	80 - 120	101	80 - 120	<0.10	ug/L	NC (1)	20
8601126	Dissolved Barium (Ba)	2017/04/13	106	80 - 120	104	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Beryllium (Be)	2017/04/13	101	80 - 120	99	80 - 120	<0.10	ug/L	NC (1)	20
8601126	Dissolved Bismuth (Bi)	2017/04/13	102	80 - 120	101	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Boron (B)	2017/04/13	96	80 - 120	94	80 - 120	<50	ug/L	NC (1)	20
8601126	Dissolved Cadmium (Cd)	2017/04/13	106	80 - 120	101	80 - 120	<0.010	ug/L	NC (1)	20
8601126	Dissolved Chromium (Cr)	2017/04/13	100	80 - 120	103	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Cobalt (Co)	2017/04/13	100	80 - 120	102	80 - 120	<0.20	ug/L	NC (1)	20
8601126	Dissolved Copper (Cu)	2017/04/13	100	80 - 120	102	80 - 120	<0.20	ug/L	2.0 (1)	20
8601126	Dissolved Iron (Fe)	2017/04/13	105	80 - 120	105	80 - 120	<5.0	ug/L	NC (1)	20
8601126	Dissolved Lead (Pb)	2017/04/13	104	80 - 120	103	80 - 120	<0.20	ug/L	NC (1)	20
8601126	Dissolved Lithium (Li)	2017/04/13	98	80 - 120	99	80 - 120	<2.0	ug/L	NC (1)	20
8601126	Dissolved Manganese (Mn)	2017/04/13	100	80 - 120	102	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Molybdenum (Mo)	2017/04/13	101	80 - 120	98	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Nickel (Ni)	2017/04/13	101	80 - 120	103	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Phosphorus (P)	2017/04/13					<10	ug/L		
8601126	Dissolved Selenium (Se)	2017/04/13	106	80 - 120	101	80 - 120	<0.10	ug/L	NC (1)	20
8601126	Dissolved Silicon (Si)	2017/04/13					<100	ug/L	NC (1)	20
8601126	Dissolved Silver (Ag)	2017/04/13	104	80 - 120	104	80 - 120	<0.020	ug/L	NC (1)	20
8601126	Dissolved Strontium (Sr)	2017/04/13	97	80 - 120	102	80 - 120	<1.0	ug/L	NC (1)	20
8601126	Dissolved Thallium (Tl)	2017/04/13	101	80 - 120	100	80 - 120	<0.010	ug/L	NC (1)	20
8601126	Dissolved Tin (Sn)	2017/04/13	103	80 - 120	101	80 - 120	<5.0	ug/L	NC (1)	20
8601126	Dissolved Titanium (Ti)	2017/04/13	94	80 - 120	103	80 - 120	<5.0	ug/L	NC (1)	20
8601126	Dissolved Uranium (U)	2017/04/13	99	80 - 120	102	80 - 120	<0.10	ug/L	NC (1)	20

