# POWELL RIVER MARINE AVENUE SITE CLOSURE PLAN

## Final Report

**PREPARED FOR: POWELL RIVER REGIONAL DISTRICT**

**PREPARED BY: SPERLING HANSEN ASSOCIATES**

**October 2014**

**PRJ13043**

SPERLING
HANSEN
ASSOCIATES

- Landfill Engineering
- Solid Waste Planning
- Environmental Monitoring
- Landfill Fire Control

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- Landfill Fire Risk Control

October 30, 2014 PRJ13043

Mr. Mike Wall
Manager of Community Services
Powell River Regional District
202 - 4675 Marine Avenue
Powell River, BC  V8A 2L2

**Re:** **Powell River Marine Avenue Transfer Site Closure Plan Report**

Dear Mr. Wall,

Sperling Hansen Associates is pleased to submit the Powell River Marine Avenue Transfer Site Closure Plan FINAL Report.

The report includes an analysis and reporting on the site characterization including hydrogeological assessment of leachate management, surface water management, landfill gas management, landfill settlement and foundation considerations, final cover design, topsoil vegetation and fauna, material management, post closure monitoring program and costing. We have addressed all your comments in this report.

We look forward to working on the next stage of this project – the implementation of the Closure Plan.  Please do not hesitate to call with any questions or concerns.

Yours truly,
**SPERLING HANSEN ASSOCIATES**

Dr. Tony Sperling, P.Eng.
President

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# 1. INTRODUCTION

## 1.1 Background

The Powell River Marina Avenue Transfer Site is located in an exhausted gravel pit on the east side of Marine Avenue in proximity to the Willingdon Beach Campground. The subject property is comprised of two lots owned by the City of Powell River (COPD). A solid waste incinerator was operated on the subject property between the early 1970's and July, 1995. Bottom ash (clinker) from the incinerator was retained on site in four distinct piles totaling some 38,000 $m^3$. Since the incinerator was closed municipal solid waste (MSW) has been transferred out of region, originally to the Cache Creek Landfill, and more recently to Rabanco Landfill. Demolition waste has been transferred to the Ecowaste Landfill.

In 1996 COPD retained Pottinger Gaherty to characterize the ash stockpiles and to provide recommendations for remediation. Pottinger Gaherty concluded that the ash contains waste material that contains elevated levels of metals and organic pollutants including copper, lead, zinc, barium PAH's and dioxins and furans that exceed industrial level (IL) standards, but all of the concentrations remain below special waste levels. Pottinger Gaherty recommended that he best strategy for managing the waste is to risk assess / risk manage (RA/RM). RA/RM would involve capping the waste piles and undertaking monitoring to ensure that migration of contaminants is not occurring.

In addition to stockpiles of bottom ash, the City of Powell River (COPR) uses the property to stockpile other waste and recyclable materials including glass, tires, roofing, gyproc, broken asphalt, wood chips, stumps, yard waste, broken concrete, demolition waste clean fill and asbestos. In total, some 68,350 $m^3$ of waste and recyclable materials are stockpiled on site.

In 2003, COPR retained Keystone Environmental to undertake a Preliminary Site Investigation of the subject properties. In addition to the bottom ash piles, Keystone identified a number of material stockpiles that may have impacted site soil and/or groundwater at levels of concern. These included the gypsum wallboard pile, the roofing shingle pile, the ground wood waste pile (as result of potential for pressure treated wood), the truck wash area, the asphalt pile, the burn pile, the Squatter's Creek waste relocation pile, the former above ground diesel tank pad, the scrap metal pile, the grocery store fire pile.

COPR submitted a closure plan for the property to the Ministry of Environment (MOE) on December 29, 1995, but the plan was not approved as per MOE's record. Since then responsibility for the Solid Waste function, including closure of existing waste management sites, has been transferred to the Powell River Regional District (PRRD). PRRD retained Sperling Hansen Associates (SHA) to develop a Closure Plan for the ash landfill site.

Final closure of the site must be completed in a manner that will ensure long term protection of the environment. The closure activities generally require a number of constructed works to be completed such as storm water controls and gas controls, and significant ongoing monitoring and maintenance will be required. The closure and post closure requirements, along with SHA's recommended design cover system will be further presented in this report.

## 1.2 Purpose and Scope

A proposal was prepared and submitted to the Powell River Regional District on September 3rd, 2013. The proposal was accepted and SHA was asked to complete the closure plan as per Ministry of Environment's (MOE) requirements. The recommended work plan consisted of the five major tasks, each with numerous sub-tasks, as listed in the following sections.

### 1.2.1 Project Startup, Management and Coordination Meetings

The first task - Project Start-up included the following sub-tasks:

- Start-Up Meeting
- Liaison with the MOE
- Project Management

### 1.2.2 Background Review

Included the following sub-tasks:

- Background Review
- Data Compilation
- Water Quality Review
- Site History Review
- Rough Closure Concept Development

### 1.2.3 Field Program

Included the following sub-tasks:

- Site Orientation and Initial Inspection
- Base Map Processing
- Test Pit Program to Characterize Waste (17 test pits)
- Water Level Survey and Ditch Inspection / Conductivity Survey
- Water Quality Sampling
- Ash and Woodchips material sampling
- GPS Site Survey
- Drilling of three groundwater monitoring wells

SHA understands that the use of locally available materials may reduce the closure cost significantly. The field program also included an investigation of the locally available materials on-site.

### 1.2.4 Data Analysis

Included the following sub-tasks:

- Compile Filling and Closure Activity History
- Analyze Site Geology
- Conduct Volumetric Analysis
- Compile Water Quality Data (Surface Water, Groundwater Stations)
- Compile Landfill Gas Monitoring Data
- Surface Water Flow Mapping and Interpretation
- Climate Interpretation, Evapotranspiration & IDF Analysis

We gathered all available survey data and water quality results from COPR and the PRRD. SHA also collected all other available relevant data from them. Based on the available data and information, we will be able to characterize the site.

### 1.2.5 Closure Plan

Included the following sub-tasks:

- End Use Plan and Grading Strategy
- HELP Modelling Analysis of Cover Options
- Geotechnical Design for Slope Stability
- Barrier Layer Selection and Design
- Top Soil Design Considerations
- Vegetation Design Considerations
- Erosion Analysis
- Landfill Gas Monitoring
- Landfill Gas Management Plan
- Runoff Water Diversion Routing
- Surface Water Ditching and Erosion Protection
- Cut and Fill Assessment and Closure Material Balance Analysis
- Closure Cost Analysis
- Post Closure Maintenance
- Post Closure Monitoring Program

### 1.2.6 Reporting

Included the following sub-tasks:

- Draft Report Preparation
- Final Reporting

# 2. SITE CHARACTERIZATION

## 2.1 Physical Setting

The Marine Avenue waste management site is located on the Marine Avenue across the Willingdon Beach Park. The location of the site relative to the region is shown in Figure 2-1. Photo 2-1 shows an aerial view of the site including buildings and other facilities in the surrounding area.

**Photo 1: Aerial View of the Marine Avenue site with approximate boundaries of the existing site**

## 2.2 Site History

Prior to the late 1960's the Site and adjacent properties were forested and undeveloped. Gravel extraction operations were on-site circa 1970 and subsequently expanded onto the adjacent properties north, northwest and east of the site. The site is approximately 6.4 ha. A property map is presented at the end of Appendix A.

COPD constructed a small incinerator on the subject property in the early 1970's. Permit PR-509 was issued to the COPD on April 21, 1971 authorizing the discharge of inert incinerator residue to a parcel of land on portion of Block 36, District Lot 450, Group 1, New Westminster District, Plan 8096 as shown in the attached map with the permit presented in Appendix A. The permit was first amended on December 17th, 1992 . A second amendment was issued on April 1st, 1993 ordering that all disposal of refuse be stopped effective February 28th, 1994 and that the incinerator be upgraded to comply with Best Control Technology as outlined in the document "Emission Criteria for Municipal Solid Waste Incinerators" published by the MOE in June 1991. The last amendment issued on February 2nd, 1994 required that effective October 15, 1994, all discharge be ceased and existing refuse burner (incinerator) be closed.

Since closure of the incinerator a range of materials have been stockpiled on site in addition to the residual clinker/ash. The stockpiles include gypsum wall-board, roofing materials, chipped wood products, asphalt, concrete, glass, tires, demolition waste, asbestos, clean fill, yard waste and some scrap metal as shown on Figure 2-2 and presented in Table 2-1.

In 1996 the COPD retained Pottinger Gaherty to undertake a study to characterize the bottom ash stored at the solid wate transfer site. They concluded that the ash contained elevated levels of metals and organics that exceeded industrial land use levels, but that contaminant concentrations were found to be below special waste levels. Pottinger Gaherty recommended that the waste materials be risk managed on site. Their report is included in Appendix L. In 2000, the PRRD undertook an inventory of waste materials and quantities stockpiled on-site as presented in Appendix L. In 2003, the COPD retained Keystone Environmental to undertake a Preliminary Site Investigation – Stage 1 to assess the potential for constituents of concern to be present in soil and/or groundwater and to quantify the approximate volumes of materials stored on site. Keystone's Phase I investigation concluded that there were numerous materials stored on site that presented potential for releasing contaminants to soil and or groundwater. Their report is presented in Appendix L.

For this report, SHA has independently quantified the volumes of each waste material stored on-site, as determined during our December 2013 field program, and considered the end use of each waste type as summarized in Table 2-1 below. Table 2-1 shows that the volume of ash is the largest waste category of all (56% by volume and 66% by estimated weight). The unit weights of the materials from the available literature were used to convert volumes into tonnage. A more detailed description of the end use of each waste type (upcycling, recycling, reuse, or relocation) is presented in Chapter 6.

Clinker or incinerator bottom ash is present in the northwest and northeast of the site as identified by Piles F, D, M and Q on Figure 2-2. SHA estimates the total volume of ash to be 38,000 $m^3$. Keystone (2003) identified the potential for constituents of concern in the ash to impact site soil and/or groundwater.

A pile of waste glass which consists primarily of broken windows and bottles is located on the north-west corner of the site (Pile E). A pile of tires (Pile B) is also located on the north-west corner of the site. Another pile of tires was removed from the site in 1998.

**Table 2-1 Type, Quantities and End Use of Stockpiled Waste Materials at Marine Ave. Site**

| WASTE TYPE | PILE | APPROXIMATE TOTAL QUANTITY (m³) | FIGURE COLOUR LEGEND | RELOCATED | RECYCLED | REUSED | UNIT WEIGHT (tonnes/m$^3$) | WEIGHT (tonnes) |
|---|---|---|---|---|---|---|---|---|
| ASH | F | 20,000 | 🟫 | | | X | 1.45 | 29,000 |
| | D | 7,200 | 🟫 | | | X | 1.45 | 10,440 |
| | M | 800 | 🟫 | | | X | 1.45 | 1,160 |
| | Q | 10,000 | 🟫 | | | X | 1.45 | 14,500 |
| GLASS | E | 2,000 | 🟦 | | | X | 0.48 | 960 |
| TIRES | B | 100 | 🟪 | | | X | 0.60 | 60 |
| ROOFING | A | 1,800 | 🟥 | | X | | 0.40 | 720 |
| | G | 1,500 | 🟥 | | X | | 0.40 | 600 |
| GYPROC | H | 3,000 | 🟦 | | X | | 0.60 | 1,800 |
| ASPHALT | L | 1,500 | 🟥 | | | X | 2.30 | 3,450 |
| | I | 500 | 🟥 | | | X | 2.30 | 1,150 |
| | T | 100 | 🟥 | | | X | 2.30 | 230 |
| WOOD CHIPS | J | 8,000 | 🟫 | | | X | 0.63 | 5,040 |
| STUMPS | K | 2,000 | 🟧 | | | X | 0.63 | 1,260 |
| YARD WASTE | N | 1,000 | 🟩 | | | X | 1.80 | 1,800 |
| | O | 200 | 🟩 | | | X | 1.80 | 360 |
| CONCRETE | P | 1,000 | ⬜ | | | X | 2.50 | 2,500 |
| DEMO | C | 2,500 | 🟩 | | | X | 0.80 | 2,000 |
| CLEAN FILL | R | 2,000 | 🟨 | | | X | 1.30 | 2,600 |
| | S | 3,000 | 🟨 | | | X | 1.30 | 3,900 |
| ASBESTOS | U | 150 | ⬜ | X | | | 1.60 | 240 |
| **Total** | | **68,350** | | | | | | **83,770** |

Two piles of roofing materials consisting of tar and gravel roofing from construction trades can be found on site, one to the north and one to the east (Pile A and G). Keystone (2003) identified the potential for constituents of concern in these materials to impact the site soil and/or groundwater.

A pile of gyproc can be found on the east side of the site (Pile H) consisting of wallboard from the construction trades. Keystone (2003) noted that the gypsum board may be leaching acid and contaminating the ground water or reacting adversely with the stockpiled scrap metal.

Several piles of waste asphalt pavement are present throughout the site (Piles L, I, and T). Keystone (2003) noted that constituents of concern from asphalt that include polycyclic aromatic hydrocarbons (PAH), nitrogen, sulphur, oxygen and various metals may potentially impact the soil and groundwater on site.

Woodchips consisting of tub-ground trees and lumber and tree stumps are piled on the west side of the site (Piles J and K). Because treated construction materials were included in the ground material, both the District and Keystone (2003) identified the potential for constituents of concern in these materials to impact the site soil and/or groundwater.

Two piles of yard waste are found towards the south of the property (Piles N and O). The yard waste consists of soil, grass, leaves and branches. The District noted in 2000 that there is nothing to indicate that this yard waste may be contaminated.

Concrete piles are found towards the southeast of the site (Pile P), some of which contains rebar and/or paint.

Demo waste is piled at the north edge of the site (Pile C). SHA's closure plan includes the re-use/ relocation on-site of the demo waste for regrading purposes, see Chapter 6.

A pile of clean fill is found on the north side of the site (Pile R). Another is found on the southeast of the site (Pile N), where it covers the material recovered from the burnt-down grocery store. Keystone (2003) noted that constituents of concern may be present in the grocery store waste, including asbestos and PCB's, may potentially impact the soil and groundwater on site.

A small amount of asbestos containing material is stockpiled near the northeast ash pile (Pile U), which may potentially impact the soil and groundwater on site.

## 2.3 Climate

The Marine Avenue site is located within a moderately wet region of the province. Table 2-2 presents the average monthly precipitation and temperature at Powell River Airport Station representing the Marine Avenue site as reported by Environment Canada. The average annual precipitation is 1205.4 mm with 1160.0 mm of rain and 46.5 cm of snowfall. The average annual temperature is 9.6$^{o}$C with an average peak of 17.2$^{o}$C occurring in July and a minimum average of 3.1$^{o}$C occurring in December. The maximum average snowfall of 13.6 cm occurs in January.

**Table 2-2 Climate Data for Marine Avenue Transfer Site (Airport Station, 1981 to 2010)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rainfall (mm)** | 145.7 | 101.9 | 104.2 | 83.2 | 76.6 | 67.6 | 37.5 | 45.3 | 54.7 | 125.5 | 171.6 | 146.5 | 1160 |
| **Snowfall (cm)** | 13.6 | 7.8 | 6.8 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0.3 | 6.5 | 11.5 | 46.5 |
| **Total Precipitation (mm)** | 158.9 | 109.4 | 110.7 | 83.3 | 76.6 | 67.6 | 37.5 | 45.3 | 54.7 | 125.8 | 178 | 157.8 | 1205.4 |
| **Avg. Temperature ($^{o}$C)** | 3.6 | 3.9 | 5.9 | 8.6 | 11.9 | 14.9 | 17.2 | 17.2 | 14.1 | 9.4 | 5.3 | 3.1 | 9.6 |

## 2.4 Water Budget Analysis

A key aspect of this project was to conduct a water budget analysis and evaluate the existing and future leachate generation potential from the site. A water balance was performed on the site for open condition before closure using the Thornthwaite Model as well as the HELP model which is presented in Chapter 4.

## 2.5 Geology

The subject property is located in an area covered by marine and glacio marine sediments of the Capilano Group. These sediments, laid down during the late stages of the last glaciation include gravelly, sandy stoney, clay and clay veneer. The sediments are normally found overlying earlier deposits of glacial till deposited during the active ice age. A map of surficial geology of the Powell River area is presented in Appendix H-1.

SHA drilled three boreholes on site to investigate local geologic and hydrogeologic conditions. Borehole MW13-1 to the north of the site showed up to 9 m depth of fine sand to silt before end of the hole (EOH). Borehole MW132 in the middle of the site found a variety of materials including fine flowing sand, rock, gravel, asphalt, till, saturated sand and clay, respectively, to a depth of 10m EOH. Borehole MW13-3 to the south showed dense till with some cobbles and boulders to a depth of 13m, then saturated gravels and sands to 15m EOH. Borehole logs from the monitoring well boreholes installed by SHA in 2013 are shown in Appendix B. A geologic section plotting the logs and the water table is presented in Figure 2-3. Borehole locations are shown in Figure 2-4.

SHA also excavated 17 test pits on the property to further characterize shallow geologic conditions and the depth of waste materials stored on site. Test pit logs are presented in Appendix B. Test pit locations are shown on Figure 2-2. Test pits revealed that where encountered waste materials were found to depths of 2 to 4 m. Sand was the dominant material encountered beneath the waste piles and in test pits that did not encounter waste.

## 2.6 Hydrogeology

Groundwater is expected to follow regional topography flowing from areas of higher elevation to areas of lower elevation. As reported in the borehole logs, static water table was found between 5.25 m below grade at the north end of the side, increasing to 13.46 m below grade at the south end of the site. Local groundwater flow direction may vary as a result of local conditions such as topography, geology, and the presence of drainage channels and buried utilities, subject to confirmation with field measurements. Estimated groundwater table contours across the landfill indicate that the groundwater flow direction is towards the south-southwest.

SHA inferred approximate water table contours based on the three water level measurements and creek water table intersections. The these equipotential contours are shown on Figure 2-4. They indicate groundwater flow to the south-southwest and a gradient of about 10 m in 100 m, which is a fairly steep hydraulic gradient. Based on a sand hydraulic conductivity estimated at $1x10^{-3}$ cm/s, the advective groundwater flow velocity is estimated to be on the order of 300 m per year.

## 2.7 Landfill Gas Quality

### 2.7.1 Landfill Gas Composition

Landfill gas consists of principal gases of $CO_2$ and $CH_4$ (in large amounts) and trace gases in very small amounts (e.g., $N_2$, $S_2$, $O_2$, etc.). Depending on number of factors including waste composition and age of the Landfill, the exact percentage of each component of LFG varies but typically municipal solid waste landfill gas comprises 45- 60% methane ($CH_4$), 40- 60% carbon dioxide ($CO_2$), small amounts of nitrogen ($N_2$), oxygen ($O_2$), ammonia ($NH_3$), hydrogen sulfide ($H_2S$), hydrogen ($H_2$), sulfides ($S_2$), carbon monoxide (CO), and non-methane organic compounds (NMOCs) such as trichloroethylene, benzene, and vinyl chloride (Tchobanoglous et al., 1993).

Methane can become explosive when the gas is diluted with atmospheric oxygen and nitrogen to concentrations between 5 and 15% on a volume basis. This range corresponds to the lower explosive limit (LEL) and the upper explosive limits (UEL). Methane is lighter than air, which means that it can migrate up through the ground and accumulate in buildings and other structures at or around the landfill.

The main danger with carbon dioxide is its high density. Carbon dioxide can therefore displace the air from structures such as manholes and wells, which could cause asphyxiation for someone entering such a structure without properly checking the conditions and using confined space entry procedures.

Carbon monoxide (CO) can appear in landfill gas at low concentrations under certain conditions. This gas is highly toxic at higher concentrations (> 500 ppm) and will cause headaches and nausea at concentrations of less than 100 ppm. The presence of carbon monoxide above 500 ppm is a very strong indicator of a potential underground landfill fire. Carbon monoxide is formed when organic material is incompletely combusted, which is often the case with underground fires.

There are number of factors affecting quantities and rates of LFG generation most important of which are landfilled solid waste density, moisture content, composition and age, as well as landfill design aspects with regard to leachate management system and landfill cover.

There is no record from the PRRD of any LFG monitoring conducted at the site. Although the incinerator ash is unlikely to produce significant quantities of LFG, it is possible that the stockpiles of organic waste and demolition waste that is buried on site are producing some methane and other decomposition gases.

### 2.7.2 Landfill Gas Migration and Monitoring

Landfill gas can migrate great distances from landfills under favourable conditions. Landfill gas will migrate along the path of least resistance, by convection, from areas of high pressure to areas of low pressure, or by diffusion, from areas of higher concentration to areas of lower concentration. If vertical venting to the atmosphere is restricted, lateral migration can occur through coarse-grained soils or along other pathways such as conduits, drain tile and sewers. Given the sandy strata that is present beneath waste materials, the potential for LFG migration does exist at this site.

Currently there is no information available on landfill gas migration at the site. SHA recommends that a landfill gas migration risk assessment be completed for the site.

## 2.8 Field Program

SHA staff visited the Powell River Marine Avenue site on three different occasions. This section provides a summary of the findings of Sperling Hansen Associates (SHA) field program for the Closure at Powell River Marine Avenue site. The information in this section reflects all field data collected to date by SHA. The closure design was based on this information, as well additional data collected from the previous reports and information provided by the City of Powell River as well as the PRRD. The tasks performed during each visit are described in the following sections:

### 2.8.1 Initial Site Visit

Dr. Tony Sperling and Dr. Iqbal Bhuiyan of SHA initially visited the site on August 16th, 2013, accompanied by Sean McGinn from the PRRD. Items that were discussed during this site visit included the following issues:

- History of the site
- End-use plan would be to turn the site into a recycling station on one half and a botanical garden on the other half
- Use of locally available materials for closure and the possibility of utilizing fabricated soil from the organic materials on site as top soil on top of the landfill
- Obtain topographic survey data if available or conduct a topographic survey
- Install monitoring wells if necessary

### 2.8.2 Survey and Field Investigation

From December 9 to 16, 2013, SHA staff Mark Manning and Anthony Koeck conducted a field investigation and a GPS topographic survey of the site. The field investigation included a test pit program, conductivity survey, water level sounding in the monitoring wells, and water quality sampling and testing. Existing topography is shown in Figure 6-1.

### 2.8.3 Test Pit Program

A series of seventeen test pits were dug on the landfill surface at various locations (See Figure 2-3). The objective of the test pit program was to characterize the composition of waste and the existing cover material (silt/sand) as well as the depth of this material above the waste and to verify if it is an acceptable material for use in the final cover construction and to determine the existing water table elevation in the site. Various photographs showing typical test pit conditions are shown below, with the detailed test pit logs and additional photographs attached in Appendix B and Appendix C respectively. The test pits were located to allow for a representative sample of the current waste materials stockpiled across the site.

The findings of the test pits showed that the various waste material present across the site typically occur at depths of 2 to 4 below grade. The amount of cover soil on top of waste materials ranged from no cover soil found at multiple test pits to a maximum thickness of 0.4 cm observed at TP-12. The composition of the cover soil consisted mainly of silt and sand, mixed with some coarse sand and cobbles. The uncovered waste from the test pits consisted mainly of ash, roofing materials and woody debris. TP-7, 10, 14, 15, 16 and 17 consisted of clean fill.

**Photo 2: TP-1**

**Photo 3: TP-2**

**Photo 4: TP-3**

**Photo 5: TP-4**

Photo 6: TP-5

Photo 7: TP-6

Photo 8: TP-7

Photo 9: TP-8

Photo 10: TP-9

Photo 11: TP-10

Photo 12: TP-11

Photo 13: TP-12

Photo 14: TP-13

Photo 15: TP-14

Photo 16: TP-15

Photo 17: TP-16

**Photo 18: TP-17**

### 2.8.4 Groundwater Elevations

The groundwater sampling field methodology employed included measurement of the static water level in the well to determine the depth to the water table as well as the total depth of the well (required to determine the depth of the water column within the monitoring well). Groundwater well elevations as measured by SHA on December 14, 2013, are shown in the Table below. The same data is plotted on Section in Figure 2-3.

**Table 2-3: Marine Avenue Site Groundwater Levels**

| Powell River Marine Avenue Groundwater Levels - Dec. 14, 2013 | | | | | |
|---|---|---|---|---|---|
| | Total Well | Water Level | Ground | Stick up | Water Table |
| Location | Depth TOP | Depth TOP | Elevation | Height | Elevation |
| MW 13-1 | 8.23 | 5.89 | 54.2 | 0.61 | 48.92 |
| MW13-2 | 10.71 | 8.04 | 39.5 | 0.76 | 32.22 |
| MW 13-3 | 16.22 | 13.46 | 26.8 | 0.83 | 14.17 |

### 2.8.5 Site Investigation with MOE and Surface Water Sampling

Subsequently, Dr. Tony Sperling and Dr. Iqbal from SHA undertook a second visit to the site on March 26th, 2014. They were joined on site by David O'Malley and Ashley Smith from the MOE and Mike Wall from the PRRD.

During the visit the team observed the piles of different types of waste. Ashley pointed out that the MOE will support the PRRD and City of Powell River (CoPR) to achieve final closure of the site.

The MOE recommended the PRRD consider the following options for removal of discharged waste from the site:

- Option 1: Recycle and haul away all of the waste to appropriate disposal or recycling locations.
- Option 2: Excavate and haul all the waste to the Airport landfill site and dispose there.
- Option 3: Ship waste to Ecowaste Landfill or Rabanco.
- Option 4: Upcycle, Reuse, and/or Recycle Materials on Site along with Proper Public Consultation

With regards to Option 1, Dr. Sperling expressed concern that digging waste should be avoided as much as possible, or else proper precautions should be followed, as digging may create unexpected hazards such as asbestos exposure.

With regard to Option 2, Dr. Sperling mentioned that several residents have already raised concerns about possible impacts from waste present at the Airport site, concerns that the PRRD and the CoPR have been dealing with for long time. Although data from ongoing monitoring programs have shown that the Airport site has not had any significant impact on the surrounding environment to date, disposing of additional wastes with known elevated metal, dioxin and furan levels from the Incinerator Site could potentially create concerns among the neighbours as well increase the potential for impacting the surrounding environment.

The MOE also recommended that the PRRD quantify the contaminants of concern at the Marine Avenue Transfer Site and that the PRRD undertake due diligence to develop options for the long term viability of the site.

Mr. Smith pointed out that it would be much easier for the PRRD to secure a Certificate of Compliance (CoC), if needed, if the site is cleaned up. If the PRRD chose the option to risk manage the waste in place and develop a solution that involves capping the waste in situ, then the process will require public consultation as part of an amendment to the permit.

Dr. Sperling replied that SHA will initiate discussions with PRRD staff and will develop game plan for managing the waste materials in the most practical and cost effective manner.

Dr. Tony Sperling and Dr. Iqbal also completed a water quality sampling program during the visit as described in Section 2.8.6.

### 2.8.6 Water Quality Sampling and Testing

Water sampling was conducted by SHA field staff using established BC Ministry of Environment (MOE) and environmental industry protocols for water level measurement, well development, sample collection, sample preservation and storage techniques, where applicable. This ensured the collection of and representative samples for laboratory analysis.

The water sampling field methodology employed included, where applicable, measurement of the static water level in the well to determine the depth to the water table as well as the total depth of the well (required to determine the depth of the water column within the monitoring well).

**Groundwater**: Groundwater samples were collected by SHA on December 14, 2013 at three locations (MW13-1, MW13-2 and MW13-3 as shown in Figure 2-4). The samples were submitted to the laboratory for analysis. Results are shown in Table 2-4. The levels of manganese at MW13-2 exceeded BC Water Quality guidelines for Drinking Water, and the levels of iron at MW13-2 exceeded the BC Water Quality guidelines for both Drinking Water and the Protection of Aquatic Life. All other parameters were below guidelines. Iron and manganese are common indicators of landfill leachate. These metals are easily mobilized under acidic reducing conditions that are frequently encountered when impacted leachate enters the groundwater flow system. Iron and manganese are also encountered at elevated levels in many natural environments where reducing conditions exist, for example near wetlands and bogs.

The groundwater test results indicate that the groundwater is generally of good quality. There may be a slight impact from landfill leachate on groundwater quality at MW13-2.. However, iron occurs naturally at high levels in the groundwater throughout B.C., and iron levels frequently exceed guidelines even in the absence of pollution. In general, the water quality at this site is of acceptable quality provided the water does not reach any drinking water wells in the immediate vicinity.

**Surface Water:** Spot readings of conductivity were taken during the field visit along the ditches and watercourses on the site as shown in Figure 2-4. Readings ranged from a low of 100 µS/cm in the unnamed creek to the east of the site to 290 µS/cm in the western ditch, indicative of little or no impact from landfill leachate. Waters impacted with leachate typically record conductivities of 500 uS/cm for lightly impacted waters to more than 1,000 uS/cm for heavily impacted waters.

Surface water samples were collected by SHA on March 25, 2014 at three locations (SW-1, SW-2 and SW-3 as shown in Figure 2-4) and were submitted to the laboratory for analysis. Results are shown in Table 2-5. The levels of iron at all three locations exceeded the BC Water Quality guidelines for both Drinking Water and the Protection of Aquatic Life, including the upgradient location. Again, the presence of elevated iron levels in surface waters occurs frequently throughout B.C. as a result of natural processes. There is no evidence that surface water is adversely impacted by landfill leachate.

### 2.8.7 Ash and Woodchips Analysis

Landfilled incinerator bottom ash samples were collected by SHA on July 3, 2014 at four locations (F-1, F-2, F-3 and D-1) as shown in Figure 2-3. Samples were submitted to Maxxam laboratories and were analyzed for PAH, total metals, pH, moisture, dioxins and furans.

Landfilled woodchip samples were collected by SHA on July 3, 2014 at two locations (J-1 and J-2) as shown in Figure 2-3 and were submitted on July 7, 2014, to Exova laboratories and were analysed for TKN, CN-TOC, metals, moisture, pH and heating value.

Ash and woodchip sample results were compared against the BC Contaminated Sites Regulation. The planned future use for the site is commercial land (CL) and urban park (UL). For the parameters analysed, the limits are the same in both CL and UL therefore all results were compared to CSR-CL. Drinking water (DW) standards apply because the Site is located in an area in which future use of groundwater for drinking water cannot be excluded, therefore protection of groundwater used for drinking water  was selected as a site-specific factor. Because drinking water guidelines are also the most stringent of the site-specific factors, all results were compared to CSR-CL (DW) to provide a conservative estimate of water quality at the site.

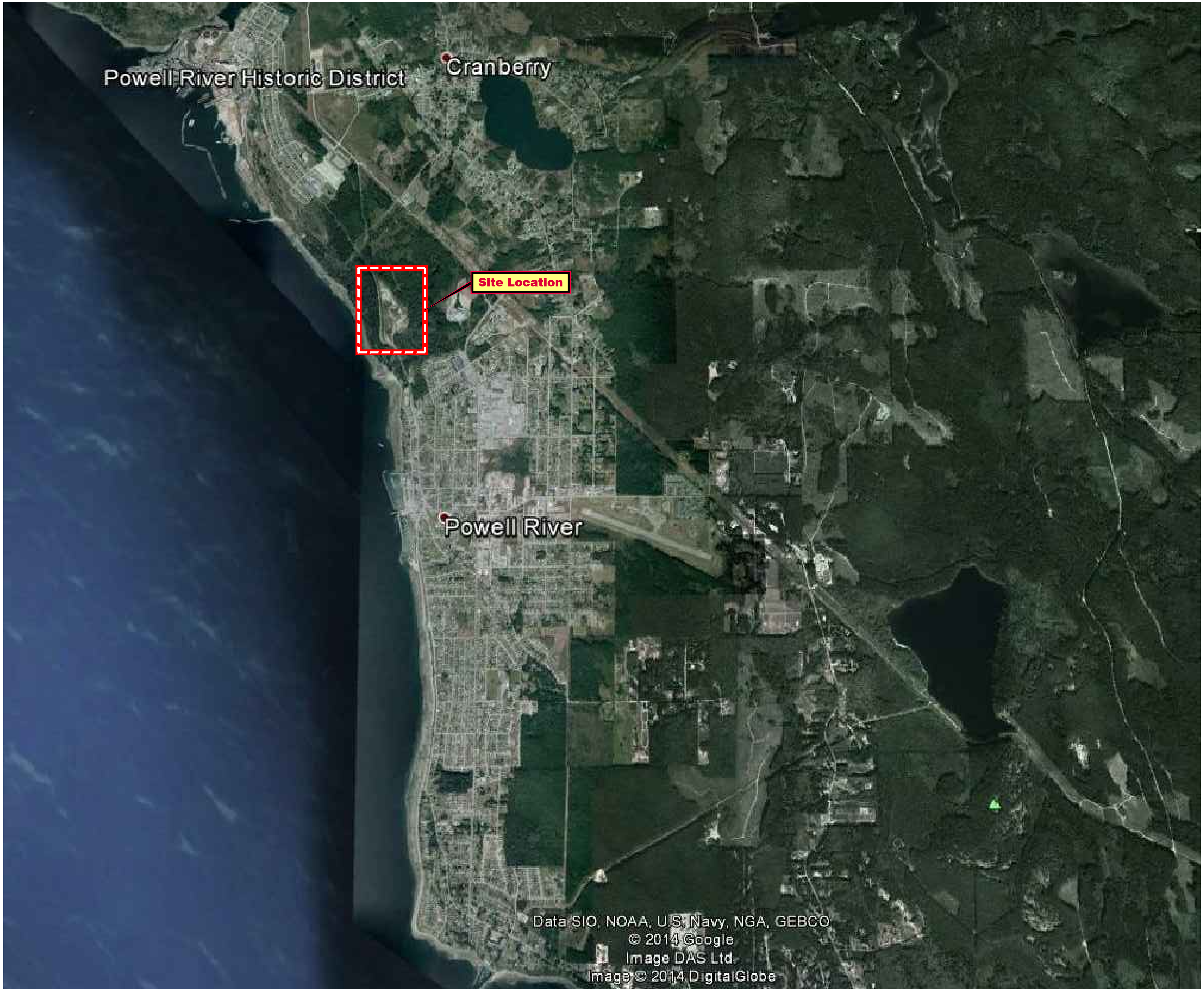
**Ash:** The following ash samples exceeded CSR-CL guidelines for DW: F-1 (total arsenic, barium and chromium; F-2 (total chromium); F-3 (total arsenic) and F-4 (total chromium). PAH levels were all low or below detection limits. The moisture content of the ash ranged from 6.3% to 16.0%. Dioxins and furan levels were adjusted for equivalency factors, and the resulting aggregate value for each ash sample ranged from 0.0226 ppb to 0.0876 ppb, well below the limit of 100ppb prescribed by the B.C. EMA Hazardous Waste Regulations. Refer to Table 2-6 for a summary of the lab results.

Landfilled incinerator bottom ash samples had previously been analysed by Pottinger Gaherty Environmental Consultants Ltd. in a report dated June 11, 1996. Exceedances of water quality guidelines for the bottom ash were noted for copper, lead and zinc, using the applicable guidelines of the day. Guidelines have changed since 1996, with new designations based on land use and site-specific factors altering the allowable limits, therefore comparing guideline exceedances between time periods is not applicable here. In general, the ash sampled by SHA in 2014 has greater levels of total metals in the soil than that which was sampled in 1996.

**Woodchips**: Both woodchip samples exceeded CSR-DW guidelines for total chromium. Total Kjeldahl nitrogen ranged from 0.32% to 0.46%. Moisture ranged from 43.3% to 44.5%. Heating values ranged from 5,282 kJ/kg to 7,110 kJ/kg. Refer to Table 2-6 for a summary of the lab results.

Raw data for ash and woodchips analysis is presented in Appendix D.

X:\PRJ\Prj13\PRJ13043 - Powel River Landfill Closures\Marine Avenue Transfer Site\04_AutoCad Drawings\Drawings\FIG 2-1 SITE LOCATION.dwg, 13/08/2014 10:44:24 AM



SPERLING
HANSEN
ASSOCIATES

Landfill Services Group
- Landfill Siting
- Design & Operations Plans
- Landfill Closure
- Environmental Monitoring

#8 - 1225 East Keith Road
North Vancouver, B.C. V7J 1J3

Phone: (604) 986-7723
Fax: (604) 986-7734

LEGEND:

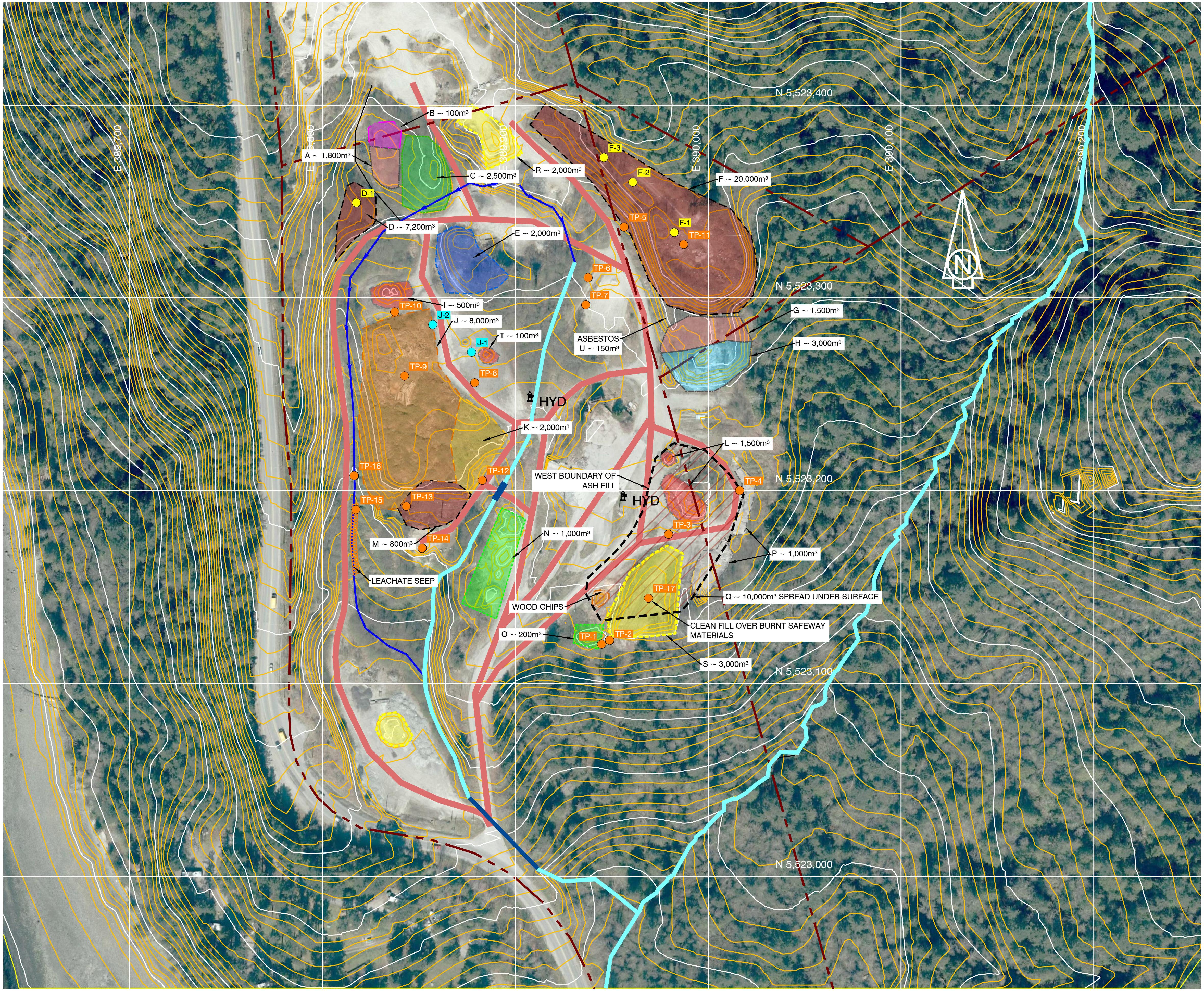
CLIENT:
**POWELL RIVER REGIONAL DISTRICT**

PROJECT:
**POWELL RIVER MARINE AVE
SITE CLOSURE PLAN**

TITLE:
## MARINE AVE.
## TRANSFER SITE LOCATION

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | DRAWING NO: |
|---|---|---|
| SURVEYED | | |
| DRAWN | NP | **FIGURE 2-1** |
| CHECKED | IB | |



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LEGEND:

5m EXISTING CONTOUR
1m EXISTING CONTOUR
PROPERTY LINE
● TEST PIT LOCATION
● ASH SAMPLE LOCATION
● WOODCHIP SAMPLE LOCATION

| WASTE TYPE | PILE | APPROXIMATE TOTAL QUANTITY (m³) | COLOUR |
|---|---|---|---|
| ASH | F | 20,000 | 🟫 |
| | D | 7,200 | 🟫 |
| | M | 800 | 🟫 |
| | Q | 10,000 | 🟫 |
| GLASS | E | 2,000 | 🟦 |
| TIRES | B | 100 | 🟪 |
| ROOFING | A | 1,800 | 🟥 |
| | G | 1,500 | 🟥 |
| GYPROC | H | 3,000 | 🟦 |
| ASPHALT | L | 1,500 | 🟥 |
| | I | 500 | 🟥 |
| | T | 100 | 🟥 |
| WOOD CHIPS | J | 8,000 | 🟫 |
| STUMPS | K | 2,000 | 🟧 |
| YARD WASTE | N | 1,000 | 🟩 |
| | O | 200 | 🟩 |
| CONCRETE | P | 1,000 | ⬜ |
| DEMO | C | 2,500 | 🟩 |
| CLEAN FILL | R | 2,000 | 🟨 |
| | S | 3,000 | 🟨 |
| ASBESTOS | U | 150 | ⬜ |
| **Total** | | **68,350** | |

CLIENT:

POWELL RIVER REGIONAL DISTRICT

PROJECT:

POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

## WASTE PILE CHARACTERIZATION, TEST PIT LOCATIONS AND ASH/WOODCHIP SAMPLE LOCATIONS

SCALE: 1:2000

DATE: 2014/08/15
yyyy/mm/dd

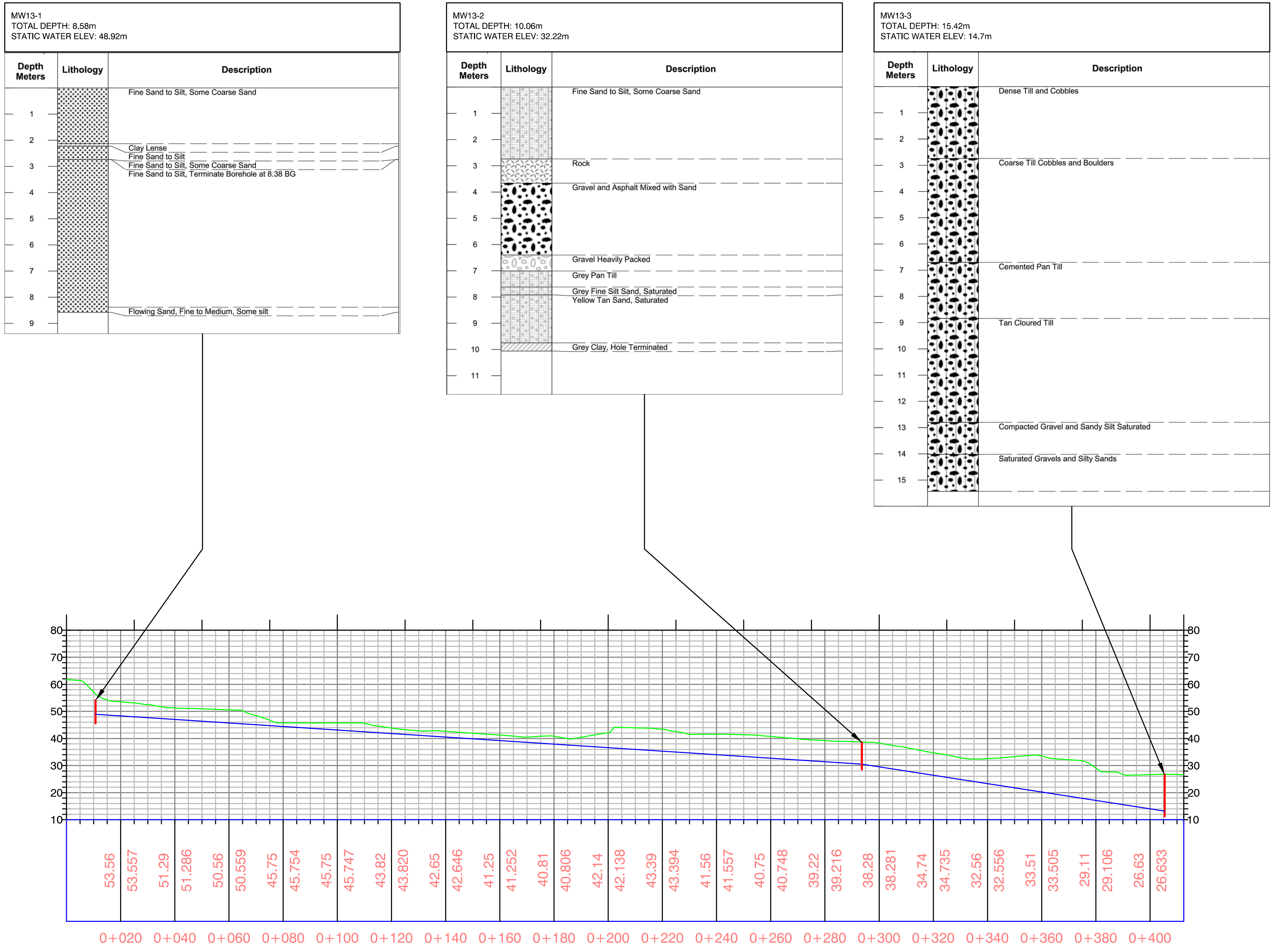
PROJECT NO: PRJ 13043

| | |
|---|---|
| SURVEYED | AK |
| DRAWN | NL |
| CHECKED | IB |

DRAWING NO:

**FIGURE 2-2**

X:\PRJ\Prj13\PRJ13043 - Powel River Landfill Closures\Marine Avenue Transfer Site\04_AutoCad Drawings\Drawings\POWELL RIVER MARINE BASEMAP 14.08.13 FIGURES 2-3_6-1_6-2_6-3_6-4_9-1.dwg, 27/08/2014 11:11:16 AM



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- Landfill Closure
- Environmental Monitoring

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Fax: (604) 986-7734

LEGEND:

EXISTING GRADE

MONITORING WELL

APPROX. EXISTING GROUNDWATER LEVEL

CLIENT:

**POWELL RIVER REGIONAL DISTRICT**

PROJECT:

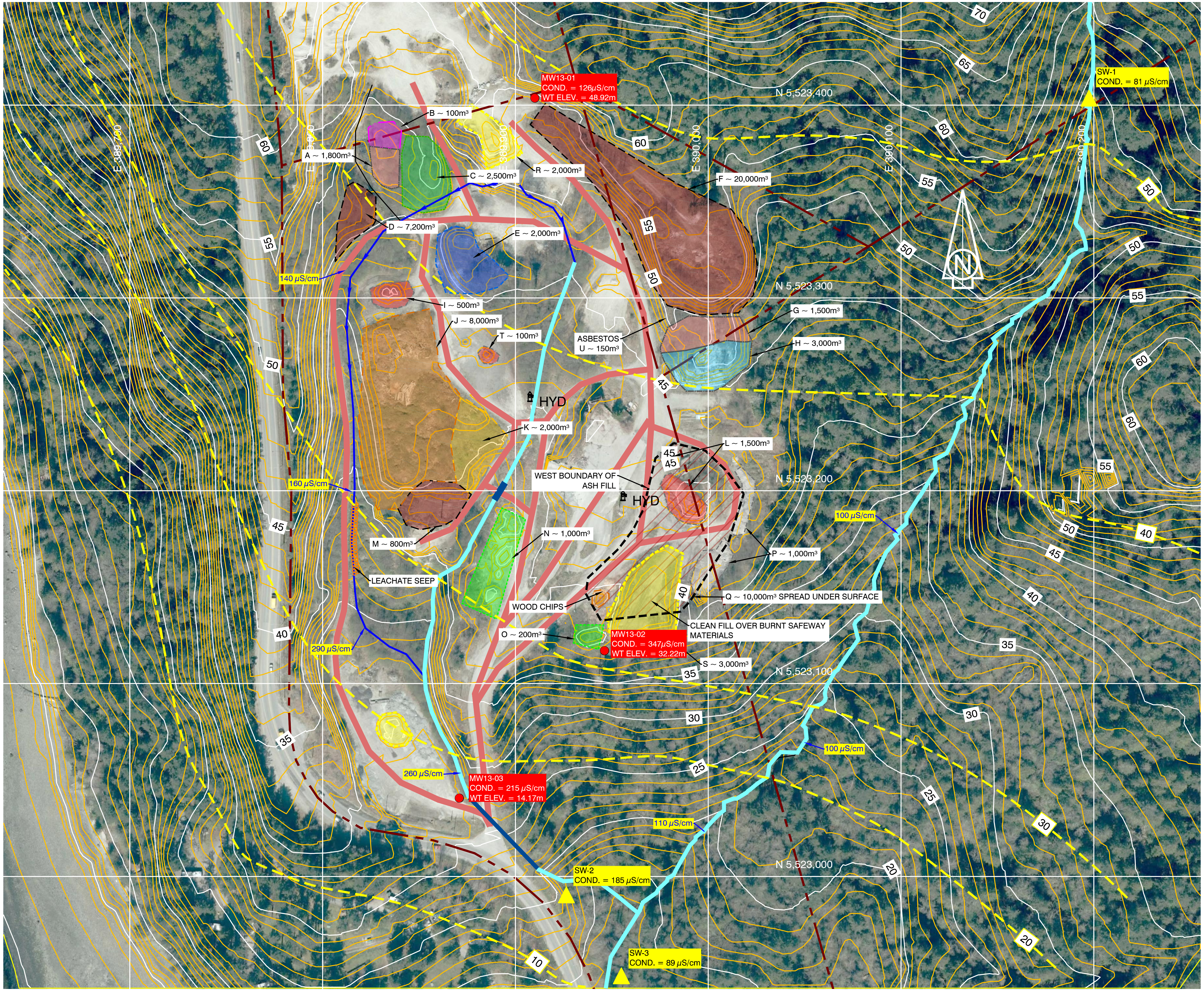
**POWELL RIVER MARINE AVENUE SITE CLOSURE PLAN**

TITLE:

# GROUNDWATER LEVELS WITH LITHOLOGY

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:1500 | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | MM | DRAWING NO: |
| DRAWN | NP | **FIGURE 2-3** |
| CHECKED | IB | |



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- Landfill Closure
- Environmental Monitoring

#8 - 1225 East Keith Road
North Vancouver, B.C. V7J 1J3

Phone: (604) 986-7723
Fax: (604) 986-7734

LEGEND:

| | |
|---|---|
| ― | 5m EXISTING CONTOUR |
| ― | 1m EXISTING CONTOUR |
| ‒ · ‒ | PROPERTY LINE |
| 100 | CONDUCTIVITY (μS/cm) |
| ● | GROUNDWATER MONITORING WELL & CONDUCTIVITY ON DEC 14., 2013 WATER TABLE ELEVATION |
| ▲ | SURFACE WATER MONITORING STATION & CONDUCTIVITY ON MAR 25, 2013 |
| 10 | INFERRED GROUNDWATER EQUIPOTENTAIL |

CLIENT:

POWELL RIVER REGIONAL DISTRICT

PROJECT:

POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

## GROUNDWATER & SURFACE WATER MONITORING LOCATIONS AND CONDUCTIVITY READINGS

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NL | FIGURE 2-4 |
| CHECKED | IB | |

# Table 2-4: Groundwater Quality Data

| Parameter | | | | Sample ID | MW13-1 | MW13-2 | MW13-3 |
|---|---|---|---|---|---|---|---|
| | | | | Site Location | Marine Ave | Marine Ave | Marine Ave |
| | | | | Date Sampled | 12/14/2013 | 12/14/2013 | 12/14/2013 |
| | | Detection Limit | BCWQG-DW$^{1,2}$ | BCWQG-AW$^{1,2}$ | | | |
| Conductivity | uS/cm | 2 | 700 | - | 126 | 347 | 215 |
| Hardness (as CaCO3) | mg/L | 0.5 | > 500 $^{4}$ | - | 45.3 | 151 | 87.3 |
| pH | pH | 0.1 | 6.5 - 8.5 | - | 7.05 | 6.9 | 6.96 |
| Total Suspended Solids | mg/L | 3 | - | - | 709 | 418 | 869 |
| Total Dissolved Solids | mg/L | 10 | - | - | 100 | 192 | 144 |
| Ammonia, Total (as N) | mg/L | 0.005 | - | - | <0.0050 | 1.42 | 0.106 |
| Bromide (Br) | mg/L | 0.05 | - | - | <0.050 | <0.050 | <0.050 |
| Chloride (Cl) | mg/L | 0.5 | 250 | 150 | 9.72 | 7.06 | 9.63 |
| Fluoride (F) | mg/L | 0.02 | 1.5 | 0.2-0.3 | 0.027 | 0.142 | 0.06 |
| Nitrate (as N) | mg/L | 0.005 | 10 | 200 | 0.171 | 0.0642 | 0.526 |
| Nitrite (as N) | mg/L | 0.001 | 1 | 0.06-0.6 | <0.0010 | 0.0052 | 0.0021 |
| Sulfate (SO4) | mg/L | 0.5 | 500 | - | 5.98 | 3.06 | 12 |
| Sulphide as S | mg/L | 0.02 | 0.05 | - | <0.020 | <0.020 | <0.020 |
| Aluminum (Al)-Dissolved | mg/L | 0.005 | 0.2 | 0.1 (ph>6.5) | <0.0050 | 0.0269 | 0.0377 |
| Antimony (Sb)-Dissolved | mg/L | 0.0005 | 0.006 | 0.002 | <0.00050 | <0.00050 | <0.00050 |
| Arsenic (As)-Dissolved | mg/L | 0.0005 | 0.025 | 0.005 | <0.00050 | 0.00294 | <0.00050 |
| Barium (Ba)-Dissolved | mg/L | 0.02 | 1 | 5 | <0.020 | 0.032 | <0.020 |
| Beryllium (Be)-Dissolved | mg/L | 0.001 | - | 0.0053 | <0.0010 | <0.0010 | <0.0010 |
| Boron (B)-Dissolved | mg/L | 0.1 | 5 | 1.2 | <0.10 | <0.10 | <0.10 |
| Cadmium (Cd)-Dissolved | mg/L | 0.00001 | 0.005 | - | <0.000010 | 0.000076 | 0.000034 |
| Calcium (Ca)-Dissolved | mg/L | 0.1 | - | - | 13.3 | 52.8 | 25.6 |
| Chromium (Cr)-Dissolved | mg/L | 0.001 | 0.05 | 0.009 | <0.0010 | <0.0010 | <0.0010 |
| Cobalt (Co)-Dissolved | mg/L | 0.0003 | - | 0.11 | <0.00030 | 0.00335 | 0.002 |
| Copper (Cu)-Dissolved | mg/L | 0.001 | 1 | Hardness | <0.0010 | <0.0010 | 0.001 |
| Iron (Fe)-Dissolved | mg/L | 0.03 | 0.3 | 0.35 | <0.030 | 13.7 | 0.083 |
| Lead (Pb)-Dissolved | mg/L | 0.0005 | 0.05 | - | <0.00050 | <0.00050 | <0.00050 |
| Lithium (Li)-Dissolved | mg/L | 0.005 | - | - | <0.0050 | <0.0050 | <0.0050 |
| Magnesium (Mg)-Dissolved | mg/L | 0.1 | 100 | - | 2.94 | 4.71 | 5.69 |
| Manganese (Mn)-Dissolved | mg/L | 0.0003 | 0.05 | 0.8-3.8 | 0.0102 | 0.627 | 0.404 |
| Mercury (Hg)-Dissolved | mg/L | 0.00001 | 0.001 | 0.0001 | <0.000010 | <0.000010 | <0.000010 |
| Molybdenum (Mo)-Dissolved | mg/L | 0.001 | 0.25 | 2 | <0.0010 | 0.0019 | 0.0021 |
| Nickel (Ni)-Dissolved | mg/L | 0.001 | - | 0.025-0.15 | <0.0010 | 0.0015 | 0.0018 |
| Potassium (K)-Dissolved | mg/L | 2 | - | - | <2.0 | 12 | 4.1 |
| Selenium (Se)-Dissolved | mg/L | 0.0001 | 0.01 | 0.001 | 0.00011 | <0.00010 | <0.00010 |
| Silver (Ag)-Dissolved | mg/L | 0.00002 | 0.05 | 0.00005-0.003 | <0.000020 | <0.000020 | <0.000020 |
| Sodium (Na)-Dissolved | mg/L | 2 | 200 | - | 7.9 | 9.6 | 17.4 |
| Thallium (Tl)-Dissolved | mg/L | 0.0002 | 0.002 | - | <0.00020 | <0.00020 | <0.00020 |
| Tin (Sn)-Dissolved | mg/L | 0.0005 | - | - | <0.00050 | <0.00050 | <0.00050 |
| Titanium (Ti)-Dissolved | mg/L | 0.01 | 0.1 | 0.1 | <0.010 | <0.010 | <0.010 |
| Uranium (U)-Dissolved | mg/L | 0.0002 | 0.1 | 0.3 | <0.00020 | 0.00159 | 0.00035 |
| Vanadium (V)-Dissolved | mg/L | 0.001 | 0.1 | - | <0.0010 | <0.0010 | <0.0010 |
| Zinc (Zn)-Dissolved | mg/L | 0.005 | 5 | - | <0.0050 | 0.0101 | 0.0108 |
| COD | mg/L | 20 | - | - | <20 | 74 | 47 |
| Phenols (4AAP) | mg/L | 0.001 | - | - | <0.0010 | 0.0040 * | <0.0010 |

**Notes:**

Exceedences of drinking water guidelines

Exceedences of both drinking water and aquatic life criteria

1. B.C. Environment Approved & Working Criteria for Water Quality, 2006.
2. Limits for metals are for total concentrations, not dissolved. As such, they are intended as guidelines, rather than approved criteria.
3. Aesthetic criteria related to taste or appearance.

# Table 2-5: Surface Water Quality Data

| Parameter | | | | Sample ID | SW-1 | SW-2 | SW-3 |
|---|---|---|---|---|---|---|---|
| | | | | Site Location | Marine Avenue | Marine Avenue | Marine Avenue |
| | | | | Date Sampled | 25/03/2014 | 25/03/2014 | 25/03/2014 |
| | Units | Detection Limit | BCWQG-DW$^{1,2}$ | BCWQG-AW$^{1,2}$ | | | |
| Conductivity | uS/cm | 2 | 700 | - | 81.3 | 185 | 88.6 |
| Hardness (as CaCO3) | mg/L | 0.5 | > 500 $^{3}$ | - | 26.8 | 71.6 | 29.5 |
| pH | pH | 0.1 | 6.5 - 8.5 | - | 7.64 | 7.9 | 7.71 |
| Total Suspended Solids | mg/L | 3 | - | - | 20.1 | 34.9 | 23.5 |
| Total Dissolved Solids | mg/L | 10 | - | - | 55 | 101 | 68 |
| Ammonia, Total (as N) | mg/L | 0.005 | - | - | 0.0057 | 0.0112 | 0.0059 |
| Bromide (Br) | mg/L | 0.05 | - | - | <0.050 | <0.050 | <0.050 |
| Chloride (Cl) | mg/L | 0.5 | 250 | 150 | 7.85 | 7.59 | 7.87 |
| Fluoride (F) | mg/L | 0.02 | 1.5 | 0.2-0.3 | 0.029 | 0.043 | 0.025 |
| Nitrate (as N) | mg/L | 0.005 | 10 | 200 | 0.202 | 0.196 | 0.212 |
| Nitrite (as N) | mg/L | 0.001 | 1 | 0.06-0.6 | 0.0015 | 0.0019 | 0.0014 |
| Sulfate (SO4) | mg/L | 0.5 | 500 | - | 2.49 | 16.4 | 3.19 |
| Aluminum (Al)-Total | mg/L | 0.005 | 0.2 | 0.1 (ph>6.5) | 0.521 | 0.774 | 0.566 |
| Antimony (Sb)-Total | mg/L | 0.0005 | 0.006 | 0.002 | <0.00050 | 0.00054 | <0.00050 |
| Arsenic (As)-Total | mg/L | 0.0005 | 0.025 | 0.005 | <0.00050 | 0.0007 | <0.00050 |
| Barium (Ba)-Total | mg/L | 0.02 | 1 | 5 | <0.020 | <0.020 | <0.020 |
| Beryllium (Be)-Total | mg/L | 0.001 | - | 0.0053 | <0.0010 | <0.0010 | <0.0010 |
| Boron (B)-Total | mg/L | 0.1 | 5 | 1.2 | <0.10 | <0.10 | <0.10 |
| Cadmium (Cd)-Total | mg/L | 0.00001 | 0.005 | - | <0.000010 | 0.000033 | <0.000010 |
| Calcium (Ca)-Total | mg/L | 0.1 | - | - | 7.98 | 21.4 | 8.83 |
| Chromium (Cr)-Total | mg/L | 0.001 | 0.05 | 0.009 | <0.0010 | <0.0010 | <0.0010 |
| Cobalt (Co)-Total | mg/L | 0.0003 | - | 0.11 | <0.00030 | 0.00034 | <0.00030 |
| Copper (Cu)-Total | mg/L | 0.001 | 1 | Hardness | 0.0015 | 0.0057 | 0.0016 |
| Iron (Fe)-Total | mg/L | 0.03 | 0.3 | 0.35 | 1.07 | 3.01 | 1.13 |
| Lead (Pb)-Total | mg/L | 0.0005 | 0.05 | - | <0.00050 | 0.00273 | 0.00056 |
| Lithium (Li)-Total | mg/L | 0.005 | - | - | <0.0050 | <0.0050 | <0.0050 |
| Magnesium (Mg)-Total | mg/L | 0.1 | 100 | - | 1.66 | 4.39 | 1.81 |
| Manganese (Mn)-Total | mg/L | 0.0003 | 0.05 | 0.8-3.8 | 0.0297 | 0.139 | 0.0376 |
| Mercury (Hg)-Total | mg/L | 0.00001 | 0.001 | 0.0001 | <0.000010 | <0.000010 | <0.000010 |
| Molybdenum (Mo)-Total | mg/L | 0.001 | 0.25 | 2 | <0.0010 | <0.0010 | <0.0010 |
| Nickel (Ni)-Total | mg/L | 0.001 | - | 0.025-0.15 | <0.0010 | <0.0010 | <0.0010 |
| Potassium (K)-Total | mg/L | 2 | - | - | <2.0 | 3.1 | <2.0 |
| Selenium (Se)-Total | mg/L | 0.0001 | 0.01 | 0.001 | <0.00010 | <0.00010 | <0.00010 |
| Silver (Ag)-Total | mg/L | 0.00002 | 0.05 | 0.00005-0.003 | <0.000020 | <0.000020 | <0.000020 |
| Sodium (Na)-Total | mg/L | 2 | 200 | - | 6.2 | 9.6 | 6.6 |
| Thallium (Tl)-Total | mg/L | 0.0002 | 0.002 | - | <0.00020 | <0.00020 | <0.00020 |
| Tin (Sn)-Total | mg/L | 0.0005 | - | - | <0.00050 | <0.00050 | <0.00050 |
| Titanium (Ti)-Total | mg/L | 0.01 | 0.1 | 0.1 | 0.028 | 0.036 | 0.028 |
| Uranium (U)-Total | mg/L | 0.0002 | 0.1 | 0.3 | <0.00020 | 0.00046 | <0.00020 |
| Vanadium (V)-Total | mg/L | 0.001 | 0.1 | - | 0.002 | 0.0025 | 0.0021 |
| Zinc (Zn)-Total | mg/L | 0.005 | 5 | - | <0.0050 | 0.0142 | <0.0050 |
| COD | mg/L | 20 | - | - | <20 | 40 | <20 |
| Phenols (4AAP) | mg/L | 0.001 | - | - | 0.0015 | 0.0045 | 0.0043 |

**Notes:**

Exceedences of both drinking water and aquatic life criteria

1. B.C. Ministry of Environment Approved & Working Criteria for Water Quality, 2006.
2. Limits for metals are for total concentrations, not dissolved. As such, they are intended as guidelines, rather than approved criteria.
3. Aesthetic criteria related to taste or appearance.

# Table 2-6: Powell River Landfill Marine Site Ash and Woodchip Sample Lab Results
# Compared to CSR guidelines for Commercial Lands (CL)

| Sampling Date | | | 2014/07/03 | 2014/07/03 | 2014/07/03 | 2014/07/03 | | 2014/07/03 | | 2014/07/03 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Material Sampled** | | | **Ash** | **Ash** | **Ash** | **Ash** | | **Woodchips** | | **Woodchips** |
| | **Location** | | **F-1** | **F-2** | **F-3** | **D-1** | | **J-1** | | **J-2** |
| | **Criteria** | *CSR-CL (6)* | | | | | ***CSR-CL (6)*** ***pH 6.10*** | | ***CSR-CL (6)*** ***pH 6.60*** | |
| **Physical Properties** | | | | | | | | | | |
| Soluble (2:1) pH | pH | | 7.56 | 8.00 | 7.87 | 7.96 | - | 6.10 | - | 6.60 |
| Total Kjeldahl Nitrogen | % | | - | - | - | - | - | 0.46 | - | 0.32 |
| Moisture | % | | 10.0 | 16.0 | 13.0 | 6.3 | - | 43.3 | - | 44.5 |
| Heating Value | kJ/kg | | - | - | - | - | - | 5,282 | - | 7,110 |
| **Total Metals by ICPMS** | | | | | | | | | | |
| Total Aluminum (Al) | mg/kg | | 11900 | 16200 | 13400 | 15900 | - | - | - | - |
| Total Antimony (Sb) | mg/kg | | 39.0 | 44.3 | 44.4 | 22.2 | - | 4.1 | - | 10.3 |
| Total Arsenic (As) | mg/kg | *15* | 75.0 | 12.9 | 32.1 | 8.57 | *15* | 12.30 | *15* | 14.20 |
| Total Barium (Ba) | mg/kg | *400* | 646 | 213 | 226 | 246 | *400* | 100 | *400* | 105 |
| Total Beryllium (Be) | mg/kg | | <0.40 | <0.40 | <0.40 | <0.40 | - | <0.01 | - | <0.01 |
| Total Bismuth (Bi) | mg/kg | | 0.63 | 0.43 | 0.47 | 0.94 | - | - | - | - |
| Total Boron (B) | | | | | | | - | 1.13 | - | 2.28 |
| Total Cadmium (Cd) | mg/kg | *200 (1)* | 1.94 | 3.68 | 2.44 | 2.97 | *1.5 (4)* | 1.05 | *3 (5)* | 0.75 |
| Total Calcium (Ca) | mg/kg | | 20300 | 21200 | 18400 | 22900 | - | 3120 | - | 3010 |
| Total Chromium (Cr) | mg/kg | *60* | 62.0 | 71.2 | 43.0 | 91.5 | *60* | 88.7 | *60* | 146.0 |
| Total Cobalt (Co) | mg/kg | | 10.7 | 7.96 | 7.08 | 10.1 | - | 5.7 | - | 6.4 |
| Total Copper (Cu) | mg/kg | *350000 (2)* | 341 | 956 | 866 | 619 | *15000 (4)* | 43 | *350000 (2)* | 60 |
| Total Iron (Fe) | mg/kg | | 45600 | 58700 | 46900 | 37000 | - | - | - | - |
| Total Lead (Pb) | mg/kg | *4000 (2)* | 344 | 435 | 1030 | 496 | *250 (4)* | 121 | *4000 (2)* | 179 |
| Total Lithium (Li) | mg/kg | | 5.4 | 6.2 | 5.2 | 6.3 | - | 4.4 | - | 3.1 |
| Total Magnesium (Mg) | mg/kg | | 3450 | 3150 | 2900 | 3350 | - | - | - | - |
| Total Manganese (Mn) | mg/kg | | 487 | 1160 | 602 | 867 | - | - | - | - |
| Total Mercury (Hg) | mg/kg | | 0.077 | <0.050 | 0.057 | <0.050 | - | 0.202 | - | 0.168 |
| Total Molybdenum (Mo) | mg/kg | | 10.4 | 12.6 | 9.35 | 5.67 | - | 7.69 | - | 9.23 |
| Total Nickel (Ni) | mg/kg | | 62.7 | 93.7 | 45.5 | 93.9 | - | 24.1 | - | 28.9 |
| Total Phosphorus (P) | mg/kg | | 1180 | 1930 | 1590 | 2240 | - | 45 | - | 33 |
| Total Potassium (K) | mg/kg | | 1430 | 1310 | 1080 | 1330 | - | 205 | - | 161 |
| Total Selenium (Se) | mg/kg | | <0.50 | <0.50 | <0.50 | <0.50 | - | <0.3 | - | <0.3 |
| Total Silver (Ag) | mg/kg | | 0.583 | 1.43 | 0.998 | 1.56 | - | <0.2 | - | <0.2 |
| Total Sodium (Na) | mg/kg | | 989 | 1820 | 1670 | 1880 | - | <30 | - | 50 |
| Total Strontium (Sr) | mg/kg | | 84.8 | 81.7 | 74.3 | 81.3 | - | 52.1 | - | 39.7 |
| Total Thallium (Tl) | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | <0.3 | - | <0.3 |
| Total Tin (Sn) | mg/kg | | 45.2 | 57.3 | 66.3 | 54.4 | - | 2.7 | - | 2.8 |
| Total Titanium (Ti) | mg/kg | | 531 | 731 | 719 | 790 | - | - | - | - |
| Total Uranium (U) | mg/kg | | 0.827 | 0.432 | 0.628 | 0.415 | - | - | - | - |
| Total Vanadium (V) | mg/kg | | 36.0 | 32.2 | 32.6 | 36.9 | - | 44.8 | - | 35.9 |
| Total Zinc (Zn) | mg/kg | *15000 (3)* | 1620 | 1480 | 1210 | 1790 | *1000 (4)* | 218 | *7500 (5)* | 255 |
| Total Zirconium (Zr) | mg/kg | | 0.99 | 2.39 | 1.91 | 2.72 | - | - | - | - |
| **Polycyclic Aromatics** | | | | | | | | | | |
| Naphthalene | mg/kg | | <0.050 | 0.10 | <0.050 | <0.050 | - | - | - | - |
| 2-Methylnaphthalene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Acenaphthylene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Acenaphthene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Fluorene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Phenanthrene | mg/kg | | 0.059 | 0.11 | 0.072 | 0.18 | - | - | - | - |
| Anthracene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Fluoranthene | mg/kg | | 0.052 | 0.081 | 0.064 | 0.27 | - | - | - | - |
| Pyrene | mg/kg | | 0.056 | 0.065 | 0.060 | 0.22 | - | - | - | - |
| Benzo(a)anthracene | mg/kg | | <0.050 | <0.050 | <0.050 | 0.068 | - | - | - | - |
| Chrysene | mg/kg | | <0.050 | <0.050 | <0.050 | 0.082 | - | - | - | - |
| Benzo(b&j)fluoranthene | mg/kg | | <0.059 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Benzo(k)fluoranthene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Benzo(a)pyrene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Indeno(1,2,3-cd)pyrene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Dibenz(a,h)anthracene | mg/kg | | <0.050 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Benzo(g,h,i)perylene | mg/kg | | 0.084 | <0.050 | <0.050 | <0.050 | - | - | - | - |
| Low Molecular Weight PAH`s | mg/kg | | 0.059 | 0.22 | 0.073 | 0.18 | - | - | - | - |
| High Molecular Weight PAH`s | mg/kg | | 0.19 | 0.15 | 0.12 | 0.64 | - | - | - | - |
| Total PAH | mg/kg | | 0.25 | 0.36 | 0.20 | 0.83 | - | - | - | - |

**NOTES**

1.0 Shading indicates exceedance of Guideline

1. Based on pH range 7.5 to 8.0
2. Based on pH greater than or equal to 6.5
3. Based on ph greater than or equal to 7.0
4. Based on pH range 6.0 to 6.5
5. Based on pH range 6.5 to 7.0
6. CSR-CL = Contaminated Sites Regulations - Commercial Land end-use
   Site specific factor : Groundwater used for drinking water

# 3. DESIGN OBJECTIVES FOR CLOSURE

## 3.1 Purpose

This Chapter describes the goals and objectives of the closure plan. Design objectives and goals for closure are based in part on Provincial regulations and in part on Sperling Hansen Associates' experience with landfill closures throughout British Columbia. The specific characteristics of the final cover will depend on the particular end use taking into consideration, the type of waste and the design objectives for the cover.

## 3.2 Future End Use

The site is currently being used as a storage and transfer site for different types of waste and recyclable materials.

PRRD is required to submit a Closure Plan for the site. The plan shall include information regarding:

- Leachate generation and migration, including the need to assess existing conditions and compare with historical data, and develop a leachate control strategy, if needed.
- Surface and groundwater quality performance criteria.
- Existing topographic conditions and final topography.
- Final grade requirements and the need for future structural fills.
- Relocation strategy for materials that can be cost effectively recycled.
- Utility crossings as well as site access.
- Final cover design, including a review of alternative design concepts.
- Surface water drainage management on the final grades.
- Landfill gas generation, emission and control.
- Control of erosion and sedimentation during closure activities and for post closure.
- Implementation of a fire protection plan to deal with potential combustion of the wastes.
- A review of site access and security for closure and post closure.
- Establish a monitoring program and frequency that includes surface water and groundwater, landfill gas (if needed), performance of the final cover and surface drainage, slope stability and settlement (when required).
- End use strategy post closure.

## 3.3 Overview of Regulations

The Provincial regulatory standards and guidelines applicable to the site are described in the following sections. As mentioned in the updated Criteria, municipal waste landfilling is a specified activity in Schedule 2 of the Contaminated Sites Regulation (CSR). Section 40 of Environmental Management Act (EMA) requires, at the time of decommissioning (when site no longer accepts waste), the Owner to submit a site profile to the MOE.

The approval of a Closure Plan does not exempt the property Owner from the duty to submit a site profile nor does it prevent a local government to issue an authorization, such as a development permit as specified in Section 40(1) of the EMA.

Based on the discussions with the MOE, the CSR in conjunction with the BC Landfill Criteria for Municipal Solid Waste and the BC Guidelines for Environmental Monitoring at Municipal Waste Landfills are applied to assess the environmental conditions at the Site to develop a Closure Plan. If a Certificate of Compliance is requested for a site, the MOE recommends that the professionals involved in landfill closure and site remediation work together to share information.

### 3.3.1 Site Profile Requirement

SHA understands that a site profile for the Site will be submitted to the MOE by the PRRD under a separate cover at a later date.

### 3.3.2 Landfill Criteria for Municipal Solid Waste

The Provincial Government issued the *Landfill Criteria for Municipal Solid Waste* in June 1993. The Criteria provide guidelines for development, operation and closure of landfills in British Columbia. The Criteria are not regulations; rather, they are guidelines to be used by Regional Waste Managers as standards in permits, waste management plans and operational certificates issued under the Waste Management Act. A draft updated criteria originally developed by SHA was launched at the SWANA Conference in Richmond on the 6th December, 2013 and will be finalized by the MOE in 2014. SHA has followed the existing criteria in developing this plan, any changes that may need to be adjusted when the new criteria is finalized and comes into effect have been highlighted.

### 3.3.3 Contaminated Site Criteria

The contaminated sites statutes in the Province of British Columbia are regulated by the *Environmental Management Act* (EMA), and the *Contaminated Sites Regulation* 1997 (CSR) as amended in March 18, 2013. This legislation includes a comprehensive framework for environmental investigation. In 1988, the *Hazardous Waste Regulation* (HWR) pursuant to the EMA came into force and was amended in April 1, 2009. The HWR identifies certain wastes as being particularly hazardous.

If the Site is redeveloped in the future for a different land use, it will have to be assessed and remediated within the regulatory framework for contaminated sites. Currently, the legislation governing contaminated sites in British Columbia consists of the EMA, the CSR and the HWR.

The CSR specifies numeric concentration limits for a large number of substances. In soil, generic numerical standards have been established for some parameters, and matrix numerical standards have been established for others. Different standards have been designated for various uses of the land, industrial (IL), commercial (CL), residential (RL), urban park (PL) or agricultural (AL), to protect environmentally sensitive organisms or to protect human health (matrix numerical standards). In water, generic numerical standards have been established to protect specific uses of the groundwater, specifically aquatic life (AW), irrigation (IW), livestock watering (LW) and drinking water (DW). When the concentration of one or more contaminants exceeds the applicable numeric standards, corrective or remedial action is called for. Remedial action can either reduce the concentration of offending substances or parameters to less than the applicable numeric standard or can reduce the risk to human health and the environment to less than defined limits using specific engineered or administrative controls.

### 3.3.4 Hazardous Waste Regulation

Section 41.1 of the Hazardous Waste Regulation states that a person must not store, treat or use hydrocarbon contaminated soil without approved procedures and the hydrocarbon contaminated soil will be treated as a hazardous waste if one or more items listed in Colum I of the table in Section 41.1 is present. The hydrocarbon contaminated soil must be spread in single layers not exceeding 0.3 m thickness per year.

Treated hydrocarbon contaminated soil which is no longer a hazardous waste may be disposed of in a landfill if approval is secured  before disposal takes place.

### 3.3.5 Groundwater Standards

No water wells were found during a water well search conducted by Keystone Environmental (Keystone, 2003). However, drinking water (DW) standards may apply as the Site is located in an area in which future use of groundwater for drinking water cannot be excluded. The analytical results of groundwater should be interpreted using the most suitable water quality criteria. At present, these are the *"British Columbia Approved Water Quality Guidelines Criteria (BCAWQGC): 2006 Edition"* (updated August, 2006), for the protection of aquatic life (AW) and drinking water quality (DW) as per the BC Landfill Criteria for Municipal Solid Waste, 1993.

### 3.3.6 Soil Standards

The previous land use was for municipal waste incineration and landfilling which is considered a CSR Schedule 2 Industrial or Commercial activity. The Site is envisioned to be used as a Recycling Centre/ Resource Recovery Park. At that stage, an investigation should be carried out before using for the planned commercial purpose and the CSR CL numerical standards need to be used to characterize the soil and to determine possible soil contamination.

### 3.3.7 Surface Water Guidelines

The site is crossed by a small drainage course. Hence, the BC Approved and Working Water Quality Guidelines (BC AWWQG) for freshwater are applicable at the site.

## 3.4 Compilation of Regulations and Design Objectives

This section presents a compilation of all key regulations extracted from the applicable regulations and closure design objectives based on SHA's experience and discussions with the various stakeholders.

### 3.4.1 Landfill Closure Plans

The Landfill closure plan shall include information regarding:

- Estimated total waste volumes and tonnages in place, and the closure date;
- Existing topographic conditions;
- A topographic plan showing the final elevation contours of the landfill and surface water diversion and drainage controls;
- Final grading requirements and the need for future structural fills;
- Slope stability of existing landfill slopes and the need to design final grades and soil covers to maintain reasonably acceptable long-term performance;
- A review of site access and security for closure and post closure;
- Consideration of all utility crossings;
- Design of the final cover including the thickness and permeability of the barrier layers and drainage layers and information on topsoil, vegetative cover and erosion prevention controls;
- Final cover design, including a review of alternative design concepts;
- Surface water drainage management on the final grades;
- Control of erosion and sedimentation during closure activities and for post closure;
- Leachate generation and migration, including the need to assess existing conditions and compare with historic data, and develop a leachate control strategy, if needed;
- Landfill gas generation, emission and control;
- Surface and groundwater quality performance criteria;
- Rodent and nuisance wildlife control procedures;
- Implementation of a fire protection plan to deal with potential combustion of the wastes;

- Establish a monitoring program and frequency that includes surface water and groundwater, landfill gas (if required), performance of the final cover and surface drainage, slope stability and settlement (if required);
- A plan for the operation of any required pollution abatement engineering works such as leachate and landfill gas collection/treatment systems for a minimum post-closure period of 25 years as per the existing criteria. The post closure care period has been extended to 30 years as per the draft criteria launched at the SWANA Conference by the MOE on 6th December for public comments;
- A plan for monitoring groundwater, surface water, landfill gas, erosion and settlement for a minimum post-closure period of 25/30 years;
- Contingencies to address environmental impact concerns that may arise during the minimum post-closure period of 25/30 years;
- An estimated cost, updated annually, to carry out closure and post-closure activities for a minimum period of 25/30 years;
- Procedures for notifying the public about closure and alternate waste disposal plans;
- Proposed implementation schedule for the closure aspects of the plan; and
- Proposed end use of the property after closure

### 3.4.2 Landfill Settlement

- Long-term settlement is an issue at most landfills due to the organic content of the waste. Additional settlement can occur in the foundation soil beneath the landfill due to the surcharge of the overlying waste. Since, as described in Section 3.6, the landfill area is mostly filled with incinerator ash and the proposed transfer bay area will be created as a holding cell with incinerator ash, very little settlement is expected to occur.
- The option of construction of buildings or other structures will be explored. Settlement issues will be addressed and evaluated.
- If construction of buildings or other structures are contemplated, the possible Contaminated Sites Regulation (CSR) implications will have to be investigated.
- The construction of buildings or other structures is not recommended on waste for a minimum period of 25 years after closure due to concerns about combustible gas and excessive settlement.
- If buildings or other structures are constructed on site, further authorization through the CSR is required to obtain the necessary legal instrument.

### 3.4.3 Final Cover

The Final Cover Design is described in detail in Chapter 8. Key issues, as per the criteria, are summarized below:

- The owner shall apply final cover to any area of the landfill that will not receive further fill for grading purposes. Final cover shall be applied within one year of completing the subject area or within 90 days of landfill closure. As per the new Criteria, final cover shall be placed within 180 days on any part of the landfill footprint at final contours;

- The final cover shall consist of a minimum of 1.0 metre of low permeability (<1x10$^{-5}$ cm/s) compacted (or equivalent) cap plus a minimum of 0.15 metre of topsoil and suitable vegetative cover. As per the new Criteria, the final cover shall consist of a minimum of 0.6 metre of low permeability ( <1x10$^{-5}$ cm/s for landfill sites located in arid regions and <1x10$^{-7}$ cm/s for landfill sites located in non-arid regions) compacted (or equivalent) cap plus a minimum of 0.15 metre of topsoil and suitable vegetative cover;
- Final cover shall be sloped at a minimum of 4% at the top plateau to promote surface water runoff. As per the new criteria, the top plateau shall be a minimum of 10%;
- Surface water runoff shall be directed into collection systems and disbursed into existing streams;
- The barrier layer shall be protected with a minimum 150 mm thick topsoil layer with approved vegetation established. As per the new Criteria, the topsoil layer shall be 300 mm thick.
- Soil used in the final cover system, including the barrier layer, drainage layer, top soil layer and landscaping material must first be remediated such that all hazardous substances in the soil do not exceed the Industrial Level (<IL);
- A schedule shall be prepared for progressive grading fill, progressive closure and final cover application;
- Information shall be provided as to the types of materials that will comprise the final cover.

It is noted that according to the CSR, the movement of soil exceeding the levels in Column II of Schedule 7 in the CSR will require a Contaminated Soil Relocation Agreement (CSRA).

### 3.4.4 Runoff Controls

Surface Water and Runoff Control that will be required is summarized below:

- Surface water diversion works are required.
- Appropriate run-off/run-on control measures shall be provided in the final cover system.
- Run-off from the final cover system shall be directed outside the leachate collection system.

### 3.4.5 Gas Venting or Recovery Systems

Landfill Gas Management will be discussed in detail in Chapter 5. In general the requirements for landfill gas management state:

- An assessment of the need for a Landfill gas recovery system shall be conducted for landfills with a total capacity exceeding 100,000 tonnes or for landfills that are receiving 10,000 tonnes of waste per year or more after January 2008.
- If the assessment indicates that the emissions of non-methane organic compounds (NMOCs) exceed or are expected to exceed 150 tonnes/year, a gas recovery and management system is mandatory as per existing BC Landfill Criteria for MSW 1993.
- If production of methane exceeds 1,000 tonnes/year a gas recovery and management system becomes mandatory as per Landfill Gas Management Regulation 2008

## 3.5 End Use Objective

The end use plan for the Marine Ave Transfer Site is to construct a Recycling Centre and Resource Recovery Park on approximately half of the site area and a Botanical Garden and Compost Facility on the remaining half of the site as shown in Figure 6-2. The Recycling Centre and Resource Recovery Park are envisioned to be developed with a similar concept as used in the Peerless Road Recycling Centre in Cowichan Valley Regional District. The Botanical Garden will be a demonstration site for the Botanical Garden Society of Powell River.

## 3.6 End Use Plan and Grading Strategy

The preferred end use of the Marine Avenue Transfer Site is discussed in detail in Chapter 6. The proposed Closure Plan involves upcycle, reuse, recycle and innovative use of the materials on-site as much as possible. The site would incorporate a large pile of contaminated incinerator waste (ash) and DLC waste relocated from the north-west corner of the Site under an engineered landfill cover. Cover material for the synthetic membrane would be non-contaminated fill or materials sourced at the site and/or imported. The remaining ash, as described in Table 2-1, will be relocated into a holding cell. Only Roofing and Gyproc are planned to be recycled off-site. All other materials listed in Table 2-1 are planned to be either reused or recycled in innovative ways at the site. A detailed grading plan for the Recycling Centre has been discussed in Chapter 6. The availability and utilization of other materials are discussed in Chapter 11.

The Botanical Garden Society of Powell River expressed an interest to the PRRD to use their innovative ideas to remediate and restore the site. They proposed converting the entire site into a botanical garden. To achieve this goal in a cost effective manner they recommended combining methods of phytoremediation (plants), bioremediation (bacteria) and mycoremediation (fungi) in an ecological restoration framework. Although the restoration and remediation of the site in this fashion is not considered the lowest risk approach, the PRRD would like to develop a botanical garden on a portion of the site as shown on Figure 6-2 where this methodology, referred to as eco-remediation, is expected to be applied to some extent by the Society as part of research initiatives.

