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**UPDATED ENVIRONMENTAL MONITORING PLAN**  
**SECHELT LANDFILL**  
**SECHELT, BRITISH COLUMBIA**

Prepared for:  
**SUNSHINE COAST REGIONAL LANDFILL (SCRD)**  
1975 Field Road  
Sechelt, British Columbia  
V0N 3A1

Attention: Mr. Marc Sole  
Manager, Solid Waste Services

A handwritten signature in black ink that reads 'B. Voutos'. The signature is written in a cursive, flowing style.

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**APPENDICES**

- Appendix A Operational Certificate No. 106060
- Appendix B Historic Stratigraphic Logs and Geologic Cross-Section
- Appendix C Conditional Water Licence

## **1. INTRODUCTION, PURPOSE, AND USE**

### **1.1 General**

This updated environmental monitoring plan (EMP) for the Sechelt Landfill (Site) has been prepared by XCG Consulting Limited (XCG) on behalf of the Sunshine Coast Regional District (SCRD). As required under Section 2.5 of the Operational Certificate No. 106060 (OC), issued by the British Columbia Ministry of the Environment (MOE, or the Ministry<sup>1</sup>) on July 8, 2014. As required under Section 2.5 of the OC, the original EMP for the Site was completed in April 2018. Section 2.5 of the OC also requires that an updated EMP be submitted to the MOE every five years, by April 30. In order to include planning and preliminary design for a new contact water pond at the Site, the SCRD has requested, and the Ministry has granted, an extension of the deadline for submission of this updated EMP from April 30, 2023, to June 30, 2023.

This updated EMP includes the environmental controls associated with the new contact water pond. As stated in the OC, the updated EMP must include, at a minimum, any revisions submitted as part of the annual reporting during the previous five years. A copy of the OC is included as Appendix A.

This updated EMP has been prepared for the sole use by the SCRD and may not be used by any other person or entity without written authorization by XCG. Any use or reuse of this document, its findings, conclusions, and recommendations represented herein by users other than SCRD, is at the sole risk of said users.

### **1.2 Site Description and Setting**

The Site is located at 4901 Dusty Road, Sechelt, approximately 6.5 kilometres northeast of the District of Sechelt. The Site is located on Crown Land under License of Occupation No. 237204. The legal description of the Site is Block C, District Lot 7613, Group 1, New Westminster District. The Site location and setting are shown on Figure 1.

The Site property is bounded to the north, east, and west by Kwilkwil Ltd. (DL 7613), and to the south by Northcote Properties (DL 2464).

Heidelberg Materials, Aggregates (Heidelberg) owns the mineral rights and currently operates its Sechelt Mine on the land south and west of the Site, with future expansion options for the Crown Land east and north of the Site.

The Site comprises a non-hazardous solid waste landfill that accepts municipal solid waste from the District of Sechelt, Town of Gibsons, shíshálh Nation Government District (sNGD), and all of the electoral areas in the Sunshine Coast Regional District. In addition, as of July 20, 2015, waste received at the Pender Harbour Transfer Station is landfilled at the Site. The landfill encompasses an area of approximately 7 hectares, within an overall Site area of approximately 9.5 hectares.

<sup>1</sup> Currently (since 2017) known as the Ministry of Environment & Climate Change Strategy.



Figure 2 shows the auxiliary facilities associated with the on-Site landfill as of June 2023, which included:

- Scale house and scale;
- Office trailer;
- Mattress seacan;
- Mattress Trailer;
- Storage seacans;
- Contact water pond;
- Public drop-off area; and
- Maintenance shed.

Since April 2018, the following significant changes to the on-Site facilities have occurred:

- As of late summer, early fall of 2021, the special waste storage building/power shed was demolished. This shed was removed from the Site due to the construction of the new on-Site public drop off area.
- In 2013, environmental controls designed to reduce leachate generation and leachate mounding by reducing the size of the active landfilling area, diverting surface water from the limit of waste, were implemented on the Site. The specific environmental controls included:
  - Progressive closure of the landfilling area by placing final cover over the north, east, and southeast slopes of the landfill;
  - Construction of surface water ditching along the north, east, and south portion of the west side of the Site;
  - Addition of a stormwater pipe alignment discharging into Dusty Road Ditch on the west side of Site; and
  - Improvements to the contact water detention pond and forebay on the west side of the Site.
- In 2020, XCG installed two monitoring wells, including MW-2A on the west side of landfill and MW-4A on the north side of the landfill.
- In 2021, the following changes were made to the Site:
  - The existing on-Site scale shed was relocated and the power shed/tool storage building was removed. Additionally, the drop-off area was relocated and expanded to include up to ten 30-cubic metre (40-cubic yard) bins, a tire area, and a mattress storage container.
  - Groundwater monitoring well MW-2 was decommissioned and removed from the EMP and was to be replaced in upcoming reporting periods.
  - Gas probes GP13-01 and GP13-02 were decommissioned and re-installed; however, they were constructed in a manner that renders them unusable.
- In 2022, the following changes were made at the Site:



- Groundwater monitoring well MW2 was replaced in the EMP with monitoring well MW2-21.
- Three additional on-Site deep groundwater monitoring wells were installed, including:
  - MW22-01, installed north (up-gradient) of the landfill;
  - MW22-02, installed northeast of the landfill and north of Dusty Road (up-gradient) of the Site; and
  - MW22-03, installed east (cross-gradient) of the landfill.

In 2024 the current contact water pond, as shown on Figure 2, will be filled in with waste and a new contact water pond will be constructed, as shown on Figure 3.



## 2. REGULATORY ENVIRONMENT

The following section provides an overview of the regulatory environment which governs environmental monitoring of the Site.

### 2.1 Provincial Regulations

The requirements of the EMP are outlined in the following documentation issued by the MOE:

- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996);
- British Columbia Field Sampling Manual (2013); and
- Landfill Criteria for Municipal Solid Waste (June 2016).

Key elements of these documents, addressed in this updated EMP, are as follows.

#### **Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills**

These guidelines are intended to assist landfill owners and operators in designing and implementing an EMP as required by the “Landfill Criteria for Municipal Solid Waste.” Key elements of the guidelines are as follows:

#### **Groundwater:**

- The location and installation of monitoring wells should address both existing and anticipated site development, including any predicted changes in groundwater flow;
- Up-gradient and down-gradient monitoring wells should be sampled at quarterly intervals as a minimum;
- The routine parameters monitored in groundwater include pH, temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO), chemical oxygen demand (COD), specific conductivity (electrical conductivity), metals, ammoniacal nitrogen, and chloride; and
- For the monitoring of metals, the U.S Environmental Protection Agency (US EPA) recommends the following metals be monitored regularly: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium, vanadium, and zinc.

#### **Surface water:**

- Surface water monitoring locations should include the following locations:
  - Upstream to establish background water quality;
  - Immediately downstream to determine leachate impacts on water quality; and
  - Downstream to document the extent of the mixing zone and distance required for the surface water to assimilate leachate and for water quality to recover to background levels.



- Surface water should be monitored for pH, ORP, specific conductance, temperature, and DO concentration.

### **Landfill Gas:**

These guidelines are intended to assist landfill owners and operators to design and implement an environmental monitoring program as required by the “Landfill Criteria for Municipal Solid Waste.” Key Elements of the guidelines that relate to landfill gas (LFG) are as follows:

- It is considered that concentrations greater than 20% of the lower explosive limit (LEL) in on-site and off-site structures, or concentrations that exceed the LEL in soils at the property boundary, warn of conditions which could potentially be hazardous. LFG control systems should be designed to maintain concentrations well below these levels. The LEL for the LFG is equal to 5% methane, on a volumetric basis.
- The frequency of monitoring should be sufficient to detect LFG migration based on subsurface conditions.
- LFG probes should be installed in the more permeable strata, between the landfill unit and either the property boundary or structures where gas migration may pose a problem. Multiple or nested probes are useful in defining the vertical configuration of the migration pathway.

### **Landfill Criteria for Municipal Solid Waste**

This document applies to all new landfills and expansions of existing landfills, designed, and constructed for the disposal of municipal solid waste. Key elements of the criteria that pertain to environmental monitoring are as follows:

- Current and planned future uses of groundwater and surface water shall be identified within 1 km of the landfill footprint. After considering the identified uses of groundwater and surface water, a Qualified Professional (QP) must recommend the appropriate water quality criteria, compliance locations, and provide related rationale and justification.
- Water quality criteria to be considered include:
  - 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;
  - The Canadian Drinking Water Quality Guidelines; and
  - Other water quality criteria for parameters not addressed by the preceding water quality criteria.
- The appropriate water quality criteria and compliance monitoring locations are subject to the approval of the director in writing. As a minimum, the appropriate water quality criteria must be satisfied at and beyond the landfill site boundary, or



150 m from the landfill footprint, whichever is closer. More stringent requirements may be set by the director. Any discharges to surface water considered as potential fish habitat must also comply with the requirements of the federal Fisheries Act.

- A landfill shall be operated and maintained so as not to create a “nuisance” including but not limited to dust, noise, litter, odour, vectors and/or wildlife attraction.
- A detailed EMP for leachate, groundwater, surface water, and LFG must be prepared and implemented during landfill construction and landfill operation, closure, and post-closure. The EMP shall:
  - Demonstrate compliance with the performance criteria;
  - Demonstrate that monitoring results are consistent with the applicable plans and reports, listed in Section 10 of the Landfill Criteria for Municipal Solid Waste, including the groundwater and surface water impact assessment;
  - Address the need for monitoring within 1 km of the landfill footprint.
- The EMP shall be developed in accordance with the “Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills” for groundwater, surface water, leachate, and soils and vegetation or its approved replacement.
- The EMP shall be included in the Design, Operations and Closure Plan (DOCP) as per Section 10.3 of the Landfill Criteria for Municipal Solid Waste.
- Leachate monitoring is required to establish site specific leachate chemistry and contaminants and to ensure these contaminants are included in the groundwater and surface water monitoring.
- At no time shall combustible gas concentrations exceed the LEL (i.e., 5% methane, on a volumetric basis) in soils at the property boundary, or 20% of the LEL (i.e., 1% methane, on a volumetric basis) in any on-site structure or facility.
- The EMP for groundwater shall be developed based on the Hydrogeology and Hydrology Characterization Report, the Groundwater and Surface Water Impact Assessment, and the expected landfill performance. The EMP for surface water shall be developed to monitor the performance of the surface water control works constructed and operated on a landfill site. The groundwater and surface water monitoring results are to be assessed for compliance with the applicable criteria as stipulated in Section 4.1 of the Landfill Criteria for Municipal Solid Waste.

## 2.2 **Landfill Operational Certificate**

Preparation of an updated EMP is required under the OC issued by the MOE. Key elements of this OC with respect to environmental monitoring include the following:

### **Environmental Monitoring Plan**

- The OC holder must submit to the Director for approval an updated EMP by April 30, 2023. As stated above, the Ministry has granted an extension to the deadline for submitting this updated EMP to June 30, 2023. The plan must be prepared by a QP and meet the requirements set forth in the Landfill Criteria for



Municipal Solid Waste (June 2016 or most recent version) and the Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996 or most recent version).

- The OC holder must review the EMP on an annual basis to determine if changes are required. Any revisions to the plan must be prepared and certified by a qualified professional and submitted to the Director for approval and include revisions as part of the annual report. An updated EMP must be submitted every five years.

#### ***Ground and Surface Water Quality Impairment***

- The landfill must be operated in a manner such that ground or surface water quality does not decrease beyond that specified by the British Columbia Water Quality Guidelines, or other appropriate criteria as may be specified by the Director, at or beyond the landfill property boundary.
- If exceedances to the specified water quality criteria occur as a result of landfill operations, the Director may require that control measures or works be undertaken.

#### ***Inspections***

- The OC holder must inspect the authorized works regularly and maintain them in good working order. The Manager must be immediately notified of any malfunction of these works.
- The OC holder must inspect the property boundaries regularly and notify the Manager of any visual evidence of environmental impacts on adjacent properties.

#### ***LFG Management***

- The landfill must not cause combustible gas concentrations to exceed the LEL in soils at the property boundary or 25% of the LEL at or in on-site or off-site structures.

#### ***Monitoring***

- The OC holder must implement an environmental monitoring program. The OC holder must maintain records of all monitoring program data and analyses available for inspection. Based on the information submitted in the annual report, or any other information relevant to the site, the Director may vary the frequency, location, and analyses of environmental monitoring as warranted.

#### ***Sampling Procedures***

- Sampling is to be carried out in accordance with the procedures described in the British Columbia Field Sampling Manual (2013 Edition or most recent version), or by suitable alternative procedures as authorized by the Director.

#### ***Analytical Procedures***

- Analyses are to be carried out in accordance with procedures described in the British Columbia Laboratory Manual (2015 Edition or most recent version), or by suitable alternative procedures as authorized by the Director.

#### ***Reporting***

- The OC holder must prepare an annual report which must include the following, with respect to the Environmental Monitoring Plan:



- The results of all monitoring programs as specified in the OC. Data interpretation and comparison to the performance criteria in the Landfill Criteria for Municipal Solid Waste, the Guidelines for Environmental Monitoring and Municipal Solid Waste Landfills. Trend analyses, as well as an evaluation of the impacts of the discharges on the receiving environment in the previous year must be carried out by a qualified professional.
- The annual report for the preceding 12-month period from January 1 to December 31 must be submitted to the Regional Manager, Environmental Protection, by March 31 of each year.

A copy of the OC is provided as Appendix A.



### **3. CONCEPTUAL SITE MODEL**

#### **3.1 Regional and Site Setting**

##### **3.1.1 Topography and Drainage**

The Site is located in the physiographic region referred to as the Georgia Lowlands, which comprises the west coast of mainland British Columbia (Holland, 1976). The Site is located approximately 3 kilometres east of the Salish Sea and Sechelt Inlet (sea level). The Site is located on the north edge of a plateau at an approximate elevation of 200 metres above mean sea level (amsl). The majority of the plateau is used for aggregate extraction. From the plateau, the topography slopes steeply upward to the east toward the Coast Mountains.

The plateau is located on the drainage divide between the Irgens Creek watershed to the north and the Chapman Creek watershed to the south. As shown on Figure 4, the Site is located primarily within the Irgens Creek watershed.

Stormwater runoff from areas of the Site completed with final cover and interim final cover, as shown on Figure 2, is routed to the north and west by a series of ditches, pipes and culverts which discharge directly to the Dusty Road roadside ditch, which conveys water westward eventually draining into Irgens Creek. Irgens Creek runs in a westerly direction, eventually discharging to Porpoise Bay.

Stormwater run-off from active areas of the landfill is routed to the contact water pond which is allowed to infiltrate.

##### **3.1.2 Geology**

The Georgia Lowlands is underlain by granitic rocks as well as by inliers of older formations (Holland, 1976). Geologic mapping indicates that locally, the Site is underlain by a granodiorite intrusive rock (BCGS, 2013).

According to the Geological Survey of Canada Surficial Materials of Canada Map 1880A, the Site is located on the boundary between surficial deposits consisting of till veneer (thin and discontinuous till, may include extensive areas of rock outcrop) to the north, and lag (sand, gravel, and pockets of finer sediment) to the south (Fulton, 1995).

Greater detail is provided by Surficial Geology and Sand and Gravel Deposits of Sunshine Coast, Powell River, and Campbell River Areas, Bulletin 65” which indicates that:

- Surficial deposits on and south of the Site are comprised of cobbles, gravel, sand, and silt (Capilano Sediments fluvial deltaic fan and channel deposits). The Capilano deposits are the sites of most of the aggregate pits in the area.
- Surficial deposits on and north of the Site are comprised of till which extends for approximately 1,000 metres (Vachon Drift ground moraine deposits); and
- Surficial deposits north of the till consist of bare rock with thin patches of overburden (McCammon, 1977).



Records for water wells nearest the Site indicate that overburden consisting of sand and gravel with cobbles, with a layer of till or compact to dense silt (at various depths), extends to a depth of 60 to 120 metres below ground surface (bgs).

A generalized geologic cross-section through the Site based on the installation of approximately 20 boreholes to construct groundwater monitoring wells is shown on Figure B1 in Appendix B. Historic cross-sections are also included in Appendix B, as part of monitoring well installation reports (Appendix B Figures 3 and 4). As shown on the geologic cross-section, the overburden at the Site is comprised of silty sand and gravel to a maximum depth of 32 metres bgs. A dense silt (bouldery) till layer of varying thickness is present in the majority of deep boreholes from approximately 14 to 23 metres bgs. The dense silt till layer was not present, or was not noted, at deep boreholes located in the southeast portion of the Site (MW99-9, MW13-1, and MW9) (XCG, 2015).

### 3.1.3 Hydrogeology

Regionally, the Site is located within an area that has not been mapped or classified in the British Columbia aquifer classification system. This is likely due to the low number of residences, large area used for aggregate mining, and low usage of groundwater for drinking water in the area.

The area approximately 2 kilometres northwest of the Site is a classified aquifer. The aquifer is #566 and is classified as IIIA (lightly developed, high vulnerability) and ranked for hydrogeologic and water use as a 9 in a range of 1 to 25.

According to British Columbia water wells records, the nearest water wells to the Site are located approximately 1.7 kilometres west of, and cross-gradient to, the Site. The locations of water wells near the Site are shown on Figure 5. The records for water wells near the Site indicate that the wells are completed in overburden at a depth ranging from 12 to 105 metres bgs, and groundwater is typically located at depths ranging from 8 to 72 metres bgs (Table 1).

Groundwater levels in the on-site monitoring wells are monitored on a quarterly basis as part of the current EMP to determine the depth to the water table, water table elevation, and the approximate direction of groundwater flow.

Based on the Site geology and the observed groundwater levels, perched groundwater appears to be present at the Site on top of the dense silt till layer from a depth of approximately 1 metre to 14 metres bgs (Piteau, 1999). The perched groundwater is reflected in the water levels observed in groundwater monitoring wells where a confining layer is present, or groundwater monitoring wells screened above the confining layer. The elevation of the perched groundwater during the 2022 monitoring period ranged from approximately 209 metres amsl at the north end of the Site, to approximately 215 metres amsl at the south end of the Site.

Deep overburden groundwater monitoring wells MW13-01 and MW13-02 are screened in the deep gravelly sediments which are interpreted to be hydraulically connected to underlying bedrock aquifer. The bedrock hydraulic conditions are reflected in the water levels for these deep groundwater monitoring wells where the confining layer is not present, or groundwater monitoring wells are screened below



the confining layer. During the 2022 monitoring period the interpreted bedrock groundwater elevation at the Site ranges from approximately 192 metres to 200 metres amsl.

Historic groundwater elevations indicate seasonal fluctuations which are more pronounced in monitoring wells instrumented in the perched aquifer (XCG, 2023).

Groundwater levels measured as part of the monitoring program indicate that the perched groundwater beneath the Site flows in a dominantly south to south-westerly direction. It is anticipated that as perched groundwater migrates to the south it will percolate down to the bedrock aquifer. According to historic monitoring results, vertical gradients between the shallow and deep monitoring wells indicate a strong downward gradient (XCG, 2023).

Measurement of leachate levels in LFG extraction wells EX1 and EX2 in 2015 indicated that leachate was located from 10 to 12 metres below the landfill surface and is mounded approximately 10 metres above the prevailing ground surface and approximately 15 metres above the perched groundwater (XCG, 2015). This leachate mounding may cause radial groundwater flow in the perched groundwater around the perimeter of the landfill which may result in impacts to groundwater near the limit of waste.

### **3.2 Potential Contaminants of Concern**

The Site is operated as a natural attenuation, non-hazardous solid waste landfill with no engineered leachate management systems in place. The potential contaminants of concern (COCs) associated with the Site include parameters present in leachate and LFG. The following sections summarize the potential COCs in leachate and LFG generated at the Site.

#### **3.2.1 Potential Leachate-Derived COCs**

Leachate is defined by the Ministry as any liquid which has percolated through or drained from a municipal solid waste disposal facility (MOE, 2016). Factors affecting the composition of leachate include the following (McBean et al., 1995):

- Solid waste composition;
- Age of waste;
- Landfill operations;
- Climate and hydrogeological conditions; and
- Conditions within the waste mass (e.g., moisture content, temperature, and pH).

Due to the fact that these factors vary significantly from cell to cell in a landfill, leachate characteristics can also vary significantly.

Landfill leachate is typically composed of a number of elements, which generally include the following constituent elements:

- Organics;
- Nitrogen;



- Chlorides;
- Phosphates;
- Dissolved metals; and
- Dissolved solids.

Based on the 2022 annual monitoring results (XCG, 2023), the leachate-derived COCs detected in groundwater in the groundwater down-gradient from the Site included ammonia, total phosphorus, iron, and manganese.

No leachate (Site)-derived surface water quality impacts were observed in Chapman Creek, Irgens Creek, or the stormwater discharging from the Site.

### **3.2.2 Potential LFG-Derived COCs**

LFG is composed of approximately 50 percent methane and 50 percent carbon dioxide (volumetric basis) and is produced in the landfill environment as a result of the biological decomposition of organic waste material. In addition, LFG typically also includes trace gases, which may include:

- Nitrogen;
- Oxygen;
- Hydrogen sulphide;
- Disulphides'
- Mercaptans; and
- Volatile organic compounds (VOCs).

Based on the 2022 annual monitoring results (XCG, 2023) high concentrations (above regulatory criteria) of methane were measured in the on-Site soil gas probes GP17-01S and GP17-01D. These soil gas probes are located in proximity to waste and the highly permeable subsurface soil (sand and gravel).

Methane concentrations measured inside of the on-Site office building, scale house, power shed, maintenance shed, and the sea can containers during all 2022 monitoring events were well below the 1% LEL trigger level (0.05% by volume).

## **3.3 Potential Migration Pathways for Contaminants of Concern**

### **3.3.1 Leachate Migration Overview**

As previously stated, the Site is operated as a natural attenuation landfill with no engineered leachate management systems in place. As such, leachate generated on-Site migrates due to hydraulic gradient from the waste and into the underlying and adjacent native soil and bedrock. During its migration from the waste, leachate mixes with groundwater, and eventually leachate movement is governed by the groundwater flow regime.

Groundwater levels measured as part of the 2022 monitoring program indicated that the groundwater beneath the Site flows predominantly to the south/south-westerly



direction, towards the Chapman Creek watershed. It is anticipated that as perched groundwater migrates to the south, it will percolate down to the bedrock aquifer. According to historic monitoring results, vertical gradients between the shallow and deep monitoring wells indicate a strong downward gradient (XCG, 2023).

### 3.3.2 **Landfill Gas Migration Overview**

The density of LFG is highly variable, and it depends on its chemical composition. The two dominant constituent elements of LFG (methane and carbon dioxide) have specific densities of approximately  $0.72 \text{ kg/m}^3$  and  $1.98 \text{ kg/m}^3$ , respectively. Hence, depending upon the gas composition, LFG can either be lighter or heavier than air. As a result, LFG can accumulate in either low lying regions (e.g., utility vault boxes) or high regions (e.g., building roof peaks and attics).

LFG migration from the waste through soil voids and bedrock fractures is of potential concern, when receptors are present (e.g., buildings, structures, and utility corridors). Due to its relatively low solubility, groundwater acts as a barrier to LFG migration; as a result, only unsaturated soil and fractured bedrock are considered to be primary pathways for LFG migration.

Three key factors which influence the migration of LFG away from the limits of waste include:

- Advection;
- Diffusion; and
- Permeability.

LFG accumulates within the waste mass, resulting in a zone of high pressure (relative to atmospheric conditions). Differential pressure results in LFG migrating from areas of high pressure to areas of low pressure by means of advection. As pressure increases in the waste mass due to on-going LFG generation, gas tends to migrate up through the landfill cover, resulting in airborne fugitive emissions, and/or through the adjacent subsurface soil, resulting in lateral migration.

Diffusion is the process by which a gas attains chemical equilibrium by moving from areas of high concentration to areas of lower concentration. This process contributes to LFG migration due to differential chemical gradients in the waste mass relative to the surrounding soil.

Permeability has a significant impact on LFG migration due to a liquid or gases' propensity to move via the "path of least resistance." Waste, soil, and fractured bedrock all contain void spaces (i.e., porosity). These voids are generally interconnected; therefore, they provide a conduit for LFG to migrate.

Migration of LFG through soil poses two primary concerns that are related to the build-up of gases within or below structures near the landfill site; the accumulation of LFG in or around a subsurface structure may expose those required to enter the structure to an oxygen deficient environment, and the accumulation of LFG introduces the risk of an explosion if a source of ignition is present.



The ability of LFG to migrate laterally from the landfill limit of waste into the surrounding soil is dependent on the following primary factors:

- LFG management system;
- Leachate management systems;
- Landfill cover system;
- Geological conditions;
- Hydrogeological condition;
- Meteorological conditions; and
- Civil works.

Modern landfill design typically includes a liner system constructed of low permeability non-cohesive clay, geosynthetic materials (e.g., HDPE) or a composite system incorporating both materials. These liner systems present a barrier to LFG lateral migration to the surrounding environment unless tears in the liner system are present. Hence, the detection of LFG in the vadose zone immediately adjacent to the liner landfill cell is indicative of damage to the liner system.

As previously stated, the Site is operated as a natural attenuation landfill with no engineered liner, LFG or leachate management systems in place. As such, the lateral migration of LFG at the Site is relatively unobstructed.

The landfill cover system may have a significant impact on the potential for LFG migration. In landfills with a low permeable cover system, gases may exhibit greater propensity for lateral migration relative to a landfill cover with a more permeable material.

Soil stratigraphy beneath and in the immediate vicinity of the landfill can significantly impact LFG migration potential. Highly permeable, non-cohesive soil or fractured rock tend to act as preferential pathways for migration of LFG, while fine grained or cohesive soil tend to impede the movement of LFG. Non-cohesive, high permeability soil, bound between two lower permeability soil layers can also significantly impact LFG migration potential. This geologic condition can result in higher pressure gradients which increase the lateral migration potential.

Hydrogeological conditions also impact the migration potential of LFG. Since methane is only slightly soluble in water, methane migration (the primary COC in LFG) is precluded by saturated soil which acts as a barrier to gas migration.

Meteorological conditions may also affect LFG migration potential. Precipitation can saturate the soil cover, resulting in reduced LFG venting to the atmosphere; thus, resulting in increased surficial lateral pressure gradients. During the winter, frozen ground conditions may also impede LFG venting to the surface and also result in increased lateral pressure gradients.

Civil works adjacent to the landfill may also impact migration potential. Paved areas provide a barrier to venting, thus increasing the potential for lateral migration of LFG. In addition, utility corridors, backfilled with non-cohesive and free draining bedding



material, may provide a conduit for migration to adjacent civil works, buildings or structures.

An additional consideration, when undertaking an assessment of potential LFG migration impacts, is the potential for methane oxidation in the shallow surficial soil. It is recognized that microbial oxidation of methane in aerobic soil can play a significant role in reducing the emission of methane to the atmosphere (Lelieveld et al., 1998). As a result of oxidation, the concentration of methane in the soil gas matrix is attenuated, thereby reducing the risk of concentrations exceeding trigger levels.

The rate of oxidation in surficial soil is dependent upon both biochemical and physical processes (Hettiaratchi and Hansen, 1996). In an aerobic atmosphere, methane can be decomposed by methanotropic bacteria, which result in the generation of carbon dioxide and water.

As previously stated, the Site is operated as a natural attenuation landfill with no engineered liner, LFG or leachate management systems in place. As such, the migration of LFG from the waste is relatively unobstructed. The surficial soil on Site primarily consists of sand and gravel, or silty sand. Due to the high permeability of the overburden soils, the potential for lateral LFG migration is low. It is noted that no evidence of vegetative stress was noted adjacent to the limit of waste.

### **3.4 Potential Receptors**

The primary environmental receptors include potential downstream uses of either surface water or groundwater, and the on-site buildings and adjacent property owners with respect to LFG.

#### **3.4.1 Surface Water**

As noted previously, surface watercourses located down-gradient of the Site include:

- Chapman Creek, located approximately 550 metres south of the Site, which drains into Trail Bay; and
- Irgens Creek, located approximately 100 metres north of the Site, which drains into Porpoise Bay.

According to the District of Sechelt Official Community Plan (SCRD, 2009), both Chapman Creek and Irgens Creek provide habitat for fish populations. Moreover, Chapman Creek is reported to provide the majority of the water for the SCR D water supply system (Appendix C). Water intake locations along Chapman Creek are indicated on Figure 4.

A number of other water intake licenses exist for Chapman Creek and Irgens Creek. Summaries of these licenses are provided in Tables 2 and 3, respectively.

According to the BC Water Resources Atlas, Sechelt Spring is located north of the Site. A surface water intake license (C007970) from 1925 exists for irrigation and domestic purposes along Sechelt Spring as show on Figure 4 under licensee name “Sechelt Indian Band” and appears to supply water to a series of buildings in the southwest part of the town of Sechelt on the Sechelt Band Lands. However, the SCR D



reviewed the properties in this area, and they appear to be using SCR D water services. The BC Water Resources Atlas also shows some line work running to the southwest through the Sechelt Landfill towards the town of Sechelt, which would have had to be abandoned or decommissioned at some point due to landfill development. On March 14, 2019, the SCR D conducted reconnaissance on the Sechelt Spring. The Sechelt Spring appears to be part of Irgens Creek which is intermittent at this point. The SCR D was able to locate what appeared to be an old man-made conveyance ditch that would have diverted water from the Sechelt Spring/Irgens Creek. It originates at Irgens Creek and ends at Dusty Road just east of groundwater monitoring wells MW4 and MW4A, as shown on Figure 6. Water was present in the first half (northern portion) of the conveyance ditch but was dry farther south, likely due to the increase in ground elevation and the natural topography in the area sloping back toward Irgens Creek. This intake license (which is suspected to be inactive) is located up-gradient of the Site and therefore is not considered a potential receptor.

#### 3.4.2 Groundwater

The characteristics of the down-gradient water wells are summarized in Table 1. As indicated in Table 1, the majority of the nearby off-site groundwater wells are owned by Construction Aggregates Ltd. and are located on the LHML mine property west of the Site. According to Sylvis Environmental Services, quarterly surface and groundwater quality monitoring has been ongoing at the mine since 1999. The mine monitoring program has demonstrated that surface and groundwater quality have remained consistent since the inception of the monitoring program.

Based on the foregoing, it is apparent that the primary receptor for the Site is the bedrock aquifer. As indicated above, the shallow perched aquifer is believed to flow in a dominantly south to south-westerly direction, and percolate down to the bedrock aquifer. According to historic monitoring results, vertical gradients between the shallow and deep monitoring wells indicate a strong downward gradient (XCG, 2023). Groundwater is anticipated to concentrate along low points in the bedrock surface and flow in the direction of the bedrock surface gradient. For this reason, any monitoring wells completed in the bedrock aquifer along the southern property boundary of the Site are considered to represent compliance monitoring locations.

As part of a multi-phase regional groundwater investigation implemented by the SCR D, in October 2018, Associated Environmental Consultants Inc. (Associated) conducted a pumping test evaluation on a test production well (WIN54929) located approximately 2 kilometres west of the Site.

This test production well, referred to as the Dusty Road Well, was reportedly installed to a depth of 83.5 metres bgs in an unconfined sand and gravel unit.

Associated issued the summary report to the SCR D in January 2019, and the reported pumping test analysis indicated the Dusty Road Well had a high sustainable yield of approximately 300 gallons per minute. However, due to its unconfined aquifer setting, the proximity of the adjacent quarry, and the resultant low source protection score, the SCR D determined that the Dusty Road site would not be developed for municipal water supplies at that time. These findings were outlined in the SCR D Infrastructure



Committee Meeting of January 24, 2019. It should be noted that recently, the SCRDR has revisited utilizing this well for short term drinking water use.

### 3.4.3 Landfill Gas

The potential for LFG to displace oxygen can result in health and safety issues with respect to accessing confined spaces such as manholes, subsurface utility/valve boxes, or septic tanks.

The ability of LFG to displace oxygen in the soil matrix in the vadose zone can result in vegetative stress which can adversely affect agricultural lands, landfill cover systems, and screening vegetation.

Receptors are generally defined and grouped based upon risk type. With respect to LFG, these risks can broadly be categorized as: exposure to combustible gases, asphyxiation potential, and ecotoxicity. The on-site buildings were the only receptor type identified which could potentially be adversely impacted by LFG migration.

There are currently several on-site buildings located at the Site (Figure 2). These include the office trailer, scale house, and maintenance shed. XCG assessed the risk of LFG migration into each on-site building based on the construction and ventilation of each building in 2017 (XCG, 2018). The following was concluded:

- The office trailer is constructed on raised foundations with a ventilated space between the bottom of the building and the ground surface. As a result, the potential for the LFG migration into these buildings is low, as long as continued ventilation is maintained.
- The maintenance shed has a slab on grade foundation with a metal frame and large bay doors. The slab on grade serves as a barrier for the migration of the LFG from the subsurface to indoor air; however, there is a potential for LFG to migrate through cracks in the floor slab. Due to the proximity of the maintenance shed to the landfill, the potential risk of LFG migration into the inside of this shed is deemed moderate to high.
- The scale house is constructed with a concrete foundation and a vented crawl space beneath the floor. There are two vents allowing for air flow beneath the scale house; however, caution should be taken when accessing the crawl space under the scale house as this area is considered a confined space, and due to the potential for LFG accumulation. The concrete slab foundation of the scale house serves as a physical barrier against the migration of LFG; however, there is potential for LFG to migrate through cracks in the concrete into the crawl space. As the foundation is below ground there is an increased risk of LFG migration into the scale house. The LFG could then migrate from the crawl space into the scale house itself. Although the crawl space is vented, it should only be accessed by appropriately trained staff wearing a personal gas monitor. The risk of LFG migration toward the Scale House is deemed low to moderate due to its distance from the limit of waste and the fact that the crawl space is vented.
- In 2021, hard-wired interior gas monitors were added to the buildings on Site as part of the ongoing LFG monitoring program.



The landfill's neighbouring properties to the north, east, and west are currently forested areas (crown lands). There is also an aggregate mine south of the Site. There are no structures within the immediate vicinity (i.e. within 300 metres) of the Site on the surrounding properties.



## **4. HISTORICAL ENVIRONMENTAL MONITORING PROGRAM**

### **4.1 History of Monitoring Program**

The following outlines a history of environmental monitoring and infrastructure at the Sechelt Landfill:

#### **1993**

- Semi-annual monitoring program commences with monitoring wells MW-1 through MW6 (Piteau, 2012).

#### **1996**

- Piteau installed monitoring wells MW-7, MW-8, and MW-9 and added these to the monitoring program (Piteau, 2012).

#### **1999**

- Piteau installed monitoring wells MW99-7, MW99-8, and MW99-9 and added these to the monitoring program. These wells were installed to replace monitoring wells MW-7, MW-8, and MW-9 which were destroyed shortly after their construction (Piteau, 1999).

#### **2002**

- Samples from two monitoring wells at the LHML facility have been submitted for basic parameters six times between 2002 and 2011. Well WP5 and the Sound Berm well are situated approximately 2.2 kilometres west and 2.5 kilometres west-southwest of the Sechelt Landfill, respectively.

#### **2013**

- XCG decommissioned monitoring wells MW99-7, MW99-8, and MW99-9 as part of the Phase 1 Final Closure project and replaced them with monitoring wells MW13-3, MW13-2, and MW13-1, respectively. In addition, background monitoring wells MW13-4 and MW13-5 were installed on the north side of Dusty Road to characterize shallow and deep up-gradient groundwater quality, as recommended in the “2012 Environmental Monitoring Report” (XCG, November 2013).
- Two soil gas probes, GP13-01 and GP13-02, were installed near the scale house, respectively, as recommended in the “Draft Environmental Monitoring Plan” (XCG, March 2013).

#### **2017**

- XCG decommissioned monitoring wells MW13-5 and MW-5. XCG installed monitoring well MW17-01 to monitor groundwater east of the landfill and to replace monitoring well MW-5 which was located off-site in a wet area. XCG installed MW17-02 to replace MW13-5, as MW13-5 has historically been dry. These locations were added to the monitoring program.
- XCG installed an additional soil gas probe GP17-01 near the maintenance shed, as recommended in the “Environmental Monitoring Plan” (XCG, March 2013).



- A LFG monitoring program was implemented at the Site using wells GP13-01 and GP13-02 installed in 2013 and GP17-01 installed in 2017.

#### **2018**

- Indoor air monitoring of six on-Site buildings commenced as recommended in the 2017 Annual Report (XCG, March 2018).

#### **2019**

- Groundwater monitoring well MW-1A was removed from the EMP. It was installed in 1993 and has never been sampled due to insufficient water. The groundwater monitoring well has also been damaged for several years. It was therefore recommended that this groundwater monitoring well be removed from the EMP. Groundwater monitoring well MW-1 provides sufficient groundwater quality data in this area of the Site.

#### **2020**

- XCG installed monitoring well (MW-2A) located on the west side of landfill. MW-4A is on located on the north side of the landfill.

#### **2021**

- Groundwater monitoring well MW-2 was decommissioned and removed from the EMP and was to be replaced in upcoming reporting periods.
- Gas probes GP13-01 and GP13-02 were decommissioned and re-installed, however they were constructed in a manner that renders them unusable.

#### **2022**

- Groundwater monitoring well MW2 was replaced in the EMP with monitoring well MW2-21.
- Three additional groundwater monitoring wells were installed in the deep groundwater throughout the Site. Monitoring well MW22-01 was installed north and up-gradient of the landfill. Monitoring well MW22-02 was installed northeast of the landfill and north of Dusty Road to characterize deep groundwater up-gradient of the Site. Monitoring well MW22-03 was installed east and cross-gradient of the landfill.