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Maxxam Job #: B726014
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8601126	Dissolved Vanadium (V)	2017/04/13	100	80 - 120	100	80 - 120	<5.0	ug/L	NC (1)	20
8601126	Dissolved Zinc (Zn)	2017/04/13	105	80 - 120	103	80 - 120	<5.0	ug/L	NC (1)	20
8601126	Dissolved Zirconium (Zr)	2017/04/13					<0.10	ug/L	NC (1)	20
8601312	Chemical Oxygen Demand	2017/04/12	98	80 - 120	106	80 - 120	<10	mg/L	NC (1)	20
8601313	Chemical Oxygen Demand	2017/04/12	96	80 - 120	104	80 - 120	<10	mg/L	NC (1)	20
8601383	Total Nitrogen (N)	2017/04/11	100	80 - 120	96	80 - 120	<0.020	mg/L	3.7 (1)	20
8601385	Total Nitrogen (N)	2017/04/11	103	80 - 120	97	80 - 120	<0.020	mg/L	3.5 (1)	20
8601388	Total Nitrogen (N)	2017/04/11	104 (6)	80 - 120	95	80 - 120	<0.020	mg/L	NC (7)	20
8601429	Dissolved Aluminum (Al)	2017/04/13	111	80 - 120	112	80 - 120	<3.0	ug/L	NC (1)	20
8601429	Dissolved Antimony (Sb)	2017/04/13	103	80 - 120	100	80 - 120	<0.50	ug/L	NC (1)	20
8601429	Dissolved Arsenic (As)	2017/04/13	102	80 - 120	102	80 - 120	<0.10	ug/L	NC (1)	20
8601429	Dissolved Barium (Ba)	2017/04/13	101	80 - 120	100	80 - 120	<1.0	ug/L	NC (1)	20
8601429	Dissolved Beryllium (Be)	2017/04/13	97	80 - 120	97	80 - 120	<0.10	ug/L	NC (1)	20
8601429	Dissolved Bismuth (Bi)	2017/04/13	96	80 - 120	97	80 - 120	<1.0	ug/L	NC (1)	20
8601429	Dissolved Boron (B)	2017/04/13	113	80 - 120	113	80 - 120	<50	ug/L	NC (1)	20
8601429	Dissolved Cadmium (Cd)	2017/04/13	103	80 - 120	99	80 - 120	<0.010	ug/L	NC (1)	20
8601429	Dissolved Chromium (Cr)	2017/04/13	99	80 - 120	101	80 - 120	<1.0	ug/L	NC (1)	20
8601429	Dissolved Cobalt (Co)	2017/04/13	97	80 - 120	99	80 - 120	<0.20	ug/L	NC (1)	20
8601429	Dissolved Copper (Cu)	2017/04/13	98	80 - 120	99	80 - 120	<0.20	ug/L	NC (1)	20
8601429	Dissolved Iron (Fe)	2017/04/13	107	80 - 120	112	80 - 120	<5.0	ug/L	NC (1)	20
8601429	Dissolved Lead (Pb)	2017/04/13	97	80 - 120	97	80 - 120	<0.20	ug/L	NC (1)	20
8601429	Dissolved Lithium (Li)	2017/04/13	98	80 - 120	103	80 - 120	<2.0	ug/L	NC (1)	20
8601429	Dissolved Manganese (Mn)	2017/04/13	96	80 - 120	99	80 - 120	<1.0	ug/L	NC (1)	20
8601429	Dissolved Molybdenum (Mo)	2017/04/13	105	80 - 120	101	80 - 120	<1.0	ug/L	NC (1)	20
8601429	Dissolved Nickel (Ni)	2017/04/13	99	80 - 120	100	80 - 120	<1.0	ug/L	NC (1)	20
8601429	Dissolved Phosphorus (P)	2017/04/13					<10	ug/L	NC (1)	20
8601429	Dissolved Selenium (Se)	2017/04/13	106	80 - 120	103	80 - 120	<0.10	ug/L	NC (1)	20
8601429	Dissolved Silicon (Si)	2017/04/13					<100	ug/L	NC (1)	20
8601429	Dissolved Silver (Ag)	2017/04/13	107	80 - 120	102	80 - 120	<0.020	ug/L	NC (1)	20
8601429	Dissolved Strontium (Sr)	2017/04/13	99	80 - 120	103	80 - 120	<1.0	ug/L	NC (1)	20

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Maxxam Job #: B726014
Report Date: 2017/04/21

QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8601429	Dissolved Thallium (Tl)	2017/04/13	101	80 - 120	100	80 - 120	<0.010	ug/L	NC (1)	20
8601429	Dissolved Tin (Sn)	2017/04/13	101	80 - 120	101	80 - 120	<5.0	ug/L	NC (1)	20
8601429	Dissolved Titanium (Ti)	2017/04/13	97	80 - 120	95	80 - 120	<5.0	ug/L	NC (1)	20
8601429	Dissolved Uranium (U)	2017/04/13	95	80 - 120	96	80 - 120	<0.10	ug/L	NC (1)	20
8601429	Dissolved Vanadium (V)	2017/04/13	100	80 - 120	99	80 - 120	<5.0	ug/L	NC (1)	20
8601429	Dissolved Zinc (Zn)	2017/04/13	103	80 - 120	99	80 - 120	<5.0	ug/L	NC (1)	20
8601429	Dissolved Zirconium (Zr)	2017/04/13					<0.10	ug/L	NC (1)	20
8601794	Total Sulphide	2017/04/12			92	80 - 120	<0.0019	mg/L	NC (1)	20
8601957	Dissolved Sulphate (SO4)	2017/04/11	118	80 - 120	100	80 - 120	0.50, RDL=0.50	mg/L	1.1 (1)	20
8602116	Total Dissolved Solids	2017/04/13	99	80 - 120	86	80 - 120	<10	mg/L	3.6 (1)	20
8602135	Total Dissolved Solids	2017/04/13	99	80 - 120	88	80 - 120	<10	mg/L		
8602424	Phenols	2017/04/12	95	80 - 120	104	80 - 120	<0.0010	mg/L	NC (1)	20

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QUALITY ASSURANCE REPORT(CONT'D)

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8603106	Dissolved Mercury (Hg)	2017/04/13	100 (8)	80 - 120	102	80 - 120	<0.010	ug/L	NC (9)	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Duplicate Parent ID

(2) Duplicate Parent ID [QV8545-01]

(3) Matrix Spike Parent ID [QV8545-02]

(4) Duplicate Parent ID [QV8545-02]

(5) Duplicate Parent ID [QV8539-02]

(6) Matrix Spike Parent ID [QV8540-07]

(7) Duplicate Parent ID [QV8540-07]