The woodchips, stumps and yard waste are planned to be utilized for composting facility and a portion or all of the wood chips are envisioned to be used for making fabricated topsoil at the site. This plan is described in more detail in Chapter 10.

# 4 LEACHATE MANAGEMENT

## 4.1. Leachate Management

Landfill leachate is generated by precipitation filtering through the soil cover into the underlying refuse layer and from moisture contained in the waste being squeezed out by compaction from the weight of overlying solid waste. The volume of leachate produced depends on several factors. The most relevant factors are the type of refuse, local climate, the surface area of the cells and the type of cover incorporated in the refuse.

Marine Avenue Transfer Site receives an average of 1205 mm of precipitation annually. Therefore, potential leachate impact issues at the site would have occurred had the landfill been used for MSW containing organic waste. Over time precipitation may mobilize contaminants contained in the ash and in the various material stockpiles that exist on the site.

## 4.2. Leachate Generation Potential

The Marine Avenue Transfer Site has a moderate leachate generation potential, based on the amount of precipitation received at the Site and based on natural protection and attenuation by the underlying material. A comparison of the leachate generation potential of Marine Avenue Transfer Site with other sites in B.C. is provided in Figure 4-1. The leachate generation potential of all the sites has been calculated using Thornthwaite Model.

## 4.3. Water Balance

A key aspect of this project was to conduct a water budget analysis and evaluate the existing and future leachate generation potential from the Landfill. A Water Balance was performed on the landfill site using the Thornthwaite Model as well as the HELP model. The results of the two analyses are discussed in the following sections.

### 4.3.1 Thornthwaite Model

Currently, this Landfill site depends on natural attenuation by the underlying soil to limit leachate impacts. Several piles of different types of waste are scattered all around the site. To estimate the amount of leachate that is being generated before closure, SHA conducted a water balance analysis for the site using the Thornthwaite and Mather (1957) numerical method to determine leachate production potential for the site after consolidation of the waste piles. This method is a water balance approach to modelling surface water fluxes that employs a relatively simple method of estimating the partition of soil evaporation and recharge.

The water balance examines the relationship between precipitation and evapotranspiration, the process involving the return of water to the atmosphere through evaporation and transpiration by vegetation.

During the winter months, precipitation will typically exceed evapotranspiration resulting in a moisture surplus. During the summer months, precipitation rates will be less than evapotranspiration rates thereby resulting in a moisture deficit. A moisture surplus will result in water flowing over the landfill surface as runoff, being retained in storage (i.e. snow or soil moisture) or infiltrating and generating leachate. During a moisture deficit, water is drawn out of surface soils, thereby decreasing the soil moisture content.

The incinerator ash is planned to be consolidated as per the grading plan described in Chapter 6. A total area of 1.21 Ha would be generated together for the landfill and the transfer bay area. Table 4-1 and Figure 4-2 present a Water Budget Summary for the site based on the Thornthwaite Method on a month by month basis, based on site-specific climate data. The analysis predicts that the 1205 mm/yr of precipitation will be portioned as follows: Run-off 362 mm, evapotranspiration 383 mm/yr, and percolation 461 mm/yr.

The total footprint of the landfill and the transfer bay together occupying approximately 1.20 ha will produce about 9,876 $m^3$ (0.31 L/s) of leachate per year before closure when surface water run-off is considered to contribute to the leachate generation according to the Thornthwaite Method. The Landfill and the holding cell for the proposed transfer bay area is proposed to be closed with proper surface water management that will prevent the inclusion of clean water with the leachate. As such, leachate generation from the site will be reduced to that amount generated only by percolation. The total final footprint of 1.21 ha before closure, is expected to generate 5,532 $m^3$/yr (0.17 L/s) of leachate.

### 4.3.2 HELP Model

A 50-year simulation of leachate production at the site was run using the Hydrological Evaluation of Landfill Performance (HELP) model. The average monthly precipitation rate and temperature based on the Environment Canada Climatic Normal Data (1981 to 2010) were input into the model. The average annual precipitation created by the HELP model was 1229.9 mm; however, the actual average recorded annual precipitation at the Powell River Airport Station is slightly lower at 1205.4 mm/yr. This difference is due to the artificial parameters that the HELP model uses to simulate the weather.

The results are summarized in Table 4-2. The simulation suggests that much of the precipitation that falls on the site is returned to the atmosphere through the process of evapotranspiration. Under open conditions 40.1% of the precipitation (493.2 mm/yr) will be returned to the atmosphere through evapotranspiration, while 1.0% (12.45 mm/yr) will shed as run-off. Of the remaining precipitation, 58.9% (724.0 mm/yr) is predicted to become leachate, leaving 0.01 % (0.15 mm/yr) precipitation for storage change. A breakdown of the precipitation outcome is shown Figure 4-3.

For the 1.21 ha area of landfill and proposed transfer bay area, the amount of leachate generated before closure according to the HELP modelling is 8,760 $m^3$/year (0.28 L/s).

Table 4-3 below shows a comparison between the key results found using the Thornthwaite method and the HELP model. The leachate production estimation for open conditions, using HELP modelling, forecasts annual leachate percolation at 724 mm/year compared to 461 mm/year predicted by the Thornthwaite method, primarily because the HELP model forecasts significantly less run-off (12.6 mm for the HELP model vs. 362.0 mm for the Thornthwaite model). Unlike the Thornthwaite method, the HELP model has the option to define the geometry and the hydrogeological properties of different layers which may result in a variation in run-off and leachate generation estimation. Since the HELP model is especially designed for landfill systems including various combinations of vegetation, cover soils, waste cells, lateral drain layers, low permeability barrier soils, and synthetic geomembrane liner, the results from this model are used for all further analysis.

**Table 4-3: Comparison between Thornthwaite Method and HELP Model Results**

| Method | Evapotranspiration | | Run-off | | Percolation to Leachate | |
|---|---|---|---|---|---|---|
| | mm/year | % | mm/year | % | mm/year | % |
| Thornthwaite | 639 | 53.0 | 362.0 | 30.0 | 461.0 | 38.3 |
| HELP | 493.2 | 40.1 | 12.45 | 1.01 | 724.2 | 58.9 |

## 4.4. Leachate Management Strategy

The leachate management concept for the Marine Avenue Transfer Site has been developed to achieve the following objectives:

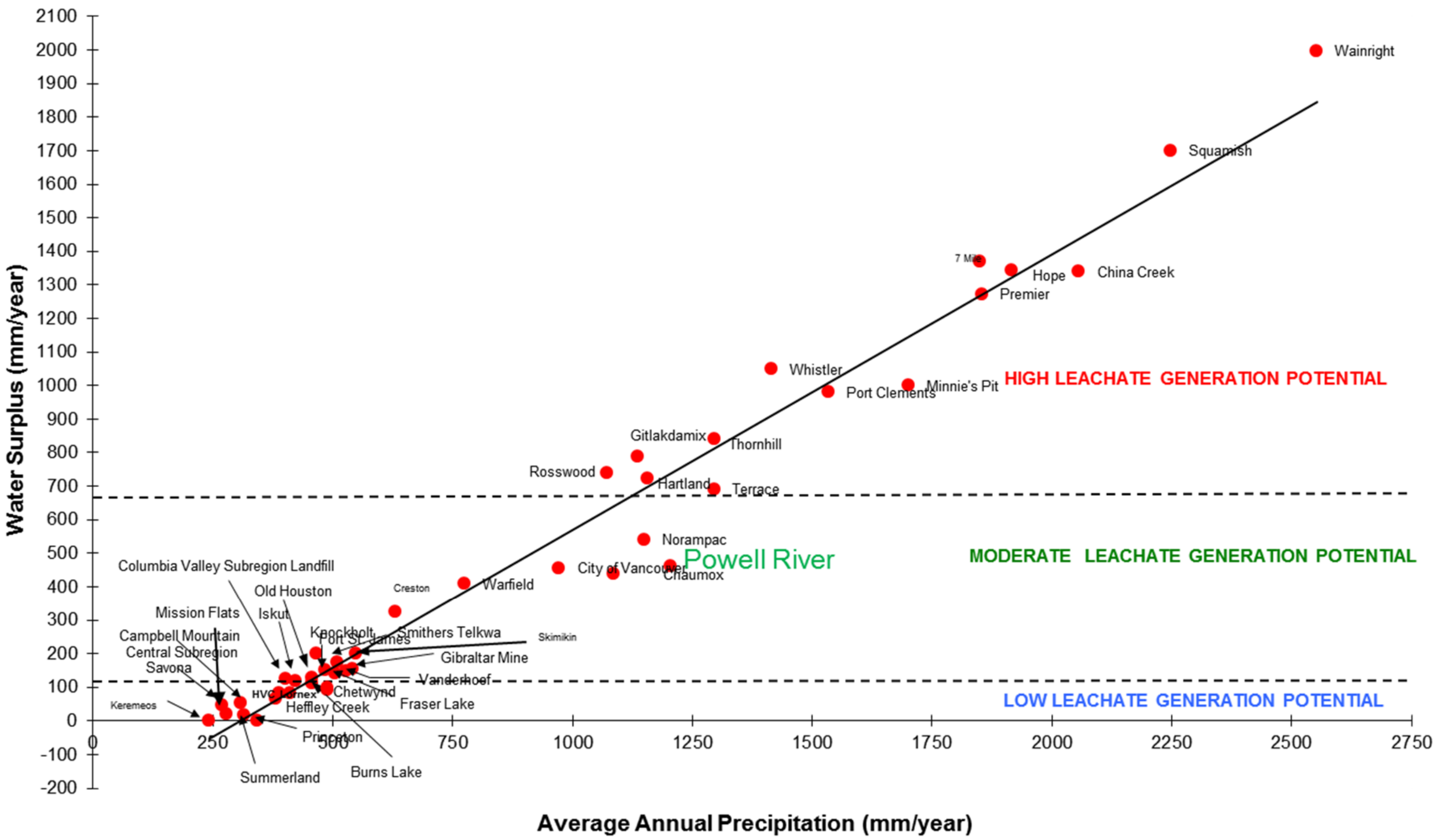
- Keep clean water clean by diverting run-on and run-off; and
- Minimize percolation by designing an impermeable cover system;

The Site is a natural barrier and natural control site, as it does not feature a leachate containment/collection/disposal system. Section 6.1.1 of the Landfill Criteria (1993) lists the criteria for a natural control facility as:

- The bottommost solid waste cell is to be 1.2 metres above the seasonal high water table. Greater or lesser separations depths may be approved based on soil permeability and the leachate renovation capacity of the soil.
- There is to be at least a 2 metre thick layer of low permeability soil with a hydraulic conductivity of 1 x $10^{-6}$ cm/s of less (i.e. silt or clay), below each of the bottommost waste cells. Lesser thicknesses or no layers of low permeability soil may be approved based on the potential for leachate generation and the unsaturated depth, permeability and leachate renovation capability of the existing soil.

Based on recent water quality results at this Site, the water quality of both surface water and groundwater is good. The concentrations of some of the parameters in the groundwater samples and surface water samples collected during the monitoring events were slightly higher than the applicable standards. Because waste materials will be consolidated into a thicker column and there will be greater potential for reducing conditions that could leach metals SHA recommends a geomembrane cover system for closure of the consolidated landfill portion of the site and asphalt pavement along with WP20 to reduce the leachate generation significantly in the transfer station area, as presented in Chapter 8, Table 8-2. The proposed cover system installation will also bring the site into compliance with the existing as well as the new Landfill Criteria for Municipal Solid Waste.

## Leachate Generation Potential of Landfills in BC



SPERLING
HANSEN
ASSOCIATES

POWELL RIVER
REGIONAL DISTRICT

PROJECT:

**Powell River Marine Avenue**
**Transfer Site**
**Closure Plan**

TITLE:

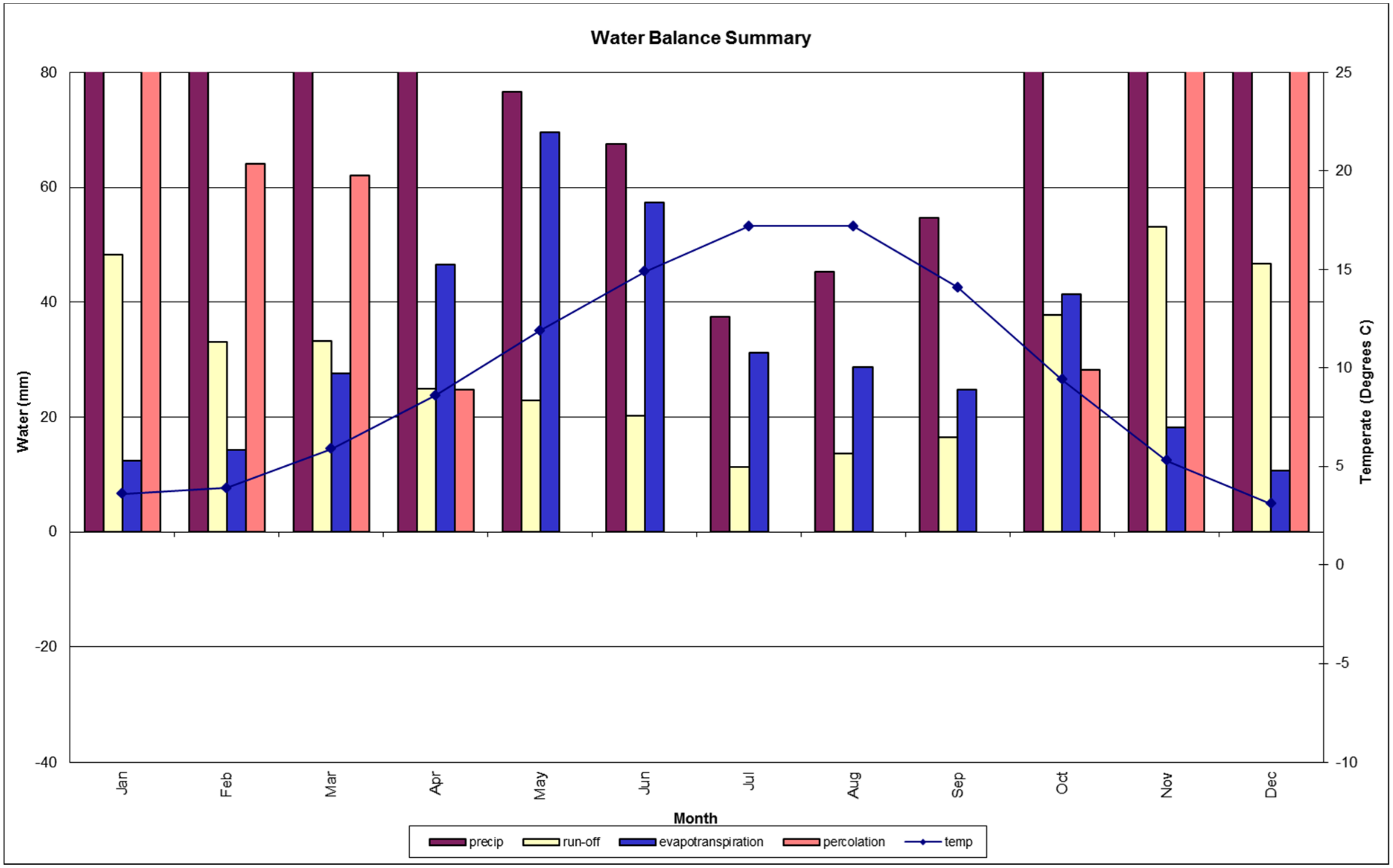
**Leachate Generation Potential**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/08/14<br>yyyy/mm/dd | **13043** |

DESIGNED IB
DRAWN IB
CHECKED TS

DRAWING NO:

**FIGURE 4-1**



**SPERLING HANSEN ASSOCIATES**

**POWELL RIVER REGIONAL DISTRICT**

PROJECT:

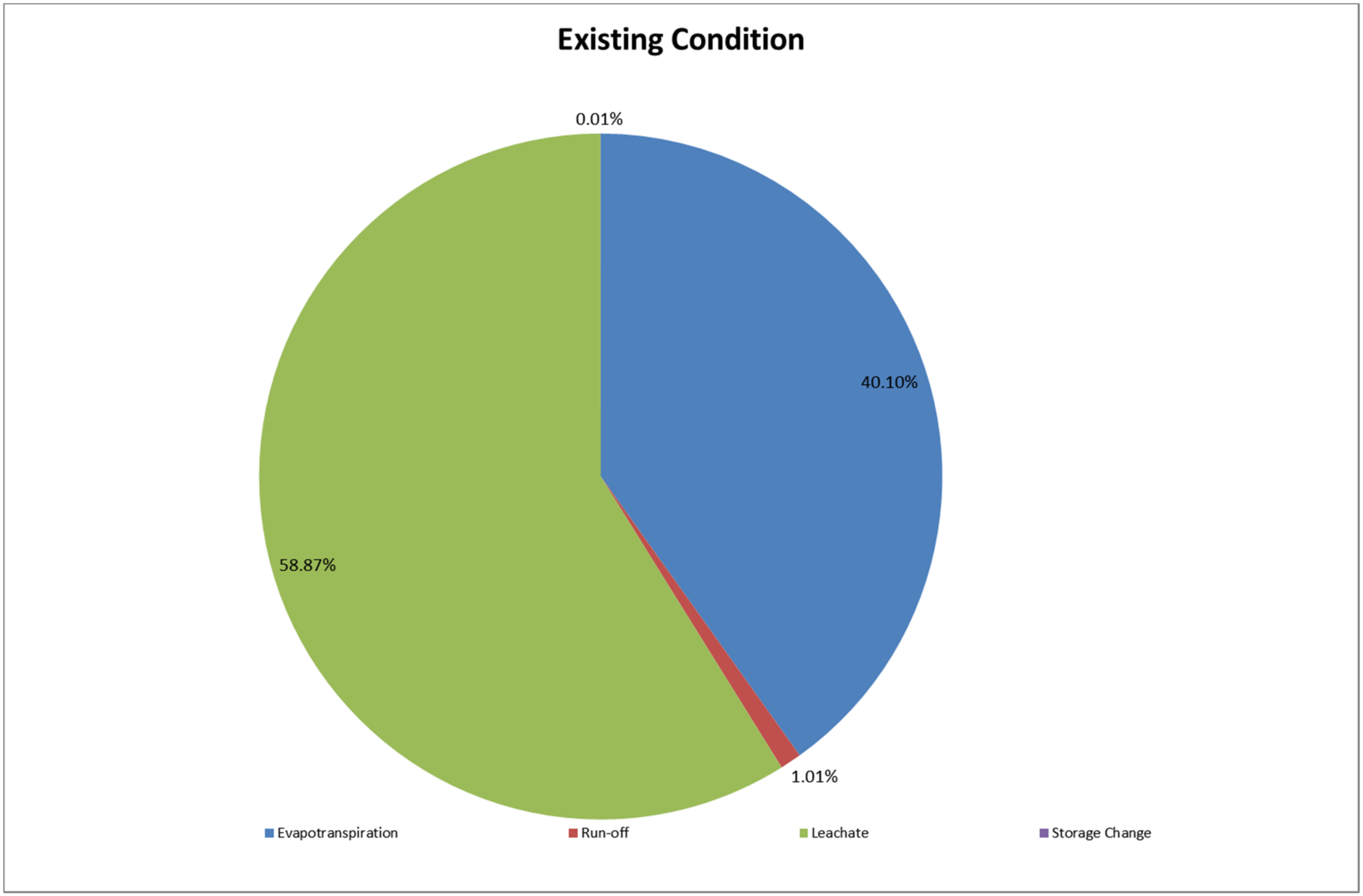
**Marine Avenue Transfer Site Closure Plan**

TITLE:

**Water Balance Summary**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/08/14<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE 4-2** |
| CHECKED | TS | |



SPERLING HANSEN ASSOCIATES

POWELL RIVER REGIONAL DISTRICT

PROJECT:

**Marine Avenue Transfer Site Closure Plan**

TITLE:

**HELP Results – Pie Chart**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/08/14<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE 4-3** |
| CHECKED | TS | |

## Table 4-1: Water Budget Summary - Using Thornthwaite Model
## Marine Avenue Transfer Site landfill - 100 mm Soil Moisture Retention

| Component | | Jan 31 | Feb 28 | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 | Nov 30 | Dec 31 | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation** | | | | | | | | | | | | | | |
| Rainfall (mm) | | 145.7 | 101.9 | 104.2 | 83.2 | 76.6 | 67.6 | 37.5 | 45.3 | 54.7 | 125.5 | 171.6 | 146.5 | 1160 |
| Snowfall (cm) | | 13.6 | 7.8 | 6.8 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0.3 | 6.5 | 11.5 | 46.5 |
| Total Precipitation (mm) | P | 158.9 | 109.4 | 110.7 | 83.3 | 76.6 | 67.6 | 37.5 | 45.3 | 54.7 | 125.8 | 178 | 157.8 | 1205.4 |
| Standard Deviation (mm) | | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | | | | | | | | | | | | | |
| Avg. Temperature ($^{o}$C) | T | 3.6 | 3.9 | 5.9 | 8.6 | 11.9 | 14.9 | 17.2 | 17.2 | 14.1 | 9.4 | 5.3 | 3.1 | 9.6 |
| | | | | | | | | | | | | | | |
| **Snow Storage and Melt** | | | | | | | | | | | | | | |
| Month End Snow Cover (cm) | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | |
| Change in Snow Cover (cm) | | -2.0 | -1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.0 | |
| Snow Melt (cm) | | 15.6 | 8.8 | 6.8 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 5.5 | 9.5 | |
| Available Precipitation (mm) | AP | 160.9 | 110.5 | 110.8 | 83.3 | 76.6 | 67.6 | 37.5 | 45.3 | 54.7 | 125.8 | 177.0 | 155.8 | 1206 |
| | | | | | | | | | | | | | | |
| **Evapotranspiration** | | | | | | | | | | | | | | |
| Heat Index | "i" | 0.58 | 0.97 | 1.29 | 2.27 | 3.72 | 5.22 | 6.49 | 6.49 | 4.81 | 2.60 | 1.09 | 0.48 | 36.0 |
| Unadjusted Potential ET (mm) | UPET | 0.6 | 0.6 | 0.9 | 1.4 | 1.9 | 2.5 | 2.9 | 2.9 | 2.3 | 1.5 | 0.8 | 0.5 | |
| Monthly Duration Corr. | r | 22.5 | 23.7 | 30.6 | 34.5 | 39.6 | 40.2 | 40.5 | 37.2 | 31.5 | 27.6 | 22.8 | 21.3 | |
| Adjusted Potential ET (mm) | PET | 12.4 | 14.2 | 27.5 | 46.6 | 75.2 | 98.5 | 115.4 | 106.0 | 72.5 | 41.4 | 18.2 | 10.7 | 639 |
| | | | | | | | | | | | | | | |
| **Runoff** | | | | | | | | | | | | | | |
| Co-efficient of run-off* | Cro | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | |
| Run-off | RO | 48.3 | 33.1 | 33.3 | 25.0 | 23.0 | 20.3 | 11.3 | 13.6 | 16.4 | 37.7 | 53.1 | 46.7 | **362** |
| | | | | | | | | | | | | | | |
| **Infiltration & Water Shortage** | | | | | | | | | | | | | | |
| Infiltration (mm) | INF | 112.7 | 77.3 | 77.6 | 58.3 | 53.6 | 47.3 | 26.3 | 31.7 | 38.3 | 88.1 | 123.9 | 109.0 | |
| Water Available for Storage (mm) | INF-PET | 100.3 | 63.1 | 50.0 | 11.7 | -21.6 | -51.2 | -89.2 | -74.3 | -34.2 | 46.7 | 105.6 | 98.4 | |
| Cumulative Water Shortage (mm) | ACCWL | 100.3 | 163.4 | 213.4 | 225.2 | 203.6 | 152.4 | 63.2 | -11.1 | -45.3 | 1.4 | 107.0 | 205.4 | |
| | | | | | | | | | | | | | | |
| **Storage** | | | | | | | | | | | | | | |
| Soil Storage (mm) | ST | 88.0 | 87.0 | 75.0 | 62.0 | 46.0 | 36.0 | 31.0 | 34.0 | 47.5 | 66.0 | 83.0 | 84.0 | |
| Change in Soil Storage (mm) | DeltaST | 4.0 | -1.0 | -12.0 | -13.0 | -16.0 | -10.0 | -5.0 | 3.0 | 13.5 | 18.5 | 17.0 | 1.0 | |
| Actual ET (mm) | AET | 12.4 | 14.2 | 27.5 | 46.6 | 69.6 | 57.3 | 31.3 | 28.7 | 24.8 | 41.4 | 18.2 | 10.7 | **383** |
| | | | | | | | | | | | | | | |
| **Percolation** | | | | | | | | | | | | | | |
| Percolation | PERC | 96.3 | 64.1 | 62.0 | 24.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.2 | 88.6 | 97.4 | **461** |

**1206**

**Station Data:**

Latitude = 49$^{o}$ 49'54.02" N
Longitude = 124$^{o}$ 29'28.34" W
Elevation = 125 m
Soil Retention Capacity = 100 mm

Source: Canadian Climate Normals 1981-2010, British Columbia, Environment Canada

**HELP MODEL RESULTS**

| Scenarios | Scenario Modelled | Evapotranspiration (mm/yr) | Evapotranspiration as % of P | Runoff (mm/yr) | Runoff as % of P | Lateral Drainage Top (mm/yr) | Lateral Drainage Top % of P | Percolation to Leachate (mm/yr) | Percolation to Leakage % of P | Leachate Produced (mm/yr) | Leachate Produced as % of P | Change in water storgae (mm/yr) | Change in water storgae as % of P | Total (mm/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I.D | Crest | | | | | | | | | | | | | |
| 0 | Open- Existing | 493 | 40.1% | 12.45 | 1.0% | N/A | N/A | 724 | 58.9% | 724.00 | 58.9% | 0.15 | 0.01% | 1229.8 |
| 1 | Closed - Option 1- Clay Cover - MOE | 481 | 39.1% | 51.13 | 4.2% | N/A | N/A | 696.53 | 56.6% | 696.53 | 56.6% | 0.78 | 0.1% | 1229.9 |
| 2 | Closed - Option 2- Clay Cover (SHA) w ith a Drainage Layer | 513 | 41.7% | 1.39 | 0.1% | 566.1 | 46.0% | 141.52 | 11.508% | 141.52 | 11.5% | 7.70 | 0.6% | 1229.9 |
| 3 | Closed - Option 3 - Geomembrane Cover w ith a Drainage Layer | 513 | 41.7% | 1.4 | 0.1% | 714.7 | 58.1% | 0.4 | 0.0% | 0.40 | 0.0% | 0.20 | 0.0% | 1229.9 |
| 4 | Closed - Option 4 - Paved w ith Asphalt | 216 | 17.5% | 1014.32 | 82.5% | 0 | 0.0% | 0.02 | 0.0% | 0.02 | 0.0% | -0.01 | 0.0% | 1229.9 |
| | 33% Slope | | | | | | | | | | | | | |
| 0 | Open- Existing | 493 | 40.1% | 13.75 | 1.1% | N/A | N/A | 723.1 | 58.8% | 723.10 | 58.8% | -0.31 | 0.0% | 1229.9 |
| 1 | Closed - Option 1- Clay Cover - MOE | 481 | 39.1% | 51.2 | 4.2% | N/A | N/A | 696.4 | 56.6% | 696.40 | 56.6% | 0.79 | 0.1% | 1229.8 |
| 2 | Closed - Option 2- Clay Cover (SHA) w ith a Drainage Layer | 513 | 41.8% | 2.29 | 0.2% | 588.9 | N/A | 117.55 | 9.559% | 117.55 | 9.6% | 7.68 | 0.6% | 1229.9 |
| 3 | Closed - Option 3 - Geomembrane Cover w ith a Drainage Layer | 513 | 41.8% | 2.29 | 0.2% | 714 | 58.1% | 0.09 | 0.0% | 0.09 | 0.0% | 0.07 | 0.0% | 1229.9 |
| 4 | Closed- Option 4- Paved w ith Asphalt | 216 | 17.5% | 1014.13 | 82.5% | 0.02 | 0.0% | 0.02 | 0.0% | 0.02 | 0.0% | -0.01 | 0.0% | 1229.9 |

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REGIONAL DISTRICT

PROJECT:

**Marine Avenue Transfer Site
Closure Plan**

TITLE:

**HELP Results**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/07/17<br>yyyy/mm/dd | **PRJ13043** |
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **TABLE 4-2** |
| CHECKED | TS | |

# 5. LANDFILL GAS MANAGEMENT

## 5.1 Introduction

Landfill gas (LFG) emissions and odours are a concern due to potential health issues, nuisance odours and because LFG contributes to global climate change. When a geomembrane final cover is applied, if the generated LFG is not vented, gas pressures can build up beneath the final cover, ultimately leading to uplift and potentially damaging the cover system. Additionally, gas can migrate from the site to nearby properties and structures if it is prevented from venting directly to the atmosphere and / or if there is a preferential pathway for the gas to travel easily off of the site.

LFG is a by-product of the natural decomposition of organic materials in landfills. The most common form of LFG, which is created when biological anaerobic decomposition occurs, consists primarily of equal parts methane ($CH_4$) and carbon dioxide ($CO_2$). Other trace constituents include more than 166 different Non-Methane Organic Compounds (NMOC), nitrogen ($N_2$) and oxygen ($O_2$); the concentrations of these constituents are subject to the amount and composition of contributing waste material within the landfill, the decomposition rate of the specific contributing material, and the level of atmospheric air intrusion into the landfill.

Methane, at concentrations between 5 to 15 % by volume in air, will cause an explosion if it comes in contact with an ignition source (flame). The lower end of the range (5%) is referred to as the lower explosive limit (LEL). Combustible gases are a concern in relation to LFG migration issues.

Carbon dioxide, another major component of LFG, is found at low concentrations in atmospheric air. The main danger posed by $CO_2$ is that it can displace atmospheric air in confined structures such as manholes and wells. This could cause asphyxiation for someone entering such a structure without properly checking the conditions.

LFG may also contain Hydrogen Sulphide ($H_2S$), which originates from biological consumption of sulphur found in gypsum wallboard, depending on the sulphur content of the waste filled. Hydrogen Sulphide is highly toxic in concentrations above 50 ppm (i.e. 0.005%). Normally $H_2S$ can be smelled at concentrations as low as 0.05 ppm, and by 3 ppm, a distinctive odour of rotten egg is normally noted. A concern with $H_2S$ is that the ability to smell the gas decreases gradually with increased exposure. At concentrations between 10 and 50 ppm, most people experience headaches and nausea.

## 5.2 Landfill Criteria

According to the British Columbia (BC) Landfill Criteria (Landfill Criteria) for Municipal Solid Waste (1993), landfills with more than 100,000 tonnes of refuse require an assessment of the potential emissions of NMOCs. If the assessment reveals that the emission of NMOCs exceeds or is expected to surpass 150 tonnes/year, the installation and operation of a landfill gas recovery and management system is mandatory. An interim second edition of the Landfill Criteria was recently released by the BC Ministry of Environment (MOE). Stakeholders were asked to provide the MOE with any comments and feedback on the Draft before June 30, 2014. The final version of the new Landfill Criteria is yet to be released by the BC MOE.

The MOE has also developed a new LFG Management Regulation that came into effect on January 1st, 2009. This regulation is stricter than the initial Landfill Criteria to support BC's commitment to reduce greenhouse gases (GHG) by 2020 to at least 33% below the 2007 levels. The regulation applies to landfill sites that accepted Municipal Solid Waste (MSW) for disposal on or after January 1st, 2009 or which have 100,000 tonnes or more of MSW in place, or receive 10,000 tonnes or more of MSW for disposal into the landfill site in any calendar year after 2008. If a landfill is determined to generate 1,000 tonnes or more of methane per year, the regulation requires that an active landfill gas management system be installed by 2016. This system, if required, is to capture at least 75% of the generated LFG and to reduce methane emissions by flaring (thermal oxidation) or other methods that would result in the same amount of emission reduction as flaring.

Based on the disposal activities discussed in Chapter 2, the LFG Management Regulation does not apply to the Marine Avenue Transfer Site. Furthermore, a minimal amount of organic waste including wood chips, stumps, yard waste, and demo waste, totaling approximately 10,000 tonnes has been historically deposited at this site. These materials are planned to be reused for composting and/or be remediated at the Botanical Garden. Therefore, SHA believes that conducting a LFG generation assessment (modeling) is not necessary for the Marine Avenue Transfer Site. However, a quick calculation shows that by reusing and remediating the deposited organic material, the PRRD will avoid an annual GHG emission of approximately 210 tonnes $CO_2$-e. Figure 5-1 shows the potential GHG emissions from the existing deposited organic material.

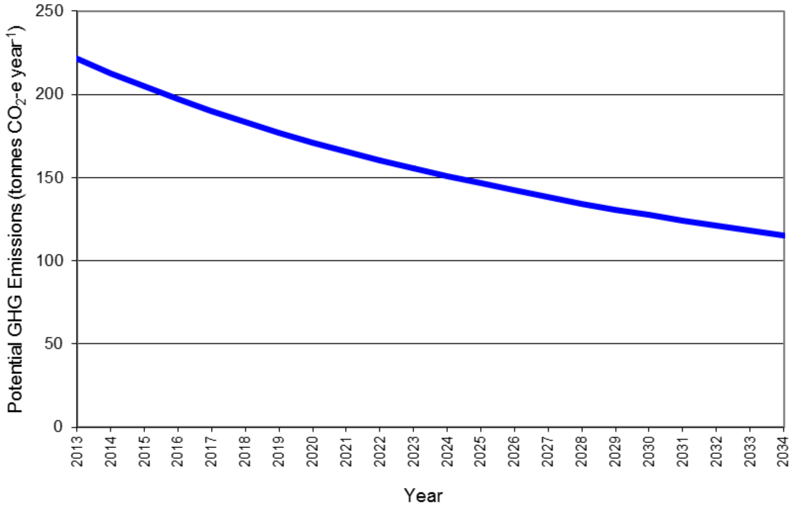

**Figure 5-1 Potential GHG Emissions from the Existing Organic Wastes Deposited on site**

## 5.3 Landfill Gas Management Strategy

It is expected that the existing waste will emit very small amounts of LFG to the environment during the post closure period. As discussed previously, the majority of waste material is inorganic and will be relocated beneath the closure area including the DLC waste which will be used to re-grade the site to the final design contours and appropriate side slopes. Therefore, it is safe to assume that the landfill will continue to generate a minimal amount of landfill gas. However, this amount will not trigger mandatory LFG collection, as specified in the LFG Regulations. Thus, active collection of LFG is not considered necessary at the Marine Avenue Transfer Site and also the LFG Regulation does not warrant that.

The fate of the small amount of the generated LFG will largely depend on the final cover system constructed. As described in Chapter 8, SHA recommends final cover systems for the Marine Avenue Transfer Site that includes passive gas collectors and vents. The proposed passive LFG collection system is shown in Figure 5-2. Horizontal LFG collectors are preferred as they will result in fewer penetrations of the final cover and minimize any interference with the intended end use. The horizontal gas collectors should be installed in trenches under the final cap which will be installed during closure construction. Horizontal collectors will be connected to several gooseneck vents.

## 5.4 LFG Monitoring

Landfill gas sampling should be carried out monthly for $CH_4$ (vol %), LEL (%), CO (ppm), $O_2$ (vol %) and $H_2S$ (ppm). SHA also recommends that Hydrogen ($H_2$) gas be analyzed for at this site since large amounts of bottom ash has been historically deposited in the site. Typically, $H_2$ can be produced when elemental Aluminum (present in incinerator bottom ash) is deposited at a landfill. Elemental aluminum reacts with water to produce aluminum hydroxide and gaseous hydrogen. $H_2$ is explosive.

The LFG monitoring data and interpretation need to be included in the annual report as mentioned in the Section 7.17 of the BC Landfill Criteria for Municipal Solid Waste (MSW). Following Guidelines for Environmental Monitoring at MSW Landfills and Landfill Criteria for MSW Landfills, this program should be based on bar-hole punch probe gas monitoring along the property boundary, at an interval of approximately 100 m between two measurement points.

SHA recommends the bar-hole punch gas monitoring be conducted for 4 to 6 months on a monthly basis to monitor the gas migration potential from the landfill. However, the amount of gas generation from this site is nearly zero. Therefore, we recommend once low LFG levels are confirmed by the initial monitoring results, the frequency of such monitoring can be reduced to quarterly readings after reviewing these initial results with the MOE. Nevertheless, according to the existing Landfill Criteria, if methane concentrations exceed the recommended performance criteria (100% LEL at property boundaries or 25% LEL in on-site structures), then a more detailed assessment of landfill gas migration should be conducted to determine if any corrective actions are necessary.

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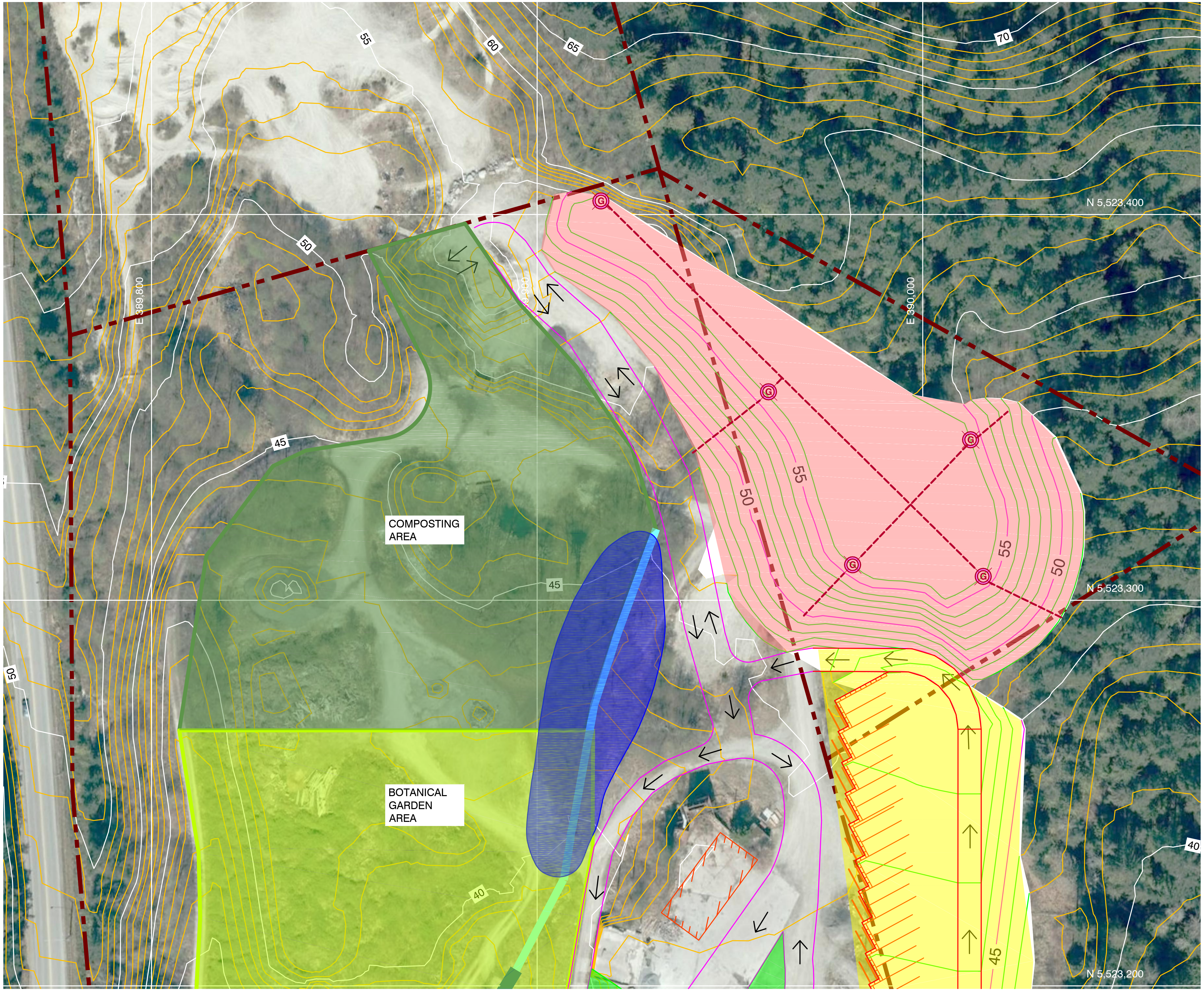

SPERLING HANSEN ASSOCIATES

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LEGEND:

| | |
|---|---|
| ▬ | 5m EXISTING CONTOUR |
| — | 1m EXISTING CONTOUR |
| — | 5m PROPOSED CONTOUR |
| — | 1m PROPOSED CONTOUR |
| 🟨 | TRANSFER BAY AREA |
| -·- | PROPERTY LINE |
| 🟩 | GREEN SPACE |
| 🟥 | LANDFILLED AREA |
| - - | LFG PERFORATED PIPE |
| Ⓖ | LFG PASSIVE VENT |
| — | ROAD |
| ← | TRAFFIC FLOW DIRECTION |
| ● | MANHOLE |
| ☐ | RECYCLING AREA BIN |
| 🟪 | RECYCLING AREA |
| ▨ | EDUCATION CENTRE |
| 🟦 | RETENTION POND |

CLIENT:

POWELL RIVER REGIONAL DISTRICT

PROJECT:

POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

TITLE:

## PASSIVE LANDFILL GAS COLLECTION SYSTEM

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:1000 | 2014/08/12<br>yyyy/mm/dd | PRJ 13043 |

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| SURVEYED | AK | DRAWING NO: |
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| CHECKED | IB | |

# 6. GRADING PLAN

## 6.1 MOE Closure Requirements and Design Considerations

The grading concept for Marine Avenue site was developed to meet all the MOE slope constraints listed in the Landfill Criteria for Municipal Solid Waste (MOE, 1993) as well as SHA's standard design guidelines for developing industrial landfills in B.C. These design criteria include:

- Side slopes no steeper than 3H:1V.
- Crest at slopes steeper than 4% to meet MOE Criteria – SHA recommends 2-4% slopes will be sufficient based on the age or nature of the waste and final cover structure.
- Ramps/roads no steeper than 8%.
- Ramps/roads to provide a minimum 10 m wide operating surface – SHA recommends 6 m wide will be sufficient for the site for one-way trafic.
- Maintenance access to all areas of landfill.
- Run-off discharge control.

## 6.2 End Use Plan

The planned end use of the Marine Avenue site is to be a Recycling Centre and Resource Recovery Park (RCRRP) on approximately half of the area and a Botanical Garden and a Composting Facility on the remaining half.

The proposed grading plan for the closure of the site will help PRRD to realize its vision by incorporating all possible materials on the site for reuse and recycling in the engineered cover system and transfer bay area construction. The recycling centre will be a one-stop shop for upcycling, recycling, reuse, recovery and will involve collaboration with local businesses.

PRRD also envisions that the RCRRP will be surrounded and interwoven with a locally organized botanical garden that would provide for aesthetic, sound buffering, shade and carbon sequestering values while focusing on the main goal of remediating the site using natural remediation processes.

Once finished, the RCRRP and the Botanical Garden combination will attract many user groups as well as provide for an educational experience that will promote environmental stewardship. The educational experience will attract not only local user and school groups but also environmentally minded visitors, lifecycle-type educators and students from British Columbia and beyond. This will create business opportunities and varying degrees of employment opportunities including opportunities for people with disabilities.

The PRRD has a future plan to implement curb-side organics pick-up. The proposed composting facility will help the PRRD achieve the Zero Waste goal. As shown in Table 2-1, the wood chips in Pile J, Stumps in Pile K and Yard waste in Pile N and O can be used for composting. The finished compost or the yard waste can also be used as an ingredient of the fabricated topsoil to be used in the final cover system.

## 6.3 Grading Plan

The grading plan for the site is to excavate all the ash stockpiled throughout the landfill and consolidate it in one location, and then place a cover system on the ash waste. Figure 6-1 shows the existing contours based on the December, 2013 survey completed by SHA. Figure 6-2 shows the planned end uses for the site. Figure 6-3 shows a conceptual plan and proposed final contours of the site after closure.

The Cut and Fill of final contours versus existing contours are shown in Figure 6-4. The cut and fill has been calculated based on the regraded surface created after the removal of Ash Pile Q, leaving one-fifth of Pile Q beneath the ground surface that falls within the transfer bay/holding cell area and relocating roofing Piles, A,G and Gyproc Pile H for recycling. Ash Pile F will remain in place and be covered as a landfill. The borrow area generated after removal of the material in Ash Pile Q, of which a portion is below the surface, will be filled by the available clean fill from Piles R and S.

Ash Pile F shown in Figure 2-5 that has 20,000 $m^3$ in place will remain in its place and be developed as a landfill. As shown in Table 2-1, the 8,000 $m^3$ of ash in Pile D and M will be relocated either to the new landfill or to the holding cell/ transfer bay area. Ash Pile Q contains 10,000 $m^3$ of ash of which around 50% is buried under the ground surface. Approximately one-fifth of the 10,000 $m^3$ will remain under the ground surface in the transfer bay area and will not need to be relocated. Hence, 8,500 $m^3$ of ash will be relocated from Pile Q to the Transfer Bay/ Holding Cell area. A total of 2,500 $m^3$ of Construction and Demolition Waste from Pile C will be relocated to the landfill area to serve as grading fill for regrading along with the ash.

The PRRD has contracted with Augusta, a local recycler, to recycle a total 3,300 $m^3$ of roofing material from Pile A and G and 3,000 $m^3$ of gyproc.

A total of 2,600 $m^3$ of asphalt from Pile L, I and T will be ground up and used to surface the Transfer Bay Area/Holding Cell crest, the access roads and the internal roads.

As mentioned in Section 6.2, a total 8,000 $m^3$ of woodchips from Pile J and 2,000 $m^3$ of Stumps from Pile K will be composted on site and consumed in a locally fabricated soil product. As discussed in Chapter 2, wood chips and stumps will be transported to Catalyst Paper Mill for their co-generation facility if the Mill agrees to receive the chipped waste based on the heating value of the woodchips. Catalyst Paper Mill has also agreed to accept asbestos-containing waste identified near Pile F into their landfill site.

A total of 2,000 $m^3$ of Glass from Pile E will be reused in the drainage layer and/or will be upcycled for making a unique concrete floor at the resource recovery park.  A total of 100 $m^3$ of tires from Pile B will be recycled or will be applied in an innovative use at the site in the landfill or the transfer bay area closure construction.

A total of 1,000 $m^3$ of concrete will be used in the base or sub-base layer of on-site roads.

A total of 5,000 $m^3$ of clean fill from Pile R and S will be used for refilling the excavated area that will be created when ash from Pile Q is relocated.

### 6.3.1 Cut and Fill Volumes

Table 6-1 presents a summary of the cut and fills volumes. The Cut and Fill drawing shown in Figure 6-4 indicates that a total of 22,500 $m^3$ of airspace will be available, of which 13,000 $m^3$ is in the Transfer Bay/ Holding Cell area and 9,500 $m^3$ is in the landfill area. This volume includes the air space consumed by the waste and by the final cover system.

The total volume of waste (ash and DLC waste) to be relocated to either the landfill area or the transfer bay/holding cell area is 19,200 $m^3$. SHA's experience with other landfill closures shows that approximately 25% compaction will occur during relocation and regrading. In addition, approximately 10% settlement will occur initially. Thus the total resulting waste volume is expected to be 12,480 $m^3$.

The total volume of final cover material is 10,722 $m^3$. Waste and cover together will require 23,202 $m^3$ of airspace. As there are some approximations in the calculation and estimation of the volumes, SHA believes that the 22,500 $m^3$ of design airspace provided will accommodate the waste and cover system.

## Table 6-1: Cut and Fill Volume Summary

| | Location | Volume ($m^3$) |
|---|---|---|
| Airspace | Landfill | 9,500 |
| | Holding Cell/Transfer Bay Area | 13,000 |
| | | **22,500** |
| Waste | Relocated Ash from Pile Q | 8,500 |
| | Relocated Ash from Pile D and M | 8,200 |
| | Relocated DLC | 2,500 |
| | | **19,200** |
| | Compaction (25%) | (4,800) |
| | Settlement (10%) | (1,920) |
| | | **12,480** |
| Cover | Landfill Area Slope | 3,836 |
| | Landfill Area Crest | 2,079 |
| | Transfer Bay Area Slope | 1,950 |
| | Transfer Bay Area Crest | 2,857 |
| | | **10,722** |
| Waste and Cover | | **23,202** |

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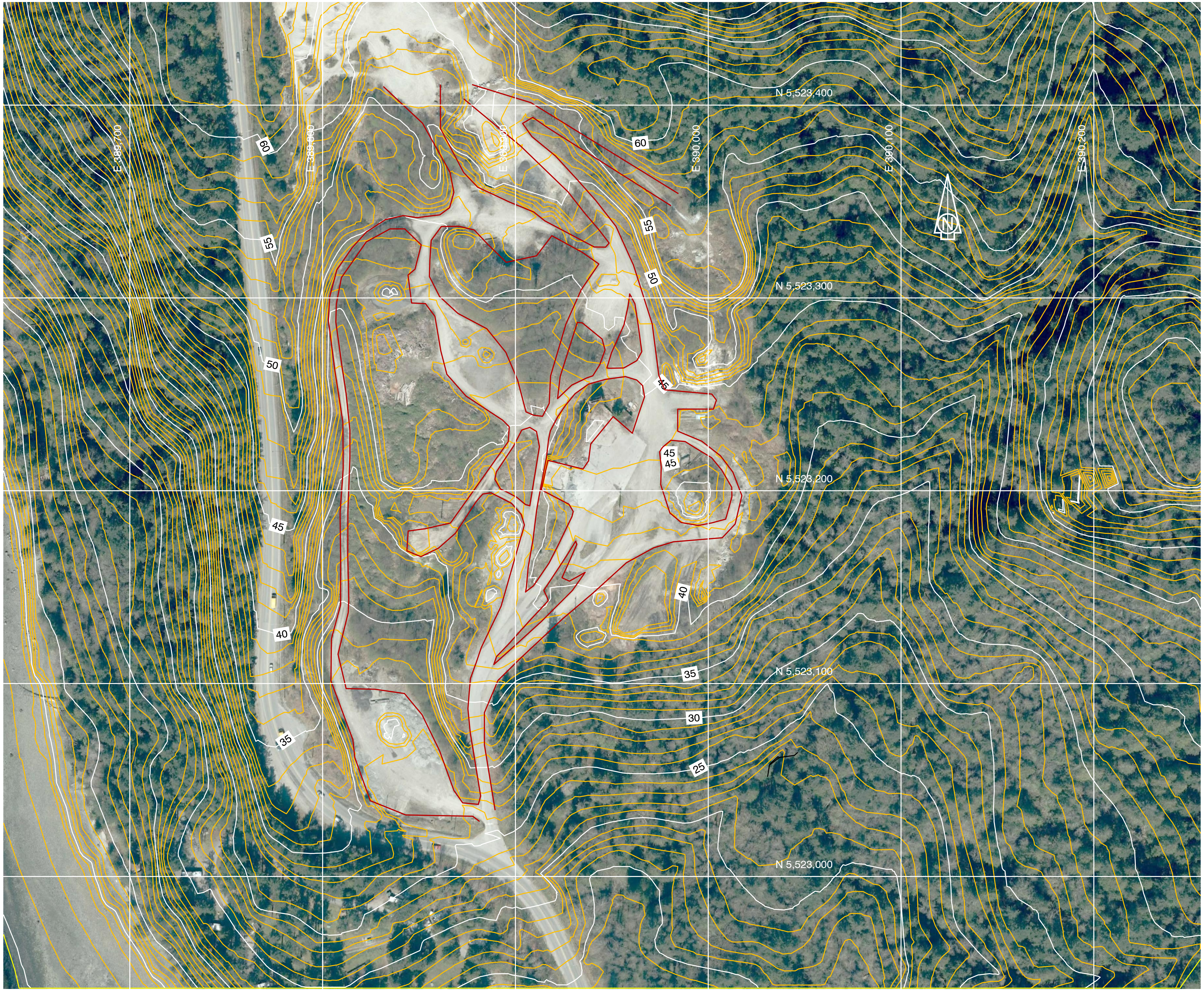

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LEGEND:

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| ▬ | 5m EXISTING CONTOUR |
| ― | 1m EXISTING CONTOUR |
| ― | EXISTING ROAD |

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PROJECT:

POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

TITLE:

EXISTING TOPOGRAPHY

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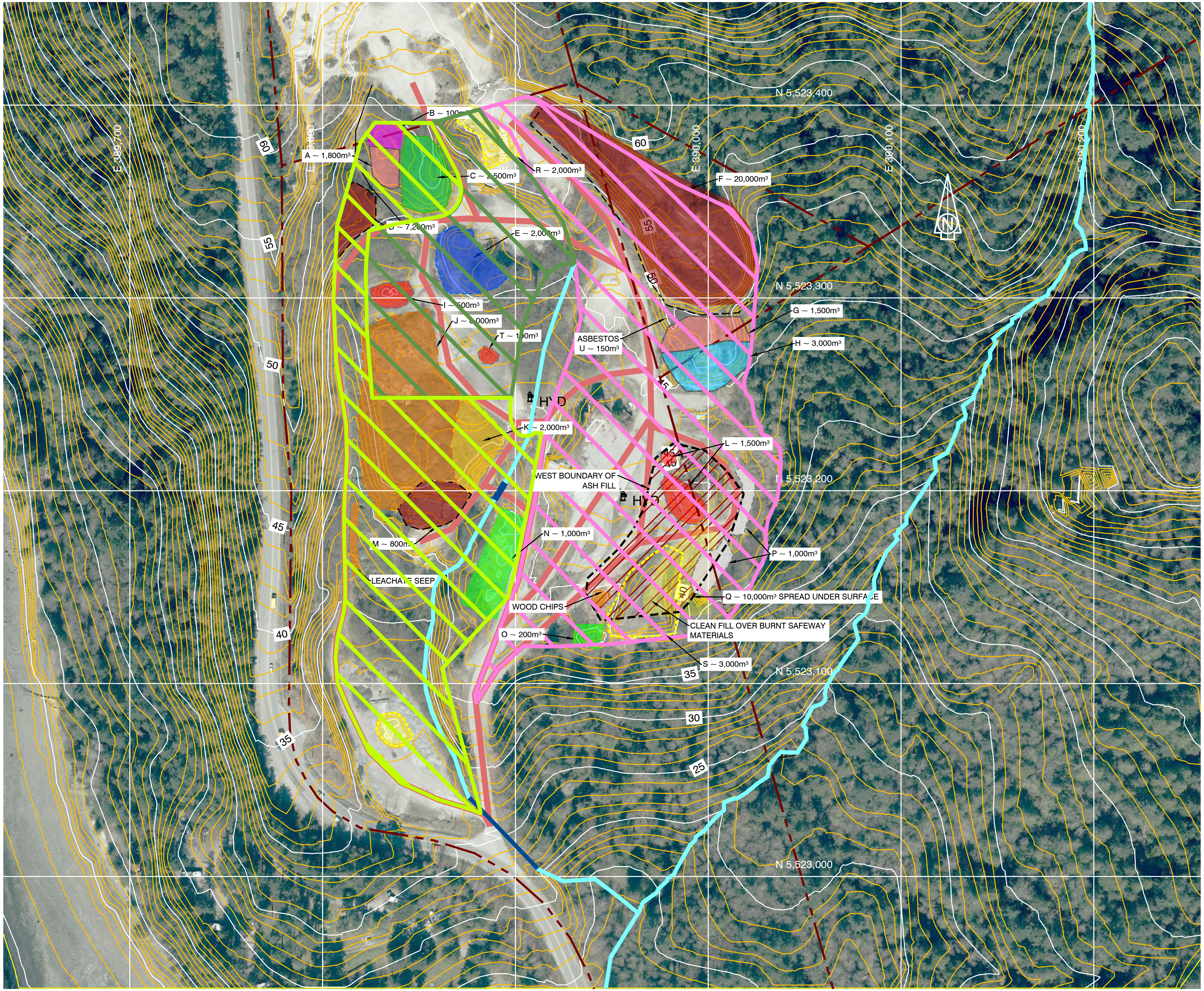
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NP | FIGURE 6-1 |
| CHECKED | IB | |



X:\PRJ\Prj13\PRJ13043 - Powel River Landfill Closures\Marine Avenue Transfer Site\04_AutoCad Drawings\Drawings\POWELL RIVER MARINE BASEMAP 14.08.13 FIGURES 2-4_6-1_6-2_6-3_6-4_9-1.dwg, 15/08/2014 3:15:12 PM

**SPERLING HANSEN ASSOCIATES**

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- Landfill Siting
- Design & Operations Plans
- Landfill Closure
- Environmental Monitoring

#8 - 1225 East Keith Road
North Vancouver, B.C. V7J 1J3

Phone: (604) 986-7723
Fax: (604) 986-7734

LEGEND:

5m EXISTING CONTOUR
1m EXISTING CONTOUR
▨ BOTANICAL GARDEN AREA
▨ COMPOSTING AREA
▨ RECYCLING CENTRE AREA
PROPERTY LINE

| WASTE TYPE | PILE | APPROXIMATE TOTAL QUANTITY (m³) | COLOUR |
|---|---|---|---|
| ASH | F | 20,000 | 🟫 |
| | D | 7,200 | 🟫 |
| | M | 800 | 🟫 |
| | Q | 10,000 | 🟫 |
| GLASS | E | 2,000 | 🟦 |
| TIRES | B | 100 | 🟪 |
| ROOFING | A | 1,800 | 🟥 |
| | G | 1,500 | 🟥 |
| GYPROC | H | 3,000 | 🟦 |
| ASPHALT | L | 1,500 | 🟥 |
| | I | 500 | 🟥 |
| | T | 100 | 🟥 |
| WOOD CHIPS | J | 8,000 | 🟫 |
| STUMPS | K | 2,000 | 🟧 |
| YARD WASTE | N | 1,000 | 🟩 |
| | O | 200 | 🟩 |
| CONCRETE | P | 1,000 | ⬜ |
| DEMO | C | 2,500 | 🟩 |
| CLEAN FILL | R | 2,000 | 🟨 |
| | S | 3,000 | 🟨 |
| ASBESTOS | U | 150 | ⬜ |
| **Total** | | **68,350** | |

CLIENT:

**POWELL RIVER REGIONAL DISTRICT**

PROJECT:

**POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN**

TITLE:

## END USE PLAN

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NP | **FIGURE 6-2** |
| CHECKED | IB | |

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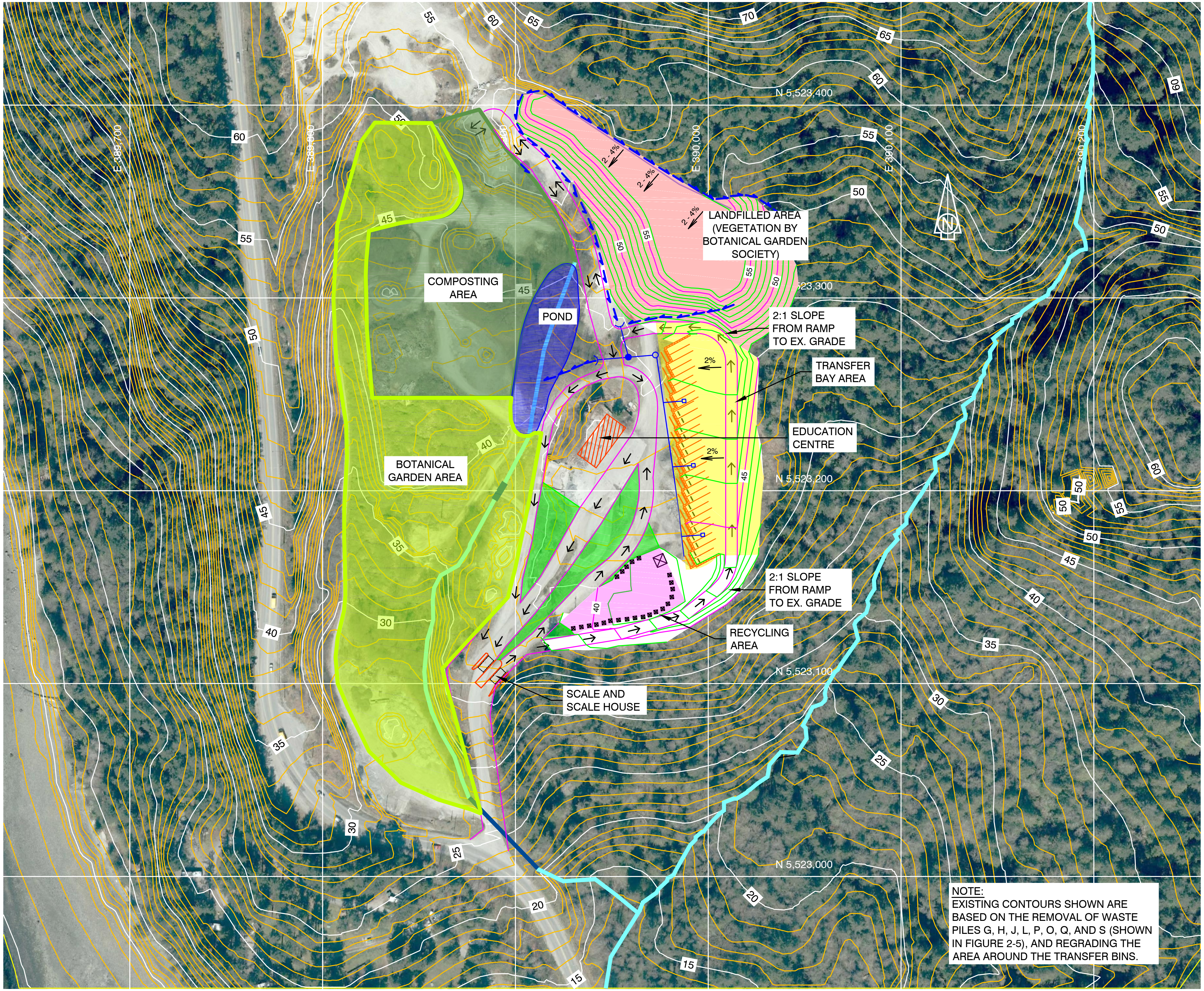

NOTE:
EXISTING CONTOURS SHOWN ARE BASED ON THE REMOVAL OF WASTE PILES G, H, J, L, P, O, Q, AND S (SHOWN IN FIGURE 2-5), AND REGRADING THE AREA AROUND THE TRANSFER BINS.

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LEGEND:
- ▬ 5m EXISTING CONTOUR
- ― 1m EXISTING CONTOUR
- 🟩 BOTANICAL GARDEN AREA
- 🟨 TRANSFER BAY AREA
- ‐ · ‐ PROPERTY LINE
- 🟩 GREEN SPACE
- 🟩 COMPOST AREA
- 🟥 LANDFILLED AREA
- ← LINED DITCH
- ▬ EXISTING DITCH
- ▬ EXISTING CULVERT
- ― CULVERT
- ― ROAD
- ← TRAFFIC FLOW DIRECTION
- ● MANHOLE
- □ CATCH BASIN
- ☒ RECYCLING AREA BIN
- 🟪 RECYCLING AREA
- ▨ EDUCATION CENTRE
- 🟦 RETENTION POND
- ― 5m PROPOSED CONTOUR
- ― 1m PROPOSED CONTOUR

CLIENT:
**POWELL RIVER REGIONAL DISTRICT**

PROJECT:
**POWELL RIVER MARINE AVENUE SITE CLOSURE PLAN**

TITLE:
## FINAL CONTOURS

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/12<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NP | **FIGURE 6-3** |
| CHECKED | IB | |

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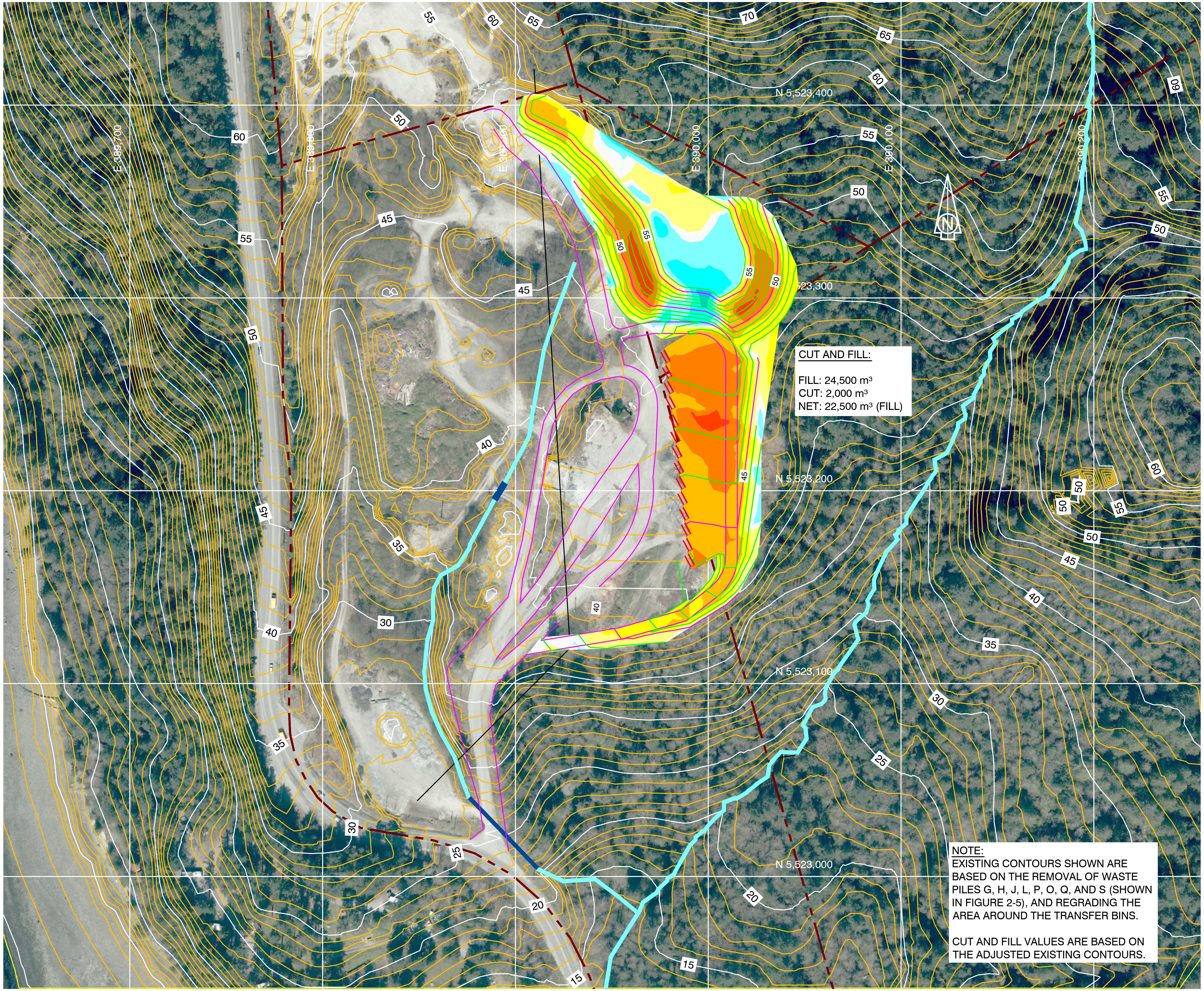

CUT AND FILL:

FILL: 24,500 m³
CUT: 2,000 m³
NET: 22,500 m³ (FILL)

NOTE:
EXISTING CONTOURS SHOWN ARE BASED ON THE REMOVAL OF WASTE PILES G, H, J, L, P, O, Q, AND S (SHOWN IN FIGURE 2-5), AND REGRADING THE AREA AROUND THE TRANSFER BINS.

CUT AND FILL VALUES ARE BASED ON THE ADJUSTED EXISTING CONTOURS.

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LEGEND:
- 5m EXISTING CONTOUR
- 1m EXISTING CONTOUR
- PROPERTY LINE
- EXISTING DITCH
- EXISTING CULVERT
- CULVERT
- ROAD
- 5m PROPOSED CONTOUR
- 1m PROPOSED CONTOUR

Elevations Table

| MIN. ELEVATION | MAX. ELEVATION | COLOUR |
|---|---|---|
| -4.0m | -3.0m | 🟦 |
| -3.0m | -2.0m | 🟦 |
| -2.0m | -1.0m | 🟦 |
| -1.0m | 0.0m | 🟦 |
| -0.2m | 0.2m | ⬜ |
| 0.2m | 1.0m | 🟨 |
| 1.0m | 2.0m | 🟨 |
| 2.0m | 3.0m | 🟧 |
| 3.0m | 4.0m | 🟧 |
| 4.0m | 6.0m | 🟥 |

CLIENT:
POWELL RIVER REGIONAL DISTRICT

PROJECT:
POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

TITLE:
CUT AND FILL
EXISTING TOPOGRAPHY
VERSUS FINAL CONTOURS

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

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|---|---|---|
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NP | FIGURE 6-4 |
| CHECKED | IB | |

# 7. GEOTECHNICAL CONSIDERATIONS

## 7.1 Underlying Stratigraphy

In December 2013, SHA completed a test pit program as shown on Figure 2-5. The findings of the test pits showed various depths of different material throughout the landfill. The uncovered waste from the test pits consisted mainly of ash. Sand was the predominant native material encountered below the waste.

A map of surficial geology of the Powell River area is presented in H1 in Appendix H. The area where the landfill is located has Marine and Glacio-Marine deposits which has varied gravelly, sandy stoney, clay and clay veneer over till.

## 7.2 Settlement Issues

### 7.2.1 Overview

Long term settlement is an issue at most landfills as the organic content of the solid waste stream deposited in the landfill decomposes. It has been SHA's experience that MSW landfills initially settle at a rate of about 2% per year (2 cm settlement per 1 m of refuse thickness). Additional settlement can also occur in the foundation soils beneath the landfill due to the surcharge of overlying waste. For example, at Vancouver Landfill, settlement of up to 6.0 m was experienced in the foundations. Due to the mostly ash content of the waste deposited or relocated at the Marine Avenue Site, settlement is expected to be slower and to occur at a smaller rate after initial settlement.

### 7.2.2 Expected Settlement

The average height of the waste lift in the landfill is 7.0 m, while in the transfer bay area the relocated ash thickness would be 3.0 m. Therefore any expected initial settlement is likely to have already occurred in the existing waste in the landfill portion.

A small amount of settlement is expected to continue to occur at the site into the long term, 25 to 50 years into the future. SHA anticipates settlement rates of 1-20% for first 5 years as a result of regarding, after which a settlement rate of gradually decreasing to 0.25% per year should be anticipated.

## 7.3 Slope Stability Analysis

The purpose of this section is to prove that the proposed final design for the Marine Avenue Site Landfill is within acceptable factor of safety for failure and that the slope stability is improved to acceptable levels as a result of the design. Since the Transfer bay area/holding cell height will be constructed to a height of only 3 m and reinforced with a lock-block wall with proper reinforcing material, stability will not be an issue for this portion of the closure construction. Stability of the landfill site was modeled using the program SLIDE 4.0 designed for 2D slope stability analysis for soil and rock slopes.

### 7.3.1 Instability History

Based on the available information no record of instability was found. Furthermore, no sign of instability was noticed during the site visits on August 2013 and March 2014.

### 7.3.2 Slope Stability Model

To verify stability of the proposed regrading, SHA conducted a detailed analysis using SLIDE computer analysis. The slope stability models discussed below have been developed largely from strength parameters based on SHA's own experience and using commonly adopted lower bound geotechnical parameters, existing contour data, the final proposed contours, and the expected worst case leachate mounding levels in the landfills.

A cross section was selected through a representative sloped area of the Landfill portion of the closure site. The cross section was developed from the proposed design contours shown in Figure 7-1. The cross section location analyzed is identified in plan view in the Figure. A section view of the cross section used in the stability analyses is located in Figure H-2 in Appendix H which shows the underlying geology of the landfill, the proposed profile and the material parameters used in the analysis. The analysis was performed using the limit equilibrium technique and the Bishop Simplified method of analysis. Materials are modeled using a Mohr-Coulomb strength envelope. The soil profile for the cross section was developed from Test pits and Borehole logs developed by SHA.

Failure scenarios were modeled for both static and seismic (earthquake) conditions for the proposed and existing profiles. The following factors of safety (FOS) for slope failure have been adopted as minimum standards:

| | |
|---|---|
| Static Conditions adjacent to Developed Land and Infrastructure | 1.5 |
| Static Conditions adjacent to Undeveloped Land | 1.3 |
| Seismic (Earthquake) Loading adjacent to Developed Land | 1.0 |

A pseudo-static analysis was performed to determine if the slopes would be stable during an earthquake when subjected to peak ground acceleration expected for the area. The 2005 National

Research Council of Canada's Structural Commentaries User's Guide (NRC, 2005) provides seismic values for a number of locations across Canada. The peak horizontal ground acceleration (PGA) of 0.31 g for the Powell River Marine Avnue Landfill was found using the website http://earthquakescanada.nrcan.gc.ca. This PGA has a probability of exceedance of 2% in 50 years.

The PGA acts momentarily in one direction and its use with static material properties may yield very low and incorrect factors of safety. The United States Environmental Protection Agency document "RCRA Subtitle D (258) Seismic Design Guidance for Municipal Waste Landfill Facilities (1995)" recommends using a seismic coefficient ($k_s$) of 50% of the PGA, in combination with the dynamic shear strength properties of the materials. In this case, the dynamic shear strength properties were assumed to be the same as the static shear properties. Using this method, the resultant design PGA would be 0.165 which would provide better factor of safety. However, we have selected a conservative PGA as 0.31. A vertical acceleration was also applied to the model and is typically between 60% and 75% of the horizontal acceleration. Therefore, 0.19 g for the vertical acceleration was chosen.

A number of assumptions were made in the process of simplifying complex situations in the field to a computer model:

- Strength characteristics of the ground materials were generalized;
- Stabilizing effects of vegetative cover on the side slopes were not included;
- Ground water levels were assumed to be groundwater contours as shown in Figure 2-2.

### 7.3.3 Soil Strength Parameters

Table 7-1 outlines the geotechnical parameters used for the modeled materials. Five types of materials were chosen to represent the site conditions: landfill cover, waste material (ash), an underlying silt layer, a gravel/till layer, a sand layer and a till layer.

As there was no data available on the shear strength properties of the materials that constitute the geologic profile of the landfill and the surrounding area, most of the parameters of the underlying foundation material used in this analysis were taken from SHA's previous works. Shear strength properties of incinerator ash were taken from a study performed by Geliga et al (2010).

Table 7-1 Geotechnical Parameters for SLIDE Analysis

| Material | Unit Weight, γ ($kN/m^3$) | Cohesion, c' ($kN/m^2$) | Internal Friction Angle, φ' (degrees) |
|---|---|---|---|
| Incinerator Ash | 20 | 0 | 27 |
| Silt and Sand with Cobble | 18 | 0 | 30 |
| DLC Waste | 12 | 0 | 35 |

### 7.3.4 Ground Water Conditions

Groundwater surface elevations beneath the landfill range from approximately 48.9 masl (near MW13-1) to 14.17 masl (near MW13-3) as mentioned in Chapter 2 and shown in Figure 2-2. As shown in Figure 2-3, the estimated groundwater table contours across the landfill indicate that the groundwater flow direction is towards south and slightly towards the east.

### 7.3.5 Global Slope Stability Results

Results of the SLIDE analysis for the proposed grading design conditions can be found in Appendix I, Figures I-1. The figure shows the soil profile, the resultant failure circle, the minimum FOS and the deep-seated FOS if the minimum FOS is a shallow slump failure. The following table summarizes the lowest FOS obtained for the cross section, the FOS of the deep-seated failure, the FOS under seismic condition and the expected horizontal movement of the proposed slope if a design earthquake did occur.

Table 7-2 Results from Slope Stability Analysis

| Slope Cross Section | Condition | Slope Height (m) | Slope Angle (H:V) | FOS Static | FOS Seismic | Maximum Seismic Displacement (mm)* |
|---|---|---|---|---|---|---|
| **A-A'** | **Proposed** | **10** | **3.00:1** | **1.56** | **0.822** | **17.9** |

* Numbers determined from Newmark Seismic Deformation Analysis. See Appendix K for calculations.

The proposed design is stable for the static loading condition with FOS values exceeding 1.50 from, the standard mentioned before, to 1.56. For the seismic loading conditions, the FOS was determined to be 0.822. The seismic results for the proposed section are presented in Figure I-2 in Appendix I.

SHA is confident that the parameters and water tables used in the analysis were conservative and that the actual FOS's are likely higher. Over the long term, it is anticipated that the FOS will increase as settlement occurs within the landfill.

As the dynamic FOS was less than 1.0, indicating a potentially unstable situation, SHA undertook a Newmark seismic deformation analysis to determine whether an earthquake would generate large scale movement. The analysis showed a maximum displacement of 17.9 mm which is considered stable.

## 7.4 Veneer Stability Analysis

A detailed slope stability analysis was conducted to verify that the cover system proposed for a typical slope at this Site would remain stable at different expected mounding depths above the barrier layer. The analysis was conducted for both static conditions and for seismic conditions as would be experienced during an earthquake. Figure H-3 in Appendix H shows a cross-section of the cover veneer.

The longest continuous veneer slope to receive final cover will be 10 m in vertical height with a maximum slope of 3.0H: 1V. Stability of this veneer geometry was modeled using the program SLIDE 4.0 designed to be used for 2D slope stability analysis for soil and rock slopes.

The following industry standard factors of safety (FOS) for slope failure have been adopted as design goals:

| | |
|---|---|
| Static Conditions | 1.5 |
| Seismic Loading (pseudo-static analysis) | 1.0 |

### 7.4.1 Mounding and Cover System Shear Strength Parameter Review

Three mounding scenarios namely for 20 mm, 200 mm and 300 mm were considered for veneer stability analysis.

Table 7-3 outlines the geotechnical parameters expected within various materials in the cover system. All parameters selected are considered conservative and have been obtained either through past experience, review of literature, testing done by SHA in the past, and estimations of expected strength.

**Table 7-3 Material Properties used in SLIDE**

| Material | Unit Weight, γ (kN/m$^3$) | Cohesion, c (kN/m$^2$) | Internal Friction Angle, φ (degrees) |
|---|---|---|---|
| **Topsoil (woodchips/ sand/ biosolids)** | 14 | 2 | 30 |
| **Gravel** | 18 | 0 | 35 |
| **Geotextile-Geomembrane Interface** | 18 | 1.53 | 26 |
| **DLC Waste** | 12 | 0 | 35 |
| **Ash** | 20 | 0 | 27 |

The selected topsoil unit weight was adopted from a typical soil blend comprised of one part wood chips, one part biosolids and one part sand while the strength properties were estimated.

### 7.4.2 SLIDE Stability Analysis for Cover Veneer

Veneer stability analysis was performed using SLIDE. The static FOS for all three mounding depth scenarios were found to be 2.47. The results of the SLIDE analysis are presented in Table 7-4 and in Figures J-1 to J-3 for static conditions and in Figures J-4 to J-6 for seismic conditions as presented in Appendix J. The results indicate that the final cover veneer will be very stable.

**Table 7-4 SLIDE Slope Stability Analysis Results**

| Mounding Depth (mm) | Static FOS | Seismic FOS |
|---|---|---|
| 20 | 2.47 | 1.248 |
| 200 | 2.47 | 1.248 |
| 300 | 2.47 | 1.248 |

| **Static** | **Seismic** | **Risk** |
|---|---|---|
| ≥1.5 | ≥1.0 | Stable |
| 1.0 to 1.49 | 0.6 to 1.0 | Elevated Risk |
| <1.0 | <0.6 | Unstable |

### 7.4.3 Seismic Considerations

The proposed design is stable for the static loading condition. For the seismic loading condition, FOS less than 1.0 was obtained as shown in Table 7-2. As described in Section 7.3.2, a highly conservative PGA value has been assumed. If the seismic coefficient ($k_s$) of 50% of the PGA value is used as recommended in the US EPA RCRA Subtitle D (258) Seismic Design Guidance for Municipal Waste Landfill Facilities (1995), then the FOS for the seismic condition was found to be greater than 1.0. The seismic result is summarized in Table 7-2 and also presented in Figure I-2 in Appendix I and discussed in Section 7.3.5.

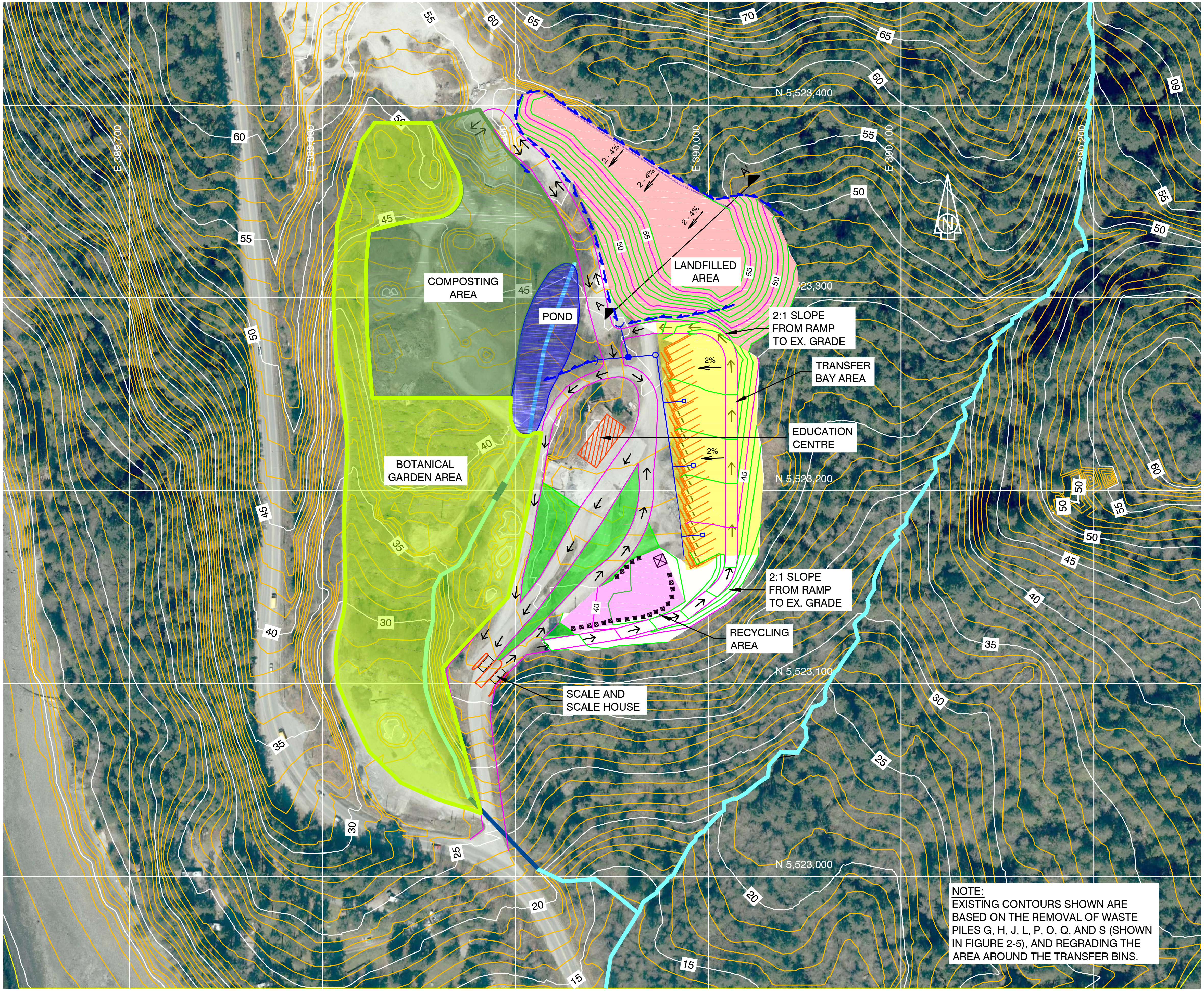
The results for the seismic analysis for veneer stability are documented in Table 7-4. The result for the 20 mm, 200 mm and 300 mm mounding scenarios show that the seismic FOS are 1.248 for all three mounding scenarios. The veneer is found to be stable (i.e. FOS>1.0) in all mounding scenarios for strength parameters as shown in Table 7-3 and used in the analyses.

Based on our experience on closure construction on several similar landfills in the River Road area of Delta, it is recommended that backfill materials be placed with a very light LGP Dozer with a total machine height of less than 8 tonnes (e.g., John Deere 450J) during construction.

### 7.4.4 Newmark Seismic Displacement Analysis

As there is no way to prevent instability of the slopes in a seismic event, dynamic displacements were calculated using the Newmark Method (1965) to see if the movement of the failed slope would be significant. For each case, SLIDE was used to calculate the yield horizontal acceleration resulting in a static FOS of 1.0. Calculations are provided in Appendix K. The Newmark equation was then solved for the expected displacement during the design earthquake. It was found that the resultant deformation of a seismic event would not produce major movement in the slope. As shown in Table 7-2, 17.9 mm of horizontal movement is expected for a 1 in 475 year event, which is a minor amount.

The expected movement, as a result of slope failure, is considered minimal in this area.



NOTE:
EXISTING CONTOURS SHOWN ARE BASED ON THE REMOVAL OF WASTE PILES G, H, J, L, P, O, Q, AND S (SHOWN IN FIGURE 2-5), AND REGRADING THE AREA AROUND THE TRANSFER BINS.