## **4.2 Historic Monitoring Results**

This section presents a summary of the most recent results from the 2022 Environmental Monitoring Program presented in the 2022 Annual Report (XCG, 2022):

### **4.2.1 Groundwater**

- The environmental monitoring program included the quarterly (March, July, September, and December 2022) monitoring of fifteen on-site monitoring wells, including MW-1, MW-2A, MW-3, MW-4, MW-4A, MW-13-1, MW-13-2, MW-13-3, MW-13-4, MW2-21, MW22-01, MW22-02, and MW22-03.



- A number of wells could not be sampled during the reporting period due to insufficient water.
- Perched groundwater conditions exist at the Site. The perched aquifer is believed to flow in a dominantly south to south-westerly direction and percolate down to the bedrock aquifer. Groundwater is anticipated to concentrate along low points in the bedrock surface and flow in the direction of the bedrock surface gradient.
- Monitoring wells completed in the bedrock aquifer along the southern property boundary of the Site are considered to represent compliance monitoring locations (MW13-1, MW13-2, and MW13-3).
- Slight to moderate landfill related impacts have been observed at all down-gradient groundwater monitoring wells completed in the bedrock aquifer.
- Varying degrees of landfill impacts were observed at all cross-gradient shallow groundwater monitoring wells.
- Results from the environmental monitoring program have indicated that the Site is in compliance compared to the applicable drinking water quality criteria based on the monitoring data collected from the three compliance wells (MW13-1, MW13-2, and MW13-3), except for varying exceedances of turbidity, total phosphorous, iron, manganese, ammonia, aluminum and arsenic.
- Natural attenuation appears to be occurring as impacted water from the perched aquifer migrates down to the bedrock aquifer. As evidenced at groundwater monitoring wells MW13-1, MW13-2, and MW13-3, groundwater quality at these locations has been improving over time, except for ammonia, total phosphorus, iron, and manganese. These impacts are expected to continue to decrease due to the construction of final cover, interim cover, and surface water management controls at the Site. Construction of additional final cover is planned for 2024.
- Risk to off-site groundwater users is deemed to be low.

#### **4.2.2 Surface Water**

- Five surface water locations were sampled during the March, July, September, and December monitoring events, including Site A, Site B, Site C, and Site E, and SW-01 which is located outside the landfill perimeter in the stormwater outfall.
- Samples could not be collected at surface water monitoring location Site E during the July, September, and December monitoring events due to insufficient water.
- Samples could not be collected at surface water location SW-01 during the 2022 reporting period due to insufficient water.

There is no evidence of landfill impacts at the surface water quality in Chapman Creek, Irgens Creek, or the stormwater discharging from the Site.

- Risk to surface water environmental receptors is deemed to be low.



### **4.2.3 Landfill Gas**

- The LFG monitoring events were complete at the Site during the April and December monitoring events and involved sampling the shallow (S) and deep (D) soil gas probes nested at sampling location GP17-01 and indoor monitoring in four on-site buildings, including the office building, scale house, and maintenance shed and the staff metal paint container (April only) and contractor's metal container (April only).
- It is noted that data was not collected from the share shed, special waste storage (storage bunker), and power shed because as of late summer, early fall in 2021 these structures were demolished due to the construction of the new on-Site public drop off area. In addition, no LFG monitoring was completed at the two nested gas probes GP13-01S/D and GP13-02S/D, as both of these probes were determined to be either installed incorrectly and/or were damaged during the construction activities completed on-site in the fall of 2021.
- High concentrations (above regulatory criteria) of methane that were measured in nested soil gas probes GP17-01S and GP17-01D are likely due to their relative proximity to waste and the highly permeable subsurface soil conditions on-Site (e.g., sand and gravel). It is noted that the highest concentration of methane is observed in GP17-01 which is located within 2 metres of the approximate historical limit of waste.
- Contingency measures were implemented including notifying the MOE of regulatory exceedances, additional confirmatory sampling, assessing the nature and risk of the problem, and identifying appropriate corrective actions, including continued monitoring and mandating venting (airing) of the maintenance shop prior to entering it.
- Based on the monitoring results at GP17-01S and GP17-01D, the risk of LFG migration toward on-site buildings is deemed moderate to high. LFG related impacts were not observed in any of the on-Site buildings during the 2022 interior building gas monitoring.
- LFG monitoring should continue to be completed quarterly with the addition of interior methane monitoring in the on-site buildings. The implementation of personal monitors and the fixed gas monitor within the scale house will aid in mitigating the risk to on-site staff and public.



## **5. ENVIRONMENTAL MONITORING PROGRAM**

The following section presents the environmental monitoring program. The groundwater, surface water and LFG monitoring is based on the existing monitoring program as presented in the 2022 Annual Report (XCG, 2022), except for additional groundwater monitoring locations that have been added as part of this 2023 EMP update. The location of these new groundwater monitoring locations is further discussed in Section 5.1.1 below.

### **5.1 Groundwater Monitoring**

The objective of the groundwater monitoring program is to detect, qualify, and quantify the extent and magnitude of the groundwater contaminants derived from landfill activities. The data compiled from the groundwater monitoring program is utilized to confirm that adequate attenuation is occurring prior to discharge from the landfill property.

#### **5.1.1 Monitoring Locations**

On-site and off-site monitoring well locations for the Sechelt Landfill are shown in Figures 6 and 7, respectively. A summary of the monitoring wells is included as Table 4. It is noted that monitoring for well WP5 and the Sound Berm well are completed by Sylvis Environmental on behalf of Heidelberg for operation of the Sechelt mine. Stratigraphic logs for all historic and existing monitoring wells are provided as Appendix B.

As part of this 2023 EMP Update, two new on-site groundwater monitoring wells will be added to the quarterly sampling program. These new proposed groundwater monitoring wells are shown on Figure 6. One proposed groundwater monitoring well location is along western property boundary, north of existing MW-3. The second proposed groundwater monitoring well location is along the northwestern property boundary, west of the contact water pond located in the northwest corner of the Site, and south of existing groundwater monitoring wells MW1 and MW1-A.

Additionally, global positioning system (GPS) coordinates should be obtained for all on-site and off-site groundwater monitoring locations.

#### **5.1.2 Monitoring Frequency**

The environmental monitoring program includes quarterly sampling of groundwater monitoring wells.

#### **5.1.3 Analytes**

The groundwater monitoring wells are analyzed for the following analytical parameters.

##### **Field Measurements**

- Temperature, pH, electrical conductivity, ORP, DO, odour, and visual inspection of colour.



### Laboratory Analysis

- General Chemistry, Nutrients and Anions;
  - pH, electrical conductivity, hardness, COD, dissolved organic carbon (DOC), alkalinity, bicarbonate, carbonate, hydroxide, turbidity, ammonia, nitrate, nitrite, total phosphorus, total nitrogen, total kjeldahl nitrogen (TKN), chloride, and sulphate.
- Dissolved Metals
  - Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silicon, silver, sodium, strontium, sulphur, thallium, tin, titanium, uranium, vanadium, zinc, and zirconium.
- Volatile Organic Compounds Package (VOCs)
  - 1,1,1,2-tetrachloroethane, 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-Trichloro-1,2,2-Trifluoroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dibromoethane, 1,2-dichlorobenzene, 1,2-dichloroethane, 1,2-dichloropropane, 1,3,5-trimethylbenzene, 1,3-dichlorobenzene, 1,3-dichloropropane, 1,4-dichlorobenzene, Benzene, Bromobenzene, Bromodichloromethane, Bromoform, Bromomethane, Dibromomethane, Carbon Tetrachloride, Chlorobenzene, Chlorodibromomethane, Chloroethane, Chloroform, Chloromethane, cis-1,2-dichloroethene, cis-1,3-dichloropropene, Dichlorodifluoromethane, Dichloromethane, Ethylbenzene, Hexachlorobutadiene, Isopropylbenzene, m & p-Xylene, Methyl-tert-butylether (MTBE), o-Xylene, Styrene, Tetrachloroethene, Toluene, trans-1,2-dichloroethene, trans-1,3-dichloropropene, Trichloroethene, Trichlorofluoromethane, VH C6-C10, Vinyl Chloride, VPH (VHW6 to 10 - BTEX), and Xylenes (total).

#### 5.1.4 Sampling Collection and Handling

The following sample collection and handling protocols are based on the following applicable documents:

- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (MOE, 1996); and
- British Columbia Field Sampling Manual, Part E - Water and Wastewater Sampling (MOE, 2013).

In order to ensure that representative groundwater samples are obtained from the monitoring wells and that no contamination of the recovered samples occurs, the following sampling protocols should be applied:

- After each well is opened to allow for the pressure inside the well to equalize with the atmospheric pressure, record the static water level in each monitoring well.



- Prior to the groundwater sample collection, purge each well of the standing volume of water. The objective of purging is to remove groundwater from the well until a representative sample of the formation groundwater is obtained. While this is generally achieved by the removal of three to 10 times the volume of standing water in the well or purging the well dry three times, it is recommended that the appropriate number be determined on a site-specific basis according to the number required to reach equilibrium. Purging should be completed by removing groundwater from the well at low flow rates using a low flow, e.g., peristaltic, pump. In general, purging is considered complete once sediment-free groundwater is obtained and the specific conductance, temperature, and pH measured in the field have stabilized within ranges prescribed in the MOE's Standard Operating Procedure (SOP) E2-06.
- Groundwater samples should be collected using low-flow sampling method in accordance with the MOE's SOP-E2-06.
- Collect groundwater samples in the appropriate laboratory-supplied sample containers and preserve as required. All laboratory-supplied sample containers will be properly labelled with the correct respective sample IDs. Samples IDs must include the monitoring well IDs consistent with the well IDs presented on EMP figures.
- Groundwater samples to be analysed for dissolved metals should be field-filtered (before preservation) using 0.45- $\mu\text{m}$  in-line filters. If samples collected for total metal analyses are field-filtered, they must be collected into a laboratory-supplied container with an acid solution. If the samples for total metals analyses cannot be field-filtered, the laboratory-supplied sampling container for the total metals must be rinsed to remove the acid solution prior to collecting the samples. The rinsing should be completed using deionized water.
- Groundwater samples designated for VOC analysis should be collected in a manner that does not agitate the sample or expose it to the air. Samples should be placed directly to the laboratory-supplied container with no air space/bubbles present in the sampling container.
- Field measurements should always be collected using a separate sub-sample that is discarded once the measurements are complete. Field measurements should never be collected using a water sample that is to be submitted for laboratory analyses.
- All samples should be packaged in a cooler, on ice, stored at a temperature of approximately 4°C, and delivered to the laboratory for analysis. All samples should be submitted under a chain of custody to an accredited analytical laboratory certified for environmental analysis by the Ministry.

## **5.2 Surface Water Monitoring**

The objective of the surface water monitoring program is to ensure that contaminants derived from landfill activities are not impacting surface watercourses located in proximity to the Site.



### **5.2.1 Monitoring Locations**

There are currently five surface water monitoring locations included in the annual monitoring program (Figure 4). These locations are as follows:

- Upper Chapman Creek – Background surface water sampling site upstream of the landfill (Site A);
- Lower Chapman Creek – Surface water sampling site downstream of the landfill (Site B);
- Lower Irgens Creek – Surface water sampling site downstream of the landfill (Site C); and
- Upper Irgens Creek - Surface water sampling site upstream of the landfill (Site E).

A stormwater management system was constructed at the Site in 2013. Stormwater from areas of the landfill completed with final and intermediate cover are being directed to the Dusty Road south roadside ditch via on-site perimeter ditches and gravity main piping as shown on Figure 2.

Additionally, GPS coordinates should be obtained for all on-site and off-site surface water monitoring locations.

### **5.2.2 Monitoring Frequency**

The environmental monitoring program includes quarterly sampling of surface water monitoring locations.

### **5.2.3 Analytes**

The surface water monitoring locations are analyzed for the following analytical parameters.

#### **Field Measurements**

- Temperature, pH, electrical conductivity, ORP, and DO.

#### **Laboratory Analysis**

- General Chemistry, Nutrients and Anions
  - pH, electrical conductivity, hardness, COD, DOC, ammonia, nitrate, nitrite, total nitrogen, and chloride.
- Total Metals
  - Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silicon, silver, sodium, strontium, sulphur, thallium, tin, titanium, uranium, vanadium, zinc, and zirconium.

### **5.2.4 Sampling Collection and Handling**

The following sample collection and handling protocols are based on the following applicable documents:



- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (MOE, 1996); and
- British Columbia Field Sampling Manual, Part E - Water and Wastewater Sampling, Ambient Freshwater and Effluent Sampling (MOE, 2013).

As indicated in Section 4.2.1 of Part E “Water and Wastewater Sampling” of the BC Field Sampling Manual, the most important issue to consider when deciding where the surface water sample should be collected from is safety. As a result, surface water samples will be grab samples collected from the stream bank.

The following protocol for sampling from the stream bank is presented in the Field Sampling Manual and will be used to collect surface water samples.

- Secure yourself to a solid object on shore (with a safety harness and line if necessary). If possible, a second person should remain nearby while the first person is collecting the samples.
- Remove lid from a labelled sample bottle and place into a clean reusable bag so both hands can be used to take sample. If rinsing is required for the type of bottle, rinse three times.
- Hold the sample bottle well below the neck or secure it to a pole sampler.
- Reach out (arm’s length only) and plunge the bottle under the water with the opening facing directly down and immediately orient it into the current.
- When the bottle is full, pull it up through the water while forcing it into the current.
- Immediately recap the bottle.
- All laboratory-supplied sample containers must be properly labelled with the correct sample IDs consistent with the sampling location IDs present on EMP figures.

It should be noted that preservative (as required) should be added to the samples after collection to ensure proper sample preservation.

Field measurements should always be collected using a separate sub-sample that is discarded once the measurements are complete. Field measurements should never be collected using a water sample that is to be submitted for laboratory analyses.

Samples will be packed on ice and submitted under a chain of custody to an accredited analytical laboratory certified for environmental analysis by the Ministry.

### **5.3 Leachate Monitoring**

The objective of the leachate monitoring will be to confirm parameters of concern for the groundwater and surface water monitoring programs.

#### **5.3.1 Monitoring Locations**

As discussed in the Updated Leachate Management Plan prepared by XCG in November 2020, comparison of historic monitoring data from various groundwater monitoring wells MW-4, MW-4A, MW13-4 (used for background water quality), and MW-3. MW-3 provides the closest approximation of leachate quality at the Site.



Monitoring well MW-3 is located at the southwestern corner of the landfill, near the former sludge disposal pits and for these reasons, is considered to represent leachate quality at the Site, as it is the most down-gradient shallow well.

### 5.3.2 **Monitoring Frequency**

Although, the OC requires that leachate quality monitoring is to be completed only annually as part of the winter monitoring event, MW-3, as the leachate monitoring well, is monitored quarterly as part of the regular monitoring program. However, only the samples collected from MW-3 during the winter monitoring event will be analysed for the parameters associated with the leachate quality.

### 5.3.3 **Analytes**

Analysis shall be undertaken to monitor the following parameters:

#### **Field Measurements**

- Temperature, pH, electrical conductivity, ORP, and DO.

#### **Laboratory Analysis**

- General Chemistry, Nutrients and Anions:
  - pH, electrical conductivity, hardness, COD, DOC, alkalinity, bicarbonate, carbonate, hydroxide, ammonia, nitrate, nitrite, total phosphorus, total nitrogen, total kjeldahl nitrogen (TKN), chloride, and sulphate.
- Dissolved Metals:
  - Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silicon, silver, sodium, strontium, sulphur, thallium, tin, titanium, uranium, vanadium, zinc, and zirconium.
- VOC package:
  - 1,1,1,2-tetrachloroethane, 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2Trichloro-1,2,2Trifluoroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dibromoethane, 1,2-dichlorobenzene, 1,2-dichloroethane, 1,2-dichloropropane, 1,3,5-trimethylbenzene, 1,3-dichlorobenzene, 1,3-dichloropropane, 1,4-dichlorobenzene, Benzene, Bromobenzene, Bromodichloromethane, Bromoform, Bromomethane, Dibromomethane, Carbon Tetrachloride, Chlorobenzene, Chlorodibromomethane, Chloroethane, Chloroform, Chloromethane, cis-1,2-dichloroethene, cis-1,3-dichloropropene, Dichlorodifluoromethane, Dichloromethane, Ethylbenzene, Hexachlorobutadiene, Isopropylbenzene, m & p-Xylene, Methyl-tert-butylether (MTBE), o-Xylene, Styrene, Tetrachloroethene, Toluene, trans-1,2-dichloroethene, trans-1,3-dichloropropene, Trichloroethene, Trichlorofluoromethane, VH C6-C10, Vinyl Chloride, VPH (VHW6 to 10 - BTEX), and Xylenes (total).



#### 5.3.4 Sample Collection and Handling

The following sample collection and handling protocols are based on the following applicable documents:

- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (MOE, 1996); and
- British Columbia Field Sampling Manual, Part E - Water and Wastewater Sampling (MOE, 2013).

In order to ensure that representative groundwater samples are obtained from the monitoring wells and that no contamination of the recovered samples occurs, the following sampling protocols should be applied:

- After each well is opened to allow for the pressure inside the well to equalize with the atmospheric pressure, record the static water level in each monitoring well.
- Prior to the groundwater sample collection, purge each well of the standing volume of water. The objective of purging is to remove groundwater from the well until a representative sample of the formation groundwater is obtained. While this is generally achieved by the removal of three to 10 times the volume of standing water in the well or purging the well dry three times it is recommended that the appropriated number be determined on a site-specific basis according to the number required to reach equilibrium. Purging should be completed by removing groundwater from the well at low flow rates using a low-flow, e.g., peristaltic, pump. In general, purging is considered complete once sediment-free groundwater is obtained and the specific conductance, temperature, and pH measured in the field have stabilized within ranges prescribed in the MOE's SOP E2-06.
- Groundwater samples should be collected using low-flow sampling method in accordance with the MOE's SOP-E2-06.
- Collect groundwater samples in the appropriate laboratory-supplied sample containers and preserve as required. All laboratory-supplied sample containers will be properly labelled with the correct respective sample IDs. Sample IDs must include the monitoring well IDs consistent with the well IDs presented on EMP figures.
- Groundwater samples to be analysed for dissolved metals should be field-filtered (before preservation) using 0.45- $\mu$ m in-line filters. If samples collected for total metal analyses are field-filtered, they must be collected into a laboratory-supplied container with an acid solution. If the samples for total metals analyses cannot be field-filtered, the laboratory-supplied sampling container for the total metals must be rinsed to remove the acid solution prior to collecting the samples. The rinsing should be completed using deionized water.
- Groundwater samples designated for VOC analysis should be collected in a manner that does not agitate the sample or expose it to the air. Samples should be placed directly to the laboratory-supplied container with no air space/bubbles present in the sampling container.



- Field measurements should always be collected using a separate sub-sample that is discarded once the measurements are complete. Field measurements should never be collected using a water sample that is to be submitted for laboratory analyses.
- All samples should be packaged in a cooler, on ice, stored at a temperature of approximately 4°C, and delivered to the laboratory for analysis. All samples should be submitted under a chain of custody to an accredited analytical laboratory certified for environmental analysis by the Ministry.

#### **5.4 LFG Monitoring**

The objective of landfill gas monitoring is to ensure the subsurface migration of LFG does not pose a risk to human health or the surrounding environment.

The lateral migration of soil gas poses three primary concerns associated with the accumulation of gases within the soil matrix or below building structures in close proximity to a landfill site:

- The accumulation of LFG in subsurface structures (e.g., manholes and vault boxes) which may create an oxygen deficient atmosphere;
- The accumulation of LFG at concentrations exceeding the LEL, thereby posing a risk of explosion; and
- Vegetation stress effects due to displacement of oxygen in the root zone.

##### **5.4.1 Monitoring Locations**

The soil gas monitoring program is conducted to monitor for the presence of lateral LFG migration through the subsurface adjacent to identified receptors (i.e., on-site building structures).

There are currently three soil gas probe locations included in the annual monitoring program (Figure 6). These locations are as follows:

- GP13-01D/S – two nested (deep and shallow) probes adjacent to the site entrance.
- GP13-02D/S – two nested (deep and shallow) probes adjacent to the scale house.
- GP17-01D/S – two nested (deep and shallow) probes adjacent to the maintenance shed.

It should be noted that, during the 2022 LFG monitoring event, no LFG monitoring was completed at probes GP13-01S/D and GP13-02S/D, as both of these probes were determined to be either installed incorrectly and/or were damaged during the construction activities completed on-site in the fall of 2021. As a result, as part of the 2023 EMP Update, going forward, GP13-01 S/D and GP13-02S/D will no longer be monitored. New gas probes will be installed to be included in the quarterly monitoring program. One proposed gas probe location is adjacent to the on-site office building, and the second proposed gas probe location is adjacent to the west of the on-site scale house.



Each of the soil gas monitoring locations consists of a dedicated multi-level probe installation. The depth of each probe depends on depth to groundwater and geological conditions encountered at each borehole. The nested probes allow monitoring of LFG migration at multiple discrete depths from surface, down to the seasonal low water table. The probes are screened in areas of higher permeability unsaturated soil (e.g., sand), if present, in the surficial stratigraphy. By locating the screened intervals within discrete permeable hydrogeologic units, it is possible to better delineate subsurface gas migration point sources and determine risk to potential receptors in the event that elevated methane concentrations are detected in the soil gas matrix. When possible, the soil gas probes are installed above the water table, as groundwater can inhibit the migration of LFG.

Each probe was constructed of an approximate 20-millimetre diameter, Schedule 40 PVC pipe. The lengths of PVC pipe were connected with threaded joints. The perforated pipe sections were backfilled with washed pea gravel and sealed with a concrete/bentonite seal at the ground surface. Each probe was equipped with a slip cap cover (greased with a non-petroleum-based lubricant) and a 6-millimetre PVC labcock valve fitted with a 6-millimetre hose barb and PVC end-cap.

A summary of the on-site soil gas probes and completion details is presented in Table 5. Stratigraphic logs are provided in Appendix B.

Interior methane monitoring in all on-site buildings has been added to the monitoring program due to high concentrations (above regulatory criteria) of methane historically measured in nested soil gas probes GP13-01, GP13-02, and GP17-01 in 2017.

The updated interior building monitoring locations are as follows:

- Scale House (three rooms): Office, Main Area, and Lunchroom;
- Office Trailer;
- Maintenance Shed
- Mattress Container; and
- Storage Sea Cans.

Caution should be taken when accessing the crawl space under the scale house as this is a confined space where LFG may accumulate. The crawl space should only be accessed by appropriately trained staff wearing a personal gas monitor.

Additionally, GPS coordinates should be obtained for all on-Site and off-Site LFG monitoring locations

#### **5.4.2 Monitoring Frequency**

Soil gas and interior methane monitoring shall be undertaken quarterly to coincide with groundwater and surface water monitoring events.

#### **5.4.3 Monitoring Parameters**

Soil gas monitoring is undertaken to monitor the following parameters:

- Soil gas pressure;



- Methane concentration;
- Oxygen concentration;
- Carbon dioxide concentration; and
- Groundwater level.
- Interior building monitoring is conducted for methane as it is the main indicator for the presence of LFG.

#### **5.4.4 Soil Gas (LFG) Probe Monitoring Procedures**

Soil gas probe monitoring shall strictly adhere to the following sequence of execution:

- Probe inspection;
- In-situ pressure measurement;
- Soil gas monitoring for methane, carbon dioxide, and oxygen concentrations; and
- Water level measurement.

##### **Soil Gas Probe Inspection**

Prior to undertaking field sampling activities, a thorough inspection of the gas probe shall be undertaken to ensure that the probe has not been damaged or tampered with and that the probe labcock is in the closed position. Any cracking of the surface well seal should be noted, as well as any surface water ponding in the vicinity of the probe.

##### **Pressure Measurement**

In-situ gas pressure should always be measured and recorded prior to gas sampling activities or measuring groundwater elevation, as these tasks will affect the in-situ gas pressure within and adjacent to the probe. At monitoring locations consisting of multiple nested probes, all pressure measurements shall be conducted first.

The following pressure measurement protocols shall be strictly adhered to:

1. Zero the digital manometer.
2. Connect “positive” sample port on the digital manometer to the probe labcock hose barb, while ensuring a tight seal at all connections.
3. Open the labcock.
4. Record pressure measurement and pressure units.
5. Close the labcock.
6. Disconnect digital manometer and ensure that the static pressure has returned to zero. If not zero, repeat procedure.

##### **Combustible Gas Concentration Measurement**

To monitor combustible gas concentration in the gas probe, the following steps shall be taken:

1. Turn on gas meter(s) prior to commencing sampling and allow the unit(s) to warm up.



2. Purge unit(s) with fresh air and ensure the unit is zeroed (methane and carbon dioxide read 0%, oxygen reads 20.9% on a volumetric basis). If the unit(s) are not zeroed, field calibrate prior to commencing sampling program.
3. Connect the analyzer sampling hose to the hose barb labcock. Ensure that all connections are tight.
4. Open labcock and turn on analyzer pump.
5. A minimum of three well volumes shall be purged at a flow rate between 0.1 litres per minute and 0.2 litres per minute, prior to sampling or recording measurements. In the case of deeper soil gas probes, or large diameter probes (i.e., groundwater monitoring wells) a higher flow rate of up to 5 litres per minute can be used to reduce purging time. As a general rule, a minimum of 100% and maximum of 300% of the probe and granular filter pack volume should be purged prior to undertaking monitoring and/or measurement activities. In addition, purging shall continue until the reading has stabilized.
6. Record analyzer measurements and note any fluctuations (including the range of fluctuations).
7. Shut off analyzer pump, close probe labcock, and disconnect hose.
8. Purge unit(s) with fresh air to ensure the unit(s) are still zeroed. If not zeroed, calibrate unit(s) and repeat procedure.

#### ***Water Level Measurements***

The measurement of water level in gas probes is the final measurement to be undertaken at a given probe location and is critical to the determination of the installation's operability (i.e. is the screened interval in the probe installation flooded?) and to assist in the evaluation of LFG migration potential by delineating the depth of the vadose zone.

Due to the narrow soil gas probe pipe diameter, the water level is measured with a coaxial electronic water level indicator. Measurements are undertaken within the gas probe by removing the slip cap assembly from the top of the riser pipe. The depth to water is recorded relative to the top of casing (TOC). If no water is encountered in the probe, "dry" is recorded on the data sheet.

Upon completion of water level measurement at a given probe location, the slip cap is cleaned, greased with a non-petroleum-based lubricant, and fitted snugly to the top of the probe riser pipe.

Prior to closing and locking the probe's steel protective casing, ensure that the labcock is in the closed position.

#### ***Data Recording***

All data measured during the gas monitoring program shall be recorded. The recorded data should, at a minimum include the following information:

- Probe #;
- Time and date of measurement;



- Pressure;
- Purge time;
- Methane concentration;
- Carbon dioxide concentration;
- Oxygen concentration;
- Depth to water table; and
- Status of probe (i.e. damage, evidence of tampering, or labcock open).

#### **Data Evaluation**

Upon completion of each monitoring event, the recorded data collected shall be reviewed in consideration of the following objectives:

- Verify that trigger levels have not been exceeded; and
- Identify maintenance issues, and contact appropriate landfill personnel to initiate appropriate remedial actions.

A detailed evaluation should be undertaken as part of the annual monitoring report to review the following elements:

- Identify significant changes in measurements (typically greater than 20% relative to the previous year's data);
- Identify trends which may be indicative of LFG migration;
- Assess the performance of the engineered control systems, remedial measures or contingency actions (if implemented); and
- Consider if modifications to the monitoring program are deemed appropriate.

## **5.5 Field Equipment**

### **5.5.1 Groundwater and Surface Water**

Guidance on equipment for collection of field temperature, pH, and conductivity is detailed in the previously noted BC Field Sampling Manual.

#### **Temperature**

A calibrated electronic or alcohol-filled thermometer capable of producing results within  $\pm 0.5^{\circ}\text{C}$  of the true temperature.

#### **pH**

A calibrated electronic pH or multi-parameter meter capable of recording to the nearest 0.1 pH unit.

#### **Conductivity**

A calibrated electronic specific conductance (electrical conductivity) meter or multi-parameter meter capable of recording to the nearest 1 microsiemens per centimetre ( $\mu\text{S}/\text{cm}$ ).

**Dissolved Oxygen**

A calibrated multi-parameter meter capable of recording to the nearest 1 milligram per litre.

**Water Level Meter**

Water level meters are utilized to measure the depth of water in the monitoring wells to record seasonal fluctuations in the groundwater. The water level meter shall be a coaxial cable type water level meter.

**5.5.2 Soil Gas**

The following field instrumentation shall be used for soil gas monitoring.

**Portable Gas Analyzer**

The combustible gas meter shall be a non-dispersive infrared (NDIR) combustible gas sensor equipped with an intrinsically safe pump. The sensor shall operate at the following scales:

- 0-100% methane (volumetric basis) with an accuracy of 3%; and
- 0-100% LEL with an accuracy of 0.3%.

The combustible gas of concern is methane; however, it is noted that combustible gas sensing devices usually respond to all combustible gases present. Therefore, concentrations measured during monitoring are normally expressed as an equivalent to a known calibration gas (typically methane for landfill applications). For the purpose of soil gas monitoring, the sensor should be calibrated to a 2.5% methane (50% LEL) span gas. Calibrations with other combustible gases shall be converted to methane equivalents. The portable gas analyzer will be serviced and calibrated on an annual basis.

It is noted that catalytic combustible gas sensor equipment is not suitable for this application as methane concentrations greater than 5% (as can readily occur on LFG) may poison the sensor. In addition, the sensor requires oxygen to function, which may not be present in a LFG atmosphere.

In addition, it is noted that flame ionization detection (FID) equipment is not appropriate due to the fact that low levels of oxygen can cause a “flame out” in the FID and that the unit’s sensitivity is impacted by elevated levels of carbon dioxide.

It is further noted that photo ionization detectors (PID) are not suitable for this application due to the potential for elevated concentrations of methane to accumulate in the probe casing which can “quench” the PID signal, resulting in a reading biased low.

**Carbon Dioxide Gas Sensor**

The carbon dioxide gas sensor shall be a non-dispersive infrared (NDIR) gas sensor equipped with an intrinsically safe pump. The sensor shall have at a minimum the following operating ranges:

- 0-5% carbon dioxide (volumetric basis) with an accuracy of 0.3%.
- 0-60% carbon dioxide (volumetric basis) with an accuracy of 3%.

**Oxygen Sensor**

The oxygen sensor shall be an electrochemical or paramagnetic sensor with a range of 0-21% (volumetric basis) and an accuracy of 1% full scale.

It is noted that the portable gas analyzer should be field calibrated daily, prior to the commencement of sampling activities.

**Digital Manometer**

The measurement of the in-situ pressure at soil gas monitoring probes provides useful data for assessing the migration of combustible gas. A portable digital manometer shall be used to measure in-situ pressure. This device shall have a minimum resolution of 2.0 pascals (0.01 inches water column) and pressure hysteresis of 0.1%, and manual pressure zeroing capacity.

**Water Level Meter**

Water level meters are utilized to measure the depth of water in gas probes to record seasonal fluctuations in the groundwater table and ensure that the probes screened interval is not blinded. The water level meter shall be a coaxial cable type water level meter, capable of insertion into a 19-millimetre diameter PVC pipe.

**5.5.3 Interior Building Monitoring**

A portable gas analyzer capable of measuring methane concentration in parts per million (ppm) should be used in order to detect LFG at low levels. The PID should be accurate to +/- 25 ppm or 5% of the reading, whichever is greater. A PID should be suitable for this application since methane concentrations within the buildings (if any) are expected to be low. The PID should be calibrated to methane. If concentrations are expected to be high (greater than 50,000 ppm (100% LEL)) then a combustible gas meter with a non-dispersive infrared (NDIR) sensor shall be used as well.

The portable gas analyzer will be serviced and calibrated on an annual basis.

**5.6 Quality Assurance/Quality Control (QA/QC)**

The quality assurance procedures will be in general accordance with the BC Field Sampling Manual.

The quality control procedures will include the collection of field duplicates at a frequency of 1 per every 10 water samples. One field blank and one trip blank should be collected per monitoring event.

**5.7 Criteria****5.7.1 Groundwater and Surface Water**

As per the OC, analytical parameters should be compared to the British Columbia Approved and Working Criteria for Water Quality (whichever is applicable), prepared by the MOE.

As indicated in Section 3.5, the primary environmental receptors for the Site include potential downstream uses of either surface water or groundwater. Based on these



potential receptors, the water quality data will be compared to the drinking water and aquatic life standards of the above referenced criteria.

### **5.7.2 Landfill Gas**

According to the Landfill Criteria for Municipal Solid Waste (MOE, June 2016), at no time shall combustible gas concentrations exceed the LEL (5% methane, on a volumetric basis) in soils at the property boundary, or 20% of the LEL (1% methane, on a volumetric basis) in any on-site structure or facility.

According to the OC, the landfill must not cause combustible gas concentrations to exceed the lower explosive limit in soils at the property boundary or 25% of the LEL at or in on-site or off-site structures.

### **5.8 Inspections**

Visual inspections of the landfill surrounding areas will be completed during each monitoring event to identify areas of vegetative stress or erosion that may require repair, or may be indicative of soil gas and/or leachate migration.

### **5.9 Reporting**

As stipulated in Section 4.6 of the OC, the SCRDR shall submit the Annual Report to the Regional Waste Manager, by March 31 of each year.

Key elements of the Annual Report that relate to the environmental monitoring program are as follows:

- The results of all monitoring programs as specified in this OC. Data interpretation and comparison to the performance criteria in the Landfill Criteria for Municipal Solid Waste, the Guidelines for Environmental Monitoring and Municipal Solid Waste Landfills. Trend analyses, as well as an evaluation of the impacts of the discharges on the receiving environment in the previous year must be carried out by a qualified professional.



## **6. CONTINGENCY RESPONSE**

This contingency response protocol for the Site EMP enables a systematic evaluation and response procedure to address potential environmental concerns.

### **6.1 Groundwater**

The groundwater trigger level and contingency program serves to identify potential environmental concerns and evaluate the need for suitable mitigation measures.

Routine groundwater monitoring will be conducted as outlined in Section 5.1 above. In the event that water quality parameter(s) exceed applicable criteria at compliance monitoring wells, a confirmatory sample will be collected and analysed within one month of being advised of the exceedance.

If exceedances are again recorded based on confirmatory sampling, the following actions will be taken:

- Notification of the Ministry;
- Evaluation of the nature, extent, and source of the environmental impacts;
- Conduct a risk assessment; and
- Completion of additional monitoring and investigation and/or development of a suitable mitigation plan.

### **6.2 Surface Water**

The surface water trigger level and contingency program serves to identify potential environmental concerns and evaluate the need for suitable mitigation measures.

Routine surface water monitoring will be conducted as outlined in Section 5.2 above. In the event that water quality parameter(s) exceed applicable criteria at down-gradient surface water monitoring locations, a confirmatory sample will be collected and analysed within eleven days of being advised of the exceedance.

If exceedances are again recorded based on confirmatory sampling, the following actions will be taken:

- Notification of the Ministry;
- Evaluation of the nature, extent, and source of the environmental impacts;
- Conduct a risk assessment; and
- Completion of additional monitoring and investigation and/or development of a suitable mitigation plan.

### **6.3 Soil Gas**

The soil gas trigger level and contingency program has been developed in response to potential odour and lateral migration issues associated with potential LFG fugitive emissions.



### **6.3.1 Trigger Levels**

The following trigger levels will necessitate the implementation of contingency measures:

- Concentration of methane at gas probes exceeding 10% LEL (conservative concentration to comply with OC criteria of 25% LEL at on-site structures);
- Concentration of methane inside on-site buildings of 1% LEL (500 ppm) [conservative concentration to comply with regulatory criteria of 20% of the LEL (10,000 ppm) in any on-site structure or facility];
- Vegetative stress relative to LFG impacts; and
- LFG emissions from the landfill resulting in odour issues and/or impacts to the air quality in the area.

### **6.3.2 Contingency Response – Odour**

In the event of LFG-related odour complaints by the public, or excessive LFG related odour being noted by landfill staff, the following contingency response plan shall be implemented.

The recommended procedure for managing LFG related odour complaints commences with recording the event. Event-specific information to be recorded includes the following:

- Nature of incident;
- Location;
- Time and date of the incident;
- Landfill operations which may have triggered the event;
- Wind direction at the time of the incident; and
- Description of the measures taken to address the cause of the incident and to prevent a similar occurrence in the future.

Site personnel should investigate and determine, where possible, the source of the odour issue and take appropriate action based on the contingency actions described herein.

Mitigative measures that should be considered for implementation to address odour/air quality problems include the following:

- Initiation of additional monitoring;
- Inspection and/or surface monitoring of final cover for sources of fugitive emissions;
- Placement of additional cover material or covering exposed waste;
- Placement of bio-cover material;
- Installation of an active LFG collection system; and
- Other effective measures that may also be available.



It is noted that other mitigative strategies should be considered depending upon the nature and cause of the incident. If it is determined that mitigative measures should be implemented, a monitoring program shall also be implemented to assess the effectiveness of the measures applied.

### **6.3.3 Contingency Response – Subsurface Lateral Migration**

The following section provides an overview of the contingency response for subsurface lateral gas migration.