(8) Matrix Spike Parent ID [QV8539-06]

(9) Duplicate Parent ID [QV8539-06]

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Maxxam Job #: B726014
Report Date: 2017/04/21

GHD Limited
Client Project #: 088877-02-01
Site Location: 7295 GOLD RIVER HIGHWAY
Your P.O. #: 73506780
Sampler Initials: JS

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Ph.D., P.Chem., Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Page 1 of 4

B726014_COC

Bottle Order #: 520094

Project Manager: VJ Oco

C#520094-03-01

INVOICE TO:		Report Information		Project Information	
Company Name	#163 GHD Limited	Company Name		Quotation #	B61466
Contact Name	Airesse MacPhee	Contact Name		P.O. #	73506780
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address		Project #	088877-02-01
				Project Name	
Phone	(519) 884-0510 x Fax: (519) 725-1394 x	Phone	Fax:	Site #	
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email		Sampled By	J. Stewart

Regulatory Criteria:
- [ ] CSR
- [ ] CCME
- [ ] BC Water Quality
- [ ] Other

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY [ ] 2 Day [ ] 3 Day [ ] Date Required: [ ]
Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity	Biochemical Oxygen Demand	COD	Chloride	Conductivity	Cyanide	pH	Total Phenols	Sulphate	Sulphide (w/ H2S)	# of Bottles	Comments
1		WG-88877-060417-JS-01	06/04/17	1000	W	Y	X	X	X	X	X		X	X	X	X	9	
2		-02		1045		Y											9	
3		-03		1130		Y											9	
4		-04		1230		Y											9	
5		-05		1430		Y											9	
6		-06		1500		Y											9	
7		-07		1505		Y											9	
8		WG-88877-060417-JS-08	06/04/17	1530		Y											9	
9		WG-88877-060417-JS-09	07/04/17	900		Y											9	
10		-10		930		Y											9	

RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Present on Cooler?
James Stewart	17/04/07	1300	J WAHNE HOY	17/04/07	17:30		[ ]	6,7,7 / 5,5,7 / 6,7,5	N/A [ ] Yes [ ] No

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C#520094-03-02

INVOICE TO:		Report Information		Project Information	
Company Name	#163 GHD Limited	Company Name		Quotation #	B61466
Contact Name	Airesse MacPhee	Contact Name		P.O. #	73506780
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address		Project #	088877-02-01
Phone	(519) 884-0510 x Fax: (519) 725-1394 x	Phone	Fax:	Project Name	
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email		Site #	
				Sampled By	J. Stewart

se Only
Bottle Order #: 520094
Project Manager: VJ Oco

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other

Special Instructions

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Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: ☐
Rush Confirmation Number: *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Total Dissolved Solids	Ammonia-N	Nitrite / Nitrate / Nitrogen	Orthophosphate	TKN	Dissolved Metals (inc Phophorus, Hg and Hardness)	LL Sulphide	Total Suspended Solids	Total Metals (inc Phosphorus, Hg and Hardness)	Dissolved Hardness	# of Bottles	Comments
1		WG-88877-060417-JS-01	06/04/17	1000	W	Y	X	X	X	X	X	X	X		X	X	9	
2		-02		1045		Y											9	
3		-03		1130		Y											9	
4		-04		1230		Y											9	
5		-05		1430		Y											9	
6		-06		1500		Y											9	
7		-07		1505		Y											9	
8		-08		1530		Y											9	
9		WG-88877-070417-JS-09	07/04/17	900		Y											9	
10		-10		930		Y											9	

RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
J. Stewart	17/04/07	1300	JUVAHINNE NOV	2017/04/07	17:30	

Lab Use Only: Time Sensitive ☐ | Temperature (°C) on Receipt: 6,7,7/5,5,7 | Custody Seal on Cooler? ☐ Yes ☐ No

6,7,5

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B726014_COC

INVOICE TO:		Report Information		Project Information	
Company Name	#163 GHD Limited	Company Name		Quotation #	B61466
Contact Name	Airesse MacPhee	Contact Name		P.O. #	73506780
Address	651 COLBY DRIVE WATERLOO ON N2V 1C2	Address		Project #	088877-02-01
				Project Name	
Phone	(519) 884-0510 x Fax: (519) 725-1394 x	Phone	Fax:	Site #	
Email	airesse.macphee@ghd.com; NationalEDDSupport@ma	Email		Sampled By	J. Stewart

Lab Use Only
Bottle Order #: 520094
Project Manager: VJ Oco
C#520094-02-01

Regulatory Criteria:
- [ ] CSR
- [ ] CCME
- [ ] BC Water Quality
- [ ] Other

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Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: ☐
Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Alkalinity	Biochemical Oxygen Demand	COD	Chloride	Conductivity	Cyanide	pH	Total Phenols	Sulphate	Sulphide (w/ H2S)	# of Bottles	Comments
1		WG-88877-070417-JS-11	07/04/17	1000	U	Y	X	X	X	X	X		X	X	X	X	9	
2		↓ -12	↓	1030	W	Y	X	X	X	X	X		X	X	X	X	9	
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
James Stewart	17/04/07	13:00	JWAHNNE MOY	2017/04/07	17:30	