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LEGEND:

| | |
|---|---|
| ▬ | 5m EXISTING CONTOUR |
| — | 1m EXISTING CONTOUR |
| 🟩 | BOTANICAL GARDEN AREA |
| 🟨 | TRANSFER BAY AREA |
| -·- | PROPERTY LINE |
| 🟩 | GREEN SPACE |
| 🟩 | COMPOST AREA |
| 🟥 | LANDFILLED AREA |
| ← | CONCEPTUAL DITCH |
| — | EXISTING DITCH |
| ▬ | EXISTING CULVERT |
| — | CULVERT |
| — | ROAD |
| ← | TRAFFIC FLOW DIRECTION |
| ● | MANHOLE |
| ☐ | CATCH BASIN |
| ☒ | RECYCLING AREA BIN |
| 🟪 | RECYCLING AREA |
| ▨ | EDUCATION CENTRE |
| 🟦 | SEDIMENTATION POND |
| — | 5m PROPOSED CONTOUR |
| — | 1m PROPOSED CONTOUR |

CLIENT:
**POWELL RIVER REGIONAL DISTRICT**

PROJECT:
**POWELL RIVER MARINE AVENUE SITE CLOSURE PLAN**

TITLE:
# SECTION A-A FOR SLOPE STABILITY ANALYSIS

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NP | **FIGURE 7-1** |
| CHECKED | IB | |

# 8. FINAL COVER DESIGN

## 8.1 Introduction

A key goal of a site specific Final Closure Plan is to identify the most effective type of final cover system for the landfill under consideration. In British Columbia, four basic types of cover systems are used:

1) clay cover,
2) geosynthetic cover,
3) composite cover and
4) evaporative cover.

This chapter explores the potential effectiveness of each of these cover systems, identifies the best barrier layer option and then fine tunes the design in terms of identifying the optimum barrier layer thickness, drainage layer media and top soil thickness. In short, the objective of this Closure Plan chapter is to provide a detailed guide for construction of an effective closure system at the Powell River Landfill.

## 8.2 Final Cover Objectives

The purpose of final closure of any landfill is to put in place the necessary environmental control systems to effectively manage leachate, landfill gas and settlement. A well-designed closure system should provide the following benefits:

- Isolation of refuse preventing direct contact with humans and vectors.
- Minimization of infiltration and leachate production through diversion and run-off.
- Prevention of leachate breakouts at landfill toe and on side slopes.
- Protection of the cover from erosion through maintenance of a sustainable vegetative community.
- Enhancement of landfill gas collection by preventing upward venting of landfill gas and downward intrusion of oxygen from the atmosphere.

The final cover design developed in this chapter has been designed to meet all of the MoE closure objectives. It is designed:

- 
- To minimize the risk to the receiving environment by minimizing percolation of water into the landfill.
- To develop a top soil horizon on the landfill surface that will support vegetation.
- To utilize locally available materials as much as possible to keep construction costs low.

- To manage the small quantities of landfill gas in a way that will not cause unacceptable odour impacts.

In developing the final cover design for the Landfill to meet the above objectives, the local site conditions and end-use had to be considered. The types and thickness of soils and other materials selected for the cover were based both on regulatory guidelines as well as site-specific objectives. Key elements considered in the final cover design were:

- Leachate minimization objectives could be achieved with a low permeability soil barrier layer with K (hydraulic conductivity) less than $1x10^{-6}$ cm/s or a geomembrane barrier.
- A drainage layer should be evaluated in the cover system above the barrier layer to determine if such a layer would minimize head build up.
- A topsoil layer at least 150 mm thick, perhaps thicker, should be adopted to protect the underlying barrier layer and to provide a medium that will support vibrant vegetation growth for the areas where a vegetated end use is planned. Where an industrial end use is planned, the erosion control layer can be substituted by a pavement or gravel layer.
- Fire Risk reduction - Landfill fires can threaten the health of residents in surrounding neighbourhoods as well as lead to undesirable impacts on the environment in terms of toxic emissions of pollutants to the air and groundwater. Effective measures should be taken with respect to prevention of fires. To limit oxygen entry, a proper impermeable cover system must be installed on all exposed areas with particular attention to windward slopes and the landfill crest.

The closure plan for the Marine Avenue Site builds on the concepts identified above. In addition, our engineering team explored several other design issues to answer questions that were not previously investigated and to optimize the cover design concepts. These questions included:

- Is there a drainage layer required on the landfill crest and slope? If so, should it be gravel, sand or a drainage geocomposite? What is the minimum acceptable hydraulic conductivity of the drainage layer?
- How thick should the topsoil cover be?
- What cover system would be appropriate for the holding cell?
- Is asphalt alone good enough to prevent leachate percolation?

Based on the results of the engineering work a basic final cover design concept was identified, approximate performance levels were established and approximate capital construction costs were estimated.

## 8.3 Regulatory Requirements

Regulatory requirements for landfill closure have been specified in the MoE Landfill Criteria. The key requirements that dictate design of the final cover system are summarized below:

- Each completed Phase shall be covered within 1 year of completing the subject area. As per the new Criteria, final cover shall be placed within 180 days on any part of the landfill footprint at final contours;
- The final cover barrier layer shall consist of a minimum of 1,000 mm of low permeability ($<1x10^{-5}$ cm/s) compacted soil (or equivalent) cap. As per the new Criteria, the final cover shall consist of a minimum of 0.6 m of low permeability ($<1x10^{-5}$ cm/s for landfill sites located in arid regions and $<1x10^{-7}$ cm/s for landfill sites located in non-arid regions) compacted (or equivalent) cap plus a minimum of 0.15 m of topsoil and suitable vegetative cover;
- The barrier layer shall be protected with a minimum 150 mm thick topsoil layer with approved vegetation established. Final cover shall be sloped at a minimum of 4%, to promote surface water runoff, to a maximum slope of 33%. As per the new criteria, the top plateau shall be a minimum of 10%;
- Surface water runoff shall be directed into collection systems and disbursed into existing streams;

## 8.4 Landfill Closure Examples

A number of landfills in B.C. have been closed in the past ten years. These include Jackman Landfill in Langley, Port Mann Landfill in Surrey, Iona Grit Landfill in Richmond and Premier Street Landfill in North Vancouver, amongst others. As well, progressive landfill closure has become standard operating practice at many landfills in British Columbia, including Hartland Landfill in Victoria, Nanaimo Regional Landfill, Minnie's Pit Landfill in Mission, and Bailey Landfill in Chilliwack, amongst others.

Two basic closure strategies have been adopted. One strategy has been to use low permeability native soils, if available on site or easily accessible (e.g. Bailey Landfill, Port Mann Landfill). The second strategy, adopted at sites where low permeability soils are not readily available or where leachate production is a particular concern, has been to use a plastic geomembrane cover system (e.g. Hartland Landfill, Nanaimo Landfill, Minnie's Pit Landfill).

**Hartland Landfill:** The Hartland Landfill was the first MSW landfill in B.C. to adopt a geomembrane final cover. The cover system constructed in 1995 and 1996 on top of the intermediate cover on Hartland Phase 1 is comprised of:

- 300 mm top soil (peat Heal Lake)

- 200 mm gravel drainage layer
- 100 mm cushion sand
- 40 mil PVC membrane
- 300 mm compacted clay ($K<1x10^{-8}$ cm/s)
- Geotextile separation layer
- Coarse gravel gas / leachate collection layer

**Photo 8-1. Deploying Minus 25 mm Drainage Layer on Sand Cushion at Hartland**

The cover system was constructed on 4H:1V side slopes. Over the past eight years the cover system has been performing exceptionally well. Diversion efficiency has been monitored using V-notch weirs. The diversion efficiency has consistently been above 90% and is believed to be 100%. The uncertainty in confirming efficiency is due to the inaccuracy in estimating evapotranspiration losses.

Vegetation at Hartland Landfill is comprised of a blend of grasses and legumes. Because the top soil is only 300 mm thick and the underlying drainage layer is highly transmissive ($1x10^{-1}$ cm/s), the grasses die back during the summer, to be regenerated once the fall rains come. As such, the cover would not support trees and shrubs requiring a deeper rooting zone and a steady moisture supply.

**Nanaimo Landfill:** Nanaimo Landfill has been conducting annual progressive closure contracts since 1992. Each year a one to two hectare area is capped as part of ongoing progressive closure. In 1997 Nanaimo switched from using a clay-based final cover to using a geomembrane / clay composite. Side slopes at Nanaimo are steeper than Hartland, typically at 3H:1V. In designing the cover strategy, smooth PVC with sand friction layers was initially used, but the last progressive closure contract in 2002 utilized 40 mil textured LLDPE membrane. As well, due to problems in securing suitable clay, the liner was deployed directly on a sand cushion.

**Photo 8-2. Progressive Closures, Nanaimo Landfill North Face**

The typical Nanaimo cover system profile involves:

- 300 mm top soil (fabricated soil with biosolids, sand and compost)
- 150 mm minus 25 mm pit run sand and gravel drainage layer
- 150 mm cushion sand
- 40 mil PVC membrane (or LLDPE textured membrane)
- 150 mm sand cushion layer
- Geotextile separation layer
- Coarse gravel gas / leachate collection layer

**Hope Landfill:** Phase 1 of Hope Landfill has been constructed with slopes as steep as 2H:1V. Due to concerns regarding slope stability a decision was made to cap this landfill with an imported Fraser River silt material with a high friction angle. The barrier layer material was placed and compacted to a 600 mm thickness with a narrow track bulldozer in excess of 95% Standard Proctor. A reduced thickness of barrier layer was approved due to the in-situ permeability of the soil, which was less than $1x10^{-6}$ cm/s.

The design cover profile at Hope Landfill included:

- 300 mm top soil (fabricated soil with biosolids, sand and compost)
- Geotextile separation layer
- 150 mm coarse sand drainage layer

- 600 mm silt barrier layer

**Photo 8-3 Clay Cover at Hope Landfill**

The cover system has been performing well, except for some minor hydraulic fracturing of the top soil layer. This was brought on by the drainage layer (K of $1x10^{-2}$ cm/s) not having enough permeability to carry the infiltrating rainwater from crest to toe during a 1:100 year storm event. Cracks opened up in the topsoil, which allowed excess pore pressures to dissipate. Cross slope ditches were subsequently added. The performance of this cover system emphasizes the need for a highly conductive drainage layer and careful design of the maximum drainage length between cross-slope ditches.

**Port Mann Landfill:** The Port Mann Landfill was capped with excavated glacial till soil. A fabricated topsoil including biosolids was placed on top of the barrier layer. The cover design did not include internal leachate collection layers nor drainage layers beneath the cover. A slumping failure developed in the cover system because of leachate breakouts saturating the barrier and topsoil layers, resulting in a rotational type failure.

**Photo 8-4. Slope Failure in Top Soil at Port Mann Landfill**

**Peerless Road Landfill:**

The old ash landfill and the recycling facility at the Peerless Road in Cowichan Valley Regional District (CVRD) were upgraded in 2013. Franz Environmental Inc. was retained by the CVRD to prepare the closure plan that was approved by the MOE. During the upgrades, more than 45,000 cubic metres of old incinerator ash were reused on the site to form the sealed base of the new recycling centre. The holding cell is located at the centre of the new facility and consists of a fill area that is used for vehicle traffic for waste drop off and truck traffic for bin removal and dropoff. The holding cell is constructed with fill material excavated on site, supported on the sides by lock-block concrete block on the north, west and south side and bedrock on the east side. The top of the holding cell is completed with an impervious cap, consisting of imported engineered fill, and surfaced with asphalt as well as concrete pavement. The old incinerator building was reused and refurbished and now provides more than 2000 square metres of space for recyclables collection and storage as well as for new features such as a Free Store and community bottle drive area. Plus, the new centre now accepts over 650 different products for recycling, most of which can be dropped off free of charge.

Several green design elements have been incorporated into the new Peerless Road Recycling Centre that include but not limited to:

- Reuse and refurbishment of the existing incinerator building to form the new Recycling Centre, rather than demolition and replacement;
- Using locally sourced wood for construction of new buildings, including roof decking for the new Recycling Centre milled from trees harvested on the site;

- Reusing stumps harvested on the site to provide forage and security habitat for amphibians and small mammals;
- Restoring an onsite riparian area using native species;
- Using native, drought-tolerant plants in all onsite landscaping to reduce water

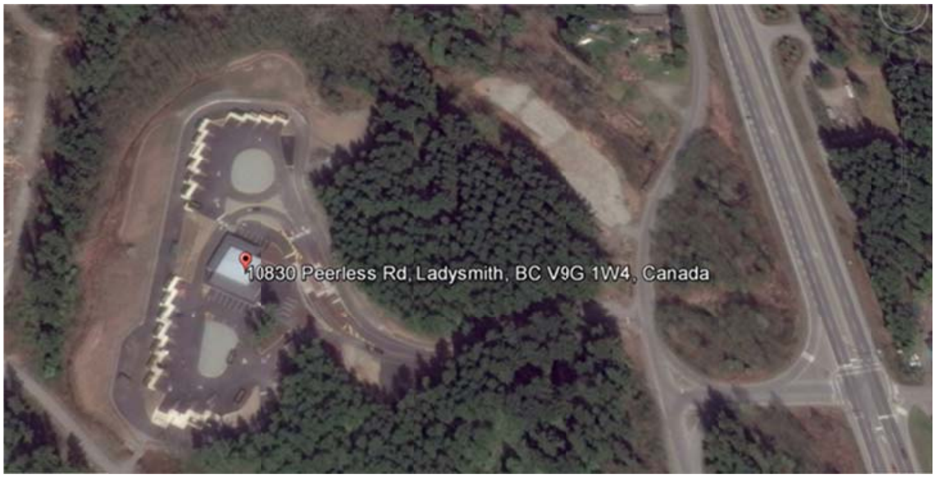


**Photo 8-5. Peerless Road Recycling Centre, Lady Smith**

SHA envisions using a similar approach in closing the Marine Avenue Transfer Site.

## 8.5 Elements of Final Cover Systems

To achieve the objectives outlined above, a minimum cover system comprising of a topsoil horizon and barrier layer is required by MoE. Additional layers including a drainage layer on top of the barrier system and a gas collection layer under the barrier layer may also be required to achieve the objectives at specific sites.

Figure 8-1 provides a schematic illustration of a generic final cover veneer. As shown in Figure 8-1, depending on the particle size gradation of the various layers, it may also be necessary to introduce geotextile separation / cushion layers at key interfaces to prevent migration of topsoil or clay into the various drainage layers. Healthy vegetation is also a key element of final closure. In the discussion below layers are presented in a bottom to top order.

### 8.1.1 Gas / Leachate Collection Layer

The purpose of a gas/leachate collection layer is to provide a high permeability pathway for leachate generated from break-outs to migrate to the landfill toe and for landfill gas to travel laterally beneath the cover system to the closest collection point. Leachate breakouts may be experienced on the landfill side slopes. To prevent head build-up as a result of these breakouts, the gas / leachate drainage layer must attain a permeability of $1x10^{-2}$ cm/s or better. Based on local experience at sites in the B.C. interiors and the deep water table, leachate breakouts are not expected to be a problem at the Airport site and a Gas/Leachate collection layer is not considered necessary at this site.

Although a continuous drainage blanket is not considered necessary, gas control is considered desirable beneath the barrier layer to eliminate the risk of landfill gas displacing atmospheric air in the root zone of trees. For this reason a network of passive lateral gas vents beneath the landfill cap was recommended in Chapter 5 of this plan.

### 8.1.2 Barrier Layer

A low permeability soil or geosynthetic layer forms the backbone of an effective cover system. In British Columbia, a 600 to 1,000 mm layer of low permeability soil has typically been used in constructing a landfill cap (e.g. Port Mann, Bailey, Premier St., Hope). As a second closure option geosynthetic barrier layers are being introduced at landfill sites where low permeability soil is not readily available. There is also the third option, which is a composite liner, consisting of both low permeability soil and geosynthetic barrier components. In the case of a composite liner, a fine-grained soil layer (e.g. clay or silt) is typically used as a cushion layer on top of which the primary geomembrane liner is deployed.

**Compacted Soil Barriers:** In British Columbia, the minimum regulatory requirement for a final cover system is a 1,000 mm thick compacted soil barrier with a hydraulic conductivity of $1x10^{-5}$ cm/s. To achieve a high level of diversion efficiency (e.g. 70% or better), the compacted soil barrier should attain an in-situ hydraulic conductivity of $1x10^{-6}$ cm/s or less. To achieve this low level of permeability, soils must contain a significant percentage of clay-sized particles.

Natural low permeability soil cover systems have the following advantages over geosynthetic cover systems:

- Low permeability soil covers have been used widely in British Columbia and are accepted by MoE as an effective means of landfill closure,
- A natural soil cover system may provide the lowest overall cost solution through the use of inexpensive, locally available materials,
- A natural cover system will allow infiltration of small quantities of water into the refuse, thereby increasing the rate of stabilization of the refuse as well as increasing the production of landfill gas,
- Use of synthetic materials may increase long term post-closure maintenance costs because it will be important to regularly mow the cover to protect the underlying membrane from root penetration by certain tree and brush species, except in areas protected by a thick subsoil (e.g. tree islands).
- Soil cover systems have self healing properties, whereby clays swell to reseal penetrations and/or cracks, and

- Soil may provide better performance in the very long term (e.g. > 100 years) in the event geomembranes deteriorate over time.

However, as a low permeability soil is not locally available we do not recommend this option for the Airport Landfill.

**Geomembrane Barriers:** A number of geosynthetic membrane products have been used successfully for landfill closure applications, including polyvinyl chloride (PVC), high density polyethylene (HDPE), very low density polyethylene (VLDPE), linear low density polyethylene (LLDPE), polypropylene and geosynthetic clay liners (GCL's). Of these options, PVC geomembranes have been installed in more than 80% of projects completed in North America prior to 2000; however, LLDPE membranes have become popular recently on steep slope applications because the textured LLDPE product has a more aggressive texture and higher friction angle compared to PVC. Geomembrane caps have become prevalent in the U.S. where Subtitle D regulations require the final cover barrier layer to be less pervious than the bottom liner in order to prevent development of the bathtub effect. In British Columbia, PVC geomembrane caps have been successfully installed by SHA at Hartland Landfill in Victoria, Cedar Road Landfill in Nanaimo and the Iona Grit Landfill in Richmond. LLDPE caps have been successfully installed by SHA at Prince George, Nanaimo, Minnie's Pit Landfill in Mission and at Vancouver Landfill.

Advantages of geomembrane barriers include:

- Less susceptibility to settlement induced stress cracking;
- No susceptibility to desiccation;
- Superior containment of landfill gas;
- Lower consumption of air space; and
- Reduced leachate generation.

Disadvantages of geomembranes include:

- Lower interface friction resistance than clay (without texture or sand friction layer);
- Skilled labour and more stringent QA/QC is required to achieve a reliable barrier;
- Reliability of membranes in very long term (>100 years) not clearly defined;
- Membrane needs to be deployed on smooth, well compacted ground;
- Synthetic covers can be more susceptible to damage from inappropriate end uses, potentially limiting end use options;
- Overlying drainage and top soil layers must be placed with care;
- Reduced infiltration will slow the rate of decomposition of the garbage, thereby increasing the contaminating lifespan of the landfill;

- Capital costs typically higher than those experienced with soil barriers, if soil material is available on site.

In the absence of good quality locally available low permeability soil, we recommend using a geomembrane solution. In particular we recommend a 40 mil LLDPE geomembrane. This material will provide an adequate barrier layer for the slope and crest are areas of the landfill.

**Composite Barrier Systems:** Composite systems are comprised of two barrier layers in intimate contact. The most common composite design is to deploy a geosynthetic membrane on top of a compacted clay liner of reduced thickness (e.g. 300 to 500 mm). The primary advantage of composite lining systems is that they provide a higher level of leak protection and greater security in the very long term. Composite barrier systems are frequently specified for hazardous waste containment facilities. As a fine-grained cushion layer (or geotextile) is required beneath the primary liner in any case, 300 mm thick secondary liners have been adopted in the closure of many B.C. MSW landfills as well.

Given the low environmental impacts observed to date, a composite barrier is not deemed necessary at this site as we can anticipate at this stage. However, this should be finalized during detail design.

### 8.1.3 Drainage / Cushion Layer

The purpose of a drainage layer on top of the barrier is to quickly convey water passing through the topsoil horizon down slope to the landfill toe or mid-slope groundwater interceptor ditch. Without an effective drainage layer, the topsoil could become saturated during heavy rainfall events. This condition could lead to excessive head build-up on the barrier layer and can lead to erosion and slumping problems on side slopes and increased infiltration over the landfill crest. Use of a high permeability topsoil medium could be considered, however, in our opinion, a high permeability topsoil layer would not achieve the same performance as a gravel drainage layer and would likely become saturated and unstable during extreme precipitation events.

Detailed HELP flow modelling will be completed as part of the detailed design process, however based on previous experience we anticipate that a 200 mm thick layer of gravel placed beneath the topsoil layer should provide the necessary drainage for the cover system.

### 8.1.4 Top Soil Layer

A layer of organic topsoil is essential to ensure a healthy and sustainable vegetative community on top of the final cover system. The minimum requirement is for a 150 mm thick layer of topsoil. In most final cover designs SHA recommends a thicker layer of topsoil, in this case a 300 mm thick layer, to provide sufficient moisture retention in the soil during periods of drought, thereby preventing plant mortality, and to reduce the risk of root penetration into the underlying barrier layer.

### 8.1.5 Subsoil Layer

The primary function of a subsoil layer is to provide a deep soil horizon in which roots can establish. This layer is important when considering planting of shrubs and trees with deep, penetrating root systems. Without such a protective layer, the roots could penetrate the underlying barrier systems.

To date SHA has utilized a subsoil layer on only a few closure projects engineered by our company. The primary reason has been that most landfills do not have a surplus of soil material, in fact many run short of soil even for operational cover. In addition, subsoil could potentially occupy landfill air space that is seen as a valuable commodity by landfill owners.

Based on the end-use plan contemplated, a subsoil layer is not proposed at the Marine Avenue Transfer site.

### 8.1.6 Filter Layer

To prevent migrating fines from the topsoil from clogging the underlying drainage layer, we recommend that a non-woven geotextile blanket be placed over top of the drainage layer. The most important characteristic of the geotextile in this application is the opening size. This should be small enough to ensure that overlying topsoil or subsoil material cannot pass into the drainage layer, a light to medium weight geotextile should be utilized. Geotextile panels should be sewn in the field to ensure that they do not become separated during placement. Detailed specifications for the material should be developed once the exact composition of the topsoil is known. Standard geotextile filter criteria should be referenced during detailed design to ensure that the material will prevent migration of the fine cover soils. Also, a laboratory shear strength test should be conducted to determine shear strength properties at the topsoil geotextile interface in order to ensure that the topsoil will not slip, especially under saturated conditions.

## 8.6 HELP Modelling of Closure Options

A range of final cover system options were considered in this study to explore the most suitable final cover system at the Marine Avenue Transfer site. To investigate these aspects of cover performance, various model scenarios were constructed and analyzed with HELP (Schroeder, et. al., 1994). Table 8-1 shows the HELP modeling profiles and input details for different scenarios. The k value for the existing bottom silt/sand layer has been assumed to be $1x10^{-4}$ cm/s and for the clay cover system $1x10^{-5}$ cm/s as per MOE's recommendation. The k-values used for other layers are presented in Table 8-1. The results of the modeling are presented in Table 8-2.

All of the scenarios used the same geologic profile representative of average conditions at the site. It was estimated that, the typical refuse thickness is 7.0 m at the landfill portion and 3.0 m at the proposed transfer bay area portion of the Site. The average hydraulic conductivity, K, for the refuse (mostly ash) was estimated to be $2x10^{-3}$ cm/s based on SHA's previous experience and the value available from the HELP model database.

The analysis was done separately for the crest (4%) of the landfill, and for the side slopes (33%). For this project, all the cover option profiles were assessed using a 50 year simulation based on climate patterns from the Powell River Airport Station. These climate values were corrected to reflect the temperature and precipitation experienced at the landfill site and its surrounding areas. The average monthly precipitation rate and temperature based on the Environment Canada Climatic Normal Data (1981 to 2010) were input into the model. The average annual precipitation created by the HELP model was 1229.9 mm; however the actual average recorded on site is higher at 1205.4 mm/yr. This difference is due to the artificial parameters that the HELP model uses to simulate the weather.

In the simulations four different cover system designs, as described in Table 8-1, were utilized.

***Option 1****(MOE Recommended Silt/Clay Cover)*, which is also the cover system required as per the existing criteria, involves a 150 mm top soil horizon (k= 1x$10^{-4}$ cm/s) and a 1000 mm Silt/Clay Barrier Layer (k= 1x$10^{-5}$ cm/s). In the recently launched draft criteria a 600 mm layer with a k-value of 1x$10^{-5}$ cm/s (arid region) or 1x$10^{-5}$ cm/s (non-arid region) is required.

***Option 2****(SHA Recommended Clay Cover)* involves a 300 mm top soil horizon (k= 1x$10^{-4}$ cm/s), a 200 mm gravel drainage layer (k= 5x$10^{-1}$ cm/s) and a 1000 mm Silt/Clay Barrier Layer (k= 1x$10^{-6}$ cm/s).

***Option 3****(Geomembrane with Drainage Layer)* involves a 300 mm top soil horizon (k= 1x$10^{-5}$ cm/s), a 200 mm gravel drainage layer (k= 5x$10^{-1}$ cm/s), and a LLDPE geomembrane as barrier (k= 4x$10^{-13}$ cm/s).

***Option 4****(Asphalt Pavement with WPE20)* involves a 100 mm asphalt pavement (k= 1x$10^{-10}$ cm/s), a 200 mm base gravel pad (k= 5x$10^{-1}$ cm/s), a 500 mm Sub-base gravel pad (k= 5x$10^{-1}$ cm/s) and a WPE20 or equivalent material layer as barrier (k= 5.4x$10^{-10}$ cm/s).

In each case the cover veneer was constructed on a 300 mm thick intermediate cover layer (K= 1x$10^{-4}$ cm/s). Each option was simulated for both crest (4%) and side slopes (33%). The results show that leachate generation was found to be more or less similar for both options. Since leachate generation on the crest (4%) would be critical, and was found to be slightly higher, the results for the crest options are discussed in detail below:

**Option 1 – MOE Recommended Silt/Clay Cover:** This option is based on the MOE recommended option as mentioned in the existing criteria for MSW Landfills. As mentioned in Table 8-2, the runoff, evapotranspiration and change in water storage were found to be 12.5 mm/yr, 493.2 mm/yr and 0.15 mm/yr respectively for the open condition. Leachate production prior to closure is 724.0 mm/yr. After closure, run-off increased to 51.1 mm/yr, while evapotranspiration decreased to 481.4 mm/yr and change in water storage increased to 0.78 mm/yr. Leachate production was found to decrease to 696.5 mm/yr for the closed condition under this option.

**Option 2 –Clay Cover (SHA) with a Drainage Layer**: This option involves a Clay layer with a drainage layer. As mentioned in Table 8-2, the runoff, evapotranspiration and change in water storage were found to be 1.39 mm/yr, 513.12 mm/yr and 7.7 mm/yr respectively after closure with this option. Lateral drainage was found to be 714.69 mm/yr when the landfill is closed under this option. Leachate production decreased to 0.40 mm/yr for the closed condition under this option.

**Option 3 – Geomembrane with a Drainage Layer**: This option involves a geomembrane barrier layer with a drainage layer. As mentioned in Table 8-2, the runoff, evapotranspiration and change in water storage were found to be 1.40 mm/yr, 513.2 mm/yr and 0.2 mm/yr respectively after closure with this option. Lateral drainage was found to be 714.69 mm/yr when the landfill is closed under this option. Leachate production decreased to 0.40 mm/yr for the closed condition under this option.

**Option 4 – Asphalt Pavement with WPE20 Membrane**: This option involves an asphalt pavement layer with a gravel pad layer and a WPE20 or equivalent material barrier layer. As mentioned in Table 8-2, the runoff, evapotranspiration and change in water storage were found to be 1014.3 mm/yr, 215.56 mm/yr and -0.013 mm/yr respectively after closure with this option. Lateral drainage was found to be 0 mm/yr in the gravel pad layer when the landfill is closed under this option. Leachate production decreased to 0.02 mm/yr for the closed condition under this option.

## 8.7 Recommended Cover Design for Final Consideration

Based on the results of our detailed analysis SHA concludes that an effective cover system can best be realized with an LLDPE geomembrane cover system with a drainage layer for the proposed landfill portion and an asphalt pavement layer or a gravel pad and WPE20 or equivalent material barrier layer for the holding cell that can potentially be used as a transfer bay in future. The sand cushion layer can be used as a bedding layer with horizontal collector trenches filled with coarse grained material or gravel for passive gas collection. SHA is of the opinion that the Option 3 design can be effective and meet all performance requirements for closure at the Marine Avenue Transfer Site – specifically, for the landfill crest and landfill slope and holding cell side slope. The Option 4 design is recommended for the crest of the holding cell.

The Recommended Cover System as per Option 3, as shown in Figure 8-2, includes the following layers:

- 150 mm Sand Cushion Layer with Horizontal Trenches for Passive Gas Collection
- 40 mil LLDPE Geomembrane
- 12 oz Heavy Weight Geotextile Layer
- 200 mm Gravel Drainage Layer
- 8 oz Seperation Geotextile

- 300 mm Topsoil Layer

The Recommended Cover System as per Option 4, as shown in Figure 8-3, includes the following layers:

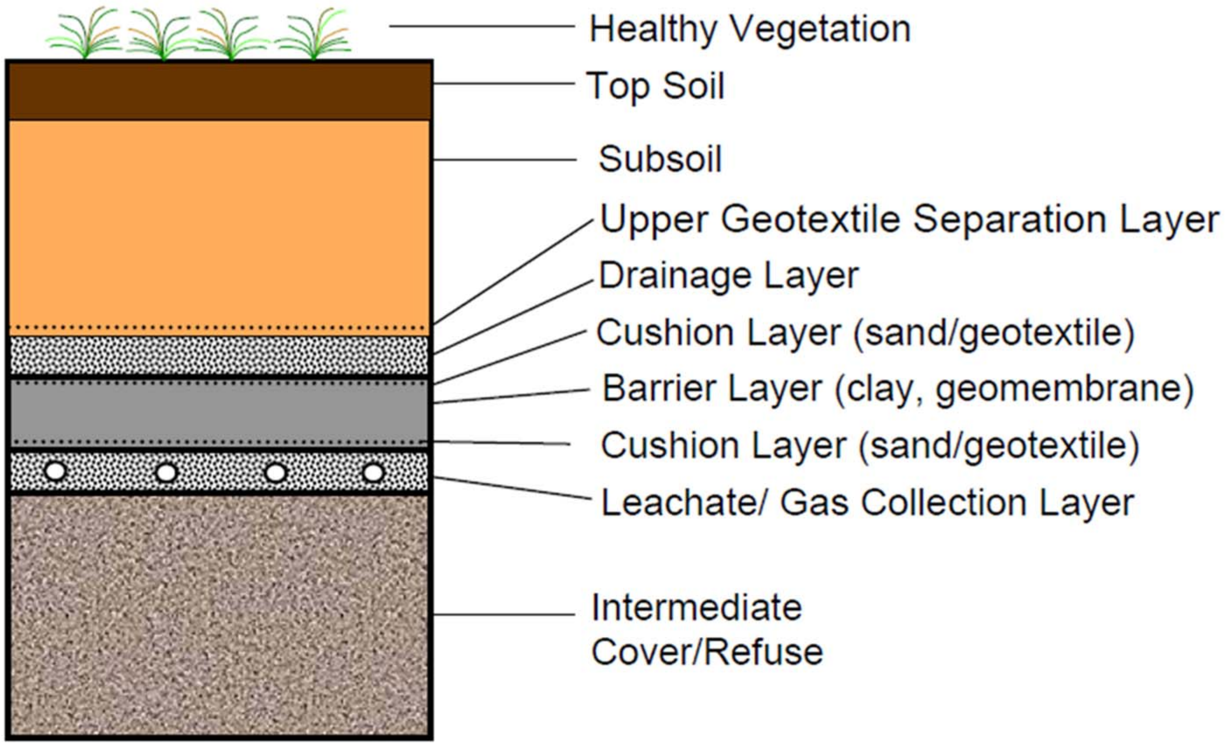
- 150 mm Sand Cushion Layer with Horizontal Trenches for Passive Gas Collection
- 16 mil WPE20 or Equivalent Material for Barrier Layer
- 12 oz Heavy Weight Geotextile Layer
- 12 oz Heavy Weight Geotextile (2 Layers)
- 500 mm Sub-Base Gravel Pad Layer
- 200 mm Base Gravel Pad Layer
- 100 mm Asphalt Pavement Layer

The holding cell will have an access ramp and an exit ramp as shown on Figure 6-3 as it will potentially be used for the top pad of the transfer bays. The holding cell will abut on the lock-block walls on the west side that will accommodate 15 transfer bays. Along the inside of the lock-block walls and underneath, engineered fill may need to be used to secure the walls. The details of the fill can be determined during the detailed design.

The recycle area is recommended to be paved with concrete or asphalt underlain by the following layers from bottom to top:

- 150 mm Sand Cushion Layer
- 500 mm Sub-Base Gravel Pad Layer
- 200 mm Base Gravel Pad Layer

A similar closure approach and cover systems have been used at Peerless Road Recycling Centre with MOE's approval. This site was also a former incinerator site (Franz, 2013).



Sperling Hansen Associates

CLIENT: Powell River Regional District

PROJECT: **Marine Avenue Site Closure Plan**

TITLE: **Typical Final Cover System Elements**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/07/17 yyyy/mm/dd | **PRJ13043** |

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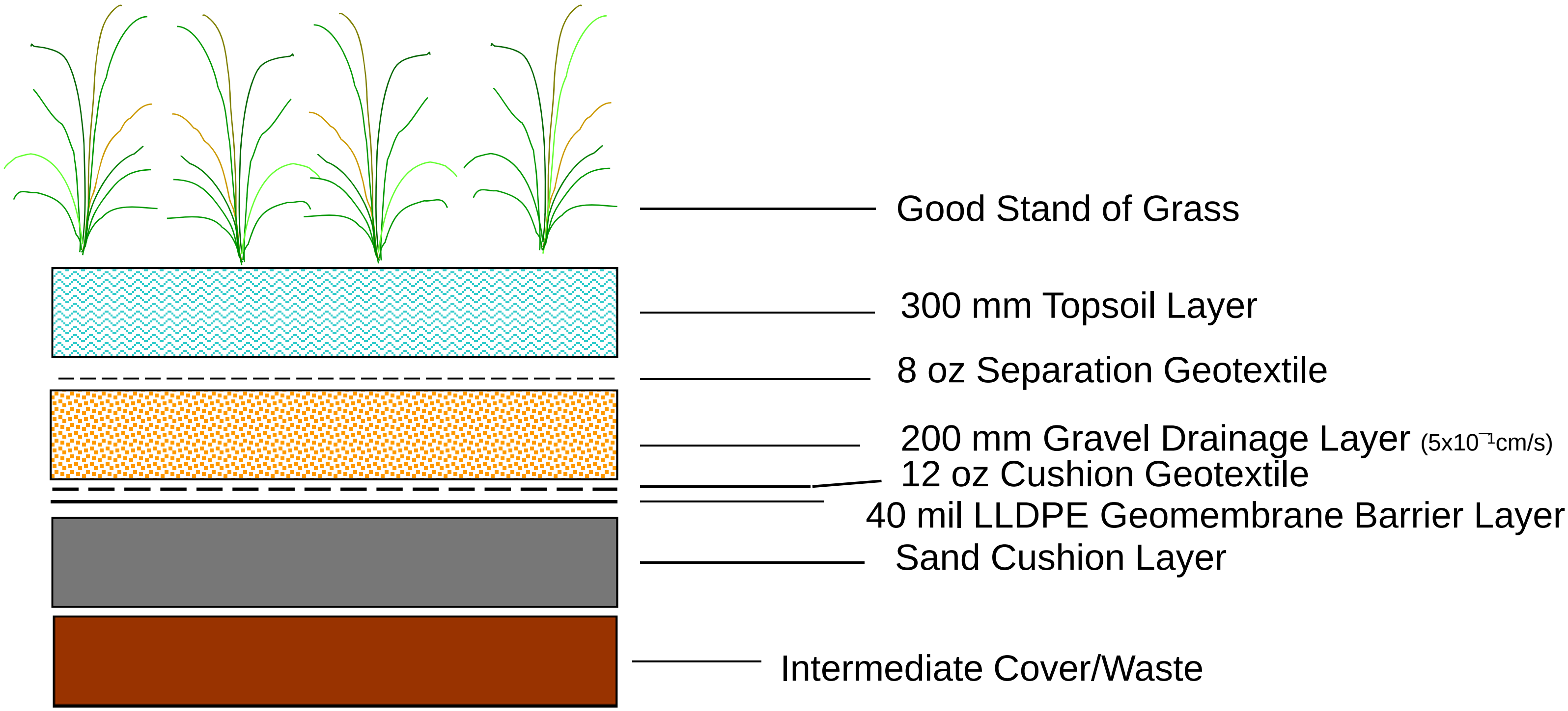
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE 8-1** |
| CHECKED | TS | |



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CLIENT:
Powell River
Regional District

PROJECT:
**Powell River Marine Avenue**
**Site Closure Plan**

TITLE:
**Recommended Cover**
**System Profile**
**Landfill Crest and**
**All Slope Areas**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/07/17<br>yyyy/mm/dd | **PRJ13043** |

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| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE 8-2** |
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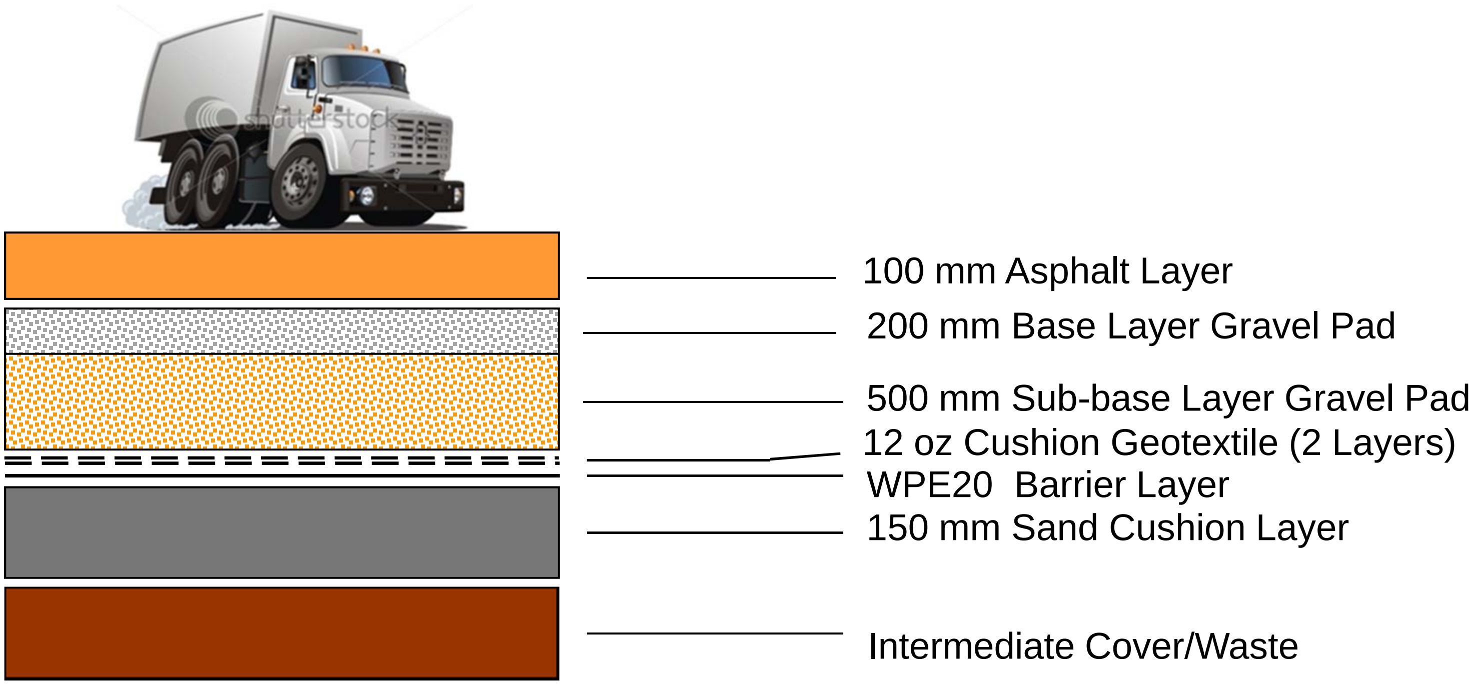

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Associates

CLIENT:
Powell River
Regional District

PROJECT:
**Powell River Marine Avenue**
**Site Closure Plan**

TITLE:
**Recommended Cover**
**System Profile**
**Transfer Bay Area Crest**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/07/17<br>yyyy/mm/dd | **PRJ13043** |

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|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE 8-3** |
| CHECKED | TS | |

**Table 8-1: HELP MODEL PROFILE AND SCENARIOS**

| | | Open | Closed | | | |
|---|---|---|---|---|---|---|
| | **Vegetation** | **Existing** | **Option 1 (Clay- MOE)** | **Option 2 (Clay - SHA)** | **Option 3 (Geomembrane)** | **Option 4 (Paved Surface)** |
| | | Poor Stand of Grass | | | | |
| **Layers** | | Evaporative Zone Depth = 20cm | Evaporative Zone Depth= 51cm | Evaporative Zone Depth= 51cm | Evaporative Zone Depth= 51cm | |
| Layer 1 | Material | Intermediate Cover | Topsoil | Topsoil | Topsoil | Asphalt |
| | Function | Vertical Percolation Layer | Vertical Percolation Layer | Vertical Percolation Layer | Vertical Percolation Layer | Vertical Percolation Layer |
| | Thickness (mm) | 300 | 150 | 300 | 300 | 300 |
| | K Value (cm/s) | 1x10$^{-4}$ | 1x10$^{-4}$ | 1x10$^{-4}$ | 1x10$^{-4}$ | 1x10$^{-10}$ |
| Layer 2 | Material | Incinerator Ash Refuse | Clay | Clay | Gravel | Gravel |
| | Function | Vertical Percolation Layer | Barrier Layer | Barrier Layer | Drainage Layer | Base and Sub-Base |
| | Thickness (mm) | 3,000-7,000 | 1000 | 1000 | 200 | 700 |
| | K Value (cm/s) | 2x10$^{-3}$ | 1x10$^{-5}$ | 1x10$^{-6}$ | 5x10$^{-1}$ | 5x10$^{-1}$ |
| Layer 3 | Material | Silty Sand Layer | Intermediate Cover | Intermediate Cover | Geomembrane | WP20 |
| | Function | Bottom Barrier Layer | Vertical Percolation Layer | Vertical Percolation Layer | Barrier Layer | Barrier Layer |
| | Thickness (mm) | 2,000 | 300 | 300 | 40 Mil | 16 Mil |
| | K Value (cm/s) | 1x10$^{-4}$ | 1x10$^{-4}$ | 1x10$^{-4}$ | 4.0x10$^{-13}$ | 5.4x10$^{-10}$ |
| Layer 4 | Material | | Refuse | Refuse | Intermediate Cover | Intermediate Cover |
| | Function | | Vertical Percolation Layer | Vertical Percolation Layer | Vertical Percolation Layer | Vertical Percolation Layer |
| | Thickness (mm) | | 3,000-7,000 | 3,000-7,000 | 300 | 300 |
| | K Value (cm/s) | | 2x10$^{-3}$ | 2x10$^{-3}$ | 1x10$^{-4}$ | 1x10$^{-4}$ |
| Layer 5 | Material | | Silty Sand Layer | Silty Sand Layer | Refuse | Refuse |
| | Function | | Bottom Barrier Layer | Bottom Barrier Layer | Vertical Percolation Layer | Vertical Percolation Layer |
| | Thickness (mm) | | 2,000 | 2,000 | 3,000-7,000 | 3,000-7,000 |
| | K Value (cm/s) | | 1x10$^{-4}$ | 1x10$^{-4}$ | 2x10$^{-3}$ | 2x10$^{-3}$ |
| Layer 6 | Material | | | | Silty Sand Layer | Silty Sand Layer |
| | Function | | | | Bottom Barrier Layer | Bottom Barrier Layer |
| | Thickness (mm) | | | | 2,000 | 2,000 |
| | K Value (cm/s) | | | | 1x10$^{-4}$ | 1x10$^{-4}$ |

**HELP MODEL RESULTS**

| Scenarios | Scenario Modelled | Evapotranspiration (mm/yr) | Evapotranspiration as % of P | Runoff (mm/yr) | Runoff as % of P | Lateral Drainage Top (mm/yr) | Lateral Drainage Top % of P | Percolation to Leachate (mm/yr) | Percolation to Leakage % of P | Leachate Produced (mm/yr) | Leachate Produced as % of P | Change in water storgae (mm/yr) | Change in water storgae as % of P | Total (mm/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I.D | **Crest** | | | | | | | | | | | | | |
| 0 | Open- Existing | 493 | 40.1% | 12.45 | 1.0% | N/A | N/A | 724 | 58.9% | 724.00 | 58.9% | 0.15 | 0.01% | 1229.8 |
| 1 | Closed - Option 1- Clay Cover - MOE | 481 | 39.1% | 51.13 | 4.2% | N/A | N/A | 696.53 | 56.6% | 696.53 | 56.6% | 0.78 | 0.1% | 1229.9 |
| 2 | Closed - Option 2- Clay Cover (SHA) with a Drainage Layer | 513 | 41.7% | 1.39 | 0.1% | 566.1 | 46.0% | 141.52 | 11.508% | 141.52 | 11.5% | 7.70 | 0.6% | 1229.9 |
| 3 | Closed - Option 3 - Geomembrane Cover with a Drainage Layer | 513 | 41.7% | 1.4 | 0.1% | 714.7 | 58.1% | 0.4 | 0.0% | 0.40 | 0.0% | 0.20 | 0.0% | 1229.9 |
| 4 | Closed - Option 4 - Paved with Asphalt | 216 | 17.5% | 1014.32 | 82.5% | 0 | 0.0% | 0.02 | 0.0% | 0.02 | 0.0% | -0.01 | 0.0% | 1229.9 |
| | **33% Slope** | | | | | | | | | | | | | |
| 0 | Open- Existing | 493 | 40.1% | 13.75 | 1.1% | N/A | N/A | 723.1 | 58.8% | 723.10 | 58.8% | -0.31 | 0.0% | 1229.9 |
| 1 | Closed - Option 1- Clay Cover - MOE | 481 | 39.1% | 51.2 | 4.2% | N/A | N/A | 696.4 | 56.6% | 696.40 | 56.6% | 0.79 | 0.1% | 1229.8 |
| 2 | Closed - Option 2- Clay Cover (SHA) with a Drainage Layer | 513 | 41.8% | 2.29 | 0.2% | 588.9 | N/A | 117.55 | 9.559% | 117.55 | 9.6% | 7.68 | 0.6% | 1229.9 |
| 3 | Closed - Option 3 - Geomembrane Cover with a Drainage Layer | 513 | 41.8% | 2.29 | 0.2% | 714 | 58.1% | 0.09 | 0.0% | 0.09 | 0.0% | 0.07 | 0.0% | 1229.9 |
| 4 | Closed- Option 4- Paved with Asphalt | 216 | 17.5% | 1014.13 | 82.5% | 0.02 | 0.0% | 0.02 | 0.0% | 0.02 | 0.0% | -0.01 | 0.0% | 1229.9 |

Sperling
Hansen
Associates

Powell River
Regional District

PROJECT:
**Marine Avenue Transfer Site
Closure Plan**

TITLE:
**HELP Results**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/07/17<br>yyyy/mm/dd | **PRJ13043** |
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **TABLE 8-2** |
| CHECKED | TS | |

# 9. SURFACE WATER CONTROL AND RUN-OFF MANAGEMENT

The primary objectives of the surface water management plan are to prevent erosion of the final cover system, to prevent ponding of surface water on the cover system, except in designated areas, to control flooding on the cover system, to minimize leachate production and to control surface water in a manner compatible with the proposed end-uses. This chapter reviews the existing conditions and provides recommendations on runoff diversion, stormwater control and ditch sizing.

## 9.1 Background

As mentioned in Chapter 2 and 7, groundwater beneath the landfill is generally expected to flow to the southwest toward the unnamed creek flowing from Cranberry Lake.

There are two existing ditches on the site, draining groundwater seepage as well as surface water from the site. The surface water after closure of the site will be managed efficiently so that clean water remains clean. The existing ditch that runs through the middle of the site will be widened to increase the retention capacity.

## 9.2 Run-on Diversion

The conceptual surface water management plan for the landfill closure is shown on Figure 9-1. Drainage on the site is generally from north to south as overland flow. Because of the nature of the topography and difference of elevations of the areas, run-on from the upslope area of the landfill is currently diverted to the unnamed creek running north-east to south-west. As the landfill is developed, run-on from the upslope area will be intercepted and diverted through the crest ditch and will be discharged to the forested area that will eventually fall into the unnamed creek as is occurring at present.

## 9.3 Runoff Management and Drainage Plan

In order to manage the surface water from the Marine Avenue site and to protect the area from erosion, toe ditches lined with an erosion control blanket and armoured with riprap need to be installed along the toe of the landfill for surface water drainage as shown on Figure 9-1.

### 9.3.1 Crest and Toe Ditches

In order to determine the sizing of the crest and toe ditches, peak flows were determined using the Rational Method, a calculation commonly used in determining the peak flow runoff rates in small watersheds. The rationale behind this method is that steady uniform rainfall intensity will cause runoff to reach its maximum rate when all parts of a watershed are contributing to the point of outflow. This is dependent on the time of concentration, which is taken as the time for water to flow to the outflow from the most remote point of the watershed. Along with the rainfall intensity and drainage area, which are relatively straightforward to determine, the peak flow is dependent on the runoff coefficient. The runoff coefficient is dependent on the final cover design. It is primarily influenced by topography, vegetation, the seasons and the subsurface material type. The method and coefficients for the analysis were obtained from the BC Agricultural Drainage Manual (1997). This method allows variations of the material types, the vegetation types and the topography (slope) conditions. The Intensity-Duration-Frequency (IDF) curve for Powell River Airport Station was used as the nearest climate station, as shown on Figure 9-1.

The following dimensions are recommended for crest and toe ditches:

- Crest Ditches – Triangular cross section, depth of 0.75m, side slopes at 2.5 H: 1V, and lined with erosion control blanket.

- Toe Ditches – Triangular cross section, depth of 0.75 m, side slopes at 2.5 H:1V, and lined with erosion control blanket.

## 9.4 Pond/ Wetlands

### 9.4.1 Retention Pond

The purpose of a retention pond is to capture the peak flows during high rainfall events for discharge at a lower flow rate in the future. Key parameters to be considered in sizing the basin are the predicted inflow rates, the allowable maximum outflow rate and flow regime, evaporation and precipitation taking place on the basin surface and any operational measures that may be required such as maintaining a minimum water level in the basin.

SHA has designed several detention ponds in BC. Photo 9-1 shows a retention pond at Delta Shake and Shingle (DSS) Landfill at Delta, BC. SHA included a topsoil layer on pond bottom to facilitate planting cattails that would help improve the water quality.

**Photo 9-1: Retention Pond at DSS Landfill**

### 9.4.2 Sedimentation Pond

Sedimentation ponds are designed to facilitate settlement of particulate matter present in the runoff. The volume and surface area of the ponds need to be sized to provide the necessary retention time to allow the precipitates to settle. The rate of settling for the precipitate is expected to be on the order of 0.2 m/hr, and the pond is expected to provide a retention time of around three days. Photo 9-2 shows a sedimentation pond at the 7 Mile Landfill.

**Photo 9-2: Sedimentation Pond at 7 Mile Landfill**

### 9.4.3 Polishing Wetlands

Wetlands can perform several functions in the leachate treatment / storm water management system. From a storm water quantity management point of view, wetlands can perform a similar function as a detention pond, acting as a buffer and minimizing the peak flows discharged during high rainfall events. Furthermore, wetlands can provide a polishing effect, further removing pollutants attached to suspended solids in the leachate. Wetlands also facilitate a large amount of nitrogen uptake from the water, converting the ammonia present in water to nitrogen gas which is transferred to the atmosphere through biological processes taking place in the water. Photo 9-3 shows a polishing wetland at Gibraltar Landfill.

**Photo 9-3: Polishing Wetlands at Gibraltar Landfill, B.C.**

### 9.4.4 Detention/Sedimentation Pond and Polishing Wetlands at the Site

To prevent the off-site discharge of any sediment laden surface water and provide storage during peak flow, SHA recommends that all captured surface water be discharged through a retention pond. Due to site topography, it is recommended that a pond be constructed on site as shown in Figure 9-2. The pond will require a geomembrane lining system to prevent leakage. If, during the detailed design, the water table is found to be too high to excavate the west pond, an alternative approach is to build the pond above ground using a 2 m high berm against the existing side slopes.

The pond bed will be planted with appropriate vegetation to be selected during detailed design that will serve as a polishing wetland. Once vegetation will be established on the cover systems and ditches, sediment transport will be greatly reduced. The retention pond has been sized for a 1 in 25 year storm event and approximately 2,000 $m^3$ of volume is required for the sedimentation pond. A 1,000 $m^3$ pond along with increasing the capacity of the existing ditch to around 1,200 $m^3$ (rectangular cross section depth of 1 m, bottom 2 m and side slopes at 2.0 H:1V) will meet the requirement for storage and sedimentation. The analysis for the pond and ditch design is presented in Appendix F.

To further enhance the natural treatment characteristics of the storm water system the ditch should be set up as a series of cascading pools, each with integral wetland habitat.

## 9.5 Erosion Control

Once final cover is constructed, the slopes should experience an average annual soil loss of around 0.079 cm per year providing a fair stand of grass vegetation is established. This represents a stable situation where erosion damage is under control.

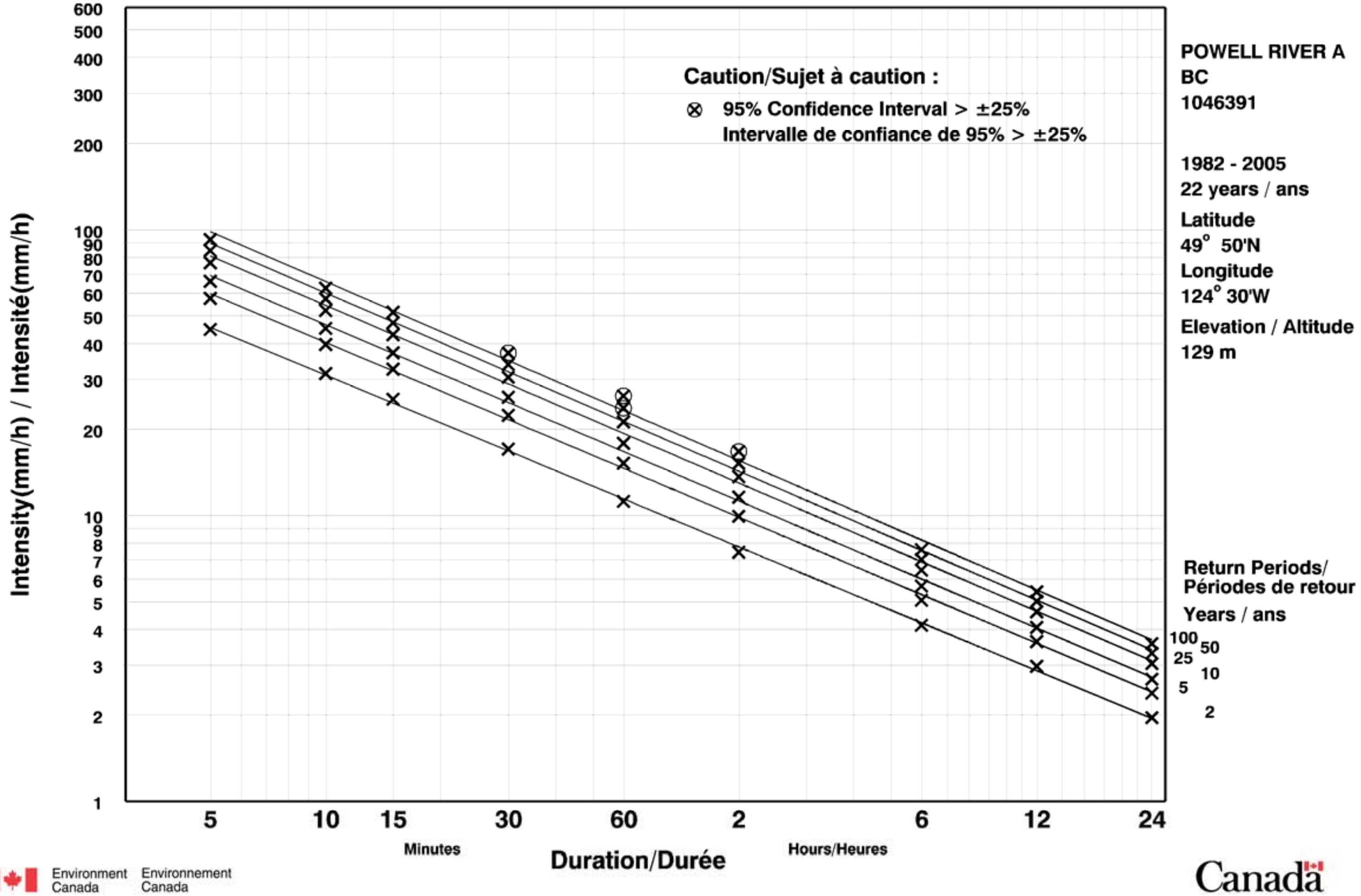
During the post construction period, erosion on the slopes will be controlled with straw mulch on completed slopes, straw wattle and straw/coconut erosion control material above all ditches, as shown in Photo 9-4.

**Photo 9-4: Effective Straw Wattle and Matting at Vancouver Landfill**

## Short Duration Rainfall Intensity-Duration-Frequency Data

## Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

2012/02/09



**POWELL RIVER A**
**BC**
**1046391**

**1982 - 2005**
**22 years / ans**

**Latitude**
**49° 50'N**
**Longitude**
**124° 30'W**
**Elevation / Altitude**
**129 m**

Environment Canada  Environnement Canada

Canada

Sperling Hansen Associates

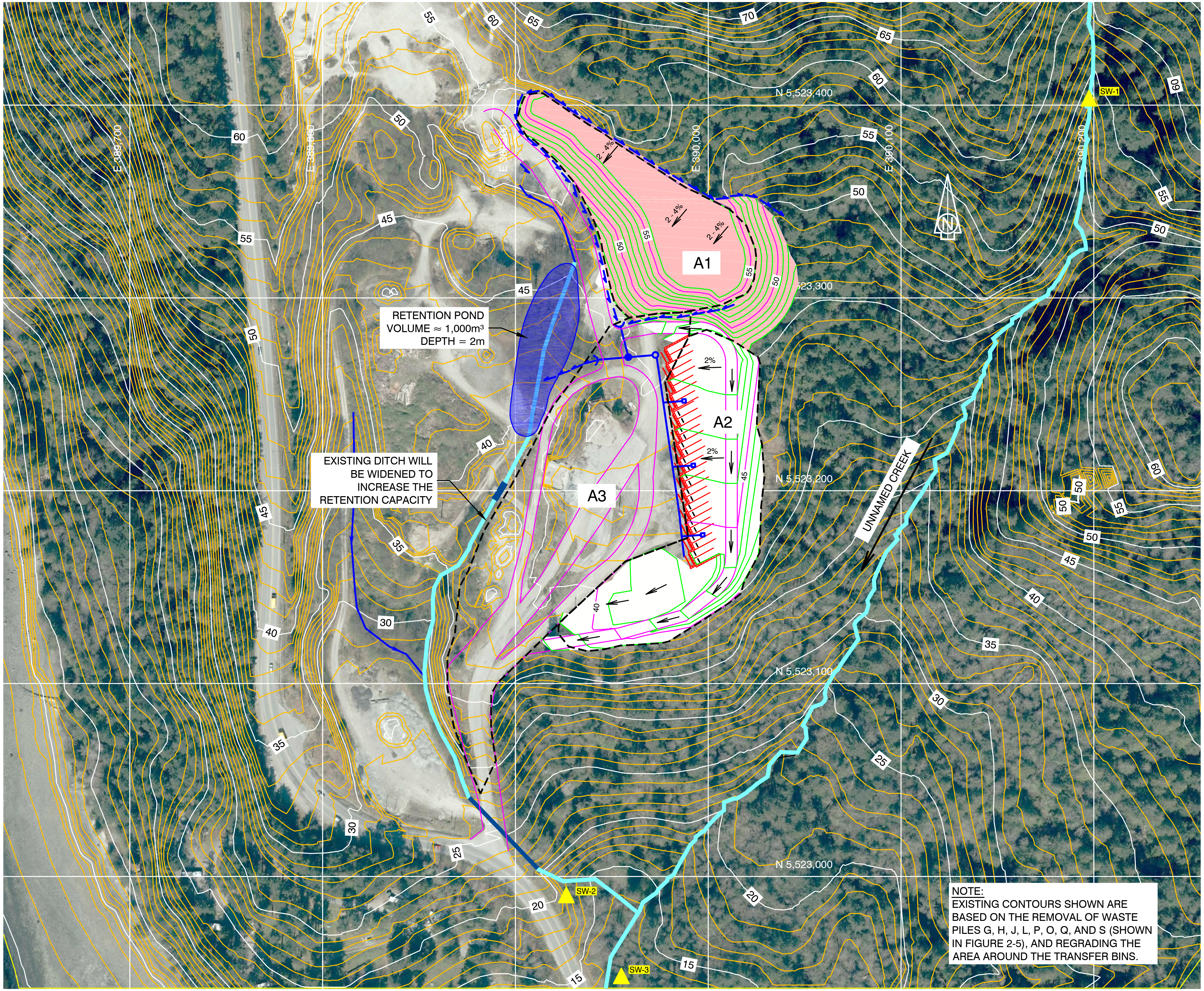
CLIENT:
Powell River Regional District

PROJECT:
**Powell River Marine Avenue Site Closure Plan**

TITLE:
**IDF Curve**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/08/14<br>yyyy/mm/dd | **PRJ13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE 9-1** |
| CHECKED | TS | |



RETENTION POND
VOLUME ≈ 1,000m³
DEPTH = 2m

EXISTING DITCH WILL
BE WIDENED TO
INCREASE THE
RETENTION CAPACITY

NOTE:
EXISTING CONTOURS SHOWN ARE BASED ON THE REMOVAL OF WASTE PILES G, H, J, L, P, O, Q, AND S (SHOWN IN FIGURE 2-5), AND REGRADING THE AREA AROUND THE TRANSFER BINS.

SPERLING
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LEGEND:

5m EXISTING CONTOUR
1m EXISTING CONTOUR
PROPERTY LINE
LANDFILLED AREA
LINED DITCH
EXISTING DITCH
EXISTING CULVERT
CULVERT
ROAD
● MANHOLE
○ CLEANOUT
RETENTION POND
5m PROPOSED CONTOUR
1m PROPOSED CONTOUR
← SURFACE WATER DRAINAGE DIRECTION
☐ CATCH BASIN
▲ EXISTING SURFACE WATER MONITORING STATION
CATCHMENT AREAS
EXISTING SURFACE WATER

CLIENT:
POWELL RIVER REGIONAL DISTRICT

PROJECT:
POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

TITLE:
SURFACE WATER
MANAGEMENT PLAN

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | DRAWING NO: |
|---|---|---|
| SURVEYED | AK | FIGURE 9-2 |
| DRAWN | NP | |
| CHECKED | IB | |

# 10. TOP SOIL, VEGETATION AND FAUNA

## 10.1 Introduction

This chapter describes the elements of the closure plan that will ensure that a vibrant ecosystem is established on the closed landfill areas. The elements described in this chapter include the procedures for establishing appropriate soil horizons that are conducive to plant growth, and the planting of native grass, shrub and tree species that will thrive in the environment and create a habitat that will ultimately provide the attributes that will, over time, allow for the area to be colonized by wildlife.

## 10.2 Soil, Vegetation and Habitat Objectives

The objectives of the closure activities include:

- Creation of topographical differences within economic and regulatory constraints,
- Utilization of native trees, shrubs and grasses, and
- Provision of appropriate erosion control through primarily shallow rooted and fast growing plant species

## 10.3 Landscaping Plan

Based on the basic closure design principles of the project, namely environmental protection, compliance with regulatory requirements and flexibility of closure plan, the following objectives were established in designing the overall landscaping plan:

Objectives:

- To create a protective layer for the final cover system,
- To provide and enhance wildlife habitat,
- To provide erosion control protection for the final cover system.
- To create a planting structure or framework that would be applicable and flexible for at least two end use options.

In general, the successful establishment of a plant community is largely based on the soil characteristics at the site. By providing the appropriate soil conditions for a specific plant community, the likelihood of successful establishment increases significantly.

## 10.4 Soil Quality and Quantity

The soil placed over the barrier layer serves three main functions. It provides a structural media to support the above ground portion of established plants, water holding capacity to store and supply moisture in periods of drought, and essential plant nutrients for optimum growth. To an extent these factors are inter-related.

The depth and structure of the soil is important as a structural media for plant growth. Without sufficient rooting depth, taller plant species, or species with a larger wind sail can wind-throw, resulting in a loss of vegetation and increased erosion. The organic matter concentration and soil texture are important in water storage and release. These same characteristics are important in the adsorption and release of nutrients to growing plants. There must also be a readily available and cycling supply of nutrients for the soil exchange complexes to adsorb and release these nutrients to plants.

The quality of the soil used in closure activities is the "ecosystem capital" on which the subsequent plant communities develop. Without sufficient soil depth and appropriate soil physical, chemical and biological characteristics the vegetation community will not be sustainable, and will require increased maintenance through repeated seeding and nutrient additions.

Plants allocate photosynthate to balance the requirements for water, nutrients and light. In restored ecosystems with insufficient water storage or a lack of nutrients, plant resources are directed below ground, extending roots down to obtain water and laterally to acquire nutrients. If provided with a sufficient soil water and nutrient reserve, there is a balance between above and below ground plant growth. The prevention of barrier layer penetration by roots is important in the establishment of vegetation on a closed landfill. Appropriate soil quality and quantity will ensure the establishment of a sustainable community of vegetation without any adverse risk to the landfill cover integrity.

In the closure of many landfills the growing media placed as final cover is fabricated – allowing a design to meet certain soil specifications. Depending on the availability of growing media, existing soils can be amended with different materials or a soil can be created *de novo*. Municipal biosolids, pulp mill sludges, woodwaste, ash, compost, animal manures, greenwaste, fish morts, food processing wastes, sand and mine tailings have all been used in the fabrication of productive growth media to exacting specifications.

The proposed landfill closure plan proposes to use a fabricated top soil produced from locally stockpiled materials including wood chips, yard and garden waste and sand to provide a uniform coverage of at least 300 mm (up to 600 mm) depth over the site. The quality of this soil has not been determined. In conjunction with final closure activities this soil should be analyzed for standard soil physical and chemical parameters. Typically, stockpiled or imported soil requires some form of amendment – either inorganic or chemical fertilizer additions or organic soil amendments to provide for an optimum growing media. A preliminary investigation into soil quality may reveal an opportunity to use local organic "wastes" as soil amendments, recycling these materials and assisting in the development of a soil that will sustain a diverse community of plants.

## 10.5 Climate and Plant Establishment

The relatively thin veneer of final cover soil (minimum 300 mm) proposed is not a sufficient depth for the establishment of trees on the landfill. An increased soil depth would be required to provide sufficient water holding capacity for trees. A 300 mm subsoil layer has been proposed in the closure plan, which will serve this purpose to some extent. If tap-rooted species such as pine are to be planted, a 1500 mm thick subsoil layer is recommended. A 300 mm soil depth is adequate for the establishment of a community of grasses. With an appropriate seed mixture and application rate, the germination and establishment of grasses should be rapid, resulting in the establishment of a dense community of grasses and legumes. Once established, this community of grasses should suppress the survival of tree seedlings germinating from the seedbank or from neighbouring trees through competition for light.

Species selected for the vegetative community that will be established on the landfill should possess an extensive fibrous root system, which will assist with soil stability. The aboveground portions of the plants should facilitate water interception and mitigate the erosive action of precipitation directly on the soil surface. Vegetation without a large standing dry biomass during the summer moisture deficit period will minimize fuel loading for accidental ignition and minimize the chance of fire.

Soil nutrient and/or amendment requirements should be assessed through a soil test, and, if chemical additions are required these should be completed after the soil placement is complete. In the absence of a soil test, between 300 to 400 kg ha$^{-1}$ of a balanced starter fertilizer (6-24-24) should be applied and harrowed (or raked) to incorporate the fertilizer. A recommended seed mix for the landfill is:

**Table 10-1. Suggested Species of Grass**

| Species | % by weight |
|---|---|
| Kentucky bluegrass | 15% |
| Hard fescue | 15% |
| Creeping red fescue | 30% |
| Annual rye grass | 10% |
| Perennial rye grass | 10% |
| White clover | 20% |

If knapweed is a concern, a portion of the creeping red fescue should be replaced with orchard grass. The seed mixture should be applied after fertilization and in the early spring, just after the snow is gone, or if this is not possible in late fall before permanent snowfall. The legumes (clover) should be inoculated. The suggested seeding rate is 35 to 40 kg ha$^{-1}$. It is assumed that the site will not be irrigated. Under irrigation a different seed mixture would be recommended. It is not recommended that the newly seeded community be irrigated to enhance germination and survival. Artificial conditions of increased moisture can result in inadequate root growth required for long-term erosion prevention and sustainability.

## 10.6 Organic Residuals in Fabricated Soils – Case Studies

Two case studies provide the background and regional experience for the use of organic residuals in the fabrication of growing media in reclamation and landfill closure.

The first case study presents Construction Aggregates Limited – Sechelt Mine, an aggregate mine on BC's Sunshine Coast. In an innovative approach to attain successful reclamation the mine partnered with the local pulp and paper mill and local municipalities to develop a regional organic residuals mine reclamation program. Sludge and lime mud from the mill and municipal biosolids are being used at the mine site in the fabrication of soil products for use in reclamation. Ongoing environmental monitoring has shown environmental benefits without adverse environmental impacts.

In the second case study mill sludge and dry land sort debris were used in the fabrication of a soil amendment in the establishment of vegetation on Howe Sound Pulp and Paper Limited Partnership's closed ash landfill located in Port Mellon, BC. A self-sustaining community of vegetation supporting local wildlife now exists over the closed landfill.

### 10.6.1 Construction Aggregates Limited Fabricated Soil

Construction Aggregates Limited (CAL) Sechelt Mine is one of the largest aggregate mines in the world, covering over 400 ha (1,000 acres) and producing up to 6 million tonnes of high quality aggregate product per annum. Aggregate from this coastal mining operation is shipped by barge and freighter along the Pacific Rim, from San Francisco to Alaska. The mine is located on BC's Sunshine Coast.

In 1995, CAL was looking to improve their reclamation program and initiated a partnership with Howe Sound Pulp and Paper Limited Partnership (HSLP) and municipalities with the establishment of a series of demonstration plots using various application rates and mixtures of the paper mill sludge and biosolids. These demonstration plots, clearly visible to the community of Sechelt, allowed for the refinement of application rates and the ability to tailor these mixtures to the specific site characteristics. Based on the success of the research and demonstration plots, CAL and HSLP have continued with a large-scale operational organic reclamation program that uses mill sludge, lime mud and biosolids in reclamation.

HSLP combined primary and secondary sludge is typically dewatered to approximately 25% solids and transported by truck to CAL for land application. The nitrogen content is approximately 2%. All but one of the trace elements is present in low concentrations and often below those of background soils. The exception is zinc, which is an additive often required in the treatment process to remedy hydrogen sulfide production. The sludge is sampled throughout transport and use to monitor quality. The sludge is mixed with sand and/or lime mud, aggregate wash fines or wood waste to produce "CAL Reclamation Mix" (Mix). Mix ratios are determined using a model that optimizes the ratios to obtain target fertility, organic matter and texture. The Mix is used on areas of the mine devoid of vegetation and when a one-time application is required. The Mix is fabricated using an ALLU bucket or equivalent mixing technology. The mixture is applied and contoured over the site using standard mine equipment. Incorporation of the reclamation mix is not completed on slopes, but is practiced on the top of berms and settling ponds.

The Mix application rate is calculated for each specific reclamation area. In many applications, the Mix is the soil in which the plants were seeded or planted. The development of a plant community, and subsequent leaf litter and root turnover, initiate ongoing nutrient cycling. Fast growing pioneer plant species are often established to facilitate nutrient cycling and pedogenic processes. Soil and foliage samples collected following application ensure that the reclamation objectives have been attained. The developing soil may require subsequent fertilization with either municipal biosolids or inorganic fertilizers to maintain soil productivity. Photographs of *Populus spp*. trees established in an operational reclamation area are shown in Photo 9-1.

**Photo 9-1: Poplar trees established in fabricated soil**

### 10.6.2 Howe Sound Pulp and Paper Landfill Closure Growing Media

HSLP is a pulp and paper mill located in Port Mellon, on the Sunshine Coast. HSLP typically produces 1,000 metric tons day of bleached Kraft pulp and 550 metric tons a day of newsprint. As part of its ongoing operations, HSLP closed an old landfill. In combination with closure operations there was a need to improve the visual quality and restore a self-sustaining community of vegetation on the covered landfill. HSLP pursued the use of pulp sludge to form a growing media on the top of the closed landfill. A thin mantle of sand placed on the geomembrane (for protection) was not conducive to the incorporation of pulp sludge, nor would it support a sustainable community of vegetation. The use of pulp sludge alone as a growing media would supply excess nutrients. The opportunity of using mill TMP rejects as a carbon source was evaluated – mixing the high nitrogen sludge with the high carbon TMP rejects to fabricate a soil amendment that would regulate the supply of nutrients and increase the organic matter content. An appropriate mix ratio was determined, and authorization for the project sought from the British Columbia Ministry of Water, Land and Air Protection (now Ministry of Environment).

## 10.7 Enhancing Wildlife Habitat

Further wildlife habitat enhancement treatments could include: placement of coarse woody debris and snags, standing deadwood, rock piles, and nest boxes for cavity nesters. Within each broad category, further biodiversity could occur by varying microclimatic conditions such as soil depth, topography, available coarse woody debris, rock groupings and plant species.

# 11. MATERIALS MANAGEMENT

## 11.1 Material Availability

The materials onsite include a variety of waste materials, recyclable construction materials, and clean fill. In total approximately 68,350 m$^3$ or 83,770 tonnes of material are available on site as shown on Figure 2-2 and presented in Tables 11-1 and 11-2. The PRRD envisions utilizing most of the materials on-site. If some of the materials cannot be utilized on site, they will be either recycled or relocated. The following two scenarios describe PRRD's material utilization and management plan:

**Scenario 1**: Involves reusing everything on-site except asbestos waste

**Scenario 2**: Involves relocating woodchips, stumps and asbestos to Catalyst Paper and recycling the glass and tires.

Under Scenario 1, as presented in Table 11-1, in total, an estimated 150 m$^3$ or 240 tonnes of asbestos material will need to be relocated to Catalyst Paper Landfill. A total of 6,300 m$^3$ or 3,120 tonnes of roofing material and gyproc will be recycled at an off-site recycle facility located in Powell River. The remaining 61,900 m$^3$ or 80,410 tonnes of various materials, as presented in Table 11-1, will be reused at the site. Out of the remaining 61,900 m$^3$of materials, a total of 38,000 m$^3$ or 55,100 tonnes is ash that will be risk managed on site with an engineered capping system within the existing stockpile and as foundation fill for the transfer bay area/ holding cell. The remaining 23,900 m$^3$ or 25,310 tonnes will be reused in the construction of the Recycling Centre and Resource Recovery Park development or in the proposed composting facility.

Under Scenario 2, as presented in Table 11-2, an estimated 10,000 m$^3$ or 6,300 tonnes of wood chips and stumps as well as an estimated 150 m$^3$ or 240 tonnes of asbestos material will need to be relocated to Catalyst Paper Landfill. A total of 6,300 m$^3$ or 3,120 tonnes of roofing material and gyproc as well as 2,100 m$^3$ or 1,020 tonnes of glass and tires will be recycled at an off-site recycle facility. The remaining material to be for reused on site is 49,800 m$^3$ or 73,090 tonnes.

## 11.2 Material Requirements

The materials required for building the proposed cover system are topsoil, asphalt for pavement, gravel for gravel pad, road base and sub-base and drainage layer, sand for cushioning and gravel/rock for erosion control as riprap. The cover system includes a 300mm layer of top soil and a 200mm drainage layer and 150 mm sand cushion on landfill area and 100 mm asphalt with 700 mm base and sub-base gravel pad and 150 mm sand cushion on transfer bay area. Table 11-3 shows a material break-down for the proposed uses.

**Table 11-3 – Landfill Material Requirements**

| Area of Use | Purpose of Use | Area ($m^2$) | Topsoil ($m^3$) | Gravel ($m^3$) | Sand ($m^3$) | Asphalt ($m^3$) | Riprap ($m^3$) |
|---|---|---|---|---|---|---|---|
| Landfill Crest | Cover System | 3,199 | 960 | 640 | 480 | - | - |
| Landfill Slope | Cover System | 5,901 | 1,770 | 1,180 | 885 | - | - |
| Transfer Bay Area Crest | Cover System | 3,361 | - | 2,353 | 504 | 336 | - |
| Transfer Bay Area Slope | Cover System | 3,000 | 900 | 600 | 450 | - | - |
| Surace Water Ditch | Surface Water Management | 425 | - | - | - | - | 128 |
| Pond Bed | Surface Water Management | 228 | 68 | - | - | - | - |
| Pond Slope | Surface Water Management | 624 | 94 | 187 | - | - | - |
| Acess and Internal Roads | Road Base and Subbase | 3,820 | - | 1,910 | - | 382 | - |
| Recycle Area | Paving | 500 | - | 250 | 75 | - | - |
| Total | | **21,058** | **3,792** | **7,120** | **2,394** | **718** | **128** |

A large portion of these materials may be manufactured onsite. The topsoil will be fabricated with wood chips and clean fill from onsite along with imported biosolids. Since the yard waste on site appeared to be largely composed of soil, it will be considered as clean fill in the fabrication of topsoil. The stumps and logs onsite could also be processed to potentially generate more wood chips.

If not overly contaminated, the glass may be processed into a suitable drainage material for placing over the geomembrane layer. Tire chips will be used as bedding for any foundation. Tire chips may also be used for the drainage layer.

Concrete available on site can be used as road sub base and road base. This will require that rebar is removed and concrete is crushed down to desired gradation.

The broken asphalt can be crushed to produce a suitable road base material for storage pads that will perform in the same fashion as pavement grindings. This material is suitable for surfacing of light use storage areas and roads that do not receive a lot of traffic. Main transfer station areas should be paved and tipping areas should utilize concrete pads.

Total asphalt available on site is 2,100 $m^3$. A total of 720 $m^3$ will be used in the recycling centre and resource recovery park area. The rest of the asphalt will be potentially used in the access road construction for the botanical garden area.

## 11.3 Material Balance

With an estimated 8,000$m^3$ of wood chips on site, it is possible to manufacture about 24,000$m^3$ of topsoil, provided there is an ample supply of biosolids. The topsoil/biocover can also be applied on the botanical garden area for bioremediation. The use of engineered biocover systems to reduce fugitive methane ($CH_4$) emissions from landfills is an emerging greenhouse gas (GHG) mitigation technology. Biocovers, fabricated using organic residuals such as biosolids and compost, can have ideal physicochemical properties that stimulate the growth of methanotrophic bacteria that consume $CH_4$ and produce carbon dioxide, a less potent GHG. Biocovers can reduce the emissions of nitrous oxide ($N_2O$) through nitrification and nutrient assimilation in contrast to denitrification. Globally, $N_2O$ is an important GHG, with a 100-year time horizon global warming potential of 310 times that of carbon dioxide. The Botanical Garden Society of PR will have an opportunity to conduct research in the designated area with fabricated biocover. The woodchips can also be used for composting. The 2,000 $m^3$ of stumps can also be ground and used for composting. Any clean fill needed to be used for fabrication may be excavated onsite.

The total amount of top soil to be produced will exceed capping requirements. The surplus will be utilized to establish a thick organic growing medium layer in the botanical garden area.

It is assumed in the analysis that topsoil will be sourced from on-site materials. A total of 1,000 $m^3$ of concrete will be used either on the gravel pad or road construction or as riprap.

The total 2,000 $m^3$ of glass available can be used in the drainage layer that requires 2,420 $m^3$ of gravel. The remaining gravel need to be sourced from off-site or from the nearby gravel quarry.

**Table 11-1 : Utilization Plan for On-site Materials- Scenario 1**

| WASTE TYPE | PILE | APPROXIMATE TOTAL QUANTITY (m³) | FIGURE COLOUR LEGEND | RELOCATED | RECYCLED | REUSED | UNIT WEIGHT (tonnes/m$^3$) | WEIGHT (tonnes) | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| ASH | F | 20,000 | 🟫 | | | X | 1.45 | 29,000 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| | D | 7,200 | 🟫 | | | X | 1.45 | 10,440 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| | M | 800 | 🟫 | | | X | 1.45 | 1,160 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| | Q | 10,000 | 🟫 | | | X | 1.45 | 14,500 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| GLASS | E | 2,000 | 🟦 | | | X | 0.48 | 960 | Reused in Drainage Layer |
| TIRES | B | 100 | 🟪 | | | X | 0.60 | 60 | Reused in an Innovative Way |
| ROOFING | A | 1,800 | 🟥 | | X | | 0.40 | 720 | Recycled |
| | G | 1,500 | 🟥 | | X | | 0.40 | 600 | Recycled |
| GYPROC | H | 3,000 | 🟦 | | X | | 0.60 | 1,800 | Recycled |
| ASPHALT | L | 1,500 | 🟥 | | | X | 2.30 | 3,450 | To be Reused in the Road Pavement |
| | I | 500 | 🟥 | | | X | 2.30 | 1,150 | To be Reused in the Road Pavement |
| | T | 100 | 🟥 | | | X | 2.30 | 230 | To be Reused in the Road Pavement |
| WOOD CHIPS | J | 8,000 | 🟫 | | | X | 0.63 | 5,040 | Reused for Composting |
| STUMPS | K | 2,000 | 🟧 | | | X | 0.63 | 1,260 | Reused for Composting |
| YARD WASTE | N | 1,000 | 🟩 | | | X | 1.80 | 1,800 | Reused for Composting |
| | O | 200 | 🟩 | | | X | 1.80 | 360 | Reused for Composting |
| CONCRETE | P | 1,000 | ⬜ | | | X | 2.50 | 2,500 | Reused in Road Construction, Base or Sub-base Layer or for Erosion Control |
| DEMO | C | 2,500 | 🟩 | | | X | 0.80 | 2,000 | Relocated to the Landfill for Regrading |
| CLEAN FILL | R | 2,000 | 🟨 | | | X | 1.30 | 2,600 | Reused for regrading |
| | S | 3,000 | 🟨 | | | X | 1.30 | 3,900 | Reused for regrading |
| ASBESTOS | U | 150 | ▨ | X | | | 1.60 | 240 | Relocated to Catalyst Paper |
| **Total** | | **68,350** | | | | | | **83,770** | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Scenario 1** | Note : | To be relocated | 150 | m$^3$ | or | 0.2% | 240 | tonnes |
| | | To be recycled | 6,300 | m$^3$ | or | 9% | 3,120 | tonnes |
| | | To be Reused | 61,900 | m$^3$ | or | 91% | 80,410 | tonnes |
| | | **Total** | **68,350** | | | | **83,770** | tonnes |

Note: **Scenario 1** involves reusing everything on-site except asbestos, while **Scenario 2** involves relocating woodchips, stumps and asbestos to Catalyst Paper and Recycling Glass and Tires

**Table 11-2 : Utilization Plan for On-site Materials- Scenario 2**

| WASTE TYPE | PILE | APPROXIMATE TOTAL QUANTITY (m³) | FIGURE COLOUR LEGEND | RELOCATED | RECYCLED | REUSED | UNIT WEIGHT (tonnes/m$^3$) | WEIGHT (tonnes) | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| ASH | F | 20,000 | 🟫 | | | X | 1.45 | 29,000 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| | D | 7,200 | 🟫 | | | X | 1.45 | 10,440 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| | M | 800 | 🟫 | | | X | 1.45 | 1,160 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| | Q | 10,000 | 🟫 | | | X | 1.45 | 14,500 | Reused and Sealed Under Landfill or Recycle Centre Pavement |
| GLASS | E | 2,000 | 🟦 | | X | | 0.48 | 960 | Recycled |
| TIRES | B | 100 | 🟪 | | X | | 0.60 | 60 | Recycled |
| ROOFING | A | 1,800 | 🟥 | | X | | 0.40 | 720 | Recycled |
| | G | 1,500 | 🟥 | | X | | 0.40 | 600 | Recycled |
| GYPROC | H | 3,000 | 🟦 | | X | | 0.60 | 1,800 | Recycled |
| ASPHALT | L | 1,500 | 🟥 | | | X | 2.30 | 3,450 | To be Reused in the Road Pavement |
| | I | 500 | 🟥 | | | X | 2.30 | 1,150 | To be Reused in the Road Pavement |
| | T | 100 | 🟥 | | | X | 2.30 | 230 | To be Reused in the Road Pavement |
| WOOD CHIPS | J | 8,000 | 🟫 | | | X | 0.63 | 5,040 | Relocated to Catalyst Paper |
| STUMPS | K | 2,000 | 🟧 | | | X | 0.63 | 1,260 | Relocated to Catalyst Paper |
| YARD WASTE | N | 1,000 | 🟩 | | | X | 1.80 | 1,800 | Reused for Composting |
| | O | 200 | 🟩 | | | X | 1.80 | 360 | Reused for Composting |
| CONCRETE | P | 1,000 | ⬜ | | | X | 2.50 | 2,500 | Reused in Road Construction, Base or Sub-base Layer or for Erosion Control |
| DEMO | C | 2,500 | 🟩 | | | X | 0.80 | 2,000 | Relocated to the Landfill for Regrading |
| CLEAN FILL | R | 2,000 | 🟨 | | | X | 1.30 | 2,600 | Reused for regrading |
| | S | 3,000 | 🟨 | | | X | 1.30 | 3,900 | Reused for regrading |
| ASBESTOS | U | 150 | ⬜ | X | | | 1.60 | 240 | Relocated to Catalyst Paper |
| **Total** | | **68,350** | | | | | | **83,770** | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Scenario 2** | To be relocated | 10,150 | m$^3$ | or | 15% | 6,540 | tonnes |
| | To be recycled | 8,400 | m$^3$ | or | 12% | 4,140 | tonnes |
| | To be Reused | 49,800 | m$^3$ | or | 73% | 73,090 | tonnes |
| | **Total** | **68,350** | | | | **83,770** | tonnes |

Note: Scenario 1 involves reusing everything on-site except asbestos, while **Scenario 2** involves relocating woodchips, stumps and asbestos to Catalyst Paper and Recycling Glass and Tires

# 12. POST CLOSURE MONITORING PROGRAM

## 12.1 Regulatory Requirements

Post closure monitoring is required after the final closure system has been constructed. Key closure monitoring requirements are presented below.