#### **6.3.3.1 Site-Specific Trigger Levels**

As indicated above, site-specific trigger levels have been generated for the proposed gas probe locations. In addition to the aforementioned methane concentrations in the soil gas matrix, contingency measures should also be implemented in the event of LFG related vegetative stress at or beyond the limit of waste.

Should it be determined that these trigger levels are exceeded, contingency measures, as outlined herein, should be implemented.

#### **6.3.3.2 Contingency Plan Overview**

The LFG contingency plan is based on a five-stage contingency implementation strategy. This strategy includes the following stages and associated elements:

- Stage 1 Regular gas monitoring program. If any of the established trigger levels are exceeded, Stage 2 is initiated.
- Stage 2 Undertake confirmatory analysis: recalibration and re-testing with portable combustible gas analyzer. If trigger level is exceeded, determine if the exceedance is landfill related. If landfill related, Stage 3 is initiated.
- Stage 3 The performance of existing environmental management controls (e.g., liner system) shall be evaluated to determine if the impact might have been caused by the failure of one or more of these controls. If failure identified, remedial measures shall be undertaken and gas monitoring program continued to monitor the effectiveness of repairs. If remedial measures cannot be undertaken (i.e. liner cannot be repaired) than Stage 4 shall be initiated.
- Stage 4 An evaluation of potential receptors shall be undertaken. Additional soil gas probes shall be installed in proximity of the identified receptors and/or at the property boundary. The frequency of the soil gas monitoring program shall be re-evaluated and altered as deemed necessary. The extent of impact shall be evaluated to delineate the extent of lateral migration. A risk evaluation shall be made to determine if mitigative measures are warranted. If mitigative measures are warranted, Stage 5 is initiated.
- Stage 5 A review and assessment of potential mitigation measures shall be undertaken. The preferred mitigation measure shall be identified, designed, and implemented. The soil gas monitoring program will be modified to monitor the effectiveness of the measures undertaken.



**7. LIMITATIONS**

The scope of this document is limited to the matters expressly covered. This updated Environmental Monitoring Plan for the Sechelt Landfill has been prepared for the sole use by the Sunshine Coast Regional District and may not be relied upon by any other person or entity without written authorization of XCG Consulting Limited. The scope of this document may not be appropriate to satisfy the needs of other users, and any use or reuse of this document or the findings, conclusions, and recommendations represented herein, is at the sole risk of said users.

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## 8. REFERENCES

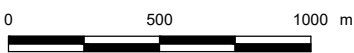
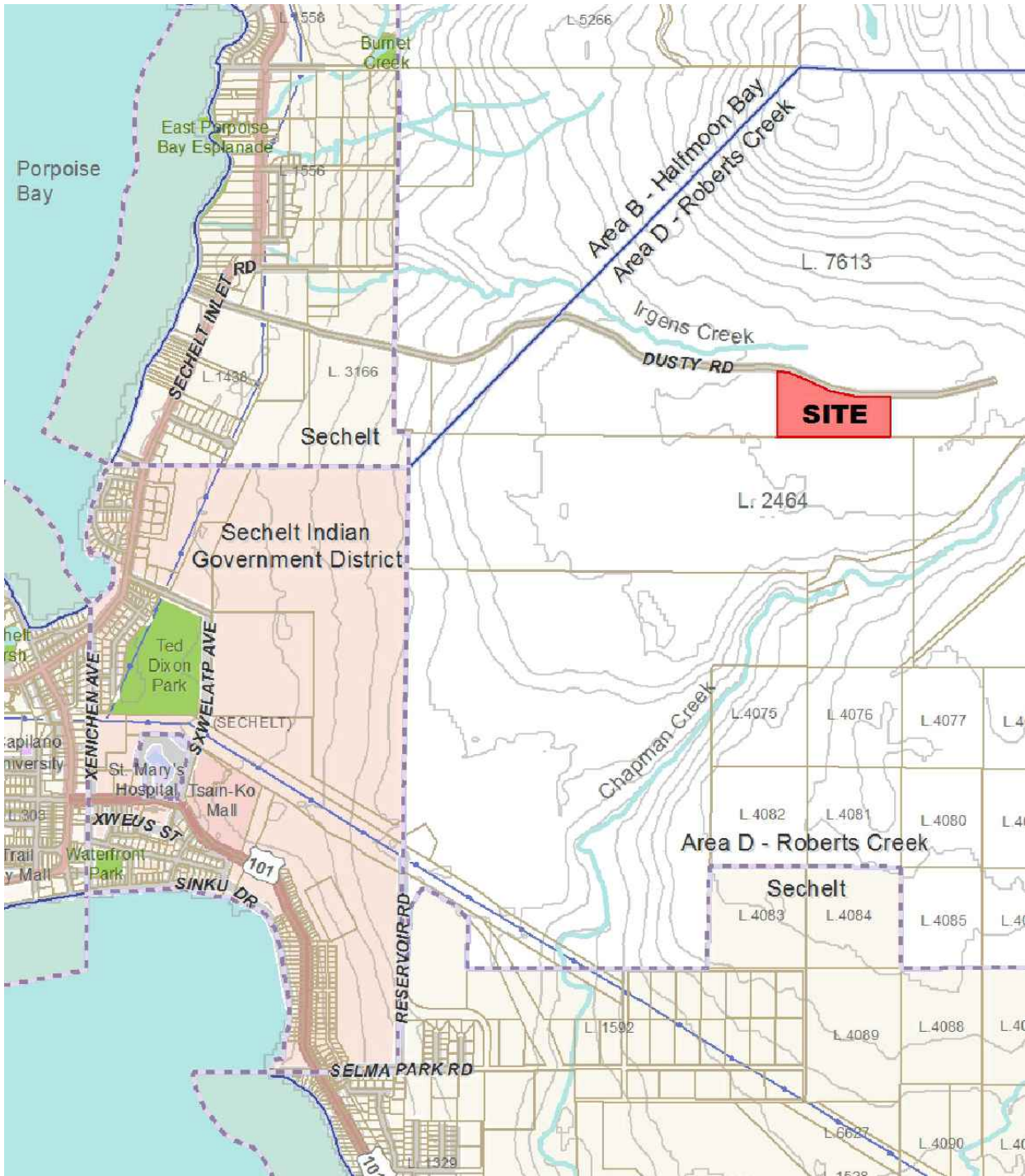
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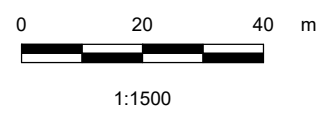
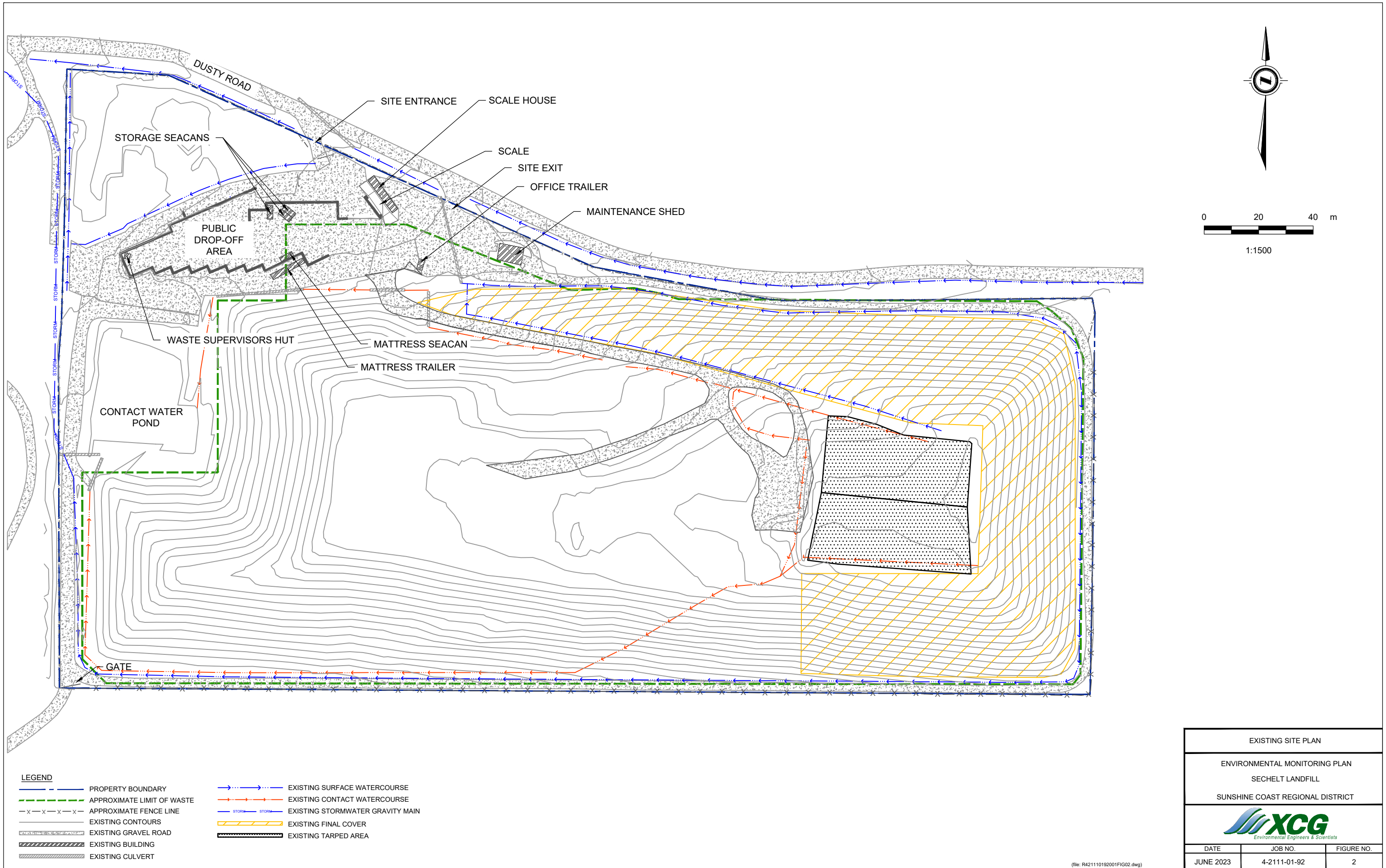


**FIGURES**



1 : 25000

SITE LOCATION MAP		
ENVIRONMENTAL MONITORING PLAN SECHELT LANDFILL SUNSHINE COAST REGIONAL DISTRICT		
		
DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	1

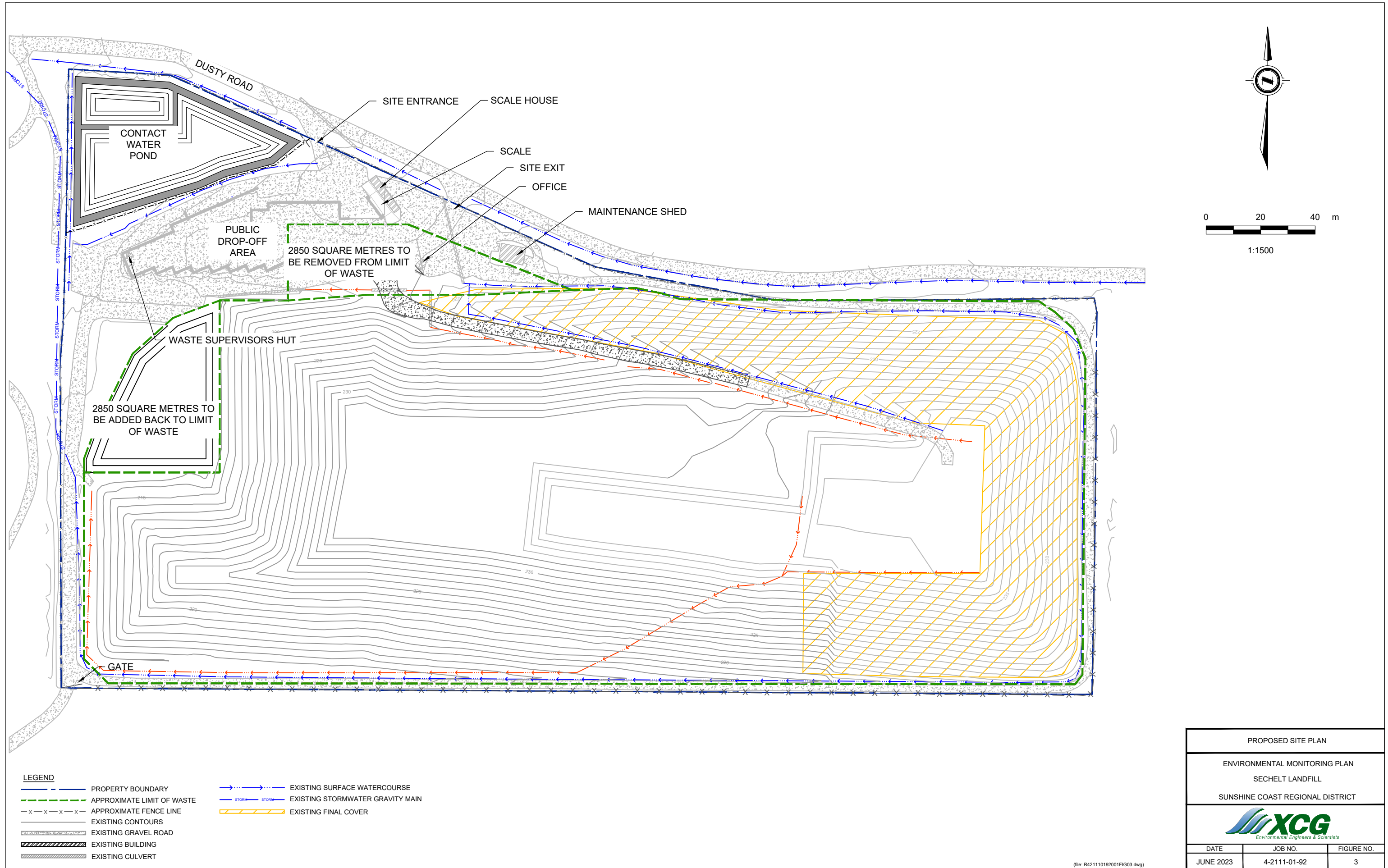


**LEGEND**

	PROPERTY BOUNDARY		EXISTING SURFACE WATERCOURSE
	APPROXIMATE LIMIT OF WASTE		EXISTING CONTACT WATERCOURSE
	APPROXIMATE FENCE LINE		EXISTING STORMWATER GRAVITY MAIN
	EXISTING CONTOURS		EXISTING FINAL COVER
	EXISTING GRAVEL ROAD		EXISTING TARPED AREA
	EXISTING BUILDING		
	EXISTING CULVERT		

EXISTING SITE PLAN		
ENVIRONMENTAL MONITORING PLAN		
SECHULT LANDFILL		
SUNSHINE COAST REGIONAL DISTRICT		
DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	2

(file: R421110192001FIG02.dwg)

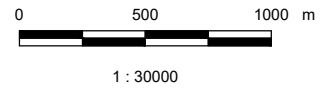
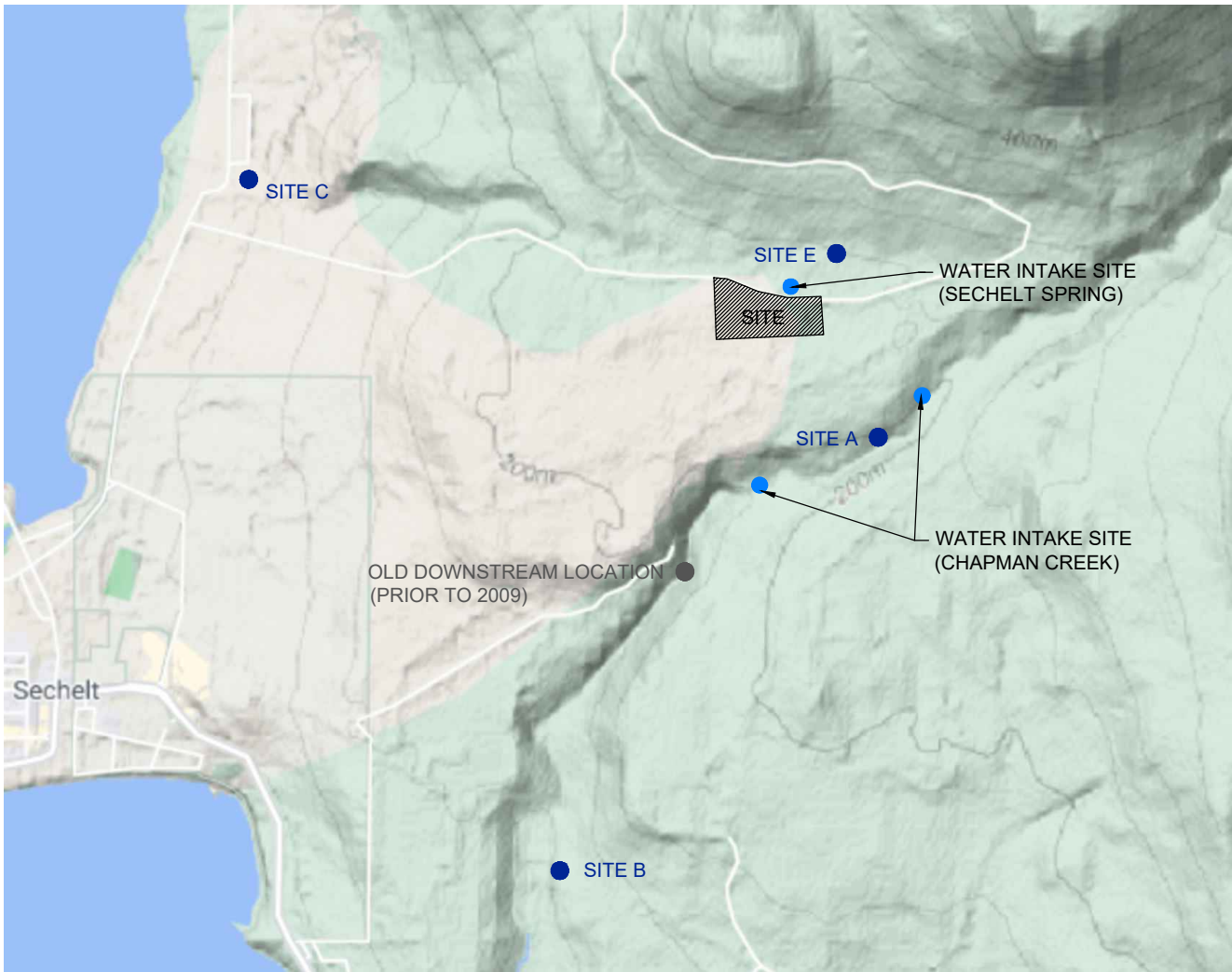


**LEGEND**

PROPERTY BOUNDARY	EXISTING SURFACE WATERCOURSE
APPROXIMATE LIMIT OF WASTE	EXISTING STORMWATER GRAVITY MAIN
APPROXIMATE FENCE LINE	EXISTING FINAL COVER
EXISTING CONTOURS	
EXISTING GRAVEL ROAD	
EXISTING BUILDING	
EXISTING CULVERT	


PROPOSED SITE PLAN		
ENVIRONMENTAL MONITORING PLAN		
SECHULT LANDFILL		
SUNSHINE COAST REGIONAL DISTRICT		
DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	3

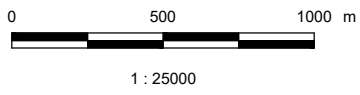
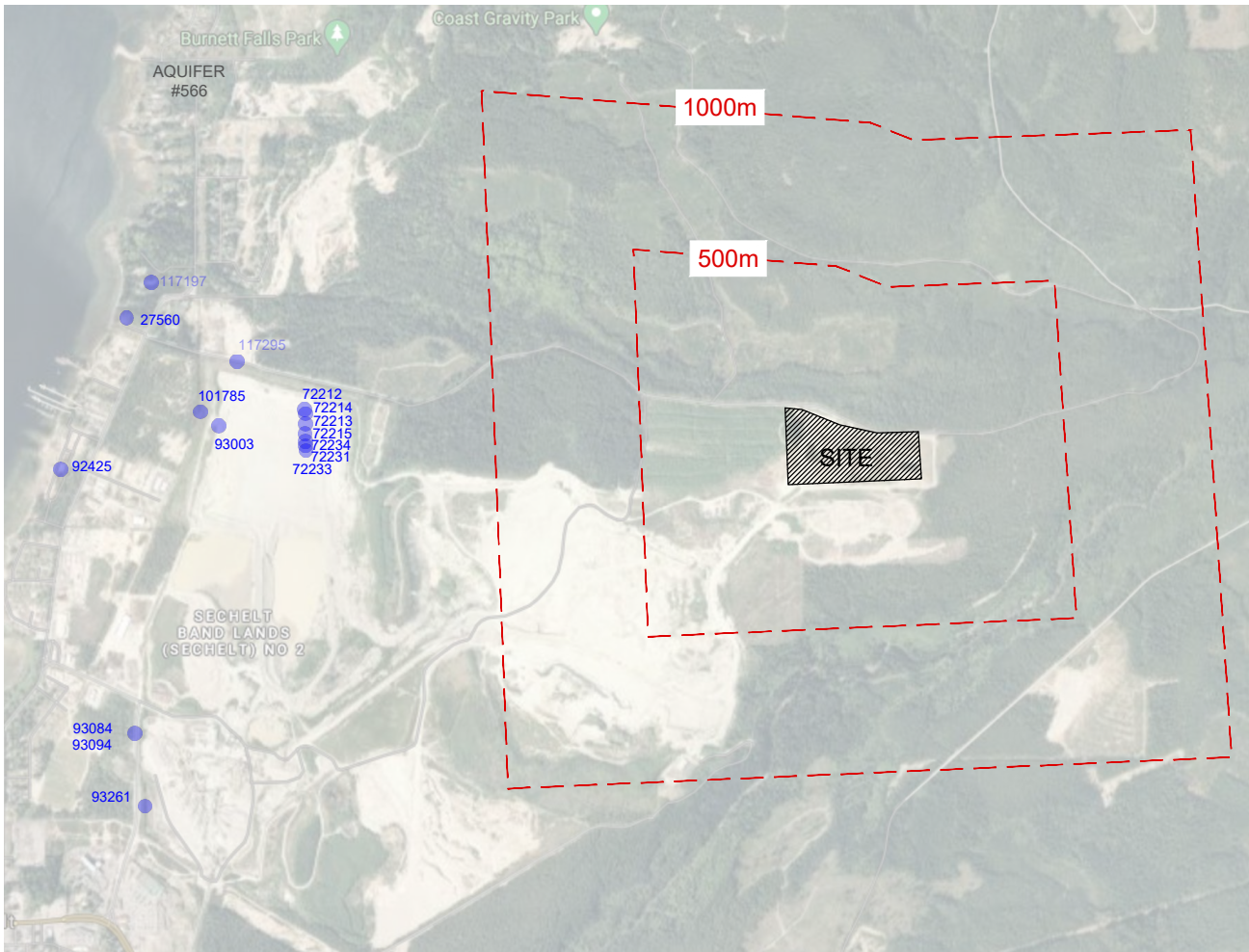
(file: R421110192001FIG03.dwg)



**LEGEND**


- SITE A SURFACE WATER SAMPLING LOCATION
- HISTORIC SURFACE WATER SAMPLING LOCATION
- WATERSHED BOUNDARIES

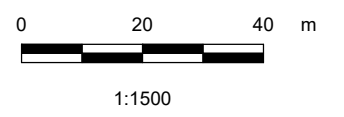
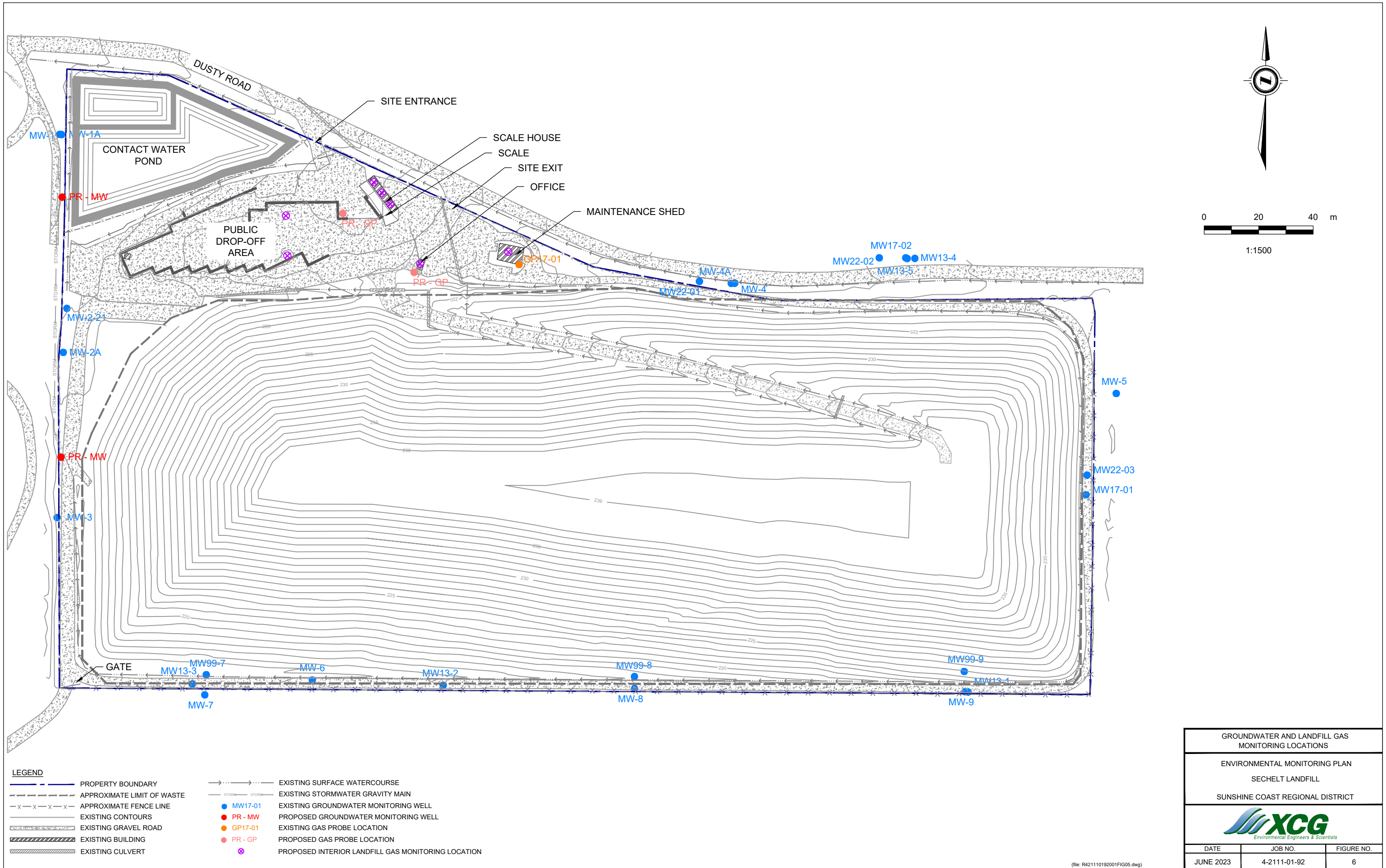
SURFACE WATER MONITORING LOCATIONS		
ENVIRONMENTAL MONITORING PLAN SECHELT LANDFILL SUNSHINE COAST REGIONAL DISTRICT		
		
DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	4



**LEGEND**

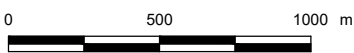
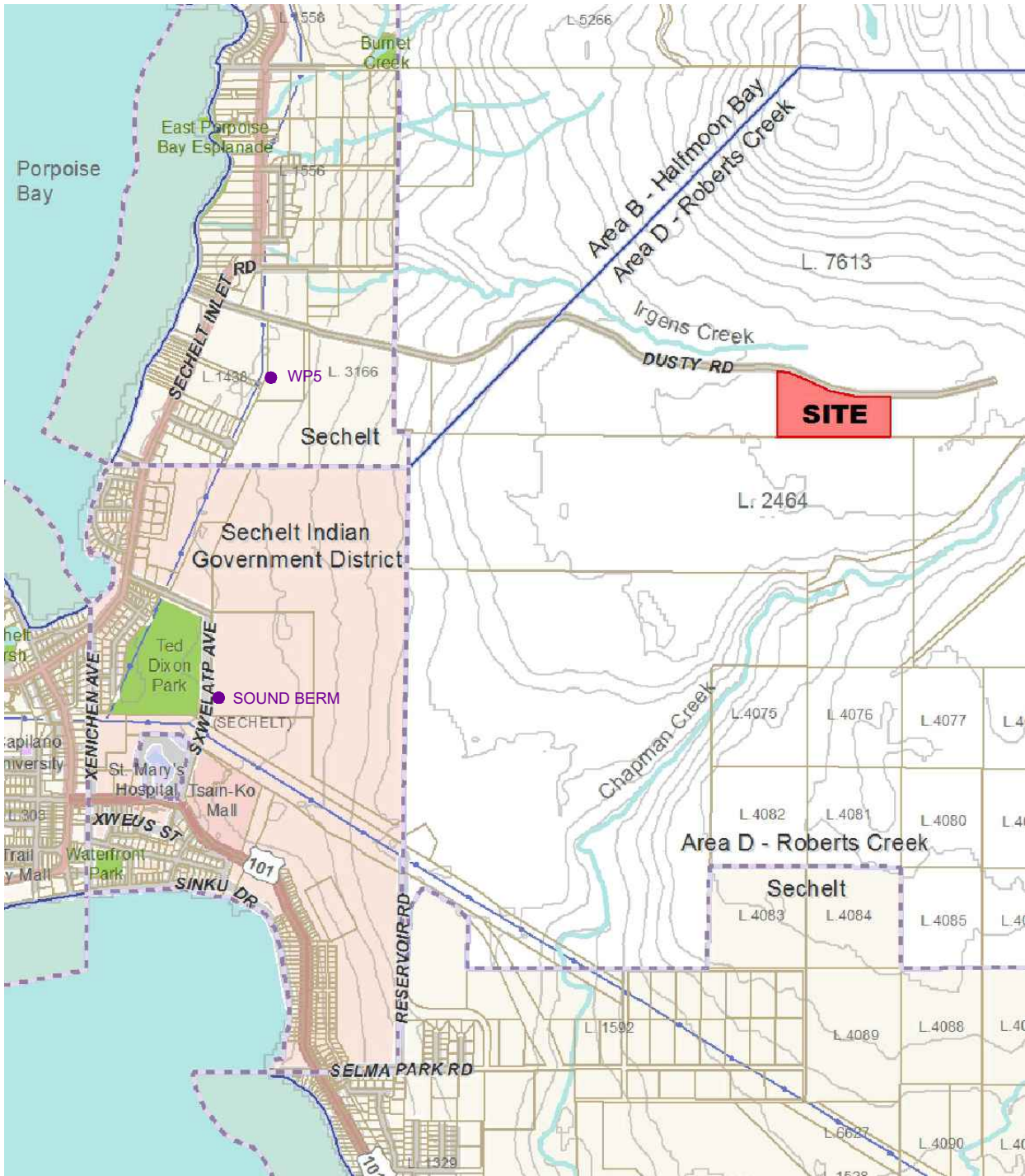
- - - - - DISTANCE FROM SITE
- AQUIFER BOUNDARY
- 74684 WATER WELLS

SITE AND SURROUNDING AREA		
ENVIRONMENTAL MONITORING PLAN SECHELT LANDFILL SUNSHINE COAST REGIONAL DISTRICT		
 XCG CONSULTING LTD.		
DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	5



GROUNDWATER AND LANDFILL GAS MONITORING LOCATIONS		
ENVIRONMENTAL MONITORING PLAN		
SECHULT LANDFILL		
SUNSHINE COAST REGIONAL DISTRICT		
DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	6

(file: R421110192001FIG05.dwg)



1 : 25000

OFF-SITE GROUDWATER MONITORING LOCATIONS

ENVIRONMENTAL MONITORING PLAN  
 SECHELT LANDFILL  
 SUNSHINE COAST REGIONAL DISTRICT



DATE	JOB NO.	FIGURE NO.
JUNE 2023	4-2111-01-92	7



**TABLES**

**Table 1 Water Well Summary**

Well ID	Owner	Location	Well Use	Completion Date	Well Depth (mbgs)	Water Depth (mbgs)	Diameter (m)	Yield (Gallons/Minute)	Screened Interval (mbgs)	Screened Lithology
72212	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1994	101	72	2.4	400	0.6 - 97	-
72214	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1994	88	-	2.4	-	-	-
72213	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1994	87	-	2.4	-	0.9 - 50	-
72215	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1994	105	-	1.8	-	0.8 - 97	-
72234	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1996	75	28	2.4	30	0.8 - 68	-
72231	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1996	98	-	-	-	-	-
72233	Construction Aggregates Ltd.	Approximately 1.6 km west of Site	-	1996	73	-	2.4	-	0.6 - 68	-
93003	Construction Aggregates Ltd.	Approximately 1.9 km west of Site	Private Domestic	2004	-	36	-	100	-	-
101785	Construction Aggregates Ltd.	Approximately 2.0 km west of Site	Private Domestic	2001	77	-	-	50	-	-
93084	Construction Aggregates Ltd.	Approximately 2.4 km southwest of Site	Private Domestic	2003	-	30	-	-	41 - 50	-
93094	Construction Aggregates Ltd.	Approximately 2.4 km southwest of Site	Private Domestic	2003	-	30	-	400	41 - 50	-
93261	Construction Aggregates Ltd.	Approximately 2.5 km southwest of Site	Private Domestic	2002	-	30	-	10	-	-
92425	Choquer & Sons Ltd.	Approximately 2.5 km west of Site	Private Domestic	1996	30	8	-	-	20 - 23	-
27560	Harry Chin	Approximately 2.3 km northwest of Site	-	1973	12	11	1.8	10	-	-

**Notes:**  
 Well information taken from iMapBC. Entries that are N/A or Unknown in the database are represented by a "-"  
 mbgs - Metres below ground surface

**Table 2 Water Licenses for Chapman Creek**

License No.	Stream Name	Purpose	Quantity	Units	Licensee	License Status
C016599	Chapman Creek	Waterworks Local Authority	8296.61	MY	Sunshine Coast Regional District	Current
C022345	Chapman Creek	Waterworks Local Authority	33186.46	MY	Sunshine Coast Regional District	Current
C050724	Chapman Creek	Storage-Non Power	906607.80	MY	Sunshine Coast Regional District	Current
C065258	Chapman Creek	Waterworks Local Authority	2986781.13	MY	Sunshine Coast Regional District	Current
C069217	Chapman Creek	Waterworks Local Authority	497796.86	MY	Sunshine Coast Regional District	Current
C069999	Chapman Creek	Waterworks Local Authority	2986781.13	MY	Sunshine Coast Regional District	Current
C107474	Chapman Creek	Waterworks Local Authority	9955593.71	MY	Sunshine Coast Regional District	Current
C114222	Chapman Creek	Conserv. - Construct. Works	0.17	MS	Forests, Lands & Natural Resource Operat	Current
C129269	Chapman Creek	Ponds	0.28	MS	Sunshine Coast Salmonid Enhancement Soc.	Current

**Table 3 Water Licenses for Irgens Creek**

License No.	Stream Name	Purpose	Quantity	Units	Licensee	License Status
C025134	Irgens Creek	Domestic	2.27	MD	0889507 B.C. Ltd.	Current
C025433	Irgens Creek	Domestic	4.55	MD	Deacon Gregory W & Buckingham Linda H	Current
C025434	Irgens Creek	Domestic	2.27	MD	Deacon Gregory W & Buckingham Linda H	Current
C025435	Irgens Creek	Domestic	2.27	MD	Buckingham Sandra L	Current
C111440	Irgens Creek	Irrigation	2466.96	MY	Alvarez John Osborne	Current

**Table 4 Monitoring Well Completion Details**

Monitoring Well	Top of Well Casing (mAMSL)	Ground Elevation (mAMSL)	Completion Depth (mbgs)	Screened Interval (mbgs)	Screened Lithology	Depth	Location
MW-1	213.36	212.32	11.2	approx. 3.0 - 4.5	Silty sand	Shallow	Northwestern corner of landfill, near former gypsum waste disposal area
MW-1A	213.42	212.32	5.0	approx. 9.5 - 11	Silty sand	Shallow	Northwestern corner of landfill. Has not been sampled due to insufficient water
MW-2A	214.02	213.62	7.1	approx. 5.7 - 7.2	Medium sand	Shallow	Western landfill boundary
MW-3	214.47*	213.47	4.3	approx. 2.8 - 4.3	Silty sand	Shallow	Southwestern corner of landfill by the former sludge disposal pits
MW-4	219.85	219.04	11.5	approx. 9.0 - 11.5	Compact sandy silt	Shallow	Northern landfill boundary. Considered to represent background groundwater quality
MW-4A	219.79	219.04	4.0	approx. 2.5 - 4.0	Silty sand	Shallow	Northern landfill boundary. Considered to represent background groundwater quality
MW-5	223.20	222.12	14.3	approx. 11.0 - 14.0	Sandy silt	Shallow	<i>Decommissioned in 2017</i>
MW6	212.82	212.20	8.4	approx. 4.4 - 7.4	Silty sand	Shallow	<i>Not monitored</i>
MW7	211.01	211.04	18.3	16.8 - 18.3	Gravel, sandy silt	Deep	<i>Decommissioned in 1999</i>
MW8	215.77	215.85	29.9	28.3 - 29.9	Gravel, silt and sand	Deep	<i>Decommissioned in 1999</i>
MW9	220.49	220.55	26.0	24.5 - 26	Sand, sandy gravel	Deep	<i>Decommissioned in 1999</i>
MW99-7	212.33	approx. 211.5	19.5	18.0 - 19.5	Sand, sandy silt, till	Deep	<i>Decommissioned in 2013</i>
MW99-8	216.93	approx. 216.0	29.0	27.5 - 29.0	Sand and gravel	Deep	<i>Decommissioned in 2013</i>
MW99-9	approx. 220.9	approx. 220.0	25.9	24.4 - 25.9	Gravelly sand	Deep	<i>Decommissioned in 2013</i>
MW13-1	221.91	221.91	25.9	22.9 - 25.9	Gravelly Sand	Deep	West end of southern landfill boundary
MW13-2	215.23	215.23	32.3	26.2 - 32.3	Silty Sand and Gravel	Deep	Middle of southern landfill boundary
MW13-3	213.81	213.81	17.1	14.0 - 17.1	Silty Sand	Deep	East end of southern landfill boundary
MW13-4	221.67	approx. 220.667	20.1	17.1 - 20.1	Sand, Silty Sand	Deep	Northeast of landfill. Considered to represent background groundwater quality
MW13-5	221.52	approx. 220.521	10.4	7.3 - 10.4	Sandy Gravel, Sand	Shallow	<i>Decommissioned in 2017</i>
MW17-01	224.79	224.00	14.9	11.9 - 14.9	Gravel and Cobbles/Silty Sand	Shallow	Eastern landfill boundary
MW17-02	222.20	221.37	9.8	6.8 - 9.8	Sandy Gravel/Sand	Shallow	Northeast of landfill. Considered to represent background groundwater quality
MW22-01	NM	NM	37.2	34-37.2	Silty sand/sandy gravel	Deep	Northern landfill boundary. Considered to represent background groundwater quality
MW22-02	NM	NM	30.8	27.5-30.8	Silty sand/sandy gravel	Deep	Northeast of landfill. Considered to represent background groundwater quality. Has not been sampled due to insufficient water
MW22-03	NM	NM	30.8	27.5-30.8	Silty sand/sandy gravel	Deep	Eastern landfill boundary
MW2-21	NM	NM	5.77	approx. 3.3 - 5.8	Silty sand	Shallow	Northwestern corner of landfill. Installed to replace MW2.
WP5	-	-	-	-	-	-	Heidelberg Materials Aggregates monitoring well, 2.2 km west of the landfill
Sound Berm	-	-	-	-	-	-	Heidelberg Materials Aggregates monitoring well, 2.5 km west-southwest of the landfill

Notes:

- Monitoring well completion details for MW-1 to MW-6 obtained from Dayton & Knight (1993)
- Monitoring well completion details for MW7 to MW9 obtained from Piteau Associates (1996)
- Monitoring well completion details for MW99-7 to MW99-9 obtained from Piteau Associates (1999)
- Monitoring well completion details for MW13-01 to MW13-05 provided by Strait Land Surveying Inc. (2013)
- Monitoring well completion details for MW17-01 to MW17-02 provided by Strait Land Surveying Inc. (2017)

mAMSL - Metres above mean sea level  
 mbgs - Metres below ground surface

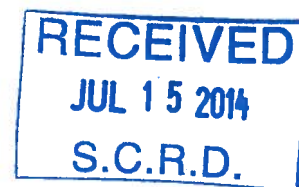
**Table 5 Soil Gas Probe Completion Details**

Soil Gas Probe	Location <sup>(1)</sup>		Top of Casing Elevation (mASL)	Ground Elevation (mASL)	Measured Depth (mbgs)	Screened Interval (mbgs)	Lithology
	Northing	Easting					
GP17-01S	5482085.863	448375.303	219.32	218.51	2.7*	1.8 - 2.7	Sandy Silt
GP17-01D	5482085.863	448375.303	219.32	218.51	4.6*	3.7 - 4.6	Sandy Gravel

**Notes:**  
 (1) Soil Gas Probe locations obtained from survey completed by Strait Land Surveying Inc. in 2013 (GP13-01, GP13-02) and 2017 (GP17-01).  
 \* Depth on completion  
 mASL - Metres above sea level



**APPENDIX A**  
**OPERATIONAL CERTIFICATE No. 106060**



July 8, 2014

Tracking Number: 243546  
Authorization Number: 106060

**REGISTERED MAIL**

SUNSHINE COAST REGIONAL DISTRICT  
1975 FIELD ROAD  
SECHELT, BC  
V0N 3A1

MASTER FILE COPY

Dear Operational Certificate Holder:

Enclosed is Operational Certificate 106060 issued under the provisions of the *Environmental Management Act*. Your attention is respectfully directed to the terms and conditions outlined in the operational certificate. An annual fee will be determined according to the Permit Fees Regulation.