Lab Use Only: Time Sensitive ☐ | Temperature (°C) on Receipt: 6,7,7/5,5,7 | Custody Seal Intact on Cooler? ☐ Yes ☐ No

N/A

6,7,5

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Page 4 of 4

B726014_COC

C#520094-01-02

INVOICE TO:

Company Name: #163 GHD Limited
Contact Name: Airesse MacPhee
Address: 651 COLBY DRIVE, WATERLOO ON N2V 1C2
Phone: (519) 884-0510 x Fax: (519) 725-1394 x
Email: airesse.macphee@ghd.com; NationalEDDSupport@ma

Report Information

Company Name:
Contact Name:
Address:
Phone: Fax:
Email:

Project Information

Quotation #: B61466
P.O. #: 73506780
Project #: 088877-02-01
Project Name:
Site #:
Sampled By: J. Stewart

Lab Use Only

Bottle Order #: 520094
Project Manager: VJ Oco

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other

Special Instructions

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1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: ☐
Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Total Dissolved Solids	Ammonia-N	Nitrite / Nitrate / Nitrogen	Orthophosphate	TKN	Dissolved Metals (inc Phophorus, Hg and Hardness)	LL Sulphide	Total Suspended Solids	Total Metals (inc Phosphorus, Hg and Hardness)	Dissolved Hardness	# of Bottles	Comments
1		WG-88877-070417-JS-11	07/04/17	1000	W	Y	✓	✓	✓	✓	✓	✓	✓	✓		✓	9	
2		↓ -12	↓	1030	W	Y	✓	✓	✓	✓	✓	✓	✓	✓		✓	9	
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only: Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
James Stewart	17/04/07	1300	JWATHNE	2017/04/07	17:30		☐	6.7, 7/5.5.7 / 6.7.5	☐ Yes ☐ No

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GHD Field Sample Key (FSK)

Site	088877-03-07 Uplands
Sample Reason	Hydrogeo Investigation
Sampler Name	J. Stewart/M. Dyck
Sampling Company	GHD Ltd
Laboratory(s)	Maxxam Analytics

								pH	Temperature			Conductivity		Turbidity		DO		Eh / ORP	
Sample ID	Location	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Sample Type	Sample Matrix	Parent Sample ID for Field Dups	Footnote(s)	Volume of Water Purged	Field pH	Sample Temp.	TDS g/L	Temp Units	Conductivity	Conductivity Units	Turbidity	Turbidity Units	DO	DO Units	Eh/ORP	Eh/ORP Units
WG-88877-060417-JS-01	MW10-17	4/6/2017	10:00	N	WG			112	7.74	10.39	0.085	C	131	uS	24.3	ntu	9.97	mg/L	214	mV
WG-88877-060417-JS-02	MW9-17	4/6/2017	10:45	N	WG			60	7.84	8.21	0.039	C	60	uS	4.8	ntu	9.71	mg/L	192	mV
WG-88877-060417-JS-03	MW1-14	4/6/2017	11:30	N	WG			50	7.47	12.95	0.067	C	103	uS	101	ntu	9.45	mg/L	217	mV
WG-88877-060417-JS-04	MW2-14	4/6/2017	12:30	N	WG			48	7.34	11.63	0.093	C	143	uS	71.4	ntu	8.11	mg/L	233	mV
WG-88877-060417-JS-05	MW6-17	4/6/2017	14:30	N	WG			6	7.16	8.66	0.347	C	543	uS	OOR	ntu	5.91	mg/L	235	mV
WG-88877-060417-JS-06	MW5A-15	4/6/2017	15:00	N	WG			14	7.36	9.26	0.383	C	599	uS	630	ntu	3.09	mg/L	212	mV
WG-88877-060417-JS-07	MW5A-15	4/6/2017	15:05	FD	WG	Duplicate of WG-88877-060417-JS-06		-	-	-	-	-	-	-	-	-	-	-	-	-
WG-88877-060417-JS-08	MW5B-15	4/6/2017	15:30	N	WG			9	7.16	8.61	0.185	C	285	uS	950	ntu	7.55	mg/L	229	mV
WG-88877-070417-JS-09	MW2A-16	4/7/2017	9:00	N	WG			208	7.39	10.99	0.047	C	72	uS	63	ntu	8.42	mg/L	233	mV
WG-88877-070417-JS-10	MW3-14	4/7/2017	9:30	N	WG			44	7.21	7.65	0.068	C	104	uS	72.5	ntu	9.74	mg/L	255	mV
WG-88877-070417-JS-11	MW4B-15	4/7/2017	10:00	N	WG			104	6.35	8.02	0.262	C	402	uS	8.6	ntu	8.99	mg/L	287	mV
WG-88877-070417-JS-12	MW4A-15	4/7/2017	10:30	N	WG			136	6.33	7.95	0.283	C	436	uS	4	ntu	6.84	mg/L	285	mV
WS-88877-060417-JS-01	SW16-03	4/6/2017	13:00	N	WS			-	7.65	8.95	0.059	C	90	uS	26	ntu	12.81	mg/L	197	mV
WS-88877-060417-JS-02	SW15-02	4/6/2017	13:30	N	WS			-	7.5	7.56	0.038	C	58	uS	1.8	ntu	9.05	mg/L	222	mV
WS-88877-060417-JS-03	SW15-01	4/6/2017	13:45	N	WS			-	7.47	5.65	0.031	C	48	uS	0		12.4	mg/L	228	mV