- A closure plan must be submitted detailing all elements of closure. The plan shall be prepared at least six months prior to the closure of the landfill.
- A plan must be prepared for the operation of any required pollution abatement engineering works such as landfill gas collection/treatment systems for a minimum post-closure period of 25 years (30 years as per updated draft criteria).
- The post closure care period may be extended up to 1000 years as per draft updated criteria based upon the risk of continued environmental impact and contaminating lifespan.
- No structures shall be constructed on the landfill during the 25-year (30 years as per updated draft criteria) post closure period unless a qualified professional addresses landfill gas and settlement issues and approval is given by the MoE.

## 12.2 Post Closure Groundwater Monitoring

The site is currently relying on natural attenuation for leachate treatment. Since no leachate is collected and/or treated at the site, no leachate monitoring is required at this time. To address the possibility that leachate may enter the environment for reasons unforeseen, SHA recommends the ongoing monitoring of three existing groundwater wells MW13-01, MW13-02 and MW-13-03, according to MoE post-closure requirements (See also Figure 12-1 and Table 12-1).

The groundwater monitoring program should include:

- A field reading of the pH, conductivity, temperature and dissolved oxygen.
- The collection of representative samples. Samples will be collected in parameter specific bottles, preserved, and kept on ice.
- The submission of samples for laboratory analysis as soon as feasible after collection. Sampling parameters are presented in Table 12-1.
- The collection and submission of at least one randomly selected duplicate sample every sampling event as a quality control/quality assurance measure, in order to check analytical reliability. A full discussion of QA/QC is presented in this Chapter.

**Table 12-1 Suggested Groundwater Monitoring Regime**

| **Sampling Parameters** | **Frequency** | **Comments** |
|---|---|---|
| Field Measurements | Quarterly | pH, Conductivity, Temperature, Dissolved oxygen |
| Cation and Anion Scan | Quarterly | Ammonia, Chloride, Sulphate, Sulphide, Nitrate, Nitrite |
| Hardness ($CaCO_3$) | Quarterly | |
| Metal Scan | Semi-Annually | Dissolved metals |
| Organic Parameters | Semi-Annually | COD, BOD, Acidity (pH 8.3), TSS |
| Hydrocarbons | Annually | PAH, VH and EPH |
| Other | Annually | Total Phenols, Resin Acids |
| Duplicates | | One duplicate sample should be collected at each sampling event per QA/QC program. |
| **Reporting** | Annual | An annual report should be prepared detailing collected data. |

The analytical results for each of the sampling parameters from the monitoring locations for groundwater should be compared to historic data to assess if there are any changes in the water quality over time.

The analytical results of groundwater should be interpreted using the most suitable water quality criteria. At present, these are the *"British Columbia Approved Water Quality Guidelines Criteria (BCAWQGC): 2006 Edition"* (updated August, 2006), for the protection of aquatic life (AW) and drinking water quality (DW) as per the BC Landfill Criteria for Municipal Solid Waste, 1993.

A mitigation program should be implemented should the groundwater quality results indicate that the proposed leachate management system (currently natural attenuation and later either treating on site or transporting to the WWTP) is not capable of controlling off site migration of landfill leachate, or that surface water impacts are detected.

Water quality improvements are expected once landfill closure is complete and stormwater is managed in accordance with this plan. The need for a biological risk assessment should be evaluated in the post-closure monitoring phase.

The groundwater monitoring frequency and selected parameters should be reviewed and revised after three years of data has been collected, subject to Ministry approval, based on the interpretation of the analytical data and developing trends.

Monitoring program documentation should be prepared and should include site maps with the exact position and GPS coordinates for each location, and history of each sampling location. The monitoring locations should be well marked in the field with high posts to aid in identification and to prevent accidental damage.

## 12.3 Post Closure Surface Water Monitoring

An on-site surface water quality monitoring program is required to confirm that the landfill is not impacting on water quality of runoff from the site. Recommended surface water monitoring locations are shown on Figure 12-1. SHA recommends continuing to sample from the three established locations SW-1, SW-2, and SW-3, in addition to a new proposed location SW-4 located near the outlet of the future retention pond (Figure 12-1). The sample parameters are indicted in Table 12-2, they are the same as for groundwater in Table 12-1, except that metals should be tested for total rather than dissolved concentrations.

**Table 12-2 Suggested Surface Water Monitoring Regime**

| **Sampling Parameters** | **Frequency** | **Comments** |
|---|---|---|
| Field Measurements | Quarterly | pH, Conductivity, Temperature, Dissolved oxygen |
| Cation and Anion Scan | Quarterly | Ammonia, Chloride, Sulphate, Sulphide, Nitrate, Nitrite |
| Hardness ($CaCO_3$) | Quarterly | |
| Metal Scan | Semi-Annually | Total metals |
| Organic Parameters | Semi-Annually | COD, BOD, Acidity (pH 8.3), TSS |
| Hydrocarbons | Annually | PAH, VH and EPH |
| Other | Annually | Total Phenols, Resin Acids |
| Duplicates | | One duplicate sample should be collected at each sampling event per QA/QC program. |
| **Reporting** | Annual | An annual report should be prepared detailing collected data. |

## 12.4 Quality Assurance/Quality Control Program

SHA recommends that a quality assurance/quality control (QA/QC) program be implemented by the client as part of the monitoring program. A QA/QC program is a system of procedures, checks, audits and corrective actions that will assist in ensuring that the data generated at the laboratory is of the highest achievable quality. This is of prime importance, as the monitoring data will form the basis for all of the conclusions regarding the impact of the landfill on the surrounding environment. As a first step in the QA/QC program, we recommend that all samples be submitted to an analytical laboratory that is certified by the Canadian Association of Environmental Laboratories.

The primary purpose of the QA/QC program is not to check up on the environmental laboratory conducting the analyses, but to demonstrate the reproducibility of the analytical data.

Reproducibility demonstrates that the data is of high quality and that, in turn, the conclusions drawn from the data have an associated high level of confidence.

There are two main types of laboratory QA/QC samples – internal and external. Internal QA/QC refers to the routine procedures that laboratories perform, on a daily or a "batch" basis, in order to ensure that nothing inside the laboratory is influencing the analytical results. External QA/QC refers to blind QC samples submitted to the laboratory to determine whether the sampling methodology contaminated the samples, to determine the laboratory analytical precision and accuracy and to assess sampling variability.

### 12.1.1 Internal QA/QC

As discussed, internal QA/QC consists of routine checks and procedures that are undertaken by the laboratory on a daily or batch basis. Internal QC includes (but is not limited to):

- Standard methods for cleaning sample bottles, utensils and analytical equipment;
- Storage, handling and quality of internal QC samples;
- Sample storage procedures;
- Sample documentation (e.g. analytical technician, analytical technique, control charts and other information);
- Storage, handling and quality of cleaning agents, reagents, acids, distilled or deionized water;
- QA/QC training for and certification of staff.

Laboratories that are certified by the Canadian Association of Environmental Laboratories also undergo a bi-annual audit to ensure that the standard operating procedures meet the minimum standards and that all the technical staff is certified.

### 12.1.2 External QA/QC

External QA/QC involves submitting blind QC samples as part of a sampling suite. The blind samples usually consist of a combination of blank, duplicate, reference and spike samples. Each type of external QC sample is discussed below.

**Blank Samples**

Blank samples are used to determine whether any systematic sampling contamination is affecting the samples. Blanks typically consist of commercially available de-ionized or distilled water that is taken with the field staff during a sampling event. The blanks are treated identically to all other samples, by being poured into a sample bottle, by undergoing any routine filtration or acidification in the field and by being submitted to the laboratory as a discrete sample.

**Field Duplicates**
Duplicate samples are used to determine the analytical precision of the laboratory and to assess sample variability. Field duplicates, as their name implies, are two samples collected from the same sampling point. The sample is duplicated by either collecting the samples sequentially, or by collecting one large sample, which is subsequently split into two sub-samples. The samples are submitted separately.

**Reference Samples**
Reference samples are used to determine a laboratory's analytical accuracy. Reference samples are commercially available samples with a known composition. These samples are submitted to the laboratory and the results checked against the "ingredient list" once analysis is complete.

**Spike Samples**
Spike samples, like reference samples, are used to determine the analytical accuracy of a laboratory. They differ from reference samples by containing only one or two dissolved parameters of known concentration, rather than a full suite of parameters. Spiked samples are typically used for VOCs, hydrocarbons or other organic parameters, as opposed to inorganic parameters.

QA/QC samples typically constitute 10-20% of each sampling suite submitted to a laboratory. For example, a suite of twenty samples may contain seventeen "real" samples, one duplicate, one blank and one reference. The duplicate, blank and reference samples are submitted under "dummy" numbers that match the rest of the sampling suite. The duplicate sample should be collected from a different, randomly chosen location during each monitoring event.

### 12.1.3 Data Acceptance Criteria

As part of the QA/QC program, data acceptance criteria are used to assess whether the analytical results being generated by the laboratory are within acceptable bounds. Data that falls outside the acceptable bounds will require further assessment in order to determine the reasons behind the data variability. Table 11-2 lists typical acceptance criteria for the main parameter of interest in groundwater and surface water samples.

**Table 12-3. Data Acceptance Criteria**

| Parameter | Blank | Duplicate | Reference/Spike |
|---|---|---|---|
| Inorganic | No positive detection | 25% Variance allowed. | < 3 standard deviations |
| VOC's | No positive detection | 30% Variance allowed | 30% Variance allowed |
| PAH | No positive detection | 30% Variance allowed | 30% Variance allowed |

A common method of identifying data that are outside acceptable limits is through "flagging". Flagging can be performed electronically by comparing the data that is returned by the analytical laboratory to the data acceptance criteria. Flagged data should be brought to the attention of laboratory staff for clarification.

We recommend the following QA/QC program be adopted:

- One duplicate surface water sample should be collected per sampling event.
- The data acceptance criteria in Table 12-3 should be adopted.

## 12.5 QA/QC Protocols

A rigorous QA/QC- protocol should be developed by the consultant doing the sampling. The protocol should be reviewed by the consultant that will prepare the annual report, and by the MoE, before commencing the monitoring program. The QA/QC protocol should include the procedures for: sampling, calibration of field instruments, chain of custody reports and the use of blank, reference and duplicate samples. The protocol should also specify the QA/QC procedures that the selected laboratory will use.

## 12.6 Landfill Gas Monitoring

Landfill gas sampling should be carried out initially at least bi-annually and if dictated by levels climbing above limits monthly for $CH_4$, $CO_2$, NMOC, $H_2S$, $N_2$, $H_2$, $O_2$ and CO (ppm), as well as LEL (%), as per the B.C. MoE. *Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills* and the *Landfill Criteria for Municipal Solid Waste*. This program should be based on bar-hole punch probe gas monitoring along the property boundary, at an interval of approximately 50 m between two measurement points. The bar punch hole gas monitoring should initially be done on a bi-annual basis to monitor the gas migration potential from the landfill. However, once the initial monitoring results show the compliance with the MoE gas composition limits at the property line, the frequency of such monitoring may be reduced after reviewing the monitoring results with the MOE.

If methane concentrations exceed the recommended performance criteria (100% of the Lower Explosive Limit (LEL)) at property boundaries and/or 25% LEL in on-site structures), then a more detailed assessment of landfill gas migration with monthly readings should be conducted to determine if any corrective actions are necessary. The contingency plan for this includes adding perimeter venting at the landfill toe, and possibly upgrading the passive LFG venting system to an active system, or some other form of LFG control.

The program should also include semi-annual monitoring of near-surface LFG emissions for methane, carbon monoxide, and hydrogen sulphide.

## 12.7 Annual Inspection

SHA recommends one dry weather and one wet weather inspection be conducted every year as per the requirements mentioned in Section 7.15 of the BC Landfill Criteria for MSW Landfills (1993), including a geotechnical inspection and a landfill survey by a specialist landfill consultancy. The wet weather geotechnical inspection should be conducted at the peak of the spring freshet and should include an assessment of the cover for potential problems arising from cracking, erosion (especially after heavy rains or during snow melt) or slumping and to determine the state of any infrastructure that does not receive regular inspection or maintenance. If significant geotechnical problems are discovered, then a qualified geotechnical engineer should be retained to mitigate the problems.

The dry weather inspection should include an inspection of the vegetation growth on the side slopes and detection of ditch clogging, blow-outs, sediment accumulation, leachate break-outs on side slopes and seeps.

## 12.8 Annual Report

According to Section 7.17 of the B.C. MoE Landfill Criteria, annual Operating and Monitoring Reports are to be submitted to the Regional Manager of the local Environmental Protection Division. Additionally, the MoE recommends that the monitoring and submission of the annual report follow the requirements laid out in the Ministry’s guideline document entitled “Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills”.

All of the monitoring data should be compiled annually into a comprehensive Annual Monitoring Report containing not only the most recent data, but also all available historical data. The annual review should be completed as a stand-alone document building on the available historical data. The data should be reviewed annually and interpreted by a qualified professional prior to its inclusion in the annual report. Monitoring data should be compared to relevant criteria, e.g. BC Water Quality Guidelines (BCWQG). The report should look at the current data on its own, as well as in a historical context. Annual reporting is a requirement of the Landfill Criteria and is also a useful way to ensure that all the necessary monitoring is being completed.

The minimum requirements for this report are:

- Services from a professional environmental consulting firm and an accredited laboratory;
- Leachate, water quality and landfill gas monitoring data and interpretation;
- Semi-annual inspection for settlement and slope stability;
- Any changes from approved reports, plans and specifications.
- Provide any mitigative action taken to address problems as they arise.

The Annual Report should be submitted by March 31st of every year.

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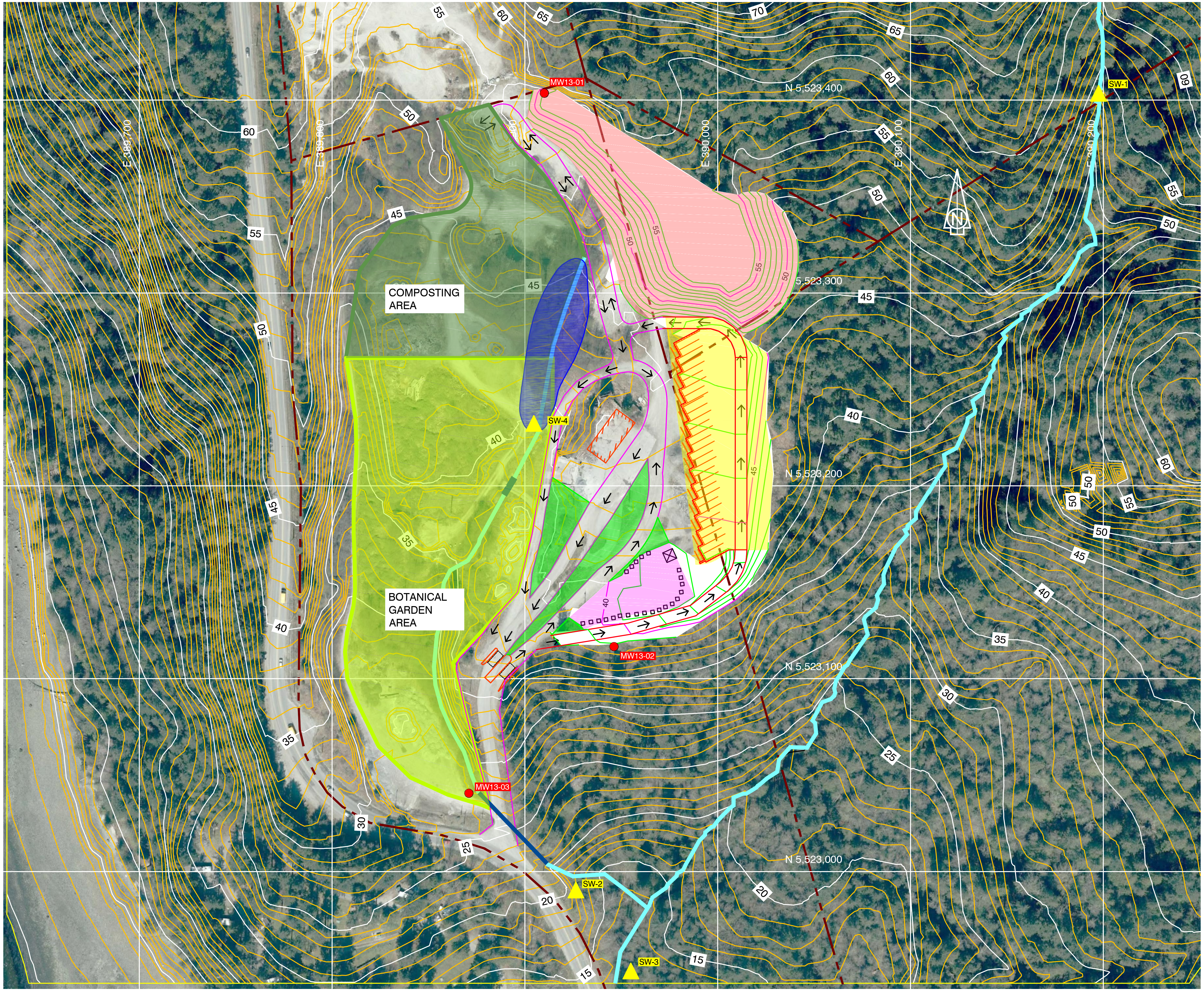

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LEGEND:

- ▬ 5m EXISTING CONTOUR
- — 1m EXISTING CONTOUR
- — 5m PROPOSED CONTOUR
- — 1m PROPOSED CONTOUR
- 🟨 TRANSFER BAY AREA
- —·— PROPERTY LINE
- 🟩 GREEN SPACE
- 🟥 LANDFILLED AREA
- ● GROUNDWATER MONITORING WELL
- ▲ SURFACE WATER MONITORING STATION
- — ROAD
- ← TRAFFIC FLOW DIRECTION
- ● MANHOLE
- □ RECYCLING AREA BIN
- 🟪 RECYCLING AREA
- ▨ EDUCATION CENTRE
- 🟦 RETENTION POND

CLIENT:
**POWELL RIVER REGIONAL DISTRICT**

PROJECT:
**POWELL RIVER MARINE AVENUE SITE CLOSURE PLAN**

TITLE:
**PROPOSED POST-CLOSURE MONITORING LOCATIONS**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| 1:2000 | 2014/08/12<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | AK | DRAWING NO: |
| DRAWN | NP | **FIGURE 12-1** |
| CHECKED | IB | |

# 13. ECONOMIC ANALYSIS

As described in Chapter 2 (Section 2.8.5) the following options were recommended by the MOE to be analyzed.

- Option 1: Recycle and haul away all the waste to the appropriate disposal places.
- Option 2: Excavate and haul all the waste to the Airport site and dispose there.
- Option 3: Ship waste to Ecowaste Landfill or Robanco.
- Option 4: Upcycle, Reuse, Recycle Materials on Site along with Proper Public Consultation

For context, SHA also investigated what it would cost to consolidate all of the materials on site and to risk manage them beneath engineered capping system. The costs of that solution are presented as Option 5.

## 13.1 Option 1- Recycle and haul away all the waste to the appropriate facilities

The regional Catalyst Paper Mill landfill was contacted with regards to relocating waste from the Marine Avenue Transfer Site as the closest landfill. Catalyst Paper has indicated they will only accept woodchips, log stumps and yard waste if they qualify for cogeneration, as well as asbestos waste. The usefulness of the wood and yard waste for cogeneration would depend on some physical parameters of the waste including moisture content and heating value. As discussed in Chapter 2.8.7, lab analyses of woodchips showed a moisture content ranging from 43.3% to 44.5% and heating values ranging from 5,282 kJ/kg to 7,110 kJ/kg. The lab analyses were conducted only on two samples. The compositions of waste in the woodchip and stump piles are widely variable. However, based on these results, SHA subsequently made contact with the Catalyst Paper Mill to determine if they would be interested in accepting these wastes and to determine the tipping fees. Catalyst Paper Mill has agreed to accept the waste subject to some additional tests which have not been completed as yet as they were outside the scope of the current landfill closure project.

SHA also tried to find any other landfill available in the region that would accept the majority of the waste. As mentioned in Chapter 2 and 6, the majority of the waste (56% by volume) consists of ash waste. Mike Wall from the PRRD also attempted to find such a landfill in the region but none was found.

## 13.2 Excavate and haul all the waste to the Airport site and dispose there

As discussed in Section 2.8.5, SHA believes that Option 2 is not a feasible option due to concerns about transferring a large volume of ash to the Airport site, thus doubling the amount of waste material that is already in place at that site. Given that groundwater from the Airport site reports to Myrtle Creek and considering there are a number of domestic water wells in the area, the Airport site is considered less suitable to risk manage the ash material that is stored at the Marine Avenue site then managing that material at the current location.

## 13.3 Option 3- Shipping to Rabanco

SHA evaluated the option of shipping all the waste to Rabanco Landfill in eastern Washington State as the PRRD is currently shipping their collected solid waste to that facility. The actual cost of shipping waste to Rabanco in Washington State varies depending on the exchange rate for the Canadian dollar. The current cost per tonne that the PRRD pays is approximately $80.31 CAD per tonne shipped from Surrey (based on a conservative exchange rate of $0.85U.S./$1Cdn), plus $56.87 per tonne in shipping from Powell River to Surrey. This represents a total cost of $137.18 per tonne. SHA has estimated that the total weight of the waste at the Marine Avenue site is 83,530 tonnes or 68,350 $m^3$ (Table 2-1). The total cost of relocating all of the waste from the Marine Avenue Site to Rabanco would be $11,458,645. In addition to that the PRRD would incur excavation and loading costs. Assuming costs of $5/$m^3$ for excavation and $8/$m^3$ for hauling loads to the terminal, these costs would add another $888,550. As such, a total of $12,347,195 would be required for this solution excluding the costs for upgrading the Site to a usable condition and excluding post closure monitoring costs. This solution is not considered affordable for the PRRD.

## 13.4 Option 4- Recycle, Reuse and Relocate Waste, including Landfill Closure

In Chapter 6, SHA presented a plan to recycle, reuse and relocate on site waste materials. This plan included consolidation of the ash into a small landfill and reconfiguration of the facility to convert it to an efficient recycling centre and resource recovery facility on the east half of the property and an attractive botanical garden and compost facility on the west half of the property. The estimated costs for closing the Site under this option following the design concept presented in Chapter 8 are priced out in Table 13-1 and Table 13-2.

Under this option, SHA estimated approximate costs of closure implementation at the Site and costs for recycling of some of the materials that can neither be landfilled nor be reused on-site for closure. The estimated post-closure expenses are also presented below. Cost estimates have been prepared for all capital costs, including engineering, material and soil supply, ditching, soil application, hydro seeding and maintenance, erosion control works as well as construction QA/QC. The unit costs are based on SHA’s experience in closure construction at numerous projects throughout B.C. As a leader in landfill closure design, SHA has completed more than thirty closure construction projects in the past 20 years. The quantity estimates detailed below are based on the average unit costs required during the actual construction works for the landfills in BC as well as on the industry average rates for similar types of works. Actual costs will vary and can be accurately determined during detailed design.

As this Design option includes relocation of asbestos and recycling of roofing materials and gyproc the costs for these items are discussed below:

SHA contacted with the Catalyst Paper Mill as they agreed to accept asbestos. A removal and disposal cost of $150/tonne of asbestos was considered. Thus, a total cost of $36,000 was estimated for asbestos removal and disposal.

For roofing material and gyproc recycling, $120/tonne was estimated for removal and disposal. Thus a total of $ 374,400 will be required for removal and disposal of 1,320 tonnes of roofing material and 1,800 tonnes of gyproc.

Table 13-1 presents the closure cost estimates that have been prepared for the landfill site, including materials, construction works and engineering services. A 15% construction contingency has been included at this stage, which will be reduced to 10% following detailed design.

In summary, the projected costs of site closure of the residual ash landfill and removal of the gyproc and asphalt roofing materials are as follows:

| | |
|---|---|
| • Site Preparation and Clean-up (including removal of materials) | $1,267,240 |
| • Construction of Final Cover on Ash Landfill | $ 399,300 |
| • Surface Water Management | $ 335,600 |
| • Landfill Gas Management (Passive) | $ 16,850 |
| • Engineering | $ 262,469 |
| • Contingency (15%) | $ 302,849 |
| • Total: | $2,584,307 |

Table 13-2 presents the projected costs of constructing a 15 bay transfer / recycling facility with a lock-block "Z" wall, concrete pads for bins and tipping areas and a paved traffic surface. The cost estimate includes the geomembrane environmental controls that will allow for the encapsulation of approximately 8,500 m3 of bottom ash as grading fill in the facility.

| | |
|---|---|
| • Site Preparation and Clean-up (including relocation of ash | $ 153,200 |
| • Construction of Closure System on Ash Holding Cell | $ 190,500 |
| • Surface Water Management | $ 56,280 |
| • Transfer Bay Construction | $ 930,800 |
| • Engineering | $ 187,983 |
| • Contingency (15%) | $ 165,867 |
| • Total: | $1,684,630 |

The Class "C" cost estimate for all of the works outlined in this Closure Plan totals $4,268,937, about 33% of the cost of moving all of the waste materials off-site.

The aforementioned costs include detailed design, construction QA/QC of the closure system and a 15% contingency. The costs for construction of a recycling facility, resource recovery facility, education centre, compost facility and any costs associated with the botanical garden development are not included in this Design option as they are additional costs and do not fall within the scope of the analysis for this report. Also, costs related to the decommissioning of the old incinerator have not been included. Materials from the old incinerator may be recyclable in the landfill closure construction, and any remaining material from decommissioning could be recycled.

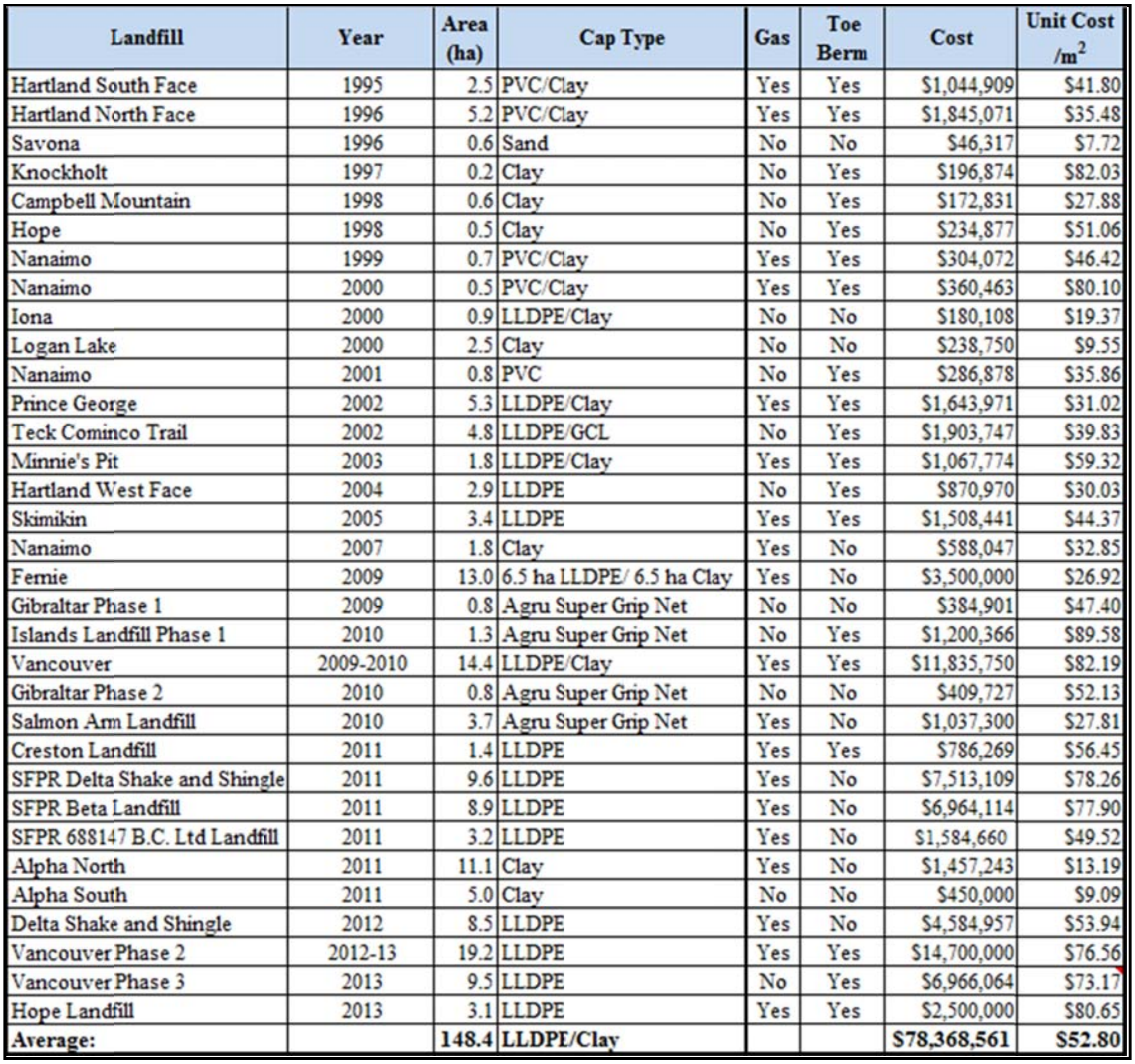
## 13.5 Typical Closure Costs in British Columbia

Table 13-3 shows a summary of capital costs for the closure of a number of landfills throughout British Columbia. SHA has been directly involved in the design, project management and inspection of each of these 28 projects. Starting on the left of the table and moving to the right are the landfill name, the year in which the project occurred, the approximate area of closure in hectares, indication of whether some type of gas collection or venting system was installed, whether a toe berm was installed, the total construction cost and the unit cost per square meter. The purpose of the table is to show the range of total and unit costs for closure and to compare the costs of the different types of capping systems.

The closures summarized in Table 13-3 span over a 20 year period, but do not take inflation of current construction costs into account. Therefore this table is included for reference purposes only. The average closure cost is approximately \$52.80/m$^2$. The total costs range from \$46,300 for a small closure construction at the Savona Landfill in 1996 to \$14.7 million a 19.2 hectare closure at the Vancouver Landfill in 2012-2013. Unit costs per square meter range from \$7.70/m$^2$ for Savona to \$82.19/m$^2$ for Vancouver Landfill. The cost of construction generally depends on the type of cap (membrane vs. clay only), gas collection or venting, and whether some type of toe berm is constructed. Generally, clay caps are less expensive than a membrane cap or a composite cap with a membrane and clay.

Note that the very low costs previously experienced by the TNRD at Logan Lake and Savona are not representative of true closure costs because these closures utilized on-site soils on very gently sloped landfills, and in the case of Savona Landfill, were based on an exemption from the landfill criteria.

**Table 13.3 Capital Costs of Landfill Closure in British Columbia**



| Landfill | Year | Area (ha) | Cap Type | Gas | Toe Berm | Cost | Unit Cost /m² |
|---|---|---|---|---|---|---|---|
| Hartland South Face | 1995 | 2.5 | PVC/Clay | Yes | Yes | $1,044,909 | $41.80 |
| Hartland North Face | 1996 | 5.2 | PVC/Clay | Yes | Yes | $1,845,071 | $35.48 |
| Savona | 1996 | 0.6 | Sand | No | No | $46,317 | $7.72 |
| Knockholt | 1997 | 0.2 | Clay | No | Yes | $196,874 | $82.03 |
| Campbell Mountain | 1998 | 0.6 | Clay | No | Yes | $172,831 | $27.88 |
| Hope | 1998 | 0.5 | Clay | No | Yes | $234,877 | $51.06 |
| Nanaimo | 1999 | 0.7 | PVC/Clay | Yes | Yes | $304,072 | $46.42 |
| Nanaimo | 2000 | 0.5 | PVC/Clay | Yes | Yes | $360,463 | $80.10 |
| Iona | 2000 | 0.9 | LLDPE/Clay | No | No | $180,108 | $19.37 |
| Logan Lake | 2000 | 2.5 | Clay | No | No | $238,750 | $9.55 |
| Nanaimo | 2001 | 0.8 | PVC | No | Yes | $286,878 | $35.86 |
| Prince George | 2002 | 5.3 | LLDPE/Clay | Yes | Yes | $1,643,971 | $31.02 |
| Teck Cominco Trail | 2002 | 4.8 | LLDPE/GCL | No | Yes | $1,903,747 | $39.83 |
| Minnie's Pit | 2003 | 1.8 | LLDPE/Clay | Yes | Yes | $1,067,774 | $59.32 |
| Hartland West Face | 2004 | 2.9 | LLDPE | No | Yes | $870,970 | $30.03 |
| Skimikin | 2005 | 3.4 | LLDPE | Yes | Yes | $1,508,441 | $44.37 |
| Nanaimo | 2007 | 1.8 | Clay | Yes | No | $588,047 | $32.85 |
| Fernie | 2009 | 13.0 | 6.5 ha LLDPE/ 6.5 ha Clay | Yes | No | $3,500,000 | $26.92 |
| Gibraltar Phase 1 | 2009 | 0.8 | Agru Super Grip Net | No | No | $384,901 | $47.40 |
| Islands Landfill Phase 1 | 2010 | 1.3 | Agru Super Grip Net | No | Yes | $1,200,366 | $89.58 |
| Vancouver | 2009-2010 | 14.4 | LLDPE/Clay | Yes | Yes | $11,835,750 | $82.19 |
| Gibraltar Phase 2 | 2010 | 0.8 | Agru Super Grip Net | No | No | $409,727 | $52.13 |
| Salmon Arm Landfill | 2010 | 3.7 | Agru Super Grip Net | Yes | No | $1,037,300 | $27.81 |
| Creston Landfill | 2011 | 1.4 | LLDPE | Yes | Yes | $786,269 | $56.45 |
| SFPR Delta Shake and Shingle | 2011 | 9.6 | LLDPE | Yes | No | $7,513,109 | $78.26 |
| SFPR Beta Landfill | 2011 | 8.9 | LLDPE | Yes | No | $6,964,114 | $77.90 |
| SFPR 688147 B.C. Ltd Landfill | 2011 | 3.2 | LLDPE | Yes | No | $1,584,660 | $49.52 |
| Alpha North | 2011 | 11.1 | Clay | Yes | No | $1,457,243 | $13.19 |
| Alpha South | 2011 | 5.0 | Clay | No | No | $450,000 | $9.09 |
| Delta Shake and Shingle | 2012 | 8.5 | LLDPE | Yes | No | $4,584,957 | $53.94 |
| Vancouver Phase 2 | 2012-13 | 19.2 | LLDPE | Yes | Yes | $14,700,000 | $76.56 |
| Vancouver Phase 3 | 2013 | 9.5 | LLDPE | No | Yes | $6,966,064 | $73.17 |
| Hope Landfill | 2013 | 3.1 | LLDPE | Yes | Yes | $2,500,000 | $80.65 |
| **Average:** | | **148.4** | **LLDPI/Clay** | | | **$78,368,561** | **$52.80** |

As currently developed, the various piles of waste and recyclables that are stored at the Marine Avenue waste management site occupy approximately 6.5 Ha of space. If the entire area were to be simply graded and capped over with an engineered cover system, the costs of closure would be in the range of $3.4 to $5.0 million and the land would be sterilized for future beneficial use. Clearly, the solution presented in Option 4, to consolidate the waste materials, to beneficially use all materials that can be recycled, and to establish a useful transfer station / recycling facility on the site together with a botanical garden and composting facility provides the best value.

## 13.6 Post Closure Costs

Estimated annual post closure costs for the Landfill are shown in Table 13-4 and include costing for maintenance and monitoring.

It is important to note that the post closure costs in Table 13-4 were based on the cost estimate of monitoring and maintenance for the current year. Over a 25 or 30 year period, due to inflation, the cost for monitoring will undoubtedly increase. This inflation has not been accounted for in our projections.

A summary of the annual post closure operating costs is presented below.

| | |
|---|---|
| Environmental Controls | $2,000 |
| Maintenance | $3,510 |
| Monitoring and Reporting | $30,000 |
| Administration | $20,000 |
| TOTAL CAPITAL COST | $55,510 |

The annual post closure costs above exclude taxes. The annual post closure cost equates to $3.68 per square meter of the closed area over the 25 or 30 years during the post closure period.

## 13.7 Financial Security

A post closure fund should be established by the owner of the landfill to put in place sufficient security to cover the costs of post closure care for a period of approximately 25 or 30 years. The fund should contain sufficient reserves to pay for the net present value of approximately $55,510 of post closure care annually for a period of 30 years.

## Table 13-1

## CONCEPTUAL DESIGN ENGINEERING COST ESTIMATE - MATERIAL MANAGEMENT AND CONSTRUCTION OF GEOMEMBRANE CLOSURE SYSTEM ON LANDFILL

## (PER SHA COVER DESIGN OPTION 3)

| Item | Description | Amount Length (m), Area ($m^2$), Volume ($m^3$) | Units | Unit Rate | Estimated Cost | Totals |
|---|---|---|---|---|---|---|
| | | | | | | |
| **A** | **SITE PREPARATION AND CLEAN-UP** | 12,100 | $m^2$ | | | |
| A-1 | Mobilization / Demobilization | 1 | LS | $100,000 | $100,000 | |
| A-2 | Smoothing and Proof Rolling | 12,100 | $m^2$ | $0.40 | $4,840 | |
| A-3 | Bottom Ash Relocation to Landfill and Transfer Station Cell | 19,200 | $m^3$ | $10.00 | $192,000 | |
| A-4 | Relocation of Asbestos to Catalyst Paper Landfill | 240 | tonnes | $150.00 | $36,000 | |
| A-5 | Removal and Recycling of Gyproc | 1,800 | tonnes | $120.00 | $216,000 | |
| A-6 | Removal and Recycling of Roofing Material | 1,320 | tonnes | $120.00 | $158,400 | |
| A-7 | Process Organic Material to Produce Compost and Top Soil | 11,200 | $m^3$ | $50.00 | $560,000 | |
| | | | | | | **$1,267,240** |
| **B** | **CLOSURE SYSTEM CONSTRUCTION** | | | | | |
| B-1 | Supply and Install Sand Cushion Layer (150 mm) | 12,100 | $m^2$ | $7.00 | $84,700 | |
| B-2 | Supply and Install LLDPE Geomembrane | 12,100 | $m^2$ | $8.00 | $96,800 | |
| B-3 | Supply and Install Heavyweight Geotextile | 12,100 | $m^2$ | $3.00 | $36,300 | |
| B-4 | Supply and Install Gravel Drainage Layer (200 mm) | 12,100 | $m^2$ | $7.00 | $84,700 | |
| B-5 | Supply and Install Lightweight Geotextile | 12,100 | $m^2$ | $3.00 | $36,300 | |
| B-6 | Supply and Install Topsoil Layer (300 mm) (Fabricated) | 12,100 | $m^2$ | $4.00 | $48,400 | |
| B-7 | Hydro seeding | 12,100 | $m^2$ | $1.00 | $12,100 | |
| | | | | | | **$399,300** |
| **C** | **SURFACE WATER MANAGEMENT** | | | | | |
| C-1 | Ditching | 600 | m | $100.00 | $60,000 | |
| C-2 | Lined Stormwater Pond | 1 | LS | $250,000.00 | $250,000 | |
| C-3 | Stormwater Culvert | 140 | m | $90.00 | $12,600 | |
| C-4 | Supply and Install Surface Water Manhole | 1 | each | $10,000.00 | $10,000 | |
| C-5 | Headwalls | 2 | each | $1,500.00 | $3,000 | |
| | | | | | | **$335,600** |
| **D** | **LANDFILL GAS MANAGEMENT SYSTEM** | | | | | |
| D-1 | Excavate LFG Trench | 300 | m | $12.00 | $3,600 | |
| D-2 | Supply and Install Gravel Backfill | 300 | m | $15.00 | $4,500 | |
| D-3 | Supply and Install LFG Collection Pipe | 300 | m | $25.00 | $7,500 | |
| D-4 | Supply and Install LFG Vents | 5 | each | $250.00 | $1,250 | |
| | | | | | | **$16,850** |
| | | | | | | |
| | **SUBTOTAL (excluding HST)** | | | | **$2,018,990** | **$2,018,990** |
| **E** | **ENGINEERING** | | | | | |
| **E-1** | Detailed Design and Permitting | 1 | LS | 6.00% | $121,139 | |
| **E-2** | On Site QA-QC | 1 | LS | 7.00% | $141,329 | |
| | | | | | | **$262,469** |
| **F** | **CONTINGENCY** | | | | | |
| | | | | | | |
| **F-1** | Contingency at 15% | 1 | LS | 15.00% | $302,849 | |
| | | | | | | **$302,849** |
| | **TOTAL COST ESTIMATE (excluding HST):** | | | | | **$2,584,307** |

Prepared by: Sperling Hansen Associates Inc.
Based on unit costs of past construction projects of other landfill sites.
The plan view area has been adjusted to account for slope factors.

**Construction Unit Cost Excluding Engineering and Contingency (per $m^2$) =** **$166.86**
**Including Engineering and Contingency (per $m^2$) =** **$213.58**

**Unit Cost without Pond Construction Cost** **$ 192.92**

## Table 13-2

## CONCEPTUAL DESIGN ENGINEERING COST ESTIMATE - TRANSFER STATION DEVELOPMENT AND ASPHALT LAYER COVER SYSTEM
## (PER SHA COVER DESIGN OPTION 4)

| Item | Description | Amount Length (m), Area ($m^2$), Volume ($m^3$) | Units | Unit Rate | Estimated Cost | Totals |
|---|---|---|---|---|---|---|
| A | **SITE PREPARATION** | 3,000 | $m^2$ | | | |
| A-1 | Mobilization / Demobilization | 1 | LS | $50,000 | $50,000 | |
| A-2 | Smoothing and Proof Rolling | 3,000 | $m^2$ | $0.40 | $1,200 | |
| A-3 | Ash Material Relocation and Compaction | 8,500 | $m^2$ | $12.00 | $102,000 | |
| | | | | | | **$153,200** |
| B | **CLOSURE SYSTEM CONSTRUCTION** | | | | | |
| B-1 | Supply and Install Sand Cushion Layer (150 mm) | 3,000 | $m^2$ | $4.00 | $12,000 | |
| B-2 | Supply and Install WPE20 Barrier Layer | 3,000 | $m^2$ | $4.00 | $12,000 | |
| B-3 | Supply and Install Heavyweight Geotextile | 3,000 | $m^2$ | $3.00 | $9,000 | |
| B-4 | Supply and Install Sub-base Gravel Drainage Layer (500 mm) | 3,000 | $m^2$ | $33.00 | $99,000 | |
| B-5 | Supply and Install Base Gravel Drainage Layer (200 mm) | 3,000 | $m^2$ | $13.50 | $40,500 | |
| B-6 | Process and Install Asphalt Layer (100 mm) | 3,000 | $m^2$ | $5.00 | $15,000 | |
| B-7 | Hydro seeding | 3,000 | $m^2$ | $1.00 | $3,000 | |
| | | | | | | **$190,500** |
| C | **SURFACE WATER MANAGEMENT** | | | | | |
| C-1 | Catchbasins | 3 | each | $3,000.00 | $9,000 | |
| C-2 | Stormwater Sewer | 150 | m | $200.00 | $30,000 | |
| C-3 | Asphalt Paving for Internal Roads (100mm) | 4,320 | $m^2$ | $4.00 | $17,280 | |
| | | | | | | **$56,280** |
| D | **TRANSFER BAY UPGRADES (15 Bay Site)** | | | | | |
| D-1 | Misc Cost for Railings etc. | 1 | LS | $60,000 | $60,000 | |
| D-2 | Lock Blocks | 350 | LS | $120.00 | $42,000 | |
| D-3 | Subbase | 720 | m3 | $40.00 | $28,800 | |
| D-4 | Concrete Pads | 15 | LS | $5,000.00 | $75,000 | |
| D-5 | Paved Access Roads | 3,000 | $m^2$ | $40.00 | $120,000 | |
| D-6 | Access and Exit Ramp | 1 | LS | $100,000 | $100,000 | |
| D-7 | Lighting / Electrical | 1 | LS | $80,000 | $80,000 | |
| D-8 | Geogrid Reinforcment | 1 | LS | $200,000.00 | $200,000 | |
| D-9 | Roll-Off Containers | 15 | LS | $15,000.00 | $225,000 | |
| | | | | | | **$930,800** |
| | | | | | | |
| | **SUBTOTAL (excluding HST)** | | | | **$1,105,780** | **$1,330,780** |
| E | **ENGINEERING** | | | | | |
| **E-1** | Detailed Design and Permitting | 1 | LS | 10.00% | $110,578 | |
| **E-2** | On Site QA-QC | 1 | LS | 7.00% | $77,405 | |
| | | | | | | **$187,983** |
| F | **CONTINGENCY** | | | | | |
| | | | | | | |
| **F-1** | Contingency at 15% | 1 | LS | 15.00% | $165,867 | |
| | | | | | | **$165,867** |
| | **TOTAL COST ESTIMATE (excluding HST):** | | | | | **$1,684,630** |

| | |
|---|---|
| **Construction Unit Cost Excluding Engineering and Contingency (per $m^2$) =** | **$443.59** |
| **Including Engineering and Contingency (per $m^2$) =** | **$561.54** |

Prepared by: Sperling Hansen Associates Inc.

Based on unit costs of past construction projects of other landfill sites.

The plan view area has been adjusted to account for slope factors.

# Table 13-4
## Annual Post Closure Costs

**ANNUAL POST CLOSURE COSTS** **Total Area = 15,100 m$^2$** (Lined area only)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Environmental Controls** | | | | | **$2,000** | |
| Erosion Control | 1 | LS | $2,000 | $2,000 | | |
| **Maintenance** | | | | | **$3,510** | |
| Cover system maintenance | 1 | LS | $2,000 | $2,000 | | |
| Mowing & Fertilizing | 15,100 | m$^2$ | $0.10 | $1,510 | | |
| **Monitoring and Reporting** | | | | | **$30,000** | |
| Annual Water Quality Monitoring | 1 | LS | $10,000 | $10,000 | | annual water quality program |
| Annual Landfill Gas Monitoring | 1 | LS | $5,000 | $5,000 | | Landfill Gas Survey and Report once per year |
| Annual Erosion Control Inspection | 1 | LS | $3,000 | $3,000 | | annual inspection of erosion, slope stability |
| Annual Settlement Survey | 1 | LS | $2,000 | $2,000 | | |
| Annual Reporting | 1 | LS | $10,000 | $10,000 | | |
| **Administration** | | | | | **$20,000** | |
| Local Staff | 1 | LS | $20,000 | $20,000 | | |
| **TOTAL** | | | | | **$55,510** | |

**Unit Cost (per m$^2$ ) = $3.68**

# 14. CONCLUSIONS AND RECOMMENDATIONS

## 14.1 Conclusions & Recommendations

The following is a summary of key conclusions, findings and recommendations from the Powell River Marine Avenue Site Closure Plan. The following points are taken from the detailed report and should be used only to gain a general understanding of the issues described in the body of the report.

### Site Characterization (Chapter 2)

An incinerator was constructed in the early 1970s at the Marine Avenue Site where operations continued until the early 1990s as long as the permit allowed. During operation, many materials were stockpiled on site including clinker/ash, gypsum wall-board, roofing materials, chipped wood products, asphalt, concrete, glass, tires, demolition waste, asbestos, clean fill, yard waste and some scrap metal. The site is approximately 6.4 ha. SHA has estimated the quantities of each waste type on-site and considered the end use of each waste type. Ash is the largest waste category of all (56% by volume and 66% by estimated weight).

The Marine Avenue site is located within a moderately wet region of the province. The average annual precipitation is 1205.4 mm with 1160.0 mm of rain and 46.5 cm of snowfall.

SHA's field program for the Closure at Powell River Marine Avenue site included an initial site visit, in which the following was discussed:

- History of the site
- End-use plan would be to turn the site into a transfer site/recycling facility on the east half of the property and a botanical garden on the west half
- Use of locally available materials for closure and the possibility of utilizing soil applied on top of the landfill
- Obtain topographic survey data if available or conduct a topographic survey
- Install monitoring wells if necessary

SHA's field program included a topographic survey, test pit program, groundwater well installation, groundwater and surface water quality monitoring, and sampling of ash and woodchips to assess contamination and potential for reuse as cogeneration fuel.

### Closure Objectives (Chapter 3)

Chapter 3 outlined the various regulations and requirements involved with the landfill closure. The end use plan for the Marine Ave Transfer Site is to construct a Recycling Centre and Resource Recovery Park on approximately half of the site area and a Botanical Garden and Compost Facility on the remaining half of the site. The Recycling Centre and Resource Recovery Park are envisioned to be developed with a similar concept as used in the Peerless Road Recycling Centre in Cowichan Valley Regional District. The Botanical Garden will be a demonstration site for the Botanical Garden Society of Powell River.

### Leachate Management (Chapter 4)

The water balance analysis for the Landfill was performed using the Thornthwaite method as well as by HELP modeling. The HELP analysis predicts that the 1229.9 mm/yr of precipitation will be portioned as follows: Evapotranspiration 40%, Run-off 1% and Percolation to Leachate 59%.

The leachate management concept for the Marine Avenue Transfer Site has been developed to achieve the following objectives:

- Keep clean water clean by diverting run-on and run-off; and
- Minimize percolation by designing an impermeable cover system;

### Landfill Gas Management (Chapter 5)

It is expected that the existing waste will emit very small amounts of LFG to the environment during the post closure period. The majority of waste material is inorganic and will be relocated beneath the closure area including the DLC waste which will be used to re-grade the site to the final design contours and appropriate side slopes. Therefore, it is safe to assume that the landfill will continue to generate a minimal amount of landfill gas. SHA recommends that the final cover system for the Marine Avenue Transfer Site landfill area include passive gas collectors and vents.

### Grading Plan (Chapter 6)

The grading concept for Marine Avenue site was developed to meet all the MOE slope constraints listed in the Landfill Criteria for Municipal Solid Waste (MOE, 1993) as well as SHA’s standard design guidelines for developing industrial landfills in B.C. The proposed grading plan for the closure of the site will help PRRD to realize its vision by incorporating all possible materials on the site for reuse and recycling in the engineered cover system and transfer bay area construction. The grading plan for the site is to excavate all the ash stockpiled throughout the landfill and consolidate it at one location, and then to place a cover system on the ash waste. This will permit the construction of a Transfer Station on the holding cell portion of the landfill, and free up ground space for the construction of a Recycling Centre and Resource Recovery Park and possible future Botanical Gardens and/or composting facility. The remaining waste will be reused or recycled.

### Geotechnical Consideration (Chapter 7)

Settlement is not expected to be an issue at this landfill (1-20% first 5 years, decreasing to 0.25% per year long-term). Based on the available information no record of instability was found. Furthermore, no sign of instability was noticed during the site visits on August 2013 and March 2014. SHA conducted a detailed analysis using SLIDE computer analysis and Newmark Seismic Displacement Analysis. Failure scenarios were modeled for both static and seismic (earthquake) conditions for the proposed and existing profiles. Conservative parameters yielded factors of safety of 1.56 under static conditions and 0.822 under seismic conditions with a conservative PGA value. A displacement analysis confirmed thatgrond movements during the design earthquake would be minimal. The proposed landfill does not pose any significant stability or slope failure issues.

### Final Cover Design (Chapter 8)

HELP modeling analysis for both the crest and side slopes was used to determine water balance. SHA developed four options for closure cover. Based on the results of our detailed analysis SHA concludes that the most effective cover system can be realized with an LLDPE geomembrane cover system with a drainage layer for the proposed landfill portion and an asphalt pavement layer with gravel pad and WPE20 or equivalent material barrier layer for the holding cell. The holding cell area can potentially be used as a transfer bay facility with 15 bays for diverting various recyclables in future. The sand cushion layer can be used as a bedding layer for the geomembrane cap with horizontal collector trenches filled with coarse grained material or gravel for passive gas collection. SHA is of the opinion that Option 3 is the most effective design that will meet all performance requirements for closure of the crest and slopes of the landfill portion and the side slope portion of the transfer bay area at the Marine Avenue Transfer Site. Option 4 is the most effective design for closure of the crest of the holding cell.

The Recommended Cover System as per Option 3 includes the following layers:

- 150 mm Sand Cushion Layer with Horizontal Trenches for Passive Gas Collection
- 40 mil LLDPE Geomembrane
- 12 oz Heavy Weight Geotextile Layer
- 200 mm Gravel Drainage Layer
- 8 oz Separation Geotextile
- 300 mm Topsoil Layer

The Recommended Cover System as per Design Option 4, includes the following layers:

- 150 mm Sand Cushion Layer with Horizontal Trenches for Passive Gas Collection
- 16 mil WPE20 or Equivalent Material for Barrier Layer
- 12 oz Heavy Weight Geotextile Layer
- 500 mm Sub-Base Gravel Pad Layer
- 200 mm Base Gravel Pad Layer
- 100 mm Asphalt Pavement Layer

The holding cell will have an access ramp and an exit ramp as it will potentially be used to construct the Recycling Centre/Resource Park. The holding cell will abut on the lock-block walls on the west side that will accommodate 15 transfer bays. Along the inside of the lock-block walls and underneath, engineered fill may need to be used to secure the walls. The details of the fill can be determined during the detailed design.

The recycle area is recommended to be paved with concrete underlain by the following layers from bottom to top:

- 150 mm Sand Cushion Layer
- 500 mm Sub-Base Gravel Pad Layer
- 200 mm Base Gravel Pad Layer

### Surface Water Control and Run-off Management (Chapter 9)

In order to determine the sizing of the crest and toe ditches, peak flows were determined using the Rational Method. The following dimensions are recommended for crest and toe ditches:

- Crest Ditches – Triangular cross section, depth of 0.75m, side slopes at 2.5 H: 1V, and lined with erosion control blanket.
- Toe Ditches – Triangular cross section, depth of 0.75 m, side slopes at 2.5 H:1V, and lined with erosion control blanket.

To prevent the off-site discharge of any sediment laden surface water and provide storage during peak flow, SHA recommends that all captured surface water be discharged through a retention pond, that will provide sedimentation and wetland polishing. During the post construction period, erosion on the slopes will be controlled with straw mulch on completed slopes, straw wattle and straw/coconut erosion control material above all ditches. The ditches should be structured with cascades and wetland pools to provide additional runoff polishing.

### Topsoil, Vegetation and Fauna (Chapter 10)

Species selected for the vegetative community that will be established on the landfill should possess an extensive fibrous root system, which will assist with soil stability. The aboveground portions of the plants should facilitate water interception and mitigate the erosive action of precipitation directly on the soil surface. Vegetation without a large standing dry biomass during the summer moisture deficit period will minimize fuel loading for accidental ignition and minimize the chance of fire.

### Materials Management (Chapter 11)

Materials Availability

The materials onsite include a variety of waste materials, recyclable construction materials, and clean fill. In total approximately 68,350 $m^3$ or 83,770 tonnes of material are available on site. The PRRD envisions utilizing most of the materials on-site. If some of the materials cannot be utilized on site, they will be either recycled or relocated. Two scenarios were developed for materials availability.

Under Scenario 1, asbestos material will need to be relocated to Catalyst Paper Landfill, and roofing material and gyproc will be recycled at an off-site recycle facility located in Powell River. The remaining materials will be beneficially reused at the site. Out of the remaining materials, a total of 38,000 m$^3$ or 55,100 tonnes is ash will be risk managed in the landfill and the transfer bay area/ holding cell. The remaining 23,900 m$^3$ or 25,310 tonnes of mainly organic materials will be reused in the construction of the Recycling Centre and Resource Recovery Park development or in the proposed composting facility.

Under Scenario 2, wood chips and stumps as well as asbestos material will be relocated to Catalyst Paper Landfill. Roofing material and gyproc as well as 2,100 m$^3$ or 1,020 tonnes of glass and tires will be recycled at an off-site recycle facility. The remaining material available for reuse is 49,800 m$^3$ or 73,090 tonnes.

Materials Requirements

The materials required for building the proposed cover system are topsoil, asphalt for pavement, gravel for a gravel pad, road base and sub-base and drainage layer, sand for cushioning and gravel/rock for erosion control as riprap. The cover system includes a 300mm layer of top soil and a 200mm drainage layer and 150 mm sand cushion over the landfill area and 100 mm asphalt with 700 mm base and sub-base gravel pad and 150 mm sand cushion in the transfer bay area. This Chapter shows how on-site materials may be reused to provide materials for construction.

With an estimated 8,000m$^3$ of wood chips on site, it is possible to manufacture about 24,000m$^3$ of topsoil, provided there is an ample supply of biosolids. The topsoil/biocover can then be beneficially used during development of the botanical garden area for bioremediation.

## Post Closure Monitoring (Chapter 12)

The site is currently relying on natural attenuation for leachate treatment. Since no leachate is collected and/or treated at the site, no leachate monitoring is required at this time. To address the possibility that leachate may enter the environment for reasons unforeseen, SHA recommends the ongoing monitoring of three existing groundwater wells MW13-01, MW13-02 and MW-13-03, according to MoE post-closure requirements shown in Chapter 12. Recommended surface water monitoring locations are shown on Figure 12-1. SHA recommends continuing to sample from the three established locations SW-1, SW-2, and SW-3, in addition to a new proposed location SW-4 located near the outlet of the future retention pond.

SHA recommends that a quality assurance/quality control (QA/QC) program be implemented by the client as part of the monitoring program. A QA/QC program is a system of procedures, checks, audits and corrective actions that will assist in ensuring that the data generated at the laboratory is of the highest achievable quality. This is of prime importance, as the monitoring data will form the basis for all of the conclusions regarding the impact of the landfill on the surrounding environment.

## Economic Analysis (Chapter 13)

SHA considered several Options to close the landfill site. SHA and the PRRD were unable to find landfills that would accept all of the waste from the site in a cost-effective manner. SHA's preferred Option and that for which costing was prepared was to Upcycle, Reuse, Recycle Materials on Site proceeded by an appropriate level of Public Consultation (Chapter 13, Option 4). Further, SHA determined that the most cost effective and successful means of closure will include a geomembrane cap (Design Option 3) on the slope and crest of the landfill and on the slopes of the Transfer Bay Area, as well as an Asphalt layer cover system (Design Option 4) for the Crest of the Transfer Bays.

The summary of costs for this option is presented in the Table below.

**Table 14.1 Summary of Costs:**

| Items | Gemembrane Closure Area | Transfer Bay Crest | Total |
|---|---|---|---|
| **SITE PREPARATION** | $ 1,267,240 | $ 153,200 | $ 1,420,440 |
| **CLOSURE SYSTEM CONSTRUCTION** | $ 399,300 | $ 190,500 | $ 589,800 |
| **SURFACE WATER MANAGEMENT** | $ 335,600 | $ 56,280 | $ 391,880 |
| **LANDFILL GAS MANAGEMENT SYSTEM** | $ 16,850 | $ - | $ 16,850 |
| **TRANSFER BAY UPGRADES** | $ - | $ 930,800 | $ 930,800 |
| **ENGINEERING** | $ 262,469 | $ 187,983 | $ 450,451 |
| **CONTINGENCY** | $ 302,849 | $ 165,867 | $ 468,716 |
| **Total** | **$ 2,584,307** | **$ 1,684,630** | **$ 4,268,937** |

The aforementioned costs include detailed design, construction QA/QC of the closure system and a 15% contingency. The grand total of closure implementation and site upgrade to a 15 bay transfer site that can be incorporated into a modern Recycling Centre and Resource Recovery Park is estimated at $4,268,937.

The costs for recycling facility, resource recovery facility, education centre, compost facility and any costs associated with the botanical garden development are not included in this Design option as they are additional costs and do not fall within the scope of the analysis for this report. Also, costs related to the decommissioning of the old incinerator have not been included. Materials from the old incinerator may be recyclable in the landfill closure construction, and any remaining material from decommissioning could be recycled.

A summary of the annual post closure operating costs is presented below.

| | |
|---|---|
| Environmental Controls | $2,000 |
| Maintenance | $3,510 |
| Monitoring and Reporting | $30,000 |
| Administration | $20,000 |
| TOTAL CAPITAL COST | $55,510 |

The annual post closure costs above exclude taxes. The annual post closure cost equates to $3.68 per square meter of the closed area over the 25 or 30 years during the post closure period.

A post closure fund should be established by the owner of the landfill to put in place sufficient security to cover the costs of post closure care for a period of approximately 25 or 30 years. The fund should contain sufficient reserves to pay for the net present value of approximately $55,510 of post closure care annually.

# 15. LIMITATIONS

This report has been prepared by Sperling Hansen Associates (SHA) on behalf of the Powell River Regional District in accordance with generally accepted engineering practices to a level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions in British Columbia, subject to the time limits and financial and physical constraints applicable to the services.

The report, which specifically includes all tables and figures, is based on engineering analysis by SHA staff of data compiled during the course of the project. Except where specifically stated to the contrary, the information on which this study is based has been obtained from external sources. This external information has not been independently verified or otherwise examined by Sperling Hansen Associates to determine its accuracy and completeness. Sperling Hansen Associates has relied in good faith on this information and does not accept responsibility of any deficiency, misstatements or inaccuracies contained in the reports as a result of omissions, misinterpretation and/or fraudulent acts of the persons interviewed or contacted, or errors or omissions in the reviewed documentation.

The report is intended solely for the use of the Powell River Regional District. Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Sperling Hansen Associates does not accept any responsibility for other uses of the material contained herein nor for damages, if any, suffered by any third party because of decisions made or actions based on this report. Copying of this intellectual property for other purposes is not permitted.

The findings and conclusions of this report are valid only as of the date of this report. The interpretations presented in this report and the conclusions and recommendations that are drawn are based on information that was made available to Sperling Hansen Associates during the course of this project. Should additional new data become available in the future, Sperling Hansen Associates should be requested to re-evaluate the findings of this report and modify the conclusions and recommendations drawn, as required.

**Report prepared by:**

**Iqbal Hossain Bhuiyan, PhD, P.Eng.**
**Senior Environmental Engineer**

**Nicholas Lamm**
**Engineering Technologist**

**Report reviewed by:**

**Dr. Tony Sperling, P.En**
**President**
**Sperling Hansen Associa**

A. S...LING
TS
October 27, 2014

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# APPENDICES

# APPENDIX A
# Landfill Permit

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE

POLLUTION CONTROL BRANCH

# PROVISIONAL PERMIT

*Under the Provisions of Section 5 (1) of the Pollution Control Act, 1967*

The Corporation of the District of Powell River
(Name.)

of 6910 Duncan Street, Powell River, British Columbia
(Address.)

is hereby authorized to discharge ~~effluent~~ refuse from an incinerator
(Plant, factory, municipality, etc.)

located at Powell River, B.C., subject to the conditions set out below and to the conditions set forth in any appendix attached hereto.

(*a*) The approximate point of discharge to a parcel of land on portion of Block 36, District Lot 450, Group 1, New Westminster District, Plan 8096 is located as shown on the attached plan.

(*b*) The quantity of ~~effluent~~ refuse which may be discharged is a maximum of 5 cubic yards per day

(*c*) The characteristics of the ~~effluent~~ refuse shall be ~~[illegible]~~ those of substantially inert incinerator residue

(*d*) The works authorized to be constructed are an incinerator and residue storage facilities approximately located as shown on the attached plan.

(*e*) The land from which the ~~effluent~~ refuse originates and to which this permit is appurtenant is the area of the Powell River Regional District

~~(*f*) The appendix attached hereto contains~~ ~~items dealing with~~

~~, which are an integral part of this permit.~~

~~(*g*)~~

(f) The incinerator shall be operated in such a manner that the emission of air contaminants does not create a health hazard or a nuisance condition, or contravene any provision of the Pollution Control Act, 1967, or Regulations.

(g) The authority to discharge under this Permit is contingent upon the works authorized having been constructed as per final construction plans approved in accordance with the Pollution Control Act, 1967.

(h) The works are to be constructed on or before June 30, 1972.

This permit, or any of the conditions contained herein, may be amended, varied, or rescinded by order, at any time.

*Director of Pollution Control.*

Date issued 21st April, 1971

Permit No. R-9-P

697

**DOUBLE REGISTERED**

Our File: PR-509

Date: FEB 02 1994

THE CORPORATION OF THE
DISTRICT OF POWELL RIVER
6910 Duncan Street
Powell River, British Columbia
V8A 1V2

Attention: V. H. Petersen
Administrator

Dear Permittee:

AMENDMENT TO PERMIT

Pursuant to Section 11 of the Waste Management Act, Permit PR-509 issued to **THE CORPORATION OF THE DISTRICT OF POWELL RIVER** on April 21, 1971 and last amended April 1, 1993 authorizing the discharge of refuse to land and contaminants to air, is hereby amended as follows:

1. Effective October 15, 1994, all discharge shall cease and the existing refuse burner shall be closed.

2. Progress reports outlining your activities and action in a form suitable for public release shall be submitted on:

    i April 15, 1994;
    ii May 31, 1994;
    iii July 15, 1994;
    iv August 31, 1994;
    v October 14, 1994.

We look forward to your cooperation and strict compliance.

Yours very truly,

E. M. Lawson

E. M. Lawson
Assistant Regional Waste Manager

Enc.

cc: Environment Canada
Powell River Regional District

APR 0 1 1993

File: PR-509

**DOUBLE REGISTERED**

**THE CORPORATION OF THE**
**DISTRICT OF POWELL RIVER**
6910 Duncan Street
Powell River, B. C.
V8A 1V2

Dear Permittee:

**AMENDED PERMIT NO. PR-509**

Pursuant to Section 11 of the Waste Management Act, Permit PR-509, issued to the Corporation of the District of Powell River on April 21, 1971 and amended December 17, 1992 authorizing the discharge of refuse to land and contaminants to air,is hereby amended as follows:

1. Add the following line to clause (b) of the permit

   **Effective February 28, 1994, the quantity of refuse that may be discharged is zero (0) cubic metres per day.**

2. Add the following line to clause (f) of the permit

   **Effective February 28, 1994, the incinerator shall comply with BACT (Best Available Control Technology) which is as outlined in the document "Emission Criteria for Municipal Solid Waste Incinerators" published by B.C. Environment, June 1991.**

All other terms of the Permit shall remain in full force and effect.

Yours very truly,

E. M. Lawson

E.M. Lawson
Assistant Regional Waste Manager

EML/fo

c.c. Environment Canada
Powell River Regional District

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE

POLLUTION CONTROL BRANCH

# PROVISIONAL PERMIT

*Under the Provisions of Section 5 (1) of the Pollution Control Act, 1967*

The Corporation of the District of Powell River
(Name.)

of 6910 Duncan Street, Powell River, British Columbia
(Address.)

is hereby authorized to discharge ~~effluent~~ refuse from an incinerator
(Plant, factory, municipality, etc.)

located at Powell River, B.C., subject to the conditions set out below and to the conditions set forth in any appendix attached hereto.

(*a*) The approximate point of discharge to a parcel of land on portion of Block 36, District Lot 450, Group 1, New Westminster District, Plan 8096 is located as shown on the attached plan.

(*b*) The quantity of ~~effluent~~ refuse which may be discharged is a maximum of 5 cubic yards per day

(*c*) The characteristics of the ~~effluent~~ refuse shall be ~~equivalent to or better than~~ those of substantially inert incinerator residue

(*d*) The works authorized to be constructed are an incinerator and residue storage facilities approximately located as shown on the attached plan.

(*e*) The land from which the ~~effluent~~ refuse originates and to which this permit is appurtenant is the area of the Powell River Regional District

~~(f) The appendix attached hereto contains items dealing with~~

~~, which are an integral part of this permit.~~

~~(x)~~

(f) The incinerator shall be operated in such a manner that the emission of air contaminants does not create a health hazard or a nuisance condition, or contravene any provision of the Pollution Control Act, 1967, or Regulations.

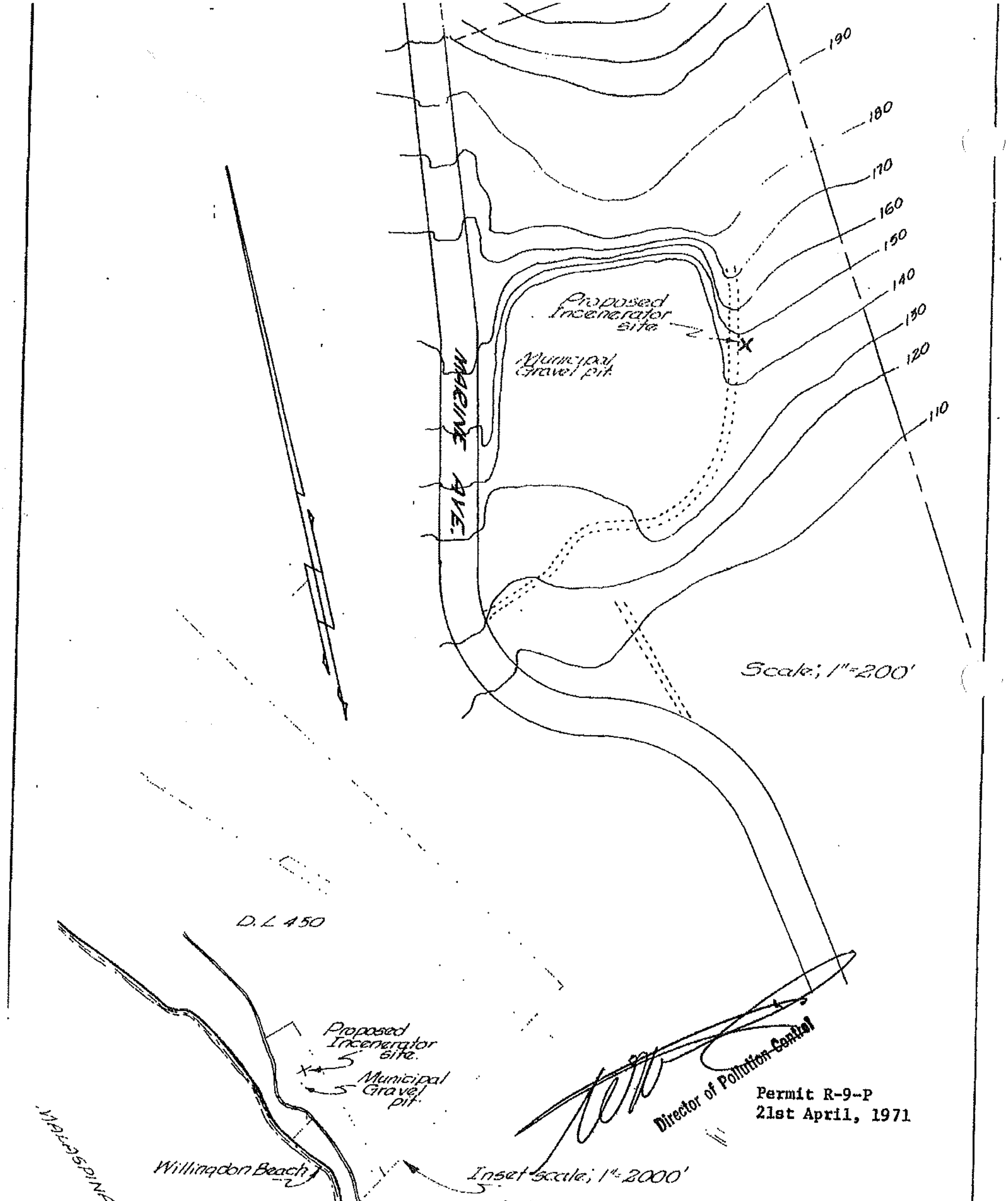
(g) The authority to discharge under this Permit is contingent upon the works authorized having been constructed as per final construction plans approved in accordance with the Pollution Control Act, 1967.

(h) The works are to be constructed on or before June 30, 1972.

This permit, or any of the conditions contained herein, may be amended, varied, or rescinded by order, at any time.

*Director of Pollution Control.*

Date issued 21st April, 1971



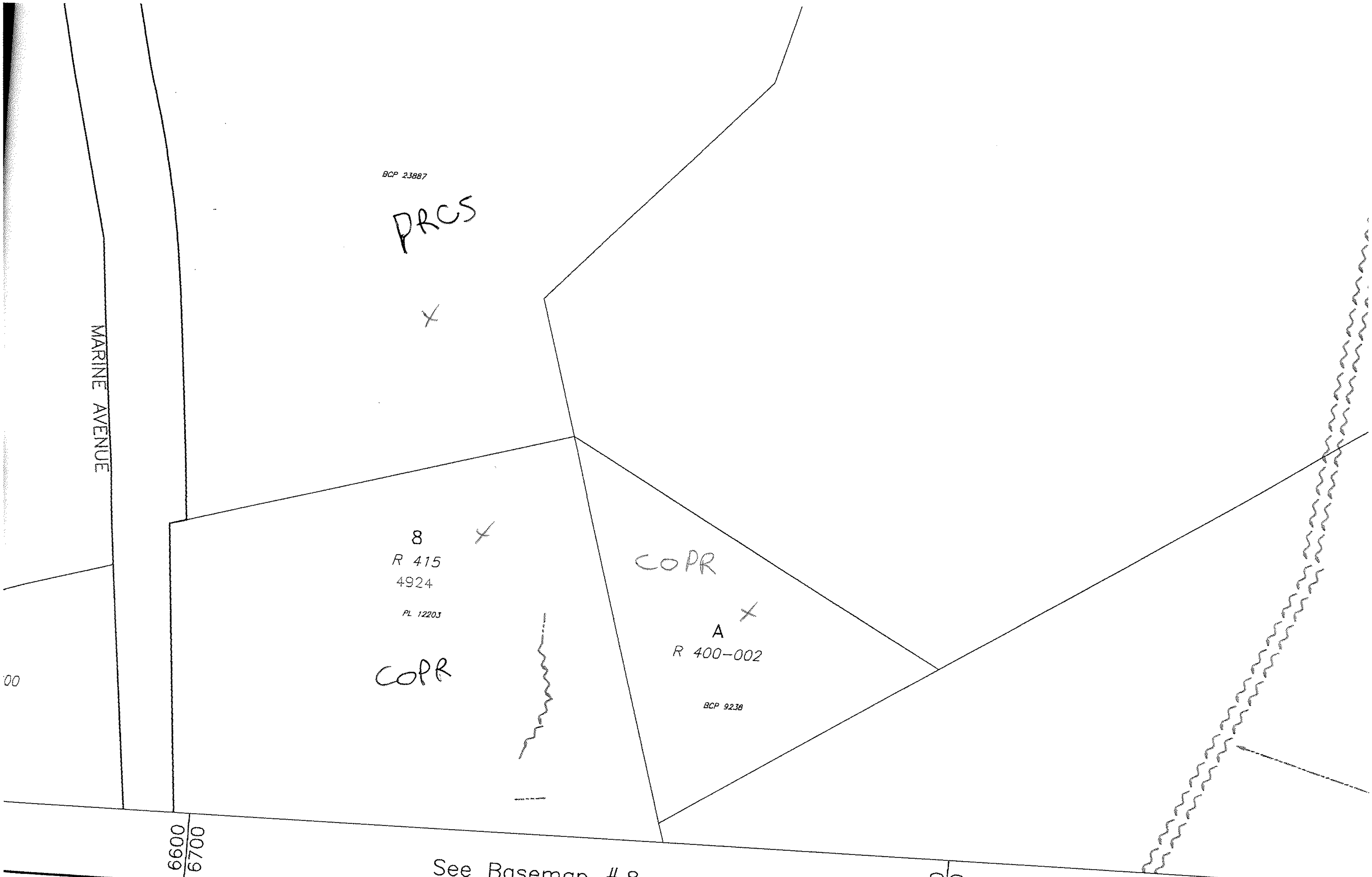
Director of Pollution Control

Permit R-9-P
21st April, 1971

THE CORPORATION OF THE
DISTRICT OF POWELL RIVER.

MUNICIPAL ENGINEER'S
OFFICE.

PLAN OF PROPOSED
INCENERATOR SITE



See Basemap # 8

50 0 50

| | | | | | |
|---|---|---|---|---|---|
| .. 7344 | District Lot Number | | | | |
| | Road Allowance | | | | |
| | Lot Boundary | | | | |
| ========== | Easement/Right-of-Way | 4 | UPDATED | 20/01/12 | K.J.P. |
| | Legal Plan Number | 3 | UPDATED | 30/03/09 | K.J.P. |
| | Sanitary Main | 2 | UPDATED | | |
| | Storm M... | | | | |

Drawn by: K.J.P.

Designed by:

Scale: Hor.SEE BAR S

Vert.

Date: 29 JUN 1993

# APPENDIX B
# TEST PIT AND BOREHOLE LOGS

SPERLING
HANSEN
ASSOCIATES

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-1
**Logged by:** Mark Manning
**Date:** Dec-10-13
**Elevation:** 39 m
**Easting:** 389944
**Northing:** 5223120

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ░ | 0.5 | ░ | concrete/cobbles and silty sand |
| | ░ | 1 | ░ | |
| | ░ | 1.5 | ▨ | |
| | ░ | 2 | ▨ | |
| | ░ | 2.5 | ▨ | silty sand with some cobbles |
| | ░ | 3 | ▨ | |
| | ░ | 3.5 | ▨ | |
| | ░ | 4 | ▨ | |

**Total Depth:** 4.03m

**Notes:**

No Groundwater Encountered
No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-2
**Logged by:** Mark Manning
**Date:** Dec-10-13
**Elevation:** 39 m
**Easting:** 389942
**Northing:** 5223120

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | 0.5 | | |
| | | 1 | | |
| | | 1.5 | | |
| | | 2 | | Sand and silty sand, traces of waste |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 3.9m

**Notes:**

No Groundwater Encountered
No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-3
**Logged by:** Mark Manning
**Date:** Dec-10-13
**Elevation:** 42 m
**Easting:** 389979
**Northing:** 5523177

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | 0.5 | | Ash with cobbles |
| | | 1 | | |
| | | 1.5 | | |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 3.2m

**Notes:**

No Groundwater Encountered
No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-4
**Logged by:** Mark Manning
**Date:** Dec-10-13
**Elevation:** 42 m
**Easting:** 390015
**Northing:** 5523181

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | 0.5 | ▦ | Wood debris, Sand silt + rock, some charred wood |
| | | 1 | ▦ | |
| | | 1.5 | ▦ | |
| | | 2 | ▨ | Mixed wood debris, rock and sand |
| | | 2.5 | ▨ | |
| | | 3 | ▨ | |
| | | 3.5 | ▨ | |
| | | 4 | ▨ | |

**Total Depth:** 2.3m
**Static Water Level:** N/A

**Notes:**
End of Test Pit at 2.3 m
No Groundwater Encountered
No Slumping of Test Pit Walls
Sample Taken at 1.8m

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

SPERLING
HANSEN
ASSOCIATES

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-5
**Logged by:** Mark Manning
**Date:** Dec-10-13
**Elevation:** 48 m
**Easting:** 389950
**Northing:** 5523339

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ░ | 0.5 | ▓ | Shingles, roofing material |
| | ░ | 1 | ▓ | |
| | ░ | 1.5 | ░ | |
| | ░ | 2 | ░ | Stained sand |
| | ░ | 2.5 | ░ | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 2.3m
**Static Water Level:** N/A

**Notes:**
End of Test Pit at 2.3 m
No Groundwater Encountered
No Slumping of Test Pit Walls
Sample Taken at 1.8m

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-6
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 46 m
**Easting:** 389937
**Northing:** 5523310

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | | | Skim of topsoil and organics |
| | | 0.5 | | |
| | | 1 | | Medium to coarse sand, stained |
| | | WT | | |
| | | 1.5 | | |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 2.0m

**Notes:**

Groundwater Encountered at 1.2m
Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

SPERLING HANSEN ASSOCIATES

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-7
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 45 m
**Easting:** 5523296
**Northing:** 389936

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | | | Skim of topsoil and organics |
| | | 0.5 | | |
| | | | | Sand w/ cobbles up to 200mm |
| | | 1 | | |
| | | 1.5 | | |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 1.5m

**Notes:**
No slumping of walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

SPERLING
HANSEN
ASSOCIATES

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-8
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 41 m
**Easting:** 389 879
**Northing:** 523256

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ▒ | | ▨ | Gravel driving surface |
| | ▒ | 0.5 | ▨ | |
| | ▒ | 1 | ▨ | Hard packed sand and 25-75mm cobbles |
| | ▒ | 1.5 | ▨ | |
| | ▒ | 2 | ▨ | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 2.0m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-9
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 43 m
**Easting:** 389843
**Northing:** 5523259

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | 0.5 | | |
| | | 1 | | |
| | | 1.5 | | |
| | | | | Wood chips mixed with soil |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | Hard packed sand and cobbles at bottom of pit |
| | | 4 | | |

**Total Depth:** 3.5m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

SPERLING
HANSEN
ASSOCIATES

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-10
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 42 m
**Easting:** 389837
**Northing:** 5523293

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ▨ | 0.5 | ▨ | Clean fill<br>Small layer of organics - Old ground surface |
| | ▨ | 1<br>1.5 | ▨ | sand with cobbles and fines |
| | | 2<br>2.5<br>3<br>3.5<br>4 | | |

**Total Depth:** 1.8m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-11
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 56 m
**Easting:** 389987
**Northing:** 5523327

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ░ | | ▤ | Skim of cover material and organics |
| | ░ | 0.5 | ■ | |
| | ░ | | ■ | Ash with metal |
| | ░ | 1 | ■ | |
| | ░ | 1.5 | ■ | |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 1.8m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-12
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 37 m
**Easting:** 389883
**Northing:** 5523205

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ░ | 0.5 | ▓ | Cover soil |
| | ░ | 1 | ░ | Stained sand |
| | | 1.5 | | |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 0.9m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-13
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 37 m
**Easting:** 389843
**Northing:** 5523191

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ░ | | ▤ | Skim of topsoil and organics |
| | ░ | 0.5 | ■ | |
| | ░ | | ■ | Ash |
| | ░ | 1 | ■ | |
| | ░ | 1.5 | ■ | |
| | ░ | 2 | ░ | Stained sand |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 2.1m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-14
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 38 m
**Easting:** 389852
**Northing:** 5523170

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | ░ | 0.5 | ▨ | |
| | ░ | 1 | ▨ | Clean fill |
| | ░ | 1.5 | ▨ | Layer of organics - old ground surface |
| | ░ | 2 | ░ | |
| | ░ | 2.5 | ░ | Sand |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 2.8m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-15
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 34 m
**Easting:** 389817
**Northing:** 5523191

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
|  | ░ |  | ▤ | Topsoil and roots |
|  | ░ | 0.5<br>1 | ▨ | Clean fill |
|  |  | 1.5<br>2<br>2.5<br>3<br>3.5<br>4 |  |  |

**Total Depth:** 1.0m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-16
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 35 m
**Easting:** 389816
**Northing:** 5523207

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | | ▤ | Topsoil and roots |
| | | 0.5 | ▨ | Clean fill |
| | | 1 | | |
| | | 1.5 | | |
| | | 2 | | |
| | | 2.5 | | |
| | | 3 | | |
| | | 3.5 | | |
| | | 4 | | |

**Total Depth:** 1.0m

**Notes:**

No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

**Client: Powell River** Regional District
**Project Name:** Powell River Landfill Closures
**Site:** Marine Ave.
**Project Number:** PRJ13043

**Test Pit:** TP-17
**Logged by:** Anthony Koeck
**Date:** Dec-11-13
**Elevation:** 43 m
**Easting:** 389969
**Northing:** 5523144

| Sample | Completion | Depth (m) | Lithology | Description |
|---|---|---|---|---|
| | | 0.5<br>1<br>1.5<br>2<br>2.5 | | Clean fill |
| | | 3<br>3.5<br>4 | | |

**Total Depth:** 2.8m

**Notes:**

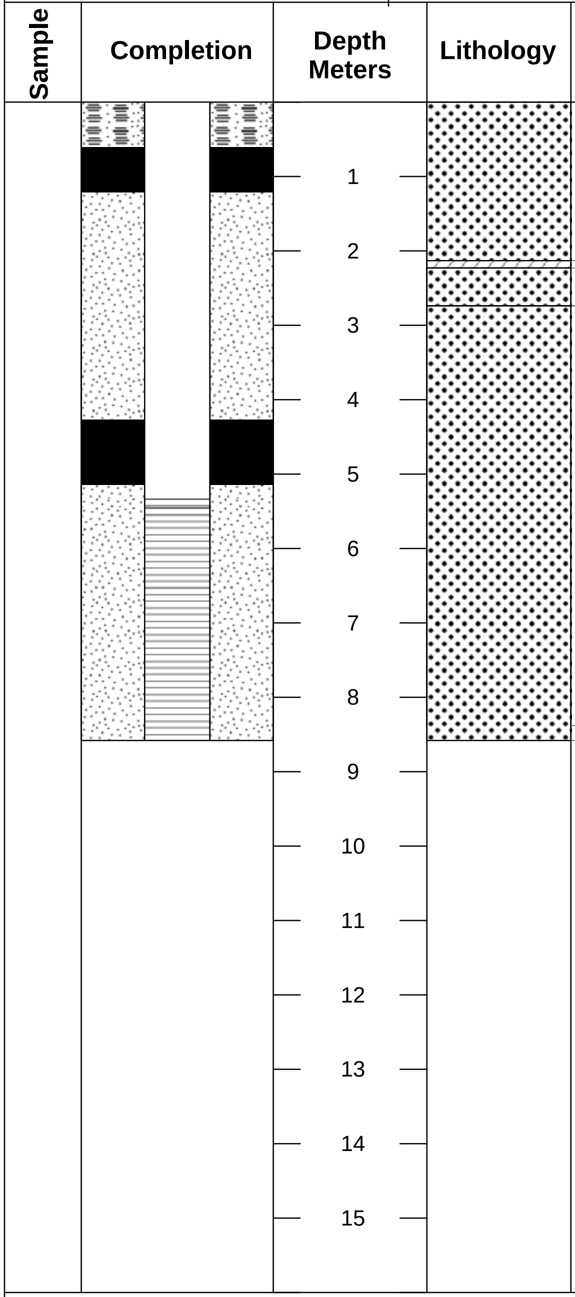
No Slumping of Test Pit Walls

**Powell River Regional District**
202-4675 Marine Avenue
Powell River, V8A 2L2
BC

SPERLING HANSEN ASSOCIATES

**Client:** District of Powell River
**Project Name:** Powell River Landfill Closure
**Site:** Marine Way
**Project No.:** Prj13043

**BOREHOLE: MW13-1**
**Logged By:** Mark Manning
**Date:** Dec 11, 2013
**Elevation:** 36 Meters
**Easting:** 389911
**Northing:** 5523403



**Description**

Fine Sand to Silt, Some Coarse Sand

Clay Lense
Fine Sand to Silt
Fine Sand to Silt, Some Coarse Sand
Fine Sand to Silt, Terminate Borehole at 8.38 BG

Flowing Sand, Fine to Medium, Some silt

**Total Depth:** 8.58 Meters
**Static Water Level:** 5.25 Meters

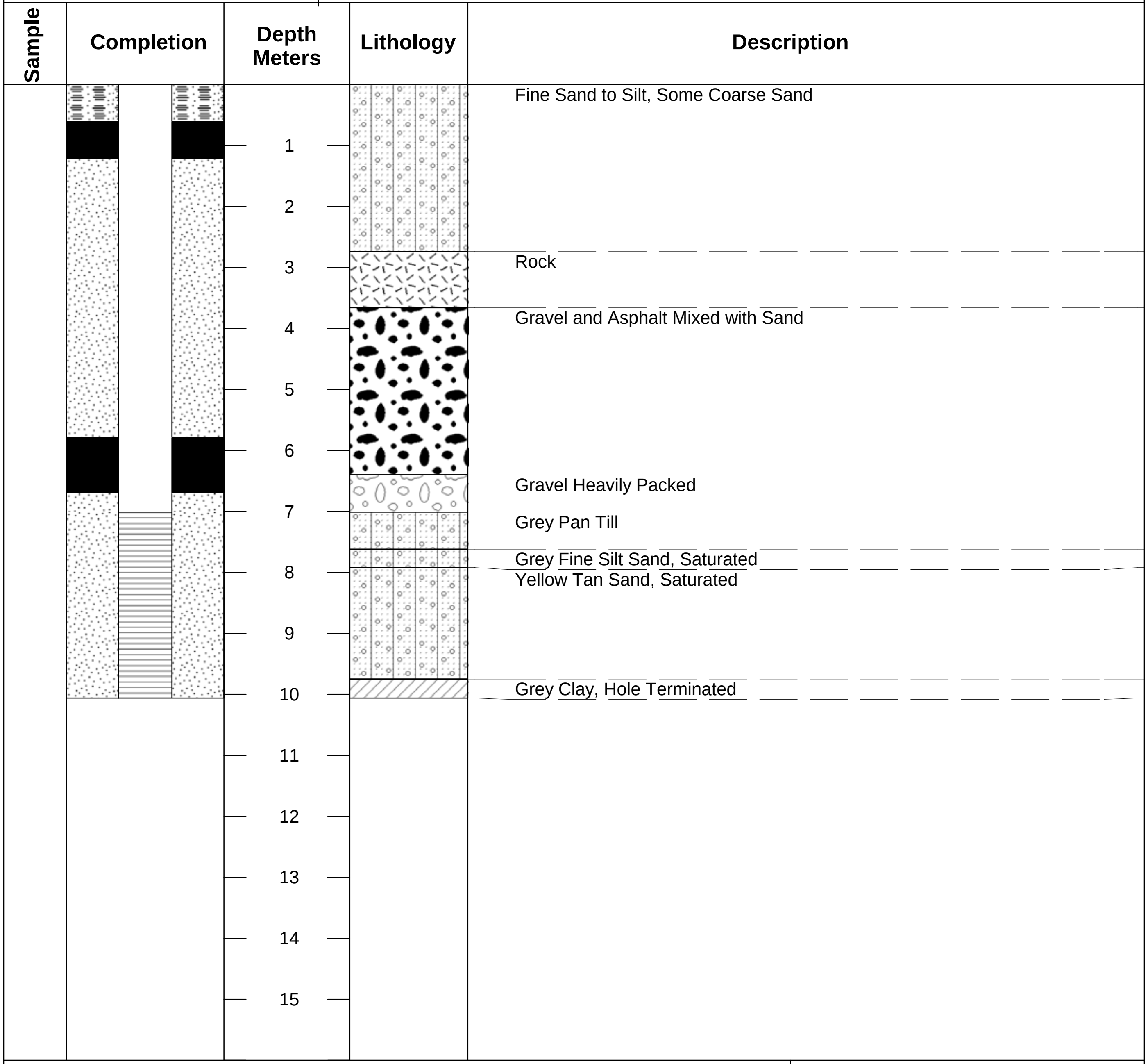
**Notes:**

Borehole Terminated at 8.38 m BG where a well with a 3.05 m screen was installed.