Please be aware that the following documents are required for submission by the specified dates set forth in the operational certificate:

- A hydrogeologic characterization and impact assessment of the landfill by August 31, 2015;
- An updated design and operating plan by December 31, 2017;
- An geotechnical and seismic assessment by April 30, 2018
- An environmental monitoring plan by April 30, 2018
- A leachate management plan for the landfill, acceptable to the Director, by December 31, 2015; and
- An annual report for the preceding 12 month period from January 1 to December 31 must be submitted to the Regional Director, Environmental Protection, by March 31 of each year.

This operational certificate 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 rests with the operational certificate holder. It is also the responsibility of the operational certificate holder to ensure that all activities conducted under this authorization are carried out with regard to the rights of third parties, and comply with other applicable legislation that may be in force.

.../2

RECEIVED

This decision may be appealed to the Environmental Appeal Board in accordance with Part 8 of the *Environmental Management Act*. An appeal must be delivered within 30 days from the date that notice of this decision is given. For further information, please contact the Environmental Appeal Board at (250) 387-3464.

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Administration of this operational certificate will be carried out by staff from the Coast Region. Plans, data and reports pertinent to the operational certificate are to be submitted to the Regional Director, Environmental Protection, at Ministry of Environment, Regional Operations, Coast Region, 2nd Floor, 10470 - 152 Street, Surrey, BC V3R 0Y3.

Yours truly,



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
Coast Region

Enclosure

cc: Environment Canada



MINISTRY OF  
ENVIRONMENT

OPERATIONAL CERTIFICATE

106060

*Under the Provisions of the Environmental Management Act and  
in accordance with the Sunshine Coast Regional District's  
Solid Waste Management Plan*

**SUNSHINE COAST REGIONAL DISTRICT  
1975 FIELD ROAD  
SECHELT, BC  
V0N 3A1**

is authorized to manage municipal solid waste / recyclable material and discharge residual solid waste to the ground at the Sechelt Landfill located at 4901 Dusty Road, Sechelt, British Columbia, subject to the conditions listed herein. Contravention of any of these conditions is a violation of the *Environmental Management Act* and may result in prosecution.

This Operational Certificate supersedes and cancels all previous versions of the permit PR-02547 issued under the authority of the *Environmental Management Act*.

1. **AUTHORIZED DISCHARGES**

- 1.1 This section applies to the discharge of municipal solid waste and contaminated soil to the Sechelt Landfill. The discharge of municipal solid waste must be restricted to sources within the Sunshine Coast Regional District. The site reference number for this discharge is E208123.

Date issued: July 8, 2014

Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

1.1.1 The discharge is authorized by the Sunshine Coast Regional District's approved solid waste management plan. The maximum rate of discharge is 15,000 metric tonnes per year.

1.1.2 The characteristics of the discharge must be municipal solid waste as defined in the *Environmental Management Act* and include other material as specifically authorized by the Director. Waste asbestos may be discharged in accordance to Section 40 of the Hazardous Waste Regulation and in accordance with the Sunshine Coast Regional District's bylaws.

Materials prohibited from discharge include hazardous waste (excluding asbestos), liquids, semi-solid waste, biomedical waste and the following:

- Recyclable Materials including:
  - a. used white goods,
  - b. auto hulks and other large metallic waste,
  - c. used tires,
  - d. used lead acid batteries,
  - e. gypsum wallboard, and
  - f. corrugated cardboard.
  
- any other waste and/or recyclable material regulated under the Ministry's Recycling Regulation when alternate disposal options become available;
  
- other materials banned by the regional district in implementing the Sunshine Coast Regional District's solid waste management plan or bylaws; and
  
- other materials which may be designated by the Director when alternative disposal becomes available.

1.1.3 Waste must not be discharged into water or within a buffer zone as identified in Section 2.9, 2.10 and 2.11. The burning of waste is prohibited.

1.1.4 The authorized works common to this section and Section 1.2 and 1.3 are a sanitary landfill, locking gate to control access by the public, weigh scale and related appurtenances, approximately located as shown on Site Plan A.

Date issued: July 8, 2014



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

- 1.1.5 The authorized works specific to this section are those associated with a landfill operation and include berms, covering material, electrified bear fence, surface water diversionary works and environmental monitoring systems, approximately located as shown on attached Site Plan A and Site Plan B.
- 
- 1.1.6 The authorized works must be complete and in operation while discharging.
- 1.1.7 The legal description of the location of the area of discharge is:
- Block C, District Lot 7613, Group 1, New Westminster District.
- 1.1.8 The civic address of the Sechelt Landfill is 4901 Dusty Road, Sechelt, BC.
- 1.2 This section applies to a public drop off and recycling area for the management of municipal solid waste and recyclable material from sources within the Sunshine Coast Regional District.
- 1.2.1 The types of materials which may be managed in this area include waste as set out in Section 1.1.2, and typical recyclable materials.
- 1.2.2 The quantity of recyclable material that may be stored is limited to the capacity that can be reasonably handled on the site.
- 1.2.3 The authorized works are those associated with a public drop of and recycling area and include an access area, roll-off bins and related appurtenances approximately located as shown on Site Plan A.
- 1.2.4 The facility is located on a portion of Block C, District Lot 7613, Group 1, New Westminster District.
- 1.3 This section applies to a return collection facility for the management of household hazardous waste from sources within the Sunshine Coast Regional District.
- 1.3.1 The operational certificate holder must obtain the necessary approvals prior to commencement of operation of the return collection facility and ensure compliance with all applicable legislation. The operational certificate holder must notify the Director at least 30 days prior to commencement of operations.

Date issued: July 8, 2014



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

- 1.3.2 The types of material which may be managed at this facility are typical household hazardous wastes.
- 1.3.3 The quantity of household hazardous waste that may be stored must be in accordance with the Hazardous Waste Regulation and is limited to the registration quantity as a return collection facility.
- 1.3.4 The authorized works are those associated with a return collection facility and include an access area, a secured storage area for household hazardous waste and related appurtenances approximately located as shown on Site Plan A.
- 1.3.5 The facility location is proposed to be on a portion of Block C, District Lot 7613, Group 1, New Westminster District.
- 1.3.6 The operational certificate holder must submit an updated Site Plan A at least 30 days prior to commencement of operations.

## 2. **DESIGN AND PERFORMANCE REQUIREMENTS**

### 2.1 **Design and Operating Plan**

The operational certificate holder must operate the facilities authorized in Section 1 in accordance with a design and operating plan certified by a qualified professional. The operational certificate holder must submit an updated design and operating plan of the existing landfill authorized in Section 1, acceptable to the Director. The plan must address each of the subsections in the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version) including performance, siting, design, operational, closure and post-closure criteria and the Guideline for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996 or the most recent version).

The plan must include, but is not limited to, information regarding:

- A fill strategy for the design capacity of the landfill. The plan must incorporate the concept of progressive closure and take into consideration environmental protection measures and the proposed end use of the site.

Date issued: July 8, 2014



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

- A contingency plan (including funding) to close the landfill is to be developed prior to the design capacity being achieved should the landfill not be supported by future Sunshine Coast Regional District solid waste management plans or is closed for any other reason;
- Estimated elevations;
- Cell size, compaction details, daily, intermediate and final cover including types of materials used;
- Actions taken to ensure slope stability;
- Anticipated schedule for progressive closure activities;
- Measures to minimize leachate generation, including surface water diversion measures;
- A groundwater monitoring program in accordance with the requirements of Section 2.5;
- Recommended action plan to be undertaken as a result of the existing and subsequent leachate management assessment required in Section 3.13;
- A landfill gas management plan if required by Section 2.4 and updated in accordance with anticipated legislation changes;
- Recommended actions as a result of the existing and subsequent geotechnical, hydrogeological, landfill gas and any other assessments;
- Contingencies to address environmental protection issues, including leachate, landfill gas management and slope stability, in the event of an earthquake or any other emergency;
- Fire prevention measures;
- Operational requirements for the return collection facility for household hazardous waste, if applicable;
- List of recyclable materials accepted and how they are managed at the site;
- Incoming waste inspection, removal of unauthorized waste and staff supervision on the active face;
- Estimated closure/post closure-costs and details of how the closure/post-closure funds will be accrued;
- Measures to minimize hazards to public safety; and
- Measures to control vectors, odours, dust, wind-blown litter and scavenging.

The facilities must be developed, operated and closed in accordance with the design and operating plan. Should there be any inconsistency between this Operational Certificate and the design and operating plan, this Operational Certificate must take precedence unless otherwise agreed in writing by the Director.

Date issued: July 8, 2014



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

The Interim Design and Operating Plan was submitted in December 2012. The operational certificate holder must review the design and operating plan on an annual basis to determine if changes are required. Any revisions to the design and operating plan must be certified by a qualified professional and acceptable to the Director as part of the annual report required in Section 4.6.

The operational certificate holder must also submit an updated design and operating plan every five (5) years which includes, at a minimum, any revisions submitted as part of the previous five years of annual reporting. The next design and operating plan is required by December 31, 2017

## 2.2 Geotechnical and Seismic Assessment

The operational certificate holder must submit a geotechnical and seismic assessment for the landfill, acceptable to the Director, which meets the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version). The assessment must address, at a minimum, slope stability during construction, operation, and post-closure is required. The geotechnical and seismic assessment must be reviewed and updated every five (5) years hereafter. The next assessment is required by **April 30, 2018**. Actions recommended in the assessment and subsequent reviews must be incorporated into the design and operating plan as required in Section 2.1. A qualified professional must conduct the assessment and subsequent reviews.

## 2.3 Hydrogeological Assessment

The operational certificate holder must review the hydrogeology of the landfill authorized in Section 1.1 annually and submit the results with the annual report required in Section 4.6. Actions recommended in the annual reviews must be incorporated into the design and operating plan as required in Section 2.1 and form the basis of a recommended groundwater monitoring program as required in Section 2.5. A qualified professional must conduct the annual reviews.

The operational certificate holder must submit an updated hydrogeologic characterization and impact assessment of the landfill authorized in Section 1.1 acceptable to the Director, by **August 31, 2015**. The assessment must meet the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version) and be reviewed and updated every five (5) years hereafter. A qualified professional must conduct the assessment and subsequent reviews.

Date issued: July 8, 2014



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

## 2.4 Landfill Gas Assessment

The operational certificate holder must submit to the Director supplemental landfill gas assessments and generation reports every five years as required under the Landfill Gas Management Regulation. Annual monitoring and reporting of landfill gas must be done in accordance with the Landfill Gas Management Regulation and the criteria set out in the Environmental Monitoring Program (EMP) in Section 2.5.

The landfill gas assessment must address, but is not limited to, each relevant subsection in the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version) and the Guideline for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996 or the most recent version). Should the assessment indicate that the nonmethane organic compounds (NMOCs) will exceed 150 tonnes/year, then the operational certificate holder must submit a landfill gas management plan, acceptable to the Director.

At any time, based on the assessment or any other information, the Director may require the installation and operation of gas recovery and pollution prevention works, including landfill gas monitoring wells. It should be noted that the Ministry of Environment has developed the Landfill Gas Management Regulation under the Greenhouse Gas Reduction (Emissions Standards) Statutes Amendment Act, 2008. The requirements of the Regulation and its guideline documents must be incorporated by the operational certificate holder into the landfill gas management plan and design and operating plan as they come into effect.

## 2.5 Environmental Monitoring Plan

The Operational Certificate holder must submit an Environmental Monitoring Plan acceptable to the Director by April 30, 2018. The plan must be prepared by a qualified professional and meet the requirements set forth in the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version) and the Guideline for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996 or the most recent version).

Date issued: July 8, 2014



Avtar S. Sundher BSc.  
for Director, *Environmental Management Act*  
South Coast Region

The operational certificate holder must review the environmental monitoring plan on an annual basis to determine if changes are required. Any revisions to the plan must be prepared and certified by a qualified professional acceptable to the Director. The operational certificate holder must also submit an updated environmental monitoring plan every five (5) years, which includes, at a minimum, any revisions submitted as part of the previous five years of annual reporting required in Section 4.6.

## 2.6 **Qualified Professionals**

All facilities and information, including works, plans, assessments, investigations, surveys, programs and reports, must be certified by qualified professionals. Refer to Section 3.1 of the operational certificate for the definition of a qualified professional.

## 2.7 **Additional Facilities or Works**

The Director may require investigations, surveys, and the construction of additional facilities or works including, but not limited to, leachate and bear-proofing measures. The Director may also amend the requirements of any of the information required by this operational certificate including plans, programs, assessments and reports.

## 2.8 **Public Health, Safety and Nuisance**

The landfill must be operated in a manner such that it will not create a public nuisance or become a significant threat to public health or safety with respect to landfill gas, unauthorized access, roads, traffic, airport activity, noise, dust, litter, vectors, or wildlife attraction.

## 2.9 **Surface Water Diversion**

Discharge of municipal solid waste into water is prohibited. The Operational Certificate holder must construct adequate surface water and groundwater diversion works to minimize surface water run-off and groundwater seepage from entering the landfill.

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for Director, *Environmental Management Act*  
South Coast Region

## 2.10 Ground and Surface Water Quality Impairment

The landfill must be operated in a manner such that ground or surface water quality does not decrease beyond that specified by the British Columbia Water Quality Guidelines, or other appropriate criteria as may be specified by the Director, at or beyond the landfill property boundary.

If exceedances to the specified water quality criteria occur as a result of landfill operations, the Director may require that control measures or works be undertaken in addition to those outlined in Section 3.13.

## 2.11 Buffer Zones

The operational certificate holder must maintain the existing buffer zone relative to the property boundary of: 2 to 4.5 metres to the south, 10 to 98 metres to the west, 4.42 metres to the north and 4 to 18 metres to the east as shown in Site Plan A and Site Plan B.

The buffer zone must include an adequate firebreak. The firebreak must be maintained free of combustibles.

## 2.12 Survey of the Landfill

The Operational Certificate holder must conduct a legal survey which identifies the metes and bounds for both the limits of the landfill footprint and the boundaries of the landfill site. Copies of the land surveys are to be kept on file for review if requested by the Director. The corners and breakpoints of landfill footprint limits and landfill site boundaries are to be established and maintained in the field.

The operational certificate holder must also conduct an annual survey of the height, contour, surface area and settlement of the landfill and submit as part of the annual report required in Section 4.6.

# 3. OPERATIONAL REQUIREMENTS

## 3.1 Definitions

“**director**” means the Director or a person delegated to act on behalf of the Director, as defined in the *Environmental Management Act*;

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“**commercial quality soil**” means soil which does not contain any substance with a concentration exceeding the lowest applicable numerical soil standard for commercial land as set forth in the Contaminated Sites Regulation.

“**hazardous wastes**” as defined by the Hazardous Waste Regulation pursuant to the *Environmental Management Act* are prohibited from disposal unless expressly authorised by the Hazardous Waste Regulation, approved by the Director or as specified in the Operational Certificate;

“**regional director**” means Regional Director, Environmental Protection;

“**qualified professional**” means an applied scientist or technologist specializing in a particular applied science including, but not necessarily limited to, agrology, biology, chemistry, engineering, geology, or hydrogeology and

- who is registered in British Columbia with their appropriate professional organization, acting under that association’s Code of Ethics and subject to disciplinary action by that association, and
- who, through suitable education, experience, accreditation and knowledge, may be reasonably relied on to provide advice within their area of expertise;

“**return collection facility**” means a household hazardous waste collection facility or a mobile household hazardous waste collection facility;

“**suitable cover**” means soils utilized in accordance with Section 3.5 of this operational certificate or other material acceptable to the Director:

“**commercial quality soil**” means soil which does not contain any substance with a concentration exceeding the lowest applicable numerical soil standard for commercial land (CL) use as set forth in the Contaminated Sites Regulation.

### 3.2 Bypasses

The discharge of effluent which has bypassed site control works as listed in Section 1.1.5 is prohibited unless the prior approval of the Director is obtained and confirmed in writing. In the event of an emergency, Section 3.3 must be followed.

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### 3.3 Emergency Procedures

The authorized works must be inspected regularly and maintained in good working order. In the event of an emergency or condition beyond the control of the operational certificate holder including, but not limited to, unauthorized fires arising from spontaneous combustion or other causes, or detection of leachate on the property, the operational certificate holder must take appropriate remedial action and notify the Director immediately. The Director may reduce or suspend operations to protect the environment until the authorized works has been restored, and/or corrective steps taken to prevent unauthorized discharges.

### 3.4 Inspections

The operational certificate holder must inspect the authorized works regularly and maintain them in good working order. The Director must be immediately notified of any malfunction of these works.

The operational certificate holder must inspect the property boundaries regularly and notify the Director of any visual evidence of environmental impacts on adjacent properties.

### 3.5 Soil Management

Soil meeting the commercial land use standard, as set forth in the Contaminated Sites Regulation, may be utilized for berm construction, daily, intermediate and final cover, top dressing and landscaping. Soil with any substance with a concentration exceeding the lowest applicable numerical soil standard for commercial land may only be used for internal berms or daily or intermediate cover. The utilization or discharge exceeding the industrial quality soil and hazardous waste soil is prohibited.

Soils utilized for berm construction, intermediate and final cover, top dressing and landscaping must not be included in determining the rate of discharge specified in Section 1.1.1.

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### 3.6 Waste Compaction and Covering

All waste must be placed in cells of a size determined by a qualified professional, and in accordance with the design and operating plan and must address each of the subsections in the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version). The working face must be confined to the smallest practical area. The waste must be compacted and covered as per the design and operating plan.

Daily cover consisting of a minimum of 0.15 metres of suitable cover material or a functionally alternate cover material, as authorized by the Director, must be applied to the working face at the end of each operating day. If alternate cover is utilized, then the working face must be covered with a minimum of 0.15 meters of suitable cover at least once every week or as approved by the Director. Intermediate cover, consisting of a minimum 0.30 metre of suitable cover material must be applied within thirty (30) days to any area of the landfill which will not receive any further waste for thirty (30) days. The Director may vary the frequency of covering when freezing conditions adversely affect normal operation.

### 3.7 Completed Areas of the Landfill

The operational certificate holder must apply final cover to any area of the landfill which will not receive any further waste. Final cover must be applied in accordance with the design and operating plan required in Section 2.1 and, at a minimum, must consist of a minimum of 1.0 metre of low permeability ( $<1 \times 10^{-5}$  cm/s) compacted soil (or equivalent) cap plus a minimum of 0.15 metre of topsoil and suitable vegetative cover, or as approved the Director.

With the written approval of the Director, the topsoil used for the final covering may be mixed with conditioning agents such as sludge (biosolids), compost and the like to add organics and improve the moisture holding capacity and nutrient value of the soil. Soil must be utilized in accordance with Section 3.5. Final cover must be constructed and maintained with adequate drainage and erosion controls and seeded with suitable grasses. Surface water runoff must be directed away from the landfill footprint. Soils must be in accordance with the Organic Matter Recycling Regulation (OMRR) and the Contaminated Sites Regulation (CSR).

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### 3.8 **Wildlife and Vector Management**

Vectors (carriers capable of transmitting a pathogen from one organism to another including, but not limited to flies and other insects, rodents, and birds) must be controlled by the application of cover material at the required frequency per Section 3.6 or by such additional methods as specified by the design and operating plan and the Director. This landfill must be operated so as to minimize the attraction of wildlife such as bears and birds by applying cover at required frequencies and instituting a good housekeeping program.

Additional works may be required or other operating instructions may be issued by the Director should a wildlife nuisance or hazard arise.

### 3.9 **Litter Control**

Litter must be controlled by compacting the waste, minimizing the work face area, applying cover at the required frequencies, providing litter control fences and instituting a regular litter pickup and general good housekeeping program or as specified by the Director.

### 3.10 **Electric Fencing**

The operational certificate holder must maintain an electrified bear fence, at a minimum, around the landfill footprint, or implement alternative bear-proofing measures, acceptable to the Director, that will deter bears from entering that part of the site. The electric fence must be energized at all times, unless otherwise approved prior by the Director in writing. The fence must be maintained to the standards set out by the manufacturer until implementation of the landfill closure plan required in Section 5.2. Any penetrations through the electric fencing by bears must be immediately reported to the Ministry's Conservation Officer Service.

### 3.11 **Fire Prevention and Control**

The operational certificate holder must take all reasonable measures necessary to prevent fires from occurring at the site and is responsible for complying with all local fire safety requirements. The operational certificate holder must provide adequate fire breaks that are free of combustibles around the perimeter of the landfill footprint.

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The operational certificate holder must maintain firefighting equipment and materials as required. In the event of a landfill fire, immediately notify the local fire department, the Provincial Emergency Program and the Director.

### 3.12 Posting of Signs

The operational certificate holder must post signage, to the satisfaction of the Director, at the entrance of the landfill site with the following current information including:

- Site name;
- Owner and operator;
- Contact telephone number and address for the owner and operator;
- 24 hour telephone number in case of emergency;
- Hours of operation;
- Materials and wastes accepted for recycling and land filling;
- Prohibited materials and wastes; and
- Tipping fees.

### 3.13 Leachate Management

The operational certificate holder must, to the satisfaction of the Director, take measures to minimize leachate generation, including but not limited to, providing effective covering and surface water runoff. Actions taken and their effectiveness must be detailed in the annual report as required in Section 4.6.

The operational certificate holder must submit a leachate management plan for the landfill authorized in Section 1.1, acceptable to the Director, by **August 31, 2015**. The plan must meet the Landfill Criteria for Municipal Solid Waste (June 1993, or the most recent version) and the Guideline for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996 or the most recent version) and must be reviewed and updated every five (5) years hereafter. The leachate management plan, prepared by a qualified professional, must review the adequacy of the existing works to protect the receiving environment and identify any necessary upgrades and include a schedule for their implementation. Once implemented, the upgraded works must form part of the authorized works identified in Section 1.1.5.

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### 3.14 Landfill Gas Management

The Landfill must not cause combustible gas concentrations to exceed the lower explosive limit in soils at the property boundary or 25% of the lower explosive limit at or in on-site or off-site structures.

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### 3.15 Management of Recyclable Materials

The operational certificate holder must take all practical measures to segregate for recycling and reuse of waste destined for disposal at this site.

Recyclable materials must be managed in a manner to not cause pollution and in accordance with the *Environmental Management Act* and its regulations.

### 3.16 Management of Household Hazardous Waste

The amount of household hazardous waste accumulated at the facility authorized in Section 1.4 must be stored in accordance with the Hazardous Waste Regulation and is limited to the registration quantity as a return collection facility.

## 4. MONITORING AND REPORTING REQUIREMENTS

### 4.1 Monitoring

The Operational Certificate holder must implement an environmental monitoring program as required in Section 2.5. The Operational Certificate holder must maintain records of all monitoring program data and analyses available for inspection. Based on the information submitted in the annual report, or any other information relevant to the site, the Director may vary the frequency, location and analyses of environmental monitoring as warranted.

#### 4.1.1 Slope Stability Monitoring

The operational certificate holder must regularly monitor for evidence of slope instability as part of regular operations for evidence of tension cracking, veneer instability or failure.

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#### 4.2 **Sampling Procedures**

Sampling is to be carried out in accordance with the procedures described in the "British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 2003 Edition (Permittee)", or most recent edition, or by suitable alternative procedures as authorized by the Director.

A copy of the above manual is available on the Ministry web page at [http://www.env.gov.bc.ca/wsd/data\\_searches/field\\_sampling\\_manual/field\\_man\\_03.html](http://www.env.gov.bc.ca/wsd/data_searches/field_sampling_manual/field_man_03.html)

#### 4.3 **Analytical Procedures**

Analyses are to be carried out in accordance with procedures described in the "British Columbia Laboratory Manual (2009 Permittee Edition)", or the most recent edition, or by suitable alternative procedures as authorized by the Director.

A copy of the above manual is available on the Ministry web page at [www.env.gov.bc.ca/epe/wamr/labsys/lab\\_meth\\_manual.html](http://www.env.gov.bc.ca/epe/wamr/labsys/lab_meth_manual.html).

#### 4.4 **Waste and Recyclable Materials Recording**

The operational certificate holder must record the quantity, in tonnes, of waste, recycling, and return collection received at the landfill. Also, the quantity of recyclable materials and household hazardous waste removed from these facilities must be recorded.

#### 4.5 **Records Management**

The operational certificate holder must maintain the following information and records, current and suitably tabulated, at the landfill office or Regional District office for inspection:

- A copy of Operational Certificate 106060;
- Training procedures and personnel training records;
- Contingency plans and notification procedures;
- The current design and operating plan;
- Inspection records from staff and regulatory agencies;
- Most recent hydrogeological, geotechnical and landfill gas assessments;

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- Incoming waste and soil records;
- Records of recyclable material and household hazardous wastes shipped offsite including the name of company and location the recyclable material and household hazardous waste is sent;
- Environmental monitoring results and interpretations;
- Records of commercial quality soil used as cover material identified in Section 3.5 along with records of soil shipped offsite; and
- Annual operating and monitoring reports for the previous 5 years.

#### 4.6 **Reporting**

The operational certificate holder must prepare an annual report which must include, but is not limited to, the following:

- A review and interpretation of the analytical data from receiving environment monitoring for the calendar year;
- Summaries of waste and recyclable material records, with the amount of waste landfilled reported as a volume and tonnage;
- Summary of recyclable material and household hazardous wastes shipped offsite including the name of company and location the recyclable material and household hazardous waste is sent;
- Summary of amount of commercial quality soil brought onsite;
- Updated estimates for the remaining capacity, closure date for the current phase and closure date for the current landfill footprint;
- Results of the annual survey required under Section 2.12;
- An evaluation of leachate generation control measures;
- Results of the landfill gas monitoring;
- Revised closure/post closure costs, confirmation of sufficient funds available, and a statement of the current dollar value of the Closure Fund and the amount earmarked for the Sechelt Landfill site;
- Revised design and operating plan and planned improvements if applicable for minor revisions;
- Revised environmental monitoring program;
- Identification of operating problems and corrective actions taken;
- An evaluation of the recycling programs including waste diversion;
- Summary of public complaint/resolutions for the landfill;
- In the event of any non-compliance with the conditions of this operational certificate, an action plan and schedule to achieve compliance; and

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- The results of all monitoring programs as specified in this Operational Certificate. Data interpretation and comparison to the performance criteria in the Landfill Criteria for Municipal Solid Waste, the Guidelines for Environmental Monitoring and Municipal Solid Waste Landfills. Trend analyses, as well as an evaluation of the impacts of the discharges on the receiving environment in the previous year must be carried out by a qualified professional.
- Monitoring data must be entered into EMS – Environmental Monitoring System electronically and submitted in electronic and printed format satisfactory to the Regional Director.

The annual report for the preceding 12 month period from January 1 to December 31 must be submitted to the Regional Director, Environmental Protection, by **March 31** of each year.

## 5. CLOSURE AND POST-CLOSURE REQUIREMENTS

### 5.1 Closure Plan / Funding

The operational certificate holder must accrue, during the life of the landfill, a dedicated reserve fund in a form acceptable to the Director, sufficient to finance closure and environmental contingencies related to the landfill. The estimated cost of carrying out closure and how the fund will be accrued must be included in the design and operating plan required in Section 2.1. The estimated costs of closure and post-closure activities must be updated annually and submitted to the Director as part of the annual report required in Section 4.6. Should the estimated costs of closure and post-closure increase then the operational certificate holder must increase the rate of accrual as

### 5.2 Progressive Closure

The operational certificate holder must submit a closure plan as part of a Design and Operating Plan for the facilities authorized in Section 1 by **December 31, 2015** acceptable to the Director. The plan must be reviewed and updated every 5 years as part of the Design and Operating Plan or until the site is decommissioned and a closure-plan under Section 5.3 is approved. The plan must be prepared by an independent qualified professional and include information regarding:

- Phasing plan showing areas to be progressively closed.
- Estimated total waste volumes and tonnage and the closure date;

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- A topographical plan showing the final elevation contours of the landfill and surface water diversion and drainage controls;
- Design of the final cover including the thickness and permeability of barrier layers and drainage layers and information on topsoil, vegetative cover and erosion prevention controls;
- Rodent and nuisance wildlife control procedures;
- Proposed end use of the property after closure;
- A post-closure monitoring program for groundwater, surface water, landfill gas, erosion and settlement for a minimum period of 25 years;
- Post-closure operation of pollution abatement engineering works such as leachate and landfill gas collection/treatment systems for a minimum period of 25 years; and
- Contingencies to address environmental impact concerns which may arise during the minimum post-closure period of 25 years.

### 5.3 **Post-Closure Operation and Maintenance**

A post-closure plan must be submitted not less than 2 years prior to decommissioning of the landfill. The closure plan must be reviewed every 5 years following closure and updated to encompass the next 10 years of post-closure activities. The post-closure plan and subsequent updates must be prepared by an independent qualified professional licensed to practice in the province of British Columbia and knowledgeable in such matters. The post-closure plan and subsequent updates must be submitted to the Director for approval and must include at least the following:

- a complete review and assessment report of the overall integrity of the landfill,
- Procedures for notifying the public about the closure and alternative waste disposal facilities;
- a detailed timetable for post-closure procedures and correction of any deficiency identified in the review and assessment report,
- a detailed schedule of inspection, monitoring and maintenance to be carried out for a minimum post-closure period of 25 years, and
- a process for the administration of the post-closure security fund required under Section 5.1 of this operational certificate.

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5.4 **Declaration of Landfill**

Landfills sited on titled land must register a covenant that the property was used for the purpose of waste disposal as a charge against the title to the property as provided for under Section 219 (1) of the *Land Title Act*. Landfills located on crown land are to have a “notation on file” registered that the property was used for the purpose of waste disposal. The registration of the charge or legal notification is to be submitted to the Regional Director.

5.5 **Site Decommissioning**

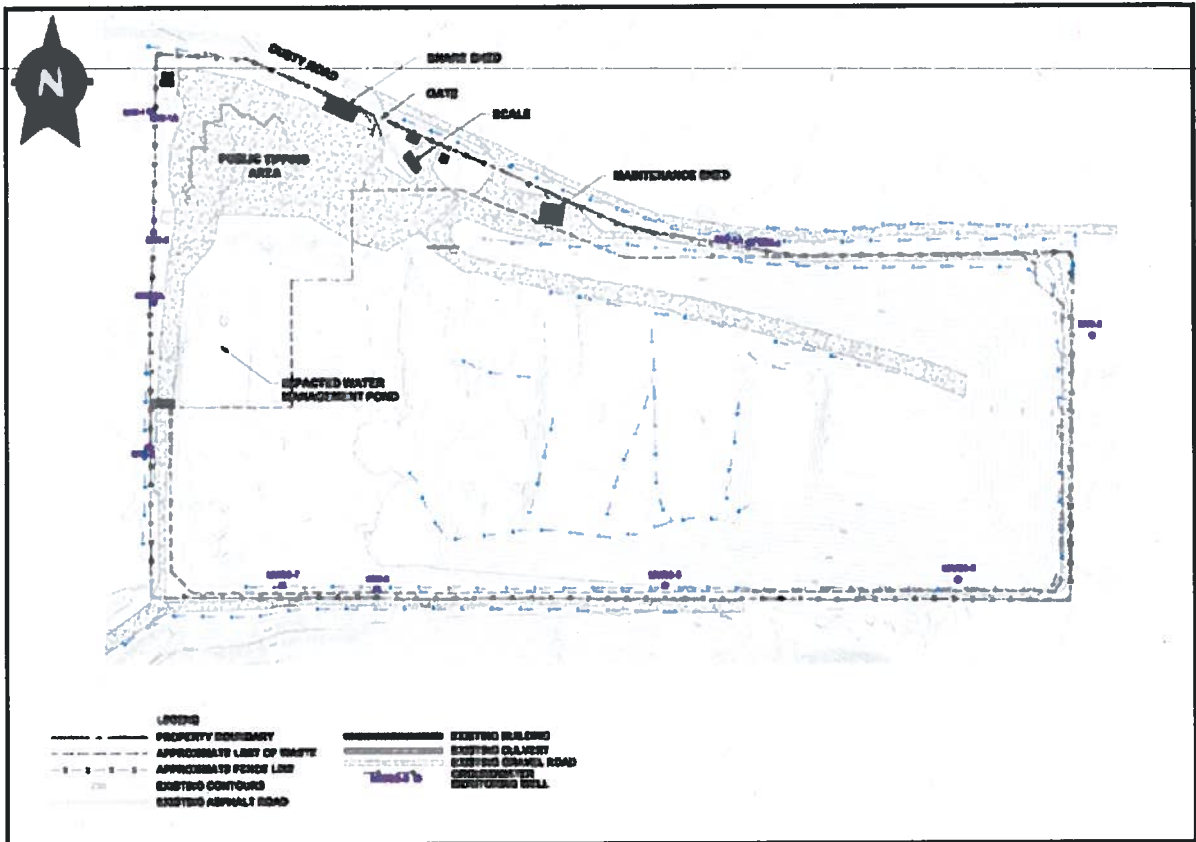
In accordance with Section 40 of the *Environmental Management Act* and Part 2 of the Contaminated Sites Regulation, the operational certificate holder must submit a site profile to the Director not less than 10 days prior to decommissioning the facilities authorized in Section 1.