Footnotes

All groundwater samples collected using convential Waterra sampling methodology.

Key

- Required Field
- Populate When Appropriate
- Field Data

Appendix I
Quality Assurance/Quality Control Memorandum

Memorandum

To:	Rose Marie Rocca	Ref. No.:	088877
From:	Airesse MacPhee/al/1	Date: Revised:	October 29, 2015 October 30, 2015

Re: Data Quality Assessment and Validation

Laboratory:	Maxxam Analytics International Corporation	**Date(s) Sampled:**	September 17-18, October 5-6, 2015
Lab Job No.:	B582021, B588841		
Sampled By:	Thomas Elliott, Danny Fitzgerald		
Media Sampled:	Groundwater, Surface Water		

QA/QC	Criteria	Pass	Qualifiers	Fail	N/A
Holding Times	Analyte specific	☐	☒	☐	☐
Field Duplicate (blind)	Matrix specific	☐	☒	☐	☐
Field Blank (blind)	Non-detect	☐	☐	☐	☒
Trip Blank	Non-detect	☐	☐	☐	☒
Temperature	Analyte specific	☒	☐	☐	☐
Lab QA/QC	Within standard recoveries	☐	☒	☐	☐

Data OK for Use Yes ☐ With Qualifiers ☒ No ☐ Initial: AM

The following results are qualified based on holding time exceedance:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B582021	W-88877-091715-TDF-01	pH	8.12	J	pH units
B582021	W-88877-091715-TDF-02	pH	7.80	J	pH units
B582021	W-88877-091715-TDF-03	pH	8.15	J	pH units
B582021	W-88877-091715-TDF-04	pH	7.83	J	pH units
B582021	W-88877-091715-TDF-05	pH	8.01	J	pH units
B582021	W-88877-091715-TDF-06	pH	7.96	J	pH units
B582021	W-88877-091715-TDF-07	pH	7.65	J	pH units
B582021	W-88877-091815-TDF-08	pH	7.52	J	pH units
B582021	W-88877-091815-TDF-09	pH	7.45	J	pH units
B582021	W-88877-091815-TDF-10	pH	7.33	J	pH units
B588841	WG-88877-05102015-TE-01	pH	7.85	J	pH units
B588841	WG-88877-05102015-TE-02	pH	7.98	J	pH units

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Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B588841	WG-88877-05102015-TE-03	pH	7.73	J	pH units
B588841	WG-88877-05102015-TE-04	pH	8.03	J	pH units
B588841	WG-88877-05102015-TE-05	pH	8.13	J	pH units
B588841	WG-88877-06102015-TE-07	pH	7.48	J	pH units
B588841	WG-88877-06102015-TE-08	pH	8.00	J	pH units
B588841	WG-88877-06102015-TE-09	pH	8.16	J	pH units
B588841	WS-88877-05102015-TE-06	pH	8.18	J	pH units
B588841	WS-88877-06102015-TE-10	pH	7.54	J	pH units
B588841	WS-88877-06102015-TE-11	pH	7.46	J	pH units
B582021	W-88877-091715-TDF-01	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-02	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-03	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-04	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-05	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-06	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-07	Orthophosphate	0.10	UJ	mg/L
B582021	W-88877-091715-TDF-01	Total dissolved solids (TDS)	146	J	mg/L
B582021	W-88877-091715-TDF-03	Total dissolved solids (TDS)	292	J	mg/L
B582021	W-88877-091715-TDF-04	Total dissolved solids (TDS)	78	J	mg/L
B582021	W-88877-091715-TDF-05	Total dissolved solids (TDS)	108	J	mg/L
B582021	W-88877-091715-TDF-06	Total dissolved solids (TDS)	100	J	mg/L
B582021	W-88877-091715-TDF-07	Total dissolved solids (TDS)	52	J	mg/L
B588841	WS-88877-06102015-TE-10	Total suspended solids (TSS)	4.0	UJ	mg/L
B588841	WS-88877-06102015-TE-11	Total suspended solids (TSS)	4.0	UJ	mg/L