**District of Powell River**
Community Services Department
5811 Crown Ave
Powell River , V8A2L2

**Client:** District of Powell River
**Project Name:** Powell River Landfill Closure
**Site:** Marine Way
**Project No.:** Prj13043

**BOREHOLE:** **MW13-2**
**Logged By:** Mark Manning
**Date:** Dec 12, 2013
**Elevation:** 36 Meters
**Easting:** 389929
**Northing:** 5523114



**Total Depth:** 10.06 Meters
**Static Water Level:** 8.04 Meters

**Notes:**

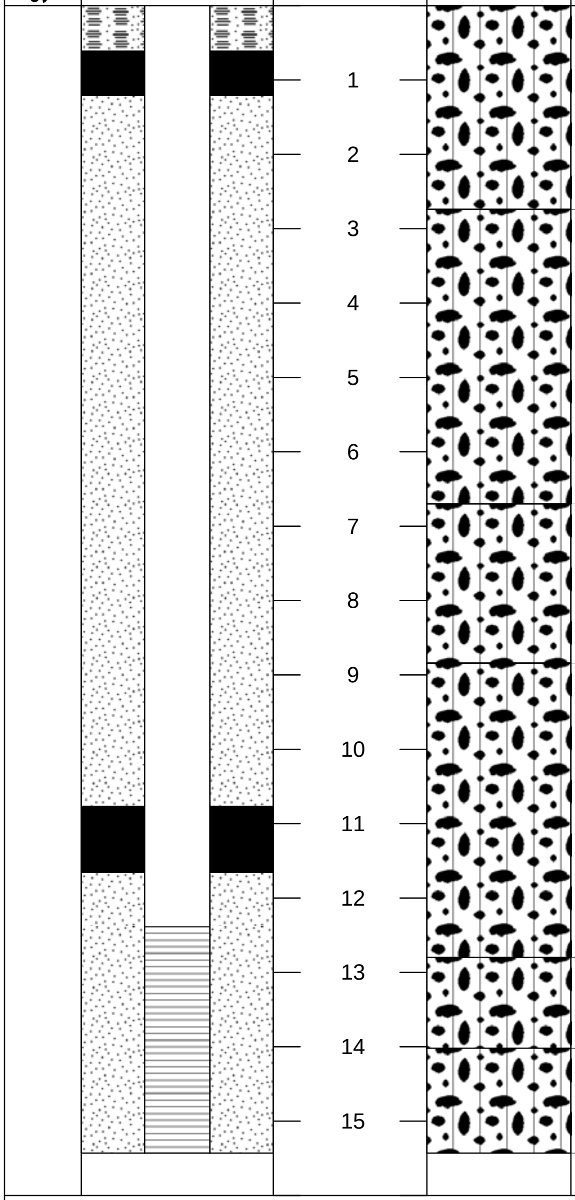
Borehole Terminated at 10.06 m BG where a well with a 3.05 m screen was installed.

**District of Powell River**
Community Services Department
5811 Crown Ave
Powell River , V8A2L2

**Client:** District of Powell River
**Project Name:** Powell River Landfill Closure
**Site:** Marine Way
**Project No.:** Prj13043

**BOREHOLE:** MW13-3
**Logged By:** Mark Manning
**Date:** Dec 16, 2013
**Elevation:** 47 Meters
**Easting:** 389856
**Northing:** 5523041

| Sample | Completion | Depth Meters | Lithology | Description |
|---|---|---|---|---|



Dense Till and Cobbles

Coarse Till Cobbles and Boulders

Cemented Pan Till

Tan Cloured Till

Compacted Gravel and Sandy Silt Saturated

Saturated Gravels and Silty Sands

**Total Depth:** 15.42 Meters
**Static Water Level:** 13.46 Meters

**Notes:**

Borehole Terminated at 15.43 m BG where a well with a 3.05 m screen was installed.

**District of Powell River**
Community Services Department
5811 Crown Ave
Powell River , V8A2L2

# APPENDIX C
# Test Pit and Borehole Photo logs

**Photograph 1:**
Marine Ave TP-1
Excavation

**Photograph 2:**
Marine Ave TP-1
Excavation

**Photograph 3:**
Marine Ave TP-2
Excavation

**Photograph 4:**
Marine Ave TP-2
Excavation

**Photograph 5:**
Marine Ave TP-3
Excavation

**Photograph 6:**
Marine Ave TP-3
Excavation

**Photograph 7:**
Marine Ave TP-4
Excavation

**Photograph 8:**
Marine Ave TP-4
Excavation

**Photograph 9:**
Marine Ave TP-5
Excavation

**Photograph 10:**
Marine Ave TP-5
Excavation

**Photograph 11:**
Marine Ave TP-6
Excavation

**Photograph 12:**
Marine Ave TP-6
Excavation

**Photograph 13:**
Marine Ave TP-7
Excavation

**Photograph 14:**
Marine Ave TP-8
Excavation

**Photograph 15:**
Marine Ave TP-9
Excavation

**Photograph 16:**
Marine Ave TP-9
Excavation

**Photograph 17:**
Marine Ave TP-10
Excavation

**Photograph 18:**
Marine Ave TP-10
Excavation

**Photograph 19:**
Marine Ave TP-11
Excavation

**Photograph 20:**
Marine Ave TP-12
Excavation

**Photograph 21:**
Marine Ave TP-13
Excavation

**Photograph 22:**
Marine Ave TP-14
Excavation

**Photograph 23:**
Marine Ave TP-15
Excavation

**Photograph 24:**
Marine Ave TP-16
Excavation

**Photograph 25:**
Marine Ave TP-17
Excavation

# APPENDIX D
# Wood Chips and Ash Analytical Results

Your Project #: 13043
Site Location: POWELL RIVER MARINE AVE
Your C.O.C. #: G091838

**Attention:Iqbal Bhuiyan**

Sperling Hansen Associates
#8-1225 East Keith Road
North Vancouver, BC
CANADA V7J 1J3

**Report Date: 2014/08/08**
Report #: R1617938
Version: 2

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B456369**
**Received: 2014/07/04, 11:26**

Sample Matrix: Soil
# Samples Received: 4

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Analytical Method |
|---|---|---|---|---|---|
| Elements by ICPMS (total) | 3 | 2014/07/07 | 2014/07/08 | BBY7SOP-00001 | EPA 6020A R1 m |
| Elements by ICPMS (total) | 1 | 2014/07/08 | 2014/07/09 | BBY7SOP-00001 | EPA 6020A R1 m |
| Moisture | 4 | N/A | 2014/07/07 | BBY8SOP-00017 | Ont MOE -E 3139 |
| PAH in Soil by GC/MS (SIM) | 2 | 2014/07/06 | 2014/07/08 | BBY8SOP-00022 | EPA 8270D |
| PAH in Soil by GC/MS (SIM) | 2 | 2014/07/06 | 2014/07/11 | BBY8SOP-00022 | EPA 8270D |
| Total LMW, HMW, Total PAH Calc | 2 | N/A | 2014/07/08 | BBY WI-00033 | BC MOE Lab Method |
| Total LMW, HMW, Total PAH Calc | 2 | N/A | 2014/07/11 | BBY WI-00033 | BC MOE Lab Method |
| pH (2:1 DI Water Extract) | 4 | 2014/07/08 | 2014/07/08 | BBY6SOP-00028 | BCMOE BCLM Jun2009 m |
| Dioxins/Furans Soil HRMS Subcontract (1) | 4 | 2014/08/08 | 2014/08/08 | | |

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Ontario (From Burnaby)

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Namita Sahni, Burnaby Project Manager
Email: NSahni@maxxam.ca
Phone# (604)639-2614
====================================================================

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

## RESULTS OF CHEMICAL ANALYSES OF SOIL

| **Maxxam ID** | | KA0700 | KA0701 | KA0702 | KA0703 | |
|---|---|---|---|---|---|---|
| **Sampling Date** | | 2014/07/03 | 2014/07/03 | 2014/07/03 | 2014/07/03 | |
| **COC Number** | | G091838 | G091838 | G091838 | G091838 | |
| | **Units** | **F-1** | **F-2** | **F-3** | **D-1** | **QC Batch** |
| **Parameter** | | | | | | |
| Subcontract Parameter | N/A | ATTACHED | ATTACHED | ATTACHED | ATTACHED | 7593798 |

# PHYSICAL TESTING (SOIL)

| **Maxxam ID** | | KA0700 | KA0701 | KA0702 | KA0703 | | |
|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2014/07/03 | 2014/07/03 | 2014/07/03 | 2014/07/03 | | |
| **COC Number** | | G091838 | G091838 | G091838 | G091838 | | |
| | **Units** | **F-1** | **F-2** | **F-3** | **D-1** | **RDL** | **QC Batch** |
| **Physical Properties** | | | | | | | |
| Moisture | % | 10 | 16 | 13 | 6.3 | 0.30 | 7552716 |

RDL = Reportable Detection Limit

Maxxam Job #: B456369
Report Date: 2014/08/08

Sperling Hansen Associates
Client Project #: 13043
Site Location: POWELL RIVER MARINE AVE

## CSR/CCME METALS IN SOIL (SOIL)

| **Maxxam ID** | | KA0700 | KA0701 | | KA0702 | | KA0703 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2014/07/03 | 2014/07/03 | | 2014/07/03 | | 2014/07/03 | | |
| **COC Number** | | G091838 | G091838 | | G091838 | | G091838 | | |
| | **Units** | **F-1** | **F-2** | **QC Batch** | **F-3** | **QC Batch** | **D-1** | **RDL** | **QC Batch** |
| **Physical Properties** | | | | | | | | | |
| Soluble (2:1) pH | pH | 7.56 | 8.00 | 7553999 | 7.87 | 7555947 | 7.96 | N/A | 7553999 |
| **Total Metals by ICPMS** | | | | | | | | | |
| Total Aluminum (Al) | mg/kg | 11900 | 16200 | 7553978 | 13400 | 7555938 | 15900 | 100 | 7553978 |
| Total Antimony (Sb) | mg/kg | 39.0 | 44.3 | 7553978 | 44.4 | 7555938 | 22.2 | 0.10 | 7553978 |
| Total Arsenic (As) | mg/kg | 75.0 | 12.9 | 7553978 | 32.1 | 7555938 | 8.57 | 0.50 | 7553978 |
| Total Barium (Ba) | mg/kg | 646 | 213 | 7553978 | 226 | 7555938 | 246 | 0.10 | 7553978 |
| Total Beryllium (Be) | mg/kg | <0.40 | <0.40 | 7553978 | <0.40 | 7555938 | <0.40 | 0.40 | 7553978 |
| Total Bismuth (Bi) | mg/kg | 0.63 | 0.43 | 7553978 | 0.47 | 7555938 | 0.94 | 0.10 | 7553978 |
| Total Cadmium (Cd) | mg/kg | 1.94 | 3.68 | 7553978 | 2.44 | 7555938 | 2.97 | 0.050 | 7553978 |
| Total Calcium (Ca) | mg/kg | 20300 | 21200 | 7553978 | 18400 | 7555938 | 22900 | 100 | 7553978 |
| Total Chromium (Cr) | mg/kg | 62.0 | 71.2 | 7553978 | 43.0 | 7555938 | 91.5 | 1.0 | 7553978 |
| Total Cobalt (Co) | mg/kg | 10.7 | 7.96 | 7553978 | 7.08 | 7555938 | 10.1 | 0.30 | 7553978 |
| Total Copper (Cu) | mg/kg | 341 | 956 | 7553978 | 866 | 7555938 | 619 | 0.50 | 7553978 |
| Total Iron (Fe) | mg/kg | 45600 | 58700 | 7553978 | 46900 | 7555938 | 37000 | 100 | 7553978 |
| Total Lead (Pb) | mg/kg | 344 | 435 | 7553978 | 1030 | 7555938 | 496 | 0.10 | 7553978 |
| Total Lithium (Li) | mg/kg | 5.4 | 6.2 | 7553978 | 5.2 | 7555938 | 6.3 | 5.0 | 7553978 |
| Total Magnesium (Mg) | mg/kg | 3450 | 3150 | 7553978 | 2900 | 7555938 | 3350 | 100 | 7553978 |
| Total Manganese (Mn) | mg/kg | 487 | 1160 | 7553978 | 602 | 7555938 | 867 | 0.20 | 7553978 |
| Total Mercury (Hg) | mg/kg | 0.077 | <0.050 | 7553978 | 0.057 | 7555938 | <0.050 | 0.050 | 7553978 |
| Total Molybdenum (Mo) | mg/kg | 10.4 | 12.6 | 7553978 | 9.35 | 7555938 | 5.67 | 0.10 | 7553978 |
| Total Nickel (Ni) | mg/kg | 62.7 | 93.7 | 7553978 | 45.5 | 7555938 | 93.9 | 0.80 | 7553978 |
| Total Phosphorus (P) | mg/kg | 1180 | 1930 | 7553978 | 1590 | 7555938 | 2240 | 10 | 7553978 |
| Total Potassium (K) | mg/kg | 1430 | 1310 | 7553978 | 1080 | 7555938 | 1330 | 100 | 7553978 |
| Total Selenium (Se) | mg/kg | <0.50 | <0.50 | 7553978 | <0.50 | 7555938 | <0.50 | 0.50 | 7553978 |
| Total Silver (Ag) | mg/kg | 0.583 | 1.43 | 7553978 | 0.998 | 7555938 | 1.56 | 0.050 | 7553978 |
| Total Sodium (Na) | mg/kg | 989 | 1820 | 7553978 | 1670 | 7555938 | 1880 | 100 | 7553978 |
| Total Strontium (Sr) | mg/kg | 84.8 | 81.7 | 7553978 | 74.3 | 7555938 | 81.3 | 0.10 | 7553978 |
| Total Thallium (Tl) | mg/kg | <0.050 | <0.050 | 7553978 | <0.050 | 7555938 | <0.050 | 0.050 | 7553978 |
| Total Tin (Sn) | mg/kg | 45.2 | 57.3 | 7553978 | 66.3 | 7555938 | 54.4 | 0.10 | 7553978 |
| Total Titanium (Ti) | mg/kg | 531 | 731 | 7553978 | 719 | 7555938 | 790 | 1.0 | 7553978 |
| Total Uranium (U) | mg/kg | 0.827 | 0.432 | 7553978 | 0.628 | 7555938 | 0.415 | 0.050 | 7553978 |
| Total Vanadium (V) | mg/kg | 36.0 | 32.2 | 7553978 | 32.6 | 7555938 | 36.9 | 2.0 | 7553978 |
| Total Zinc (Zn) | mg/kg | 1620 | 1480 | 7553978 | 1210 | 7555938 | 1790 | 1.0 | 7553978 |
| Total Zirconium (Zr) | mg/kg | 0.99 | 2.39 | 7553978 | 1.91 | 7555938 | 2.72 | 0.50 | 7553978 |

RDL = Reportable Detection Limit
N/A = Not Applicable

## CSR PAH IN SOIL BY GC-MS (SOIL)

| **Maxxam ID** | | KA0700 | | KA0701 | KA0702 | KA0703 | | |
|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2014/07/03 | | 2014/07/03 | 2014/07/03 | 2014/07/03 | | |
| **COC Number** | | G091838 | | G091838 | G091838 | G091838 | | |
| | **Units** | **F-1** | **RDL** | **F-2** | **F-3** | **D-1** | **RDL** | **QC Batch** |
| **Polycyclic Aromatics** | | | | | | | | |
| Naphthalene | mg/kg | <0.050 | 0.050 | 0.10 | <0.050 | <0.050 | 0.050 | 7554304 |
| 2-Methylnaphthalene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Acenaphthylene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Acenaphthene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Fluorene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Phenanthrene | mg/kg | 0.059 | 0.050 | 0.11 | 0.072 | 0.18 | 0.050 | 7554304 |
| Anthracene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Fluoranthene | mg/kg | 0.052 | 0.050 | 0.081 | 0.064 | 0.27 | 0.050 | 7554304 |
| Pyrene | mg/kg | 0.056 | 0.050 | 0.065 | 0.060 | 0.22 | 0.050 | 7554304 |
| Benzo(a)anthracene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | 0.068 | 0.050 | 7554304 |
| Chrysene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | 0.082 | 0.050 | 7554304 |
| Benzo(b&j)fluoranthene | mg/kg | <0.059 (1) | 0.059 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Benzo(k)fluoranthene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Benzo(a)pyrene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Indeno(1,2,3-cd)pyrene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Dibenz(a,h)anthracene | mg/kg | <0.050 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Benzo(g,h,i)perylene | mg/kg | 0.084 | 0.050 | <0.050 | <0.050 | <0.050 | 0.050 | 7554304 |
| Low Molecular Weight PAH`s | mg/kg | 0.059 | 0.050 | 0.22 | 0.073 | 0.18 | 0.050 | 7553023 |
| High Molecular Weight PAH`s | mg/kg | 0.19 | 0.059 | 0.15 | 0.12 | 0.64 | 0.050 | 7553023 |
| Total PAH | mg/kg | 0.25 | 0.059 | 0.36 | 0.20 | 0.83 | 0.050 | 7553023 |
| **Surrogate Recovery (%)** | | | | | | | | |
| D10-ANTHRACENE (sur.) | % | 74 | | 69 | 73 | 78 | | 7554304 |
| D8-ACENAPHTHYLENE (sur.) | % | 76 | | 85 | 81 | 88 | | 7554304 |
| D8-NAPHTHALENE (sur.) | % | 83 | | 86 | 85 | 89 | | 7554304 |
| TERPHENYL-D14 (sur.) | % | 79 | | 78 | 79 | 87 | | 7554304 |

RDL = Reportable Detection Limit

(1) RDL raised due to sample matrix interference.

## GENERAL COMMENTS

**Results relate only to the items tested.**

## QUALITY ASSURANCE REPORT

| | | | Matrix Spike | | Spiked Blank | | Method Blank | | QC Standard | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | Units | % Recovery | QC Limits |
| 7554304 | D10-ANTHRACENE (sur.) | 2014/07/07 | 93 | 60 - 130 | 93 | 60 - 130 | 94 | % | | |
| 7554304 | D8-ACENAPHTHYLENE (sur.) | 2014/07/07 | 91 | 50 - 130 | 90 | 50 - 130 | 89 | % | | |
| 7554304 | D8-NAPHTHALENE (sur.) | 2014/07/07 | 91 | 50 - 130 | 91 | 50 - 130 | 91 | % | | |
| 7554304 | TERPHENYL-D14 (sur.) | 2014/07/07 | 94 | 60 - 130 | 98 | 60 - 130 | 96 | % | | |
| 7552716 | Moisture | 2014/07/07 | | | | | <0.30 | % | | |
| 7553978 | Total Aluminum (Al) | 2014/07/08 | | | | | <100 | mg/kg | 111 | 70 - 130 |
| 7553978 | Total Antimony (Sb) | 2014/07/08 | 104 | 75 - 125 | 98 | 75 - 125 | <0.10 | mg/kg | 94 | 70 - 130 |
| 7553978 | Total Arsenic (As) | 2014/07/08 | 112 | 75 - 125 | 103 | 75 - 125 | 0.60 ,RDL=0.50 | mg/kg | 100 | 70 - 130 |
| 7553978 | Total Barium (Ba) | 2014/07/08 | NC | 75 - 125 | 101 | 75 - 125 | <0.10 | mg/kg | 102 | 70 - 130 |
| 7553978 | Total Beryllium (Be) | 2014/07/08 | 109 | 75 - 125 | 101 | 75 - 125 | <0.40 | mg/kg | | |
| 7553978 | Total Bismuth (Bi) | 2014/07/08 | | | | | <0.10 | mg/kg | | |
| 7553978 | Total Cadmium (Cd) | 2014/07/08 | 111 | 75 - 125 | 108 | 75 - 125 | <0.050 | mg/kg | 105 | 70 - 130 |
| 7553978 | Total Calcium (Ca) | 2014/07/08 | | | | | <100 | mg/kg | 96 | 70 - 130 |
| 7553978 | Total Chromium (Cr) | 2014/07/08 | NC | 75 - 125 | 106 | 75 - 125 | <1.0 | mg/kg | 117 | 70 - 130 |
| 7553978 | Total Cobalt (Co) | 2014/07/08 | 103 | 75 - 125 | 104 | 75 - 125 | <0.30 | mg/kg | 98 | 70 - 130 |
| 7553978 | Total Copper (Cu) | 2014/07/08 | NC | 75 - 125 | 102 | 75 - 125 | <0.50 | mg/kg | 97 | 70 - 130 |
| 7553978 | Total Iron (Fe) | 2014/07/08 | | | | | <100 | mg/kg | 99 | 70 - 130 |
| 7553978 | Total Lead (Pb) | 2014/07/08 | 104 | 75 - 125 | 103 | 75 - 125 | <0.10 | mg/kg | 98 | 70 - 130 |
| 7553978 | Total Lithium (Li) | 2014/07/08 | 109 | 75 - 125 | 95 | 75 - 125 | <5.0 | mg/kg | | |
| 7553978 | Total Magnesium (Mg) | 2014/07/08 | | | | | <100 | mg/kg | 98 | 70 - 130 |
| 7553978 | Total Manganese (Mn) | 2014/07/08 | NC | 75 - 125 | 103 | 75 - 125 | <0.20 | mg/kg | 103 | 70 - 130 |
| 7553978 | Total Mercury (Hg) | 2014/07/08 | 109 | 75 - 125 | 102 | 75 - 125 | <0.050 | mg/kg | 91 | 70 - 130 |
| 7553978 | Total Molybdenum (Mo) | 2014/07/08 | 106 | 75 - 125 | 93 | 75 - 125 | <0.10 | mg/kg | 103 | 70 - 130 |
| 7553978 | Total Nickel (Ni) | 2014/07/08 | 110 | 75 - 125 | 100 | 75 - 125 | <0.80 | mg/kg | 97 | 70 - 130 |
| 7553978 | Total Phosphorus (P) | 2014/07/08 | | | | | <10 | mg/kg | 97 | 70 - 130 |
| 7553978 | Total Potassium (K) | 2014/07/08 | | | | | <100 | mg/kg | | |
| 7553978 | Total Selenium (Se) | 2014/07/08 | 122 | 75 - 125 | 116 | 75 - 125 | <0.50 | mg/kg | | |
| 7553978 | Total Silver (Ag) | 2014/07/08 | 103 | 75 - 125 | 98 | 75 - 125 | <0.050 | mg/kg | | |
| 7553978 | Total Sodium (Na) | 2014/07/08 | | | | | <100 | mg/kg | | |
| 7553978 | Total Strontium (Sr) | 2014/07/08 | NC | 75 - 125 | 96 | 75 - 125 | <0.10 | mg/kg | 100 | 70 - 130 |
| 7553978 | Total Thallium (Tl) | 2014/07/08 | 92 | 75 - 125 | 97 | 75 - 125 | <0.050 | mg/kg | 91 | 70 - 130 |
| 7553978 | Total Tin (Sn) | 2014/07/08 | 97 | 75 - 125 | 90 | 75 - 125 | <0.10 | mg/kg | | |

# QUALITY ASSURANCE REPORT(CONT'D)

| | | | Matrix Spike | | Spiked Blank | | Method Blank | | QC Standard | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | Units | % Recovery | QC Limits |
| 7553978 | Total Titanium (Ti) | 2014/07/08 | NC | 75 - 125 | 98 | 75 - 125 | <1.0 | mg/kg | 117 | 70 - 130 |
| 7553978 | Total Uranium (U) | 2014/07/08 | 107 | 75 - 125 | 99 | 75 - 125 | <0.050 | mg/kg | 100 | 70 - 130 |
| 7553978 | Total Vanadium (V) | 2014/07/08 | NC | 75 - 125 | 102 | 75 - 125 | <2.0 | mg/kg | 114 | 70 - 130 |
| 7553978 | Total Zinc (Zn) | 2014/07/08 | NC | 75 - 125 | 116 | 75 - 125 | <1.0 | mg/kg | 96 | 70 - 130 |
| 7553978 | Total Zirconium (Zr) | 2014/07/08 | | | | | <0.50 | mg/kg | | |
| 7553999 | Soluble (2:1) pH | 2014/07/08 | | | 100 | 97 - 103 | | | | |
| 7554304 | 2-Methylnaphthalene | 2014/07/07 | 92 | 50 - 130 | 93 | 50 - 130 | <0.050 | mg/kg | | |
| 7554304 | Acenaphthene | 2014/07/07 | 91 | 50 - 130 | 95 | 50 - 130 | <0.050 | mg/kg | | |
| 7554304 | Acenaphthylene | 2014/07/07 | 90 | 50 - 130 | 92 | 50 - 130 | <0.050 | mg/kg | | |
| 7554304 | Anthracene | 2014/07/07 | 93 | 60 - 130 | 98 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Benzo(a)anthracene | 2014/07/07 | 85 | 60 - 130 | 92 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Benzo(a)pyrene | 2014/07/07 | 95 | 60 - 130 | 100 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Benzo(b&j)fluoranthene | 2014/07/07 | 101 | 60 - 130 | 107 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Benzo(g,h,i)perylene | 2014/07/07 | 97 | 60 - 130 | 95 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Benzo(k)fluoranthene | 2014/07/07 | 87 | 60 - 130 | 93 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Chrysene | 2014/07/07 | 87 | 60 - 130 | 94 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Dibenz(a,h)anthracene | 2014/07/07 | 108 | 60 - 130 | 106 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Fluoranthene | 2014/07/07 | 93 | 60 - 130 | 99 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Fluorene | 2014/07/07 | 92 | 50 - 130 | 96 | 50 - 130 | <0.050 | mg/kg | | |
| 7554304 | Indeno(1,2,3-cd)pyrene | 2014/07/07 | 108 | 60 - 130 | 106 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Naphthalene | 2014/07/07 | 91 | 50 - 130 | 93 | 50 - 130 | <0.050 | mg/kg | | |
| 7554304 | Phenanthrene | 2014/07/07 | 86 | 60 - 130 | 91 | 60 - 130 | <0.050 | mg/kg | | |
| 7554304 | Pyrene | 2014/07/07 | 93 | 60 - 130 | 100 | 60 - 130 | <0.050 | mg/kg | | |
| 7555938 | Total Aluminum (Al) | 2014/07/09 | | | | | <100 | mg/kg | 111 | 70 - 130 |
| 7555938 | Total Antimony (Sb) | 2014/07/09 | 100 | 75 - 125 | 96 | 75 - 125 | <0.10 | mg/kg | 89 | 70 - 130 |
| 7555938 | Total Arsenic (As) | 2014/07/09 | NC | 75 - 125 | 101 | 75 - 125 | 0.83 ,RDL=0.50 | mg/kg | 101 | 70 - 130 |
| 7555938 | Total Barium (Ba) | 2014/07/09 | NC | 75 - 125 | 103 | 75 - 125 | <0.10 | mg/kg | 100 | 70 - 130 |
| 7555938 | Total Beryllium (Be) | 2014/07/09 | 98 | 75 - 125 | 102 | 75 - 125 | <0.40 | mg/kg | | |
| 7555938 | Total Bismuth (Bi) | 2014/07/09 | | | | | <0.10 | mg/kg | | |
| 7555938 | Total Cadmium (Cd) | 2014/07/09 | 104 | 75 - 125 | 106 | 75 - 125 | <0.050 | mg/kg | 106 | 70 - 130 |
| 7555938 | Total Calcium (Ca) | 2014/07/09 | | | | | <100 | mg/kg | 93 | 70 - 130 |
| 7555938 | Total Chromium (Cr) | 2014/07/09 | 103 | 75 - 125 | 101 | 75 - 125 | <1.0 | mg/kg | 111 | 70 - 130 |

## QUALITY ASSURANCE REPORT(CONT'D)

| | | | Matrix Spike | | Spiked Blank | | Method Blank | | QC Standard | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | Units | % Recovery | QC Limits |
| 7555938 | Total Cobalt (Co) | 2014/07/09 | NC | 75 - 125 | 101 | 75 - 125 | <0.30 | mg/kg | 92 | 70 - 130 |
| 7555938 | Total Copper (Cu) | 2014/07/09 | 106 | 75 - 125 | 107 | 75 - 125 | <0.50 | mg/kg | 92 | 70 - 130 |
| 7555938 | Total Iron (Fe) | 2014/07/09 | | | | | <100 | mg/kg | 97 | 70 - 130 |
| 7555938 | Total Lead (Pb) | 2014/07/09 | 104 | 75 - 125 | 106 | 75 - 125 | <0.10 | mg/kg | 101 | 70 - 130 |
| 7555938 | Total Lithium (Li) | 2014/07/09 | 94 | 75 - 125 | 99 | 75 - 125 | <5.0 | mg/kg | | |
| 7555938 | Total Magnesium (Mg) | 2014/07/09 | | | | | <100 | mg/kg | 93 | 70 - 130 |
| 7555938 | Total Manganese (Mn) | 2014/07/09 | NC | 75 - 125 | 101 | 75 - 125 | 0.23 ,RDL=0.20 | mg/kg | 98 | 70 - 130 |
| 7555938 | Total Mercury (Hg) | 2014/07/09 | 96 | 75 - 125 | 98 | 75 - 125 | <0.050 | mg/kg | 84 | 70 - 130 |
| 7555938 | Total Molybdenum (Mo) | 2014/07/09 | NC | 75 - 125 | 98 | 75 - 125 | <0.10 | mg/kg | 107 | 70 - 130 |
| 7555938 | Total Nickel (Ni) | 2014/07/09 | NC | 75 - 125 | 104 | 75 - 125 | <0.80 | mg/kg | 98 | 70 - 130 |
| 7555938 | Total Phosphorus (P) | 2014/07/09 | | | | | <10 | mg/kg | 95 | 70 - 130 |
| 7555938 | Total Potassium (K) | 2014/07/09 | | | | | <100 | mg/kg | | |
| 7555938 | Total Selenium (Se) | 2014/07/09 | 111 | 75 - 125 | 106 | 75 - 125 | <0.50 | mg/kg | | |
| 7555938 | Total Silver (Ag) | 2014/07/09 | 94 | 75 - 125 | 101 | 75 - 125 | <0.050 | mg/kg | | |
| 7555938 | Total Sodium (Na) | 2014/07/09 | | | | | <100 | mg/kg | | |
| 7555938 | Total Strontium (Sr) | 2014/07/09 | NC | 75 - 125 | 99 | 75 - 125 | <0.10 | mg/kg | 102 | 70 - 130 |
| 7555938 | Total Thallium (Tl) | 2014/07/09 | 99 | 75 - 125 | 99 | 75 - 125 | <0.050 | mg/kg | 96 | 70 - 130 |
| 7555938 | Total Tin (Sn) | 2014/07/09 | 92 | 75 - 125 | 95 | 75 - 125 | <0.10 | mg/kg | | |
| 7555938 | Total Titanium (Ti) | 2014/07/09 | NC | 75 - 125 | 93 | 75 - 125 | <1.0 | mg/kg | 113 | 70 - 130 |
| 7555938 | Total Uranium (U) | 2014/07/09 | 107 | 75 - 125 | 103 | 75 - 125 | <0.050 | mg/kg | 106 | 70 - 130 |
| 7555938 | Total Vanadium (V) | 2014/07/09 | 101 | 75 - 125 | 99 | 75 - 125 | <2.0 | mg/kg | 110 | 70 - 130 |
| 7555938 | Total Zinc (Zn) | 2014/07/09 | NC | 75 - 125 | 112 | 75 - 125 | <1.0 | mg/kg | 94 | 70 - 130 |
| 7555938 | Total Zirconium (Zr) | 2014/07/09 | | | | | <0.50 | mg/kg | | |
| 7555947 | Soluble (2:1) pH | 2014/07/08 | | | 99 | 97 - 103 | | | | |

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

## VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Data Validation Coordinator

S. Namita.

Namita Sahni, Burnaby Project Manager

---

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

4606 Canada Way, Burnaby, BC Canada V5G 1K5 Ph: 604 734 7276 Toll Free: 1 800 665 8566 Fax: 604 731 2386

Maxxam Job#: B456369

**CHAIN OF CUSTODY RECORD**

Page: ___ of ___

G 091838

**Invoice To:** Require Report? Yes ☐ No ☒

Company Name: Sperling Hansen Assoc
Contact Name: Mark [illegible]
Address: #8 1225 East Keith Rd
PC:
Phone / Fax#: Ph: Fax:
E-mail Ibhuiyan@sperlinghansen.com

**Report To:**

Company Name: Iqbal Bhuiyan
Contact Name:
Address:
PC:
Phone / Fax#: Ph: Fax:
E-mail

PO #:
Quotation #:
Project #: Pr. ~~[illegible]~~, 13043
Proj. Name: Powell River Marine Ave
Location:
Sampled By:

**REGULATORY REQUIREMENTS SERVICE REQUESTED:**

☐ CSR
☐ CCME
☐ BC Water Quality
☐ Other
☐ DRINKING WATER

☒ Regular Turn Around Time (TAT)
(5 days for most tests)
☐ RUSH (Please contact the lab)
☐ 1 Day ☐ 2 Day ☐ 3 Day
Date Required:

**Special Instructions:**

**Return Cooler** ☐ **Ship Sample Bottles (please specify)** ☐

**ANALYSIS REQUESTED**

| | Sample Identification | Lab Identification | Sample Type | Date/Time Sampled | BTEX/VPH ☐ MTBE ☐ | VOC/VPH ☐ | EPH ☐ TEH ☐ | PAH ☑ LEPH/HEPH ☐ | CCME-PHC (Fractions 1-4 Plus BTEX) | CCME-PHC (Fractions 2-4) | CCME BTEX (Fraction 1 Plus BTEX) | PCB ☐ | Phenols by 4AAP ☐ Phenols by GCMS ☐ | TOG ☐ MOG ☐ SWOG ☐ | Dissolved Metals Field Filtered? Y ☐ N ☐ | Dissolved Metals Field Acidified? Y ☐ N ☐ | Totals Metals Field Acidified? Y ☐ N ☐ | Nitrate ☐ Nitrite ☐ Ammonia ☐ | Chloride ☐ Fluoride ☐ Sulphate ☐ | Total Suspended Solids-TSS ☐ TDS ☐ | pH ☐ Conductivity ☐ Alkalinity ☐ | BOD ☐ | COD ☐ | Coliform, Total & E.coli ☐ Fecal ☐ | Asbestos ☐ | DIOXINS + FURANS | | | | | | HOLD ☐ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F-1 | KA0700 | ASH 1 | ~~Sm~~ July | | | | X | | | | | | | | | X | | | | | | | | | X | | | | | | |
| 2 | F-2 | KA0701 | ASH | 3/14 | | | | X | | | | | | | | | X | | | | | | | | | X | | | | | | |
| 3 | F-3 | KA0702 | ASH | 〃 | | | | X | | | | | | | | | X | | | | | | | | | X | | | | | | |
| 4 | D-1 | KA0703 | ASH | 〃 | | | | X | | | | | | | | | X | | | | | | | | | X | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

B456369

Samples are from a Drinking Water Source? YES ☐ NO ☐
Does source supply multiple households? YES ☐ NO ☐

| *Relinquished by: | Date (YY/MM/DD): | Time: | Received by: | Date (YY/MM/DD): | Time: |
|---|---|---|---|---|---|
| | 4/7/14 | 11:26 | | ~~July 3/2014~~ | |

Laboratory Use Only

| Time Sensitive | Temperature on Receipt (°C) | Custody Seal Intact on Cooler? |
|---|---|---|
| ☐ | 21, 21, 22 | NA<br>Yes ☐ No ☐ |

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

COC-1020 (05/10)

Maxxam International Corporation o/a Maxxam Analytics

Noelle Laurel Berthier 2014/07/04 11:26

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E: Surrey@exova.com
W: www.exova.com

## Report Transmission Cover Page

|  |  |  |  |
|---|---|---|---|
| Bill To: | Sperling Hansen & Associates | Project: |  |
| Report To: | Sperling Hansen & Associates | ID: | PM 13043 |
|  | 8 - 1225 East Keith Road | Name: | Powell River Marine |
|  | North Vancouver, BC, Canada | Location: | Powell River |
|  | V7M 1J3 | LSD: |  |
| Attn: | Iqbal Bhuiyan | P.O.: |  |
| Sampled By: | MN | Acct code: | (Additional) |
| Company: | Sperling Hansen |  |  |

|  |  |
|---|---|
| Lot ID: | **1012186** |
| Control Number: | B047899 |
| Date Received: | Jul 4, 2014 |
| Date Reported: | Aug 5, 2014 |
| Report Number: | 1936588 |

| Contact & Affiliation | Address | Delivery Commitments |
|---|---|---|
| Iqbal Bhuiyan<br>Sperling Hansen & Associates | 8 - 1225 East Keith Road<br>North Vancouver, British Columbia V7M 1J3<br>Phone: (604) 986-7723<br>Fax: (604) 986-7734<br>Email: ibhuiyan@sperlinghansen.com | On [Lot Verification] send<br>(COA) by Email - Single Report<br>On [Report Approval] send<br>(COC, Test Report) by Email - Merge Reports<br>On [Report Approval] send<br>(Test Report, COC) by Email - Merge Reports<br>On [Lot Approval and Final Test Report Approval] send<br>(Invoice) by Email - Single Report<br>On [Lot Approval and Final Test Report Approval] send<br>(Invoice) by Email - Single Report |

**Notes To Clients:**

- Report was issued to include addition of Heating Value analysis on 1012186-1 and -2 requested by Iqbal Bhuiyan of Sperling Hansen & Associates on July 30, 2014. Previous report 1929847.
- %TKN analysis was performed by a subcontract laboratory. See attached 3 page report #2014715160918_0015.
- Heating Value analysis was performed by a subcontract laboratory. See attached 3 page certificate of analysis 14-612535.

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## Analytical Report

Bill To: Sperling Hansen & Associates
Report To: Sperling Hansen & Associates
8 - 1225 East Keith Road
North Vancouver, BC, Canada
V7M 1J3
Attn: Iqbal Bhuiyan
Sampled By: MN
Company: Sperling Hansen

Project:
ID: PM 13043
Name: Powell River Marine
Location: Powell River
LSD:
P.O.:
Acct code: (Additional)

Lot ID: **1012186**
Control Number: B047899
Date Received: Jul 4, 2014
Date Reported: Aug 5, 2014
Report Number: 1936588

| | | |
|---|---|---|
| **Reference Number** | 1012186-1 | 1012186-2 |
| **Sample Date** | Jul 03, 2014 | Jul 03, 2014 |
| **Sample Time** | NA | NA |
| **Sample Location** | | |
| **Sample Description** | J-1 | J-2 |
| **Matrix** | Soil | Soil |

| **Analyte** | | **Units** | **Results** | **Results** | **Results** | Nominal Detection Limit |
|---|---|---|---|---|---|---|
| **Available Nutrients** | | | | | | |
| Nitrate - N | Available | ug/g | 3 | <2 | | 2 |
| Phosphorus | Available | ug/g | 45 | 33 | | 5 |
| Potassium | Available | ug/g | 205 | 161 | | 25 |
| Sulfate-S | Available | mg/kg | 38 | 30 | | 1 |
| Calcium | Available | mg/kg | 3120 | 3010 | | 30 |
| Magnesium | Available | mg/kg | 283 | 185 | | 5 |
| Sodium | Available | mg/kg | <30 | 50 | | 30 |
| Ammonium - N | Available-dry basis | ug/g | 1.2 | 1.3 | | 0.3 |
| **Classification** | | | | | | |
| C:N Ratio | | | 38.6 | 37.4 | | 0.1 |
| Carbon | Total | % | 16.7 | 13.5 | | 0.02 |
| Nitrogen | Total | % | 0.43 | 0.36 | | 0.02 |
| Organic Matter | Calculated Value | % | 33.2 | 26.8 | | 0.04 |
| Carbon | Total Organic | % | 16.6 | 13.4 | | 0.04 |
| **Hot Water Soluble** | | | | | | |
| Boron | Water Soluble | ug/g | 1.13 | 2.28 | | 0.02 |
| **Metals Strong Acid Digestion** | | | | | | |
| Antimony | Strong Acid Extractable | ug/g | 4.1 | 10.3 | | 0.5 |
| Arsenic | Strong Acid Extractable | ug/g | 12.3 | 14.2 | | 0.2 |
| Barium | Strong Acid Extractable | ug/g | 100 | 105 | | 0.03 |
| Beryllium | Strong Acid Extractable | ug/g | <0.01 | <0.01 | | 0.01 |
| Cadmium | Strong Acid Extractable | ug/g | 1.05 | 0.75 | | 0.05 |
| Chromium | Strong Acid Extractable | ug/g | 88.7 | 146 | | 0.04 |
| Cobalt | Strong Acid Extractable | ug/g | 5.68 | 6.38 | | 0.05 |
| Copper | Strong Acid Extractable | ug/g | 43.1 | 59.5 | | 0.05 |
| Lead | Strong Acid Extractable | ug/g | 121 | 179 | | 0.3 |
| Lithium | Strong Acid Extractable | ug/g | 4.4 | 3.1 | | 0.1 |
| Mercury | Strong Acid Extractable | ug/g | 0.202 | 0.168 | | 0.003 |
| Molybdenum | Strong Acid Extractable | ug/g | 7.69 | 9.23 | | 0.05 |
| Nickel | Strong Acid Extractable | ug/g | 24.1 | 28.9 | | 0.1 |
| Selenium | Strong Acid Extractable | ug/g | <0.3 | <0.3 | | 0.3 |
| Silver | Strong Acid Extractable | ug/g | <0.2 | <0.2 | | 0.2 |
| Strontium | Strong Acid Extractable | ug/g | 52.1 | 39.7 | | 0.02 |
| Thallium | Strong Acid Extractable | ug/g | <0.3 | <0.3 | | 0.3 |
| Tin | Strong Acid Extractable | ug/g | 2.7 | 2.8 | | 0.2 |
| Vanadium | Strong Acid Extractable | ug/g | 44.8 | 35.9 | | 0.1 |

## Analytical Report

Bill To: Sperling Hansen & Associates
Report To: Sperling Hansen & Associates
8 - 1225 East Keith Road
North Vancouver, BC, Canada
V7M 1J3
Attn: Iqbal Bhuiyan
Sampled By: MN
Company: Sperling Hansen

Project:
ID: PM 13043
Name: Powell River Marine
Location: Powell River
LSD:
P.O.:
Acct code: (Additional)

Lot ID: **1012186**
Control Number: B047899
Date Received: Jul 4, 2014
Date Reported: Aug 5, 2014
Report Number: 1936588

---

| | | | | | | |
|---|---|---|---|---|---|---|
| | | **Reference Number** | 1012186-1 | 1012186-2 | | |
| | | **Sample Date** | Jul 03, 2014 | Jul 03, 2014 | | |
| | | **Sample Time** | NA | NA | | |
| | | **Sample Location** | | | | |
| | | **Sample Description** | J-1 | J-2 | | |
| | | **Matrix** | Soil | Soil | | |
| **Analyte** | | **Units** | **Results** | **Results** | **Results** | Nominal Detection Limit |
| **Metals Strong Acid Digestion - Continued** | | | | | | |
| Zinc | Strong Acid Extractable | ug/g | 218 | 255 | | 0.1 |
| **Physical and Aggregate Properties** | | | | | | |
| Moisture | Wet Weight @ 105°C | % | 43.3 | 44.5 | | 0.1 |
| **Soil Acidity** | | | | | | |
| pH | 1:2 Soil:Water | pH | 6.1 | 6.6 | | 0.5 |

Approved by: RL Neumann

Randy Neumann, BSc
Vice President

## Methodology and Notes

| | | | | | |
|---|---|---|---|---|---|
| Bill To: | Sperling Hansen & Associates | Project: | | Lot ID: | **1012186** |
| Report To: | Sperling Hansen & Associates | ID: | PM 13043 | Control Number: | B047899 |
| | 8 - 1225 East Keith Road | Name: | Powell River Marine | Date Received: | Jul 4, 2014 |
| | North Vancouver, BC, Canada | Location: | Powell River | Date Reported: | Aug 5, 2014 |
| | V7M 1J3 | LSD: | | Report Number: | 1936588 |
| Attn: | Iqbal  Bhuiyan | P.O.: | | | |
| Sampled By: | MN | Acct code: | (Additional) | | |
| Company: | Sperling Hansen | | | | |

---

## Method of Analysis

| Method Name | Reference | | Method | Date Analysis Started | Location |
|---|---|---|---|---|---|
| Ammonium-N (Extractable) in Soil | Carter | * | Extraction of NO3-N and NH4-N with 2.0 M KCl, 6.2 | 08-Jul-14 | Exova Edmonton |
| Boron - Hot Water Soluble (Surrey) | McKeague | * | Hot Water Soluble Boron - Azomethine-H Method, 4.61 | 10-Jul-14 | Exova Surrey |
| Macronutrients in General Soils | McKeague | * | Ammonium Acetate Extractable Cations, 4.51 | 08-Jul-14 | Exova Edmonton |
| Metals (Strong Acid Leachable) in soils (Surrey) | B.C.M.O.E | * | Strong Acid Leachable Metals (SALM) in Soil, V 1.0, SALM | 07-Jul-14 | Exova Surrey |
| Moisture | Carter | * | Gravimetric Method with Oven Drying, 51.2 | 08-Jul-14 | Exova Edmonton |
| Nutrients in General Soil | Comm. Soil Sci. Pl. Anal. | * | Modified Kelowna Soil Test, Vol 26, 1995 | 08-Jul-14 | Exova Edmonton |
| pH and EC - 1:2 (Surrey) | Carter | * | Soil pH (1:2 Water), 16.2 | 09-Jul-14 | Exova Surrey |
| Sulfate in General Soil | McKeague | * | Sulfate Extractable by 0.1M CaCl2, 4.47 | 08-Jul-14 | Exova Edmonton |
| Total Carbon, Nitrogen & Sulfur by Leco Combustion (Surrey) | SSSA Book Series 5 | * | Nitrogen-Total, Ch 37 | 05-Jul-14 | Exova Surrey |
| Total Carbon, Nitrogen & Sulfur by Leco Combustion (Surrey) | SSSA Book Series 5 | * | Total Carbon, Organic Carbon, and Organic Matter, Ch 34 | 05-Jul-14 | Exova Surrey |

** Reference Method Modified*

## References

| | |
|---|---|
| B.C.M.O.E | B.C. Ministry of Environment |
| Carter | Soil Sampling and Methods of Analysis. |
| Comm. Soil Sci. Pl. | Communications in Soil Science and Plant Analysis |
| McKeague | Manual on Soil Sampling and Methods of Analysis |

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## Methodology and Notes

Bill To: Sperling Hansen & Associates
Report To: Sperling Hansen & Associates
8 - 1225 East Keith Road
North Vancouver, BC, Canada
V7M 1J3
Attn: Iqbal Bhuiyan
Sampled By: MN
Company: Sperling Hansen

Project:
ID: PM 13043
Name: Powell River Marine
Location: Powell River
LSD:
P.O.:
Acct code: (Additional)

Lot ID: **1012186**
Control Number: B047899
Date Received: Jul 4, 2014
Date Reported: Aug 5, 2014
Report Number: 1936588

---

### Comments:

- Report was issued to include addition of Heating Value analysis on 1012186-1 and -2 requested by Iqbal Bhuiyan of Sperling Hansen & Associates on July 30, 2014. Previous report 1929847.
- %TKN analysis was performed by a subcontract laboratory. See attached 3 page report #2014715160918_0015.
- Heating Value analysis was performed by a subcontract laboratory. See attached 3 page certificate of analysis 14-612535.

**EXOVA ENVIRONMENTAL ONTARIO**

# Certificate of Analysis

| | |
|---|---|
| Client: | Exova Canada Inc. (Edmonton)<br>7217 Roper Rd.<br>Edmonton, AB<br>T6B 3J4 |
| Attention: | Edmonton |
| PO#: | 519888 |
| Invoice to: | Exova Canada Inc. (Edmonton) |

| | |
|---|---|
| Report Number: | 1414039 |
| Date Submitted: | 2014-07-09 |
| Date Reported: | 2014-07-15 |
| Project: | 1012186 |
| COC #: | 787367 |

**Dear Edmonton:**

**Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).**

Report Comments:

APPROVAL: ______________________________

Lorna Wilson
Laboratory Supervisor, Inorganics

Exova (Ottawa) is certified and accredited for specific parameters by:
CALA, Canadian Association for Laboratory Accreditation (to ISO 17025), OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils), Licensed by Ontario MOE for specific tests in drinking water.

Exova (Mississauga) is accredited for specific parameters by:
SCC, Standards Council of Canada (to ISO 17025)

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only.

Guideline values listed on this report are provided for ease of use (informational purposes) only. Exova recommends consulting the official provincial or federal guideline as required.

# Certificate of Analysis

| | |
|---|---|
| Client: | Exova Canada Inc. (Edmonton)<br>7217 Roper Rd.<br>Edmonton, AB<br>T6B 3J4 |
| Attention: | Edmonton |
| PO#: | 519888 |
| Invoice to: | Exova Canada Inc. (Edmonton) |

| | |
|---|---|
| Report Number: | 1414039 |
| Date Submitted: | 2014-07-09 |
| Date Reported: | 2014-07-15 |
| Project: | 1012186 |
| COC #: | 787367 |

---

| | | | | Lab I.D.<br>Sample Matrix<br>Sample Type<br>Sampling Date<br>Sample I.D. | 1117995<br>Soil<br><br>2014-07-03<br>1012186 - 1 | 1117996<br>Soil<br><br>2014-07-03<br>1012186 - 2 |
|---|---|---|---|---|---|---|
| **Group** | **Analyte** | **MRL** | **Units** | **Guideline** | | |
| Nutrients | Total Kjeldahl Nitrogen | 0.01 | % | | 0.46 | 0.32 |

**Guideline =** *** = Guideline Exceedence**

** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

# Certificate of Analysis

Client: Exova Canada Inc. (Edmonton)
7217 Roper Rd.
Edmonton, AB
T6B 3J4
Attention: Edmonton
PO#: 519888
Invoice to: Exova Canada Inc. (Edmonton)

Report Number: 1414039
Date Submitted: 2014-07-09
Date Reported: 2014-07-15
Project: 1012186
COC #: 787367

---

## *QC Summary*

| Analyte | Blank | QC<br>% Rec | QC<br>Limits |
|---|---|---|---|
| **Run No** 272699 **Analysis Date** 2014-07-14 | **Method** C SM4500-Norg-B | | |
| Total Kjeldahl Nitrogen | <0.01 % | 98 | 90-110 |

**Guideline =** *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

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W: www.exova.com

Exova

# Certificate of analysis

Attention : Client Services Department

Client : EXOVA (Norwest)
address : 7217 Roper road
Edmonton, Alberta
T6B 3J4

Certificate No. : 14-612535
Version : 1
Date received : 2014-07-31
Project No. : 1012186

P.O. No. : 520123
Client No. : 179467

| Identification | Accredited CEAEQ | | | | 1012186-1<br>J-1 | 1012186-2<br>J-2 |
|---|---|---|---|---|---|---|
| Matrix | | | | | Solid | Solid |
| Date sampled | | | | | 2014-07-03 | 2014-07-03 |
| Sampling location | | | | | NA | NA |
| Collected by | | | | | Client | Client |
| Laboratory No. | | | | | 2638240 | 2638241 |
| Parameters | | Units | Date Prepared | Date Analysed | Result(s) | Result(s) |
| Heating value | | kJ/kg | ---- | 2014-08-04 | 5282 | 7110 |

Comments:

Analytical methods: Appendix I
Quality control: Appendix II

CHIMISTE
Oana Pascuta
2014-102
QUÉBEC

Chemist :
2014-08-05

**Note: These results only apply to the samples submitted**

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F : +1 (514) 697-2090
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W: www.exova.com

# Certificate of analysis

**Attention :** **Client Services Department**

**Client :** **EXOVA (Norwest)**
**address :** **7217 Roper road**
**Edmonton, Alberta**
**T6B 3J4**

| | |
|---|---|
| Certificate No. : | 14-612535 |
| Version : | 1 |
| Date received : | 2014-07-31 |
| Project No. : | 1012186 |
| P.O. No. : | 520123 |
| Client No. : | 179467 |

## Appendix I

| Parameters | Methods No. or references | Technics or instruments |
|---|---|---|
| Heating value | ASTM D-240 | Parr calorimeter |

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# Certificate of analysis

**Attention : Client Services Department**

**Client : EXOVA (Norwest)**
**address : 7217 Roper road**
**Edmonton, Alberta**
**T6B 3J4**

Certificate No. : 14-612535
Version : 1
Date received : 2014-07-31
Project No. : 1012186

P.O. No. : 520123
Client No. : 179467

## Appendix II

| Identification | | Blank | Duplicate | | | Reference material | | |
|---|---|---|---|---|---|---|---|---|
| Parameters | Units | Results | Laboratory No. | Results 1 | Results 2 | Value | Range | Obtained |
| Heating value | kJ/kg | NA | ---- | ---- | ---- | 26453 | 25 924 - 26 982 | 26535 |

NA : Non applicable

**Note: These results only apply to the samples submitted**

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**Exova** Testing Advising Assuring

www.exova.com

## Project Information

Project ID: PJ 13043
Project Name: Powell River Marine
Project Location: Powell River
Legal Location:
PO/AFE#:
Proj. Acct. Code:

## Billing Information

Company: Sperling Hansen Assoc
Address: #8 1225 East Keith Rd North Vancouver
Attention: Iqbal Bhuiyan
Phone: 604-986-7723
Cell:
Fax:
E-mail: Ibhuiyan@sperlinghansen.com
Agreement ID:
Copy of report: SAME

## Copy of Report To:

Company: SAME
Address:
Attention:
Phone:
Cell:
Fax:
E-mail:
Copy of invoice: SAME

## RUSH Priority

Upon filling out this section, client accepts that surcharges will be applied to the analysis

| | | | |
|---|---|---|---|
| Date Required | | | |
| As Indicated | ☐ | All Analysis | ☐ |

When "ASAP" is requested, turn around will default to a 100% RUSH priority, with pricing and turn around time to match. Please contact the lab prior to submitting RUSH samples.

Signature

**Sample Custody (please print)**

Sampled by: MARK MANNING
Company: Sperling Hansen.
I authorize Exova to proceed with the work indicated on this form:
Date: July 4/14 Initial:

**Report Results** ☒ E-mail ☐ Mail ☐ Online ☐ Fax ☐ PDF ☐ Excel ☐ QA/QC Report

Special Instructions/Comments (please include contact information including ph. # if different from above).

See Attached Quote ☺

Include Regulatory Requirements Below:

**This section for Lab use only**

Date/Time stamp:
14-07-04P12:30 RCVD

| | Sample Identification | Location | Depth IN CM M | Date/Time sampled | Matrix | Sampling Method | Number of Containers ↓ | TKN | CN - TOC | Total Carbon | NH4-N, NO3-N | Metals | SO | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | J-1 | | 1.0(m) | July 3/14 | Wood | Composite | 1 | | | | | | | | | | |
| 2 | J-2 | | 1.0(m) | " | Chips | site | 1 | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | |

Enter tests above (√ relevant samples below)

Indicate below any deficiencies in the condition of samples:

| | |
|---|---|
| | Were Exova supplies used? |
| | Was there any damage to the shipping container? |
| | Were the containers packaged well? |
| | Were any extra samples received (document below)? |
| | Are samples within recommended holding times/temp? |

# and size of coolers received:
Delivery Method: H
Waybill:
Received by: Lynn

Shipping:
COD Y/N
Cooler temp: 20.0°

Indicate lot number or affix lot label here
LOT: 1012186 COC

**Environmental Sample Information Sheet**

Note: Proper completion of this form is required in order to proceed with analysis

**Please indicate any potentially hazardous samples**

Page of Control # B047899

ED 120-00

Your Project #: B456369
Your C.O.C. #: na

**Attention: Namita Sahni**
Maxxam Analytics
4606 Canada Way
Burnaby, BC
V5G 1K5

**Report Date: 2014/08/08**
**Report #: R3114518**
**Version: 1**

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B4B9759**
**Received: 2014/07/09, 10:45**

Sample Matrix: Soil
# Samples Received: 4

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Method Reference |
|---|---|---|---|---|---|
| Dioxins/Furans in Soil (EPS 1/RM/23) (1) | 2 | 2014/07/16 | 2014/07/26 | BRL SOP-00410 | EPS 1/RM/23 m |
| Dioxins/Furans in Soil (EPS 1/RM/23) (1) | 2 | 2014/07/16 | 2014/07/27 | BRL SOP-00410 | EPS 1/RM/23 m |

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Soils are reported on a dry weight basis unless otherwise specified.

Confirmatory runs for 2,3,7,8-TCDF are performed only if the primary result is greater than the RDL.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Shaun Nowickyj, Customer Service
Email: SNowickyj@maxxam.ca
Phone# (905) 817-5700

====================================================================
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

## DIOXINS AND FURANS BY HRMS (SOIL)

| Maxxam ID | | WP8477 | | WP8478 | | WP8479 | | WP8480 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2014/07/03 | | 2014/07/03 | | 2014/07/03 | | 2014/07/03 | | |
| | **Units** | **KA0700 \ F-1** | **RDL** | **KA0701 \ F-2** | **RDL** | **KA0702 \ F-3** | **RDL** | **KA0703 \ D-1** | **RDL** | **QC Batch** |
| **Dioxins & Furans** | | | | | | | | | | |
| 2,3,7,8-Tetra CDD | pg/g | 1.28 | 5.00 | 4.89 | 0.999 | 2.38 | 2.50 | 2.03 | 0.999 | 3688431 |
| 1,2,3,7,8-Penta CDD | pg/g | 5.75 | 5.00 | 12.5 | 0.999 | 6.65 | 2.50 | 4.23 | 0.999 | 3688431 |
| 1,2,3,4,7,8-Hexa CDD | pg/g | <3.61(1) | 5.00 | 11.8 | 0.999 | 5.49 | 2.50 | 3.94 | 0.999 | 3688431 |
| 1,2,3,6,7,8-Hexa CDD | pg/g | 33.5 | 5.00 | 36.9 | 0.999 | 24.8 | 2.50 | 13.1 | 0.999 | 3688431 |
| 1,2,3,7,8,9-Hexa CDD | pg/g | 23.3 | 5.00 | 42.8(2) | 0.999 | 23.5 | 2.50 | 14.5(2) | 0.999 | 3688431 |
| 1,2,3,4,6,7,8-Hepta CDD | pg/g | 270 | 5.00 | 271(3) | 4.99 | 207 | 2.50 | 94.8 | 0.999 | 3688431 |
| Octa CDD | pg/g | 2050 | 50.0 | 1940 | 9.99 | 1860 | 25.0 | 372 | 9.99 | 3688431 |
| Total Tetra CDD | pg/g | 49.4 | 5.00 | 195 | 0.999 | 94.8 | 2.50 | 77.3 | 0.999 | 3688431 |
| Total Penta CDD | pg/g | 41.3 | 5.00 | 219 | 0.999 | 107 | 2.50 | 74.7 | 0.999 | 3688431 |
| Total Hexa CDD | pg/g | 283 | 5.00 | 428 | 0.999 | 253 | 2.50 | 148 | 0.999 | 3688431 |
| Total Hepta CDD | pg/g | 551 | 5.00 | 569(3) | 4.99 | 435 | 2.50 | 190 | 0.999 | 3688431 |
| 2,3,7,8-Tetra CDF | pg/g | 25.5 | 5.00 | 130 | 0.999 | 56.8 | 2.50 | 37.5 | 0.999 | 3688431 |
| 1,2,3,7,8-Penta CDF | pg/g | 4.82 | 5.00 | 28.4 | 0.999 | 13.4 | 2.50 | <9.32(4) | 0.999 | 3688431 |
| 2,3,4,7,8-Penta CDF | pg/g | 10.5 | 5.00 | 55.0 | 0.999 | 23.0 | 2.50 | 13.3 | 0.999 | 3688431 |
| 1,2,3,4,7,8-Hexa CDF | pg/g | 17.2 | 5.00 | 112(2) | 0.999 | 49.8(2) | 2.50 | 9.07 | 0.999 | 3688431 |
| 1,2,3,6,7,8-Hexa CDF | pg/g | 7.26 | 5.00 | 37.0 | 0.999 | 16.4 | 2.50 | 9.76 | 0.999 | 3688431 |
| 2,3,4,6,7,8-Hexa CDF | pg/g | 7.99 | 5.00 | 47.8 | 0.999 | 21.2 | 2.50 | 9.16 | 0.999 | 3688431 |
| 1,2,3,7,8,9-Hexa CDF | pg/g | <0.897 | 5.00 | 1.82 | 0.999 | 0.88 | 2.50 | 0.600 | 0.999 | 3688431 |
| 1,2,3,4,6,7,8-Hepta CDF | pg/g | 44.6 | 5.00 | 188 | 0.999 | 89.5 | 2.50 | 43.4 | 0.999 | 3688431 |
| 1,2,3,4,7,8,9-Hepta CDF | pg/g | <2.42(1) | 5.00 | 11.3 | 0.999 | 5.60 | 2.50 | 3.40 | 0.999 | 3688431 |
| Octa CDF | pg/g | 55.6 | 50.0 | 101 | 9.99 | 56.5 | 25.0 | 30.8 | 9.99 | 3688431 |
| Total Tetra CDF | pg/g | 111 | 5.00 | 717 | 0.999 | 306 | 2.50 | 201 | 0.999 | 3688431 |
| Total Penta CDF | pg/g | 156 | 5.00 | 544 | 0.999 | 259 | 2.50 | 119 | 0.999 | 3688431 |
| Total Hexa CDF | pg/g | 116 | 5.00 | 397 | 0.999 | 185 | 2.50 | 95.3 | 0.999 | 3688431 |
| Total Hepta CDF | pg/g | 96.2 | 5.00 | 266 | 0.999 | 136 | 2.50 | 65.7 | 0.999 | 3688431 |

---

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - EMPC / NDR - Peak detected does not meet ratio criteria and has resulted in an elevated detection limit.
(2) - EMPC / Merged Peak
(3) - From 5x dilution.
(4) - EMPC / DPE - Diphenylether interference present caused dibenzofuran detected to become a "non-detect" with an elevated detection limit.

## DIOXINS AND FURANS BY HRMS (SOIL)

| Maxxam ID | | WP8477 | | WP8478 | | WP8479 | | WP8480 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2014/07/03 | | 2014/07/03 | | 2014/07/03 | | 2014/07/03 | | |
| | **Units** | **KA0700 \ F-1** | **RDL** | **KA0701 \ F-2** | **RDL** | **KA0702 \ F-3** | **RDL** | **KA0703 \ D-1** | **RDL** | **QC Batch** |
| **Surrogate Recovery (%)** | | | | | | | | | | |
| C13-1234678 HeptaCDD | % | 78 | | 72 | | 72 | | 72 | | 3688431 |
| C13-1234678 HeptaCDF | % | 64 | | 67 | | 73 | | 73 | | 3688431 |
| C13-123678 HexaCDD | % | 83 | | 81 | | 93 | | 81 | | 3688431 |
| C13-123678 HexaCDF | % | 78 | | 82 | | 93 | | 81 | | 3688431 |
| C13-12378 PentaCDD | % | 68 | | 82 | | 79 | | 74 | | 3688431 |
| C13-12378 PentaCDF | % | 54 | | 66 | | 65 | | 58 | | 3688431 |
| C13-2378 TetraCDD | % | 60 | | 69 | | 71 | | 68 | | 3688431 |
| C13-2378 TetraCDF | % | 69 | | 79 | | 85 | | 72 | | 3688431 |
| C13-OCDD | % | 55 | | 59 | | 53 | | 54 | | 3688431 |

---

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

| | |
|---|---|
| Package 1 | 3.0°C |

Each temperature is the average of up to three cooler temperatures taken at receipt

**GENERAL COMMENTS**

## QUALITY ASSURANCE REPORT

| | | | Spiked Blank | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|
| **QC Batch** | **Parameter** | **Date** | **% Recovery** | **QC Limits** | **Value** | **Units** | **Value (%)** | **QC Limits** |
| 3688431 | C13-1234678 HeptaCDD | 2014/07/26 | 91 | 30 - 130 | 62 | % | | |
| 3688431 | C13-1234678 HeptaCDF | 2014/07/26 | 79 | 30 - 130 | 55 | % | | |
| 3688431 | C13-123678 HexaCDD | 2014/07/26 | 85 | 30 - 130 | 58 | % | | |
| 3688431 | C13-123678 HexaCDF | 2014/07/26 | 84 | 30 - 130 | 57 | % | | |
| 3688431 | C13-12378 PentaCDD | 2014/07/26 | 87 | 30 - 130 | 66 | % | | |
| 3688431 | C13-12378 PentaCDF | 2014/07/26 | 66 | 30 - 130 | 51 | % | | |
| 3688431 | C13-2378 TetraCDD | 2014/07/26 | 64 | 30 - 130 | 46 | % | | |
| 3688431 | C13-2378 TetraCDF | 2014/07/26 | 73 | 30 - 130 | 57 | % | | |
| 3688431 | C13-OCDD | 2014/07/26 | 86 | 30 - 130 | 57 | % | | |
| 3688431 | 2,3,7,8-Tetra CDD | 2014/07/26 | 111 | 80 - 140 | <0.101 | pg/g | NC(1) | 25 |
| 3688431 | 1,2,3,7,8-Penta CDD | 2014/07/26 | 93 | 80 - 140 | <0.0993 | pg/g | NC | 25 |
| 3688431 | 1,2,3,4,7,8-Hexa CDD | 2014/07/26 | 99 | 80 - 140 | <0.0972 | pg/g | NC | 25 |
| 3688431 | 1,2,3,6,7,8-Hexa CDD | 2014/07/26 | 104 | 80 - 140 | <0.102 | pg/g | NC | 25 |
| 3688431 | 1,2,3,7,8,9-Hexa CDD | 2014/07/26 | 103 | 80 - 140 | <0.0918 | pg/g | NC | 25 |
| 3688431 | 1,2,3,4,6,7,8-Hepta CDD | 2014/07/26 | 89 | 80 - 140 | <0.0990 | pg/g | NC | 25 |
| 3688431 | Octa CDD | 2014/07/26 | 100 | 80 - 140 | 0.5, RDL=10.0 | pg/g | NC | 25 |
| 3688431 | 2,3,7,8-Tetra CDF | 2014/07/26 | 90 | 80 - 140 | <0.0987 | pg/g | NC | 25 |
| 3688431 | 1,2,3,7,8-Penta CDF | 2014/07/26 | 107 | 80 - 140 | <0.101 | pg/g | NC | 25 |
| 3688431 | 2,3,4,7,8-Penta CDF | 2014/07/26 | 105 | 80 - 140 | <0.0985 | pg/g | NC | 25 |
| 3688431 | 1,2,3,4,7,8-Hexa CDF | 2014/07/26 | 92 | 80 - 140 | <0.0931 | pg/g | NC | 25 |
| 3688431 | 1,2,3,6,7,8-Hexa CDF | 2014/07/26 | 96 | 80 - 140 | <0.0864 | pg/g | NC | 25 |
| 3688431 | 2,3,4,6,7,8-Hexa CDF | 2014/07/26 | 100 | 80 - 140 | <0.101 | pg/g | NC | 25 |
| 3688431 | 1,2,3,7,8,9-Hexa CDF | 2014/07/26 | 93 | 80 - 140 | <0.106 | pg/g | NC | 25 |
| 3688431 | 1,2,3,4,6,7,8-Hepta CDF | 2014/07/26 | 99 | 80 - 140 | <0.0904 | pg/g | NC(1) | 25 |
| 3688431 | 1,2,3,4,7,8,9-Hepta CDF | 2014/07/26 | 95 | 80 - 140 | <0.115 | pg/g | NC | 25 |
| 3688431 | Octa CDF | 2014/07/26 | 94 | 80 - 140 | <0.0954 | pg/g | NC | 25 |
| 3688431 | Total Tetra CDD | 2014/07/26 | | | <0.101 | pg/g | NC | 25 |
| 3688431 | Total Penta CDD | 2014/07/26 | | | <0.0993 | pg/g | NC | 25 |
| 3688431 | Total Hexa CDD | 2014/07/26 | | | <0.0968 | pg/g | NC | 25 |
| 3688431 | Total Hepta CDD | 2014/07/26 | | | <0.0990 | pg/g | NC | 25 |
| 3688431 | Total Tetra CDF | 2014/07/26 | | | <0.0987 | pg/g | NC | 25 |
| 3688431 | Total Penta CDF | 2014/07/26 | | | <0.0995 | pg/g | NC | 25 |

## QUALITY ASSURANCE REPORT

| | | | Spiked Blank | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|
| **QC Batch** | **Parameter** | **Date** | **% Recovery** | **QC Limits** | **Value** | **Units** | **Value (%)** | **QC Limits** |
| 3688431 | Total Hexa CDF | 2014/07/26 | | | <0.0960 | pg/g | NC | 25 |
| 3688431 | Total Hepta CDF | 2014/07/26 | | | <0.101 | pg/g | NC (1) | 25 |

---

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) - EMPC / NDR - Peak detected does not meet ratio criteria and has resulted in an elevated detection limit.