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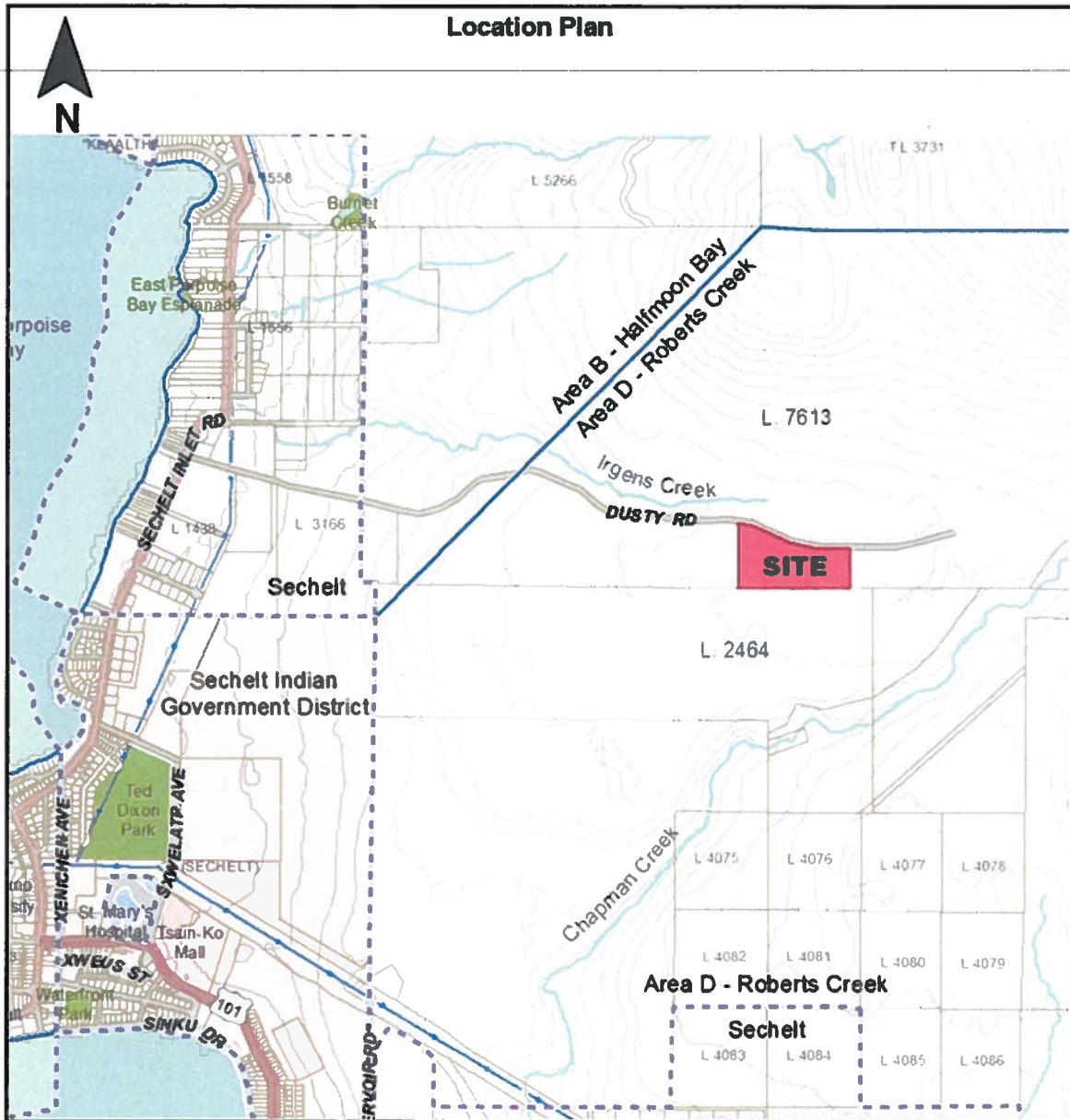
SITE PLAN A



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**SITE PLAN B**



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**APPENDIX B**  
**HISTORIC STRATIGRAPHIC LOGS AND GEOLOGIC CROSS-SECTION**

**DAYTON & KNIGHT LTD.***Consulting Engineers*P.O. BOX 91247, (612 CLYDE AVENUE), WEST VANCOUVER, BRITISH COLUMBIA, CANADA V7V 3N9  
TELEPHONE: (604) 922-3255 FAX: (604) 922-3253

July 29, 1993

Mr. S. K. Lehmann  
Superintendent of Public Works  
**Sunshine Coast Regional District**  
P.O. Box 800  
5477 Wharf Road  
Sechelt, B.C.  
V0N 3A0

Attention: Ms. Cathy Kenny  
Solid Waste Management Coordinator

Dear Ms. Kenny:

Re: **Monitoring Well Installation**  
**Sechelt Landfill**

This letter documents Dayton & Knight's installation of groundwater monitoring wells, with the assistance of SDS Drilling Ltd. at the above site, and the descriptions of the wells.

## 1.0 PROCEDURE

A total of nine (9) groundwater monitoring wells were installed between July 21 and 23, 1993. Three deep wells were constructed. The depth of these wells is approximately 15 m from the ground surface. The rest of the wells are shallow and have the depth of 4 to 5 m. The two deep wells were each nested with a shallow well. The locations of the wells are illustrated on Figure 1.

Installation of the wells was carried out by using a Becker Hammer drill. A piledriving hammer advanced a casing of double wall construction. During driving, compressed air was continuously forced down the annulus between the walls and returned up through the centre of the casing carrying the soil up to the surface through the air induced cyclone. This ensured that the boreholes, in which the wells were installed, were not contaminated.

The boreholes were driven to depths of about 4.0 m to 23.5 m below ground surface. The advancement of deep wells was stopped when a white, fine, dry, well-compacted, low impervious silt layer was encountered. Soil samples in the boreholes were collected from the cyclone. The casing of Becker Hammer was steam-cleaned between well installations to minimize cross-contamination of the installations.

- 2 -

The wells consist of 50 mm diameter schedule 40 PVC pipes with threaded couplings. The lower 1.5 m of each well consists of 0.010 inch width, 0.250 inch spacing slotted 50 mm diameter schedule 40 PVC pipe with threaded couplings. The screened portions of the wells were surrounded with Grade 16 silica sand. Bentonite chips were placed above and below the screen portion of each shallow well, as well as at 1 m below the ground surface, for all wells to prevent contamination infiltration. The portions above the screen were backfilled with selective native granular soils. Dedicated 5/8" HDPE tubing was installed with foot valve attached on the bottom in each well for sampling.

The location of the installed wells is to be determined by survey. The groundwater level of the wells is to be determined on initial sampling.

The well installation was carried out under the full-time supervision by Mr. John Lee of Dayton & Knight Ltd., who logged the well installations.

## 2.0 WELLS

The detailed records of the well installations and the soil strata encountered at the well locations are presented on the Record of Borehole sheets following this text.

The well installation depths and the screened strata are summarized as follows:

Well No.	Type	Depth of Well (m)	Strata Screened
1	Nested (deep)	11.2	Silty sand
1A	Nested (shallow)	5.03	Silty sand
2	Shallow	5.77	Silty sand
2A	Shallow	7.06	Medium sand
3	Shallow	4.27	Silty sand
4	Nested (deep)	11.50	Compacted sandy silt
4A	Nested (shallow)	4.04	Silty sand
5	Deep	14.3	Sandy silt
6	Shallow (gas)	8.38	Silty sand

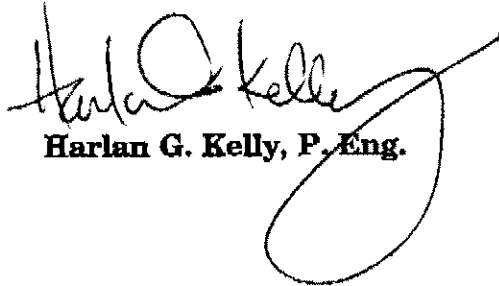
As recommended, quarterly sampling should be undertaken in accordance with Ministry of Environment requirements to determine if leachate is leaving the landfill. Analysis of the results will determine extent of required improvements.

- 3 -

We trust that this report provides the information required at this time. If you have any questions regarding the above, please do not hesitate to contact us.

Yours truly,

Dayton & Knight Ltd.



Harlan G. Kelly, P. Eng.

JL:aa  
28.146  
Encl.

RECORD OF BOREHOLE MW 1 and 1A

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Ground surface		
0.0	Top soil organics, fine to medium, brownish (Tan) Loose compacted silty sand		
0.6	Moist, Medium compacted light brownish grey silty Sand, trace few fine gravel		
6.5	Medium compacted, moist to wet, fine to medium, silty to washed clean, medium to dark grey sand		
9.5			

Cont'd on sheet 2 of 3


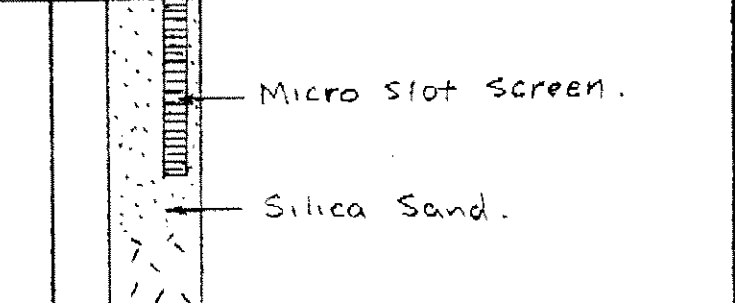

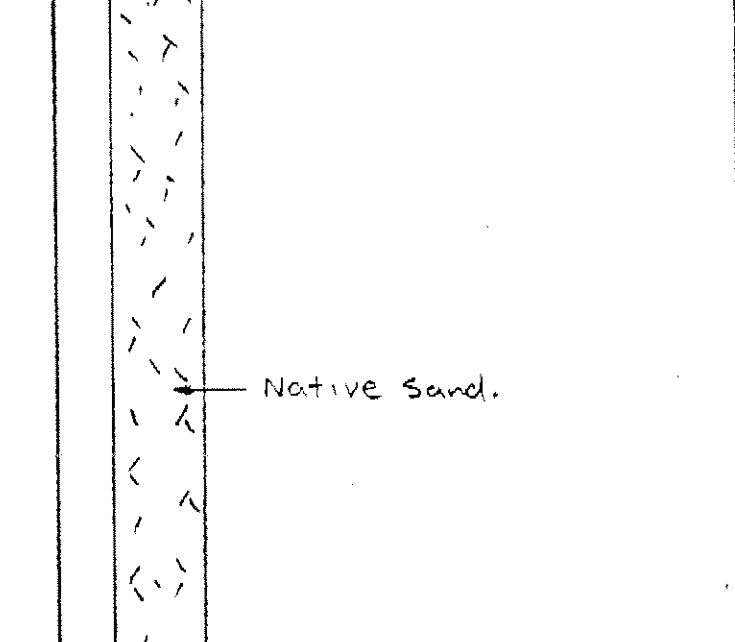



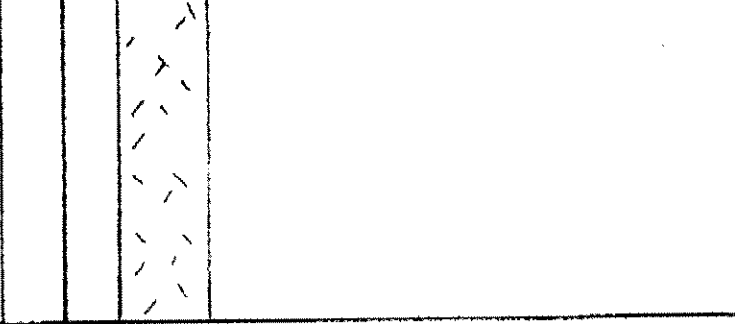
Sheet 1 of 3

Location (See Figure 1) Boring Date July 21, 1993  
 Borehole Type: Becker Ham. Borehole Dia. 6 3/8"  
 Vertical Scale: 1 : 50 Datum : Geodetic

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN J.H.S. DRAWING No. 28.146

RECORD OF BOREHOLE MW 1 and 1A

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Cont'd from Sheet 1		
	Medium compacted, Wet to very wet, fine to medium, silty to medium clean, brownish grey silty sand, trace fine gravel.		
12.0	Wet, fine, medium compacted, brownish grey, slurry silt.		
16.3	Moist, fine, grey, medium compacted, silt.		
17.8	Moist, fine to medium, medium compacted, grey, sandy silt, trace fine gravel.		

Cont'd on Sheet 3 of 3



Sheet 2 of 3

Location (See Figure 1) Boring Date : July 21, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 3/8"  
 Vertical Scale : 1 : 50 Datum : Geodetic

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JRL DRAWING No. 28.146

RECORD OF BOREHOLE MW 1 and 1A

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Cont'd from sheet 2		
20.5	Fine, moist to dry, very densely compacted, brownish grey silt, trace fine gravel.		
23.4	Very fine, dry, powder, light grey, dense, silty till		
24.0	End of Borehole		

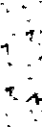

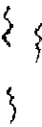



Sheet 3 of 3

Location (See Figure 1) Boring Date : July 21, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum : Geodetic

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JHL DRAWING No. 28.146

RECORD OF BOREHOLE MW 2

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Ground Surface		
0.0	Tan Brownish grey, light compacted, fine to medium silty sand, trace gravel		
1.0	Brownish to light grey, medium compacted, moist, uniform medium silty sand, trace fine gravel.		 <p>Bentonite seal</p> <p>Native sand backfill</p>
3.3	Moist to medium wet, fine to medium, medium compacted, medium to light grey silty sand, trace fine gravel.		 <p>Silica sand</p> <p>Micro slot screen</p>
5.9	End of Borehole		

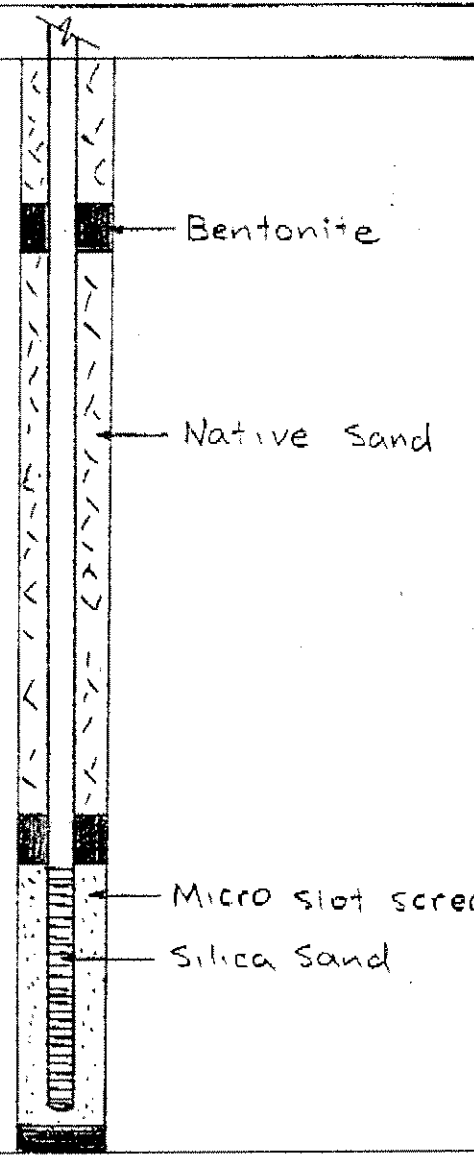
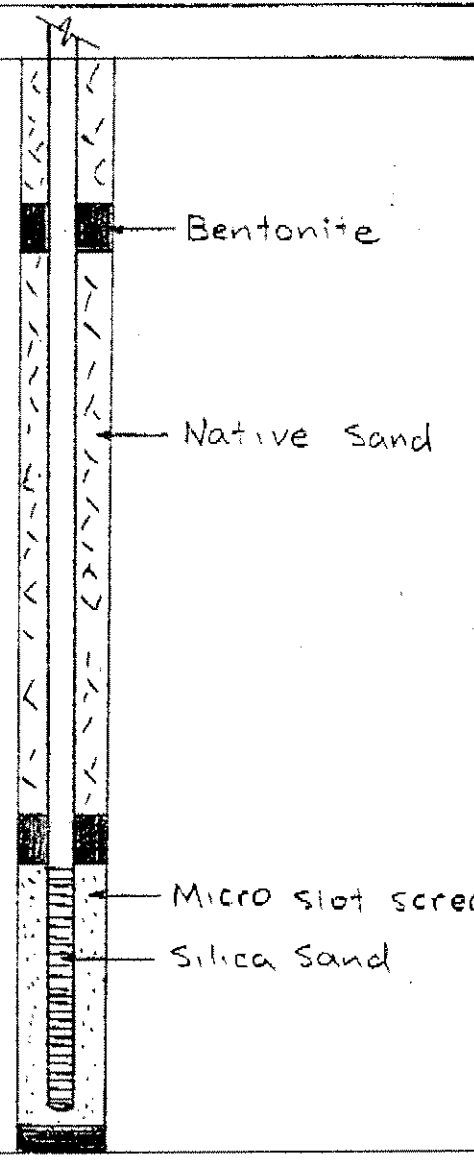
Sheet of

Location (See Figure 1) Boring Date : July 21, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum : Geodetic

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 CONSULTING ENGINEERS

DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JHL DRAWING No. 28.146

RECORD OF BOREHOLE MW 2A

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Ground Surface		
0.0	Tan brownish grey, light compacted, fine to medium silty sand, trace fine gravel		
1.0	Brownish to light grey, medium compacted, moist, silty sand		 <p>Bentonite</p> <p>Native Sand</p>
3.3	Moist to medium wet, medium compacted, fine to medium, light to medium grey, silty sand, trace fine gravel		
5.9	Medium compacted, moist to wet, fine to medium, silty to washed, medium to dark grey sand		 <p>Micro slot screen</p> <p>Silica Sand</p>
7.4	End of Borehole		

Sheet 1 of 1

Location (See Figure 1) Boring Date : July 28, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN J.V.L. DRAWING No. 28.146

# RECORD OF BOREHOLE MW 3

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Ground surface		
0.0	Tan brownish, compacted, fine uniform, silty sand.	7.7 7.1 6.5	<p style="margin-left: 20px;">Bentonite</p> <p style="margin-left: 20px;">Native sand backfill</p> <p style="margin-left: 20px;">Silica sand</p> <p style="margin-left: 20px;">Micro slot screen</p>
1.0	Moist to Wet, medium compacted, fine to medium, light to medium grey, silty sand. trace fine gravel.	5 5 5 5 5 5 5	
4.4	End of Borehole		

Sheet 1 of 1

Location (See Figure 1) Boring Date : July 21, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JHL DRAWING No. 28.146

RECORD OF BOREHOLE MW 4 and 4A

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Ground surface		
0.0	Moist, medium compact, light brownish grey, Silty sand, trace fine gravel.		
2.5	Moist, powder to fine, brownish grey, uniform, Medium compacted, Silty sand, trace some fine gravel.		
5.4	Moist, fine to medium, dark grey, medium compacted, dusty silty sand		
6.5	Moist to dry, fine, brownish grey, heavily compacted, sandy silt, trace boulders and fine gravel		
9.3	Dry, fine, light grey, heavily compacted silt.		

Cont'd on sheet 2 of 2


Sheet 1 of 2

Location (See Figure 1) Boring Date : July 23, 1993  
 Borehole Type : Becker Ham, Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JAL DRAWING No. 28-146

RECORD OF BOREHOLE MW 4 and 4A

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	cont'd from sheet 1		
	Trace boulders and fine gravel	1 ( )	
10.6	Dark grey, dry, heavily compacted, sandy silt, trace fine gravel		
12.0	End of Borehole		



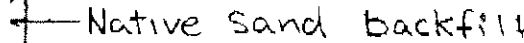



Sheet of

Location (See Figure 1) Boring Date : July 23, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 29, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JKL DRAWING No. 28.146

RECORD OF BOREHOLE M W 5 (Gas)

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
	Ground Surface		
0.0	Light brownish to grey, medium to fine, light to medium compacted, moist, silty sand. trace large sand		
4.0	Light to medium compacted, moist to dry, brownish to light grey, uniform medium fine, silty sand, trace large sand.		
7.2	Dry, dense, brownish grey, fine sandy silt trace fine gravel.		
8.1	Fine, dry, dense, grey sandy silt. trace fine to medium gravel		

cont'd on sheet 2 of 2

Sheet 1 of 2

Location (See Figure 1) Boring Date : July 23, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 3/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 23, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN BY \_\_\_\_\_ CHECKED BY \_\_\_\_\_



# RECORD OF BOREHOLE MW 6

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
0.0	<p>Ground Surface</p> <p>MEDIUM COMPACTED; MOIST, LIGHT BROWNISH TO LIGHT GRAY, UNIFORM FINE TO MEDIUM SILTY SAND TRACE OF FEW FINE GRAVEL</p>		<p>Native backfill</p>
4.5	<p>MOIST, BROWNISH TO GRAY; FINE TO MEDIUM, MEDIUM COMPACTED SILTY SAND TRACE OF SOME COARSE SAND</p>		<p>manually slotted on site. 6 in spacing</p>

Cont'd on sheet 2 of 2

Sheet 1 of 2

Location (See Figure 1) Boring Date : July 22, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 5/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_

RECORD OF BOREHOLE MW 6

ELEV.	DESCRIPTION	STRATIGRAPHY PLOT	STANDPIPE INSTALLATION
DEPTH (meters)			
Cont'd from sheet 1			
10.3	MOIST TO DRY, LIGHT BROWNISH GRAY MEDIUM COMPACTED SANDY SILT, TRACE OF COARSE SAND		
12.5	MEDIUM TO LIGHT BROWNISH GRAY, MOIST TO DRY, UNIFORMLY FINE, DENSELY COMPACTED SANDY SILT. TRACE OF COARSE SAND.		
16.0	<u>NOTE:</u> ADVANCEMENT WAS STOPPED WHEN SIMILAR SOIL FORMATION ENCOUNTERED AS MW1		

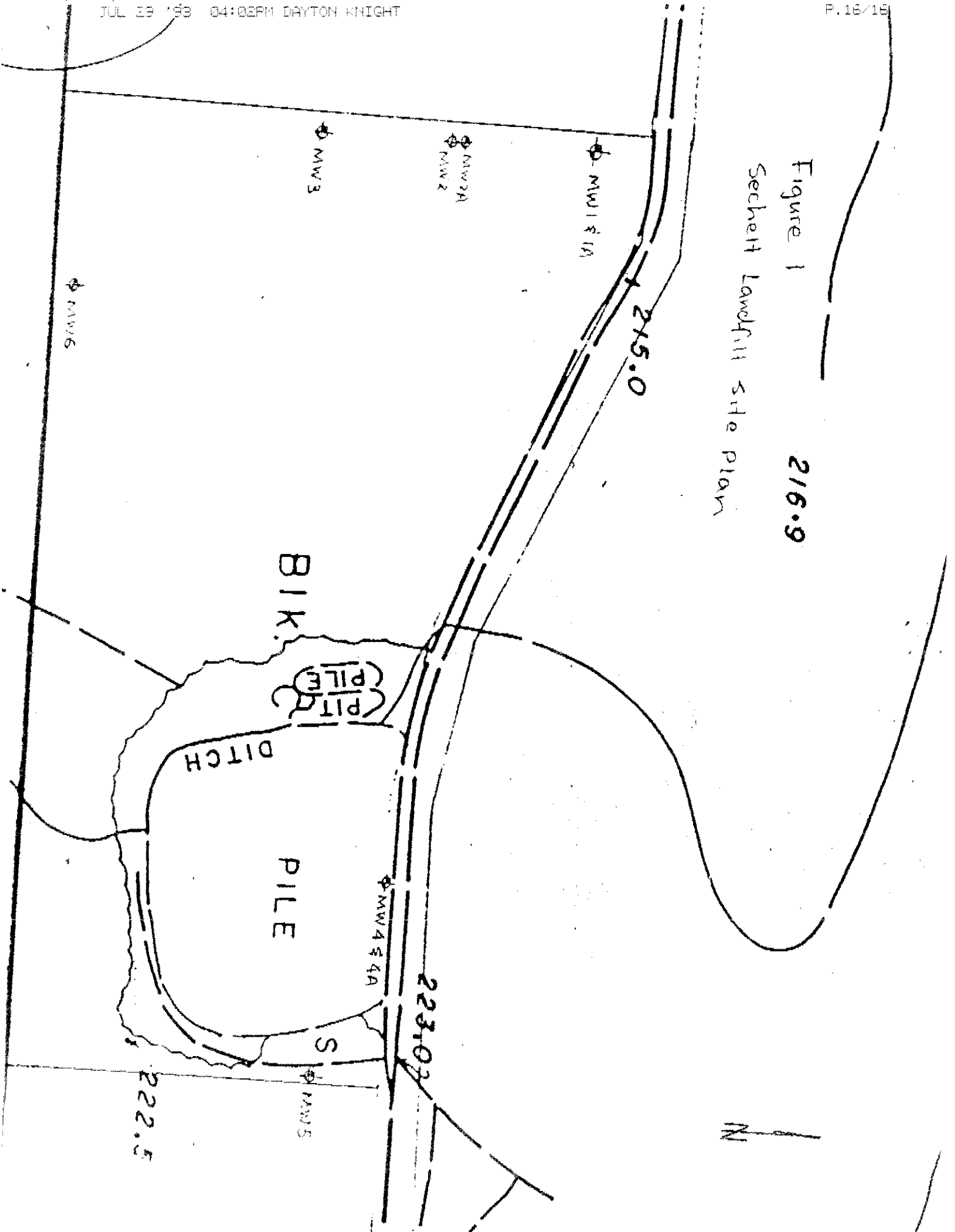
Sheet 2 of 2

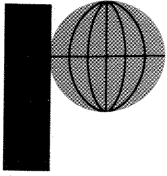
Location (See Figure 1) Boring Date : July 28, 1993  
 Borehole Type : Becker Ham. Borehole Dia. : 6 3/8"  
 Vertical Scale : 1 : 50 Datum :

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DATE July 28, 1993 SKETCH No. \_\_\_\_\_ ISSUE \_\_\_\_\_  
 DRAWN JHL DRAWING No. 26.145

Figure 1  
Sechelt Landfill site plan





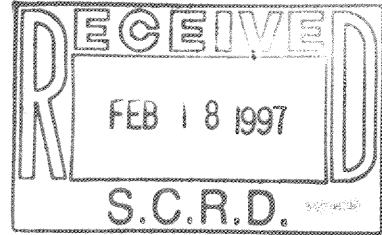
**PITEAU ASSOCIATES**

GEOTECHNICAL AND  
HYDROGEOLOGICAL CONSULTANTS

215 - 260 WEST ESPLANADE  
NORTH VANCOUVER, B.C.  
CANADA V7M 3G7  
TELEPHONE (604) 986-8551  
FAX (604) 985-7286

Our file: 1647

February 12, 1996



Sunshine Coast Regional District  
5477 Wharf Road  
Box 800  
Sechelt, B.C.  
V0N 3A0

Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

Dear Sirs:

Re: Design and Installation of New Monitoring Wells  
Sechelt Landfill, Sunshine Coast Regional District

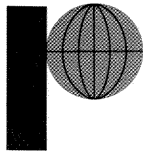
As requested in Mr. Sieg Lehmann's letter to Mr. Agris Berzins of Dayton & Knight Ltd., dated October 9, 1996, Piteau Associates Engineering Ltd. (Piteau) has expedited and supervised the construction of three new monitoring wells at the Sechelt Landfill. The scope of our services for this project included:

- Review of water level and chemistry monitoring data to determine required depth and preferred location of wells on southern boundary of site,
- Site visit to perform electromagnetic (EM) survey, to select well sites, and to make arrangements for access preparation,
- Necessary arrangements for drilling contractor to construct new wells,
- Supervision of well construction program,
- Well development and initial sampling, and
- Preparation of well logs and well completion report.

A description of the work performed and the results of the EM study and initial sampling suite are presented herein.

**EM-34 SURVEY**

Piteau performed a terrain electrical conductivity survey. A Geonics EM-34 was used for the survey at the Sechelt Landfill on November 21, 1996. This instrument involves two people traversing the survey area with two electromagnetic coils: one to transmit and a second to receive. By varying the spacing between the two coils, the apparent electrical conductance of the ground can be measured at depths varying up to 30m. The purpose of the survey was to detect changes in ground conductivity that would be indicative of the presence of highly conductive leachate plumes in the groundwater beneath the site.



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Coordinator

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Distances were measured by pacing, with fixed landmarks noted along the actual traverse lines to assist with locating anomalies. The approximate spacing between measurements was every 10m. The east and west traverse lines were compromised by dense forest, which required surveying closer to the fences than would otherwise be desirable.

Readings were taken using the vertical coil orientation (measures to 30m depth), and the horizontal coil orientation (measures to 15m depth). Horizontal readings were not performed on the west side traverse, as the proximity of the fence produced suspect readings.

#### East side

This traverse extended from south of the road ditch to just short of the southeast property corner (see location on Fig. 1). Several 0.3m deep ponds were encountered in this area. One anomaly was present (Fig. 2), suggesting a localized conductive source. Measurement accuracy in the latter half of the traverse was affected by the proximity of the fence. Monitoring well MW-5 does not appear to be in an anomalous area.

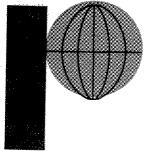
#### West side

The traverse was located inside the landfill property, between the toe of the refuse and the fence. This line was sited between the toe of the refuse and the fence, to minimize interference from either of these features. A uniform distance was maintained from the fence so that any contributory effects would be constant.

The survey indicated that higher conductivities are present adjacent to the toe of the landfill, and decline as distance from the landfill increases (Figs. 1 and 2). Monitoring well MW-3 is located within the higher conductance zone.

#### South Side

A single traverse was made across the southern boundary, at least 8m from the toe of the landfill. This is an open area with no fences parallel to the traverse. Two anomalous zones were identified, between 110 and 206m, and between 355 to 428m from the southeast property corner (Figs. 1 and 2). Drilling targets were identified at 205m and 390 from the southeast property corner. Only one monitoring well, MW-6, is present on this traverse, and is just outside an anomalous zone. It should be noted that the anomalies identified were not strong, but were interpreted to be associated with leachate, given their location on the downgradient side of the landfill, relative strength and broad distribution.



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Attention: Ms. Cathy Kenny  
Solid Waste Management Coordinator

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### MONITORING WELL DRILLING AND INSTALLATION

The monitoring well drilling and installation program was conducted on December 17 and 18, 1996 by Beck Drilling and Environmental Services Ltd. Three wells were drilled using a Becker Hammer drilling rig. All wells were drilled and cased with 4 inch (102 mm) I.D. double wall steel casing. Well locations are shown on Fig. 1.

Work was supervised by Mr. Chris Keith of Piteau. While on site, Mr. Keith logged drill cuttings, performed field water quality measurements and kept records of drilling progress and monitoring well construction details. Hydrogeologic logs and well completion details are shown in Appendix A.

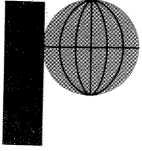
All three wells are located along the southern boundary of the landfill property line. Monitoring well MW-7 was drilled approximately 55m west of MW-6 at an EM-34 survey anomaly. Drilling encountered fine to coarse sand with some gravel and boulders to a depth of 8.8m. This was underlain by sand and gravel to gravel with some boulders to a depth of 18.0m. Drilling was terminated at 18.3m when a large boulder or bedrock was encountered. The sandy silt encountered from 18.0 to 18.3m was damp.

Monitoring well MW-8 was located roughly in the middle of the southern property line where the EM-34 survey indicated a second conductivity anomaly. Drilling encountered a complex series of fine to coarse sand and gravel layers to a depth of 29.9m. Silty sand was encountered from 2.7 to 3.4m, and there was evidence of a perched water table from 2.4 to 3.4m. Saturated soil was again encountered from 28.9 to 29.9m.

Monitoring well MW-9 was located in the southeast corner of the property, near GP-4. A complex series of fine to coarse sand and fine to coarse gravel was encountered to a depth of 26.0m. Soils were unsaturated to a depth of 24.5m.

Field electric conductivity measurements were taken for water samples blown to surface with the drill cuttings from saturated zones. These measurements are reported on the logs in Appendix A.

All screened intervals were located in the bottom 1.52m (5 ft.) of the drilled holes, with a sand filter pack set between the bottom of the hole and a point 3.1 to 3.8m above the bottom of the hole. A bentonite seal, ranging from 3.1 to 3.5m thick, was placed above the filter sand. The holes were then backfilled with drill cuttings to just below grade, where a thin bentonite seal (0.2 to 0.5m) was placed, followed by a flush mounted well casing set in concrete. MW-8 had an



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additional bentonite seal placed between 2.4 to 4.6m below grade, where perched water was encountered during drilling.

### WELL DEVELOPMENT AND SAMPLING

Development and sampling of the three new monitoring wells was conducted on January 8, 1997. The purge volume required for the monitoring wells was calculated as three well volumes, based on water level measurements taken that same day. Electrical conductivity of the water withdrawn from the wells was also monitored, to ensure that it had stabilized prior to sample collection.

Water was withdrawn using new disposable plastic bailers and nylon twine. A plastic sheet was placed around the well to coil the twine on as the bailer was pulled from the well. Once purging was complete, the field EC, pH and temperature were recorded, and appropriate sample containers were filled. Disposable latex gloves were used during the sampling procedure.

Samples were placed in a cooler with ice, and were delivered to Analytical Services Laboratories Ltd. of Vancouver on January 9, 1997.

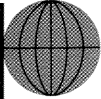
### INTERPRETED GROUNDWATER FLOW REGIME

Groundwater beneath the site is interpreted to flow in a dominantly southward direction (Fig. 1). Flows may be perched on low permeability sediments which underlie the landfill area, but these low permeability sediments do not appear to extend south of the landfill property, where permeable sediments were noted to continue to depths of 29 to 26m in MW- 8 and MW-9, respectively.

The water table shows a very steep gradient to the south, and the equipotential contours indicate groundwater flows trend towards MW-8, where the depth of permeable sediments appears to be greatest (Fig. 1).

### SAMPLING RESULTS

The first suite of sample results indicate that groundwater beneath the south landfill perimeter has been significantly impacted by leachate. COD, manganese and chloride concentrations are elevated in all three wells. Manganese exceeds the acceptable drinking water concentration of 0.05 mg/L (Health & Welfare, 1996) in all three wells, but chloride only exceeds the acceptable limit of 250 mg/L in MW-9 (Table I). Similarly, total nitrogen levels are low (<2 mg/L-N) in MW-7 and MW-8, but ammonia levels are very high (127 mg/L-N) in MW-9. The high ammonia levels indicate that very little nitrification is occurring in the unsaturated zone beneath the east end of



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Coordinator

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the landfill, which suggests a fairly rapid infiltration rate to the water table. Conditions may be more favourable for subsurface renovation of leachate beneath the western portions of the landfill, as the first suite of samples indicates water quality is generally better in MW-7 and MW-8 than in MW-9.

### RECOMMENDATIONS

Water level measurements and water quality sampling should continue on a bi-monthly or quarterly schedule, to properly define the leachate impact and groundwater flow regime on the south side of the landfill. A suite of samples collected in the late summer or early fall should be submitted for a detailed chemical analysis, and the remaining samples should be submitted for a reduced suite. A suggested list of parameters for both the detailed and reduced suites is included as Table II.

Water levels should be measured prior to purging and sampling. The new wells should be purged by removing two well volumes prior to sample collection. Due to the depth to water in the new wells, they should be sampled with either 2m long bailers or a 50mm diameter submersible pump. If a submersible pump is used, dedicated delivery tubes should be left in each well.

We trust this report presents the information you require regarding the three new monitoring wells at the Sechelt Landfill, and our recommendations for sampling these new installations. If you have any questions regarding this report, or require any additional assistance with the regular monitoring program, please contact us.

Yours very truly,

PITEAU ASSOCIATES ENGINEERING LTD.

Andrew T. Holmes, P.Eng.

ATH/ef

Att.

c: Daryl Sinclair, Dayton & Knight Ltd.