The following results are qualified based on method blank detections:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B582021	W-88877-091715-TDF-02	Cyanide (total)	0.00080	U	mg/L
B582021	W-88877-091715-TDF-03	Cyanide (total)	0.00119	U	mg/L
B582021	W-88877-091715-TDF-04	Cyanide (total)	0.00091	U	mg/L
B582021	W-88877-091715-TDF-05	Cyanide (total)	0.00057	U	mg/L
B582021	W-88877-091715-TDF-06	Cyanide (total)	0.00056	U	mg/L

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B582021	W-88877-091715-TDF-07	Cyanide (total)	0.00054	U	mg/L
B582021	W-88877-091815-TDF-08	Cyanide (total)	0.00062	U	mg/L
B582021	W-88877-091715-TDF-01	Sulfide	0.0078	U	mg/L
B582021	W-88877-091715-TDF-02	Sulfide	0.0058	U	mg/L
B582021	W-88877-091715-TDF-06	Sulfide	0.0075	U	mg/L
B588841	WS-88877-05102015-TE-06	Aluminum	9.5	U	µg/L
B588841	WS-88877-06102015-TE-10	Iron	29	U	µg/L
B588841	WG-88877-05102015-TE-01	Total dissolved solids (TDS)	72	U	mg/L
B588841	WG-88877-05102015-TE-03	Total dissolved solids (TDS)	82	U	mg/L
B588841	WG-88877-06102015-TE-07	Total dissolved solids (TDS)	58	U	mg/L
B588841	WS-88877-06102015-TE-10	Total dissolved solids (TDS)	51	U	mg/L
B588841	WS-88877-06102015-TE-11	Total dissolved solids (TDS)	51	U	mg/L

The following results are qualified based on field duplicate variability:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B582021	W-88877-091715-TDF-05	Ammonia-N	0.058	J	mg/L
B582021	W-88877-091715-TDF-06	Ammonia-N	0.034	J	mg/L
B582021	W-88877-091715-TDF-05	Phosphorus	0.275	J	mg/L
B582021	W-88877-091715-TDF-06	Phosphorus	0.387	J	mg/L
B582021	W-88877-091815-TDF-09	Total dissolved solids (TDS)	32	J	mg/L
B582021	W-88877-091815-TDF-10	Total dissolved solids (TDS)	44	J	mg/L
B588841	WG-88877-06102015-TE-08	Aluminum (dissolved)	16.6	J	µg/L
B588841	WG-88877-06102015-TE-09	Aluminum (dissolved)	8.5	J	µg/L
B588841	WG-88877-06102015-TE-08	Arsenic (dissolved)	0.26	J	µg/L
B588841	WG-88877-06102015-TE-09	Arsenic (dissolved)	0.42	J	µg/L
B588841	WG-88877-06102015-TE-08	Barium (dissolved)	2.1	J	µg/L
B588841	WG-88877-06102015-TE-09	Barium (dissolved)	15.5	J	µg/L
B588841	WG-88877-06102015-TE-08	Calcium (dissolved)	7.28	J	mg/L
B588841	WG-88877-06102015-TE-09	Calcium (dissolved)	17.9	J	mg/L
B588841	WG-88877-06102015-TE-08	Iron (dissolved)	17.5	J	µg/L
B588841	WG-88877-06102015-TE-09	Iron (dissolved)	6.1	J	µg/L

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B588841	WG-88877-06102015-TE-08	Magnesium (dissolved)	1.30	J	mg/L
B588841	WG-88877-06102015-TE-09	Magnesium (dissolved)	1.82	J	mg/L
B588841	WG-88877-06102015-TE-08	Manganese (dissolved)	1.8	J	µg/L
B588841	WG-88877-06102015-TE-09	Manganese (dissolved)	19.8	J	µg/L
B588841	WG-88877-06102015-TE-08	Potassium (dissolved)	0.288	J	mg/L
B588841	WG-88877-06102015-TE-09	Potassium (dissolved)	0.476	J	mg/L
B588841	WG-88877-06102015-TE-08	Alkalinity, total (as CaCO3)	72.0	J	mg/L
B588841	WG-88877-06102015-TE-09	Alkalinity, total (as CaCO3)	102	J	mg/L
B588841	WG-88877-06102015-TE-08	Bicarbonate (as CaCO3)	87.9	J	mg/L
B588841	WG-88877-06102015-TE-09	Bicarbonate (as CaCO3)	124	J	mg/L
B588841	WG-88877-06102015-TE-08	Conductivity	251	J	µS/cm
B588841	WG-88877-06102015-TE-09	Conductivity	309	J	µS/cm
B588841	WG-88877-06102015-TE-08	Hardness (dissolved)	23.5	J	mg/L
B588841	WG-88877-06102015-TE-09	Hardness (dissolved)	52.2	J	mg/L
B588841	WG-88877-06102015-TE-08	Nitrate (as N)	0.77	J	mg/L
B588841	WG-88877-06102015-TE-09	Nitrate (as N)	1.11	J	mg/L
B588841	WG-88877-06102015-TE-08	Nitrite/Nitrate	0.77	J	mg/L
B588841	WG-88877-06102015-TE-09	Nitrite/Nitrate	1.11	J	mg/L
B588841	WG-88877-06102015-TE-08	Nitrogen	0.990	J	mg/L
B588841	WG-88877-06102015-TE-09	Nitrogen	1.31	J	mg/L
B588841	WG-88877-06102015-TE-08	Phosphorus	0.0184	J	mg/L
B588841	WG-88877-06102015-TE-09	Phosphorus	0.0108	J	mg/L
B588841	WG-88877-06102015-TE-08	Total dissolved solids (TDS)	158	J	mg/L
B588841	WG-88877-06102015-TE-09	Total dissolved solids (TDS)	204	J	mg/L