# Validation Signature Page

**Maxxam Job #: B4B9759**

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Branko Vrzic, A.SC.T., Senior Analyst, HRMS Services

Owen Cosby, BSc.C.Chem, Supervisor, HRMS Services

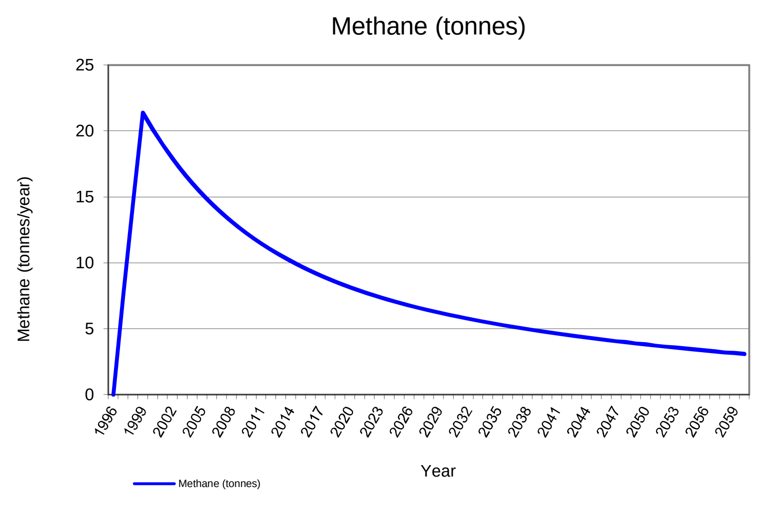
==================================================================

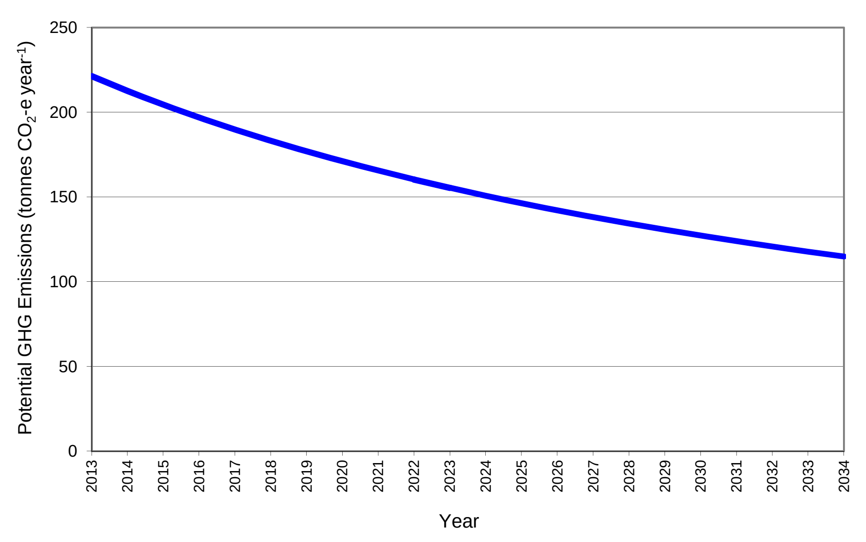
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

# APPENDIX E
# LFG Modelling Results

## Landfill Gas Generation Model Results for the Marine Avenue Transfer Site

| Year | CH4 | CO2-e | LFG | LFG | NMOC |
|---|---|---|---|---|---|
| | tonnes/year | tonnes/year | scfm | $m^3$/year | tonnes/year |
| 1996 | 0 | 0 | 0 | 0 | 0.0 |
| 1997 | 8 | 159 | 2 | 32,280 | 0.9 |
| 1998 | 15 | 308 | 4 | 62,618 | 1.8 |
| 1999 | 21 | 449 | 6 | 91,178 | 2.6 |
| 2000 | 20 | 423 | 6 | 85,828 | 2.5 |
| 2001 | 19 | 398 | 5 | 80,920 | 2.3 |
| 2002 | 18 | 376 | 5 | 76,415 | 2.2 |
| 2003 | 17 | 356 | 5 | 72,275 | 2.1 |
| 2004 | 16 | 337 | 5 | 68,468 | 2.0 |
| 2005 | 15 | 320 | 4 | 64,962 | 1.9 |
| 2006 | 14 | 304 | 4 | 61,729 | 1.8 |
| 2007 | 14 | 289 | 4 | 58,747 | 1.7 |
| 2008 | 13 | 276 | 4 | 55,990 | 1.6 |
| 2009 | 13 | 263 | 4 | 53,440 | 1.5 |
| 2010 | 12 | 252 | 3 | 51,078 | 1.5 |
| 2011 | 11 | 241 | 3 | 48,886 | 1.4 |
| 2012 | 11 | 231 | 3 | 46,850 | 1.3 |
| 2013 | 11 | 221 | 3 | 44,956 | 1.3 |
| 2014 | 10 | 213 | 3 | 43,192 | 1.2 |
| 2015 | 10 | 205 | 3 | 41,545 | 1.2 |
| 2016 | 9 | 197 | 3 | 40,007 | 1.2 |
| 2017 | 9 | 190 | 3 | 38,567 | 1.1 |
| 2018 | 9 | 183 | 3 | 37,217 | 1.1 |
| 2019 | 8 | 177 | 2 | 35,950 | 1.0 |
| 2020 | 8 | 171 | 2 | 34,758 | 1.0 |
| 2021 | 8 | 166 | 2 | 33,636 | 1.0 |
| 2022 | 8 | 160 | 2 | 32,577 | 0.9 |
| 2023 | 7 | 155 | 2 | 31,577 | 0.9 |
| 2024 | 7 | 151 | 2 | 30,630 | 0.9 |
| 2025 | 7 | 146 | 2 | 29,732 | 0.9 |
| 2026 | 7 | 142 | 2 | 28,880 | 0.8 |
| 2027 | 7 | 138 | 2 | 28,070 | 0.8 |
| 2028 | 6 | 134 | 2 | 27,299 | 0.8 |
| 2029 | 6 | 131 | 2 | 26,563 | 0.8 |
| 2030 | 6 | 127 | 2 | 25,860 | 0.7 |
| 2031 | 6 | 124 | 2 | 25,189 | 0.7 |
| 2032 | 6 | 121 | 2 | 24,545 | 0.7 |
| 2033 | 6 | 118 | 2 | 23,929 | 0.7 |
| 2034 | 5 | 115 | 2 | 23,336 | 0.7 |
| 2035 | 5 | 112 | 2 | 22,767 | 0.7 |
| 2036 | 5 | 109 | 1 | 22,220 | 0.6 |
| 2037 | 5 | 107 | 1 | 21,692 | 0.6 |
| 2038 | 5 | 104 | 1 | 21,183 | 0.6 |
| 2039 | 5 | 102 | 1 | 20,692 | 0.6 |
| 2040 | 5 | 100 | 1 | 20,217 | 0.6 |





# APPENDIX F
# Ditch Design Calculations

# Powell River Airport Landfill

## Rational Method

### Storm Flows - Rational Method (BC Agricultural Drainage Manual - 1997)

$Q = 0.0028C\textit{i}A$

$Q$ = peak runoff rate ($m^3/s$) (100yr event)

$\textit{i}$ = rainfall intensity (mm/hr) for design period and for time of concentration

$A$ = watershed area ($m^2$)

$T_c = 0.0195L^{0.77}S^{-0.385}$

$T_c$ = time of concentration (min)

$L$ = maximum length of flow (m)

$S$ = drainage area grade (m/m)

$$C = \frac{\text{Sum}(C_1A_1 + C_2A_2\ldots)}{\text{Sum}(A_1 + A_2\ldots)}$$

### Typical Catchment Area

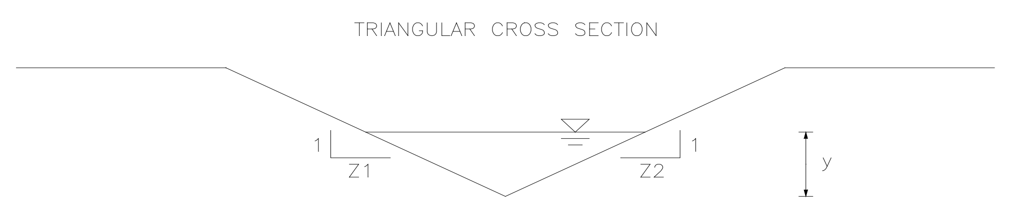
| | Typical Area |
|---|---|
| **Material** | Top Soil |
| **Vegetation** | Pasture |
| **Topography** | Rolling |

| | **A1** | **A2** | **A3** | **A4** |
|---|---|---|---|---|
| **Catchment Area (A, $m^2$) =** | 6,700 | 8,200 | 13,400 | 25,800 |
| **Catchment Area (A, ha) =** | 0.67 | 0.82 | 1.34 | 2.58 |
| **Runoff Coefficient - C =** | 0.85 | 0.85 | 0.85 | 0.85 |
| **Time of concentration - $T_c$** | | | | |
| Typical slope (S, m/m) = | 0.250 | 0.250 | 0.330 | 0.330 |
| Length of flow (L, m) = | 30 | 80 | 350 | 350 |
| $T_c$ (min) = | 0.456 | 0.971 | 2.719 | 2.719 |
| **$T_c$ (hrs) =** | **0.008** | **0.016** | **0.045** | **0.045** |
| **If $T_c$ <5mins, use** | **5mins** | **5mins** | **5mins** | **5mins** |
| **Peak Storm Intensity (*i* , mm/hr) =** | **90** | **90** | **90** | **90** |
| **Peak Flow (Q, $m^3/s$) =** | **0.14** | **0.18** | **0.29** | **0.55** |
| **Peak Flow (Q, L/s) =** | **144** | **176** | **287** | **553** |

# Powell River Airport Landfill

## North Crest Ditch Design

### Rational Method



$Z_1$ = 2.5

$Z_2$ = 2.5

Flow Depth (y) = 0.5 m

Bottom Width (b) = 0 m (Trapezoid Sections Only)

Area (A) = 0.6250 $m^2$

Wetted Perimeter (P) = 2.6926 m

Hydraulic Radius (R) = 0.2321 m

Longitudinal Ditch Slope (S) = 0.250 m/m

Manning's n = 0.02 Rip rap Lined

$$\boxed{Q = \frac{AR^{2/3}S^{1/2}}{n}}$$

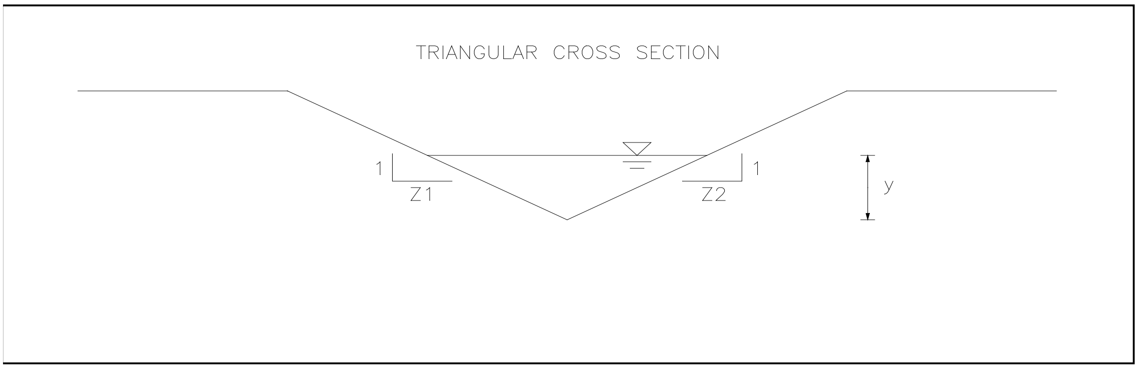
$Q_{required}$ = 0.55 $m^3/s$

$Q_{available}$ = **5.90** $m^3/s$

5901 L/s

Velocity = **2.381** m/s 7.81 ft/s

# Powell River Airport Landfill
## South Crest Ditch Design
### Rational Method



$Z_1$ = 2.5
$Z_2$ = 2.5

Flow Depth (y) = 0.5 m
Bottom Width (b) = 0 m (Trapezoid Sections Only)

Area (A) = 0.6250 $m^2$
Wetted Perimeter (P) = 2.6926 m
Hydraulic Radius (R) = 0.2321 m
Longitudinal Ditch Slope (S) = 0.250 m/m

Manning's n = 0.02 Rip rap Lined

$$\boxed{Q = \frac{AR^{2/3}S^{1/2}}{n}}$$

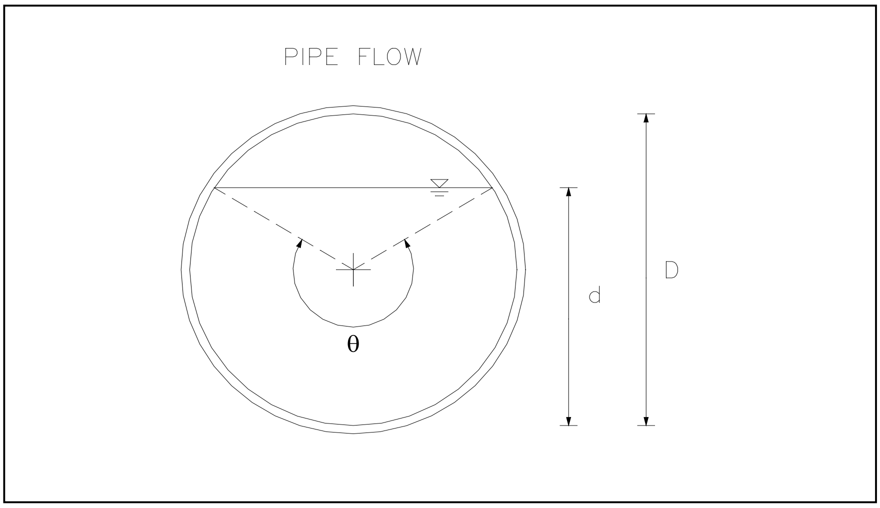
$Q_{required}$ = 0.46 $m^3/s$
$Q_{available}$ = **5.90** $m^3/s$
5901 L/s

Velocity = **1.993** m/s 6.54 ft/s

# Powell River Airport Landfill

## Pond Culvert Design

## Corrugated HDPE with smooth inner walls



Maximum Flow, d = 0.7D

Flow Depth (d) = 0.315 m

**Pipe Diameter (D) = 0.45 m**

**Pipe Diameter (D) = 17.72 in.**

Theta (θ) = 3.965 radians

Area (A) = 0.1189 $m^2$

Wetted Perimeter (P) = 0.8920 m

Hydraulic Radius (R) = 0.1333 m

Pipe Slope (S) = 0.142 m/m

Manning's n = 0.015

$$\boxed{Q = \frac{AR^{2/3}S^{1/2}}{n}}$$

$Q_{required}$ = 0.61 **$m^3$/s**

$Q_{available}$ = **0.781 $m^3$/s**

781 L/s

Velocity = 4.547 m/s

14.919 ft/s

# Storm Water Retention Design
## Discharge Rates Evaluation

**Pond Catchment Area (A, $m^2$) = 28,300**

Q = $0.0028Ci$ - peak runoff rate ($m^3/s$)
$i$ = rainfall intensity (mm/hr) for design period
A = watershed area (ha)
C = 0.85 Runoff Coefficient

Phase 2 Allowable Discharge (L/s)

**$V_{storage}$ =** 2,175 $m^3$
1 : 25y Discharge rate (L/s)= 13

| **i** | **Q** | **T** | **$V_{runoff}$** | **$V_{storage}$** | **$V_{discharge}$** | **$V_{stored}$** | **$q_{effective}$** | **$T_{empty}$** |
|---|---|---|---|---|---|---|---|---|
| **mm/hr** | **$m^3/s$** | **min** | **$m^3$** | **$m^3$** | **$m^3$** | **$m^3$** | **L/s** | **h** |
| **70** | 0.471 | 5 | 141 | 2,175 | 4 | **138** | 13.00 | 2.9 |
| **50** | 0.337 | 10 | 202 | 2,175 | 8 | **194** | 13.00 | 4.2 |
| **45** | 0.303 | 15 | 273 | 2,175 | 12 | **261** | 13.00 | 5.6 |
| **29** | 0.195 | 30 | 352 | 2,175 | 23 | **328** | 13.00 | 7.0 |
| **20** | 0.135 | 60 | 485 | 2,175 | 47 | **438** | 13.00 | 9.4 |
| **15** | 0.101 | 120 | 727 | 2,175 | 94 | **634** | 13.00 | 13.5 |
| **8** | 0.054 | 360 | 1164 | 2,175 | 281 | **883** | 13.00 | 18.9 |
| **5.9** | 0.040 | 720 | 1717 | 2,175 | 562 | **1155** | 13.00 | 24.7 |
| **4** | 0.027 | 1440 | 2328 | 2,175 | 1123 | **1205** | 13.00 | 25.7 |

# APPENDIX G
# Water Quality Results

SPERLING HANSEN ASSOCIATES INC.
ATTN: Mark Manning
# 8 - 1225 East Keith Road
North Vancouver BC V7J 1J3

| | |
|---|---|
| Date Received: | 25-MAR-14 |
| Report Date: | 03-APR-14 18:04 (MT) |
| Version: | FINAL |

Client Phone: 604-986-7723

# Certificate of Analysis

| | |
|---|---|
| **Lab Work Order #:** | **L1436334** |
| Project P.O. #: | NOT SUBMITTED |
| Job Reference: | PRJ13043 POWERLL RIVER |
| C of C Numbers: | 10-368543 |
| Legal Site Desc: | |

Dean Watt
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | **Sample ID** | L1436334-1 | L1436334-2 | L1436334-3 | L1436334-4 | L1436334-5 |
|---|---|---|---|---|---|---|
| | **Description** | S-Water | S-Water | S-Water | S-Water | S-Water |
| | **Sampled Date** | 25-MAR-14 | 25-MAR-14 | 25-MAR-14 | 25-MAR-14 | 25-MAR-14 |
| | **Sampled Time** | | | | | |
| | **Client ID** | AIRPORT SW-1 | AIRPORT SW-2 | AIRPORT SW-3 | MARINE SW-1 | MARINE SW-2 |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Physical Tests** | Conductivity (uS/cm) | 56.4 | 400 | 64.2 | 81.3 | 185 |
| | Hardness (as CaCO3) (mg/L) | 16.7 | 176 | 20.7 | 26.8 | 71.6 |
| | pH (pH) | 7.32 | 7.99 | 7.35 | 7.64 | 7.90 |
| | Total Suspended Solids (mg/L) | 3.1 | <3.0 | 6.1 | 20.1 | 34.9 |
| | Total Dissolved Solids (mg/L) | 54 | 257 | 69 | 55 | 101 |
| **Anions and Nutrients** | Ammonia, Total (as N) (mg/L) | 0.0094 | <0.0050 | 0.0096 | 0.0057 | 0.0112 |
| | Bromide (Br) (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Chloride (Cl) (mg/L) | 5.69 | 6.49 | 5.70 | 7.85 | 7.59 |
| | Fluoride (F) (mg/L) | 0.022 | 0.046 | 0.023 | 0.029 | 0.043 |
| | Nitrate (as N) (mg/L) | 0.239 | 4.03 | 0.292 | 0.202 | 0.196 |
| | Nitrite (as N) (mg/L) | <0.0010 | 0.0018 | <0.0010 | 0.0015 | 0.0019 |
| | Sulfate (SO4) (mg/L) | 1.86 | 25.5 | 2.75 | 2.49 | 16.4 |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | 0.521 | 0.290 | 0.477 | 0.521 | 0.774 |
| | Antimony (Sb)-Total (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | 0.00054 |
| | Arsenic (As)-Total (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | 0.00070 |
| | Barium (Ba)-Total (mg/L) | <0.020 | <0.020 | <0.020 | <0.020 | <0.020 |
| | Beryllium (Be)-Total (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Boron (B)-Total (mg/L) | <0.10 | 0.17 | <0.10 | <0.10 | <0.10 |
| | Cadmium (Cd)-Total (mg/L) | <0.000010 | <0.000010 | <0.000010 | <0.000010 | 0.000033 |
| | Calcium (Ca)-Total (mg/L) | 4.78 | 55.5 | 5.92 | 7.98 | 21.4 |
| | Chromium (Cr)-Total (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Cobalt (Co)-Total (mg/L) | <0.00030 | <0.00030 | <0.00030 | <0.00030 | 0.00034 |
| | Copper (Cu)-Total (mg/L) | 0.0012 | <0.0010 | <0.0010 | 0.0015 | 0.0057 |
| | Iron (Fe)-Total (mg/L) | 0.436 | 0.239 | 0.418 | 1.07 | 3.01 |
| | Lead (Pb)-Total (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | 0.00273 |
| | Lithium (Li)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Magnesium (Mg)-Total (mg/L) | 1.15 | 8.98 | 1.43 | 1.66 | 4.39 |
| | Manganese (Mn)-Total (mg/L) | 0.0129 | 0.00546 | 0.0125 | 0.0297 | 0.139 |
| | Mercury (Hg)-Total (mg/L) | <0.000010 | <0.000010 | <0.000010 | <0.000010 | <0.000010 |
| | Molybdenum (Mo)-Total (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Nickel (Ni)-Total (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Potassium (K)-Total (mg/L) | <2.0 | 3.5 | <2.0 | <2.0 | 3.1 |
| | Selenium (Se)-Total (mg/L) | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 |
| | Silver (Ag)-Total (mg/L) | <0.000020 | <0.000020 | <0.000020 | <0.000020 | <0.000020 |
| | Sodium (Na)-Total (mg/L) | 5.0 | 18.2 | 5.4 | 6.2 | 9.6 |
| | Thallium (Tl)-Total (mg/L) | <0.00020 | <0.00020 | <0.00020 | <0.00020 | <0.00020 |
| | Tin (Sn)-Total (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | <0.00050 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Sample ID** | L1436334-6 | | | | |
| | **Description** | S-Water | | | | |
| | **Sampled Date** | 25-MAR-14 | | | | |
| | **Sampled Time** | | | | | |
| | **Client ID** | MARINE SW-3 | | | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Physical Tests** | Conductivity (uS/cm) | 88.6 | | | | |
| | Hardness (as CaCO3) (mg/L) | 29.5 | | | | |
| | pH (pH) | 7.71 | | | | |
| | Total Suspended Solids (mg/L) | 23.5 | | | | |
| | Total Dissolved Solids (mg/L) | 68 | | | | |
| **Anions and Nutrients** | Ammonia, Total (as N) (mg/L) | 0.0059 | | | | |
| | Bromide (Br) (mg/L) | <0.050 | | | | |
| | Chloride (Cl) (mg/L) | 7.87 | | | | |
| | Fluoride (F) (mg/L) | 0.025 | | | | |
| | Nitrate (as N) (mg/L) | 0.212 | | | | |
| | Nitrite (as N) (mg/L) | 0.0014 | | | | |
| | Sulfate (SO4) (mg/L) | 3.19 | | | | |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | 0.566 | | | | |
| | Antimony (Sb)-Total (mg/L) | <0.00050 | | | | |
| | Arsenic (As)-Total (mg/L) | <0.00050 | | | | |
| | Barium (Ba)-Total (mg/L) | <0.020 | | | | |
| | Beryllium (Be)-Total (mg/L) | <0.0010 | | | | |
| | Boron (B)-Total (mg/L) | <0.10 | | | | |
| | Cadmium (Cd)-Total (mg/L) | <0.000010 | | | | |
| | Calcium (Ca)-Total (mg/L) | 8.83 | | | | |
| | Chromium (Cr)-Total (mg/L) | <0.0010 | | | | |
| | Cobalt (Co)-Total (mg/L) | <0.00030 | | | | |
| | Copper (Cu)-Total (mg/L) | 0.0016 | | | | |
| | Iron (Fe)-Total (mg/L) | 1.13 | | | | |
| | Lead (Pb)-Total (mg/L) | 0.00056 | | | | |
| | Lithium (Li)-Total (mg/L) | <0.0050 | | | | |
| | Magnesium (Mg)-Total (mg/L) | 1.81 | | | | |
| | Manganese (Mn)-Total (mg/L) | 0.0376 | | | | |
| | Mercury (Hg)-Total (mg/L) | <0.000010 | | | | |
| | Molybdenum (Mo)-Total (mg/L) | <0.0010 | | | | |
| | Nickel (Ni)-Total (mg/L) | <0.0010 | | | | |
| | Potassium (K)-Total (mg/L) | <2.0 | | | | |
| | Selenium (Se)-Total (mg/L) | <0.00010 | | | | |
| | Silver (Ag)-Total (mg/L) | <0.000020 | | | | |
| | Sodium (Na)-Total (mg/L) | 6.6 | | | | |
| | Thallium (Tl)-Total (mg/L) | <0.00020 | | | | |
| | Tin (Sn)-Total (mg/L) | <0.00050 | | | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | Sample ID | L1436334-1 | L1436334-2 | L1436334-3 | L1436334-4 | L1436334-5 |
|---|---|---|---|---|---|---|
| | Description | S-Water | S-Water | S-Water | S-Water | S-Water |
| | Sampled Date | 25-MAR-14 | 25-MAR-14 | 25-MAR-14 | 25-MAR-14 | 25-MAR-14 |
| | Sampled Time | | | | | |
| | Client ID | AIRPORT SW-1 | AIRPORT SW-2 | AIRPORT SW-3 | MARINE SW-1 | MARINE SW-2 |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Total Metals** | Titanium (Ti)-Total (mg/L) | 0.017 | 0.023 | 0.016 | 0.028 | 0.036 |
| | Uranium (U)-Total (mg/L) | <0.00020 | <0.00020 | <0.00020 | <0.00020 | 0.00046 |
| | Vanadium (V)-Total (mg/L) | 0.0026 | 0.0013 | 0.0025 | 0.0020 | 0.0025 |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.0142 |
| **Aggregate Organics** | COD (mg/L) | 26 | <20 | 20 | <20 | 40 |
| | Phenols (4AAP) (mg/L) | 0.0029 | 0.0026 | 0.0032 | 0.0015 | 0.0045 |

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | Sample ID<br>Description<br>Sampled Date<br>Sampled Time<br>Client ID | L1436334-6<br>S-Water<br>25-MAR-14<br><br>MARINE SW-3 | | | | |
|---|---|---|---|---|---|---|
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Total Metals** | Titanium (Ti)-Total (mg/L) | 0.028 | | | | |
| | Uranium (U)-Total (mg/L) | <0.00020 | | | | |
| | Vanadium (V)-Total (mg/L) | 0.0021 | | | | |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | | | | |
| **Aggregate Organics** | COD (mg/L) | <20 | | | | |
| | Phenols (4AAP) (mg/L) | 0.0043 | | | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# Reference Information

**Qualifiers for Sample Submission Listed:**

| Qualifier | Description |
|---|---|
| WSMT | Water sample(s) for total mercury analysis was not submitted in glass container with HCl preservative. Results may be biased low. |

**Qualifiers for Individual Samples Listed:**

| Sample Numbe | Client Sample ID | Qualifier | Description |
|---|---|---|---|
| L1436334-1 | AIRPORT SW-1 | WSMT | Water sample(s) for total mercury analysis was not submitted in glass container with HCl preservative. Results may be biased low. |

**QC Samples with Qualifiers & Comments:**

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Duplicate | Bromide (Br) | DLM | L1436334-1, -2, -3, -4, -5, -6 |
| Matrix Spike | Calcium (Ca)-Total | MS-B | L1436334-1, -2, -3, -4, -5, -6 |
| Matrix Spike | Sodium (Na)-Total | MS-B | L1436334-1, -2, -3, -4, -5, -6 |

**Qualifiers for Individual Parameters Listed:**

| Qualifier | Description |
|---|---|
| DLM | Detection Limit Adjusted due to sample matrix effects. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-BR-IC-VA** | Water | Bromide by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-F-IC-VA** | Water | Fluoride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-NO2-IC-VA** | Water | Nitrite in Water by Ion Chromatography | EPA 300.0 |

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-NO3-IC-VA** | Water | Nitrate in Water by Ion Chromatography | EPA 300.0 |

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **COD-COL-VA** | Water | Chemical Oxygen Demand by Colorimetric | APHA 5220 D. CHEMICAL OXYGEN DEMAND |

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **EC-PCT-VA** | Water | Conductivity (Automated) | APHA 2510 Auto. Conduc. |

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **HARDNESS-CALC-VA** | Water | Hardness | APHA 2340B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **HG-TOT-LOW-CVAFS-VA** | Water | Total Mercury in Water by CVAFS(Low) | EPA 245.7 |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 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 fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **MET-T-CCMS-VA** | Water | Total Metals in Water by CRC ICPMS | APHA 3030 B&E / EPA SW-846 6020A |

# Reference Information

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 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 hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

| | | | |
|---|---|---|---|
| **MET-TOT-ICP-VA** | Water | Total Metals in Water by ICPOES | EPA SW-846 3005A/6010B |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 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 hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

| | | | |
|---|---|---|---|
| **NH3-F-VA** | Water | Ammonia in Water by Fluorescence | J. ENVIRON. MONIT., 2005, 7, 37-42, RSC |

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

| | | | |
|---|---|---|---|
| **PH-PCT-VA** | Water | pH by Meter (Automated) | APHA 4500-H "pH Value" |

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

| | | | |
|---|---|---|---|
| **PH-PCT-VA** | Water | pH by Meter (Automated) | APHA 4500-H pH Value |

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

| | | | |
|---|---|---|---|
| **PHENOLS-4AAP-ED** | Water | Phenols (4AAP) | AB ENV.06537-COLORIMETRIC |

This analysis is carried out using procedures adapted from ENVIRODAT VMV 06537 689, Method Code 154, in "Methods Manual for Chemical Analysis of Water and Wastes" published by the Alberta Environmental Centre. This automated method is based on the distillation of phenol and subsequent reaction of the distillate with alkaline ferricyanide and 4-aminoantipyrine to form a red complex which is measured at 505 nm.

| | | | |
|---|---|---|---|
| **TDS-VA** | Water | Total Dissolved Solids by Gravimetric | APHA 2540 C - GRAVIMETRIC |

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

| | | | |
|---|---|---|---|
| **TSS-VA** | Water | Total Suspended Solids by Gravimetric | APHA 2540 D - GRAVIMETRIC |

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| **Laboratory Definition Code** | **Laboratory Location** |
|---|---|
| ED | ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA |
| VA | ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA |

**Chain of Custody Numbers:**

10-368543

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L1436334 Report Date: 03-APR-14

Client: SPERLING HANSEN ASSOCIATES INC.
# 8 - 1225 East Keith Road
North Vancouver BC V7J 1J3
Contact: Mark Manning

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-BR-IC-VA** | **Water** | | | | | | | |
| **Batch R2811712** | | | | | | | | |
| **WG1849482-15 LCS** | | | | | | | | |
| Bromide (Br) | | | 105.8 | | % | | 85-115 | 26-MAR-14 |
| **WG1849482-2 LCS** | | | | | | | | |
| Bromide (Br) | | | 102.1 | | % | | 85-115 | 26-MAR-14 |
| **WG1849482-1 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 26-MAR-14 |
| **WG1849482-10 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 26-MAR-14 |
| **WG1849482-13 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 26-MAR-14 |
| **WG1849482-4 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 26-MAR-14 |
| **WG1849482-7 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 26-MAR-14 |
| **WG1849482-11 MS** | | **L1436121-8** | | | | | | |
| Bromide (Br) | | | 104.0 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-8 MS** | | **L1436096-10** | | | | | | |
| Bromide (Br) | | | 110.4 | | % | | 75-125 | 26-MAR-14 |
| **ANIONS-CL-IC-VA** | **Water** | | | | | | | |
| **Batch R2811712** | | | | | | | | |
| **WG1849482-15 LCS** | | | | | | | | |
| Chloride (Cl) | | | 102.4 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 102.2 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-10 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-13 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-4 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-7 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-11 MS** | | **L1436121-8** | | | | | | |
| Chloride (Cl) | | | 101.4 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-14 MS** | | **L1436432-2** | | | | | | |
| Chloride (Cl) | | | 101.1 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-5 MS** | | **L1435966-2** | | | | | | |

# Quality Control Report

| Test | | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|---|
| **ANIONS-CL-IC-VA** | | **Water** | | | | | | | |
| **Batch** | **R2811712** | | | | | | | | |
| **WG1849482-5** | **MS** | | **L1435966-2** | | | | | | |
| Chloride (Cl) | | | | 101.6 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-8** | **MS** | | **L1436096-10** | | | | | | |
| Chloride (Cl) | | | | 99.9 | | % | | 75-125 | 26-MAR-14 |
| **ANIONS-F-IC-VA** | | **Water** | | | | | | | |
| **Batch** | **R2811712** | | | | | | | | |
| **WG1849482-15** | **LCS** | | | | | | | | |
| Fluoride (F) | | | | 108.8 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-2** | **LCS** | | | | | | | | |
| Fluoride (F) | | | | 108.5 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-1** | **MB** | | | | | | | | |
| Fluoride (F) | | | | <0.020 | | mg/L | | 0.02 | 26-MAR-14 |
| **WG1849482-10** | **MB** | | | | | | | | |
| Fluoride (F) | | | | <0.020 | | mg/L | | 0.02 | 26-MAR-14 |
| **WG1849482-13** | **MB** | | | | | | | | |
| Fluoride (F) | | | | <0.020 | | mg/L | | 0.02 | 26-MAR-14 |
| **WG1849482-4** | **MB** | | | | | | | | |
| Fluoride (F) | | | | <0.020 | | mg/L | | 0.02 | 26-MAR-14 |
| **WG1849482-7** | **MB** | | | | | | | | |
| Fluoride (F) | | | | <0.020 | | mg/L | | 0.02 | 26-MAR-14 |
| **WG1849482-11** | **MS** | | **L1436121-8** | | | | | | |
| Fluoride (F) | | | | 111.4 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-14** | **MS** | | **L1436432-2** | | | | | | |
| Fluoride (F) | | | | 110.5 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-8** | **MS** | | **L1436096-10** | | | | | | |
| Fluoride (F) | | | | 108.0 | | % | | 75-125 | 26-MAR-14 |
| **ANIONS-NO2-IC-VA** | | **Water** | | | | | | | |
| **Batch** | **R2811712** | | | | | | | | |
| **WG1849482-15** | **LCS** | | | | | | | | |
| Nitrite (as N) | | | | 102.0 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-2** | **LCS** | | | | | | | | |
| Nitrite (as N) | | | | 101.6 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-1** | **MB** | | | | | | | | |
| Nitrite (as N) | | | | <0.0010 | | mg/L | | 0.001 | 26-MAR-14 |
| **WG1849482-10** | **MB** | | | | | | | | |
| Nitrite (as N) | | | | <0.0010 | | mg/L | | 0.001 | 26-MAR-14 |
| **WG1849482-13** | **MB** | | | | | | | | |
| Nitrite (as N) | | | | <0.0010 | | mg/L | | 0.001 | 26-MAR-14 |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-NO2-IC-VA** | **Water** | | | | | | | |
| **Batch R2811712** | | | | | | | | |
| **WG1849482-4 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 26-MAR-14 |
| **WG1849482-7 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 26-MAR-14 |
| **WG1849482-11 MS** | | **L1436121-8** | | | | | | |
| Nitrite (as N) | | | 100.3 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-14 MS** | | **L1436432-2** | | | | | | |
| Nitrite (as N) | | | 99.0 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-8 MS** | | **L1436096-10** | | | | | | |
| Nitrite (as N) | | | 100.2 | | % | | 75-125 | 26-MAR-14 |
| **ANIONS-NO3-IC-VA** | **Water** | | | | | | | |
| **Batch R2811712** | | | | | | | | |
| **WG1849482-15 LCS** | | | | | | | | |
| Nitrate (as N) | | | 102.3 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 102.0 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 26-MAR-14 |
| **WG1849482-10 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 26-MAR-14 |
| **WG1849482-13 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 26-MAR-14 |
| **WG1849482-4 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 26-MAR-14 |
| **WG1849482-7 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 26-MAR-14 |
| **WG1849482-11 MS** | | **L1436121-8** | | | | | | |
| Nitrate (as N) | | | 98.9 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-14 MS** | | **L1436432-2** | | | | | | |
| Nitrate (as N) | | | 97.5 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-8 MS** | | **L1436096-10** | | | | | | |
| Nitrate (as N) | | | 100.5 | | % | | 75-125 | 26-MAR-14 |
| **ANIONS-SO4-IC-VA** | **Water** | | | | | | | |
| **Batch R2811712** | | | | | | | | |
| **WG1849482-15 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 103.0 | | % | | 90-110 | 26-MAR-14 |
| **WG1849482-2 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 102.7 | | % | | 90-110 | 26-MAR-14 |

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-SO4-IC-VA** | **Water** | | | | | | | |
| **Batch R2811712** | | | | | | | | |
| **WG1849482-1 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-10 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-13 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-4 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-7 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 26-MAR-14 |
| **WG1849482-11 MS** | | **L1436121-8** | | | | | | |
| Sulfate (SO4) | | | 101.6 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-14 MS** | | **L1436432-2** | | | | | | |
| Sulfate (SO4) | | | 101.6 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-5 MS** | | **L1435966-2** | | | | | | |
| Sulfate (SO4) | | | 100.4 | | % | | 75-125 | 26-MAR-14 |
| **WG1849482-8 MS** | | **L1436096-10** | | | | | | |
| Sulfate (SO4) | | | 92.8 | | % | | 75-125 | 26-MAR-14 |
| **COD-COL-VA** | **Water** | | | | | | | |
| **Batch R2811551** | | | | | | | | |
| **WG1850048-3 LCS** | | | | | | | | |
| COD | | | 99.2 | | % | | 85-115 | 27-MAR-14 |
| **WG1850048-5 LCS** | | | | | | | | |
| COD | | | 98.1 | | % | | 85-115 | 27-MAR-14 |
| **WG1850048-1 MB** | | | | | | | | |
| COD | | | <20 | | mg/L | | 20 | 27-MAR-14 |
| **WG1850048-4 MB** | | | | | | | | |
| COD | | | <20 | | mg/L | | 20 | 27-MAR-14 |
| **EC-PCT-VA** | **Water** | | | | | | | |
| **Batch R2811411** | | | | | | | | |
| **WG1849403-17 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 100.7 | | % | | 90-110 | 26-MAR-14 |
| **WG1849403-18 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 99.1 | | % | | 90-110 | 26-MAR-14 |
| **WG1849403-19 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 99.2 | | % | | 90-110 | 26-MAR-14 |
| **WG1849403-20 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 100.5 | | % | | 90-110 | 26-MAR-14 |

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **EC-PCT-VA** | **Water** | | | | | | | |
| **Batch R2811411** | | | | | | | | |
| **WG1849403-21 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 100.7 | | % | | 90-110 | 26-MAR-14 |
| **WG1849403-1 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 26-MAR-14 |
| **WG1849403-2 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 26-MAR-14 |
| **WG1849403-3 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 26-MAR-14 |
| **WG1849403-4 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 26-MAR-14 |
| **WG1849403-5 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 26-MAR-14 |
| **HG-TOT-LOW-CVAFS-VA** | **Water** | | | | | | | |
| **Batch R2811762** | | | | | | | | |
| **WG1850491-8 DUP** | | **L1436334-1** | | | | | | |
| Mercury (Hg)-Total | | <0.000010 | <0.000010 | RPD-NA | mg/L | N/A | 20 | 27-MAR-14 |
| **WG1850491-6 LCS** | | | | | | | | |
| Mercury (Hg)-Total | | | 97.0 | | % | | 80-120 | 27-MAR-14 |
| **WG1850491-5 MB** | | | | | | | | |
| Mercury (Hg)-Total | | | <0.000010 | | mg/L | | 0.00001 | 27-MAR-14 |
| **WG1850491-14 MS** | | **L1436483-1** | | | | | | |
| Mercury (Hg)-Total | | | 88.9 | | % | | 70-130 | 27-MAR-14 |
| **WG1850491-15 MS** | | **L1436334-2** | | | | | | |
| Mercury (Hg)-Total | | | 92.1 | | % | | 70-130 | 27-MAR-14 |
| **WG1850491-16 MS** | | **L1436620-1** | | | | | | |
| Mercury (Hg)-Total | | | 96.8 | | % | | 70-130 | 27-MAR-14 |
| **MET-T-CCMS-VA** | **Water** | | | | | | | |
| **Batch R2813318** | | | | | | | | |
| **WG1851197-3 CRM** | | **VA-HIGH-WATRM** | | | | | | |
| Aluminum (Al)-Total | | | 100.1 | | % | | 80-120 | 29-MAR-14 |
| Antimony (Sb)-Total | | | 100.9 | | % | | 80-120 | 29-MAR-14 |
| Arsenic (As)-Total | | | 97.7 | | % | | 80-120 | 29-MAR-14 |
| Beryllium (Be)-Total | | | 96.1 | | % | | 80-120 | 29-MAR-14 |
| Cadmium (Cd)-Total | | | 101.6 | | % | | 80-120 | 29-MAR-14 |
| Chromium (Cr)-Total | | | 99.6 | | % | | 80-120 | 29-MAR-14 |
| Cobalt (Co)-Total | | | 97.4 | | % | | 80-120 | 29-MAR-14 |
| Copper (Cu)-Total | | | 96.3 | | % | | 80-120 | 29-MAR-14 |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-VA** | **Water** | | | | | | | |
| **Batch R2813318** | | | | | | | | |
| **WG1851197-3 CRM** | | **VA-HIGH-WATRM** | | | | | | |
| Lead (Pb)-Total | | | 96.6 | | % | | 80-120 | 29-MAR-14 |
| Lithium (Li)-Total | | | 96.3 | | % | | 80-120 | 29-MAR-14 |
| Manganese (Mn)-Total | | | 101.3 | | % | | 80-120 | 29-MAR-14 |
| Molybdenum (Mo)-Total | | | 96.3 | | % | | 80-120 | 29-MAR-14 |
| Nickel (Ni)-Total | | | 97.6 | | % | | 80-120 | 29-MAR-14 |
| Selenium (Se)-Total | | | 98.2 | | % | | 80-120 | 29-MAR-14 |
| Silver (Ag)-Total | | | 101.4 | | % | | 80-120 | 29-MAR-14 |
| Thallium (Tl)-Total | | | 99.9 | | % | | 80-120 | 29-MAR-14 |
| Tin (Sn)-Total | | | 99.9 | | % | | 80-120 | 29-MAR-14 |
| Uranium (U)-Total | | | 98.2 | | % | | 80-120 | 29-MAR-14 |
| Vanadium (V)-Total | | | 99.6 | | % | | 80-120 | 29-MAR-14 |
| **WG1851197-1 MB** | | | | | | | | |
| Aluminum (Al)-Total | | | <0.0030 | | mg/L | | 0.003 | 29-MAR-14 |
| Antimony (Sb)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Arsenic (As)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Beryllium (Be)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Cadmium (Cd)-Total | | | <0.000010 | | mg/L | | 0.00001 | 29-MAR-14 |
| Chromium (Cr)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Cobalt (Co)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Copper (Cu)-Total | | | <0.00050 | | mg/L | | 0.0005 | 29-MAR-14 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 29-MAR-14 |
| Lithium (Li)-Total | | | <0.00050 | | mg/L | | 0.0005 | 29-MAR-14 |
| Manganese (Mn)-Total | | | <0.000050 | | mg/L | | 0.00005 | 29-MAR-14 |
| Molybdenum (Mo)-Total | | | <0.000050 | | mg/L | | 0.00005 | 29-MAR-14 |
| Nickel (Ni)-Total | | | <0.00050 | | mg/L | | 0.0005 | 29-MAR-14 |
| Selenium (Se)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Silver (Ag)-Total | | | <0.000010 | | mg/L | | 0.00001 | 29-MAR-14 |
| Tin (Sn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 29-MAR-14 |
| Uranium (U)-Total | | | <0.000010 | | mg/L | | 0.00001 | 29-MAR-14 |
| Vanadium (V)-Total | | | <0.0010 | | mg/L | | 0.001 | 29-MAR-14 |
| **Batch R2814038** | | | | | | | | |
| **WG1851197-1 MB** | | | | | | | | |
| Thallium (Tl)-Total | | | <0.000010 | | mg/L | | 0.00001 | 31-MAR-14 |
| **MET-TOT-ICP-VA** | **Water** | | | | | | | |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-TOT-ICP-VA** | **Water** | | | | | | | |
| **Batch R2813526** | | | | | | | | |
| **WG1851197-3 CRM** | | **VA-HIGH-WATRM** | | | | | | |
| Barium (Ba)-Total | | | 101.4 | | % | | 80-120 | 29-MAR-14 |
| Boron (B)-Total | | | 99.9 | | % | | 80-120 | 29-MAR-14 |
| Calcium (Ca)-Total | | | 105.0 | | % | | 80-120 | 29-MAR-14 |
| Iron (Fe)-Total | | | 98.8 | | % | | 80-120 | 29-MAR-14 |
| Magnesium (Mg)-Total | | | 104.0 | | % | | 80-120 | 29-MAR-14 |
| Potassium (K)-Total | | | 101.9 | | % | | 80-120 | 29-MAR-14 |
| Sodium (Na)-Total | | | 102.5 | | % | | 80-120 | 29-MAR-14 |
| Titanium (Ti)-Total | | | 106.3 | | % | | 80-120 | 29-MAR-14 |
| Zinc (Zn)-Total | | | 100.2 | | % | | 80-120 | 29-MAR-14 |
| **WG1851197-1 MB** | | | | | | | | |
| Barium (Ba)-Total | | | <0.010 | | mg/L | | 0.01 | 29-MAR-14 |
| Boron (B)-Total | | | <0.10 | | mg/L | | 0.1 | 29-MAR-14 |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 29-MAR-14 |
| Iron (Fe)-Total | | | <0.030 | | mg/L | | 0.03 | 29-MAR-14 |
| Magnesium (Mg)-Total | | | <0.10 | | mg/L | | 0.1 | 29-MAR-14 |
| Potassium (K)-Total | | | <2.0 | | mg/L | | 2 | 29-MAR-14 |
| Sodium (Na)-Total | | | <2.0 | | mg/L | | 2 | 29-MAR-14 |
| Titanium (Ti)-Total | | | <0.010 | | mg/L | | 0.01 | 29-MAR-14 |
| Zinc (Zn)-Total | | | <0.0050 | | mg/L | | 0.005 | 29-MAR-14 |
| **Batch R2813768** | | | | | | | | |
| **WG1851197-4 MS** | | **L1437394-1** | | | | | | |
| Boron (B)-Total | | | 101.2 | | % | | 70-130 | 31-MAR-14 |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 31-MAR-14 |
| Iron (Fe)-Total | | | 93.3 | | % | | 70-130 | 31-MAR-14 |
| Magnesium (Mg)-Total | | | 100.5 | | % | | 70-130 | 31-MAR-14 |
| Potassium (K)-Total | | | 103.8 | | % | | 70-130 | 31-MAR-14 |
| Sodium (Na)-Total | | | N/A | MS-B | % | | - | 31-MAR-14 |
| Titanium (Ti)-Total | | | 101.1 | | % | | 70-130 | 31-MAR-14 |
| Zinc (Zn)-Total | | | 91.1 | | % | | 70-130 | 31-MAR-14 |
| **NH3-F-VA** | **Water** | | | | | | | |
| **Batch R2814976** | | | | | | | | |
| **WG1852631-10 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 98.3 | | % | | 85-115 | 02-APR-14 |
| **WG1852631-2 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 99.5 | | % | | 85-115 | 02-APR-14 |

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NH3-F-VA** | **Water** | | | | | | | |
| **Batch R2814976** | | | | | | | | |
| **WG1852631-4 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 96.7 | | % | | 85-115 | 02-APR-14 |
| **WG1852631-6 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 101.0 | | % | | 85-115 | 02-APR-14 |
| **WG1852631-8 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 98.8 | | % | | 85-115 | 02-APR-14 |
| **WG1852631-1 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 02-APR-14 |
| **WG1852631-3 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 02-APR-14 |
| **WG1852631-5 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 02-APR-14 |
| **WG1852631-7 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 02-APR-14 |
| **WG1852631-9 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 02-APR-14 |
| **WG1852631-12 MS** | | **L1435746-8** | | | | | | |
| Ammonia, Total (as N) | | | 102.0 | | % | | 75-125 | 02-APR-14 |
| **WG1852631-14 MS** | | **L1435804-1** | | | | | | |
| Ammonia, Total (as N) | | | 100.4 | | % | | 75-125 | 02-APR-14 |
| **PH-PCT-VA** | **Water** | | | | | | | |
| **Batch R2811411** | | | | | | | | |
| **WG1849403-25 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.04 | | pH | | 6.9-7.1 | 26-MAR-14 |
| **WG1849403-26 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.04 | | pH | | 6.9-7.1 | 26-MAR-14 |
| **WG1849403-27 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.04 | | pH | | 6.9-7.1 | 26-MAR-14 |
| **WG1849403-28 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.05 | | pH | | 6.9-7.1 | 26-MAR-14 |
| **WG1849403-29 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.04 | | pH | | 6.9-7.1 | 26-MAR-14 |
| **PHENOLS-4AAP-ED** | **Water** | | | | | | | |
| **Batch R2812204** | | | | | | | | |
| **WG1850967-3 LCS** | | | | | | | | |
| Phenols (4AAP) | | | 100.0 | | % | | 85-115 | 28-MAR-14 |
| **WG1850967-2 MB** | | | | | | | | |
| Phenols (4AAP) | | | <0.0010 | | mg/L | | 0.001 | 28-MAR-14 |

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **PHENOLS-4AAP-ED** | **Water** | | | | | | | |
| **Batch R2812204** | | | | | | | | |
| **WG1850967-6 MS** | | **L1434626-6** | | | | | | |
| Phenols (4AAP) | | | 98.0 | | % | | 75-125 | 28-MAR-14 |
| **TDS-VA** | **Water** | | | | | | | |
| **Batch R2811770** | | | | | | | | |
| **WG1849952-3 DUP** | | **L1436334-2** | | | | | | |
| Total Dissolved Solids | | 257 | 261 | | mg/L | 1.6 | 20 | 27-MAR-14 |
| **WG1849952-2 LCS** | | | | | | | | |
| Total Dissolved Solids | | | 101.1 | | % | | 85-115 | 27-MAR-14 |
| **WG1849952-5 LCS** | | | | | | | | |
| Total Dissolved Solids | | | 101.7 | | % | | 85-115 | 27-MAR-14 |
| **WG1849952-1 MB** | | | | | | | | |
| Total Dissolved Solids | | | <10 | | mg/L | | 10 | 27-MAR-14 |
| **WG1849952-4 MB** | | | | | | | | |
| Total Dissolved Solids | | | <10 | | mg/L | | 10 | 27-MAR-14 |
| **TSS-VA** | **Water** | | | | | | | |
| **Batch R2811412** | | | | | | | | |
| **WG1849951-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 90.5 | | % | | 85-115 | 27-MAR-14 |
| **WG1849951-5 LCS** | | | | | | | | |
| Total Suspended Solids | | | 102.8 | | % | | 85-115 | 27-MAR-14 |
| **WG1849951-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 27-MAR-14 |
| **WG1849951-4 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 27-MAR-14 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| J | Duplicate results and limits are expressed in terms of absolute difference. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

# Quality Control Report

**Hold Time Exceedances:**

| ALS Product Description | Sample ID | Sampling Date | Date Processed | Rec. HT | Actual HT | Units | Qualifier |
|---|---|---|---|---|---|---|---|
| **Physical Tests** | | | | | | | |
| pH by Meter (Automated) | | | | | | | |
| | 1 | 25-MAR-14 | 26-MAR-14 23:00 | 0.25 | 35 | hours | EHTR-FM |
| | 2 | 25-MAR-14 | 26-MAR-14 23:00 | 0.25 | 35 | hours | EHTR-FM |
| | 3 | 25-MAR-14 | 26-MAR-14 23:00 | 0.25 | 35 | hours | EHTR-FM |
| | 4 | 25-MAR-14 | 26-MAR-14 23:00 | 0.25 | 35 | hours | EHTR-FM |
| | 5 | 25-MAR-14 | 26-MAR-14 23:00 | 0.25 | 35 | hours | EHTR-FM |
| | 6 | 25-MAR-14 | 26-MAR-14 23:00 | 0.25 | 35 | hours | EHTR-FM |

**Legend & Qualifier Definitions:**

| | |
|---|---|
| EHTR-FM: | Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended. |
| EHTR: | Exceeded ALS recommended hold time prior to sample receipt. |
| EHTL: | Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry. |
| EHT: | Exceeded ALS recommended hold time prior to analysis. |
| Rec. HT: | ALS recommended hold time (see units). |

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1436334 were received on 25-MAR-14 19:25.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

**10-** 368543

ALS Environmental

**Chain of Custody / Analytical**
**Canada Toll Free: 1 800**
www.alsglobal.cor

L1436334-COFC

Page 1 of 1

**Report To**
Company: Sperling Hansen Associates
Contact: MARK MANNING
Address: #8 1225 East Keith Rd
Phone: 604-986-7723 Fax:

**Invoice To** Same as Report ? (circle) [✓ Yes] or No (if No, provide details)
Copy of Invoice with Report? (circle) [✓ Yes] or No
Company:
Contact:
Address:
Phone: Fax:

**Report Format / Distribution**
Standard: X Other (specify):
Select: PDF X Excel X Digital Fax
Email 1: mmanning@sperlinghansen.com
Email 2: dKviek@sperlinghansen.com

**Client / Project Information**
Job #: Prj 13043 Powell River
PO / AFE:
LSD:
Quote #:

ility - Contact ALS to confirm TAT)
✓ Regular (Standard Turnaround Times - Business Days)
Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Same Day or Weekend Emergency - Contact ALS to confirm TAT

**Lab Work Order # (lab use only)** L1436334

**ALS Contact:** Dean Watt

**Sampler:** Iqbal Bhuiyan

**Analysis Request**
( Indicate Filtered or Preserved, F/P )

| Sample # | Sample Identification (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | pH | Conductivity | TSS | TDS | COD | Total Phenols | Anion Scan | Ammonia | Total Metals | | | | Number of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Airport SW-1 | 25/3/14 | | S-Water | X | X | X | X | X | X | X | X | X | | | | |
| | Airport SW-2 | " | | " | X | X | X | X | X | X | X | X | X | | | | |
| | Airport SW-3 | " | | " | X | X | X | X | X | X | X | X | X | | | | |
| | Marine SW-1 | " | | " | X | X | X | X | X | X | X | X | X | | | | |
| | Marine SW-2 | " | | " | X | X | X | X | X | X | X | X | X | | | | |
| | Marine SW-3 | " | | " | X | X | X | X | X | X | X | X | X | | | | |

**Short Holding Time**

*Rush Processing*

**Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details**

**Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.**

**By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.**

SHIPMENT RELEASE (client use)
Released by: Date: Time:

SHIPMENT RECEPTION (lab use only)
Received by: L Weeks Date: Mar 25,14 Time: 19:25 Temperature: 7.9 °C

SHIPMENT VERIFICATION (lab use only)
Verified by: Date: Time: Observations: Yes / No ? If Yes add SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

SPERLING HANSEN ASSOCIATES INC.
ATTN: Mark Manning
# 8 - 1225 East Keith Road
North Vancouver BC V7J 1J3

| | |
|---|---|
| Date Received: | 17-DEC-13 |
| Report Date: | 27-DEC-13 11:08 (MT) |
| Version: | FINAL |

Client Phone: 604-986-7723

# Certificate of Analysis

| | |
|---|---|
| **Lab Work Order #:** | **L1404125** |
| Project P.O. #: | NOT SUBMITTED |
| Job Reference: | PRJ 13043 POWELL RIVER |
| C of C Numbers: | 10-342337 |
| Legal Site Desc: | |

Dean Watt
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | **Sample ID** | L1404125-1 | L1404125-2 | L1404125-3 | L1404125-4 | L1404125-5 |
|---|---|---|---|---|---|---|
| | **Description** | G-Water | G-Water | G-Water | G-Water | G-Water |
| | **Sampled Date** | 14-DEC-13 | 14-DEC-13 | 14-DEC-13 | 14-DEC-13 | 14-DEC-13 |
| | **Sampled Time** | | | | | |
| | **Client ID** | MW-2 | MW-3 | MW-8 | MW-9 | MW13-1 |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Physical Tests** | Conductivity (uS/cm) | 232 | 643 | 1000 | 687 | 126 |
| | Hardness (as CaCO3) (mg/L) | 106 | 325 | 505 | 343 | 45.3 |
| | pH (pH) | 7.23 | 7.45 | 7.21 | 7.23 | 7.05 |
| | Total Suspended Solids (mg/L) | 4100 | 606 | 7540 | 347 | 709 |
| | Total Dissolved Solids (mg/L) | 1080 RRR | 407 | 665 | 443 | 100 |
| **Anions and Nutrients** | Ammonia, Total (as N) (mg/L) | | <0.0050 | 0.0056 | <0.0050 | <0.0050 |
| | Bromide (Br) (mg/L) | <0.050 | 0.153 | <0.50 DLM | 0.087 | <0.050 |
| | Chloride (Cl) (mg/L) | 2.95 | 5.99 | 7.3 | 4.93 | 9.72 |
| | Fluoride (F) (mg/L) | 0.025 | 0.045 | <0.20 DLM | 0.031 | 0.027 |
| | Nitrate (as N) (mg/L) | 5.29 | 3.38 | 3.83 | 4.51 | 0.171 |
| | Nitrite (as N) (mg/L) | 0.0016 | <0.0010 | <0.010 DLM | <0.0010 | <0.0010 |
| | Sulfate (SO4) (mg/L) | 19.2 | 39.9 | 94.9 | 51.1 | 5.98 |
| | Sulphide as S (mg/L) | | <0.020 | <0.020 | <0.020 | <0.020 |
| **Dissolved Metals** | Dissolved Mercury Filtration Location | FIELD | FIELD | FIELD | FIELD | FIELD |
| | Dissolved Metals Filtration Location | FIELD | FIELD | FIELD | FIELD | FIELD |
| | Aluminum (Al)-Dissolved (mg/L) | 0.0060 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Antimony (Sb)-Dissolved (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | <0.00050 |
| | Arsenic (As)-Dissolved (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | <0.00050 |
| | Barium (Ba)-Dissolved (mg/L) | <0.020 | <0.020 | 0.055 | <0.020 | <0.020 |
| | Beryllium (Be)-Dissolved (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Boron (B)-Dissolved (mg/L) | 0.11 | 0.16 | 0.57 | 0.27 | <0.10 |
| | Cadmium (Cd)-Dissolved (mg/L) | 0.000011 | 0.000013 | 0.000064 | 0.000025 | <0.000010 |
| | Calcium (Ca)-Dissolved (mg/L) | 34.2 | 104 | 147 | 105 | 13.3 |
| | Chromium (Cr)-Dissolved (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Cobalt (Co)-Dissolved (mg/L) | <0.00030 | <0.00030 | <0.00030 | <0.00030 | <0.00030 |
| | Copper (Cu)-Dissolved (mg/L) | <0.0010 | 0.0010 | 0.0018 | 0.0014 | <0.0010 |
| | Iron (Fe)-Dissolved (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Lead (Pb)-Dissolved (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | <0.00050 |
| | Lithium (Li)-Dissolved (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Magnesium (Mg)-Dissolved (mg/L) | 5.06 | 16.0 | 33.5 | 19.8 | 2.94 |
| | Manganese (Mn)-Dissolved (mg/L) | 0.00036 | <0.00030 | 0.0157 | <0.00030 | 0.0102 |
| | Mercury (Hg)-Dissolved (mg/L) | <0.000010 | <0.000010 | <0.000010 | <0.000010 | <0.000010 |
| | Molybdenum (Mo)-Dissolved (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Nickel (Ni)-Dissolved (mg/L) | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 |
| | Potassium (K)-Dissolved (mg/L) | 2.1 | 4.8 | 3.2 | 3.2 | <2.0 |
| | Selenium (Se)-Dissolved (mg/L) | <0.00010 | <0.00010 | <0.00010 | <0.00010 | 0.00011 |
| | Silver (Ag)-Dissolved (mg/L) | <0.000020 | <0.000020 | <0.000020 | <0.000020 | <0.000020 |

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | | | |
|---|---|---|---|
| | **Sample ID** | L1404125-6 | L1404125-7 |
| | **Description** | G-Water | G-Water |
| | **Sampled Date** | 14-DEC-13 | 14-DEC-13 |
| | **Sampled Time** | | |
| | **Client ID** | MW13-2 | MW13-3 |
| **Grouping** | **Analyte** | | |
| **WATER** | | | |
| **Physical Tests** | Conductivity (uS/cm) | 347 | 215 |
| | Hardness (as CaCO3) (mg/L) | 151 | 87.3 |
| | pH (pH) | 6.90 | 6.96 |
| | Total Suspended Solids (mg/L) | 418 | 869 |
| | Total Dissolved Solids (mg/L) | 192 | 144 |
| **Anions and Nutrients** | Ammonia, Total (as N) (mg/L) | 1.42 | 0.106 |
| | Bromide (Br) (mg/L) | <0.050 | <0.050 |
| | Chloride (Cl) (mg/L) | 7.06 | 9.63 |
| | Fluoride (F) (mg/L) | 0.142 | 0.060 |
| | Nitrate (as N) (mg/L) | 0.0642 | 0.526 |
| | Nitrite (as N) (mg/L) | 0.0052 | 0.0021 |
| | Sulfate (SO4) (mg/L) | 3.06 | 12.0 |
| | Sulphide as S (mg/L) | <0.020 | <0.020 |
| **Dissolved Metals** | Dissolved Mercury Filtration Location | FIELD | FIELD |
| | Dissolved Metals Filtration Location | FIELD | FIELD |
| | Aluminum (Al)-Dissolved (mg/L) | 0.0269 | 0.0377 |
| | Antimony (Sb)-Dissolved (mg/L) | <0.00050 | <0.00050 |
| | Arsenic (As)-Dissolved (mg/L) | 0.00294 | <0.00050 |
| | Barium (Ba)-Dissolved (mg/L) | 0.032 | <0.020 |
| | Beryllium (Be)-Dissolved (mg/L) | <0.0010 | <0.0010 |
| | Boron (B)-Dissolved (mg/L) | <0.10 | <0.10 |
| | Cadmium (Cd)-Dissolved (mg/L) | 0.000076 | 0.000034 |
| | Calcium (Ca)-Dissolved (mg/L) | 52.8 | 25.6 |
| | Chromium (Cr)-Dissolved (mg/L) | <0.0010 | <0.0010 |
| | Cobalt (Co)-Dissolved (mg/L) | 0.00335 | 0.00200 |
| | Copper (Cu)-Dissolved (mg/L) | <0.0010 | 0.0010 |
| | Iron (Fe)-Dissolved (mg/L) | 13.7 | 0.083 |
| | Lead (Pb)-Dissolved (mg/L) | <0.00050 | <0.00050 |
| | Lithium (Li)-Dissolved (mg/L) | <0.0050 | <0.0050 |
| | Magnesium (Mg)-Dissolved (mg/L) | 4.71 | 5.69 |
| | Manganese (Mn)-Dissolved (mg/L) | 0.627 | 0.404 |
| | Mercury (Hg)-Dissolved (mg/L) | <0.000010 | <0.000010 |
| | Molybdenum (Mo)-Dissolved (mg/L) | 0.0019 | 0.0021 |
| | Nickel (Ni)-Dissolved (mg/L) | 0.0015 | 0.0018 |
| | Potassium (K)-Dissolved (mg/L) | 12.0 | 4.1 |
| | Selenium (Se)-Dissolved (mg/L) | <0.00010 | <0.00010 |
| | Silver (Ag)-Dissolved (mg/L) | <0.000020 | <0.000020 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | **Sample ID** | L1404125-1 | L1404125-2 | L1404125-3 | L1404125-4 | L1404125-5 |
|---|---|---|---|---|---|---|
| | **Description** | G-Water | G-Water | G-Water | G-Water | G-Water |
| | **Sampled Date** | 14-DEC-13 | 14-DEC-13 | 14-DEC-13 | 14-DEC-13 | 14-DEC-13 |
| | **Sampled Time** | | | | | |
| | **Client ID** | MW-2 | MW-3 | MW-8 | MW-9 | MW13-1 |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Dissolved Metals** | Sodium (Na)-Dissolved (mg/L) | 12.2 | 28.7 | 70.4 | 32.5 | 7.9 |
| | Thallium (Tl)-Dissolved (mg/L) | <0.00020 | <0.00020 | <0.00020 | <0.00020 | <0.00020 |
| | Tin (Sn)-Dissolved (mg/L) | <0.00050 | <0.00050 | <0.00050 | <0.00050 | <0.00050 |
| | Titanium (Ti)-Dissolved (mg/L) | <0.010 | 0.014 | 0.017 | 0.014 | <0.010 |
| | Uranium (U)-Dissolved (mg/L) | <0.00020 | 0.00154 | 0.0107 | 0.00367 | <0.00020 |
| | Vanadium (V)-Dissolved (mg/L) | <0.0010 | 0.0013 | 0.0022 | 0.0016 | <0.0010 |
| | Zinc (Zn)-Dissolved (mg/L) | <0.0050 | <0.0050 | 0.0054 | <0.0050 | <0.0050 |
| **Aggregate Organics** | COD (mg/L) | | 37 | 94 | 23 | <20 |
| | Phenols (4AAP) (mg/L) | | <0.0010 | <0.0010 | <0.0010 | <0.0010 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | **Sample ID** | L1404125-6 | L1404125-7 | | | |
|---|---|---|---|---|---|---|
| | **Description** | G-Water | G-Water | | | |
| | **Sampled Date** | 14-DEC-13 | 14-DEC-13 | | | |
| | **Sampled Time** | | | | | |
| | **Client ID** | MW13-2 | MW13-3 | | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Dissolved Metals** | Sodium (Na)-Dissolved (mg/L) | 9.6 | 17.4 | | | |
| | Thallium (Tl)-Dissolved (mg/L) | <0.00020 | <0.00020 | | | |
| | Tin (Sn)-Dissolved (mg/L) | <0.00050 | <0.00050 | | | |
| | Titanium (Ti)-Dissolved (mg/L) | <0.010 | <0.010 | | | |
| | Uranium (U)-Dissolved (mg/L) | 0.00159 | 0.00035 | | | |
| | Vanadium (V)-Dissolved (mg/L) | <0.0010 | <0.0010 | | | |
| | Zinc (Zn)-Dissolved (mg/L) | 0.0101 | 0.0108 | | | |
| **Aggregate Organics** | COD (mg/L) | 74 | 47 | | | |
| | Phenols (4AAP) (mg/L) | 0.0040 RRV | <0.0010 | | | |

# Reference Information

**Additional Comments for Sample Listed:**

| Samplenum | Matrix | Report Remarks | Sample Comments |
|---|---|---|---|
| L1404125-1 | Water | Note: sample with very fine solids, centrefudged before filter, and light brown colour filtrate and residue in the vial of TDS testing. | |

**QC Samples with Qualifiers & Comments:**

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Duplicate | Nitrite (as N) | DLM | L1404125-1, -2, -3, -4, -5, -6, -7 |
| Matrix Spike | Ammonia, Total (as N) | MS-B | L1404125-2, -3, -4, -5, -6, -7 |
| Matrix Spike | Calcium (Ca)-Dissolved | MS-B | L1404125-1, -2, -3, -4, -5, -6, -7 |

**Qualifiers for Individual Parameters Listed:**

| Qualifier | Description |
|---|---|
| DLM | Detection Limit Adjusted due to sample matrix effects. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RRR | Refer to Report Remarks for issues regarding this analysis |
| RRV | Reported Result Verified By Repeat Analysis |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-BR-IC-VA** | Water | Bromide by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-F-IC-VA** | Water | Fluoride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-NO2-IC-VA** | Water | Nitrite in Water by Ion Chromatography | EPA 300.0 |

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

| | | | |
|---|---|---|---|
| **ANIONS-NO3-IC-VA** | Water | Nitrate in Water by Ion Chromatography | EPA 300.0 |

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

| | | | |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **COD-COL-VA** | Water | Chemical Oxygen Demand by Colorimetric | APHA 5220 D. CHEMICAL OXYGEN DEMAND |

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

| | | | |
|---|---|---|---|
| **EC-PCT-VA** | Water | Conductivity (Automated) | APHA 2510 Auto. Conduc. |

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

| | | | |
|---|---|---|---|
| **HARDNESS-CALC-VA** | Water | Hardness | APHA 2340B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| | | | |
|---|---|---|---|
| **HG-DIS-LOW-CVAFS-VA** | Water | Dissolved Mercury in Water by CVAFS(Low) | EPA SW-846 3005A & EPA 245.7 |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 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 filtration (EPA Method 3005A) and 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 fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

| | | | |
|---|---|---|---|
| **MET-D-CCMS-VA** | Water | Dissolved Metals in Water by CRC ICPMS | APHA 3030 B&E / EPA SW-846 6020A |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 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 hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method

# Reference Information

6020A).

**MET-DIS-ICP-VA** Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 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 filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

**NH3-F-VA** Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

**PH-PCT-VA** Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

**PH-PCT-VA** Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

**PHENOLS-4AAP-ED** Water Phenols (4AAP) AB ENV.06537-COLORIMETRIC

This analysis is carried out using procedures adapted from ENVIRODAT VMV 06537 689, Method Code 154, in "Methods Manual for Chemical Analysis of Water and Wastes" published by the Alberta Environmental Centre. This automated method is based on the distillation of phenol and subsequent reaction of the distillate with alkaline ferricyanide and 4-aminoantipyrine to form a red complex which is measured at 505 nm.

**S2-T-COL-VA** Water Total Sulphide by Colorimetric APHA 4500-S2 Sulphide

This analysis is carried out using procedures adapted from APHA Method 4500-S2 "Sulphide". Sulphide is determined using the methlyene blue colourimetric method.

**TDS-VA** Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

**TSS-VA** Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

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** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| ED | ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA |
| VA | ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA |

**Chain of Custody Numbers:**

10-342337

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L1404125 Report Date: 27-DEC-13

Client: SPERLING HANSEN ASSOCIATES INC.
# 8 - 1225 East Keith Road
North Vancouver BC V7J 1J3
Contact: Mark Manning

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-BR-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-13 LCS** | | | | | | | | |
| Bromide (Br) | | | 107.4 | | % | | 85-115 | 17-DEC-13 |
| **WG1806277-2 LCS** | | | | | | | | |
| Bromide (Br) | | | 105.3 | | % | | 85-115 | 17-DEC-13 |
| **WG1806277-1 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 17-DEC-13 |
| **WG1806277-11 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 17-DEC-13 |
| **WG1806277-4 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 17-DEC-13 |
| **WG1806277-7 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 17-DEC-13 |
| **WG1806277-9 MB** | | | | | | | | |
| Bromide (Br) | | | <0.050 | | mg/L | | 0.05 | 17-DEC-13 |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |
| Bromide (Br) | | | 102.5 | | % | | 75-125 | 17-DEC-13 |
| **ANIONS-CL-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-13 LCS** | | | | | | | | |
| Chloride (Cl) | | | 103.7 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 103.8 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-11 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-4 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-7 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-9 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |
| Chloride (Cl) | | | 100.5 | | % | | 75-125 | 17-DEC-13 |
| **ANIONS-F-IC-VA** | **Water** | | | | | | | |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-F-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-13 LCS** | | | | | | | | |
| Fluoride (F) | | | 109.7 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-2 LCS** | | | | | | | | |
| Fluoride (F) | | | 108.9 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-1 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806277-11 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806277-4 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806277-7 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806277-9 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806277-12 MS** | | **L1404390-1** | | | | | | |
| Fluoride (F) | | | 112.4 | | % | | 75-125 | 17-DEC-13 |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |
| Fluoride (F) | | | 101.3 | | % | | 75-125 | 17-DEC-13 |
| **ANIONS-NO2-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-13 LCS** | | | | | | | | |
| Nitrite (as N) | | | 105.1 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-2 LCS** | | | | | | | | |
| Nitrite (as N) | | | 105.2 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-1 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| **WG1806277-11 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| **WG1806277-4 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| **WG1806277-7 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| **WG1806277-9 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |
| Nitrite (as N) | | | 102.5 | | % | | 75-125 | 17-DEC-13 |
| **ANIONS-NO3-IC-VA** | **Water** | | | | | | | |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-NO3-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-13 LCS** | | | | | | | | |
| Nitrate (as N) | | | 102.3 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 104.0 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 17-DEC-13 |
| **WG1806277-11 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 17-DEC-13 |
| **WG1806277-4 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 17-DEC-13 |
| **WG1806277-7 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 17-DEC-13 |
| **WG1806277-9 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 17-DEC-13 |
| **WG1806277-5 MS** | | **L1402556-9** | | | | | | |
| Nitrate (as N) | | | 102.5 | | % | | 75-125 | 17-DEC-13 |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |
| Nitrate (as N) | | | 95.6 | | % | | 75-125 | 17-DEC-13 |
| **ANIONS-SO4-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-13 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 103.8 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-2 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 103.8 | | % | | 90-110 | 17-DEC-13 |
| **WG1806277-1 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-11 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-4 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-7 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-9 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.50 | | mg/L | | 0.5 | 17-DEC-13 |
| **WG1806277-12 MS** | | **L1404390-1** | | | | | | |
| Sulfate (SO4) | | | 101.4 | | % | | 75-125 | 17-DEC-13 |
| **WG1806277-5 MS** | | **L1402556-9** | | | | | | |
| Sulfate (SO4) | | | 102.6 | | % | | 75-125 | 17-DEC-13 |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ANIONS-SO4-IC-VA** | **Water** | | | | | | | |
| **Batch R2761931** | | | | | | | | |
| **WG1806277-8 MS** | | **L1404225-1** | | | | | | |
| Sulfate (SO4) | | | 100.1 | | % | | 75-125 | 17-DEC-13 |
| **COD-COL-VA** | **Water** | | | | | | | |
| **Batch R2763841** | | | | | | | | |
| **WG1808741-3 LCS** | | | | | | | | |
| COD | | | 101.2 | | % | | 85-115 | 20-DEC-13 |
| **WG1808741-1 MB** | | | | | | | | |
| COD | | | <20 | | mg/L | | 20 | 20-DEC-13 |
| **EC-PCT-VA** | **Water** | | | | | | | |
| **Batch R2762353** | | | | | | | | |
| **WG1806691-17 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 98.6 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-18 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 96.9 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-19 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 97.4 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-20 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 98.9 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-21 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 98.3 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-22 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 99.1 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-23 CRM** | | **VA-EC-PCT-CONTROL** | | | | | | |
| Conductivity | | | 98.2 | | % | | 90-110 | 18-DEC-13 |
| **WG1806691-34 DUP** | | **L1404125-7** | | | | | | |
| Conductivity | | 215 | 217 | | uS/cm | 0.9 | 10 | 18-DEC-13 |
| **WG1806691-1 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **WG1806691-2 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **WG1806691-3 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **WG1806691-4 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **WG1806691-5 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **WG1806691-6 MB** | | | | | | | | |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **EC-PCT-VA** | **Water** | | | | | | | |
| **Batch R2762353** | | | | | | | | |
| **WG1806691-6 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **WG1806691-7 MB** | | | | | | | | |
| Conductivity | | | <2.0 | | uS/cm | | 2 | 18-DEC-13 |
| **HG-DIS-LOW-CVAFS-VA** | **Water** | | | | | | | |
| **Batch R2762028** | | | | | | | | |
| **WG1806455-1 MB** | | | | | | | | |
| Mercury (Hg)-Dissolved | | | <0.000010 | | mg/L | | 0.00001 | 17-DEC-13 |
| **WG1806455-4 MS** | | **L1403643-1** | | | | | | |
| Mercury (Hg)-Dissolved | | | 89.3 | | % | | 70-130 | 17-DEC-13 |
| **Batch R2762539** | | | | | | | | |
| **WG1806455-2 LCS** | | | | | | | | |
| Mercury (Hg)-Dissolved | | | 92.2 | | % | | 80-120 | 18-DEC-13 |
| **WG1806661-3 LCS** | | | | | | | | |
| Mercury (Hg)-Dissolved | | | 90.9 | | % | | 80-120 | 18-DEC-13 |
| **WG1806661-1 MB** | | | | | | | | |
| Mercury (Hg)-Dissolved | | | <0.000010 | | mg/L | | 0.00001 | 18-DEC-13 |
| **MET-D-CCMS-VA** | **Water** | | | | | | | |
| **Batch R2762298** | | | | | | | | |
| **WG1806661-2 CRM** | | **VA-HIGH-WATRM** | | | | | | |
| Aluminum (Al)-Dissolved | | | 104.3 | | % | | 80-120 | 17-DEC-13 |
| Antimony (Sb)-Dissolved | | | 104.6 | | % | | 80-120 | 17-DEC-13 |
| Arsenic (As)-Dissolved | | | 99.7 | | % | | 80-120 | 17-DEC-13 |
| Beryllium (Be)-Dissolved | | | 99.6 | | % | | 80-120 | 17-DEC-13 |
| Cadmium (Cd)-Dissolved | | | 101.2 | | % | | 80-120 | 17-DEC-13 |
| Chromium (Cr)-Dissolved | | | 98.9 | | % | | 80-120 | 17-DEC-13 |
| Cobalt (Co)-Dissolved | | | 98.9 | | % | | 80-120 | 17-DEC-13 |
| Copper (Cu)-Dissolved | | | 96.3 | | % | | 80-120 | 17-DEC-13 |
| Lead (Pb)-Dissolved | | | 99.6 | | % | | 80-120 | 17-DEC-13 |
| Lithium (Li)-Dissolved | | | 97.9 | | % | | 80-120 | 17-DEC-13 |
| Manganese (Mn)-Dissolved | | | 102.7 | | % | | 80-120 | 17-DEC-13 |
| Molybdenum (Mo)-Dissolved | | | 102.3 | | % | | 80-120 | 17-DEC-13 |
| Nickel (Ni)-Dissolved | | | 99.9 | | % | | 80-120 | 17-DEC-13 |
| Selenium (Se)-Dissolved | | | 101.7 | | % | | 80-120 | 17-DEC-13 |
| Silver (Ag)-Dissolved | | | 104.6 | | % | | 80-120 | 17-DEC-13 |
| Thallium (Tl)-Dissolved | | | 100.3 | | % | | 80-120 | 17-DEC-13 |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-D-CCMS-VA** | **Water** | | | | | | | |
| **Batch R2762298** | | | | | | | | |
| **WG1806661-2 CRM** | | **VA-HIGH-WATRM** | | | | | | |
| Tin (Sn)-Dissolved | | | 101.3 | | % | | 80-120 | 17-DEC-13 |
| Uranium (U)-Dissolved | | | 100.3 | | % | | 80-120 | 17-DEC-13 |
| Vanadium (V)-Dissolved | | | 102.3 | | % | | 80-120 | 17-DEC-13 |
| **WG1806661-1 MB** | | | | | | | | |
| Aluminum (Al)-Dissolved | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| Antimony (Sb)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Arsenic (As)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Beryllium (Be)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Cadmium (Cd)-Dissolved | | | <0.000010 | | mg/L | | 0.00001 | 17-DEC-13 |
| Chromium (Cr)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Cobalt (Co)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Copper (Cu)-Dissolved | | | <0.00020 | | mg/L | | 0.0002 | 17-DEC-13 |
| Lead (Pb)-Dissolved | | | <0.000050 | | mg/L | | 0.00005 | 17-DEC-13 |
| Lithium (Li)-Dissolved | | | <0.00050 | | mg/L | | 0.0005 | 17-DEC-13 |
| Manganese (Mn)-Dissolved | | | <0.000050 | | mg/L | | 0.00005 | 17-DEC-13 |
| Molybdenum (Mo)-Dissolved | | | <0.000050 | | mg/L | | 0.00005 | 17-DEC-13 |
| Nickel (Ni)-Dissolved | | | <0.00050 | | mg/L | | 0.0005 | 17-DEC-13 |
| Selenium (Se)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Silver (Ag)-Dissolved | | | <0.000010 | | mg/L | | 0.00001 | 17-DEC-13 |
| Thallium (Tl)-Dissolved | | | <0.000010 | | mg/L | | 0.00001 | 17-DEC-13 |
| Tin (Sn)-Dissolved | | | <0.00010 | | mg/L | | 0.0001 | 17-DEC-13 |
| Uranium (U)-Dissolved | | | <0.000010 | | mg/L | | 0.00001 | 17-DEC-13 |
| Vanadium (V)-Dissolved | | | <0.0010 | | mg/L | | 0.001 | 17-DEC-13 |
| **WG1806661-5 MS** | | **L1404143-1** | | | | | | |
| Aluminum (Al)-Dissolved | | | 99.99 | | % | | 70-130 | 17-DEC-13 |
| Antimony (Sb)-Dissolved | | | 101.7 | | % | | 70-130 | 17-DEC-13 |
| Arsenic (As)-Dissolved | | | 98.9 | | % | | 70-130 | 17-DEC-13 |
| Beryllium (Be)-Dissolved | | | 101.7 | | % | | 70-130 | 17-DEC-13 |
| Cadmium (Cd)-Dissolved | | | 103.6 | | % | | 70-130 | 17-DEC-13 |
| Chromium (Cr)-Dissolved | | | 97.9 | | % | | 70-130 | 17-DEC-13 |
| Cobalt (Co)-Dissolved | | | 99.8 | | % | | 70-130 | 17-DEC-13 |
| Copper (Cu)-Dissolved | | | 97.5 | | % | | 70-130 | 17-DEC-13 |
| Lead (Pb)-Dissolved | | | 97.7 | | % | | 70-130 | 17-DEC-13 |
| Lithium (Li)-Dissolved | | | 100.7 | | % | | 70-130 | 17-DEC-13 |
| Manganese (Mn)-Dissolved | | | 97.8 | | % | | 70-130 | 17-DEC-13 |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-D-CCMS-VA** | **Water** | | | | | | | |
| **Batch R2762298** | | | | | | | | |
| **WG1806661-5 MS** | | **L1404143-1** | | | | | | |
| Molybdenum (Mo)-Dissolved | | | 97.4 | | % | | 70-130 | 17-DEC-13 |
| Nickel (Ni)-Dissolved | | | 99.9 | | % | | 70-130 | 17-DEC-13 |
| Selenium (Se)-Dissolved | | | 101.9 | | % | | 70-130 | 17-DEC-13 |
| Silver (Ag)-Dissolved | | | 80.7 | | % | | 70-130 | 17-DEC-13 |
| Thallium (Tl)-Dissolved | | | 97.3 | | % | | 70-130 | 17-DEC-13 |
| Tin (Sn)-Dissolved | | | 99.5 | | % | | 70-130 | 17-DEC-13 |
| Uranium (U)-Dissolved | | | 98.9 | | % | | 70-130 | 17-DEC-13 |
| Vanadium (V)-Dissolved | | | 97.8 | | % | | 70-130 | 17-DEC-13 |
| **MET-DIS-ICP-VA** | **Water** | | | | | | | |
| **Batch R2762400** | | | | | | | | |
| **WG1806661-2 CRM** | | **VA-HIGH-WATRM** | | | | | | |
| Barium (Ba)-Dissolved | | | 97.9 | | % | | 80-120 | 17-DEC-13 |
| Boron (B)-Dissolved | | | 99.1 | | % | | 80-120 | 17-DEC-13 |
| Calcium (Ca)-Dissolved | | | 102.5 | | % | | 80-120 | 17-DEC-13 |
| Iron (Fe)-Dissolved | | | 99.9 | | % | | 80-120 | 17-DEC-13 |
| Magnesium (Mg)-Dissolved | | | 101.0 | | % | | 80-120 | 17-DEC-13 |
| Potassium (K)-Dissolved | | | 100.2 | | % | | 80-120 | 17-DEC-13 |
| Sodium (Na)-Dissolved | | | 95.4 | | % | | 80-120 | 17-DEC-13 |
| Titanium (Ti)-Dissolved | | | 103.7 | | % | | 80-120 | 17-DEC-13 |
| Zinc (Zn)-Dissolved | | | 93.9 | | % | | 80-120 | 17-DEC-13 |
| **WG1806661-5 MS** | | **L1404143-1** | | | | | | |
| Boron (B)-Dissolved | | | 98.3 | | % | | 70-130 | 17-DEC-13 |
| Calcium (Ca)-Dissolved | | | 104.1 | | % | | 70-130 | 17-DEC-13 |
| Iron (Fe)-Dissolved | | | 98.6 | | % | | 70-130 | 17-DEC-13 |
| Magnesium (Mg)-Dissolved | | | 104.0 | | % | | 70-130 | 17-DEC-13 |
| Potassium (K)-Dissolved | | | 106.1 | | % | | 70-130 | 17-DEC-13 |
| Sodium (Na)-Dissolved | | | 103.5 | | % | | 70-130 | 17-DEC-13 |
| Titanium (Ti)-Dissolved | | | 108.1 | | % | | 70-130 | 17-DEC-13 |
| Zinc (Zn)-Dissolved | | | 94.7 | | % | | 70-130 | 17-DEC-13 |
| **Batch R2762546** | | | | | | | | |
| **WG1806661-1 MB** | | | | | | | | |
| Barium (Ba)-Dissolved | | | <0.010 | | mg/L | | 0.01 | 18-DEC-13 |
| Boron (B)-Dissolved | | | <0.10 | | mg/L | | 0.1 | 18-DEC-13 |
| Calcium (Ca)-Dissolved | | | <0.050 | | mg/L | | 0.05 | 18-DEC-13 |
| Iron (Fe)-Dissolved | | | <0.030 | | mg/L | | 0.03 | 18-DEC-13 |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-DIS-ICP-VA** | **Water** | | | | | | | |
| **Batch R2762546** | | | | | | | | |
| **WG1806661-1 MB** | | | | | | | | |
| Magnesium (Mg)-Dissolved | | | <0.10 | | mg/L | | 0.1 | 18-DEC-13 |
| Potassium (K)-Dissolved | | | <2.0 | | mg/L | | 2 | 18-DEC-13 |
| Sodium (Na)-Dissolved | | | <2.0 | | mg/L | | 2 | 18-DEC-13 |
| Titanium (Ti)-Dissolved | | | <0.010 | | mg/L | | 0.01 | 18-DEC-13 |
| Zinc (Zn)-Dissolved | | | <0.0050 | | mg/L | | 0.005 | 18-DEC-13 |
| **Batch R2764851** | | | | | | | | |
| **WG1806661-6 MS** | | **L1404144-1** | | | | | | |
| Boron (B)-Dissolved | | | 94.2 | | % | | 70-130 | 20-DEC-13 |
| Calcium (Ca)-Dissolved | | | N/A | MS-B | % | | - | 20-DEC-13 |
| Iron (Fe)-Dissolved | | | 97.8 | | % | | 70-130 | 20-DEC-13 |
| Magnesium (Mg)-Dissolved | | | 102.7 | | % | | 70-130 | 20-DEC-13 |
| Potassium (K)-Dissolved | | | 99.2 | | % | | 70-130 | 20-DEC-13 |
| Sodium (Na)-Dissolved | | | 102.8 | | % | | 70-130 | 20-DEC-13 |
| Titanium (Ti)-Dissolved | | | 96.9 | | % | | 70-130 | 20-DEC-13 |
| Zinc (Zn)-Dissolved | | | 89.2 | | % | | 70-130 | 20-DEC-13 |
| **NH3-F-VA** | **Water** | | | | | | | |
| **Batch R2764770** | | | | | | | | |
| **WG1808137-10 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 101.3 | | % | | 85-115 | 20-DEC-13 |
| **WG1808137-2 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 108.7 | | % | | 85-115 | 20-DEC-13 |
| **WG1808137-4 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 108.0 | | % | | 85-115 | 20-DEC-13 |
| **WG1808137-6 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 98.1 | | % | | 85-115 | 20-DEC-13 |
| **WG1808137-8 CRM** | | **VA-NH3-F** | | | | | | |
| Ammonia, Total (as N) | | | 98.1 | | % | | 85-115 | 20-DEC-13 |
| **WG1808137-11 DUP** | | **L1404125-3** | | | | | | |
| Ammonia, Total (as N) | | 0.0056 | <0.0050 | RPD-NA | mg/L | N/A | 20 | 20-DEC-13 |
| **WG1808137-1 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 20-DEC-13 |
| **WG1808137-3 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 20-DEC-13 |
| **WG1808137-5 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 20-DEC-13 |
| **WG1808137-7 MB** | | | | | | | | |

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NH3-F-VA** | **Water** | | | | | | | |
| **Batch R2764770** | | | | | | | | |
| **WG1808137-7 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 20-DEC-13 |
| **WG1808137-9 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.0050 | | mg/L | | 0.005 | 20-DEC-13 |
| **WG1808137-12 MS** | | **L1404125-3** | | | | | | |
| Ammonia, Total (as N) | | | 96.7 | | % | | 75-125 | 20-DEC-13 |
| **WG1808137-14 MS** | | **L1404501-11** | | | | | | |
| Ammonia, Total (as N) | | | N/A | MS-B | % | | - | 20-DEC-13 |
| **WG1808137-16 MS** | | **L1404144-1** | | | | | | |
| Ammonia, Total (as N) | | | 94.3 | | % | | 75-125 | 20-DEC-13 |
| **PH-PCT-VA** | **Water** | | | | | | | |
| **Batch R2762353** | | | | | | | | |
| **WG1806691-25 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.03 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-26 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.02 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-27 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.03 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-28 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.03 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-29 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.02 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-30 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.02 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-31 CRM** | | **VA-PH7-BUF** | | | | | | |
| pH | | | 7.01 | | pH | | 6.9-7.1 | 18-DEC-13 |
| **WG1806691-34 DUP** | | **L1404125-7** | | | | | | |
| pH | | 6.96 | 6.98 | J | pH | 0.02 | 0.3 | 18-DEC-13 |
| **PHENOLS-4AAP-ED** | **Water** | | | | | | | |
| **Batch R2763402** | | | | | | | | |
| **WG1807892-3 LCS** | | | | | | | | |
| Phenols (4AAP) | | | 99.0 | | % | | 85-115 | 19-DEC-13 |
| **WG1807892-2 MB** | | | | | | | | |
| Phenols (4AAP) | | | <0.0010 | | mg/L | | 0.001 | 19-DEC-13 |
| **WG1807892-5 MS** | | **L1401809-17** | | | | | | |
| Phenols (4AAP) | | | 110.0 | | % | | 75-125 | 19-DEC-13 |
| **S2-T-COL-VA** | **Water** | | | | | | | |

# Quality Control Report

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **S2-T-COL-VA** | **Water** | | | | | | | |
| **Batch R2762414** | | | | | | | | |
| **WG1806754-2 CRM** | | **VA-S2-C** | | | | | | |
| Sulphide as S | | | 108.3 | | % | | 75-125 | 17-DEC-13 |
| **WG1806754-5 CRM** | | **VA-S2-C** | | | | | | |
| Sulphide as S | | | 100.8 | | % | | 75-125 | 17-DEC-13 |
| **WG1806754-7 CRM** | | **VA-S2-C** | | | | | | |
| Sulphide as S | | | 107.5 | | % | | 75-125 | 17-DEC-13 |
| **WG1806754-8 DUP** | | **L1404125-2** | | | | | | |
| Sulphide as S | | <0.020 | <0.020 | RPD-NA | mg/L | N/A | 20 | 17-DEC-13 |
| **WG1806754-1 MB** | | | | | | | | |
| Sulphide as S | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806754-4 MB** | | | | | | | | |
| Sulphide as S | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **WG1806754-6 MB** | | | | | | | | |
| Sulphide as S | | | <0.020 | | mg/L | | 0.02 | 17-DEC-13 |
| **TDS-VA** | **Water** | | | | | | | |
| **Batch R2762210** | | | | | | | | |
| **WG1806739-2 LCS** | | | | | | | | |
| Total Dissolved Solids | | | 100.0 | | % | | 85-115 | 17-DEC-13 |
| **WG1806739-5 LCS** | | | | | | | | |
| Total Dissolved Solids | | | 92.2 | | % | | 85-115 | 17-DEC-13 |
| **WG1806739-1 MB** | | | | | | | | |
| Total Dissolved Solids | | | <10 | | mg/L | | 10 | 17-DEC-13 |
| **WG1806739-4 MB** | | | | | | | | |
| Total Dissolved Solids | | | <10 | | mg/L | | 10 | 17-DEC-13 |
| **TSS-VA** | **Water** | | | | | | | |
| **Batch R2762123** | | | | | | | | |
| **WG1806771-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 104.4 | | % | | 85-115 | 17-DEC-13 |
| **WG1806771-5 LCS** | | | | | | | | |
| Total Suspended Solids | | | 98.3 | | % | | 85-115 | 17-DEC-13 |
| **WG1806771-8 LCS** | | | | | | | | |
| Total Suspended Solids | | | 98.8 | | % | | 85-115 | 17-DEC-13 |
| **WG1806771-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 17-DEC-13 |
| **WG1806771-4 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 17-DEC-13 |
| **WG1806771-7 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 17-DEC-13 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| J | Duplicate results and limits are expressed in terms of absolute difference. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

| ALS Product Description | Sample ID | Sampling Date | Date Processed | Rec. HT | Actual HT | Units | Qualifier |
|---|---|---|---|---|---|---|---|
| **Physical Tests** | | | | | | | |
| pH by Meter (Automated) | | | | | | | |
| | 1 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |
| | 2 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |
| | 3 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |
| | 4 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |
| | 5 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |
| | 6 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |
| | 7 | 14-DEC-13 | 18-DEC-13 23:00 | 0.25 | 107 | hours | EHTR-FM |

**Legend & Qualifier Definitions:**

| | |
|---|---|
| EHTR-FM: | Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended. |
| EHTR: | Exceeded ALS recommended hold time prior to sample receipt. |
| EHTL: | Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry. |
| EHT: | Exceeded ALS recommended hold time prior to analysis. |
| Rec. HT: | ALS recommended hold time (see units). |

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1404125 were received on 17-DEC-13 09:20.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L1404125-COFC

ALS Environmental

**10-** 342337

## Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page 1 of 1

**Report To**
Company: Sperling Hansen Associates
Contact: MARK MANNING
Address: #8 1225 East Keith Rd
North Vancouver
Phone: 604-986-7723 Fax:

**Report Format / Distribution**
Standard: ☒ Other (specify):
Select: PDF ☒ Excel ☒ Digital ☐ Fax ☐
Email 1: mmanning@sperlinghansen.com
Email 2: dkuck@sperlinghansen.com

**Service Request:** (Rush subject to availability - Contact ALS to confirm TAT)
☒ Regular (Standard Turnaround Times - Business Days)
☐ Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
☐ Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
☐ Same Day or Weekend Emergency - Contact ALS to confirm TAT

**Invoice To** Same as Report ? (circle) Yes or No (if No, provide details)
Copy of Invoice with Report? (circle) Yes or No
Company:
Contact:
Address:
Phone: Fax:

**Client / Project Information**
Job #: PJ 13043 Powell River
PO / AFE:
LSD:
Quote #:

**Lab Work Order # (lab use only)** L1404125

**ALS Contact:** Dean Watt
**Sampler:** MARK MANNING

**Analysis Request**
( Indicate Filtered or Preserved, F/P )

| Sample # | Sample Identification (This description will ap | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | PH | Conductivity | Anion Scan | Chlorides | Ammonia | COD | TSS TDS | Total Phenols | Sulphide | Diss Metals | | | Number of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MW 2 | 14/12/13 | PM | G-water | X | X | X | X | | | X | | | X | | | |
| | MW-3 | " | " | " | X | X | X | X | X | X | X | X | X | X | | | |
| | MW-8 | " | " | " | X | X | X | X | X | X | X | X | X | X | | | |
| | MW-9 | " | " | " | X | X | X | X | X | X | X | X | X | X | | | |
| | MW 13-1 | " | " | " | X | X | X | X | X | X | X | X | X | X | | | |
| | MW 13-2 | " | " | " | X | X | X | X | X | X | X | X | X | X | | | |
| | MW 13-3 | " | " | " | X | X | X | X | X | X | X | X | X | X | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