**TABLES**

**TABLE I**  
**SUMMARY OF LABORATORY CHEMISTRY DATA**  
**FOR NEW MONITORING WELLS**

Parameter	Units/ Symbols	MW-7 Jan 8/1997	MW-8 Jan 8/1997	MW-9 Jan 8/1997	GCDWQ	
					Maximum Acceptable	Objective
<b>Physical Tests</b>						
pH - field		6.69	6.92	6.63		
EC - field	µS/cm	1190	940	3080		
Temp - field	C°	11.9	10.6	10.7		
Colour - field		med. grey/br	lt. grey/br	med. grey/br	-	-
Odour - field		none	none	faint		
pH - Lab		6.82	6.44	6.57	6.5 - 8.5	-
EC - Lab	µS/cm	1420	1150	3740	-	-
Turbidity	NTU	28500	1650	2930	5	-
<b>Dissolved Anions (mg/L)</b>						
Alkalinity	CaCO <sub>3</sub>	576	454	1250	-	-
Chloride	Cl	121.0	112.0	<b>298.0</b>	250	250
Sulphate	SO <sub>4</sub>	5.7	6.7	4.1	500	500
<b>Dissolved Cations (mg/L)</b>						
Calcium	Ca	182	147	329	-	-
Magnesium	Mg	38.0	20.5	43.9	-	-
Potassium	K	12	6	27	-	-
Sodium	Na	75	53	180	-	-
<b>Dissolved Metals (mg/L)</b>						
Arsenic	As	0.0023	0.0009	0.0099	0.025	0.005
Barium	Ba	0.29	0.0500	0.68	1	0.1
Boron	B	<0.1	<0.1	<0.1	5	0.01
Cadmium	Cd	0.0002	0.0017	<0.0002	0.005	0.001
Iron	Fe	0.10	0.07	<b>28.5</b>	0.30	0.050
Lead	Pb	<0.001	<0.001	0.002	0.01	0.001
Manganese	Mn	<b>38.0</b>	<b>20.5</b>	<b>43.9</b>	0.05	0.010
Mercury	Hg	<0.00005	<0.00005	<0.00005	0.001	0.0002
<b>Nutrients (mg/L)</b>						
Nitrate	N	0.0070	0.0160	<0.005	10	0.001
Nitrite	N	0.003	0.009	0.018	1	0.001
Ammonia Nitrogen	N	1.38	0.70	<b>127</b>	-	-
Total Kjeldahl Nitrogen	N	1.84	0.72	<b>132</b>	-	-
Total Phosphate	P	0.197	3.2	6.16	-	-
<b>Pollutant Tests (mg/L)</b>						
Chemical Oxygen Demand	COD	6260	373	809	-	-
Dissolved Organic Carbon	C	29.8	92.6	32.0	-	-

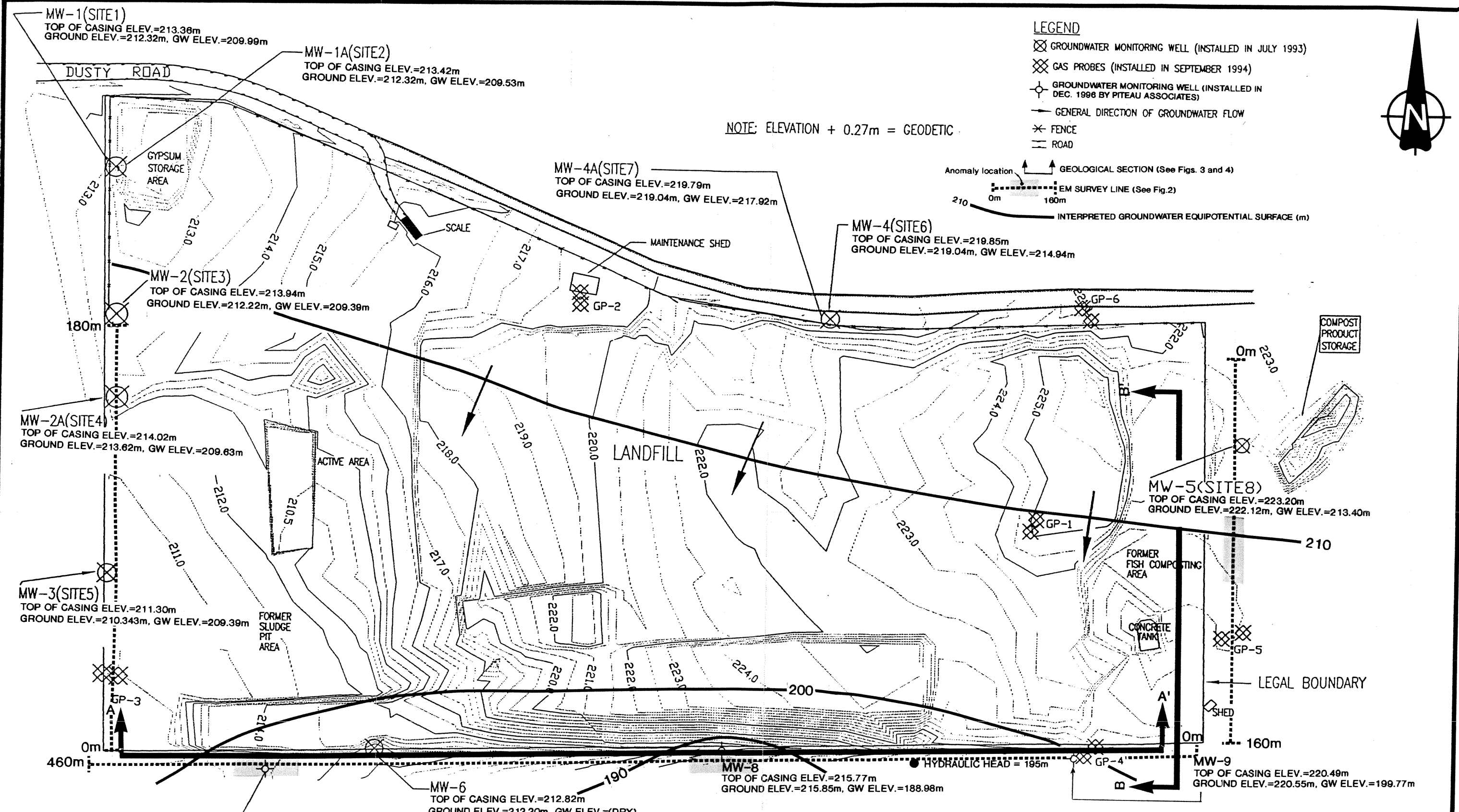
**NOTES:**

1. < = Less than detection limit
2. GCDWQ = Guidelines for Canadian Drinking Water Quality
3. Bolding indicates those parameters that exceed the GCDWQ criteria, or which are cause for concern.

**TABLE II**  
**RECOMMENDED WATER QUALITY ANALYSIS SUITES**

Analytes for detailed suite (Once per year)	Analytes for reduced suite (Three to five times per year)
<b>Physical Tests</b> pH - field EC - field Temp - field Colour - field Odour - field pH - Lab EC - Lab Turbidity	<b>Physical Tests</b> pH - field EC - field Temp - field Colour - field Odour - field pH - Lab EC - Lab Turbidity
<b>Dissolved Anions (mg/L)</b> Alkalinity Chloride Sulphate	<b>Dissolved Anions (mg/L)</b> Chloride Sulphate
<b>Dissolved Cations (mg/L)</b> Calcium Magnesium Potassium Sodium	<b>Nutrients (mg/L)</b> Nitrate Total Kjeldahl Nitrogen
<b>Dissolved Metals (mg/L)</b> Arsenic Barium Boron Cadmium Iron Lead Manganese Mercury	
<b>Nutrients (mg/L)</b> Nitrate Nitrite Ammonia Nitrogen Total Kjeldahl Nitrogen Total Phosphate	
<b>Pollutant Tests (mg/L)</b> Chemical Oxygen Demand Dissolved Organic Carbon	

**FIGURES**



MW-1(SITE1)  
TOP OF CASING ELEV.=213.38m  
GROUND ELEV.=212.32m, GW ELEV.=209.99m

MW-1A(SITE2)  
TOP OF CASING ELEV.=213.42m  
GROUND ELEV.=212.32m, GW ELEV.=209.53m

MW-4A(SITE7)  
TOP OF CASING ELEV.=219.79m  
GROUND ELEV.=219.04m, GW ELEV.=217.92m

MW-4(SITE6)  
TOP OF CASING ELEV.=219.85m  
GROUND ELEV.=219.04m, GW ELEV.=214.94m

MW-2(SITE3)  
TOP OF CASING ELEV.=213.94m  
GROUND ELEV.=212.22m, GW ELEV.=209.39m

MW-2A(SITE4)  
TOP OF CASING ELEV.=214.02m  
GROUND ELEV.=213.82m, GW ELEV.=209.63m

MW-5(SITE8)  
TOP OF CASING ELEV.=223.20m  
GROUND ELEV.=222.12m, GW ELEV.=213.40m

MW-3(SITE5)  
TOP OF CASING ELEV.=211.30m  
GROUND ELEV.=210.343m, GW ELEV.=209.39m

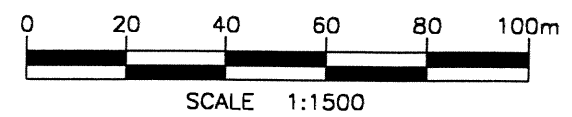
MW-8  
TOP OF CASING ELEV.=215.77m  
GROUND ELEV.=215.85m, GW ELEV.=188.98m

MW-9  
TOP OF CASING ELEV.=220.49m  
GROUND ELEV.=220.55m, GW ELEV.=199.77m

MW-7  
TOP OF CASING ELEV.=211.01m  
GROUND ELEV.=211.04, GW ELEV.=197.35m

MW-6  
TOP OF CASING ELEV.=212.82m  
GROUND ELEV.=212.20m, GW ELEV.= (DRY)

**NOTE:**  
1. SITE PLAN MODIFIED FROM DAYTON & KNIGHT SITE PLAN  
2. GROUNDWATER ELEVATIONS MEASURED ON JAN.8, 1997



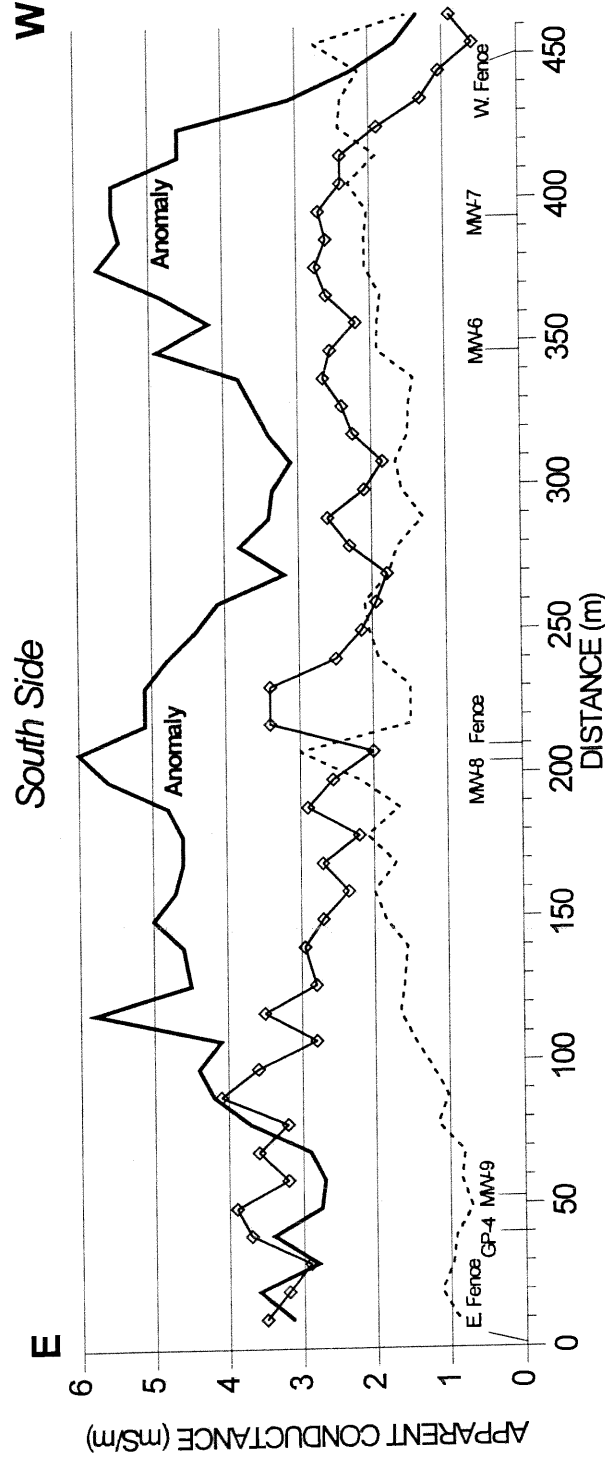
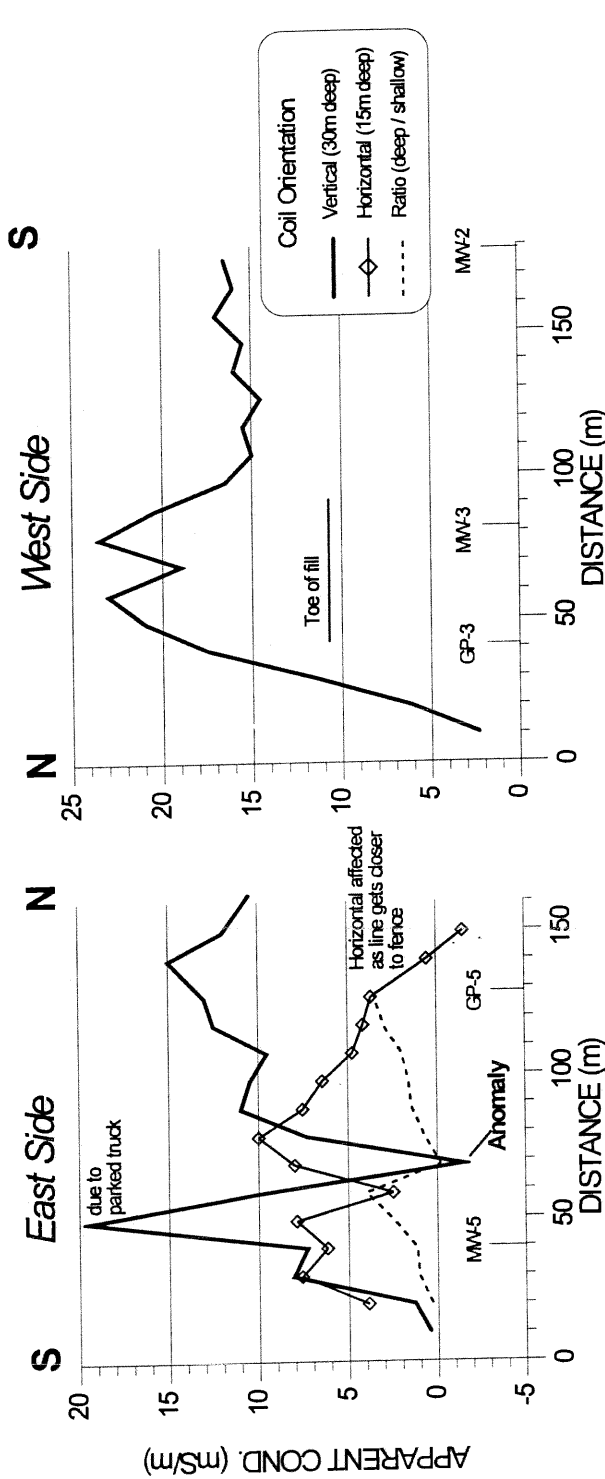
DAYTON & KNIGHT LTD.  
SUNSHINE COAST REGIONAL DISTRICT  
SECHLT, B.C.

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GEOTECHNICAL AND  
HYDROGEOLOGICAL CONSULTANTS  
VANCOUVER CALGARY

MONITORING WELL  
CONSTRUCTION PROGRAM  
SECHLT LANDFILL

**SITE PLAN**

BY: <b>CRK/CV</b>	DATE: <b>FEB.97</b>
APPROVED: <i>[Signature]</i>	DWG: <b>1</b>



Note: See Fig. 1 for location of survey lines.

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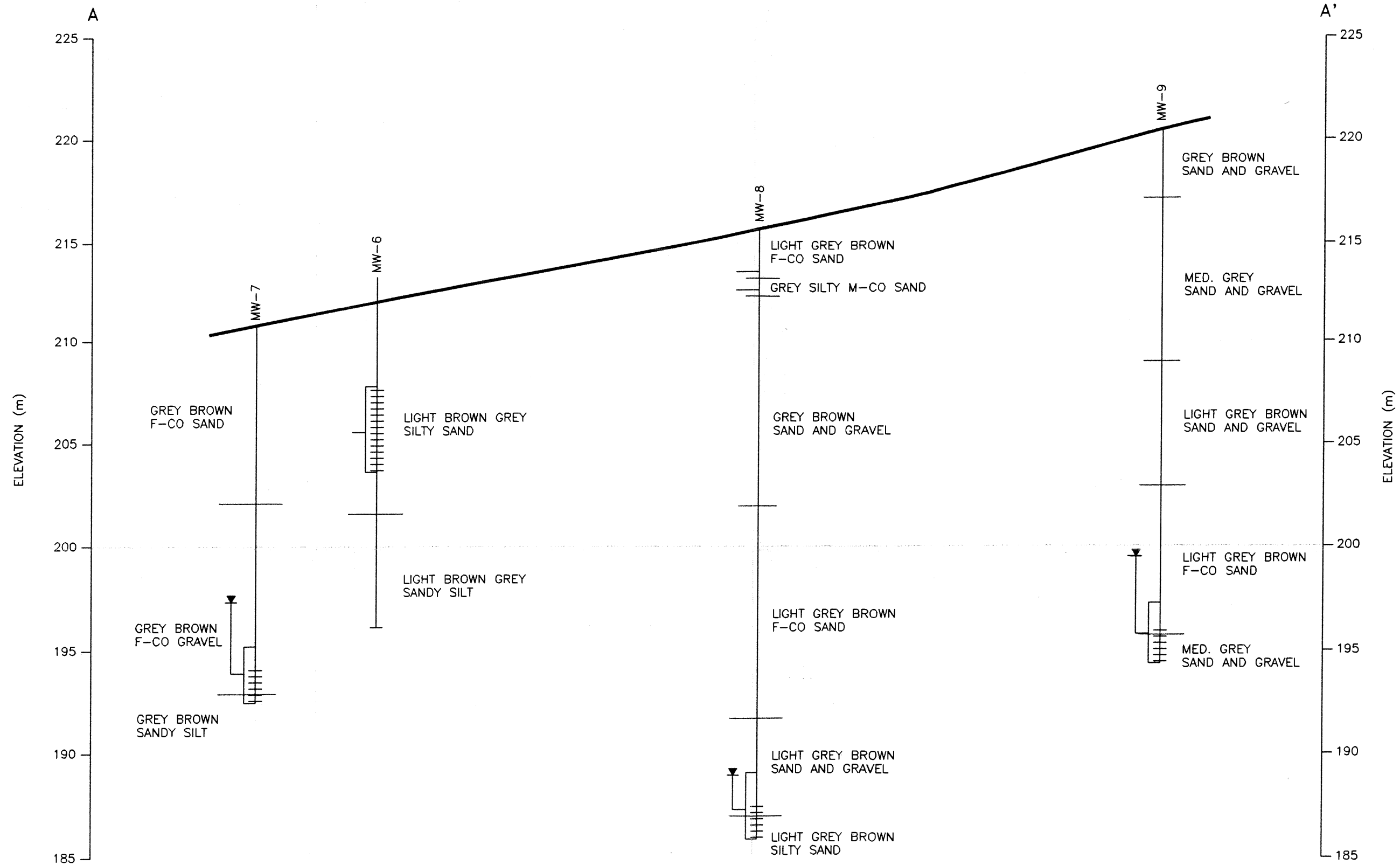


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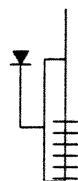
MONITORING WELL  
CONSTRUCTION PROGRAM  
SECHELT LANDFILL

EM-31 SURVEY RESULTS -  
CONDUCTANCE PROFILES  
ALONG LANDFILL PERIMETER

BY: ATH	DATE: OCT 96
APPROVED: <i>[Signature]</i>	FIG. 2



**LEGEND**



MONITORING WELL WITH  
COMPLETION INTERVAL,  
AND WATER LEVEL MEASURED  
ON JAN. 8 1997

HORIZONTAL SCALE 1:1500  
VERTICAL SCALE 1:200  
VERTICAL EXAGGERATION = 7.5x

NOTE: WATER LEVELS MEASURED ON JAN. 8 1997

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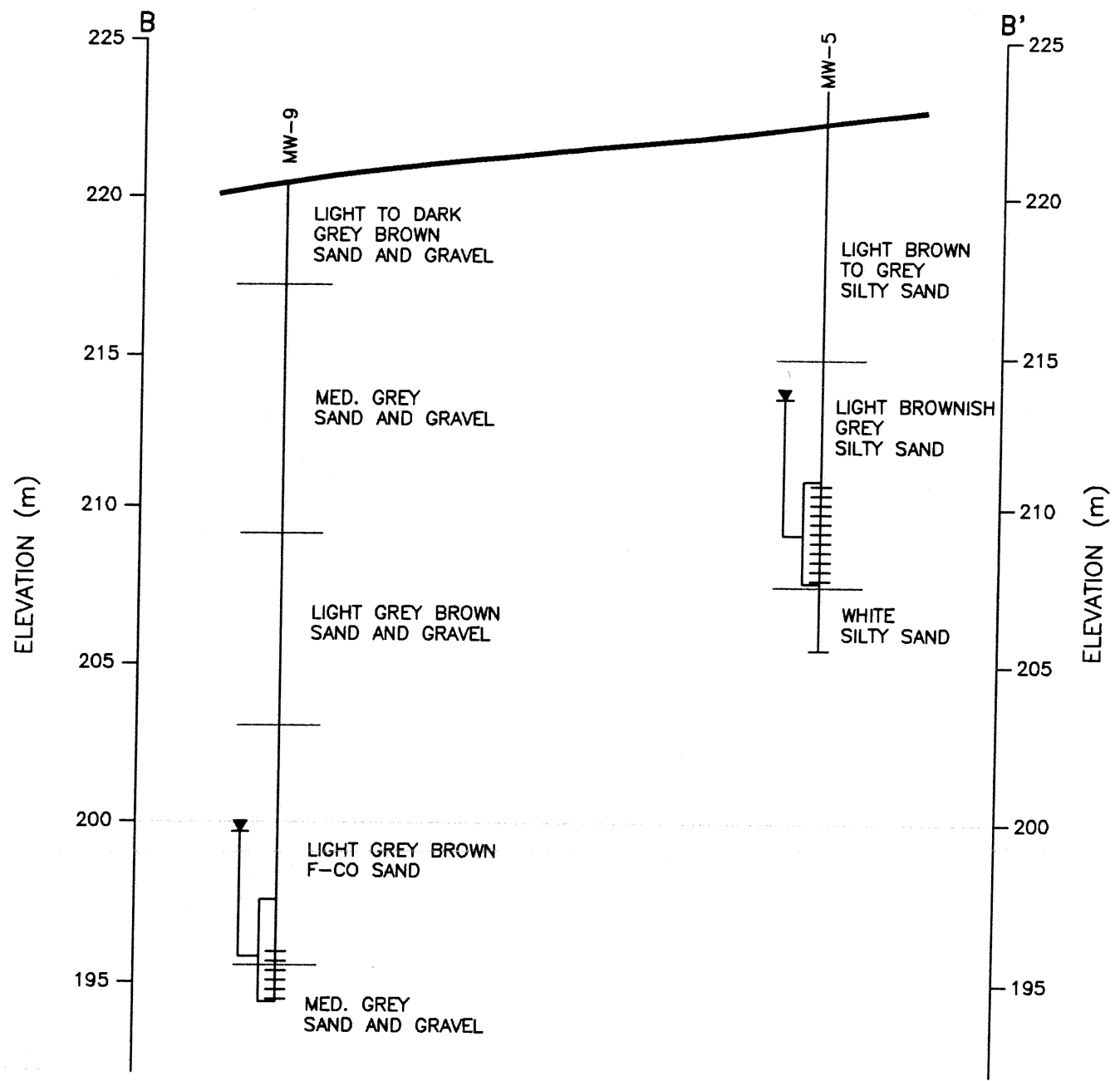


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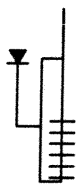
MONITORING WELL  
CONSTRUCTION PROGRAM  
SECHLT LANDFILL

**SECTION A-A'**

BY: CRK/CV	DATE: FEB. 97
APPROVED: <i>[Signature]</i>	FIG: 3



**LEGEND**



MONITORING WELL WITH  
COMPLETION INTERVAL,  
AND WATER LEVEL MEASURED  
ON JAN. 8 1997

HORIZONTAL SCALE 1:1500  
VERTICAL SCALE 1:200  
VERTICAL EXAGGERATION = 7.5x

NOTE: WATER LEVELS MEASURED ON JAN. 8 1997

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**SECTION B-B'**

BY:	DATE:
CRK/CV	FEB. 97
APPROVED:	FIG:
<i>CH</i>	4

**APPENDIX A**

**WELL LOGS**

**HYDROGEOLOGIC LOG**

PURPOSE OF HOLE: MONITORING WELL  
 TYPE OF RIG: BECKER HAMMER  
 DRILLING CONTRACTOR: BECK DRILLING AND ENVIRONMENTAL SERVICES LTD.  
 DATE DRILLED: DEC. 17, 1996  
 GROUND ELEVATION (m-asl): 211.04  
 STEEL CASING STICK UP: FLUSH MOUNTED

BOREHOLE:

**MW7**

ELEV. TOP OF PVC CASE: 211.01 m-asl  
 DEPTH TO WATER: 13.66 m-btoc  
 ELEVATION OF WATER: 197.35 m-asl

Note: Water levels were measured on Jan. 8, 97

Depth (m)	Elev. (m-asl)	DESCRIPTION OF LITHOLOGY ENCOUNTERED	WELL CONSTRUCTION MATERIALS	Well Diagram	Sample depths (m)
0.0	211.04	Ground surface	Flush Mount Well Casing	<p>The well diagram shows a vertical casing starting at the ground surface (0.0m). At approximately 0.3-0.8m depth, there is a cement bentonite seal. The casing is labeled as 50mm dia. PVC pipe with threaded joints. Between 0.8m and 12.7m, the well is backfilled with drill cuttings. At the bottom, between 12.7m and 15.8m, there is another bentonite seal. The water level is indicated by a downward-pointing triangle at 13.66m depth.</p>	
1.0		Med. brown to light-med. grey fine to med. SAND, some f-co gravel moist, lightly compacted	Cement Bentonite seal (0.3-0.8m)		
2.0	208.94				
3.0		Light grey brown m-co SAND some m-co gravel and cobbles moist, lightly compacted Boulder @3.0-3.7m	50mm dia. PVC pipe, with threaded joints		
4.0					
5.0	205.84				
6.0		Grey brown f-m SAND, trace to some m-co gravel and cobbles moist, light to med compacted	Backfill with Drill Cuttings (0.8-12.7m)		
7.0	211.04				
8.0		Grey brown f-co gravelly co SAND moist, lightly compacted			
9.0		Grey brown fine to med. SAND, some m-co gravel, moist, lightly compacted large boulder @7.9m			
10.0					
11.0		Grey brown fine sandy m-co GRAVEL trace to some cobbles and boulders trace silt, dry to moist, light to med. compacted			
12.0					
13.0					
14.0	197.34		Bentonite seal (12.7-15.8m)		
15.0		Grey brown f-m SAND and f-co GRAVEL, trace cobbles, moist, med. compacted			

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WELL LOG OF  
 BOREHOLE MW7

BY: CRK	DATE: DEC 96
APPROVED: 	FIG #: A-1

**HYDROGEOLOGIC LOG**

PURPOSE OF HOLE: MONITORING WELL  
 TYPE OF RIG: BECKER HAMMER  
 DRILLING CONTRACTOR: BECK DRILLING AND ENVIRONMENTAL SERVICES LTD.  
 DATE DRILLED: DEC. 17-18, 1996  
 GROUND ELEVATION (m-asl): 215.85  
 STEEL CASING STICK UP: FLUSH MOUNTED

BOREHOLE:  
**MW8**

ELEV. TOP OF PVC CASE: 215.77 m-asl  
 DEPTH TO WATER: 26.79 m-btoc  
 ELEVATION OF WATER: 188.98 m-asl  
 Note: Water levels were measured on Jan. 8, 97

Depth (m)	Elev. (m-asl)	DESCRIPTION OF LITHOLOGY ENCOUNTERED	WELL CONSTRUCTION MATERIALS	Well Diagram	Sample depths (m)
15.0					
16.0	199.75	cont'd 15.5 Light greyish brown m-co SAND, some m-co gravel, moist, lightly compacted 16.1		<p>50mm dia. PVC pipe, with threaded joints</p> <p>Backfill with Drill Cuttings (4.5-23.5m)</p> <p>Bentonite seal (23.5-26.8m)</p> <p>Sand Filter Pack (26.8-29.9m)</p> <p>50mm dia. PVC screen (28.3-29.9m)</p>	
17.0					
18.0					
19.0		Light greyish brown f-m SAND, tr f-co gravel and cobble, moist, lightly compacted, densely compacted @19.2-20.4m			
20.0					
21.0					
22.0	193.55				
23.0		Light greyish brown, f-m SAND with some silt to f sandy silt, moist, med to densely compacted 24.1			
24.0	191.75				
25.0		Light greyish brown f-co gravelly f-co SAND, tr. silt and cobble, moist, light to med. compacted 25.3			
26.0		Light greyish brown f-m SAND and f-co GRAVEL, some cobbles, moist, med to densely compacted 27.4			
27.0	188.45				
28.0		Light brownish grey m-co GRAVEL, some m-co sand, moist, med to densely compacted 28.9			
29.0	186.95		EC(uS/cm) 591		
		L gr br f-co gr SILT, some m-co sand, wet 29.3	768		
		L gr br m-co SAND, tr. silt, wet, m comp 29.6	865		
30.0		M gr m-co gravelly m-co SAND 29.9	976		
		END OF HOLE 29.9m			

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WELL LOG OF  
 BOREHOLE MW8 (Cont'd)

BY: CRK DATE: DEC 96  
 APPROVED: *[Signature]* FIG #: A-2

**HYDROGEOLOGIC LOG**

PURPOSE OF HOLE: MONITORING WELL  
 TYPE OF RIG: BECKER HAMMER  
 DRILLING CONTRACTOR: BECK DRILLING AND ENVIRONMENTAL SERVICES LTD.  
 DATE DRILLED: DEC. 18, 1996  
 GROUND ELEVATION (m-asl): 220.55  
 STEEL CASING STICK UP: FLUSH MOUNTED

BOREHOLE:

**MW9**

ELEV. TOP OF PVC CASE: 220.49 m-asl  
 DEPTH TO WATER: 20.72 m-btoc  
 ELEVATION OF WATER: 199.77 m-asl  
 Note: Water levels were measured on Jan. 8, 97

Depth (m)	Elev.(m-asl)	DESCRIPTION OF LITHOLOGY ENCOUNTERED	WELL CONSTRUCTION MATERIALS	Well Diagram	Sample depths (m)
0.0	220.55	Ground surface	Flush Mount Well Casing		
1.0		Med. to dark brown f-co GRAVEL, some co sand, tr silt and cobble, damp, light to med compacted 0.9			
2.0		Light grey brown to med grey, m-co SAND and f-co GRAVEL, tr cobble and silt, moist, med to densely compacted boulder @1.2m 3.4			
3.0	217.15				
4.0		Med grey m-co SAND, m-co gravelly to some f-co gravel, trace f sand, silt, and cobble, moist, med to densely compacted 7.0			
5.0					
6.0			50mm dia. PVC pipe, with threaded joints		6.1
7.0	220.55				
8.0		Med. grey, m-co GRAVEL, some m-co sand, tr cobble and silt, moist, light to med compacted 8.2			
9.0	212.35				
10.0		Med grey to light grey brown, m-co SAND, m-co gravelly to some m-co gravel, tr to some silt, tr cobble, med compacted 9.5			
11.0		Med grey f-m GRAVEL, some silty f-co sand, trco gravel, moist, light to med compacted 11.3			
12.0	209.25				
13.0		Grey to brown f-m SAND, some f-m gravel tr silt, moist, med compacted 11.9			
14.0		M grey f-m GRAV, some co grav + cobble, some silty m-co sand, moist, med comp 12.5	Backfill with Drill Cuttings (0.5-19.7m)		11.6
15.0	206.25				
		Light grey brown m-co SAND and f-m GRAVEL, some co grav and cobble tr silt, moist, lightly compacted 14.3			
	205.65				
		L grey brown f-m SAND + m-co GRAVEL 14.9			

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 CONSTRUCTION PROGRAM  
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WELL LOG OF  
 BOREHOLE MW9

BY: CRK	DATE: DEC 96
APPROVED: 	FIG #: A-3

**HYDROGEOLOGIC LOG**

BOREHOLE:

**MW9**

PURPOSE OF HOLE: MONITORING WELL

TYPE OF RIG: BECKER HAMMER

DRILLING CONTRACTOR: BECK DRILLING AND ENVIRONMENTAL SERVICES LTD.

DATE DRILLED: DEC. 18, 1996

ELEV. TOP OF PVC CASE: 220.49 m-asl

GROUND ELEVATION (m-asl): 220.55

DEPTH TO WATER: 20.72 m-btoc

STEEL CASING STICK UP: FLUSH MOUNTED

ELEVATION OF WATER: 199.77 m-asl

Note: Water levels were measured on Jan. 8, 97

Depth (m)	Elev. (m-asl)	DESCRIPTION OF LITHOLOGY ENCOUNTERED	WELL CONSTRUCTION MATERIALS	Well Diagram	Sample depths (m)
15.0					
16.0	204.35	Light grey brown f-m SAND, tr to some f-co gravel and cobble, moist, light to med compacted			
17.0	203.15	Light grey brown m-co GRAVEL, some f-m sand, tr cobble, moist, lightly compacted	50mm dia. PVC pipe, with threaded joints		17.1
18.0	201.95	Light grey brown, f-co SAND, tr f-co grav, moist, lightly compacted			
19.0	199.25	L gr br f-m gravelly m-co SAND, moist, lightly compacted	Backfill with Drill Cuttings (0.5-19.7m)		
20.0		Light grey brown, f-co SAND, some f-co gravel, tr cobble, moist, lightly compacted			
21.0	220.55	Light grey brown f-m SAND, moist, lightly compacted	Bentonite seal (19.7-23.2m)		
22.0	198.25	Med grey f SAND, some silt, damp, med compacted			22.6
23.0			Sand Filter Pack (23.2-26.0m)		
24.0	195.85	Light grey brown, f-m SAND, some f-co gravel, moist to wet, light to med compacted	EC(mS/cm)		
25.0		Med grey, f gravelly m-co SAND to m-co sandy f-co GRAVEL, tr silt and cobble, wet, light to med compacted	2.76		
26.0	220.55		2.94		
27.0		END OF HOLE 26.0m	2.89		
28.0			2.96		
29.0			2.99		
30.0			50mm dia. PVC screen (24.5-26.0m)		26.0

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SECHELT, B.C.

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MONITORING WELL  
CONSTRUCTION PROGRAM  
SECHELT LANDFILL

WELL LOG OF  
BOREHOLE MW9 (Cont'd)

BY: CRK DATE: DEC 96  
APPROVED: *CRK* FIG #: A-3

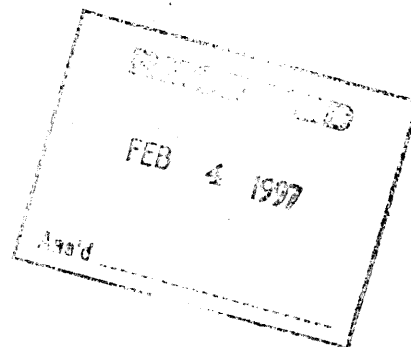
**APPENDIX B**

**CHEMICAL ANALYSIS RESULTS**



# CHEMICAL ANALYSIS REPORT

**Date:** January 29, 1997  
**ASL File No.** G8356  
**Report On:** 1647 Water Analysis



**Report To:** **Piteau Assoc. Engineering Ltd.**  
 215 - 260 West Esplanade  
 North Vancouver, BC  
 V7M 3G7

**Attention:** **Mr. Andy Holmes**

**Received:** January 9, 1997

## ASL ANALYTICAL SERVICE LABORATORIES LTD.

per:

*Andrea Seeley*  
 Andrea Seeley, B.Sc.  
 Project Chemist

*Joyce Chow*  
 Joyce Chow, B.Sc.  
 Project Chemist





**RESULTS OF ANALYSIS - Water**

File No. G8356

		MW7	MW8	MW9
		97 01 08 14:00	97 01 08 12:05	97 01 08 13:15
<hr/>				
<b>Physical Tests</b>				
Conductivity	(umhos/cm)	1420	1150	3740
pH		6.82	6.44	6.57
Turbidity	(NTU)	28500	1650	2930
<b>Dissolved Anions</b>				
Alkalinity-Total	CaCO3	576	454	1250
Chloride	Cl	121	112	298
Sulphate	SO4	26	3	<1
<b>Nutrients</b>				
Ammonia Nitrogen	N	1.38	0.699	127
Total Kjeldahl Nitrogen	N	1.84	0.72	132
Nitrate Nitrogen	N	0.007	0.016	<0.005
Nitrite Nitrogen	N	0.003	0.009	0.018
Total Phosphate	P	0.197	3.20	6.16
<b>Dissolved Metals</b>				
Arsenic	D-As	0.0023	0.0009	0.0099
Barium	D-Ba	0.29	0.05	0.68
Boron	D-B	<0.1	<0.1	<0.1
Cadmium	D-Cd	0.0002	0.0017	<0.0002
Calcium	D-Ca	182	147	329
Iron	D-Fe	0.10	0.07	28.5
Lead	D-Pb	<0.001	<0.001	<0.001
Magnesium	D-Mg	38.0	20.5	43.9
Manganese	D-Mn	4.61	10.3	15.5
Mercury	D-Hg	<0.00005	<0.00005	<0.00005
Potassium	D-K	12	6	27
Sodium	D-Na	75	53	180
<b>Organic Parameters</b>				
Chemical Oxygen Demand	COD	6260	373	809
Dissolved Organic Carbon	C	29.8	92.6	32.0

Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Turbidity (NTU).  
 < = Less than the detection limit indicated.