The following results are qualified based on laboratory duplicate variability:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B582021	W-88877-091715-TDF-01	Aluminum (dissolved)	10.6	J	µg/L
B582021	W-88877-091715-TDF-02	Aluminum (dissolved)	9.9	J	µg/L
B582021	W-88877-091715-TDF-03	Aluminum (dissolved)	17.2	J	µg/L
B582021	W-88877-091715-TDF-04	Aluminum (dissolved)	127	J	µg/L
B582021	W-88877-091715-TDF-05	Aluminum (dissolved)	9.6	J	µg/L
B582021	W-88877-091715-TDF-06	Aluminum (dissolved)	9.8	J	µg/L
B582021	W-88877-091715-TDF-07	Aluminum (dissolved)	9.0	J	µg/L
B588841	WS-88877-05102015-TE-06	Copper	0.53	J	µg/L
B588841	WS-88877-06102015-TE-10	Copper	0.67	J	µg/L
B588841	WG-88877-05102015-TE-01	Zirconium (dissolved)	0.50	UJ	µg/L

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B588841	WG-88877-05102015-TE-02	Zirconium (dissolved)	0.50	UJ	µg/L
B588841	WG-88877-05102015-TE-03	Zirconium (dissolved)	0.50	UJ	µg/L
B588841	WG-88877-05102015-TE-04	Zirconium (dissolved)	3.67	J	µg/L
B588841	WG-88877-05102015-TE-05	Zirconium (dissolved)	0.50	UJ	µg/L
B588841	WG-88877-06102015-TE-07	Zirconium (dissolved)	0.50	UJ	µg/L
B588841	WG-88877-06102015-TE-08	Zirconium (dissolved)	0.50	UJ	µg/L
B588841	WG-88877-06102015-TE-09	Zirconium (dissolved)	0.50	UJ	µg/L

The following results are qualified based on laboratory control sample recovery:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B582021	W-88877-091815-TDF-09	trans-1,3-Dichloropropene	1.0	UJ	µg/L

Notes:

J - Estimated concentration
UJ - Non-detect with an Estimated Report Limit
U - Not Detected
N - Nitrogen

Memorandum

To:	Rose Marie Rocca, Thomas Elliott	Ref. No.:	088877
From:	Airesse MacPhee/al/2	Date:	April 19, 2016

Re: Data Quality Assessment and Validation

Laboratory: Maxxam Analytics International Corporation

Date(s) Sampled: January 29, February 15, 2016

Lab Job No.: B607136, B612278

Sampled By: James Stewart

Media Sampled: Groundwater, Surface Water

QA/QC	Criteria	Pass	Qualifiers	Fail	N/A
Holding Times	Analyte specific	☐	☒	☐	☐
Field Duplicate (blind)	Matrix specific	☐	☐	☐	☒
Field Blank (blind)	Non-detect	☐	☐	☐	☒
Trip Blank	*Non-detect*	☐	☐	☐	☒
Temperature	Analyte specific	☒	☐	☐	☐
Lab QA/QC	Within standard recoveries	☐	☒	☐	☐