**Short Holding Time**
Rush Processing ●

**Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details**

*Note MW2 does not have sufficient water for all of the ANALYSIST

**Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.**

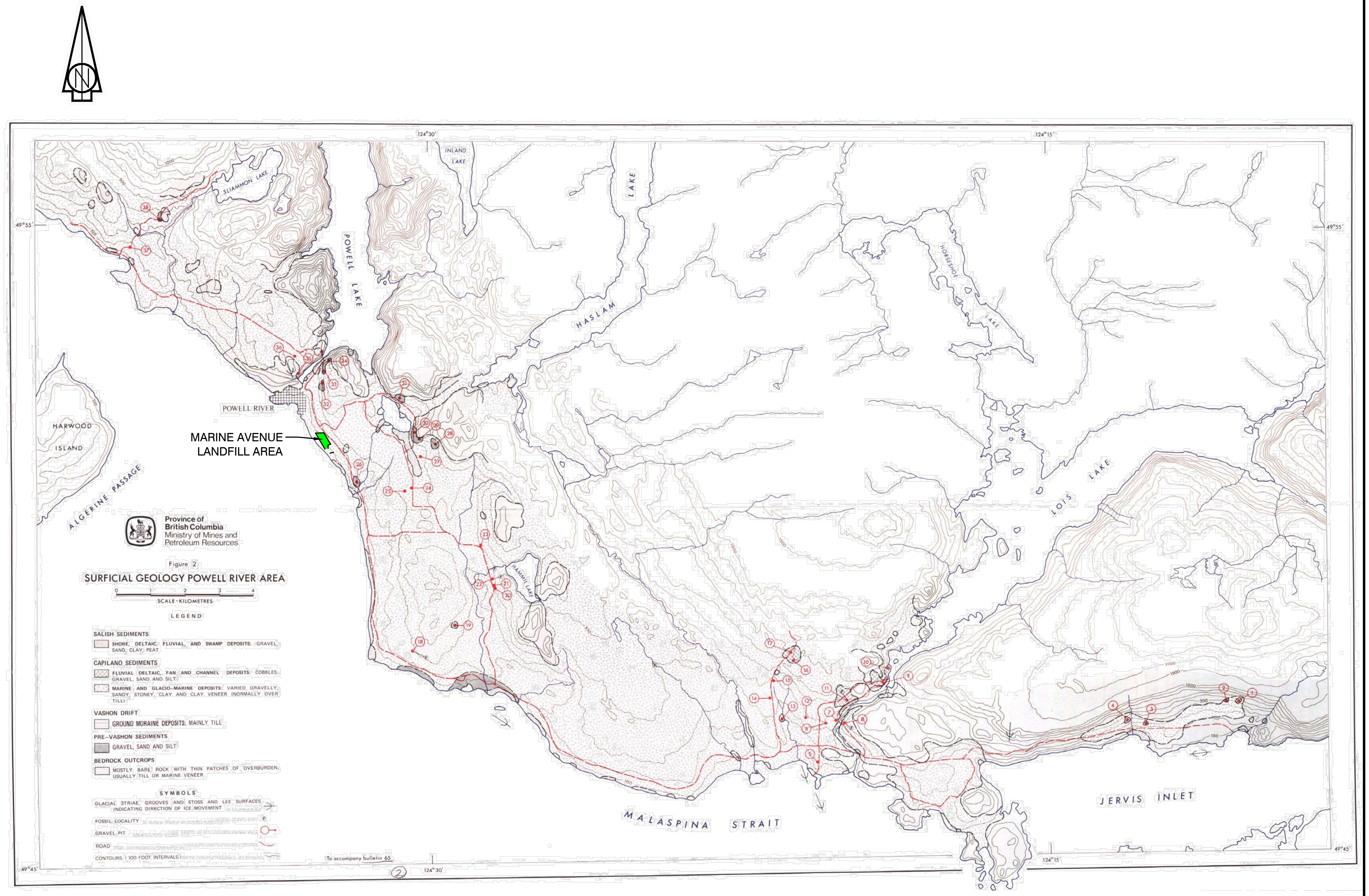
**By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.**

| SHIPMENT RELEASE (client use) | | | SHIPMENT RECEPTION (lab use only) | | | | SHIPMENT VERIFICATION (lab use only) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Released by: | Date: Dec 17/13 | Time: 9:15 | Received by: Paige | Date: Dec.17 | Time: 9:20 | Temperature: -1.5 °C | Verified by: | Date: | Time: | Observations: Yes / No ? If Yes add SIF |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

# APPENDIX H
## Surfacial Geology and SLIDE X-Section



**SPERLING HANSEN ASSOCIATES**

Landfill Services Group

- Landfill Siting
- Design & Operations Plans
- Landfill Closure
- Environmental Monitoring

#8 - 1225 East Keith Road
North Vancouver, B.C. V7J 1J3

Phone: (604) 986-7723
Fax: (604) 986-7734

LEGEND:

🟩 MARINE AVENUE LANDFILL AREA

CLIENT:

**POWELL RIVER REGIONAL DISTRICT**

PROJECT:

POWELL RIVER MARINE AVENUE
SITE CLOSURE PLAN

TITLE:

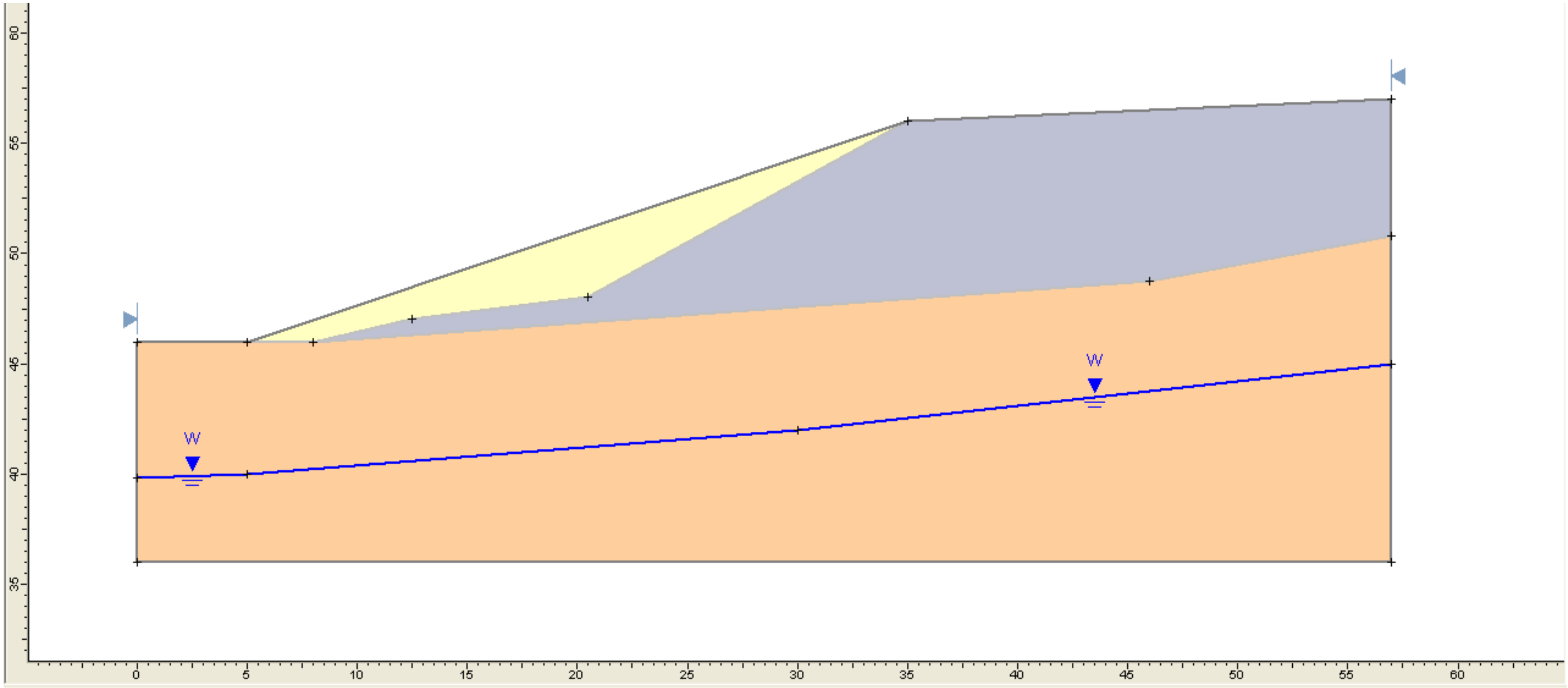
SURFICIAL GEOLOGY

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 2014/08/15<br>yyyy/mm/dd | PRJ 13043 |

| | | |
|---|---|---|
| SURVEYED | | DRAWING NO: |
| DRAWN | NP | FIGURE H-1 |
| CHECKED | IB | |

| Layers | Unit Weight (KN/m³) | Cohession (KN/m²) | Friction angle (degree) |
|---|---|---|---|
| Ash | 12 | 0 | 35 |
| Silt and Sand with Coble | 18 | 0 | 30 |
| DLC | 12 | 0 | 35 |

⬛ Ash
🟨 DLC
🟧 Silt and Sand with Coble



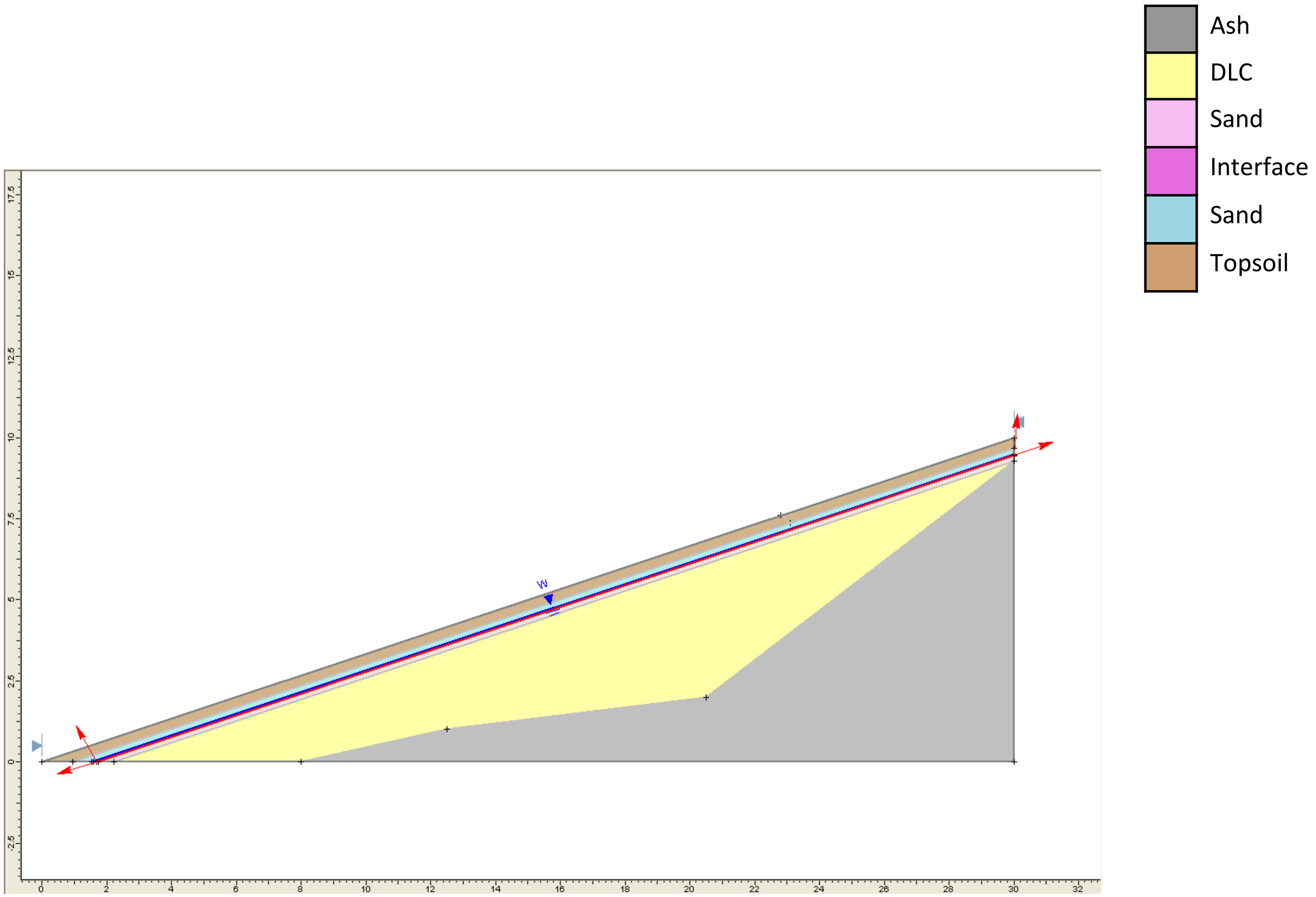
Sperling Hansen Associates

Powell River Regional District

PROJECT:
Powell River Marine Avenue
Site Closure Plan

TITLE:
**SECTION A-A'**
**Proposed**

SCALE: N/A
DATE: 14/08/15 yyyy/mm/dd
PROJECT NO: **13043**
DESIGNED: IB
DRAWN: IB
CHECKED: TS
DRAWING NO: **FIGURE H-2**



**SPERLING HANSEN ASSOCIATES**

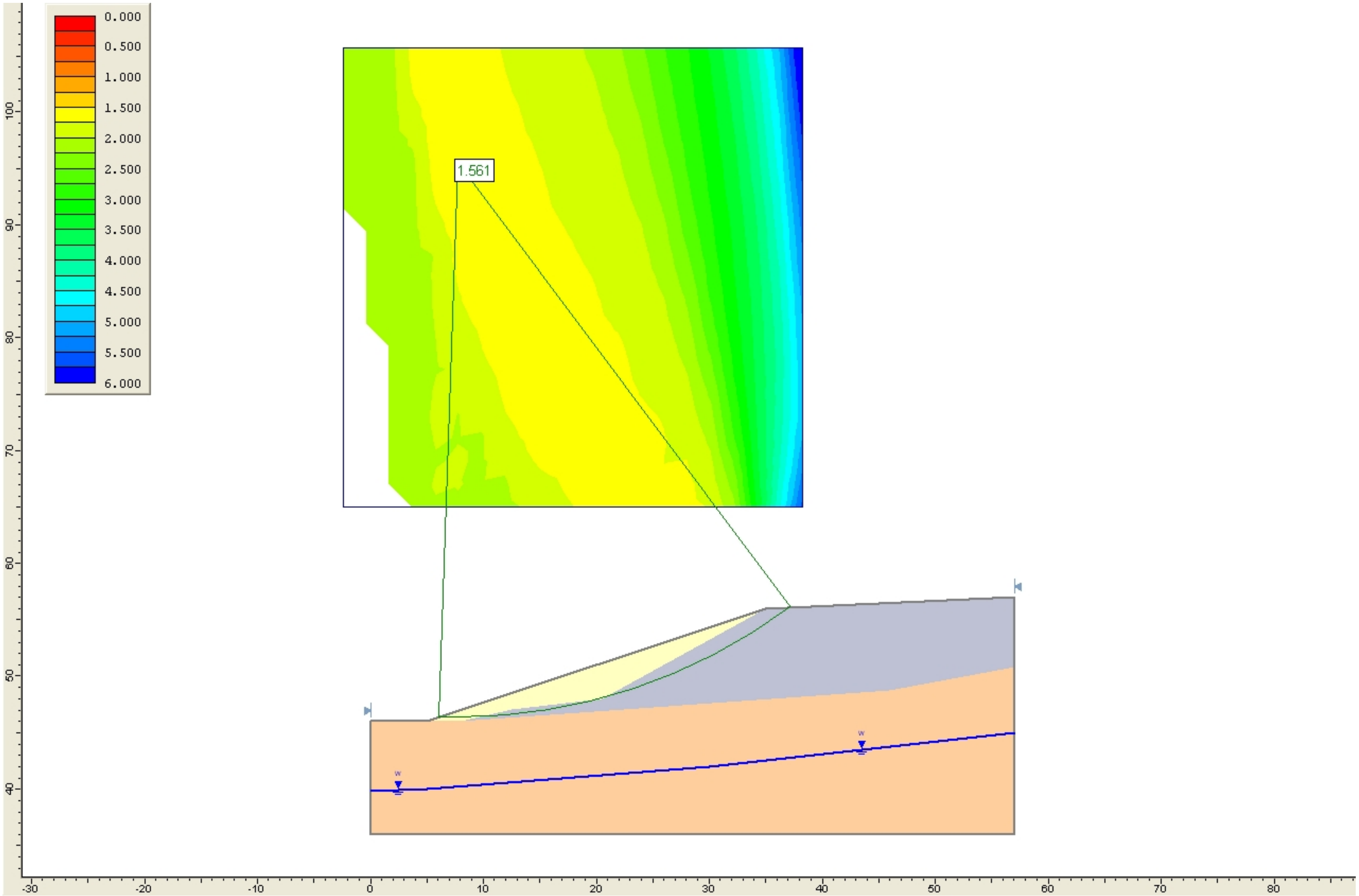
Powell River Regional District

PROJECT:
Powell River Marine Avenue
Site Closure Plan

TITLE:
## SECTION A-A' Proposed

| | | |
|---|---|---|
| SCALE: N/A | DATE: 14/08/15 yyyy/mm/dd | PROJECT NO: 13043 |
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE H-3** |
| CHECKED | TS | |

# APPENDIX I
# SLIDE Results



SPERLING HANSEN ASSOCIATES

Powell River Regional District

PROJECT:

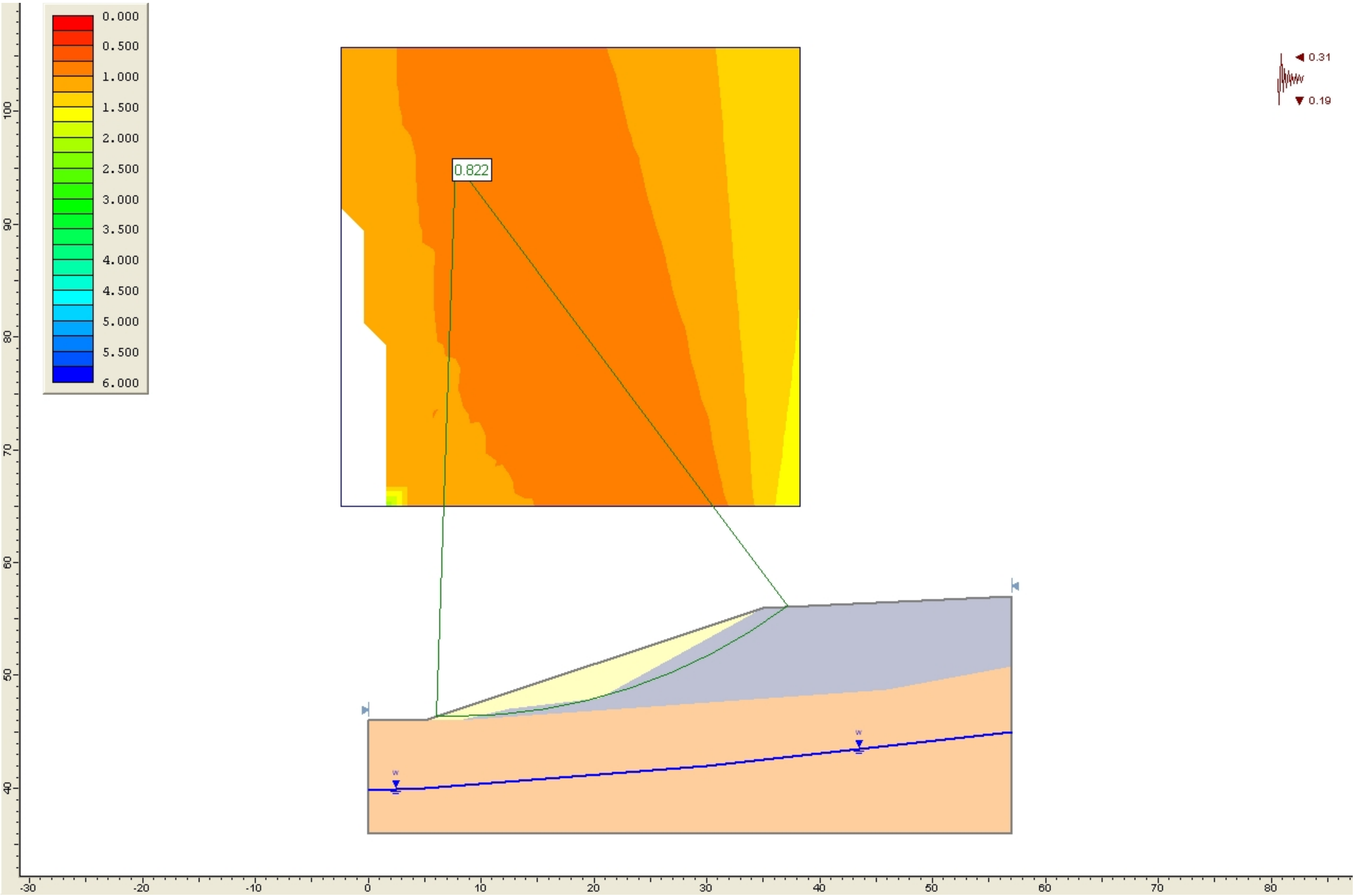
Powell River Marine Avenue
Site Closure Plan

TITLE:

**Proposed**
**Static Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE I1** |
| CHECKED | TS | |



SPERLING
HANSEN
ASSOCIATES

Powell River Regional District

PROJECT:

Powell River Marine Avenue
Site Closure Plan

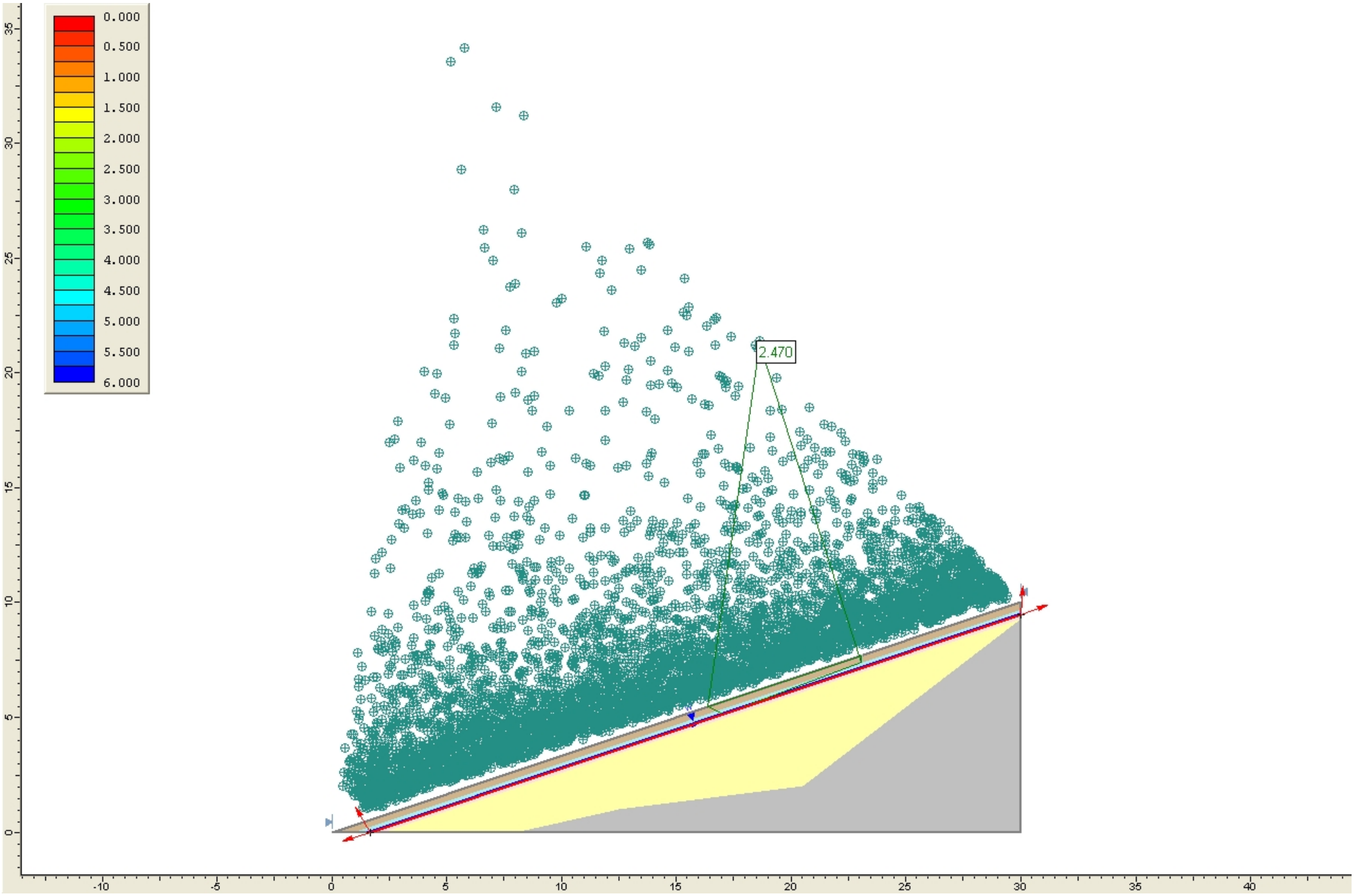
TITLE:

**Proposed**
**Siemic Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE I2** |
| CHECKED | TS | |

# APPENDIX J
# Veneer Stability Results



Sperling
Hansen
Associates

Powell River Regional District

PROJECT:

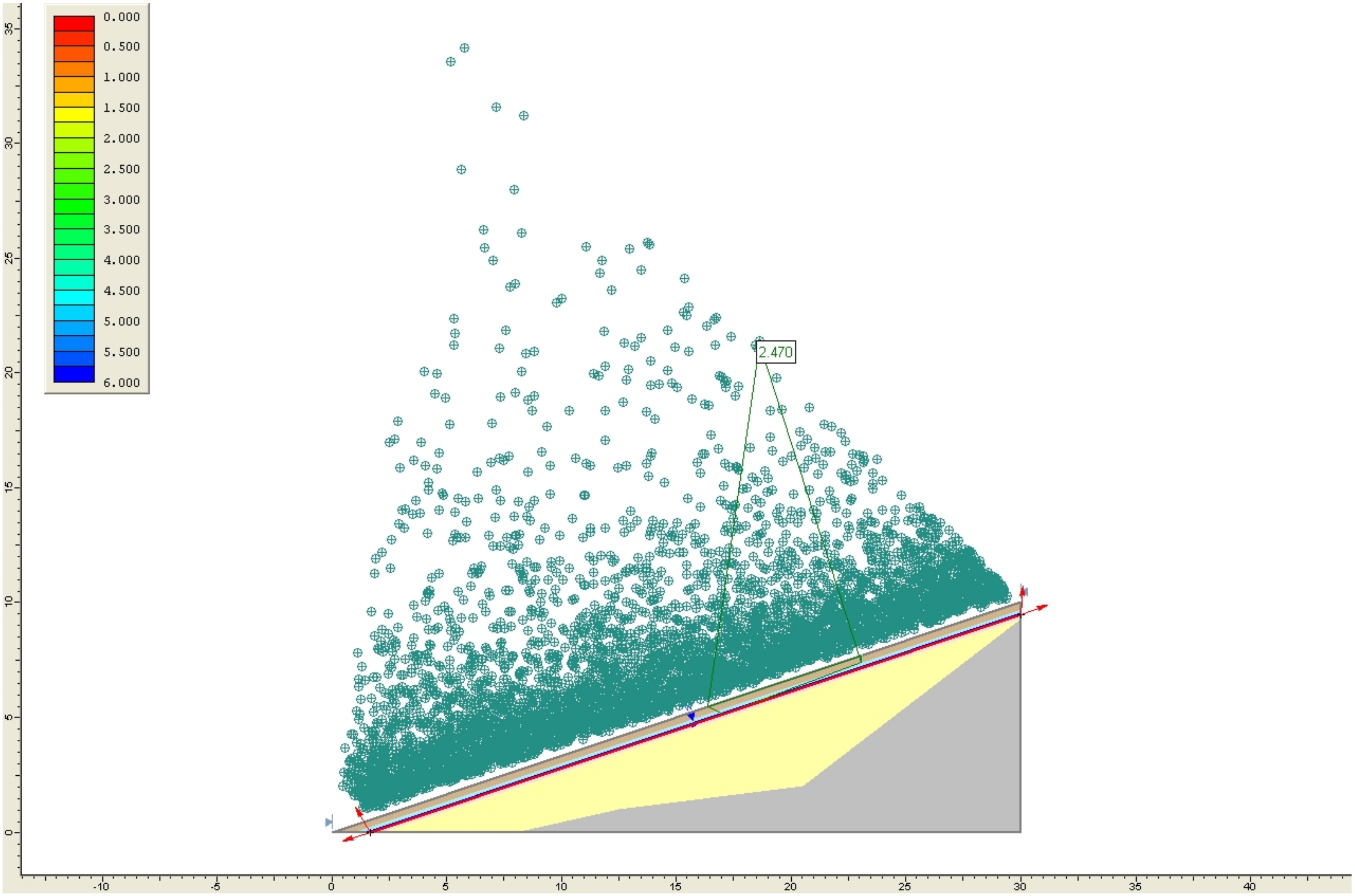
Powell River Marine Avenue
Site Closure Plan

TITLE:

**20 mm Mounding**
**Static Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE J1** |
| CHECKED | TS | |



Sperling
Hansen
Associates

Powell River Regional District

PROJECT:

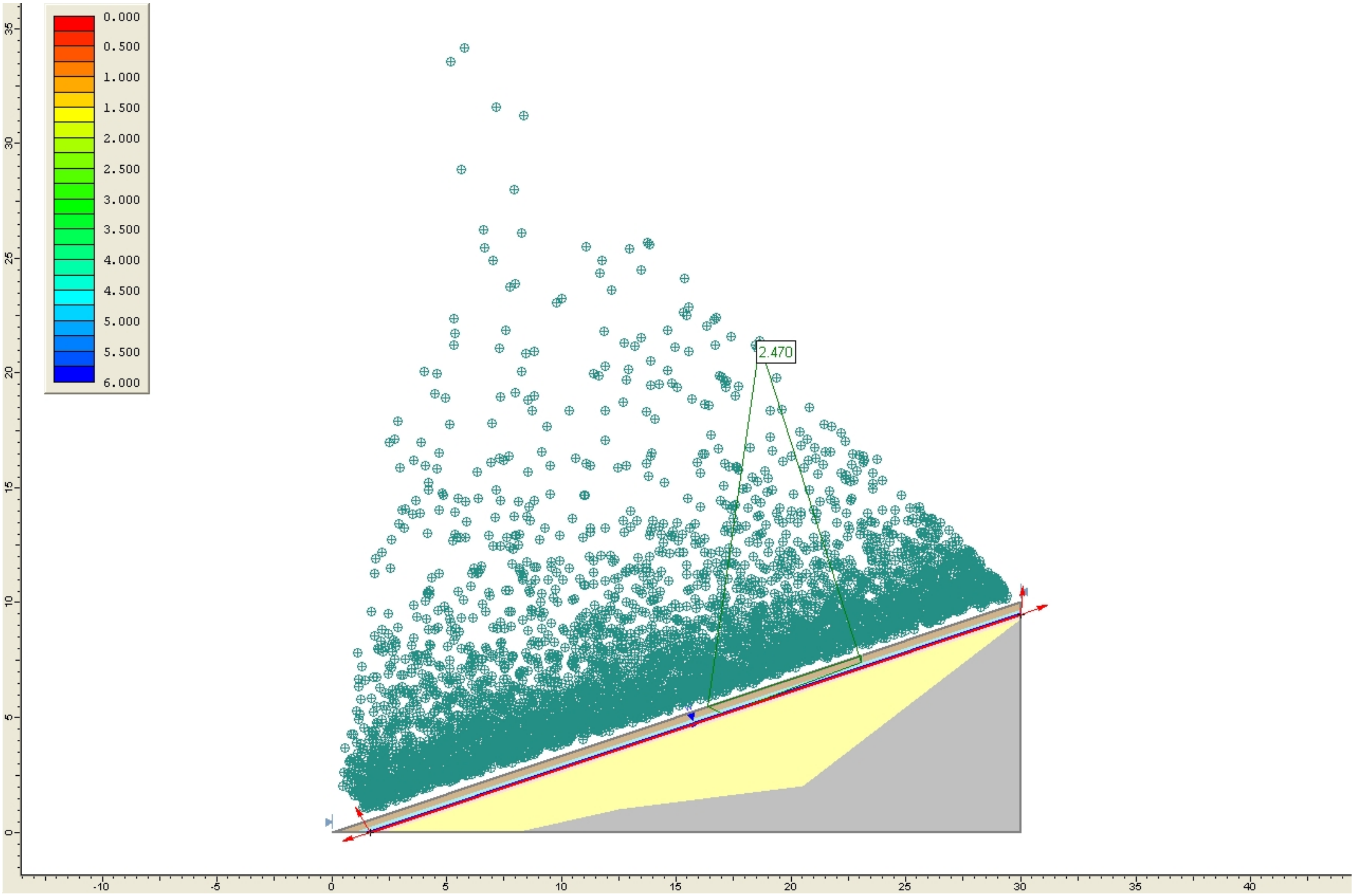
Powell River Marine Avenue
Site Closure Plan

TITLE:

**200 mm Mounding**
**Static Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE J2** |
| CHECKED | TS | |



Sperling
Hansen
Associates

Powell River Regional District

PROJECT:

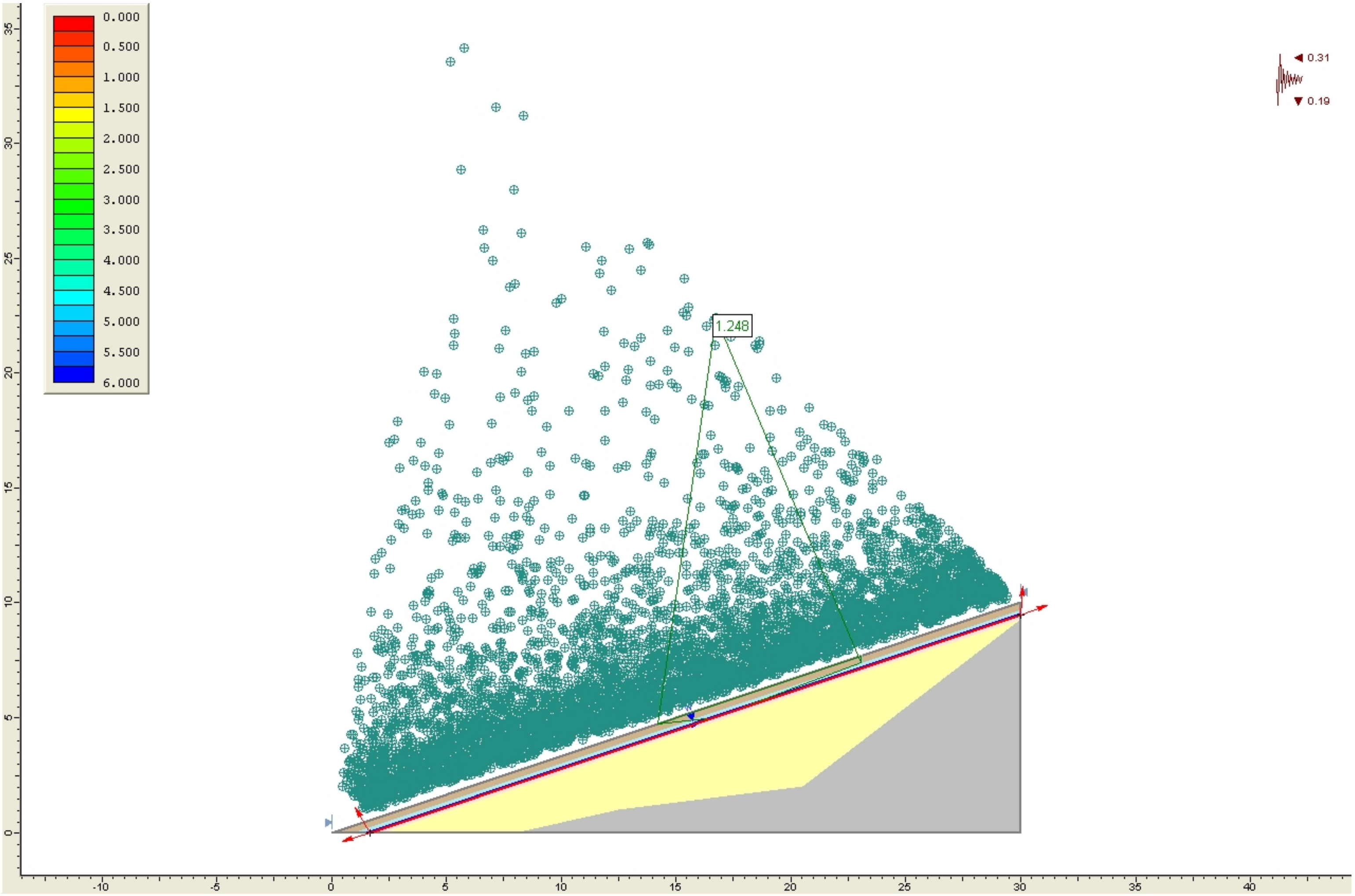
Powell River Marine Avenue
Site Closure Plan

TITLE:

**300 mm Mounding**
**Static Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE J3** |
| CHECKED | TS | |



**SPERLING HANSEN ASSOCIATES**

Powell River Regional District

PROJECT:

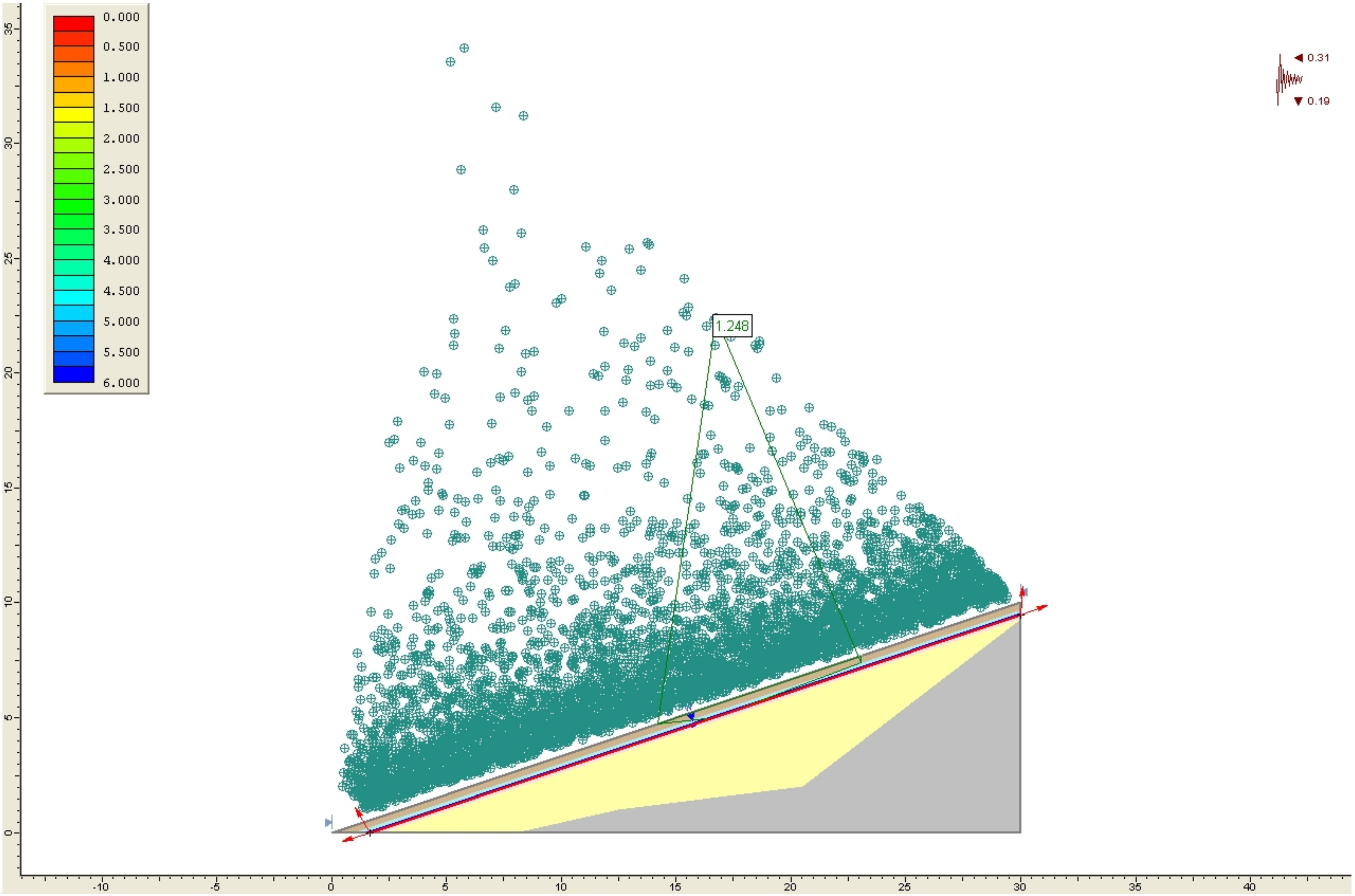
Powell River Marine Avenue
Site Closure Plan

TITLE:

**20 mm Mounding**
**Seismic Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE J4** |
| CHECKED | TS | |



SPERLING
HANSEN
ASSOCIATES

Powell River Regional District

PROJECT:

Powell River Marine Avenue
Site Closure Plan

TITLE:

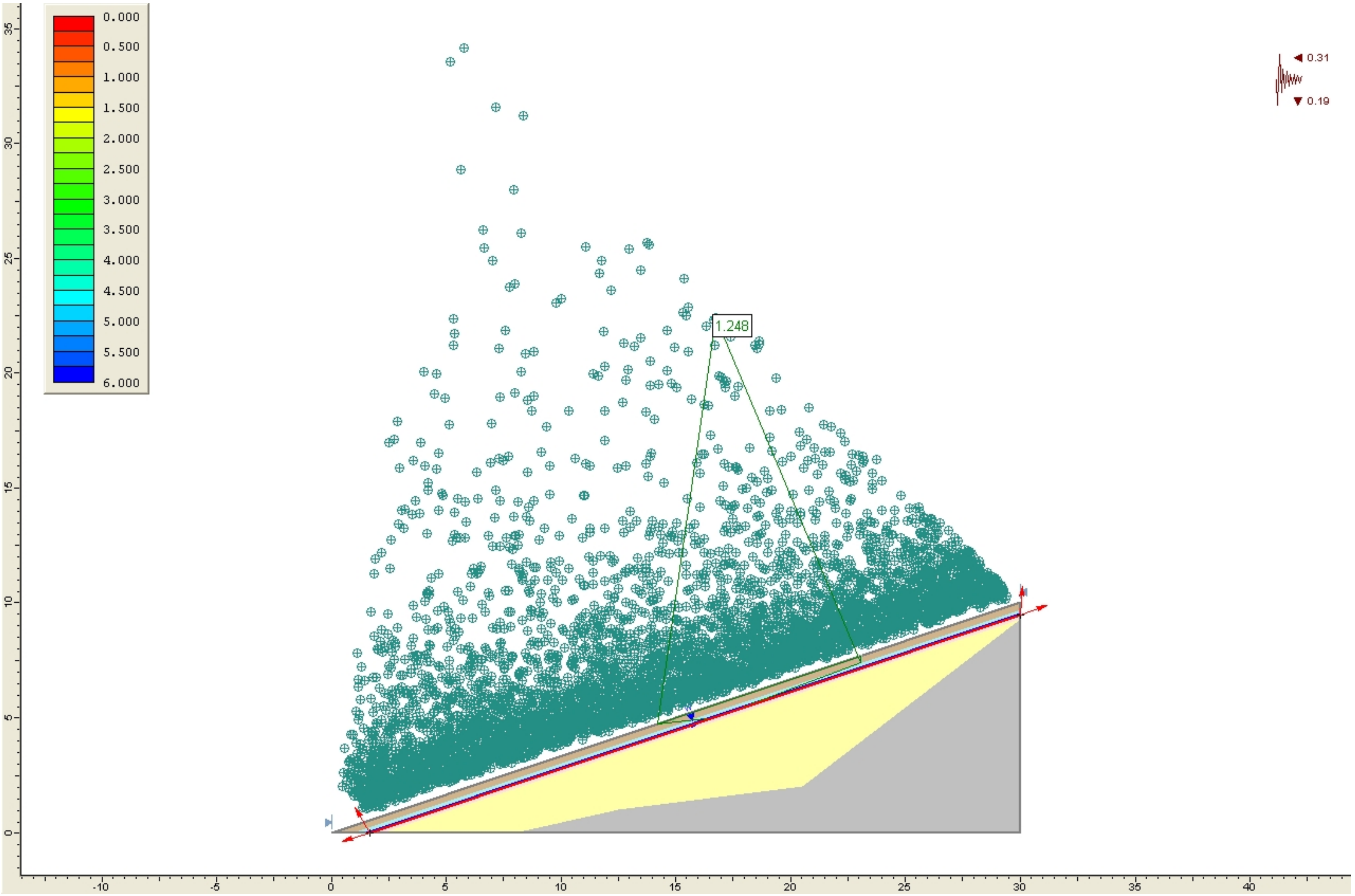
**200 mm Mounding**
**Seismic Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

DESIGNED IB
DRAWN IB
CHECKED TS

DRAWING NO:

**FIGURE J5**



SPERLING HANSEN ASSOCIATES

Powell River Regional District

PROJECT:

Powell River Marine Avenue
Site Closure Plan

TITLE:

**300 mm Mounding
Seismic Condition**

| SCALE: | DATE: | PROJECT NO: |
|---|---|---|
| N/A | 14/08/15<br>yyyy/mm/dd | **13043** |

| | | |
|---|---|---|
| DESIGNED | IB | DRAWING NO: |
| DRAWN | IB | **FIGURE J6** |
| CHECKED | TS | |

# APPENDIX K
# Newmark Results

SPERLING
HANSEN
ASSOCIATES

# NEWMARK SEISMIC DEFORMATION ANALYSIS

**PROJECT:** Assessment of Consolidated South 688147 BC Ltd and Gracia Landfill

**PROJECT NUMBER:** PRJ13043

**LOCATION:** Powell River Marine Avenue Transfer Site

**UTM COORDINATES:** Northing (m) Elevation (m)

**DESIGN SCENARIO:** Proposed Section A-A'

**SEISMIC PARAMETERS**

| Return Period | 40% Chance of Exceedance in 50 yrs (1:100 yr event) | 22% Chance of Exceedance in 50 yrs (1:200 yr event) | 10% Chance of Exceedance in 50 yrs (1:475 yr event) |
|---|---|---|---|
| Peak Horizontal Ground Acceleration (g) | 0.089 | 0.13 | 0.23 |
| Peak Horizontal Ground Velocity (m/s) | 0.077 | 0.12 | 0.21 |

**SLOPE PARAMETERS**

| | | |
|---|---|---|
| Maximum Height | 10 | (m) |
| Slope Angle | 3H:1V | H:V |
| Refuse Friction Angle | 27 | (degrees) |
| Refuse Cohesion | 0 | (kPa) |
| Slip Surface Interface | Peat, Silt, Waste | |
| Slip Surface Friction Angle | 26 | (degrees) |
| Slip Surface Cohesion | 1.53 | (kPa) |
| Yield Acceleration | 0.17 | (g) |

**N/A RATIO**

| | | |
|---|---|---|
| 1.91011236 | 1.307692308 | 0.739130435 |

**CALCULATED NEWMARK DEFORMATION**

| Return Period | 40% Chance of Exceedance in 50 yrs (1:100 yr event) | 22% Chance of Exceedance in 50 yrs (1:200 yr event) | 10% Chance of Exceedance in 50 yrs (1:475 yr event) |
|---|---|---|---|
| Horizontal Displacement (m) Upper Limit | 0.000930625 | 0.003301482 | 0.017888321 |
| Horizontal Displacement (m) Medium Range | -0.000846973 | -0.001015841 | 0.004666519 |
| Horizontal Displacement (m) Lower Limit | 0.010665587 | 0.02590394 | 0.079330815 |

Notes:
Upper limit calculated by equation: $V^2/(2gN)*(A/N)$
Medium range calculated by equation: $V^2/(2gN)*(1-N/A)*(A/N)$
Lower limit calculated by equation: $6*V^2/(2gN)$
Lower limit applicable for N/A ratios < 0.167 (1/6)

ANALYSIS BY: Iqbal Bhuiyan
DATE Aug 15th, 2014

# APPENDIX L
# Previous Reports

# REPORT OF FINDINGS
# PRELIMINARY SITE INVESTIGATION
# STAGE 1

## Marine Avenue Transfer Site
## Powell River, BC

**Prepared for:**
**CORPORATION OF THE DISTRICT OF POWELL RIVER**
**Engineering Department**
**6910 Duncan Street**
**Powell River, BC**
**V8A 1V4**

**Prepared by:**
**KEYSTONE ENVIRONMENTAL LTD.**
**Suite 320 - 4400 Dominion Street**
**Burnaby, BC**
**V5G 4M7**

**Project No. 8144**
**June 2003**

## LETTER OF TRANSMITTAL

**KEYSTONE**
ENVIRONMENTAL

Keystone Environmental Ltd.
Suite 320 4400 Dominion St.
Burnaby BC V5G 4M7

Telephone 604 430 0671
Facsimile 604 430 0672

keyinfo@keystoneenviro.com
www.keystoneenviro.com

**Greater Vancouver**
**Calgary**
**Okanagan**

June 10, 2003

Corporation of the District of Powell River
Engineering Department
6910 Duncan Street
Powell River, BC
V8A 1V4

Attention: Mr. Richard Stogre

Dear Sir:

Re: Report of Findings
Preliminary Site Investigation, Stage 1
Marine Avenue Transfer Site
Powell River, BC

This report is respectfully submitted to Corporation of the District of Powell River by Keystone Environmental Ltd.

We appreciate the opportunity to have assisted you in this matter and if there are any questions, please do not hesitate to contact the undersigned.

Keystone Environmental Ltd.

Rod Dagneau

per: Rod Dagneau, B.Sc., AScT
Environmental Technician

R. S. GREWAL
27702

June 10/03

per: Raminder Grewal, P.Eng.
Project Manager

per: Kenneth A. Evans, P.Eng.
Principal

10 JUN 03

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*Celebrating Ten Years of Success*

# EXECUTIVE SUMMARY

This KEYSTONE ENVIRONMENTAL$^{TM}$ Preliminary Site Investigation, Stage 1 (PSI 1) was conducted for the Marine Avenue Transfer Site, located in the Corporation of the District of Powell River (CDPR) (the "Site").

Prior to the late 1960s the Site and adjacent properties were forested and undeveloped. Gravel extraction operations started on-Site circa 1970 and subsequently expanded onto adjacent properties north, northeast and east of the Site. An incinerator was constructed on-Site in the early 1970s, and was used to incinerate various wastes from the Powell River area. The clinker (an incombustible residue, fused into an irregular lump, that remains after incineration) has been piled up-gradient and adjacent to the Site, as well as on-Site. Wood and yard waste, and a relatively smaller quantity of building materials and treated lumber were chipped adjacent to the east side of the Site. The chipped materials and sorted wastes have been piled on-Site, and up-gradient and adjacent to the Site. The incinerator stopped operations in the early 1990s when the existing waste transfer operation started on-Site. Chipping operations stopped circa 2000. Garbage trucks currently collect municipal waste from the Powell River area and the contents are transferred into transport truck trailers for off-site disposal. Disposal of significant quantities of waste has not occurred on or adjacent to the Site since circa 2000.

With the exception of gravel extraction operations and waste processing and disposal adjacent to the north, northeast and east sides of the Site, the surrounding area has remained forested.

The following areas of potential environmental concern (APECs) are identified, discussed and an opinion is presented with respect to whether there is a potential for constituents of concern to be present in the Site soil and/or groundwater at levels of concern.

- Clinker was piled at the northeast corner of the Site (primarily off-site) for approximately 13 years, and at the northwest corner of the Site for approximately 3 years between the late 1970s and the early 1990s. There is a potential that clinker contains constituents of concern, primarily metals, and that it has impacted the Site soil and/or groundwater at levels of concern. As well, there is considered to be a potential for constituents of concern associated with the off-site clinker to have migrated to the Site via groundwater at levels of concern.
- Gypsum wall-board is piled adjacent and up-gradient of the east side of the Site. The acids that are generated from gypsum wall-board, with exposure to water, can cause leaching of constituents of concern from other wastes, such as metals from clinker. It is recommended that the gypsum wall-board pile be removed from the Site. CDPR staff report that this pile contains asbestos. There is considered to be a potential that the gypsum wall-board has caused constituents of concern to have leached from other materials, and that these constituents of concern have impacted

the Site at levels of concern (from on-Site sources or from migration via groundwater from off-site sources).

- Roofing materials have been piled at the northwest corner of the Site, and adjacent and up-gradient of the east side of the Site. There is a potential the Site soil and/or groundwater have been impacted by constituents of concern, primarily associated with tar, at levels of concern (from on and off-site sources).
- A tub-grinder chipped wood and yard waste adjacent to the east side of the Site. The chips are piled near the centre of the Site. According to CDPR staff, treated lumber and various building materials have been chipped and mixed into the on-Site chip pile. There is a potential that the chip pile has contributed constituents of concern to the Site soil and/or groundwater at levels of concern.
- Truck washing has occurred near the centre of the Site, adjacent to a creek. CDPR staff report that sheens were visible in the creek during washing operations. There is a potential that washing operations have contributed constituents of concern at levels of concern to the Site soil and/or groundwater.
- Asphalt has been piled near the centre of the north portion of the Site and adjacent to the east side of the Site. Asphalt binder typically contains polycyclic aromatic hydrocarbons (PAHs), nitrogen, sulphur, oxygen, and various metals. In a saturated environment (groundwater, streams, etc.) constituents of concern can leach from asphalt at levels of concern. There is a potential that on and off-site asphalt piles have impacted the Site soil and/or groundwater at levels of concern.
- Yard and wood waste were burned in open fires near the centre portion of the Site. CDPR staff reported that treated lumber was mixed into the yard and wood waste, and that the majority of the ash has been removed from the Site. There remains a potential that constituents of concern associated with open burning exist in the Site soil and/or groundwater at levels of concern.
- Contents of another municipal waste disposal site (Squatters Creek) were transported and piled near the north edge of the Site (on and off-site). There is a potential that constituents of concern from this pile have impacted the Site soil and/or groundwater at levels of concern.
- A diesel aboveground storage tank (AST) has been located adjacent to the incinerator buildings. Stains were observed in sub-surficial soil in the vicinity of the tank. Constituents of concern associated with diesel potentially exist in the Site soil and/or groundwater at levels of concern.
- Scrap metal was formerly piled adjacent to the east side of the Site (adjacent to and down-gradient of the gypsum wall-board pile). There is a moderate probability that metals have leached from this pile and migrated to the Site at levels of concern.
- A local grocery store burned down, the demolished materials where transported to the southeast corner of the Site. The demolished materials are currently covered with yard waste. There is a potential that constituents of concern, such as metals, and special attention substances (SAS), such as asbestos and polychlorinated biphenyls (PCB), exist in these materials and have impacted the Site soil and/or groundwater at levels of concern.

It is concluded, that there is a potential for constituents of concern to be present in the Site soil and/or groundwater at concentrations in excess of the applicable standards provided in the British Columbia Contaminated Sites Regulation (CSR), and that further investigation is warranted.

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## LIST OF APPENDICES

# SUMMARY OF REPORT PARTICIPANTS

1. This report was commissioned by:

Company: Corporation of the District of Powell River
Contact Name/Position: Mr. Richard Stogre
Engineering Department
6910 Duncan Street
Powell River, BC

2. Report author:

Name: Rod Dagneau.
Address: Suite 320 4400 Dominion Street
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V5G 4M7
Telephone: 604-430-0671

3. Contributors to report:

Name/Position: Raminder Grewal, P.Eng.
Project Manager

Name/Position: Kenneth A. Evans, P.Eng.
Principal

4. Professional Statement:

This is to advise that this document has been prepared in accordance with the requirements of the Waste Management Act and Contaminated Sites Regulation, and to certify that the persons signing this document have demonstrable experience in investigation and remediation of the type of contamination found at the Site.

This PSI 1 was performed by Rod Dagneau B.Sc., of Keystone Environmental Ltd. Mr. Dagneau has a Bachelor of Science in Physical Geography, an Honours Diploma in Chemical Science, and has performed over 200 PSI 1s in British Columbia.

Mr. Raminder Grewal, P.Eng. graduated in 1998 from the University of British Columbia with a degree in Geological Engineering, with the specialization in environmental and geotechnical engineering. Mr. Grewal has been employed in the environmental profession since 1998. Over this period, Mr. Grewal has performed and managed numerous Stage 1/2 Preliminary Site Investigations, Detailed Site Investigations for the delineation of contamination of soil and groundwater and various soil and groundwater remediation projects.

Mr. Kenneth Evans, P.Eng. graduated from the University of British Columbia with a degree in chemical engineering in 1970. Mr. Evans was employed as a junior process engineer at the Noranda Group's potash mining operation until 1974. From 1974 to 1989, he held various positions with the Ministry of Environment including industrial processing engineer and head of the industrial and special waste section in Kamloops. During this time, Mr. Evans reviewed, assessed and adjudicated applications for permit for discharges to the air, to water and to the land, and was responsible for administration of the Special Waste Regulation. By 1981, he was Assistant Regional Waste Manager and was responsible for making a variety of decisions under the Waste Management Act. Mr. Evans joined Keystone Environmental in October, 1989 as a senior project manager and became a principal in 1993.

Mr. Kenneth Evans provides senior project management, senior advice and review on preliminary and detailed site investigations, remedial plans and site remediation, expert advice on regulatory matters, and performance and management of regulatory compliance audits, spill contingency control plans and major facility acquisition audits.

Signed Date

Signed Date

Signed Date

# REPORT OF FINDINGS
# PRELIMINARY SITE INVESTIGATION
# STAGE 1

## Marine Avenue Transfer Site
## Powell River, BC

## 1. INTRODUCTION

This KEYSTONE ENVIRONMENTAL$^{TM}$ Preliminary Site Investigation, Stage 1 (PSI 1) was prepared at the request of the Corporation of the District of Powell River (CDPR) for the property referenced as the Marine Avenue Transfer Site, located in Powell River, British Columbia (the "Site").

This PSI 1 was conducted to determine whether there is a potential for constituents of concern to be present in the soil and/or groundwater at the Site at concentrations greater than the applicable standards as outlined in the British Columbia *Contaminated Sites Regulation* (*CSR*). It is understood that report will be used in conjunction with the proposed development and/or closure of the Site.

### 1.1. Site Identification

| | |
|---|---|
| Civic Address: | (street number not assigned) Marine Avenue,<br>Powell River, BC |
| Parcel Identifier: | 008-935-670 |
| Legal Description: | Lot 8, Block 36, District Lot 450, Plan 12203 |
| Current Registered Owner: | The Corporation of the District of Powell River |
| Property Area: | 6.4 hectares (approximate) |
| Current Zoning: | P1 (Parks and Institutions) |
| Latitude: | 49° 51' 4.1" North (approximate) |
| Longitude: | 124° 31' 51.2" West (approximate) |

The approximate latitude and longitude entered for the Site was determined from a 1:20,000 scale map.

### 1.2. Scope of Work

The scope of work for this study included the following tasks:

- a review of available historic records including aerial photographs, the British Columbia Ministry of Water, Land and Air Protection (MWLAP) on-line Site Registry, a current title search, climate records, and a water well search;
- a site reconnaissance to observe Site conditions which may indicate the potential presence of contamination and to prepare a photographic record;
- a review of available documents and reports relating to waste management and site contamination;
- interviews with individuals knowledgeable about the Site in question; and
- a preliminary building survey for special attention substances such as polychlorinated biphenyls (PCBs), asbestos, lead paint, urea formaldehyde foam insulation (UFFI), and mercury which may be present in construction materials at the Site.

Previous environmental investigations have not been conducted on-Site according to CDPR staff; however, a letter report titled "Transfer Site Waste Material Cleanup", prepared by the CDPR Engineering Department, was provided and is summarized in Section 3.3 of this report.

A current title search was obtained via the BC Online website. No leases, title transfers, covenants or easements related to site contamination issues are listed in the current title search. A copy of the current title search is provided in Appendix A.

### 1.3. Study Limitations

Findings presented in this report are based upon (i) a limited visual review of accessible areas of the on-Site buildings and surrounding grounds, (ii) interviews with available personnel familiar with Site activities, and (iii) a review of available Site, environmental agency and historic archive records. No sampling and analysis of wastes, water, building materials, soil, groundwater or air was conducted as part of this review. Consequently, while findings and conclusions documented in this report have been prepared in a manner consistent with that level of care and skill normally exercised by other members of the environmental science and engineering profession practising under similar circumstances in the area at the time of the performance of the work, this report is not intended nor is it able to provide a totally comprehensive review of past or present Site environmental conditions. This report is intended to provide information to reduce, but not necessarily eliminate, uncertainty regarding the potential for contamination of a property. Where this potential has been identified, the further reduction of uncertainty requires the performance of a Preliminary Site Investigation, Stage 2.

This report has been prepared solely for the use of the Corporation of the District of Powell River pursuant to the agreement between Keystone Environmental Ltd. and the

Corporation of the District of Powell River. A copy of the general terms and conditions associated with this agreement is attached in Appendix G. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Keystone Environmental Ltd. accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made or actions based on this report.

## 2. SITE DESCRIPTION

The Site consists of an irregular-shaped lot located on the west side of Marine Avenue in the vicinity of Willingdon Beach Campground, in the Corporation of the District of Powell River, British Columbia. The properties bordering the Site are described as follows and are shown on Figures 1 and 2.

- The Site is bordered to the north by a vacant gravel pit located on a Norse Canada property.
- The area located northeast and east of the north portion of the Site has been used by the CDPR to dispose of clinker (an incombustible residue, fused into an irregular lump, that remains after incineration), and other waste materials. This area is also a Norse Canada property.
- The area located east of the south portion of the Site is a CDPR property and has been used by the CDPR to sort, process and temporarily store waste materials.
- Undeveloped forested land exists southeast of the Site.
- Marine Avenue is located adjacent to the west and southwest sides of the Site. Forested land exists west and southwest of Marine Avenue. Part of the forested land that exists south of Marine Avenue is used for camping (Willingdon Beach Campground).

Surficial geology maps or geotechnical reports were not available for the Site; however, the Site was formerly a gravel pit and parts of it have been filled with various types of waste material since that time. The remaining visible native surficial materials appear to be composed of gravel, sand, silt and clay.

Groundwater is expected to follow regional topography flowing from areas of higher elevation to areas of lower elevation. Local groundwater flow direction may vary as a result of local conditions such as topography, geology and the presence of drainage channels and buried utilities, and is subject to confirmation with field measurements. The Site is located on the southwest side of a hill, and regional groundwater flow direction is therefore inferred to be to the southwest. It is anticipated that the Site is impacted locally by groundwater flowing from adjacent properties, and properties located northeast of the Site. Groundwater springs are present on and adjacent to the Site and a small creek flows to the southwest across the centre of the Site. The Straight of Georgia is located approximately 200 metres southwest of the Site.

## 3. RECORDS REVIEW

Various documents were reviewed and interviews conducted for information concerning past uses of, and activities at, the Site. A list of references is included at the end of this report. The documents reviewed for information concerning historic land use include aerial photographs, a MWLAP Site Registry search, historic climate data, a Previous Report, and a water well search. Street directories, fire insurance maps and land use maps are not known to have been compiled for the area of the Site.

## 3.1. Aerial Photographs

Aerial photographs, dated 1932, 1947, 1964, 1974, 1980 and 1998 were reviewed for information concerning historic physical features and land use on the Site and neighbouring properties. The following is a summary of observations made during the aerial photograph review.

- The 1932 aerial photograph shows that the Site was undeveloped and forested. Marine Avenue existed west and southwest of the Site. The surrounding area was undeveloped and forested.
- The 1947 and 1964 aerial photographs reveal that a small section of the southwest corner of the Site had been cleared. The surrounding area remained forested.
- In 1974, the Site appeared to be a gravel pit and the incinerator, blower and lunchroom buildings were present. Large piles of waste materials are not apparent on or adjacent to the Site. The on and off-site area east of the incinerator buildings (east of the north portion of the Site) was cleared, a ravine (reported by CDPR staff, refer to Interviews Section 5.0) is not apparent in this cleared area; however, a forested area dips steeply down to the east from this cleared area. A creek and/or wash water flowed from the northeast corner to the southwest corner of the Site. The area adjacent to the north side of the Site appeared to have been excavated to extract gravel, otherwise the surrounding properties remained forested.
- The 1980 aerial photographs show piles east (off-site) of the incinerator buildings. No significant changes are apparent off-site.
- The 1998 aerial photographs show waste material piles on-Site and east of the Site. The existing waste transfer loading structure had been constructed south of the incinerator buildings. A structure that corresponds with a reported tub-grinder (refer to Interviews Section 5.0.) was located adjacent to the east side of the Site. Additional gravel extraction appears to have occurred north of the Site.

### 3.2. MWLAP Site Registry Search

An on-line search of the MWLAP Site Registry was conducted to determine if it contained information regarding soil and/or groundwater contamination for sites within a one square kilometre area, centred on 49° 51' 4.1" North by 124° 31' 51.2" West, the approximate latitude and longitude entered for the vicinity of the Site. No sites are listed within the search area. A copy of the search results is provided in Appendix B.

### 3.3. Previous Report

A letter report titled "Transfer Site Waste Material Cleanup", was prepared by the CDPR Engineering Department, and is dated April 17, 2000. This report is summarized as follows.

- The CDPR Engineering Department conducted a study of the Site and adjacent properties to estimate the costs associated with the cleanup of contaminated materials in the area of the Site.
- No laboratory analysis or coring of the materials was conducted.
- Various piles of materials such as yard waste, concrete, asphalt, wood chips, gyproc (gypsum wall-board), roofing, ash(clinker[1]), glass, municipal waste, tires stumps and pipe were identified. The total volume of this material was estimated to be approximately 53,000 $m^3$, the majority of which is listed as ash/clinker (approximately 28,000 $m^3$ )
- The cost to remove, transport and dispose of these materials (at another land-fill site, not in the Powell River area) was estimated to be approximately $6,000,000 to $8,000,000. The majority of this cost is for the removal of the ash/clinker

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[1] The material referenced as ash in this letter report was observed to be clinker. Clinker is the incombustible residue, fused into an irregular lump, that remains after combustion.

($4,000,000 to $6,000,000). The unit price of for the removal of the ash/clinker was estimated to be $100 to $130 per tonne.

- According to CDPR staff, a ravine originally existed adjacent to the northeast portion of the Site and has since been filled in with various waste materials (this ravine was reported to have existed east of the Site, refer to Interviews Section 5.0).
- The estimate of the volume and quality of waste materials is not clearly understood and further investigation was recommended.

A copy of the "Transfer Site Waste Material Cleanup" estimate is provided in Appendix C.

### 3.4. Historic Climate Data

Climate information is provided in Appendix D. The closest climate station to the Site is located at 49° 52' North by 124° 33' West in Powell River. The "Canadian Climate Normals" are based on data collected by Environment Canada in Powell River between 1971 and 2000. A copy of the climate information is provided in Appendix D.
The climate information is summarized as follows.

| | |
|---|---|
| Daily Mean Temperature: | 10.6$^0$C |
| Precipitation: | 1103.7 mm/year |
| Highest Monthly Average Precipitation: | December, 141.2 mm |
| Lowest Monthly Average Precipitation: | July, 40.1 mm |

Precipitation is expected to infiltrate unpaved areas of the Site.

### 3.5. Water Well Search

The Aquifers and Water Wells of British Columbia web-site displays groundwater management information for the Province of British Columbia. No water wells were shown within 1.5 kilometres of the Site. The Site is serviced by a municipal water supply system. A copy of the search result map is provided in Appendix E.

## 4. SITE RECONNAISSANCE

On June 2, 2003 Keystone Environmental Ltd. visited the Site accompanied by: Mr. Bill Koke, former Site foreman; Mr. Frank Dangio, CDPR Engineering Technologist; and Mr. Carl Pearr-son, CDPR truck driver. The purpose of the visit was to observe operations and conditions at the Site as well as neighbouring properties to determine the potential for contamination at the Site and to prepare photographic documentation. Selected photographs taken during the Site reconnaissance are included in Appendix F. Dense vegetation covered much of the Site; therefore observations were limited. The interior of an employee lunchroom (storage shed) and the incinerator were not entered.

### 4.1. Grounds Survey

The following was observed or reported during the Site reconnaissance.

- Approximately 15 percent of the Site is covered with piles of waste materials (approximately 80 percent of which is covered with vegetation), 5 percent is paved, and a relatively small area is occupied by incinerator buildings and a weigh scale kiosk. The remaining 80 percent of the Site is the floor of a former gravel pit (approximately 60 percent of which is covered with vegetation).

- The east side of the Site is currently used to transfer waste from garbage trucks and individuals' vehicles into transport truck trailers (B-trains), using a paved loading platform. A vehicle weigh scale, and an incinerator and two support buildings are also located on the east side of the Site adjacent to the loading platform. The incinerator is no longer in use.
- Various piles of sorted, chipped and/or incinerated waste materials exist on the north, west and central portions of the Site.
- The south portion of the Site is a vacant gravel pit.
- No vent or fill pipes, which may be indicative of underground storage tanks (USTs), were observed.
- One diesel aboveground storage tank (AST) is located adjacent to the employee lunchroom (a concrete shed like structure located adjacent to the incinerator). A hydrocarbon stain, covering approximately 2m$^2$, was observed under the AST. This sheen extended beyond the base of the tank stand onto unpaved soil.
- Groundwater monitoring-wells or water wells were not observed and were reported to not exist on-Site.
- The Site is below the grade of surrounding properties, with the exception of the south and southeast areas of the Site, which are above the grade of the adjacent forest and Marine Avenue.
- A clinker pile is located at the northeast corner of the Site and extends off-site to the east of the Site. The pile is overgrown with vegetation, limiting observations. The CDPR Engineering Department estimates that this pile (majority off-site) is approximately 20,500 m$^3$ in volume.
- A second clinker area of clinker disposal is located along the inner bank of the gravel pit at the northwest corner of the Site. The pile is overgrown with vegetation, limiting observations. The CDPR Engineering Department estimates the volume of this pile as approximately 7,200 m$^3$.
- Based on Mr. Koke's estimate there is likely twice the volume of clinker on or adjacent to the Site as estimated by the CDPR Engineering Department.

- Various piles of yard waste, top soil, broken asphalt and concrete exist at the southeast corner of the Site. Mr. Koke reported that a Safeway store burnt down and that the demolished building and contents were transported to the Site and are buried in the large yard waste pile at the southeast corner of the Site. This large yard waste pile is also covered with vegetation. These piles appear to total approximately 2,000 $m^3$ in volume.
- Mr. Pearr-son and Mr. Koke reported that yard waste and wood waste were formerly burned (open fire) just west of the weigh scale near the centre of the Site. The ash was reportedly removed from the Site. Treated lumber and building materials were reportedly at times mixed in with the yard and wood waste, and were also consumed in open fires. This area is currently vegetated; therefore, close observations of the ground surface was limited. A pile of unburnt beach/drift wood, approximately 500 $m^3$ in volume, was also observed in this area.
- A vegetated ridge near the centre of the Site is reportedly comprised of wood chips. Waste wood (including building materials such as treated wood, tar paper and roofing), and yard waste were chipped adjacent to the east side of the Site, and then transported and disposed in this ridge. The CDPR Engineering Department estimates the volume of this pile as approximately 8,200 $m^3$.
- A stump pile is located adjacent to the east side of the wood chip ridge. The CDPR Engineering Department estimates the volume of this pile as approximately 2,200 $m^3$.
- A soil and vegetation covered pile is located near the centre of the north portion of the Site. The CDPR Engineering Department estimated that this pile contains approximately 2,200 $m^3$ of crushed asphalt.
- A large pile of glass and window frames is located north of the crushed asphalt pile. The CDPR Engineering Department estimates the volume of this pile as approximately 1,700 $m^3$.
- A densely vegetated mound is located just north of the glass pile along the north edge of the Site. The contents of another municipal waste dumping site (Squatters Creek) was transported and disposed at this location. The CDPR Engineering

Department estimates the volume of this pile as approximately 2,400 $m^3$. The dense vegetation limited observations of this pile.

- A pile of tires and roofing material is located at the northwest corner of the Site (on and off-site). The CDPR Engineering Department estimated that the volume of roofing material is approximately 540 $m^3$ and that the volume of tires was approximately 1,800 $m^3$. However, it was reported by Mr. Koke that the majority of tires have since been removed from the Site. The volume of tires now appears to be less than 100 $m^3$.
- A stream (and/or water in a ditch) was observed flowing from the northeast corner to the southwest corner of the Site. The water was reported to originate from one or more springs near the northeast corner of the Site. Various other puddles and water filled ditches were observed on-Site. Sheens, indicative of bulk releases of constituents of concern, were not visible in the on-Site streams, ditches and puddles, with the exception of a minor amount of organic-like sheen near the northwest corner of the Site.
- The drainage of the property is by infiltration, and runoff to adjacent properties.
- One pole mounted transformer was observed on-Site. No hydrocarbon stains were observed in the vicinity of the transformer.

### 4.2. Building Survey

The following was observed or reported during the Site reconnaissance.

- Four structures exist on-Site, an incinerator, a blower room, an employee lunchroom, and a weigh scale kiosk.
- The incinerator, blower room, and employee lunchroom were constructed in the early 1970s. The weigh scale kiosk (a portable structure) was transported to the Site circa 1990.

- The incinerator is constructed of steel and concrete, and did not use an auxiliary fuel source (such as propane or natural gas) to aid combustion.
- An electric-powered blower is contained in a metal-sided shed, adjacent to the incinerator, and was used to blow additional air into the incinerator to aid combustion.
- The employee lunchroom is a small (storage-shed like) concrete block structure and is located adjacent to the incinerator.
- The kiosk is a wood structure.
- Heat is provided to the lunchroom and kiosk by electric baseboard heaters.
- Electricity is provided by BC Hydro. No diesel-fuelled back-up generators are present on-Site.

## 4.3. Special Attention Substances

### 4.3.1. Asbestos

The use of friable asbestos as a building material was banned in the U.S. in the mid 1970s. The manufacture of building materials containing asbestos was generally phased out in North America by the mid 1980s. The presence of asbestos has not been confirmed in the Site structures, but based on the ages of the buildings (constructed in the early 1970s) it is possible that asbestos may be present in such materials as insulation, cement products, grouts, plaster, compressed papers and boards, linoleum, floor tiles, duct tapes, sealants and protective coatings. As well CDPR staff report that asbestos exists in off-site waste piles, and burnt Safeway store building materials (piled on-site) may contain asbestos. Material resembling friable asbestos was not observed during the Site reconnaissance. If demolition or renovation of the structures, or removal of waste piles is considered, the identification and safe removal or containment of asbestos is regulated under Section 20.112 of the OHSR. When these materials are removed they must be managed in accordance with the *Special Waste Regulation* and the *Waste Management Act*.

### 4.3.2. Mercury

Mercury containing thermostats may exist inside the lunchroom. As long as mercury-containing equipment is in use and in good operating condition, there are no environmental management requirements associated with it. The WCB OHSR regulates the identification and safe removal or containment of mercury containing equipment prior to demolition or salvage. If such equipment is removed during renovation or demolition and is not to be reused, it is recommended that it be disposed in accordance with the *Special Waste Regulation* and the *Waste Management Act*. As well, mercury may exist in the pile of burnt Safeway store building materials.

### 4.3.3. Lead

In 1976, Canadian regulations limited the amount of lead, which could be used in the manufacture of interior paint. There are currently no regulations in place governing the removal of lead paint where the occupational health and safety exposure limits are not exceeded. Lead may be present in exterior painted surfaces, and if demolition is considered it should be identified, removed or contained in accordance with Section 20.112 of the OHSR. In addition, it is recommended that materials containing lead be disposed of in an appropriate manner. Lead may exist in the pile of burnt Safeway store building materials.

### 4.3.4. Polychlorinated Biphenyls

Current-regulating ballasts, associated with fluorescent lighting, manufactured prior to 1980 can potentially contain a small volume of polychlorinated biphenyls (PCBs). Fluorescent lighting may exist in the employee lunchroom. This structure was constructed in the early 1970s; therefore, there exists a potential that PCB containing ballasts remain on-Site. As long as this equipment is being used for its intended purpose, and is in good operating condition, it is not considered to be waste material. However, when such equipment is removed during renovation or building demolition, the storage or disposal of PCBs is regulated under the *Waste Management Act* and *Special Waste Regulation*. It is recommended that renovation and demolition activities be conducted in accordance with Section 20.112 of the WCB OHSR. As well, PCBs may exist in the pile of burnt Safeway store building materials.

### 4.3.5. Urea Formaldehyde Foam Insulation

The majority of urea formaldehyde foam insulation (UFFI) was installed in new and existing structures in Canada between 1975 and 1978. UFFI is not anticipated to exist on-Site based on the age of the structures (constructed in the early 1970s), the use of these buildings as an incinerator and a lunchroom, and no evidence of UFFI, such as injection holes was observed in the exterior of the structures. UFFI may exist in the pile of burnt Safeway store building materials.

## 4.4. Current Use - Adjacent Properties

The following was observed during the off-site reconnaissance.

- The area adjacent to the north side of the Site is a vacant gravel pit.
- Large piles of waste materials exist adjacent to and up-gradient of the east side of the Site. The largest pile is comprised of clinker. The top of the clinker pile is covered with vegetation and gravel. Additional smaller piles of asbestos-cement pipe (estimated to be approximately 150 $m^3$ in volume by CDPR staff) and wood staves (estimated to be approximately 100 $m^3$ in volume by CDPR staff) are placed on top of the clinker pile. As well, approximately 1500 $m^3$ (estimated by CDPR staff) of roofing material and approximately 3000 $m^3$ (estimated by CDPR staff) of

gypsum wall-board are placed adjacent to the south side of the clinker pile (adjacent to the east side of the Site).

- CDPR staff report that asbestos may exist in the gypsum wall-board pile.
- The majority of the gypsum wall-board and roofing material piles are exposed and not covered with vegetation.
- CDPR staff reported that a ravine formerly existed under the clinker pile. Based on aerial photographs and contour maps provided by the CDPR Engineering Department, the majority of the clinker pile does not appear to have been placed over a ravine. However, the southeast portion of the clinker pile has likely filled in part of a ravine, and the remainder of the ravine appears to exist (unfilled) to the southeast of the pile.
- A pole-mounted transformer platform, approximately two to four transformers wide, is located adjacent to the east side of the Site. CDPR staff reported that an electric powered tub-grinder was formerly located in this area and was used to produce the wood chips disposed on-Site. Mr. Koke reported that the contents of the transformers had not been spilled, while utilized on-Site or during removal. Hydrocarbon stains were not visible in the vicinity of the transformer platform.
- Small piles of sawdust and wood chips remain around the location of the former tub-grinder.
- The area to the southeast of the Site, and across Marine Avenue, to the south, southwest and west of the Site is forested. Camping occurs in the forest to the south of Marine Avenue.

## 5. INTERVIEWS

An interview was conducted on June 2, 2003, with Mr. Bill Koke, former Site foreman. Mr. Koke reported the following.

- Mr. Koke worked or supervised operations on-Site from circa 1970 to 2002 (recently retired).
- Circa 1970 the Site was a gravel pit, and provided road construction materials for roads in the Powell River area. The Site had not been used prior to gravel pit operations.
- The incinerator was constructed on-Site in the early 1970s and was used to process municipal garbage and other wastes from the Powell River area. The incinerator was usually started in the morning with burning paper and a match. Various types of municipal, commercial, light industrial and agricultural waste were incinerated. Paper from the local pulpmill was also burnt, however, Mr. Koke does not recall that effluent or other wastes associated with pulpmill pipes and boilers was disposed on-Site.
- The Site was not used as an open land-fill, for the disposal of unprocessed unsorted wastes, with minor exceptions such as small quantities of household waste being mixed into other waste piles and the Squatters Creek municipal waste pile.
- The incinerator produced about 10m$^3$ of clinker per day. The clinker was originally used as fill in other areas of Powell River (such as at the airport). However, for approximately 13 years, from around the late 1970s to the late 1980s, the clinker was disposed on or adjacent to the northeast portion of the Site. For 2 to 3 years, from the late 1980s to the early 1990s, the clinker was disposed at the northwest corner of the Site.
- Based on the average amount of clinker produced each day (approximately 10m$^3$), Mr. Koke believes that much more clinker exists on-Site than is estimated in the CDPR Engineering Department report.

- The incinerator stopped operations in the early 1990s, at that time the existing waste transfer operation started. Garbage trucks collect municipal waste from the Powell River area and the contents are transferred into transport truck trailers (B-trains). This waste material is shipped to a land-fill in Cache Creek.
- Scrap metal was formerly piled between the gypsum wall-board pile and the tub-grinder (off-site and adjacent to the east side of the Site).
- The tub-grinder chipped wood waste and yard waste. However, various other materials such as tar paper, treated lumber and metals were mixed in with the wood and yard waste.
- Trucks have been washed out in the area adjacent to the creek, just east of the incinerator and loading platform. Sheens were observed in the creek during washing activities.
- Prior to the disposal of clinker and other waste materials up-gradient of the on-Site creek, the spring water was analyzed to see if it was suitable for a fish hatchery operation. No contamination was reported to be present in the spring water; however, hatchery operations did not start because of concerns with fly ash from the incinerator.

# 6. SUMMARY, DISCUSSION AND CONCLUSIONS

## 6.1. Potential Sources of Contamination

A Preliminary Site Investigation, Stage 1 (PSI 1) was conducted for the Marine Avenue Transfer Site, located on the west side of Marine Avenue, in the Corporation of the District of Powell River (CDPR), British Columbia (the "Site"). The area of the Site is approximately 6.4 hectares.

Prior to the late 1960s the Site and adjacent properties were forested and undeveloped. Gravel extraction operations started on-Site circa 1970 and subsequently expanded onto adjacent properties north, northeast and east of the Site. An incinerator was constructed on-Site in the early 1970s, and was used to incinerate various wastes from the Powell River area. The clinker (an incombustible residue, fused into an irregular lump, that remains after incineration) has been piled up-gradient and adjacent to the Site, as well as on-Site. Wood and yard waste, and a relatively smaller quantity of building materials and treated lumber were chipped adjacent to the east side of the Site. The chipped materials and sorted wastes have been piled on-Site, and up-gradient and adjacent to the Site. The incinerator stopped operations in the early 1990s when the existing waste transfer operation started on-Site. Chipping operations stopped circa 2000. Garbage trucks currently collect municipal waste from the Powell River area and the contents are transferred into transport truck trailers for off-site disposal. Disposal of significant quantities of waste has not occurred on or adjacent to the Site since circa 2000.

With the exception of gravel extraction operations and waste processing and disposal adjacent to the north, northeast and east sides of the Site, the surrounding area has remained forested.

In the following sections, areas of potential environmental concern (APECs) are identified.

- Clinker
- Gypsum Wall-Board
- Roofing Material
- Wood Chips
- Former Truck Washing Area
- Asphalt Piles
- Former Open Burning Area
- Municipal Waste Area
- Diesel AST
- Former Scrap Metal
- Burnt Store Material

In the following sections each of the identified APECs are discussed and an opinion is presented with respect to whether there is a potential for constituents of concern to be present in the Site soil and/or groundwater at levels of concern.

### 6.1.1. Clinker Piles

Clinker was piled at the northeast corner of the Site (primarily off-site) for approximately 13 years, and at the northwest corner of the Site for approximately 3 years between the late 1970s and the early 1990s. The total volume of clinker estimated to exist (on and off-site) by CDPR staff varies between approximately 28,000 $m^3$ and 55,000 $m^3$. There is a potential that clinker contains constituents of concern, primarily metals, and that it has impacted the Site soil and/or groundwater at levels of concern. As well, there is considered to be a potential for constituents of concern associated with the off-site clinker to have migrated to the Site via groundwater at levels of concern.

### 6.1.2. Gypsum Wall-Board

Gypsum wall-board is piled adjacent and up-gradient of the east side of the Site. The acids that are generated from gypsum wall-board, with exposure to water, can cause leaching of constituents of concern from other wastes, such as metals from clinker. It is recommended that the gypsum wall-board pile be removed from the Site. CDPR staff estimate the volume of this pile is approximately 3000 $m^3$ and report that it contains asbestos. There is considered to be a potential that the gypsum wall-board has caused constituents of concern to have leached from other materials, and that these constituents of concern have impacted the Site at levels of concern (from on-Site sources or from migration via groundwater from off-site sources).

### 6.1.3 Roofing Material

Roofing materials have been piled at the northwest corner of the Site, and adjacent and up-gradient of the east side of the Site. CDPR staff estimate that the total volume of roofing material is approximately 2000 $m^3$. There is a potential the Site soil and/or groundwater have been impacted by constituents of concern, primarily associated with tar, at levels of concern (from on and off-site sources).

### 6.1.4 Wood Chips

A tub-grinder chipped wood and yard waste adjacent to the east side of the Site. The chips are piled near the centre of the Site. According to CDPR staff, treated lumber and various building materials have been chipped and mixed into the on-Site chip pile. CDPR staff estimate the volume of this material to be approximately 8200 $m^3$. There is a potential that the chip pile has contributed constituents of concern to the Site soil and/or groundwater at levels of concern.

### 6.1.5 Former Truck Washing Area

Truck washing has occurred near the centre of the Site, adjacent to a creek. CDPR staff report that sheens were visible in the creek during washing operations. There is a potential that washing operations have contributed constituents of concern at levels of concern to the Site soil and/or groundwater.

### 6.1.6 Asphalt Piles

Asphalt has been piled near the centre of the north portion of the Site and adjacent to the east side of the Site. CDPR staff estimate that the total volume of the asphalt piles is approximately 2000 m$^3$. Asphalt binder typically contains polycyclic aromatic hydrocarbons (PAHs), nitrogen, sulphur, oxygen, and various metals. In a saturated environment (groundwater, streams, etc.) constituents of concern can leach from asphalt at levels of concern. There is a potential that on and off-site asphalt piles have impacted the Site soil and/or groundwater at levels of concern.

### 6.1.7 Former Open Burning Area

Yard and wood waste were burned in open fires near the centre portion of the Site. CDPR staff reported that treated lumber was mixed into the yard and wood waste, and that the majority of the ash has been removed from the Site. There remains a potential that constituents of concern associated with open burning exist in the Site soil and/or groundwater at levels of concern.

### 6.1.8 Municipal Waste Area

Contents of another municipal waste disposal site (Squatters Creek) were transported and piled near the north edge of the Site (on and off-site). CDPR staff estimate the volume of this material to be approximately 2400 m$^3$. There is a potential that constituents of concern from this pile have impacted the Site soil and/or groundwater at levels of concern.