## **METHODOLOGY**

File No. G8356

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

### **Conventional Parameters in Water**

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

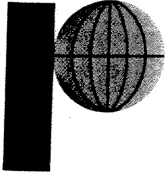
### **Metals in Water**

This analysis is carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005), followed by instrumental analysis by atomic absorption spectrophotometry (EPA Method 7000), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

### **Mercury in Water**

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association. A cold-oxidation procedure involving bromine monochloride is used, followed by instrumental analysis by cold-vapour atomic absorption spectrophotometry (CVAAS).

**End of Report**



**PITEAU ASSOCIATES**

GEOTECHNICAL AND  
HYDROGEOLOGICAL CONSULTANTS

215 - 260 WEST ESPLANADE  
NORTH VANCOUVER, B.C.  
CANADA V7M 3G7  
TELEPHONE (604) 986-8551  
FAX (604) 985-7286

Our file: 2077

December 30, 1999

Sunshine Coast Regional District  
5477 Warf Road  
Sechelt, B.C.  
V0N 3A0

Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

Dear Sirs:

Re: Replacement of Three Monitoring Wells  
Sechelt Landfill, Sunshine Coast Regional District

The Sunshine Coast Regional District (SCRD) operates the Sechelt Landfill, located about 6.5 km northeast of Sechelt (Fig. 1). Three monitoring wells installed on the south side of the landfill were recently destroyed and required replacement. Piteau Associates Engineering Ltd. (Piteau) has expedited and supervised the construction of the three new replacement monitoring wells. The scope of our services for this project included:

- Review of previous well logs, water levels and chemistry to determine the required depth and preferred location of the wells on the southern landfill boundary;
- Coordinating the monitoring well drilling contractor;
- Supervision of well construction program;
- Well development and initial sampling; and
- Preparation of well logs and well completion report.

A description of the work performed and results of the drilling and sampling program are presented herein.

**MONITORING WELL DRILLING AND INSTALLATION**

The monitoring well drilling and installation program was conducted between November 29 and December 1, 1999 by Beck Drilling and Environmental Services Ltd. The three wells were installed using a Becker Hammer drilling rig. All wells were drilled and cased with 102mm (4 inch) I.D. double wall steel casing. Well locations are shown on Fig. 1.

Work was supervised by Mr. Matt Pye of Piteau. While on site, Mr. Pye sited well locations with the assistance of Ms. Kathy Kenny from the SCRD, logged drill cuttings, and kept records of



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

-2- December 30, 1999

drilling progress and monitoring well construction details. Hydrogeological logs and well completion details are shown in Appendix A.

All three wells are located along the southern toe of the landfill footprint, within about 3 to 5m of the property line (Fig. 2). A loader was used to remove a portion of the landfill toe at each well location, to provide access for the drill rig to collar the wells off the north side of the perimeter access road.

#### Monitoring Well MW99-7

Monitoring Well MW99-7 was drilled approximately 68m from the western landfill property line. Drilling encountered the following lithologic profile:

0 to 1.8m	WASTE and FILL materials
1.8 to 8.2m	moist, medium to coarse SAND, some gravel to sand and gravel, trace silt and boulders
8.2 to 10.1m	moist, medium to coarse SAND and GRAVEL, trace silt
10.1 to 13.0m	dry, fine to medium SAND, some gravel, trace to some silt and boulders
13.0 to 14.6	moist, fine to medium SAND, some silt to silty, some gravel and trace boulders
14.6 to 18.6m	moist, well-graded, SAND, some gravel, trace to some silt; a large boulder was encountered from 16.5 to 17.0m
18.6 to 19.2m	wet sandy SILT, trace clay
19.2 to 19.5m	dry, dense, bouldery TILL

#### Monitoring Well MW99-8

Monitoring Well MW99-8 was located roughly in the middle of the southern property line, approximately 257m from the western landfill property line (Fig. 2). Drilling encountered the following:

0 to 1.2m	WASTE and FILL materials
1.2 to 11.3m	moist to wet, medium to coarse SAND to SAND and GRAVEL, trace silt
11.3 to 14.0m	dry, well graded SAND to SAND and GRAVEL, occasional boulders
14.0 to 20.4m	moist to dry, fine to coarse SAND, some gravel
20.4 to 21.6m	wet, fine to medium silty SAND
21.6 to 22.3m	dense TILL
22.3 to 29.0m	moist becoming wet, medium to coarse SAND to well graded SAND and GRAVEL, trace silt; saturated below 28.0m.



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

-3- December 30, 1999

### Monitoring Well MW99-9

Monitoring Well MW99-9 was located near the southeast corner of the property, approximately 400m from the western landfill property line (Fig. 2). Sediments encountered during drilling consisted of the following:

0 to 1.8m	WASTE and FILL materials
1.8 to 7.0m	moist to wet, medium to coarse SAND and GRAVEL, some boulders
7.0 to 10.4m	wet, gravelly SAND
10.4 to 15.9m	slightly moist, well graded SAND and GRAVEL, trace to some silt and boulders
15.9 to 20.4m	moist, fine to coarse SAND, some gravel
20.4 to 22.0m	dry, fine to medium SAND and GRAVEL, trace to some silt, boulders
22.0 to 25.9m	wet, medium to coarse gravelly SAND, trace silt

All well screens were set over the bottom 1.52m (5 ft) of the drilled holes. A sand filter pack was placed around the screens from the bottom of the hole to 3 to 3.5m above the top of the screens. A bentonite seal, ranging from 4.2 to 4.5m thick, was then placed above the sand pack. The holes were then backfilled with drill cuttings to just below grade, where a second bentonite seal was placed from 0.9 to 0.3m depth. A 1.5m steel surface casing was set in the bentonite from about 0.6 to 0.3m depth followed by concrete to ground surface. The wells were left with an approximate stick-up of 0.9m. Details of the well completions are shown graphically on the well logs (Appendix A).

The wet sediments encountered during the drilling of Monitoring Well MW99-7 did not produce any water and the piezometer was dry two days after it had been installed. Therefore, an attempt was made to drill a deeper well approximately 2m away. This second attempt encountered a similar dense bouldery till at about 18.3m depth. The Becker Hammer met refusal at this depth, as it was only able to penetrate 0.15m after 40 minutes of drilling at 90 blows/minute. A second piezometer was not installed at this location since the first hole reached a greater depth and would be more likely to intercept groundwater during peak water table conditions.

### WELL DEVELOPMENT AND SAMPLING

Monitoring Well MW99-7 was dry at the time of the drilling program but it will possibly contain water in the late winter, following the winter precipitation.

Monitoring wells MW99-8 and MW99-9 were developed and sampled on December 1, 1999. The purge volume required to develop the wells was calculated as seven well volumes, based on water level measurements taken that day. However, it will only be necessary to purge three standing water columns during subsequent sampling of these wells.



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

-4- December 30, 1999

Water was withdrawn using Waterra foot valves on high density polyethylene tubing. These foot valves are operated simply by moving the tubing up and down inside the piezometer pipe. Once purging was complete, the appropriate sample containers were filled. The dissolved metals samples were filtered in the field and preserved with nitric acid. The COD, ammonia and organic carbon sample was preserved with hydrochloric acid. Disposable latex gloves were used during the sampling procedure.

Samples were placed in a cooler with ice, and were delivered to Analytical Services Laboratories Ltd. of Vancouver on December 2, 1999.

### **INTERPRETED GROUNDWATER FLOW REGIME**

The basal groundwater flow regime (i.e. flow along the bedrock surface) beneath the site is interpreted to flow in a south to southwesterly direction (Fig. 1). Perched flows appear to be present on layers of low permeability sediments above the basal flow regime (Figs. 3 and 4), but over significant distances, these flows would eventually percolate down to the deeper sediments.

A test well, drilled at the approximate location shown on Fig. 1, encountered bedrock at about 120m elevation, with no indication of a water table (Piteau Associates Engineering Ltd., 1999). This information suggests that the groundwater will concentrate along low points in the bedrock surface and flow in the direction of the bedrock surface gradient. Bedrock will therefore control the flow direction. The possible range of flow directions is indicated on Fig. 1.

Most of the monitoring wells surrounding the Sechelt Landfill appear to encounter perched water tables. Deeper wells typically encounter deeper water tables, indicative of a strong downward hydraulic gradient. Leachate seeping from the landfill is therefore interpreted to migrate vertically through the layered sediments beneath the site, with some minor lateral flow to the west or south on the lower permeability layers. Ultimately, the leachate will seep to the basal sediment layer, and then flow in a southerly direction towards Chapman Creek, or in a westerly direction towards Trail Bay, or possibly to the head of Porpoise Bay.

There appears to be a relatively continuous perched flow regime at about elevation 210m, which displays a gradient towards the west-southwest (see posted heads on Fig. 2). This flow is interpreted to seep to depth as it moves away from the landfill, and should eventually reach the basal flow regime perched on the bedrock surface.

A water depth of 8.0m was measured in the shallow piezometer MW-6, located about 40m east of MW99-7, on November 30, 1999. Wet sediments were also seen in monitoring wells MW99-8 and MW99-9 at depths between 5 and 10m. These observations indicate the presence of some

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\* Piteau Associates Engineering Ltd., 1999. Letter to Mr. Apris Berzins at Dayton & Knight Ltd., regarding Sunshine Coast Aquifer Protection Plan, Monitoring Well Update, Jan. 19, 8p.



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

-5- December 30, 1999

shallow perched groundwater flow south of the landfill, but as noted above, this shallow groundwater is expected to seep to depth within a relatively short distance of the landfill.

### **SAMPLING RESULTS**

There have been two suites of chemical analyses performed on samples collected from deep monitoring wells installed south of the landfill. The first suite was performed on samples collected from the three destroyed wells, MW-7, MW-8 and MW-9, on January 8, 1997 (Table I). The second suite of samples was collected on December 1, 1999 from the replacement wells constructed as a part of this study (Table II). The general characteristics of the samples collected in 1999 are similar to those collected 1997, but the concentrations of most parameters are slightly lower. This may indicate that the first seasonal flush, which likely conveys the largest leachate component, had not yet reached the depth of the wells at the time of the 1999 sampling event.

The results of the two sampling suites indicate that groundwater beneath the south landfill perimeter has been significantly impacted by leachate. COD, manganese, EC and chloride concentrations are elevated in all samples collected from the three wells. Manganese concentrations exceed the aesthetic drinking water objective (AO) of 0.05 mg/L (Health & Welfare, 1996) in all samples collected to date, and chloride concentration exceeded the AO of 250 mg/L in the 1997 sample from MW-9.

The total nitrogen concentrations levels are low (<2 mg/L) in samples collected from MW-7, MW-8 and MW99-8. However, ammonia concentrations were very high in the sample collected from MW-9, and were elevated in the sample collected from MW99-9. The high ammonia and low nitrate concentrations indicate that very little nitrification is occurring in the unsaturated zone beneath the east end of the landfill, suggesting a fairly rapid infiltration rate to the water table. Conditions may be more favourable for subsurface renovation of leachate beneath the western portions of the landfill, as the sampling results indicate that water quality is generally better in MW-7, MW-8 and MW99-8 (west end of the landfill) than in MW-9 and MW99-9 (east end of the landfill). The differences in water quality may also be the result of waste partitioning within the landfill. If different types of waste have been placed in separate zones, then the resulting leachate generated from the separate zones will have different properties. Monitoring well chemistry data will reflect the leachate generated upgradient of the well locations.

### **RECOMMENDATIONS**

Water level measurements and water quality sampling should continue on a bi-monthly or quarterly schedule, to properly define the leachate impact and groundwater flow regime on the south side of the landfill. Two suites of samples, collected in the late summer or early fall and again in mid winter, should be submitted for a detailed chemical analysis, and the remaining



Sunshine Coast Regional District  
Attention: Ms. Cathy Kenny  
Solid Waste Management Co-ordinator

-6- December 30, 1999

samples should be submitted for a reduced suite. A suggested list of parameters for both the detailed and reduced suites are included as Table III.

Water levels should be measured prior to purging and sampling. The new wells should be purged by removing three well volumes prior to sample collection. A Waterra foot valve on high density polyethylene tubing has been dedicated to each of the wells for use during sampling.

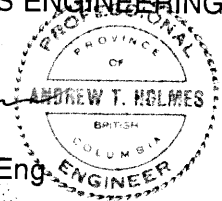
We trust this report presents the information you require regarding the recent construction of the three new monitoring wells at the Sechelt Landfill, and recommendations for sampling. If you have any further questions regarding this report, or require any additional assistance with the regular monitoring program, please contact us.

Yours truly,

PITEAU ASSOCIATES ENGINEERING LTD.

  
ANDREW T. HOLMES

Andrew T. Holmes, P.Eng.





Matthew D. Pye, E.I.T.

MDP/bms

Att.

**TABLES**

**TABLE I**  
**SUMMARY OF LABORATORY CHEMISTRY DATA**  
**FOR DESTROYED AND REPLACEMENT MONITORING WELLS**

Parameter	Units/ Symbols	MW-7 8-Jan-97	MW-8 8-Jan-97	MW99-8 1-Dec-99	MW-9 8-Jan-97	MW99-9 1-Dec-99	GCDWQ	
							Maximum Acceptable	Objective
<b>Physical Tests</b>								
pH-Field		6.69	6.92		6.63		6.5-8.5	-
EC-Field	uS/cm	1190	940		3080		-	-
Temp-Field	°C	11.9	10.6		10.7		-	-
Colour-Field		m grey/br	lt grey/br		m grey/br		-	-
Odour-Field		none	none		faint		-	-
pH-Lab		6.82	<b>6.44</b>	<b>7.52</b>	6.57	<b>7.48</b>	6.5-8.5	-
EC-Lab	umhos/cm	1420	1150	1240	3740	2040	-	-
Turbidity	NTU	<b>28500</b>	<b>1650</b>	<b>9300</b>	<b>2930</b>	<b>1780</b>	5	-
<b>Dissolved Anions (mg/L)</b>								
Alkalinity	CaCO <sub>3</sub>	576	454	598	1250	1030	-	-
Chloride	Cl	121	112	94.2	<b>298</b>	151	250	250
Sulphate	SO <sub>4</sub>	5.7	6.7	7	4.1	2	500	500
<b>Dissolved Cations (mg/L)</b>								
Calcium	Ca	182	147	140	329	232	-	-
Magnesium	Mg	38.0	20.5	22.0	43.9	32.8	-	-
Potassium	K	12	6	8	27	14	-	-
Sodium	Na	75	53	90	180	150	-	-
<b>Dissolved Metals (mg/L)</b>								
Arsenic	As	0.0023	0.0009	0.0003	0.0099	0.0067	0.025	0.005
Barium	Ba	0.29	0.05	0.05	0.68	0.15	1	0.1
Boron	Ba	<0.1	<0.1	0.2	<0.1	<0.1	5	0.01
Cadmium	Cd	0.0002	0.0017	0.0003	<0.0002	<0.0002	0.005	0.001
Iron	Fe	0.10	0.07	<0.03	<b>28.5</b>	<0.03	0.3	0.05
Lead	Pb	<0.001	<0.001	<0.001	0.002	<0.001	0.01	0.001
Manganese	Mn	<b>38.0</b>	<b>20.5</b>	<b>6.78</b>	<b>43.9</b>	<b>7.94</b>	0.05	0.01
Mercury	Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.001	0.0002
<b>Nutrients (mg/L)</b>								
Nitrate	N	0.0070	0.0160	<0.005	<0.005	0.0090	10	0.001
Nitrite	N	0.003	0.009	0.005	0.018	0.005	1	0.001
Ammonia Nitrogen	N	1.38	0.70	0.34	<b>127</b>	<b>17.4</b>	-	-
Total Kjeldahl Nitrogen	N	1.84	0.72	1.17	<b>132</b>	<b>17.4</b>	-	-
Total Phosphate	P	0.197	3.2	7.88	6.16	1.96	-	-
<b>Pollutant Tests (mg/L)</b>								
Chemical Oxygen Demand	COD	6260	373	100	809	112	-	-
Dissolved Organic Carbon	C	29.8	92.6	9.7	32.0	24.7	-	-

**NOTES:**

1. < = Less than detection limit
2. GCDWQ = Guideline for Canadian Drinking Water Quality
3. Bolding indicates those parameters that exceed GCDWQ criteria, or which are cause for concern.

**TABLE II**  
**RECOMMENDED WATER QUALITY ANALYSIS SUITES**



Analytes for detailed suite (Twice per year)	Analytes for reduced suite (Two to four times per year)
<b>Physical Tests</b> pH-Field EC-Field Temp-Field Colour-Field Odour-Field pH-Lab EC-Lab Turbidity	<b>Physical Tests</b> pH-Field EC-Field Temp-Field Colour-Field Odour-Field pH-Lab EC-Lab Turbidity
<b>Dissolved Anions (mg/L)</b> Alkalinity Chloride Sulphate	<b>Dissolved Anions (mg/L)</b> Chloride
<b>Dissolved Cations (mg/L)</b> Calcium Magnesium Potassium Sodium	<b>Nutrients (mg/L)</b> Nitrate Ammonia
<b>Dissolved Metals (mg/L)</b> Arsenic Barium Boron Cadmium Iron Lead Manganese Mercury	
<b>Nutrients (mg/L)</b> Nitrate Nitrite Ammonia Nitrogen Total Kjeldahl Nitrogen Total Phosphate	
<b>Pollutant Tests (mg/L)</b> Chemical Oxygen Demand Dissolved Organic Carbon	

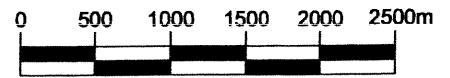
**FIGURES**

DWG NUMBER: 2077-001.CDR



**SYMBOLS**

-  INTERPRETED RANGE FOR GROUNDWATER FLOW DIRECTION
-  1998 TEST WELL LOCATION (PITEAU, 1999)



SCALE 1:50000

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SUNSHINE COAST REGIONAL DISTRICT



**PITEAU ASSOCIATES**  
 GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS  
 VANCOUVER CALGARY

MONITORING WELL  
 CONSTRUCTION PROGRAM  
 SECHULT LANDFILL  
 SECHULT, B.C.

**LANDFILL LOCATION PLAN**

BY:	DATE:
ATH/cz	DEC. 99
APPROVED:	FIG:
	1

MW-1(SITE1)  
TOP OF CASING ELEV.=213.36m  
GROUND ELEV.=212.32m, GW ELEV.=210.22m

MW-1A(SITE2)  
TOP OF CASING ELEV.=213.42m  
GROUND ELEV.=212.32m, GW ELEV.=209.39m

MW-4A(SITE7)  
TOP OF CASING ELEV.=219.79m  
GROUND ELEV.=219.04m, GW ELEV.=217.12m

MW-4(SITE6)  
TOP OF CASING ELEV.=219.85m  
GROUND ELEV.=219.04m, GW ELEV.=213.46m

MW-2(SITE3)  
TOP OF CASING ELEV.=213.94m  
GROUND ELEV.=212.22m, GW ELEV.=208.71m

MW-2A(SITE4)  
TOP OF CASING ELEV.=214.02m  
GROUND ELEV.=213.62m, GW ELEV.=208.71m

MW-3(SITE5)  
TOP OF CASING ELEV.=211.30m  
GROUND ELEV.=210.343m, GW ELEV.=208.83m

MW99-7  
TOP OF CASING ELEV.=212.33m  
GROUND ELEV.~211.5m, GW ELEV.<192.33m

MW-6  
TOP OF CASING ELEV.=212.82m  
GROUND ELEV.=212.20m, GW ELEV.=204.20m (TRANSIENT PERCHED WATERTABLE)

MW99-8  
TOP OF CASING ELEV.=216.93m  
GROUND ELEV.~216.0m, GW ELEV.=188.53m

MW99-9  
TOP OF CASING ELEV.~220.9m  
GROUND ELEV.~220m, GW ELEV.~198.3m

MW-5(SITE8)  
TOP OF CASING ELEV.=223.20m  
GROUND ELEV.=222.12m, GW ELEV.=209.32m

GP-3

GP-2

GP-1

GP-6

GP-5

GP-4

MW-7  
TOP OF CASING ELEV.=211.01m  
GROUND ELEV.=211.04m, GW ELEV.=197.35m

MW-8  
TOP OF CASING ELEV.=215.77m  
GROUND ELEV.=215.85m, GW ELEV.=188.98m

MW-9  
TOP OF CASING ELEV.=220.49m  
GROUND ELEV.=220.55m, GW ELEV.=199.77m

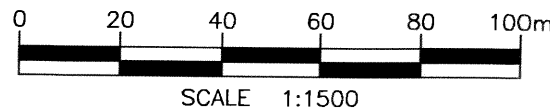
**LEGEND**

- ⊕ GROUNDWATER MONITORING WELL (INSTALLED IN JUL. 1993)
- ⊕ GAS PROBES (INSTALLED IN SEP. 1994)
- ⊕ GROUNDWATER MONITORING WELL (INSTALLED IN DEC. 1996 AND NOV. 1999 BY PITEAU ASSOCIATES)
- PERCHED WATERTABLE CONTOUR
- DEEP WATERTABLE CONTOUR
- GW ELEV.=213.46m ELEVATION OF PERCHED WATERTABLE
- GW ELEV.=188.98m ELEVATION OF DEEP WATERTABLE
- GENERAL DIRECTION OF GROUNDWATER FLOW
- × FENCE
- ROAD
- ↑↑ GEOLOGICAL SECTION (SEE FIGS. 3 AND 4)



LANDFILL

NOTE: ELEVATION + 0.27m = GEODETIC



- NOTES:**
1. SITE PLAN MODIFIED FROM DAYTON & KNIGHT SITE PLAN.
  2. GROUNDWATER ELEVATIONS MEASURED ON JAN. 8, 1997, AND DEC. 1, 1999.

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SUNSHINE COAST REGIONAL DISTRICT

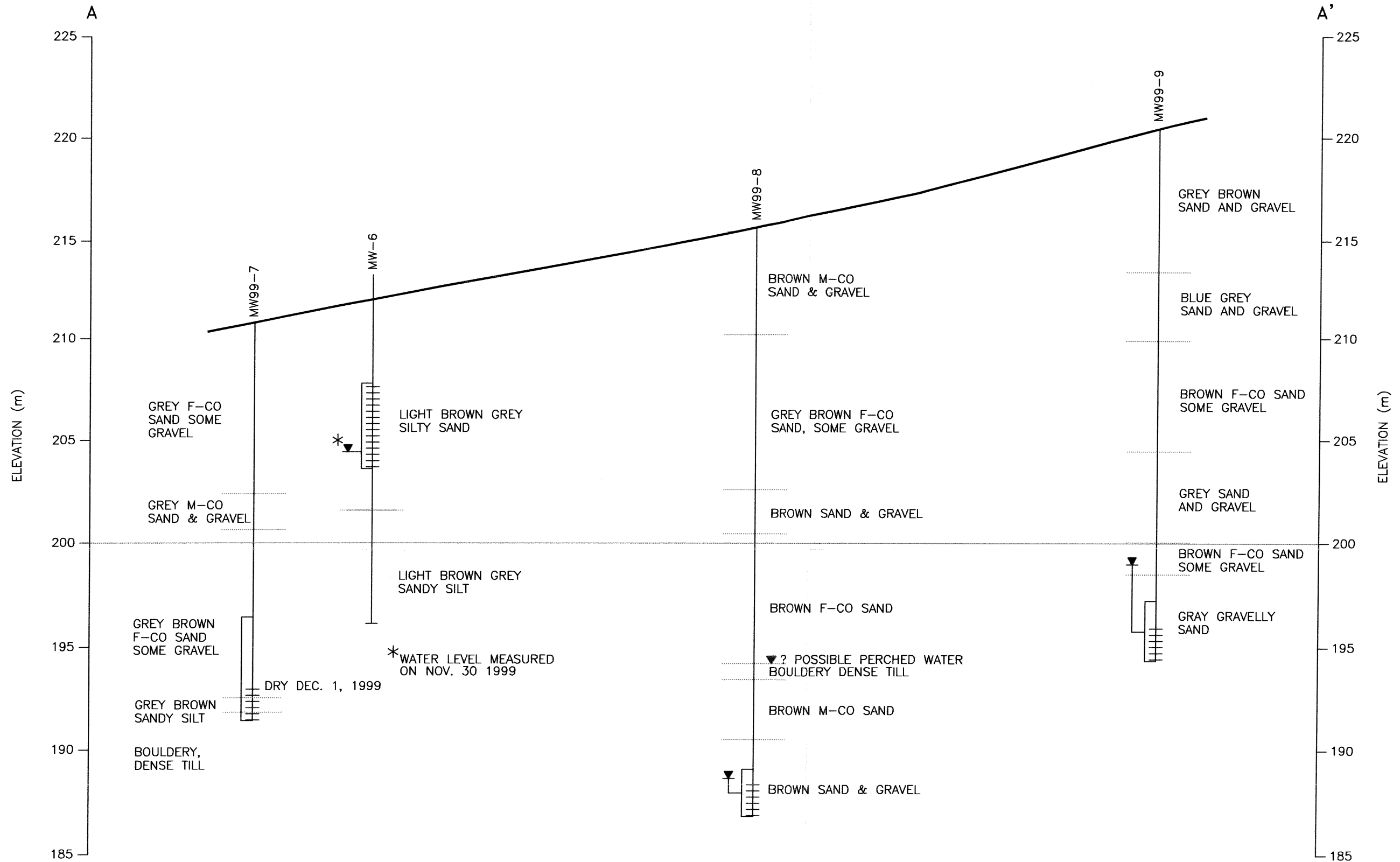


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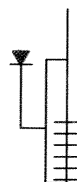
MONITORING WELL  
CONSTRUCTION PROGRAM  
SECHLT LANDFILL  
SECHLT, B.C.

**SITE PLAN**

BY:	DATE:
MDP/AB	FEB. 2000
APPROVED:	FIG:
<i>[Signature]</i>	2



**LEGEND**



MONITORING WELL WITH  
COMPLETION INTERVAL,  
AND WATER LEVEL MEASURED  
ON DEC. 1 1999

HORIZONTAL SCALE 1:1500  
VERTICAL SCALE 1:200  
VERTICAL EXAGGERATION = 7.5x

NOTE: WATER LEVELS MEASURED ON DEC. 1 1999

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SUNSHINE COAST REGIONAL DISTRICT

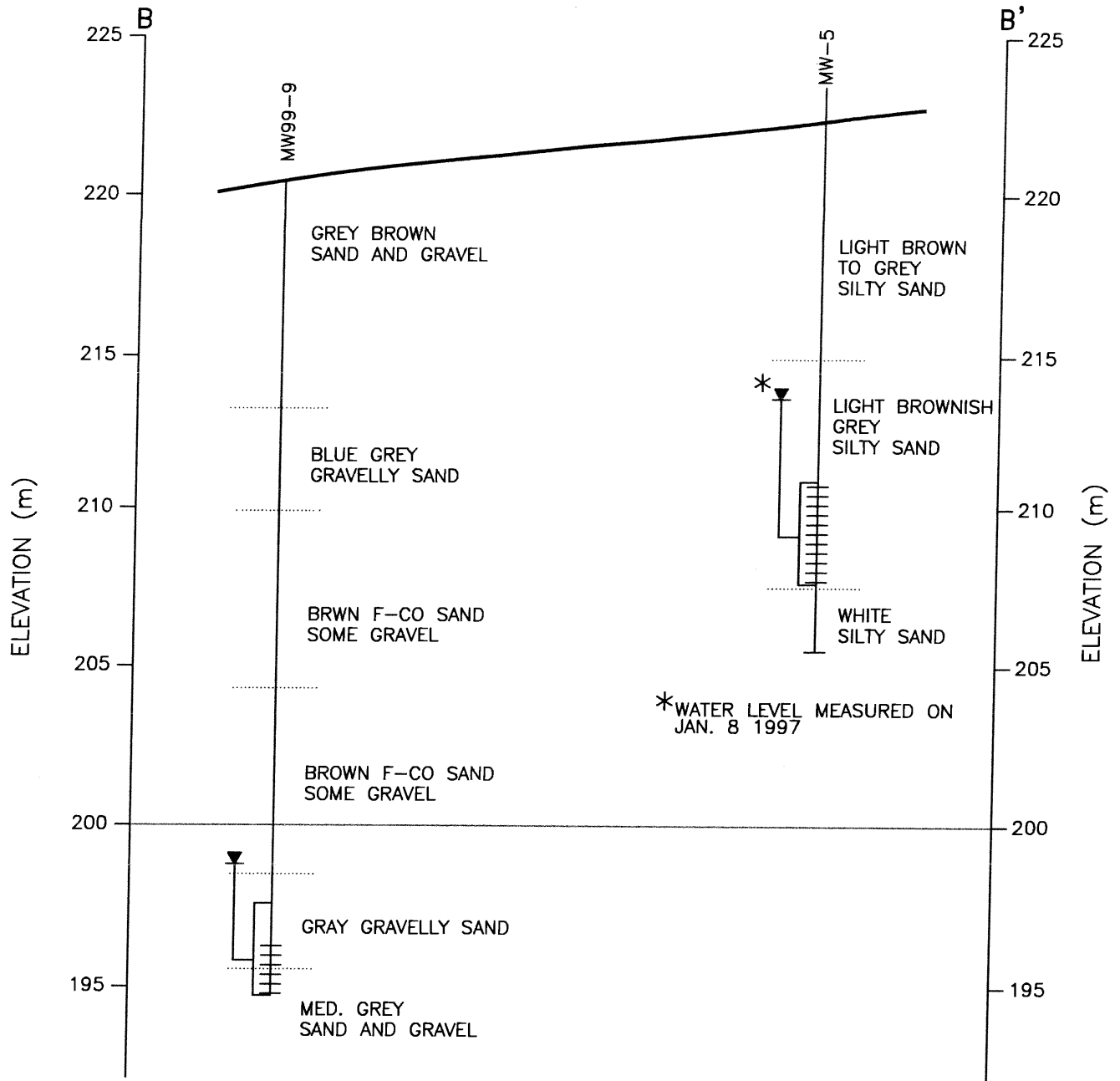


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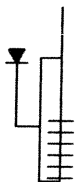
MONITORING WELL  
CONSTRUCTION PROGRAM  
SECHLT LANDFILL  
SECHLT, B.C.

**SECTION A-A'**

BY:	DATE:
MDP/cz	DEC. 99
APPROVED:	FIG:
<i>[Signature]</i>	3



**LEGEND**



MONITORING WELL WITH COMPLETION INTERVAL, AND WATER LEVEL MEASURED ON DEC. 1 1999

HORIZONTAL SCALE 1:1500  
 VERTICAL SCALE 1:200  
 VERTICAL EXAGGERATION = 7.5x

NOTE: WATER LEVELS MEASURED ON DEC. 1 1999

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SUNSHINE COAST REGIONAL DISTRICT



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 VANCOUVER CALGARY

MONITORING WELL  
 CONSTRUCTION PROGRAM  
 SECHLT LANDFILL  
 SECHLT, B.C.

**SECTION B-B'**

BY:	DATE:
MDP/cz	DEC. 99
APPROVED:	FIG:
<i>[Signature]</i>	4

**APPENDIX A**

**WELL LOGS**



SUNSHINE COAST REGIONAL DISTRICT  
 SECHULT LANDFILL  
 MONITORING WELL INSTALLATION

Date Completed : 11/29/99  
 Hole Diameter : 0.17  
 Drilling Method : Becker Hammer  
 Sampling Method : Cyclone  
 Field Engineer : M. Pye

Project Engineer : A.T. Holmes  
 Driller : Beck Drilling  
 Water Level (Date) : dry (11/30/99)

Depth in Meters	GRAPHIC	DESCRIPTION	REMARKS	Well: MW99-7 Elev.:
0		Brown, SAND, some gravel with waste material (fill). 1.8m		Surface Casing Cement to 0.3m Bentonite to 0.9m
5		Grey, medium to coarse SAND, some gravel, trace silt and boulders, moist. 8.2m		Cuttings
10		Grey, medium to coarse SAND and GRAVEL, trace silt, moist. 10.1m		50mm PVC Riser
15		Grey, fine to medium SAND, some gravel, trace to some silt and boulders, dry. 13.0m		10.1m
		Grey/brown, fine to medium, SAND, some silt to silty, some gravel, trace boulders, very slightly moist. 14.6m		Bentonite
		Brown, well-graded SAND, some gravel and silt, trace clay, moist. 16.5m		14.3m
		Boulders. 17.0m		10/20 Filter Sand
		Brown, well-graded SAND, some gravel, trace to some silt, moist. 18.6m		18.0m
		Grey, sandy SILT, trace clay, wet. 19.2m		Slotted PVC Screen
20		Bouldery, dense TILL. End of Hole at 19.5m		19.5m

12-03-1999 g:\project\207\logs\mw99-7 bor



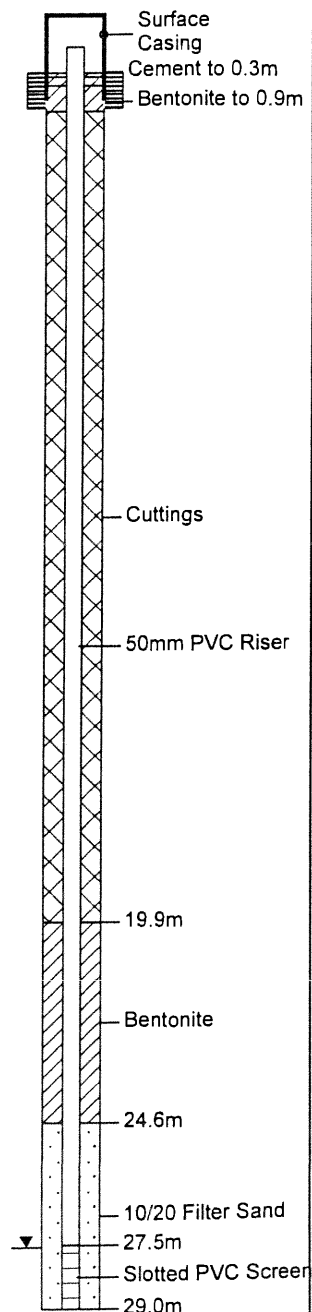
SUNSHINE COAST REGIONAL DISTRICT  
 SECHELT LANDFILL  
 MONITORING WELL INSTALLATION

Date Completed : 11/30/99  
 Hole Diameter : 0.17  
 Drilling Method : Becker Hammer  
 Sampling Method : Cyclone  
 Field Engineer : M. Pye

Project Engineer : A.T. Holmes  
 Driller : Beck Drilling  
 Water Level (Date) : 28.405m tPVC (12/01/99)

Depth in Meters	GRAPHIC	DESCRIPTION	REMARKS
0		Brown, SAND, some gravel with waste material (fill). 1.2m	Purged and sampled well on 12/01/99.
		Brown, medium to coarse SAND and GRAVEL, moist. 2.1m	
		Grey, medium to coarse SAND and GRAVEL, moist to wet. 4.0m	
		Brown/grey, coarse SAND and GRAVEL, wet. 5.2m	
5		Grey, well-graded SAND, some gravel, trace to some silt, wet. 6.9m	
		Brown, medium to coarse SAND, trace to some gravel, trace silt, moist. 11.3m	
		Brown, well-graded SAND, some gravel and boulders, dry. 13.1m	
		Brown, well graded SAND and GRAVEL, dry. 14.0m	
		Brown, silty SAND and GRAVEL, wet. 14.9m	
15		Brown, fine to medium SAND, some gravel, moist. 16.2m	
		Brown, medium to coarse SAND, dry. 20.4m	
20		Brown, fine to medium, silty SAND, wet. 21.6m	
		Bouldery, dense TILL. 22.3m	
		Brown, medium to coarse SAND, trace gravel, slightly moist. 25.3m	
25		Brown, well-graded SAND and GRAVEL, trace silt and boulders, slightly moist. 28.0m	
		Brown, coarse SAND and GRAVEL, some fine sand, trace silt, wet. End of Hole at 29.0m	

Well: MW99-8  
 Elev.:





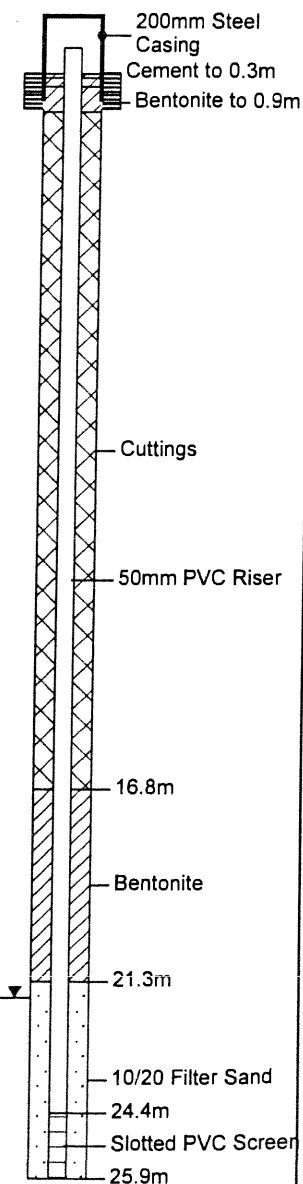
SUNSHINE COAST REGIONAL DISTRICT  
 SECHelt LANDFILL  
 MONITORING WELL INSTALLATION

Date Completed : 11/30/99  
 Hole Diameter : 0.17  
 Drilling Method : Becker Hammer  
 Sampling Method : Cyclone  
 Field Engineer : M. Pye

Project Engineer : A.T. Holmes  
 Driller : Beck Drilling  
 Water Level (Date) : 22.580m tPVC (12/01/99)

Depth in Meters	GRAPHIC	DESCRIPTION	REMARKS
0		Brown, SAND, some gravel with waste material (fill).	Purged and sampled well on 12/01/99.
1.8m		Grey/brown, medium to coarse SAND and GRAVEL, some boulders, moist.	
3.7m		Blue/grey, coarse SAND and GRAVEL, wet.	
5		Blue/grey, gravelly SAND, wet.	
7.0m		Blue/grey, gravelly SAND, wet.	
10		Grey, well-graded SAND and GRAVEL, trace to some silt, trace boulders, slightly moist.	
10.4m		Brown, medium to coarse SAND, some gravel, moist.	
15		Brown, fine to medium SAND, some gravel, slightly moist.	
15.9m		Grey, fine to medium SAND and GRAVEL, trace to some silt, trace boulders, dry.	
19.2m		Grey/brown, medium to coarse, gravelly SAND, trace silt, saturated.	
20		Grey/brown, medium to coarse, gravelly SAND, trace silt, saturated.	End of Hole at 25.9m
20.4m			
22.0m			
25			
25.9m			
30			

Well: MW99-9  
 Elev.:



**APPENDIX B**

**CHEMICAL ANALYSIS RESULTS**



## CHEMICAL ANALYSIS REPORT

---

**Date:** December 17, 1999

**ASL File No.** L3049

**Report On:** Water Analysis  
2077

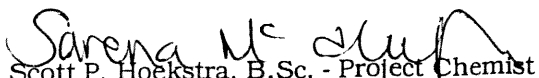
**Report To:** **Piteau Assoc. Engineering Ltd.**  
215 - 260 West Esplanade  
North Vancouver, BC  
V7M 3G7

**Attention:** **Mr. Ryan Martin**

**Received:** December 2, 1999

---

**ASL ANALYTICAL SERVICE LABORATORIES LTD.**  
per:

  
Scott P. Hoekstra, B.Sc. - Project Chemist  
Sarena McHugh, B.Sc. - Project Chemist



**RESULTS OF ANALYSIS - Water**

File No. L3049

Sample ID MW99-8 MW99-9

**Physical Tests**

Conductivity	(umhos/cm)	1240	2040
pH		7.52	7.48
Turbidity	(NTU)	9300	1780

**Dissolved Anions**

Alkalinity-Total		CaCO3	598	1030
Chloride	Cl		94.2	151
Sulphate	SO4		7	2

**Nutrients**

Ammonia Nitrogen		N	0.34	17.4
Total Kjeldahl Nitrogen		N	1.17	17.4
Nitrate Nitrogen		N	<0.005	0.009
Nitrite Nitrogen		N	0.005	0.005
Total Phosphate		P	7.88	1.96

**Dissolved Metals**

Arsenic	D-As		0.0003	0.0067
Barium	D-Ba		0.05	0.15
Boron	D-B		0.2	<0.1
Cadmium	D-Cd		0.0003	<0.0002
Calcium	D-Ca		140	232
Iron	D-Fe		<0.03	<0.03
Lead	D-Pb		<0.001	<0.001
Magnesium	D-Mg		22.0	32.8
Manganese	D-Mn		6.78	7.94
Mercury	D-Hg		<0.00005	<0.00005
Potassium	D-K		8	14
Sodium	D-Na		90	150

**Organic Parameters**

Chemical Oxygen Demand		COD	100	112
Dissolved Organic Carbon C			9.7	24.7

Results are expressed as milligrams per litre except where noted.  
< = Less than the detection limit indicated.