Data OK for Use Yes ☐ With Qualifiers ☒ No ☐ Initial: AM

The following results are qualified based on holding time exceedance:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B607136	SW-88877-290116-JS-01	Hydrogen sulfide	0.0080	J	mg/L
B607136	SW-88877-290116-JS-01	pH	7.63	J	pH units
B607136	SW-88877-290116-JS-01	Sulfide	0.0078	J	mg/L
B612278	WG-88877-150216-JS-01	Nitrate (as N)	0.15	J	mg/L
B612278	WG-88877-150216-JS-02	Nitrate (as N)	0.10	UJ	mg/L
B612278	WG-88877-150216-JS-01	Nitrite (as N)	0.10	UJ	mg/L
B612278	WG-88877-150216-JS-02	Nitrite (as N)	0.10	UJ	mg/L
B612278	WG-88877-150216-JS-01	Nitrite/Nitrate	0.15	J	mg/L
B612278	WG-88877-150216-JS-02	Nitrite/Nitrate	0.10	UJ	mg/L
B612278	WG-88877-150216-JS-01	Orthophosphate	0.10	UJ	mg/L
B612278	WG-88877-150216-JS-02	Orthophosphate	0.10	UJ	mg/L
B612278	WG-88877-150216-JS-01	pH	7.14	J	pH units
B612278	WG-88877-150216-JS-02	pH	7.85	J	pH units

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The following results are qualified based on method blank detections:

Lab Report #	Sample ID	Analyte	Result	Qualifier	Units
B612278	WG-88877-150216-JS-01	Cyanide (total)	0.00057	U	mg/L
B612278	WG-88877-150216-JS-02	Cyanide (total)	0.00054	U	mg/L

Notes:

J - Estimated concentration
UJ - Non-detect with an Estimated Report Limit
U - Not Detected
N - Nitrogen

Memorandum

April 24, 2017

To:	Cassandra Ragan, James Stewart, Shauna Sturgeon	Ref. No.:	088877
From:	Airesse MacPhee/al/	Tel:	604-248-3661

Subject: **Data Quality Assessment and Validation**

Laboratory: Maxxam Analytics International Corporation

Date(s) Sampled: April 6-7, 2017

Lab Job No.: B726014, B726019

Sampled By: James Stewart

Media Sampled: Groundwater, Surface Water

QA/QC	Criteria	Pass	Qualifiers	Fail	N/A
Holding Times	Analyte specific	☐	☒	☐	☐
Field Duplicate (blind)	Matrix specific	☐	☒	☐	☐
Field Blank (blind)	Non-detect	☐	☐	☐	☒
Trip Blank	Non-detect	☐	☐	☐	☒
Temperature	Analyte specific	☒	☐	☐	☐
Lab QA/QC	Within standard recoveries	☒	☐	☐	☐

Data OK for Use Yes ☐ With Qualifiers ☒ No ☐ Initial: AM

The following results are qualified due to holding time exceedance:

Lab Report #	Sample Date (mm/dd/yyyy)	Sample ID	Analyte	Result	Qualifier	Units
B726014	04/06/2017	WG-88877-060417-JS-01	pH	7.93	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-02	pH	7.69	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-03	pH	7.79	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-04	pH	7.83	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-05	pH	8.06	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-06	pH	8.01	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-07	pH	8.00	J	s.u.
B726014	04/06/2017	WG-88877-060417-JS-08	pH	7.21	J	s.u.
B726014	04/07/2017	WG-88877-070417-JS-09	pH	7.78	J	s.u.
B726014	04/07/2017	WG-88877-070417-JS-10	pH	7.50	J	s.u.

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Lab Report #	Sample Date (mm/dd/yyyy)	Sample ID	Analyte	Result	Qualifier	Units
B726014	04/07/2017	WG-88877-070417-JS-11	pH	7.78	J	s.u.
B726014	04/07/2017	WG-88877-070417-JS-12	pH	7.76	J	s.u.
B726019	04/06/2017	WS-88877-060417-JS-01	pH	7.78	J	s.u.
B726019	04/06/2017	WS-88877-060417-JS-02	pH	7.25	J	s.u.
B726019	04/06/2017	WS-88877-060417-JS-03	pH	7.56	J	s.u.

The following results are qualified based on field duplicate variability:

Lab Report #	Sample Date (mm/dd/yyyy)	Sample ID	Analyte	Result	Qualifier	Units
B726014	04/06/2017	WG-88877-060417-JS-06	Aluminum (dissolved)	11.4	J	µg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Aluminum (dissolved)	3.5	J	µg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Copper (dissolved)	0.79	J	µg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Copper (dissolved)	0.32	J	µg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Iron (dissolved)	17.0	J	µg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Iron (dissolved)	5.0	UJ	µg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Chemical oxygen demand (COD)	56	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Chemical oxygen demand (COD)	41	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Hydrogen sulfide	0.011	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Hydrogen sulfide	0.0070	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Sulfide	0.010	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Sulfide	0.0064	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Total kjeldahl nitrogen (TKN)	7.3	J	mg/L
B726014	04/06/2017	WG-88877-060417-JS-07	Total kjeldahl nitrogen (TKN)	2.0	UJ	mg/L
B726014	04/06/2017	WG-88877-060417-JS-06	Aluminum (dissolved)	11.4	J	µg/L

Notes:

J - Estimated concentration
UJ - Non-detect with an Estimated Report Limit
s.u. - Standard pH Units

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