## METHODOLOGY

File No. L3049

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

### **Conventional Parameters in Water**

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

### **Metals in Water**

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

### **Mercury in Water**

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic absorption spectrophotometry (EPA Method 7470A/7471A).

Recommended Holding Time:



**METHODOLOGY (cont'd)**

File No. L3049

Sample: 28 days  
Reference: EPA  
For more detail see: ASL "Collection & Sampling Guide"

**End of Report**



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation  
**Client:** Sunshine Coast Regional District  
**Location:** Sechelt Landfill

**LOG OF GAS PROBE: GP13-01**

**Driller:** Mud Bay Drilling Co. Inc,  
**Drill Method:** Sonic Drilling Rig  
**Sample Method:** N/A

**Borehole Diameter:** 20 cm  
**Start Date:** Sept. 12, 2013  
**Completed:** Sept. 12, 2013

**Checked By:** ML  
**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Conc (ppm)	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
0						Ground Surface	0.0		
0						<b>Rock</b>	-0.3		
2						<b>Silty Sand and Gravel</b> with some cobbles, compact, coarse grained, brown, moist.	-1.8		Concrete Cast Iron Flushmount Casing
4						<b>Sandy Silt</b> with some gravel and cobbles, non-plastic, compact, coarse grained, brown, moist.	-2.7		Bentonite Seal
6						<b>Sandy Gravel</b> with some cobbles, compact, coarse grained, brown, dry.	-4.9		Pea Gravel 2 cm dia. PVC Riser Bentonite Seal
10									
12									
14									
16									
18						End of Borehole			Pea Gravel 2 cm dia. Perforated PVC Screen Bentonite Seal
20									

Groundwater Elevation: 0  
 T.O.P Elevation: 0  
 Ground Surface Elevation: 0

Screening Tool: N/A

Monitoring Well Log  
 For Environmental Purposes Only



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF GAS PROBE: GP13-02**

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 12, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 12, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Conc (ppm)	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
0						Ground Surface	0.0		
0						<b>Gravelly Sand</b> with some cobbles, compact, coarse grained, brown, dry.	-0.3	<p>Concrete Bentonite Seal Cast Iron Flushmount Casing Bentonite Seal Pea Gravel 2 cm dia. PVC Riser Bentonite Seal Pea Gravel 2 cm dia. Perforated PVC Screen</p>	
2					<b>Silty Sand and Gravel</b> with some cobbles, compact, coarse grained, brown, moist.	-1.8			
4					<b>Sandy Silt</b> with some gravel and cobbles, non- plastic, compact, coarse grained, brown, moist.	-2.7			
6					<b>Sandy Gravel</b> with some cobbles, compact, coarse grained, brown, dry.	-4.9			
10						End of Borehole			
12									
14									
16									
18									
20									

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 1 of 1



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-01

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 9, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 10, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
0						Ground Surface	0.0		
0						<b>Gravelly Sand</b> with some cobbles, loose, coarse grained, brown, moist.	-0.8	<p>Soil Cuttings Cast Iron Flushmount Casing Bentonite 5 cm dia. PVC Riser</p>	
2						<b>Asphalt</b>	-1.2		
4						<b>Sandy Gravel</b> loose, coarse grained, brown, moist.	-3.0		
6						<b>Gravelly Sand</b> with cobbles and boulders, compact, coarse grained, greyish brown, dry.	-3.4		
8						<b>Gravelly Sand</b> with some boulders, compact, coarse grained, brown, slightly moist.	-4.3		
10						<b>Gravel</b> with some sand, compact, coarse grained, brown, slightly moist.	-4.9		
12						<b>Gravel</b> with some sand, cobbles, and boulders, compact, coarse grained, grey, wet.	-8.2		
14						<b>Silty Clayey Gravel</b> with some cobbles and sand, non-plastic, dense, coarse grained, grey, moist.	-9.8		
16						<b>Silty Gravel</b> with some cobbles, non-plastic, compact, coarse grained, brown, moist to wet.	-11.4		
18									
20									
22									
24									
26									
28									
30									
32									
34									
36									
38									
40									

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 1 of 3



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-01

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 9, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 10, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
42						<b>Sand</b> with some silt, clay, and cobbles, compact, coarse grained, grey, dry.	-12.5		
44						<b>Sandy Gravel</b> with some cobbles and boulders, compact, coarse grained, grey, moist.			
46	14								
48									
50									
52	16								
54									
56							-17.1		
58						<b>Sandy Gravel</b> with some silt, compact, medium grained, grey, moist.			
60	18								
62						<b>Gravel</b> with some sand and cobbles, compact, coarse grained, grey, moist.			
64									
66	20								
68						<b>Sand</b> with some gravel, compact, coarse grained, grey, moist.			
70							-20.4		
72	22					<b>Gravel</b> with sand, compact, coarse grained, grey, moist.			
74									
76							-21.6		
78	24					<b>Gravelly Sand</b> with boulders, loose, coarse grained, wet.			
80							-23.2		

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 2 of 3



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-01

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 9, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 10, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
82									
84									
86	26						-26.2		
88						End of Borehole			
90									
92	28								
94									
96									
98	30								
100									
102									
104	32								
106									
108									
110									
112	34								
114									
116									
118	36								
120									

Filter Sand Pack  
5 cm dia PVC 10 Slot Screen

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log  
For Environmental Purposes Only

Ground Surface Elevation: 0

Sheet: 3 of 3



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-02

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 10, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 10, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
0						Ground Surface	0.0		
2						<b>Gravel</b> with some sand and boulders, dense, coarse grained, brown, dry.	-0.9		
4						<b>Sand</b> compact, medium grained, brown, dry.	-1.7		
6						<b>Gravel</b> with some sand, cobbles and boulders, compact, coarse grained, brown, dry.	-2.7		
8						<b>Sandy Gravel</b> with some cobbles and boulders, compact, coarse grained, grey, dry.	-4.9		
10						<b>Gravel</b> with some boulders and trace sand, compact, coarse grained, brown, dry.	-6.1		
12						<b>Sandy Gravel</b> with some boulders, compact, coarse grained, greyish brown, moist.	-7.9		
14						<b>Silty Sand and Gravel</b> with some cobbles and boulders, non-plastic, compact, coarse grained, greyish brown, wet.	-8.8		
16						<b>Gravelly Sand</b> with some cobbles and boulders, compact, coarse grained, greyish brown, wet.	-11.0		
18						<b>Silty Sand and Gravel</b> with some cobbles and boulders, non-plastic, compact, medium grained, grey, moist.			
20									

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 1 of 3



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-02

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 10, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 10, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
42									
44									
46	14								
48							-14.6		
50						<b>Sandy Gravel</b> with some silt and cobbles, compact, coarse grained, grey and brown, moist.			
52	16								
54									
56									
58	18								
60									
62									
64									
66	20								
68									
70									
72	22								
74									
76							-23.2		
78						<b>Silty Sand</b> with boulders, non-plastic, compact, medium grained, greyish brown, wet.			
80	24								

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 2 of 3



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-02

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 10, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 10, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
82						<b>Sand</b> with some gravel and cobbles, dense, coarse grained, grey, moist.	-24.7		Filter Sand Pack 5 cm dia. PVC 10 Slot Screen
84					<b>Silt</b> with some cobbles and boulders, non-plastic, dense, fine grained, grey, moist.	-25.3			
86	26					<b>Rock</b>	-26.8		
90						<b>Silty Sand and Gravel</b> with some boulders, non-plastic, compact, coarse grained, grey, wet at 29.9 metres.	-27.4		
92	28								
94									
96									
98	30								
100									
102									
104	32								
106							-32.3		
108						End of Borehole			
110									
112	34								
114									
116									
118	36								
120									

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 3 of 3



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-03

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 11, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 11, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
0						Ground Surface	0.0		
2						<b>Sandy Gravel</b> with some cobbles, boulders, and silt, compact, coarse grained, brown, slightly moist.	-1.7	<p>Soil Cuttings Cast Iron Flushmount Casing Bentonite 5 cm dia. PVC Riser</p>	
4						<b>Gravelly Sand</b> with some cobbles and boulders, compact, coarse grained, brown, slightly moist.	-4.0		
6						<b>Sandy Gravel</b> with some cobbles and boulders, compact, coarse grained, greyish brown, moist.	-5.2		
8						<b>Sand</b> with some gravel, cobbles, and trace silt, compact, medium grained, greyish brown, moist.	-6.1		
10						<b>Rock</b>	-6.4		
12						<b>Gravelly Sand</b> with some cobbles and trace silt, compact, coarse grained, grey, moist.	-7.9		
14						<b>Silty Sand</b> with some cobbles and boulders, non-plastic, compact, medium grained, grey and brown, wet.			

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 1 of 2



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-03

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 11, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 11, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
42							-13.3		
44						<b>Rock</b>	-13.6		
46	14					<b>Silty Sand</b> with some cobbles and boulders, non-plastic, compact, medium grained, grey, wet.			
48									
50									
52	16								
54							-17.1		
56						<b>Silty Sand</b> with cobbles and boulders, non-plastic, compact, medium grained, grey and brown, moist.			
58	18								
60									
62						<b>Rock</b>	-18.9		
64							-19.2		
66	20					<b>Silty Sand</b> with cobbles and boulders, non-plastic, compact, medium grained, grey and brown, moist.	-20.1		
68						End of Borehole			
70									
72	22								
74									
76									
78	24								
80									

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 2 of 2



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-04

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 11, 2013

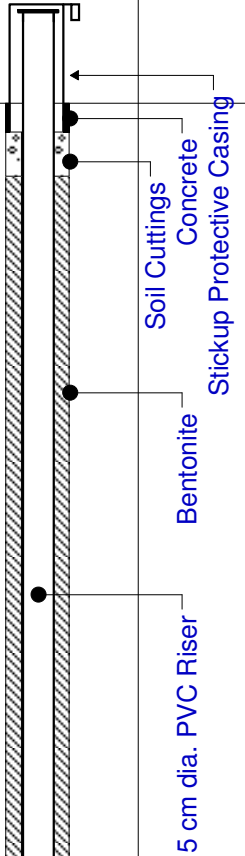
**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 11, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
ft m									
-3						Ground Surface	0.0		
-1									
1						<b>Sand and Gravel</b> with some cobbles, compact, coarse grained, brown and grey, dry.	-1.8		
3									
5									
7	2					<b>Sandy Gravel</b> with some cobbles and boulders, compact, coarse grained, brownish grey, moist.	-2.6		
9									
11						<b>Rock</b>			
13	4					<b>Sandy Gravel</b> with some cobbles and boulders, compact, coarse grained, brownish grey, moist.	-4.9		
15									
17						<b>Gravelly Sand</b> with some boulders, compact, coarse grained, brown and grey, slightly moist.	-7.6		
19	6								
21									
23									
25									
27	8					<b>Gravel</b> with some sand, cobbles, and boulders, compact, coarse grained, grey, wet.	-10.1		
29									
31									
33	10								
35						<b>Silty Sand and Gravel</b> with some boulders, non-plastic, compact, coarse grained, grey, wet.	-11.0		



Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 1 of 2



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-04

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 11, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 11, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
38	12					<b>Sand</b> with silty mottling, compact, medium grained, greyish brown, moist.			
40									
42									
44	14					<b>Sand</b> with trace silt, loose, medium grained, brownish grey, wet.	-14.0		
46									
48									
50	16					<b>Silty Sand</b> non-plastic, dense, medium grained, brownish grey, wet.			
52									
54									
56	18					<b>Silty Sand</b> non-plastic, dense, medium grained, brownish grey, wet.	-19.2		
58									
60									
62	20					<b>Silty Sand</b> non-plastic, dense, medium grained, brownish grey, wet.	-20.1		
64									
66									
68	22					End of Borehole			Filter Sand Pack 5 cm dia. PVC 10 Slot Screen
70									
72									
74									
76									

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 2 of 2



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-05

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 11, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 11, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
ft m									
-3									
-1									
						Ground Surface	0.0		
1						<b>Sand and Gravel</b> with some cobbles, compact, coarse grained, brown and grey, dry.			
3									
5									
7	2						-1.8		Soil Cuttings Concrete Stickup Protective Casing
9									
11						<b>Sandy Gravel</b> with some cobbles and boulders, compact, coarse grained, brownish grey, dry.			
13	4								
15									
							-4.9		Bentonite

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 1 of 2



**Project #: 4-2111-01-27-02**

**Privileged and Confidential**

**Project:** 2013 MW and GP Installation

**LOG OF WELL:** MW13-05

**Client:** Sunshine Coast Regional District

**Location:** Sechelt Landfill

**Driller:** Mud Bay Drilling Co. Inc,

**Borehole Diameter:** 20 cm

**Drill Method:** Sonic Drilling Rig

**Start Date:** Sept. 11, 2013

**Checked By:** ML

**Sample Method:** N/A

**Completed:** Sept. 11, 2013

**Logged By:** MV

Depth	Sample No.	N-Value	Recovery (%)	Vapour Reading	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
18						<b>Gravelly Sand</b> with some cobbles and boulders, compact, coarse grained, brown, moist.			5 cm dia. PVC Riser
20	6						-7.0		
22						<b>Sandy Gravel</b> with silty mottling and some cobbles, compact, coarse grained, grey, wet.			
24							-7.9		
26	8					<b>Sand</b> with some cobbles and boulders, compact, medium grained, grey, wet.			Filter Sand Pack 5 cm dia. PVC 10 Slot Screen
28									
30									
32	10					<b>Sand</b> with some cobbles and boulders, compact, medium grained, greyish brown, moist.	-9.8		
34									
36							-11.0		Bentonite
						End of Borehole			

Groundwater Elevation: 0

Screening Tool: N/A

T.O.P Elevation: 0

Monitoring Well Log

Ground Surface Elevation: 0

For Environmental Purposes Only

Sheet: 2 of 2



**Project #: 4-2111-01-49**

**Privileged and Confidential**

**Project:** Sechelt Landfill

**LOG OF: GP17-01**

**Client:** Sunshine Coast Regional District

**Location:** 4901 Dusty Road, Sechelt, British Columbia

**Driller:** Mud Bay Drilling

**Monitoring Well Diameter:** 15.24 cm

**Drill Method:** DB320

**Start Date:** August 16, 2017

**Checked By:** CS

**Sample Method:** Continuous

**Completed:** August 16, 2017

**Logged By:** TM

Depth	Sample No.	N-Value	Recovery (%)	Vapour Conc (ppm)	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
-3 ft 0 m									
-2									
-1									
0						Ground Surface			Monument Steel Casing Set In Concrete Collar
1						<b>SILTY SAND AND GRAVEL</b> Some cobbles, compact, coarse-grained, light brown, dry.	-0.3		
2						<b>SILTY SAND</b> Some gravel, trace cobbles, coarse-grained, brown and grey, moist.			
3						Large boulder at 1.2 mbgs.			Bentonite
4							-1.5		
5						<b>SANDY SILT</b> Some gravel and cobbles, grey, dry.			
6									
7									1.9 cm PVC Screen
8									
9							-2.7		Pea Gravel
10						<b>SANDY GRAVEL</b> Compact, coarse-grained, brownish grey, dry.			Bentonite
11									
12									1.9 cm PVC Screen
13									
14									Pea Gravel
15							-4.6		
16						End of Borehole			
17									

Groundwater Elevation: NM

Northing: 5482084.863

T.O.P. Elevation: 219.32 masl

FOR ENVIRONMENTAL PURPOSES ONLY

Easting: 448375.297

Ground Surface Elevation: 218.51 masl

Sheet: 1 of 1



**Project #: 4-2111-01-49**

**Privileged and Confidential**

**Project:** Sechelt Landfill

**LOG OF:** MW17-01

**Client:** Sunshine Coast Regional District

**Location:** 4901 Dusty Road, Sechelt, British Columbia

**Driller:** Mud Bay Drilling

**Monitoring Well Diameter:** 15.24 cm

**Drill Method:** DB320

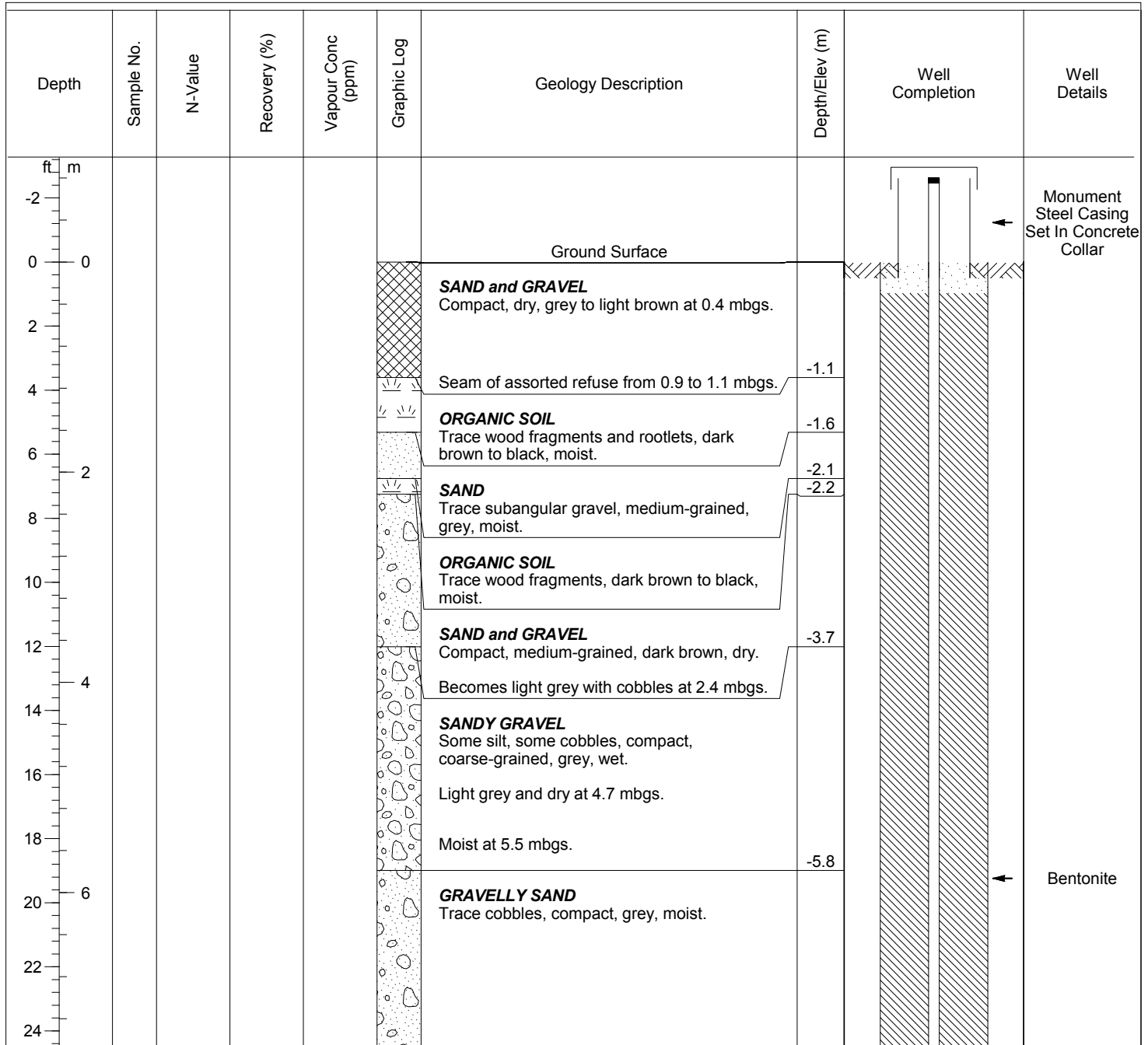
**Start Date:** August 16, 2017

**Checked By:** CS

**Sample Method:** Continuous

**Completed:** August 16, 2017

**Logged By:** TM



Groundwater Elevation: NM

Northing: 5481984.527

T.O.P. Elevation: 224.79 masl

FOR ENVIRONMENTAL PURPOSES ONLY

Easting: 448624.957

Ground Surface Elevation: 224.00 masl

Sheet: 1 of 2



**Project #: 4-2111-01-49**

**Privileged and Confidential**

**Project:** Sechelt Landfill

**LOG OF:** MW17-01

**Client:** Sunshine Coast Regional District

**Location:** 4901 Dusty Road, Sechelt, British Columbia

**Driller:** Mud Bay Drilling

**Monitoring Well Diameter:** 15.24 cm

**Drill Method:** DB320

**Start Date:** August 16, 2017

**Checked By:** CS

**Sample Method:** Continuous

**Completed:** August 16, 2017

**Logged By:** TM

Depth	Sample No.	N-Value	Recovery (%)	Vapour Conc (ppm)	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
ft-m 26-8						<b>GRAVELLY SAND</b> Trace cobbles, compact, grey, moist. (continued)	-8.8		Pea Gravel  5.08 cm PVC Screen
28					<b>SAND</b> Some silt, some gravel and subangular cobbles, grey, moist.	-9.8			
30-10					<b>GRAVELLY SAND</b> Trace cobbles, compact, grey, moist.	-11.6			
32-12					<b>GRAVEL and COBBLES</b> Trace sand, rounded gravel, grey, very moist.	-13.3			
34-14					<b>SILTY SAND</b> Some coarse subangular gravel, trace cobbles, grey, very moist to wet.	-14.9			
36					Brownish grey and damp at 14.9 metres bgs.	-14.9			
38						End of Borehole			
40						Note- Well magnet present in casing.			
42									
44									
46									
48									
50									
52									

Groundwater Elevation: NM

Northing: 5481984.527

T.O.P. Elevation: 224.79 masl

FOR ENVIRONMENTAL PURPOSES ONLY

Easting: 448624.957

Ground Surface Elevation: 224.00 masl

Sheet: 2 of 2



**Project #: 4-2111-01-49**

**Privileged and Confidential**

**Project:** Sechelt Landfill

**LOG OF:** MW17-02

**Client:** Sunshine Coast Regional District

**Location:** 4901 Dusty Road, Sechelt, British Columbia

**Driller:** Mud Bay Drilling

**Monitoring Well Diameter:** 15.24 cm

**Drill Method:** DB320

**Start Date:** August 16, 2017

**Checked By:** CS

**Sample Method:** Continuous

**Completed:** August 16, 2017

**Logged By:** TM

Depth	Sample No.	N-Value	Recovery (%)	Vapour Conc (ppm)	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
-3 ft 0 m									
-2									
-1									
0						Ground Surface			
1						<b>TOPSOIL</b> Rootlets.	-0.2		Monument Steel Casing Set In Concrete Collar
2						<b>SAND and GRAVEL</b> Some cobbles, compact, coarse-grained, brown and grey, dry.			
3									
4						Large boulder from 1.2 to 1.8 mbgs.			
5									
6							-1.8		
7						<b>SANDY GRAVEL</b> Trace large boulders and cobbles, compact, light grey, dry.			
8									
9									
10									
11									
12									Bentonite
13									
14									
15							-4.6		
16									

Groundwater Elevation: NM

Northing: 5482088.822

T.O.P. Elevation: 222.20 masl

FOR ENVIRONMENTAL PURPOSES ONLY

Easting: 448545.540

Ground Surface Elevation: 221.37 masl

Sheet: 1 of 2



**Project #: 4-2111-01-49**

**Privileged and Confidential**

**Project:** Sechelt Landfill

**LOG OF:** MW17-02

**Client:** Sunshine Coast Regional District

**Location:** 4901 Dusty Road, Sechelt, British Columbia

**Driller:** Mud Bay Drilling

**Monitoring Well Diameter:** 15.24 cm

**Drill Method:** DB320

**Start Date:** August 16, 2017

**Checked By:** CS

**Sample Method:** Continuous

**Completed:** August 16, 2017

**Logged By:** TM

Depth	Sample No.	N-Value	Recovery (%)	Vapour Conc (ppm)	Graphic Log	Geology Description	Depth/Elev (m)	Well Completion	Well Details
17 ft 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32						<b>GRAVELLY SAND</b> Some cobbles, compact, coarse-grained, brown, moist. <i>(continued)</i>	-6.4		
23 24 25 26 27 28 29 30 31 32						<b>SANDY GRAVEL</b> Some cobbles, compact, brown, moist.	-7.0		← Pea Gravel
24 25 26 27 28 29 30 31 32						<b>SAND</b> Some rounded cobbles, medium-grained, brown, wet.  Very moist with trace subangular gravel at 9.1 mbgs.	-9.8		← 5.08 cm PVC Screen
32 33 34 35						End of Borehole			

Groundwater Elevation: NM

Northing: 5482088.822

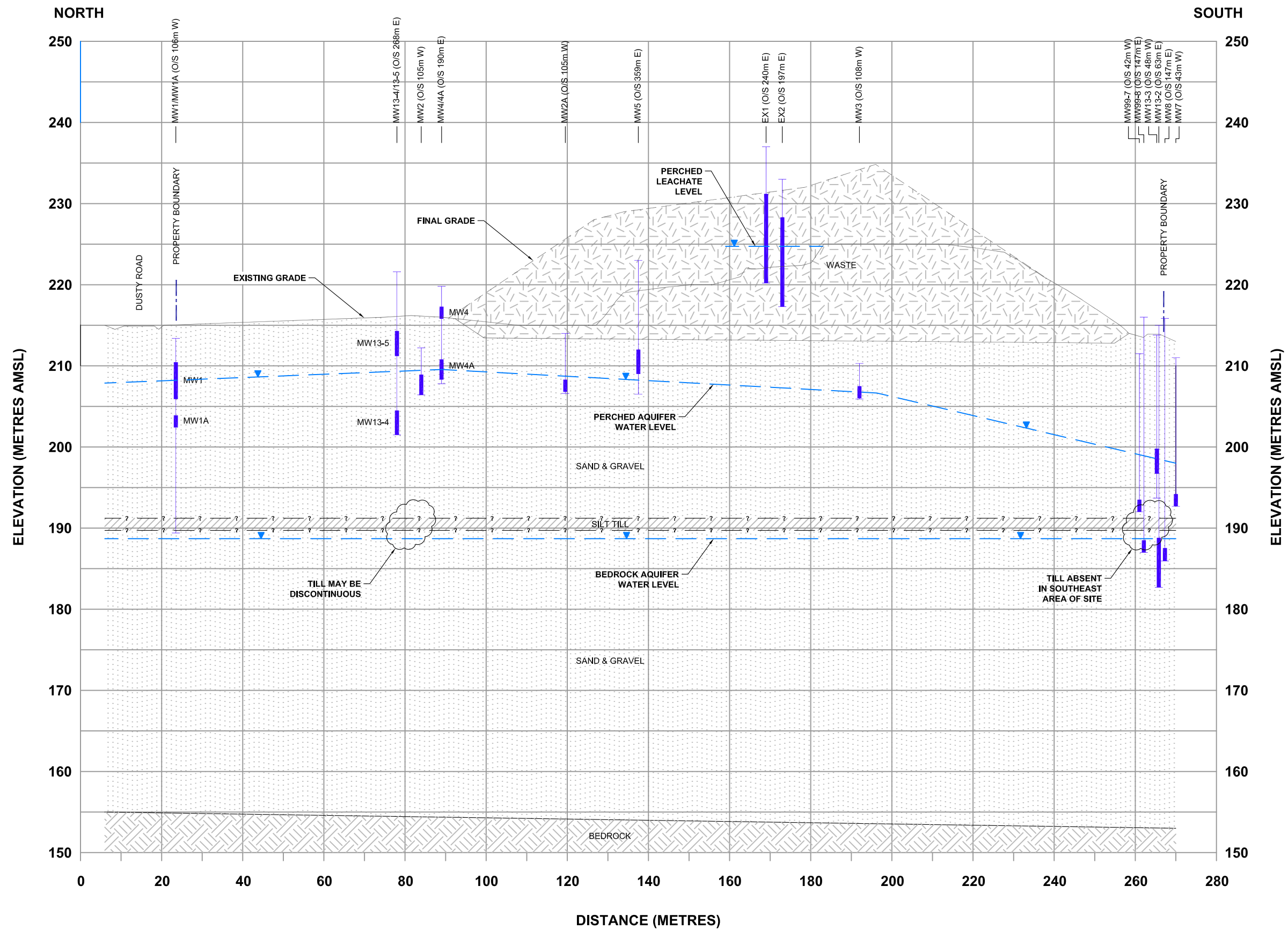
T.O.P. Elevation: 222.20 masl


FOR ENVIRONMENTAL PURPOSES ONLY

Easting: 448545.540

Ground Surface Elevation: 221.37 masl

Sheet: 2 of 2



<b>GEOLOGICAL CROSS-SECTION</b>		
2016 ANNUAL REPORT SECHLT LANDFILL SUNSHINE COAST REGIONAL DISTRICT		
 XCG CONSULTING LTD.		
DATE	JOB NO.	FIGURE NO.
MARCH 2017	4-2111-01-47	B1

(file: R421110147001FIGB1.dwg)



**APPENDIX C**  
**CONDITIONAL WATER LICENCE**


THE PROVINCE OF BRITISH COLUMBIA—WATER ACT

CONDITIONAL WATER LICENCE

Sunshine Coast Regional District of Box 800, Sechelt, B.C. V0N 3A0

is hereby authorized to divert and use water as follows:

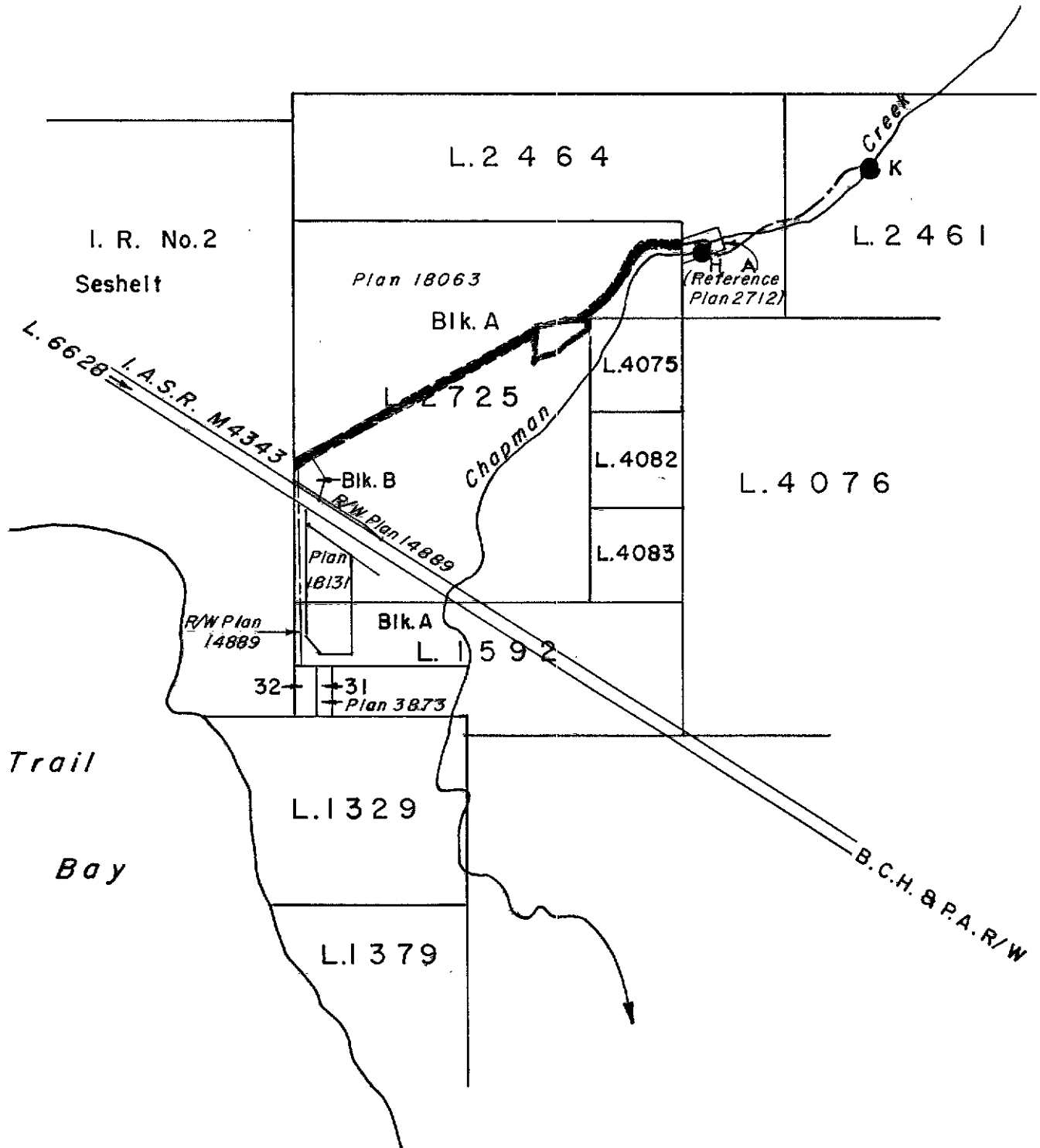
- (a) The stream on which the rights are granted is Chapman Creek.
- (b) The point of diversion is located as shown on the attached plan.
- (c) The date from which this licence shall have precedence is 3rd June, 1929.
- (d) The purpose for which this licence is issued is waterworks.
- (e) The maximum quantity of water which may be diverted is 300,000 gallons a day.
- (f) The period of the year during which the water may be used is the whole year.
- (g) This licence is appurtenant to the waterworks undertaking of the licensee within the boundaries of the Sunshine Coast Regional District.
- (h) The works authorized to be constructed are diversion structure, tank, pipe and distribution system, which shall be located approximately as shown on the attached plan.
- (i) The construction of the said works has been completed and the water is being beneficially used. The licensee shall continue to make a regular beneficial use of the water in the manner authorized herein.
- (j) This licence is issued in substitution of Conditional Licence 11728.

  
J.W. McCracken, P. Eng.  
Regional Water Manager



Province of British Columbia

2K1



WATER DISTRICT : VANCOUVER  
 PRECINCT : HOWE SOUND  
 LAND DISTRICT : GP. I, NEW WESTMINSTER

Signature J. W. M. Parker  
 Date 14th April, 1989.

LEGEND

- Scale : 1: 25,000
- Point of Diversion : ●●
- Map Number : WR 926-042-3-4
- Pipe : —
- Permit over Crown Land: ▬

C.L. 69217  
 File 0086708  
 P.C.L. 17351

This licence is appurtenant to all the land within The Sunshine Coast Regional District.