### 6.1.9 Diesel AST

A diesel aboveground storage tank (AST) has been located adjacent to the incinerator buildings. Stains were observed in sub-surficial soil in the vicinity of the tank. Constituents of concern associated with diesel potentially exist in the Site soil and/or groundwater at levels of concern.

### 6.1.10 Former Scrap Metal

Scrap metal (volume unknown) was formerly piled adjacent to the east side of the Site (adjacent to and down-gradient of the gypsum wall-board pile). There is a moderate probability that metals have leached from this pile and migrated to the Site at levels of concern.

### 6.1.11 Burnt Store Material

A local grocery store burned down, the demolished materials where transported to the southeast corner of the Site. The demolished materials are currently covered with yard waste. The volume of these materials appears to be approximately 2000 $m^3$. There is a potential that constituents of concern, such as metals, and special attention substances (SAS), such as asbestos and polychlorinated biphenyls (PCB), exist in these materials and have impacted the Site soil and/or groundwater at levels of concern.

## 6.2. Conclusion

It is concluded, that there is a potential for constituents of concern to be present in the Site soil and/or groundwater at concentrations in excess of the applicable standards provided in the British Columbia Contaminated Sites Regulation (CSR), and that further investigation is warranted.

# 8. REFERENCES

1) Current Title Search obtained via the BC Online website.

2) Natural Resources Canada Topographic Map, Powell River, 92-F/15, dated 2000.

3) Aerial photographs dated:
    1932: A4461 – 64;
    1947: BC349 – 68, 69;
    1964: BC5102 – 108, 109;
    1974: BC5587 – 26, 27;
    1980: BC80081 – 68, 69; and
    1998: BCB98008 – 4, 5.

4) "Transfer Site Waste Material Cleanup" letter report, obtained from the Corporation of the District Powell River Engineering Department, dated April, 2000.

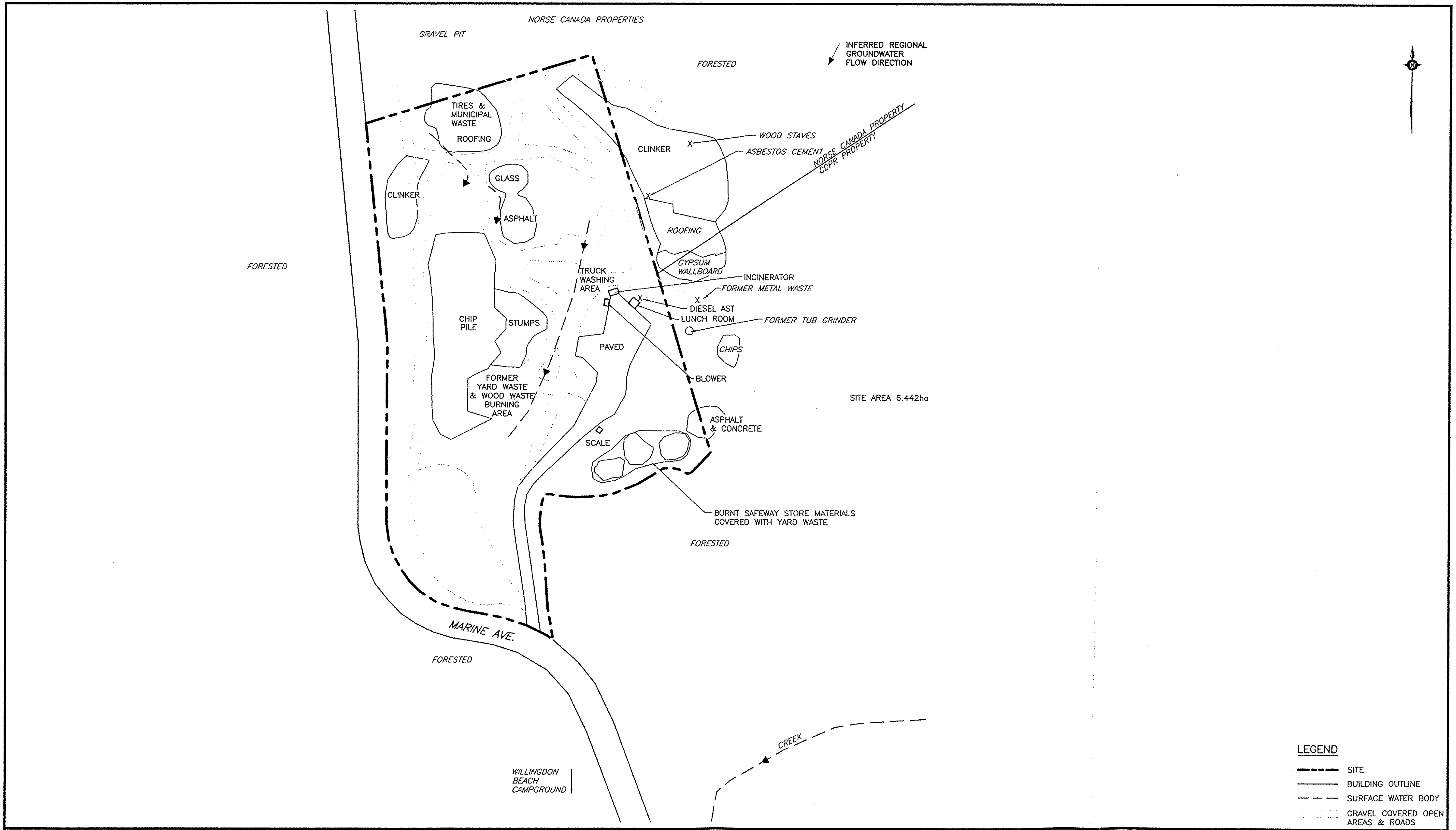
5) British Columbia Ministry of Water, Land and Air Protection (MWLAP) Site Registry; www.bconline.gov.bc.ca.

6) Environment Canada Historic Climate Data. www.msc-smc.ec.gc.ca/climate.

7) MWLAP Water Well Database; www.elp.gov.bc.ca/wat/waterbot/gwell-out.

8) Interviews with persons having knowledge of the Site including:
    - Mr. Bill Koke, former Site foreman;
    - Mr. Frank Dangio, CDPR Engineering Technologist; and
    - Mr. Carl Pearr-son. CDPR truck driver

# FIGURES



**KEYSTONE**
**ENVIRONMENTAL**

*NOTE: THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.*

50m 0 100m

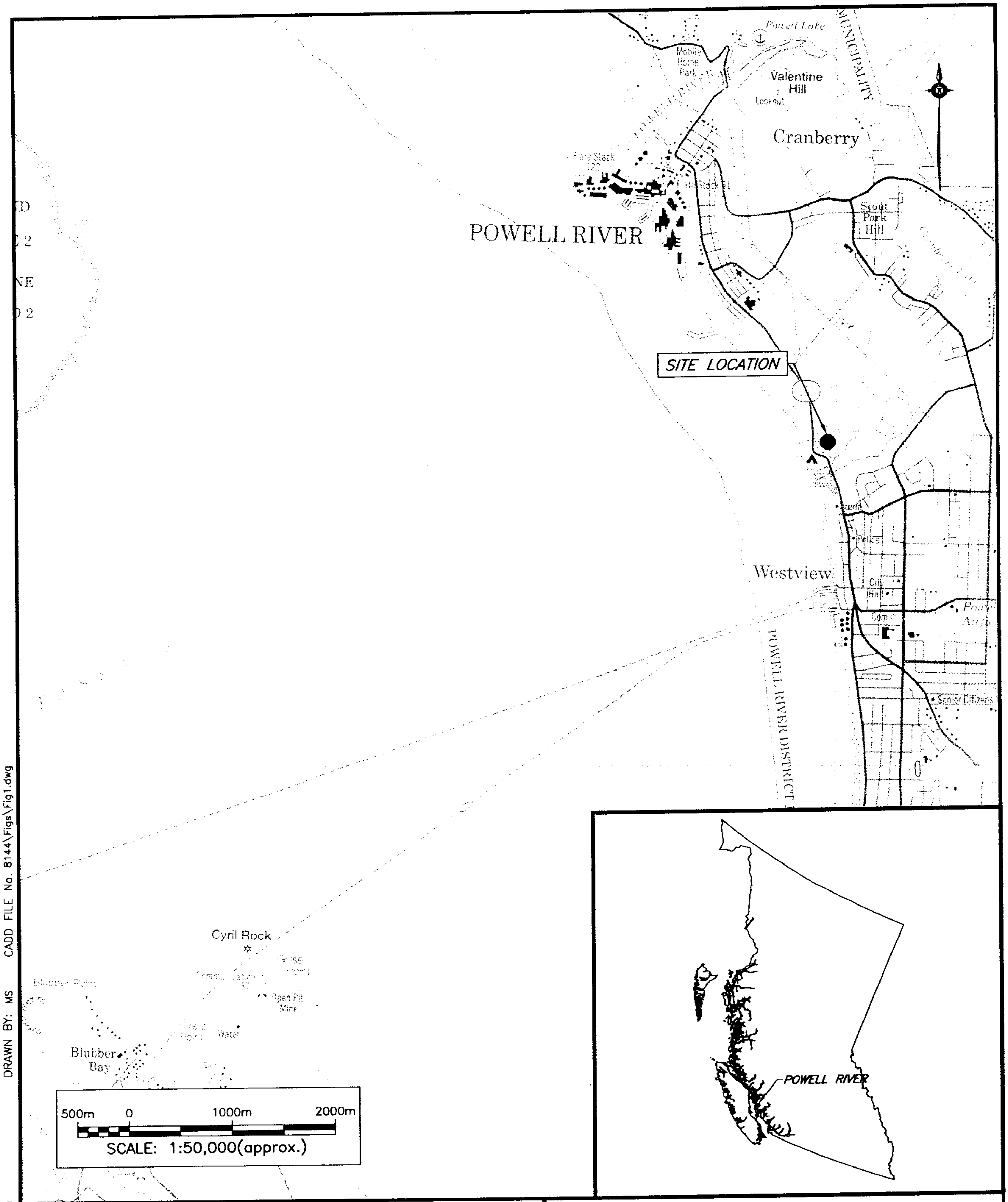
SCALE: 1:2500(approx.)

**Marine Avenue Waste Transfer Site**
**Powell River, B C**
**The Corporation Of the District of Powell River (CDPR)**

| REVISION No. | DATE | PROJECT No. |
|---|---|---|
| 00 | June 2003 | 8144-01 |

# Figure 2
## Site Plan

PLOT SCALE: 1:2.5 DRAWN BY: MS CADD FILE No. 8144\Figs\Fig2.dwg



PLOT SCALE: 1:50 DRAWN BY: MS CADD FILE No. 8144\Figs\Fig1.dwg

**KEYSTONE ENVIRONMENTAL**

**Powell River Waste Transfer Site**
**Powell River, B C**
**The Corporation of the District of Powell River (CDPR)**

| REVISION No. | DATE | PROJECT No. |
|---|---|---|
| 00 | June 2003 | 8144-01 |

Figure 1
Location Plan

VANCOUVER LAND TITLE OFFICE TITLE NO: 544121
FROM TITLE NO: 540798
CROWN GRANT

APPLICATION FOR REGISTRATION RECEIVED ON: 05 JANUARY, 1967
ENTERED: 25 JANUARY, 1967

REGISTERED OWNER IN FEE SIMPLE:
THE CORPORATION OF THE DISTRICT OF POWELL RIVER
6910 DUNCAN STREET
POWELL RIVER, B.C.

TAXATION AUTHORITY:
MUNICIPALITY OF POWELL RIVER

DESCRIPTION OF LAND:
PARCEL IDENTIFIER: 008-935-670
LOT 8 BLOCK 36 DISTRICT LOT 450 PLAN 12203

LEGAL NOTATIONS:

NOTICE OF INTEREST, BUILDERS LIEN ACT (S.3(2)), SEE BM196434
FILED 1998-07-13

FOR PARK PURPOSES SEE 544121L

HERETO IS ANNEXED RESTRICTIVE COVENANT 388796M OVER LOTS A, B, G, H, I
J, O AND P BLOCK 9 PLAN 9246 SEE 494552L

CHARGES, LIENS AND INTERESTS:
NATURE OF CHARGE
CHARGE NUMBER DATE TIME

UNDERSURFACE RIGHTS
440291M 1967-01-05 10:59
REMARKS: SEE 544121L
ANY MINERALS, PRECIOUS OR BASE INCLUDING COAL,
PETROLEUM AND ANY GAS OR GASES

LEASE
BN148785 1999-06-10 14:45
REGISTERED OWNER OF CHARGE:
PAR 4 THE COURSE ENTERTAINMENT LTD
INCORPORATION NO. 584737
BN148785
REMARKS: PLAN LMP42361
HERETO IS ANNEXED EASEMENT BN148786 OVER PART
(PLAN LMP42361)

EASEMENT
BN148786 1999-06-10 14:45
REMARKS: PLAN LMP42361, APPURTENANT TO LEASE

CONTINUES ON PAGE 002

BN148785

MORTGAGE
BN173847 1999-07-02 09:16
REGISTERED OWNER OF CHARGE:
BANK OF MONTREAL
BN173847
REMARKS: OF LEASE BN148785

"CAUTION - CHARGES MAY NOT APPEAR IN ORDER OF PRIORITY. SEE SECTION 28, L.T.A."

DUPLICATE INDEFEASIBLE TITLE: NONE OUTSTANDING

TRANSFERS: NONE

PENDING APPLICATIONS: NONE

*** CURRENT INFORMATION ONLY - NO CANCELLED INFORMATION SHOWN ***

# APPENDIX B

# MWLAP SITE REGISTRY SEARCH RESULTS

As Of: MAY 25, 2003 BC Online: Site Registry 03/05/29
For: PH43481 KEYSTONE ENVIRONMENTAL LTD. 16:34:13
Folio:

# Area Nil Search

As of MAY 25, 2003, no records from the B.C. Environment Site Registry
fall within 0.5 kilometers of coordinates
Latitude 49 degrees, 51 minutes, 4.1 seconds, and
Longitude 124 degrees, 31 minutes, 51.2 seconds.

Sites may be revealed by searching with alternate search methods. For example, a site not revealed in an Area search may be revealed by searching with another piece of information such as PID, PIN, address or Crown Lands File Number

# APPENDIX C

# PREVIOUS REPORT

# THE CORPORATION OF THE DISTRICT OF POWELL RIVER

MUNICIPAL HALL
6910 DUNCAN STREET
POWELL RIVER, B.C.
V8A 1V4

TELEPHONE (604) 485-6291
Engineering Serv. 604 485-8604
FAX (604) 485-2913

OFFICE OF THE
Engineering Services Dept.

# FACSIMILE TRANSMISSION

**TO:** Rod Dagneau

**FIRM:** Keystone

**FAX NO.:** 1-604-430-0672

**TOTAL PAGES:** 08

**FROM:** Tricia Greenwood

**OUR FAX NO.:** **(604) - 485-2913**

**MESSAGE:**
Information as requested

Friday, May 30, 2003 3:30:14 PM

THE CORPORATION OF THE DISTRICT OF POWELL RIVER

# MEMORANDUM

| | |
|---|---|
| TO: | Gino Francescutti, A.Sc.T.<br>Director of Operational/Development Services |
| FROM: | Shawn Cator, A.Sc.T.<br>Engineering Technologist |
| DATE: | 17 April 2000 |
| SUBJECT: | **Transfer Site Waste Material Cleanup** |

---

The Engineering Department has undertaken a study of the transfer site in Powell River to determine the costs associated with the cleanup of contaminated materials in the area. This study consisted of a detailed survey of the area that established volumes of various materials that need to be removed. A plan of the area with the locations of contaminated material has been attached. In addition costs to remove the material offsite was estimated and tabulated in the attached spreadsheet.

There has been no laboratory analysis of the contaminated material; therefore, the consistency and characteristics are based on an educated guess by CDPR staff. As you are aware the CDPR has been dumping waste in this area for many years. For this reason the extents of the contamination may be more extensive than outlined in this report. The waste material surveyed were from areas that staff of the Engineering and Public Works Departments were aware of. In order to obtain a true representation of the extents, a detailed coring program will be necessary.

Most of the unit pricing for removal of the waste was based on a CDPR request for proposals dating back to April 1998 with no adjustments made for inflation. Other unit pricing is an estimate made by the Engineering Department. The Engineering Department attempted to obtain more accurate unit pricing but had not received any figures at the time of this report.

It should be noted that some or all of these materials could be disposed of on site as part of a site closure plan, the cost of which has not been considered in this report. The Ministry of Environment will need to be consulted and in depth discussions will be necessary before consideration of this option.

Listed below is a description and cost for disposal of the waste materials and any alternatives to removal that may be available. The alternatives were not evaluated for costs.

1. Yard Waste – This material generally consists of soil, grass, leaves and branches; which is not believed to be contaminated. The cost to remove the yard waste is estimated at $48,222.00 based on Augusta's $15/tonne charge for disposal and cost for transportation. As an alternative the CDPR may be able to distribute the piles on site depending on the contents.

2. Concrete – This pile contains mainly concrete, some with rebar and/or paint and some tiles, etc. The cost to remove this material is estimated at $17,100.00 based on Augusta's $15/tonne charge for disposal and cost for transportation. Other alternatives to disposal are crushing the concrete on or offsite and using it for a base material in roads.

3. Asphalt – This material is asphalt pavement. The source is roadways, paths, and driveways in the Powell River area. The estimated cost to remove the asphalt is $25,080.00 based on Augusta's $15/tonne charge for disposal and cost for transportation An alternative is to have the material transported to an asphalt plant that could in turn reuse it in their pavements. The asphalt could also be ground and used as a base material in roads.

4. Wood Chip – There are two piles of wood chips at the transfer site consisting of trees, branches and construction lumber that have been put through a tub grinder. The pile is believed to be contaminated because of the miscellaneous construction material. The estimated cost to remove the wood chips is $809,959.50 based on the $130/tonne that Augusta charges the CDPR to dispose of municipal garbage to Rebanko plus loading. As an alternative the CDPR may consider making the material available to the public for planter beds etc. and for use on trails.

5. Gyproc – This material is gyproc wallboard used in the construction trade. The pile is old and is likely completely saturated causing its weight to be high. The estimated cost for removal of this material is $152,100.00 based on a 1998 request for proposal submitted by P.R. Metal. No alternative methods of disposal are known for this material.

6. Roofing – This material consists of duriod and tar & gravel roofing from the construction trades. There are two separate piles of roofing at the transfer site. The estimated cost for removal of this material is $39,168.00 based on a 1998 request for proposal submitted by P.R. Metal. No alternative methods of disposal are known for this material.

7. Ash – There are two known piles of ash at the transfer site. Powell River garbage was burned for many years in an incinerator and the remains are the ash material. The incinerator is currently not in use. The estimated cost for the removal of the ash is $6,024,750.00 based on the $130/tonne that Augusta charges the CDPR to dispose of municipal garbage to Rebanko plus loading. No alternative methods of disposal are known for this material.

8. Crushed Asphalt – The crushed asphalt is asphalt pavement that has been crushed into 2" minus in size. The estimated cost for removal of this material is $106,743.00 based on Augusta's $15.00/tonne charge for disposal and cost for transportation. Currently the Public Works Department uses this material in their construction of roads and utilities in place of sub-base and sub-grade material. As an alternative this material could also be used by a paving company for manufacturing asphalt pavement.

9. Glass – The glass pile includes vehicle windshields, jars/bottles and window pains. Some of the window pains have wood and plastic frames. The estimated cost for removal of this material is $38,707.20.00 based on a 1998 request for proposal submitted by P.R. Metal. No alternative methods of disposal are known for this material.

10. Squatters Creek – In 1995 a storm main that routes Squatters Creek broke near the intersection of Duncan Street and Franklin Avenue. The area over the storm main was known to have been a garbage dump many years ago. For this reason all contaminated excavated material was trucked to the transfer site. The estimated cost for removal of this material is $631,359.00 based on the $130/tonne that Augusta charges the CDPR to dispose of municipal garbage to Rebanko. No alternative methods of disposal are known for this material.

11. Tires – In 1998 all passenger and light truck tires were removed from the transfer site. The tires remaining are off road, oversized and tires with rims. The estimated cost for removal of the tires is $10,000.00 based on a 1998 request for proposal submitted by P.R. Metal. No alternative methods of disposal are known for this material.

12. Stumps – The stump diameters have a range of between 6" and 3ft. There is no known contamination in the stump pile; therefore, the stumps could be ground and left on site. The estimated cost for grinding of the stumps is $40,000.00 based on a 1998 request for proposal submitted by P.R. Metal. As an alternative the resulting chips could be used in trails, as discussed earlier.

13. Asbestos Cement Pipe – AC pipe was used for many years for water distribution in the Powell River area. This stock pipe is AC pipe sections that have been replaced with new pipe over the years. There is no unit cost available for the removal of the pipe. The rough estimated cost for removal of this material is $10,000.00. No alternative methods of disposal are known for this material

14. Wood Stave Pipe – Wood Stave was also used for water distribution in Powell River. The estimated cost for removal is $725.00 based on the $130/tonne that Augusta charges for disposal and cost for transportation. No alternative methods of disposal are known for this material.

Portions of stock piles 5, 6a, 7a, 13, 14 are on Weyerhaeuser property. The remaining stockpiles are on CDPR property.

Of the waste materials mentioned above, the CDPR currently accepts the following from the general public:

1. Soil
2. Concrete

The Public Works and Parks Departments currently dispose of the following waste materials at the transfer site:

1. Soil
2. Concrete
3. Asphalt
4. Trees, branches, grass and leaves
5. Stumps

There is a large area shown on the map that is labeled potentially contaminated. According to CDPR staff who are familiar with the area, this location was originally a ravine that was filled in over the years with a variety of items. The contamination could include, but is not limited to, construction debris, ash or garbage. Without a clear understanding of the content and quantity of this section it is impossible to determine a value for disposal. The range could fall between a few hundred thousand dollars to a few million. More investigation is necessary. As mentioned earlier the CDPR should consider coring throughout the site to increase the accuracy of known contamination.

Shawn Cator, A.Sc.T.
Engineering Technologist

SRC/tg

attachments

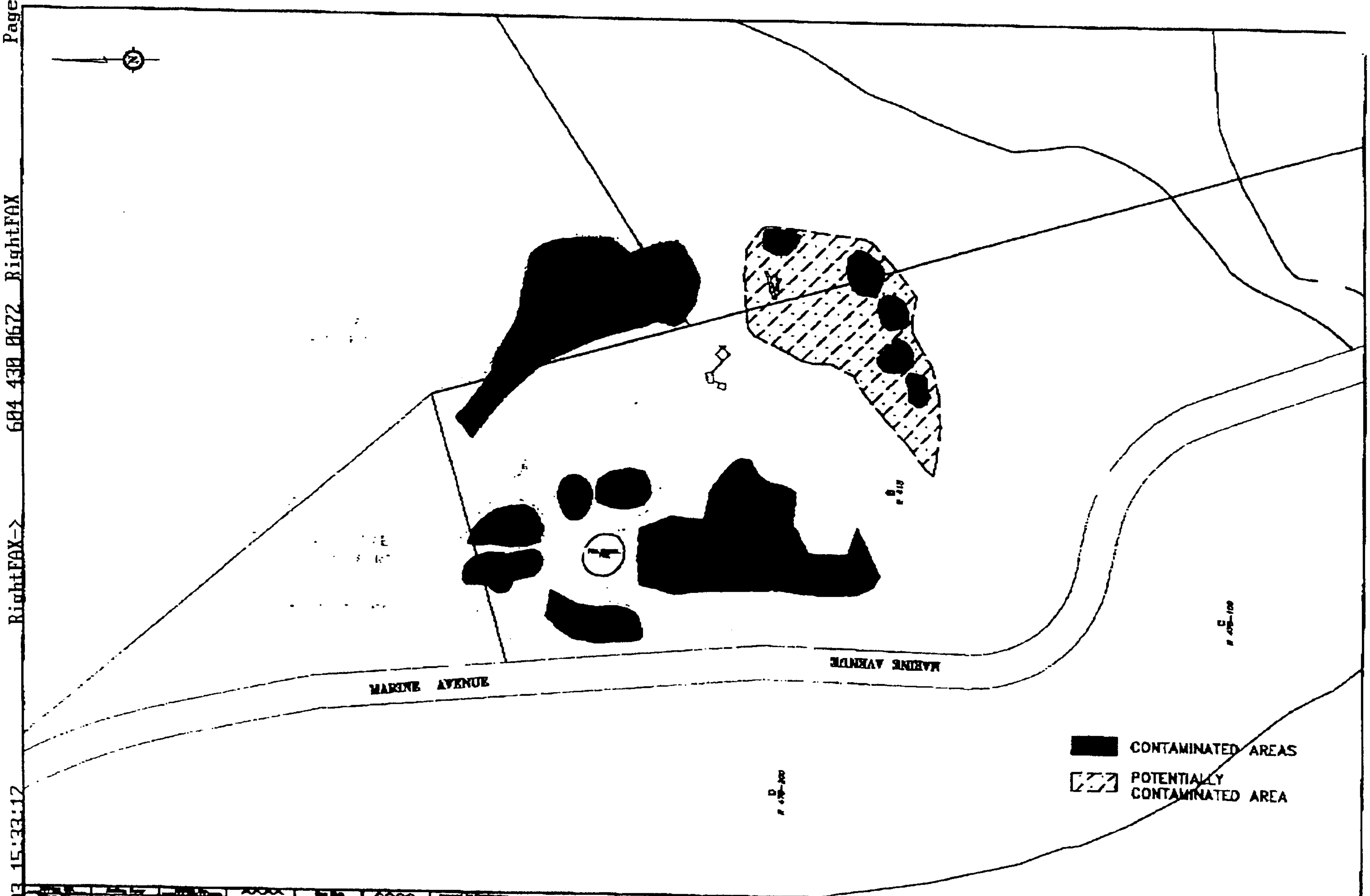
## TRANSFER SITE WASTE DISPOSAL CLEANUP

9-May-00

| MAP # | WASTE MATERIAL | VOLUME $m^3$ | UNIT WEIGHT tonne/m3 | WEIGHT tonne | UNIT PRICE tonne | COST |
|---|---|---|---|---|---|---|
| 1a | YARD WASTE | 327 | 1.8 | 588.6 | $ 100.00 | $ 58,860 |
| 1b | YARD WASTE | 566 | 1.8 | 1018.8 | $ 100.00 | $ 101,880 |
| 2 | CONCRETE | 324 | 2.5 | * 570 | $ 50.00 | $ 28,500 |
| 3 | ASPHALT | 519 | 2.3 | * 836 | $ 50.00 | $ 41,800 |
| 4a | WOOD CHIP | 395 | 0.63 | 248.85 | $ 100.00 | $ 24,885 |
| 4b | WOOD CHIP | 8176 | 0.63 | 5150.88 | $ 100.00 | $ 515,088 |
| 5 | GYPROC | 3000 | 0.6 | 1800 | $ 100.00 | $ 180,000 |
| 6a | ROOFING | 1500 | 0.4 | 600 | $ 100.00 | $ 60,000 |
| 6b | ROOFING | 540 | 0.4 | 216 | $ 100.00 | $ 21,600 |
| 7a | ASH | 20500 | 1.45 | 29725 | $ 100.00 | $ 2,972,500 |
| 7b | ASH | 7200 | 1.45 | 10440 | $ 100.00 | $ 1,044,000 |
| 8 | CRUSHED ASPHALT | 1547 | 2.3 | 3558.1 | $ 30.00 | $ 106,743 |
| 9 | GLASS | 1680 | 0.48 | 806.4 | $ 100.00 | $ 80,640 |
| 10 | SQUATTERS CK. | 2419 | 1.8 | 4354.2 | $ 100.00 | $ 435,420 |
| 11 | TIRES | 1800 | | | LS | $ 10,000 |
| 12 | STUMPS | 2169 | 0.63 | * 683 | LS | $ 40,000 |
| 13 | ASBESTOS CEMENT | 150 | | | $ 350.00 | $ 10,000 |
| 14 | WOOD STAVE PIPE | 100 | | 5 | $ 250.00 | $ 1,250 |
| | | 52912 | | | | |

* Adjusted to compensate for volume of air

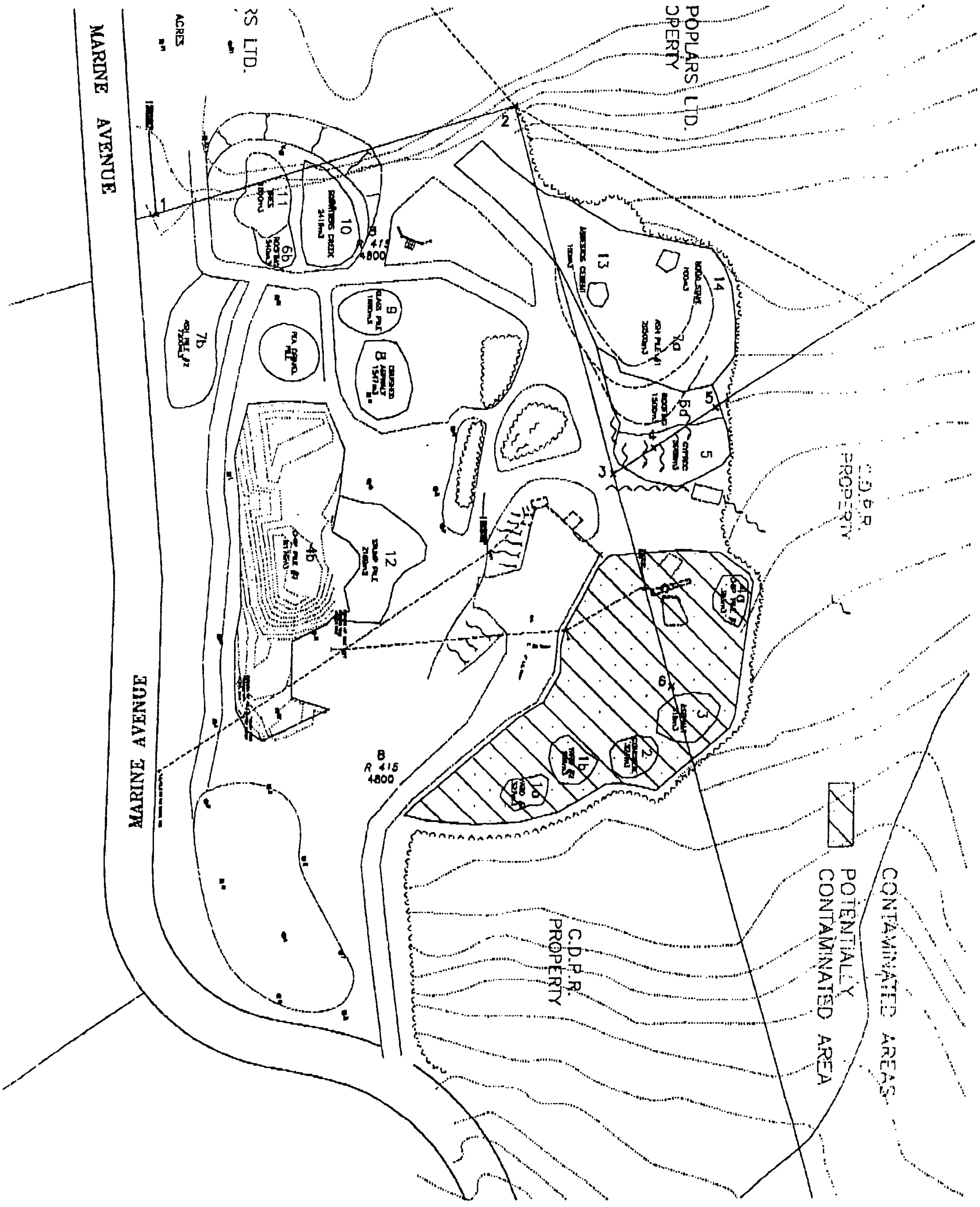
**TOTAL** $ 5,733,166.00



The Corporation of the District of
POWELL RIVER
ENGINEERING DEPARTMENT

MARINE AVENUE
TRANSFER SITE
CONTAMINATED SITES

G-2-90


MARINE AVENUE
MARINE AVENUE
ACRES
RS LTD.
POPLARS LTD.
OPERTY
1
2
3
4
5
6
10
DRIVERS CREEK
11
TIRES
6b
ROOFING
9
GLASS PILE
8
CRUSHED ASPHALT
7b
ASH PILE #2
13
ASBESTOS CEMENT
14
NOVA STONE
7a
ASH PILE #1
6a
ROOFING
5
GYPSUM
12
SCRAP PILE
4b
CHIP PILE #2
4a
3
2
1b
1a
R 415
4800
8
R 415
4800
C.D.P.R.
PROPERTY
C.D.P.R.
PROPERTY
CONTAMINATED AREAS
POTENTIALLY
CONTAMINATED AREA

# APPENDIX D

# HISTORIC CLIMATE DATA

## Canadian Climate Normals 1971-2000

NOTE!! Data used in the calculation of these Normals may be subject to further quality assurance checks. This may result in minor changes to some values presented here.

**Canadian Climate Normals 1971-2000 for**

*** POWELL RIVER**
**British Columbia**

**Latitude:** 49° 52' N **Longitude:** 124° 33' W **Elevation:** 51.8 m

*** This station meets WMO standards for temperature and precipitation.**

The minimum number of years used to calculate these Normals is indicated by a code for each element. A "+" beside an extreme date indicates that this date is the first occurrence of the extreme value.

Normals from January ▾ to Year ▾ View

January-June January-December+Year July-December

Back to station list | Another location

| Temperature: | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year | Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Daily Mean (°C) | 4.0 | 5.0 | 6.7 | 9.4 | 12.7 | 15.6 | 18.2 | 18.3 | 15.5 | 10.8 | 6.6 | 4.4 | 10.6 | A |
| Standard Deviation | 1.5 | 1.3 | 1.2 | 1.0 | 1.2 | 1.1 | 1.0 | 1.2 | 1.1 | 0.8 | 1.5 | 1.4 | 0.7 | A |
| Daily Maximum (°C) | 6.2 | 7.7 | 10.1 | 13.3 | 16.9 | 19.7 | 22.7 | 22.6 | 19.3 | 13.6 | 8.9 | 6.5 | 14.0 | A |
| Daily Minimum (°C) | 1.7 | 2.3 | 3.3 | 5.4 | 8.5 | 11.5 | 13.7 | 14.1 | 11.7 | 8.0 | 4.3 | 2.2 | 7.2 | A |
| Extreme Maximum (°C) | 15.6 | 18.0 | 20.0 | 23.9 | 33.0 | 33.0 | 33.9 | 33.0 | 29.4 | 24.0 | 20.0 | 15.0 | 33.9 | |
| Date (yyy/dd) | 940/28 | 986/27 | 926/29 | 971/25 | 983/29 | 982/18 | 961/12 | 978/07 | 951/14 | 980/03 | 950/27 | 952/14+ | 961/12 | |
| Extreme Minimum (°C) | -14.4 | -12.0 | -10.0 | -1.7 | -6.7 | 3.3 | 6.1 | 6.0 | 0.0 | -4.0 | -11.0 | -12.8 | -14.4 | |
| Date (yyy/dd) | 950/13 | 989/03 | 969/14 | 929/04 | 975/06 | 933/09 | 971/10 | 981/28 | 983/19 | 984/31 | 985/28 | 968/28 | 950/13 | |
| Precipitation: | | | | | | | | | | | | | | |
| Rainfall (mm) | 125.5 | 98.4 | 95.9 | 67.7 | 70.4 | 62.5 | 40.1 | 47.1 | 56.9 | 116.0 | 156.4 | 135.5 | 1072.1 | A |
| Snowfall (cm) | 12.9 | 6.9 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 3.9 | 5.7 | 31.6 | A |
| Precipitation (mm) | 138.4 | 105.2 | 98.0 | 67.7 | 70.4 | 62.5 | 40.1 | 47.1 | 56.9 | 116.2 | 160.3 | 141.2 | 1103.7 | A |
| Mean Snow Depth (cm) | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| Median Snow Depth (cm) | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| Snow Depth at Month-end (cm) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | D |
| Extreme Daily Rainfall (mm) | 64.8 | 49.0 | 71.2 | 27.8 | 61.8 | 58.9 | 48.3 | 46.5 | 57.2 | 49.0 | 58.0 | 68.3 | 71.2 | |
| Date (yyy/dd) | 951/24 | 951/09+ | 997/17 | 992/29 | 998/14 | 958/26 | 965/19 | 936/31 | 972/08 | 973/27 | 980/01 | 947/12 | 997/17 | |
| Extreme Daily Snowfall (cm) | 50.8 | 31.8 | 21.6 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 20.0 | 29.2 | 50.8 | |
| Date (yyy/dd) | 978/04 | 947/01 | 956/04 | 927/07 | 924/01+ | 924/01+ | 924/01+ | 924/01+ | 924/01+ | 984/31 | 985/25 | 964/29 | 978/04 | |
| Extreme Daily Precipitation (mm) | 64.8 | 49.0 | 71.2 | 27.8 | 61.8 | 58.9 | 48.3 | 46.5 | 57.2 | 49.0 | 58.0 | 68.3 | 71.2 | |
| Date (yyy/dd) | 951/24 | 951/09+ | 997/17 | 992/29 | 998/14 | 958/26 | 965/19 | 936/31 | 972/08 | 973/27 | 980/01 | 947/12 | 997/17 | |
| Extreme Snow Depth (cm) | 7.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 7.0 | |
| Date (yyy/dd) | 998/13 | 995/15 | 981/01+ | 981/01+ | 981/01+ | 981/01+ | 981/01+ | 981/01+ | 981/01+ | 981/01+ | 980/01+ | 998/24 | 998/13 | |
| Days With: | | | | | | | | | | | | | | |
| Freezing Rain or Freezing Drizzle | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | D |
| Thunderstorms | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | D |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hail | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | D |
| Days with Maximum Temperature: | | | | | | | | | | | | | | |
| <= 0 °C | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 1.1 | 2.5 | C |
| > 0 °C | 30.1 | 28.0 | 31.0 | 30.0 | 31.0 | 30.0 | 31.0 | 31.0 | 30.0 | 31.0 | 29.7 | 29.9 | 362.8 | C |
| > 10 °C | 2.4 | 4.4 | 14.9 | 25.8 | 30.5 | 30.0 | 31.0 | 31.0 | 30.0 | 27.4 | 8.9 | 2.8 | 239.0 | C |
| > 20 °C | 0.0 | 0.0 | 0.0 | 0.8 | 4.9 | 11.6 | 23.7 | 23.2 | 10.0 | 0.4 | 0.0 | 0.0 | 74.5 | C |
| > 30 °C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | C |
| > 35 °C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | C |
| Days with Minimum Temperature: | | | | | | | | | | | | | | |
| > 0 °C | 20.3 | 21.6 | 28.2 | 29.7 | 30.9 | 30.0 | 31.0 | 31.0 | 30.0 | 30.8 | 27.0 | 22.7 | 333.0 | C |
| <= 2 °C | 17.0 | 13.5 | 10.4 | 2.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 6.9 | 14.5 | 65.3 | C |
| <= 0 °C | 10.7 | 6.7 | 2.8 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 2.9 | 7.9 | 31.4 | C |
| <= -2 °C | 3.1 | 1.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 2.5 | 8.3 | C |
| <= -10 °C | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | C |
| <= -20 °C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | C |
| <= - 30 °C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | C |
| Days with Rainfall: | | | | | | | | | | | | | | |
| >= 0.2 mm | 18.0 | 15.5 | 17.2 | 14.9 | 12.5 | 11.5 | 7.5 | 8.3 | 10.1 | 16.4 | 20.3 | 18.3 | 170.6 | A |
| >= 5 mm | 8.6 | 6.7 | 6.7 | 5.3 | 4.7 | 4.1 | 2.7 | 3.1 | 3.8 | 7.5 | 9.8 | 8.9 | 72.0 | A |
| >= 10 mm | 4.0 | 3.3 | 2.8 | 1.9 | 2.2 | 2.0 | 1.3 | 1.7 | 1.8 | 4.2 | 5.6 | 4.8 | 35.7 | A |
| >= 25 mm | 0.5 | 0.2 | 0.3 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.8 | 1.1 | 0.9 | 4.8 | A |
| Days With Snowfall: | | | | | | | | | | | | | | |
| >= 0.2 cm | 2.1 | 1.3 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.9 | 1.7 | 6.5 | A |
| >= 5 cm | 0.8 | 0.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.5 | 2.4 | A |
| >= 10 cm | 0.5 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 1.1 | A |
| >= 25 cm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | A |
| Days with Precipitation: | | | | | | | | | | | | | | |
| >= 0.2 mm | 19.2 | 16.5 | 17.3 | 14.9 | 12.5 | 11.5 | 7.5 | 8.3 | 10.1 | 16.5 | 20.6 | 19.5 | 174.4 | A |
| >= 5 mm | 9.4 | 7.2 | 7.0 | 5.3 | 4.7 | 4.1 | 2.7 | 3.1 | 3.8 | 7.6 | 10.1 | 9.3 | 74.3 | A |
| >= 10 mm | 4.6 | 3.8 | 3.0 | 1.9 | 2.2 | 2.0 | 1.3 | 1.7 | 1.8 | 4.2 | 5.8 | 4.7 | 36.9 | A |
| >= 25 mm | 0.6 | 0.2 | 0.3 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.8 | 1.2 | 0.9 | 4.9 | A |
| Days with Snow Depth: | | | | | | | | | | | | | | |
| >= 1 cm | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| >= 5 cm | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| >= 10 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| >= 20 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| Degree Days: | | | | | | | | | | | | | | |
| Above 24 °C | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | C |
| Above 18 °C | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 7.3 | 32.7 | 35.3 | 3.8 | 0.0 | 0.0 | 0.0 | 80.7 | C |
| Above 15 °C | 0.0 | 0.0 | 0.0 | 0.2 | 11.2 | 39.2 | 103.8 | 105.7 | 32.3 | 1.2 | 0.0 | 0.0 | 293.6 | C |
| Above 10 °C | 0.4 | 0.4 | 1.1 | 20.2 | 93.1 | 172.0 | 256.1 | 258.2 | 161.2 | 42.3 | 3.5 | 0.2 | 1008.5 | C |
| Above 5 °C | 23.1 | 28.8 | 61.8 | 135.7 | 243.9 | 322.0 | 411.1 | 413.2 | 311.0 | 177.6 | 62.7 | 26.0 | 2216.8 | C |
| Above 0 °C | 126.8 | 143.1 | 210.5 | 285.4 | 398.8 | 472.0 | 566.1 | 568.2 | 461.0 | 331.9 | 197.5 | 140.2 | 3901.4 | C |
| Below 0 °C | 4.6 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 5.1 | 13.3 | C |
| Below 5 °C | 55.9 | 28.4 | 6.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 17.2 | 45.9 | 154.9 | C |
| Below 10 °C | 188.3 | 141.2 | 100.6 | 34.8 | 4.2 | 0.0 | 0.0 | 0.0 | 0.2 | 20.4 | 108.0 | 175.0 | 772.7 | C |
| Below 15 °C | 342.8 | 281.9 | 254.5 | 164.8 | 77.4 | 17.2 | 2.7 | 2.6 | 21.2 | 134.4 | 254.6 | 329.9 | 1884.1 | C |
| Below 18 °C | 435.8 | 366.6 | 347.5 | 254.6 | 160.8 | 75.4 | 24.6 | 25.1 | 82.7 | 226.2 | 344.6 | 422.9 | 2766.8 | C |

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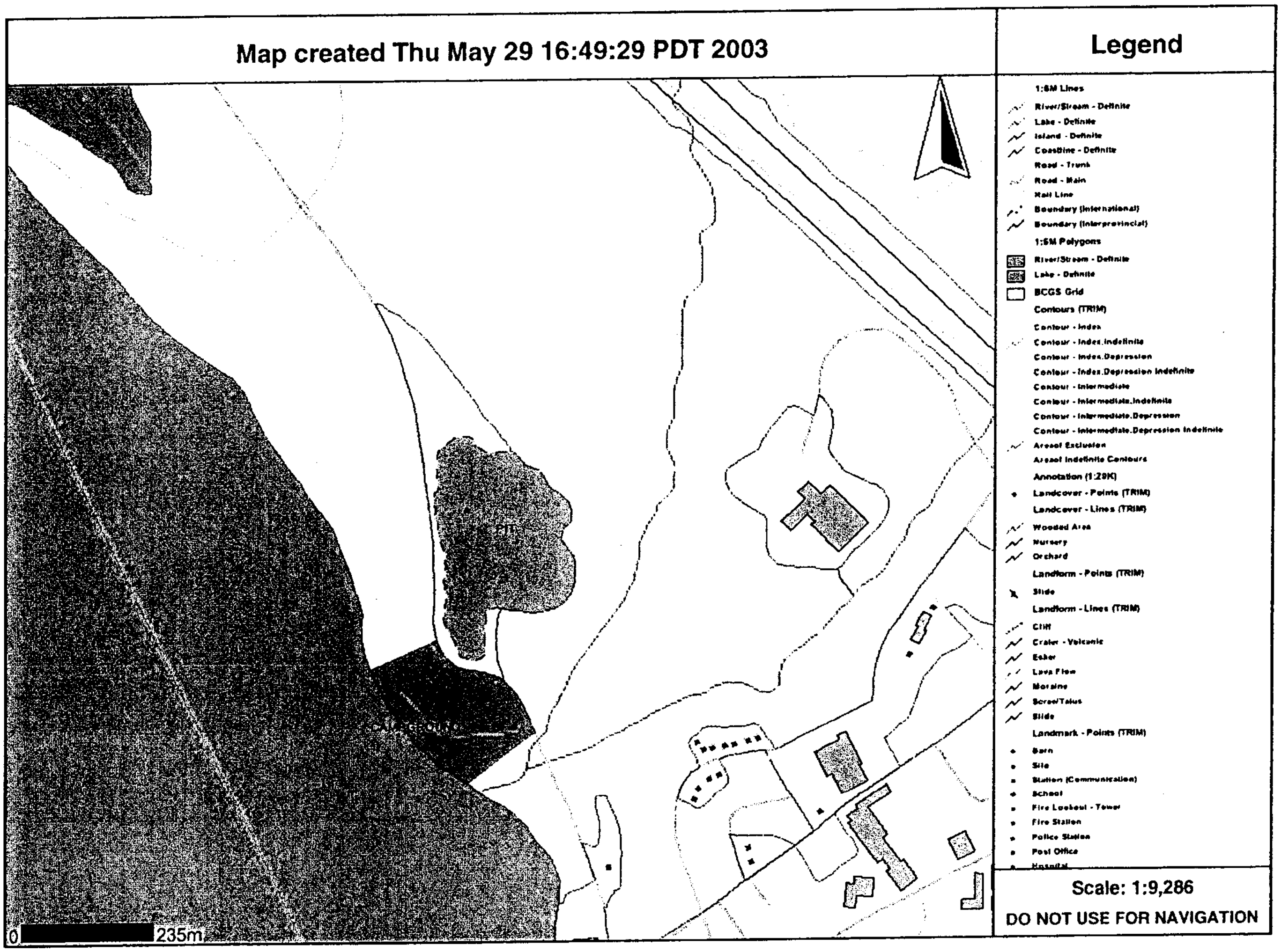
# APPENDIX E

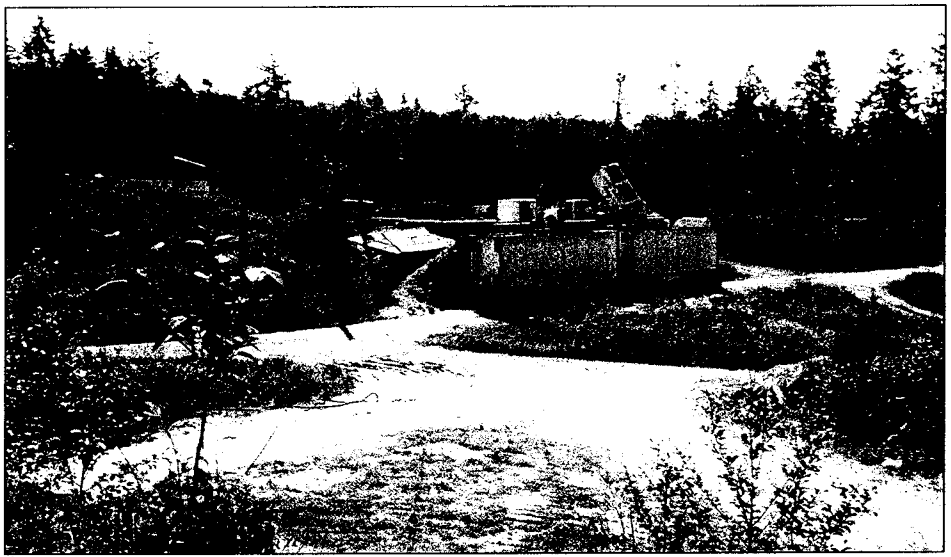
# WATER WELL SEARCH


Map created Thu May 29 16:49:29 PDT 2003
Legend
1:6M Lines
River/Stream - Definite
Lake - Definite
Island - Definite
Coastline - Definite
Road - Trunk
Road - Main
Rail Line
Boundary (International)
Boundary (Interprovincial)
1:6M Polygons
River/Stream - Definite
Lake - Definite
BCGS Grid
Contours (TRIM)
Contour - Index
Contour - Index.Indefinite
Contour - Index.Depression
Contour - Index.Depression Indefinite
Contour - Intermediate
Contour - Intermediate.Indefinite
Contour - Intermediate.Depression
Contour - Intermediate.Depression Indefinite
Areaol Exclusion
Areaol Indefinite Contours
Annotation (1:20K)
Landcover - Points (TRIM)
Landcover - Lines (TRIM)
Wooded Area
Nursery
Orchard
Landform - Points (TRIM)
Slide
Landform - Lines (TRIM)
Cliff
Crater - Volcanic
Esker
Lava Flow
Moraine
Scree/Talus
Slide
Landmark - Points (TRIM)
Barn
Silo
Station (Communication)
School
Fire Lookout - Tower
Fire Station
Police Station
Post Office
Hospital
0
235m
Scale: 1:9,286
DO NOT USE FOR NAVIGATION

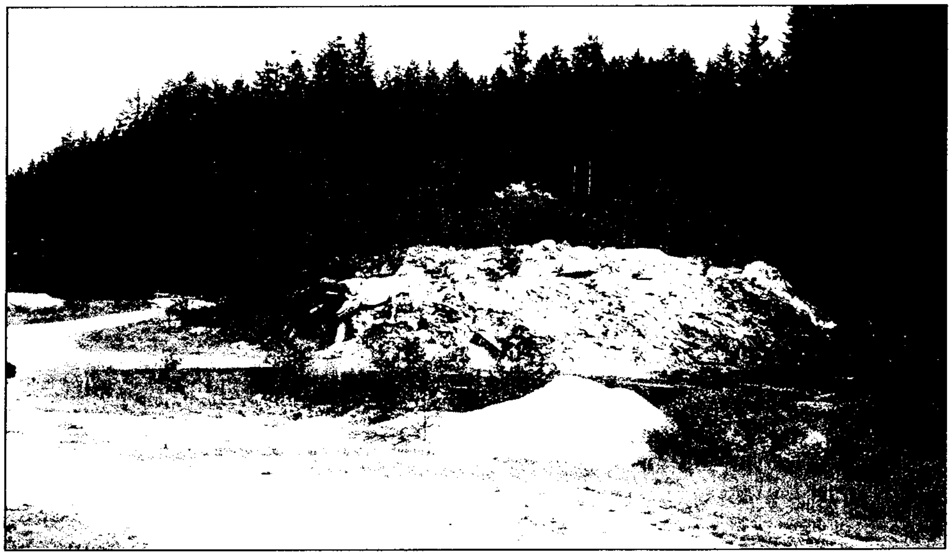
# APPENDIX F

# PHOTOGRAPHIC DOCUMENTATION

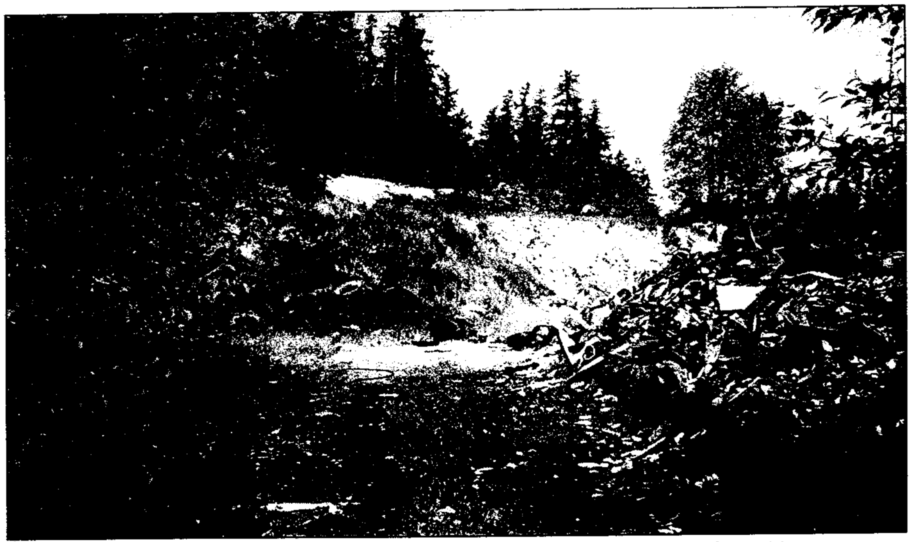
↑ View of waste transfer area and incinerator looking southwest.



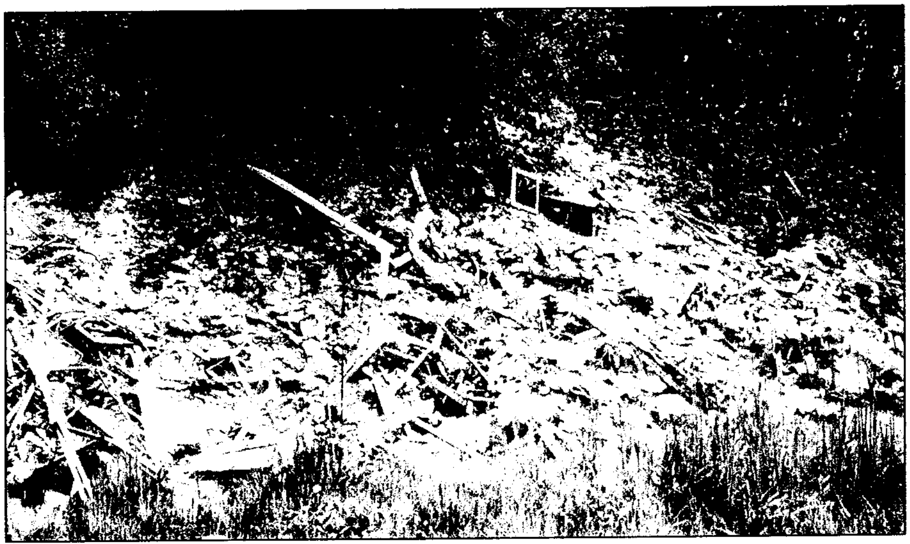
↑ View of waste transfer area looking southeast.



↑ View of clinker, gyproc and roofing material piles adjacent to the northeast corner of the Site. Looking north.

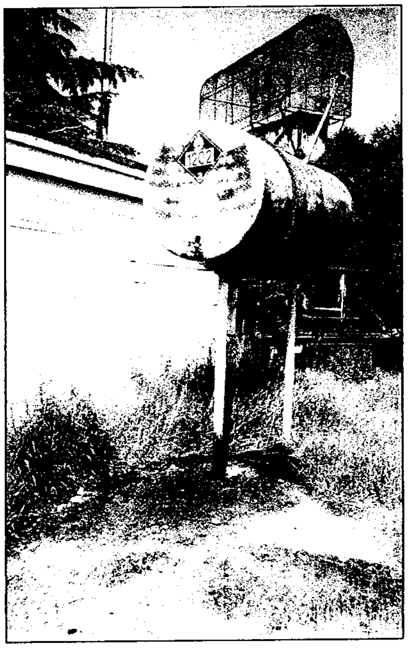


↑ View of tire and roofing material piles at the northwest corner of the Site.



↑ View of glass pile on the north portion of the Site.

→ View of diesel AST and stains (foreground) and incinerator (background).



# APPENDIX G

# GENERAL TERMS AND CONDITIONS FOR SERVICES

# KEYSTONE ENVIRONMENTAL LTD.
# GENERAL TERMS AND CONDITIONS FOR SERVICES

The terms and conditions set forth below govern all work or services requested by CLIENT as described and set forth in the Proposal of Keystone Environmental Ltd. ("Keystone") attached hereto, any Purchase Order issued by CLIENT or Agreement between Keystone and CLIENT. The provisions of said Proposal or Agreement govern the scope of services to be performed, including the time schedule, compensation, and any other special terms. The terms and conditions contained herein shall otherwise apply expressly stated to the contract or inconsistent with said Proposal or Agreement.

## 1. COMPENSATION

Unless otherwise stated in Keystone's Proposal, CLIENT agrees to compensate Keystone in accordance with Keystone's published rate schedules in effect on the date when the services are performed. Copies of the schedules currently in effect are attached hereto. Keystone's rate schedules are revised periodically; and Keystone will notify CLIENT of any such revisions and the effective date thereof which shall not be less than thirty (30) days after receipt of such notice. As to those services for which no schedule exists, Keystone shall be compensated on a time and materials basis as set forth in any change order executed pursuant to this Agreement.

## 2. PAYMENT

Unless otherwise agreed to in writing, invoices will be submitted monthly. Payment of invoices is due within thirty (30) days of receipt of the invoice. Invoices not paid within (30) days after date of receipt shall be deemed delinquent.

## 3. INDEPENDENT CONTRACTOR

Keystone shall be an independent contractor and shall be fully independent in performing the services of work and shall not act or hold themselves out as an agent, servant or employee of CLIENT.

## 4. KEYSTONE'S LIMITED WARRANTY

The sole and exclusive warranty which Keystone makes with respect to the services to be provided in the performance of the work is that they shall be performed in accordance with generally accepted professional practices and CLIENT's standards and specifications to the extent accepted by Keystone and shall be performed in a skillful manner.

In the event Keystone's performance of work, or any portion thereof, fails to conform with the above stated limited warranty, Keystone shall, at its discretion and its expense, proceed expeditiously to reperform the nonconforming, or upon the mutual agreement of the parties, refund the amount of compensation paid to Keystone for such nonconforming work. In no event shall Keystone be required to bear the cost of gaining access in order to perform its warranty obligations.

## 5. CLIENT WARRANTY

CLIENT warrants that: it will provide to Keystone all available information regarding the site, structures, facilities, buildings, and land involved with the work and that such information shall be true and correct: it will provide all licences and permits required for the work; that all work which it performs shall be in accordance with generally accepted professional practices; and it has title to or will provide right of entry or access to all property necessary to perform the work.

## 6. INDEMNITY

a. Subject to the limitations of Section 7 below, Keystone agrees to indemnify, defend and hold harmless CLIENT (including its officers, directors, employees and agents) from and against any and all losses, damages, liabilities, claims, suits, and the costs and expenses incident thereto (including legal fees and reasonable costs of investigation) which any or all of them may hereafter incur, become responsible for or pay out as a result of death or bodily injuries to any person, destruction or damage to any property, private or public, contamination or adverse effects on the environment or any violation or alleged violation of governmental laws, regulations, or orders, to the extent caused by or arising out of: (i) Keystone's errors or omissions or (ii) negligence on the part of Keystone in performing services hereunder.

b. CLIENT agrees to indemnify and hold harmless Keystone (including its officers, directors, employees and agents) from and against any and all losses, damages, liabilities, claims, suits and the costs and expenses incident thereto (including legal fees and reasonable costs of investigation) which any or all of them may hereafter incur, become responsible for or pay out as a result of death or bodily injuries to any person, destruction or damage to any property, private or public, contamination or adverse effects on the environment or any violation or alleged violation of governmental laws, regulations, or orders, caused by, or arising out of in whole or in part: (i) any negligence or willful misconduct of CLIENT, (ii) any breach of CLIENT of any warranties or other provisions hereunder, (iii) any condition including, but not limited to, contamination existing at the site, or (iv) contamination of other property arising or alleged to arise from or be related to the site provided, however, that such indemnification shall not apply to the extent any losses, damages, liabilities or expenses result from or arise out of: (i) any negligence or willful misconduct of Keystone; or(ii) any breach of Keystone of any warranties hereunder.

7. **LIMITATION OF LIABILITY**

Keystone's total liability, whether arising from or based upon breach of warranty, breach of contract, tort, including Keystone's negligence, strict liability, indemnity or any other cause of basis whatsoever, is expressly limited to the limits of Keystone's insurance coverage. This provision limiting Keystone's liability shall survive the termination, cancellation or expiration of any contract resulting from this Proposal and the completion of services thereunder. After three (3) years of completion of Keystone's services, any legal costs arising to defend third party claims made against Keystone in connection with the project defined in the Proposal or Agreement will be paid in full by the CLIENT.

8. **INSURANCE**

Keystone, during performance of this Agreement, will at its own expense carry Worker's Compensation Insurance within limits required by law; Comprehensive General Liability Insurance for bodily injury and for property damage; Professional Liability Insurance for errors omissions and negligence; and Comprehensive Automobile Liability Insurance for bodily injury and property damage. At CLIENT'S request, Keystone shall provide a Certificate of Insurance demonstrating Keystone's compliance with this section. Such Certificate of Insurance shall provide that said insurance shall not be cancelled or materially altered until at least ten (10) days after written notice to CLIENT.

9. **CONFIDENTIALITY**

Each party shall retain as confidential all information and data furnished to it by the other party which relate to the other party's technologies, formulae, procedures, processes, methods, trade secrets, ideas, improvements, inventions and/or computer programs, which are designated in writing by such other party as confidential at the time of transmission and are obtained or acquired by the receiving party in connection with work or services performed subject to this Proposal or Agreement, and shall not disclose such information to any third party.

However, nothing herein is meant to prevent nor shall it be interrupted as preventing either Keystone or CLIENT from disclosing and/or using said information or data; (i) when the information or data is actually known to the receiving party before being obtained or derived from the transmitting party; or (ii) when the information or data is generally available to the public without the receiving party's fault; or (iii) where the information or data is obtained or acquired in good faith at any time by the receiving party from a third party who has the right to disclose such information or data; or (iv) where a written release is obtained by the receiving party from the transmitting party; or (v) as required by law.

10. **PROTECTION OF INFORMATION**

Keystone specifically disclaims any warranties expressed or implied and does not make any representations regarding whether any information associated with conducting the work, including the report, can be protected from disclosure in responses to a request by a federal, provincial or local government agency, or in response to discovery or other legal process during the course of any litigation involving Keystone or CLIENT. Should Keystone receive such request from a third party, it will immediately advise CLIENT.

11. **FORCE MAJEURE**

Neither party shall be responsible or liable to the other for default or delay in the performance of any of its obligations hereunder (other than the payment of money for services already rendered) caused in whole or in part by strikes or other labour difficulties or disputes; governmental orders or regulations; war, riot, fire, explosion; acts of God; acts of omissions of the other party; any other like causes; or any other unlike causes which are beyond the reasonable control of the respective party.

In the event of delay in performance due to any such cause, the time for completion will be extended by a period of time reasonably necessary to overcome the effect of the delay. The party so prevented from complying shall within a reasonable time of its knowledge of the disability advise the other party of the effective cause, the performance suspended or affected and the anticipated length of time during which performance will be prevented or delayed and shall make all reasonable efforts to remove such disability as soon as possible, except for labour disputes, which shall be solely within said party's discretion. The party prevented from complying shall advise the other party when the cause of the delay or default has ended, the number of days which will be reasonably required to compensate for the period of suspension and the date when performance will be resumed. Any additional costs or expense accruing or arising from the delaying event shall be solely for the account of the CLIENT.

12. **NOTICE**

Any notice, communication, or statement required or permitted to be given hereunder shall be in writing and deemed to have been sufficiently given when delivered in person or sent by facsimile, wire, or certified mail, return receipt requested, postage prepaid, to the address of the party set forth below, or to such address for either party as the party may be written notice designate.

13. ASSIGNMENT/SUBCONTRACT

Neither party hereto shall assign this Agreement or any part thereof or any interest therein without the prior written approval of the other party hereto except as herein otherwise provided. Keystone shall not subcontract the performance of any work hereunder without the written approval of CLIENT. Subject to the foregoing limitation, the Agreement shall inure to the benefit of and be binding upon the successors and permitted assigns of the parties hereto.

14. ESTIMATES

To the extent the work requires Keystone to prepare opinions of probable cost, for example, opinions of probable cost for the cost of construction, such opinions shall be prepared in accordance with generally accepted engineering practice and procedure. However, Keystone has no control over construction costs, competitive bidding and market conditions, costs of financing, acquisition of land or rights-of-way and Keystone does not guarantee the accuracy of such opinion of probable cost as compared to actual costs or contractor's bid.

15. DELAYED AGREEMENTS AND OBLIGATIONS

The performance by Keystone of its obligations under this Agreement depends upon the CLIENT performing its obligations in a timely manner and cooperating with Keystone to the extent reasonably required for completion of the Work. Delays by CLIENT in providing information or approvals or performing its obligations set forth in this Agreement may result in an appropriate adjustment of contract price and schedule.

16. CONSTRUCTION PHASE

To the extent the work is related to or shall be followed by construction work not performed by Keystone, Keystone shall not be responsible during the construction phase for the construction means, methods, techniques, sequences or procedures of construction contractors, or the safety precautions and programs incident thereto, and shall not be responsible for the construction contractor's failure to perform the work in accordance with the contract documents. Keystone will not direct, supervise or control the work of the CLIENT'S contractors or the CLIENT'S subcontractors.

17. DOCUMENTATION, RECORDS, AUDIT

Keystone when requested by CLIENT, shall provide CLIENT with copies of all documents relating to the service(s) of work performed. Keystone shall retain true and correct records in connection with each service and/or work performed and all transactions related thereto and shall retain all such records for twelve (12) months after the end of the calendar year in which the last service pursuant to this Agreement was performed. CLIENT, at its expense and upon reasonable notice, may from time to time during the term of this Agreement, and at any time after the date the service(s) were performed up to twelve (12) months after the end of the calendar year in which the last service(s) were performed, audit all records of Keystone in connection with all costs and expenses which it was invoiced.

18. REPORTS, DOCUMENTS AND INFORMATION

All field data, field notes, laboratory test data, calculations, estimates and other documents prepared by Keystone in performance of the work shall remain the property of Keystone. If required as part of the work, Keystone shall prepare a written report addressing the items in the work plan including the test results. Such report shall be the property of CLIENT, Keystone shall be entitled to retain three (3) copies of such report for its internal use and reference.
All drawings and documents produces under the terms of this Agreement are the property of Keystone, and cannot be used for any reason other than to bid and construct the project as described in the Proposal or Agreement.

19. LIMITED USE OF REPORT

Any report prepared as part of the work will be prepared solely for the internal use of CLIENT. Unless otherwise agreed by Keystone and CLIENT, parties agree that third parties are not to rely upon the report.

20. SAMPLE MANAGEMENT

Ownership of all samples obtained by Keystone from the project site is maintained by the CLIENT. Keystone will store such samples in a professional manner in a secure area for the period of time necessary to complete the project. Upon completion of the project, Keystone will return any unused samples or portions thereof to the CLIENT or at Keystone's option dispose of the samples in a lawful manner and bill the CLIENT for all costs related thereto. Keystone will normally store samples for thirty (30) days. Written notice will be given to the CLIENT before finally disposing of samples.

21. RECOGNITION OF RISK

CLIENT recognized and accepts the work to be undertaken by Keystone may involve unknown conditions and hazards. CLIENT further recognizes that environmental, geologic, hydrological, and geotechnical conditions can and may vary from those encountered by Keystone at the times and locations where it obtained data and information, and that limitations on available data results in some uncertainty with respect to the interpretation of these conditions, despite the use of due professional care by Keystone. CLIENT recognizes that the performance of services hereunder or the implementation of recommendations made by Keystone may unavoidably alter the existing site conditions and affect the environment in the area being studied.

22. **DISPOSAL OF CONTAMINATED MATERIAL**

It is understood and agreed that Keystone is not, and has no responsibility as, a generator, operator or storer of pre-existing hazardous substances or wastes found or identified at work sites. Keystone shall not directly or indirectly assume title to such hazardous or toxic substances and shall not be liable to third parties.

CLIENT will indemnify and hold harmless Keystone from and against all incurred losses, damages, costs and expenses, including but not limited to attorneys' fees, arising or resulting from actions brought by third parties alleging or identifying Keystone as a generator, operator, storer or owner of pre-existing hazardous substances or wastes found or identified at work sites.

23. **SUSPENSION OR TERMINATION**

In the event the work is terminated or suspended by CLIENT prior to the completion of the services contemplated hereunder, Keystone shall be paid for: (i) the services rendered to the date of termination or suspension, (ii) the demobilization costs, and (iii) the costs incurred with respect to noncancelable commitments.

24. **GOVERNING LAW**

This Agreement shall be governed by and interpreted pursuant to the laws of the Province of British Columbia.

25. **HEADINGS AND SEVERABILITY**

Any heading preceding the text of sections hereof is inserted solely for convenience or reference and shall not constitute a part of the Agreement and shall not effect the meanings, context, effect or construction of the Agreement. Every part, term or provision of this Agreement is severable from others. Notwithstanding any possible future finding by duly constituted authority that a particular part, term or provision is invalid, void or unenforceable, this Agreement has been made with the clear intention that the validity and enforceability of the remaining parts, terms and provision shall not be affected thereby.

26. **ENTIRE AGREEMENT**

The terms and conditions set forth herein constitute the entire Agreement and understanding or the parties relating to the provision of work or services by Keystone to CLIENT, and merges and supersedes all prior agreements, commitments, representation, writings, and discussions between them and shall be incorporated in all work orders, purchase orders and authorization unless otherwise so stated therein. The terms and conditions may be amended only by written instrument signed by both parties.

PR-509

The Corporation of the District of Powell River

Office of the
Director of Engineering Services

Municipal Hall
6910 Duncan Street
Powell River, B.C.
V8A 1V4
Telephone 485-6291
Fax 485-2913

June 11, 1996

B.C. Environment
15326 103A Avenue
Surrey, B.C.
V3R 7A2

RECEIVED
JUN 17 1996
LOWER MAINLAND REGION
FILE NO.

Attention: Mr. Jeff Van Haastregt
Solid Waste Officer, Municipal Section

Dear Mr. Van Haastregt:

**Re: Incinerator Bottom Ash Testing**

Enclosed for your information is the final report from Pottinger Gahrety on the stockpiles of incinerator bottom ash currently stored at our solid waste transfer site.

We have no immediate plans for the ash stockpiles, however, as further development continues with our regional solid waste management plan the eventual use of the current site will need to be addressed. In this regard the information contained in the report will undoubtedly be used as the basis for any proposal for the final disposal of the ash.

Please contact me if you require anything further.

Yours truly,

Jim Greenwood, P. Eng.
Director of Engineering Services

JGG/lf

xc: Ms. Frances Ladret, Secretary Treasurer, Powell River Regional District

enclosures:

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PREVIOUSLY
SENT BY FAX

April 17, 1996
File: 148-01.01

Pottinger Gaherty
Environmental Consultants Ltd
1100-1130 West Pender St
Vancouver, Canada V6E 4A4
Tel 604.682 3707
Fax 604 682 3497

RECEIVED
APR 23 1996
THE CORPORATION OF
THE DISTRICT OF
POWELL RIVER

**via fax:** **(604) 485-2913 (original by mail)**

The Corporation of the District of Powell River
Municipal Hall
6910 Duncan Street
Powell River, B.C.
V8A 1V4

**Attention:** **Jim Greenwood**
**Director of Engineering Services**

**RE:** **FINAL REPORT - MUNICIPAL WASTE INCINERATOR BOTTOM ASH, SAMPLING, ANALYSIS AND CHARACTERIZATION, AND REMEDIATION RECOMMENDATIONS**

Pottinger Gaherty Environmental Consultants Ltd. (PGL) is pleased to present this report summarizing the results of the sampling, analysis and characterization of the municipal waste incinerator bottom ash material stockpiled at your municipal waste disposal site on Marine Avenue. We also provide a list of options for final disposal and management of the ash material, and make recommendations based on this list.

## BACKGROUND

The report summarized the results of an investigation to characterize residual incinerator bottom ash stockpiled at 4800 Marine Avenue, Powell River, on land owned by the Municipal District of Powell River (MDPR). The ash material was stockpiled from 1988 to 1994 in two exposed piles: the east pile of approximately 21,000m$^3$ and the west pile of approximately 7200m$^3$.

The waste disposal site is located within 500m and upgradient of a municipal park and marine beach recreation area. The site where the ash piles are located is underlain by a thick, but local deposit of unconsolidated outwash sediments consisting of medium to coarse sand, gravel and boulders, with minor fine sand and silt horizons. There is no surface water on the site and the site is well drained. The site has been used for gravel and sand extraction with the ash piles located along the east and west sides of the remaining pit. The east ash pile stands in an isolated pile over 5m high. The west ash pile has been placed along the west wall of the pit up to 5m in depth. Both piles have a thin 0.1m to 0.3m sand cap. The east pile is partially covered with weathered wood chips to a thickness of 0.8m.

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## SAMPLING PROCEDURE

Sampling of the ash residue was conducted in two stages. On September 29, 1995, a total of 10 trenches were excavated on the east pile (numbered E1 to E10) and four trenches on the west pile (numbered W11 to W14) with the aid of a backhoe (see Figure 1). A total of 33 samples were collected in plastic bags for metals in soils and metals in leachate analysis. An additional boulder-sized sample of coarse glassy slag material was also collected from the west pile. Six additional samples were collected March 4, 1996 from hand dug pits located adjacent to the sites of the original trenches in undisturbed material. These were analyzed for Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated Biphenyls (PCBs), Polychlorinated Dibenzenodioxins (Dioxins) and Polychlorinated Dibenzenofurans (Furans). All the trenches were backfilled and the locations marked with survey stakes.

Sampling of the ash was done in accordance with the B.C. Ministry of Environment, Lands & Parks (BCE) and industry standards. All samples were collected using a steel trowel from approximately 1m$^2$ panels on the pit walls. Samples collected for PAH, PCB, Dioxin/Furan analysis were put in suitably prepared glass jars with foil lid liners. Samples were taken from discrete homogenous horizons in the pits. The profiles of the pits, including the sampled intervals are described in detail (see Appendix 1).

## ANALYSIS

Analysis of the samples for metals in soil, metals in leachate, PAHs and PCBs was conducted at CanTest Ltd. in Vancouver. Samples were analyzed for Dioxins/Furans at Novamann (Quebec) Ltd. in Lachine, Quebec. All analysis was conducted in accordance with BCE and industry standards.

A total of 10 samples were submitted for metals in soil analysis, including six from the east pile, three from the west pile, and the slag material (also from the west pile). Based on the results of the metals analysis, four worst case samples (two from each pile; including the slag sample) were analyzed for metals in leachate. All six samples collected for PAH, PCB and Dioxin/Furan analysis (four from the east pile and two from the west pile) were analyzed separately.

The Leachate Extraction Procedure (LEP) used was in accordance with the methodologies described in the B.C. Special Waste Management Act. PAHs, PCBs, and Dioxins/Furans were determined with methodologies based on accepted U.S. EPA Methods 625/8270, 608/8080 and 8290, respectively.

Complete descriptions of the analytical procedures used are attached with the Laboratory Reports (Appendix 2).

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## ANALYTICAL RESULTS

Analysis of the selected samples of the ash was done in stages. Metals analysis was undertaken first to indicate worse case metal concentration samples for LEP analysis. Failing the LEP criteria would classify the ash as Special Waste under the BCE Waste Management Act and require special management. Based on results lower than the LEP criteria, samples of the ash were then submitted for analysis for PAHs, PCBs and Dioxins/Furans.

The initial metals analysis exceeded the BCE Soil Numerical Criteria for commercial (CL) and industrial (IL) sites for copper (500μg/g) for eight of the samples, for zinc (1500μg/g) for seven samples, for lead (1000μg/g) for two samples, and for barium (2000μg/g) for one sample. Only one of the samples was below the CL and IL criteria levels for all elements analyzed.

The LEP analysis was undertaken on the worse case metal concentration samples as listed in Table 1 below.

**TABLE 1**
**MDPR Incinerator Ash**
**Metals Analysis Results of Samples Selected for LEP Analysis**

| PGL No. | CanTest No. | Description | Pb (μg/g) | Zn (μg/g) | Cu (μg/g) | Ba (μg/g) |
|---|---|---|---|---|---|---|
| 95-148.01.01-E2S4 | 512290064 | Ash/Soil | 1700 | 1670 | 884 | 187 |
| 95-148.01.01-E3S8 | 512290065 | Ash/Soil | 245 | 1250 | 1080 | 195 |
| 95-148.01.01-W13S28 | 512290066 | Ash/Soil | 2410 | 19000 | 295 | 107 |
| 95-148.01.01-S34 | 512290067 | Coarse Slag | 175 | 1600 | 4030 | 3400 |

Results of the LEP analysis of the above samples yielded no results above the BCE LEP Metals Criteria based on this set of analysis. The incinerator ash is not classified as Special Waste under the BCE Waste Management Act.

On March 5, 1996, six samples were submitted for PAH/PCB analysis. Six duplicate samples were submitted for Dioxin/Furan analysis. The results of the analysis demonstrate the ash has above background levels of Dioxins/Furans, but significantly below the criteria for Special Waste classification. Analytical results indicate that PAH levels are also below the Special Waste criteria levels, while the PCB content is well below detection.

## CHARACTERIZATION

Based on the sampling described in this report, the incinerator bottom ash material stockpiled at 4800 Marine Avenue in Powell River is above the BCE IL/CL criteria, but is not Special Waste as defined in the B.C. Waste Management Act.

The fact that the ash material is above the IL/CL criteria indicates the need for some form of remediation prior to reusing the site.

## OPTIONS FOR REMEDIATION

Three options for the management of the incinerator ash are available to the MDPR.

1. Do nothing; leave the ash as is, where is, with a minimum of handling and management.
2. Landfill; relocate the ash material to a certified landfill site.
3. Risk assessment/risk management (RA/RM); leave the material onsite by capping under an impermeable surface, with long term monitoring of the ground water in the area.

## RECOMMENDED MANAGEMENT STRATEGY

Of the options listed above, PGL recommends RA/RM. It provides the best balance of sound environmental management and cost.

The "do nothing" option would leave some long term potential for metals to enter the ground water and poses risks to the nearby park and marine area. The second option to the transport the ash to an approved landfill site would be costly, especially considering no local options exist.

The RA/RM option would require an assessment of the hydrogeology of the site, the establishment of peizometers for long term ground water monitoring and control of rainwater (capping and water management). The present location of the ash material is very suitable for this option for the following reasons:

a. The proposed realignment of Marine Avenue (Highway 101) over the site is a use that fits the criteria classification and would aid in providing an impermeable cap and adequate surface water management; and
b. Ground water problems are not anticipated due to the well drained underlying material and the lack of observable surface water.

The RA/RM option may require some handling of the ash material to form a single, suitably located stockpile.

## CONCLUSION

PGL concludes that the incinerator ash material stockpiles at the MDPR waste disposal site at 4800 Marine Avenue contains traces of lead, zinc, copper and barium above the BCE criteria for IL/CL use.

Based on the analysis of several samples, the incinerator bottom ash is not a Special Waste.

The ash material requires proper management. PGL recommends a program of risk assessment and risk management (as outlined above) and review of this option with BCE representatives. Following that, a design for a RA/RM program will be required.

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## STANDARD LIMITATIONS

PGL prepared this report exclusively for our clients and its agents. The report's purpose is to provide the client with an overview of our investigation works completed on the subject property. This report is neither an endorsement nor a condemnation of the subject property.

The findings and conclusions are site specific and were developed in a manner consistent with that level of care and skill normally exercised by environmental professionals currently practicing under similar conditions in the area.

The investigation consisted of assessing the level of contamination of ash materials and, as is true for all environmental investigations, potential remains for the presence of unknown, unidentified, or unforeseen surface or subsurface contamination. More or different investigation may be required if other risks are identified or if other analytical data indicated the need. Conclusions and costs are time sensitive, so this report is for use now. The report should not be used after that without PGL review/approval.

The project has been conducted using the terms of reference and conditions set forth in our work program. No warranty, expressed or implied, is made.

We trust the foregoing meets your needs. If you have any questions or comments, please call David Tupper or Ned Pottinger at 895-7624 and 895-7600, respectively.

**POTTINGER GAHERTY ENVIRONMENTAL CONSULTANTS LTD.**

Per:

E J Pottinger

David W. Tupper, P.Geo.
Geologist

E.L. (Ned) Pottinger, M.Sc.
President

DWT/ELP/ihs

Attachments: Figure 1 - Site Plan with Test Pits
Appendix 1 - Trench Profiles and Sample Descriptions
Appendix 2 - Laboratory Reports

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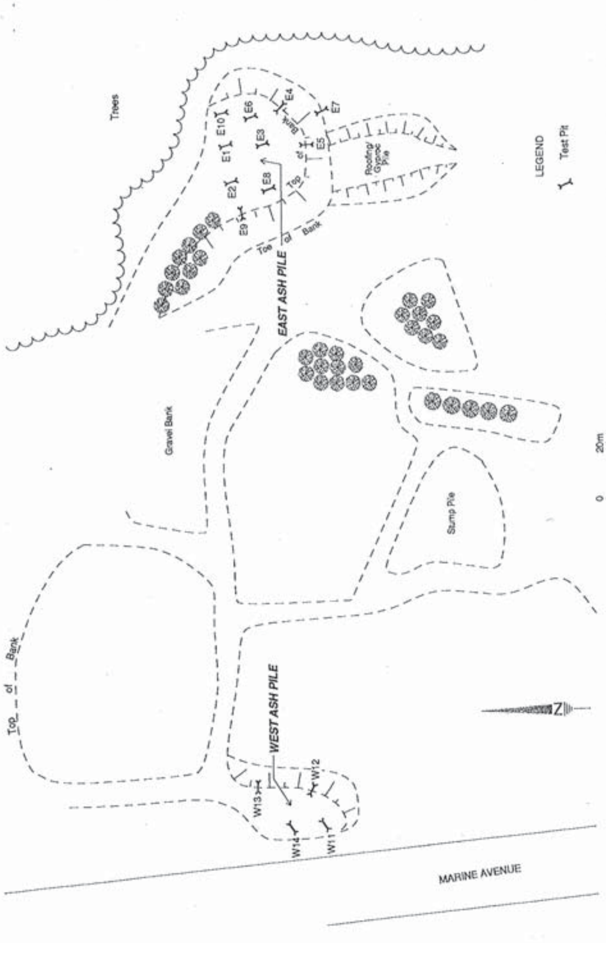

Figure: 1
Title: SITE PLAN WITH TEST PITS
Address: Municipal Waste Disposal Site, 4800 Marine Ave., Powell River, B.C.
File: 148-01.01
Date: April, 1996
For: Corporation of the District of Powell River

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## APPENDIX 1

## TRENCH PROFILES AND SAMPLE DESCRIPTIONS

## Powell River Incinerator Bottom Ash Sampling
## Trench Profiles and Sample Descriptions

| Pile | Trench No. | Total Depth (from top) (m) | Profile Interval (m) | Description | | Percent Coarse (0.03m) | Sample Interval (m) | Sample No. | Comments |
|---|---|---|---|---|---|---|---|---|---|
| East | E1 | 2.6 | 0.0-0.6 | Sand cap. | | | | | |
| | | | 0.6-1.6 | Dk. gray sandy ash | 40% | 40% | 0.6-1.6 | PGL95-148.01.01-E1S1 | |
| | | | | Mottled Gray sandy ash | 25% | | 0.4-1.2 | MAR-148-DWT-E1-S37 | |
| | | | | Rusty metal | 20% | | | | |
| | | | | Slag | 15% | | | | |
| | | | 1.6-2.6 | Dk. gray sandy ash | 70% | 20% | 1.6-2.6 | PGL95-148.01.01-E1S2 | |
| | | | | Charred wood | 10% | | | | |
| | | | | Rusty metal | 10% | | | | |
| | | | | Paper, other | 10% | | | | |
| | | | 2.6+ | Sand basement | | | | | |
| East | E2 | 5.2 | 0.0-1.0 | Gray sandy ash | 50% | 15% | 0.0-1.0 | PGL95-148.01.01-E2S6 | No basement. |
| | | | | Rusty Metal | 25% | | | | |
| | | | | Slag | 10% | | | | |
| | | | | Wood | 5% | | | | |
| | | | | Stones | 5% | | | | |
| | | | | Plastic, other | 5% | | | | |
| | | | 1.0-3.0+ | Gray-brn. gray sandy ash | 60% | 15% | 1.0-2.0 | PGL95-148.01.01-E2S4 | |
| | | | | Rusty metal | 15% | | 2.0-3.0 | PGL95-148.01.01-E2S5 | |
| | | | | Charcol | 10% | | | | |
| | | | | Wood | 10% | | | | |
| | | | | Slag | 5% | | | | |
| | | | 5.0-5.2 | Dk. gray sandy ash | 50% | 20% | Grab (5m.) | PGL95-148.01.01-E2S4 | Collected by backhoe |
| | | | | Wood | 20% | | | | |
| | | | | Rocks, bricks | 20% | | | | |
| | | | | Paper, other | 10% | | | | |

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## Powell River Incinerator Bottom Ash Sampling
## Trench Profiles and Sample Descriptions

| Pile | Trench No. | Total Depth (from top) (m) | Profile Interval (m) | Description | | Percent Coarse (0.03m) | Sample Interval (m) | Sample No. | Comments |
|---|---|---|---|---|---|---|---|---|---|
| East | E3 | 5.4 | 0.0-0.5 | Sand cap | | | | | No basement |
| | | | 0.5-1.5 | Dk. gray sandy ash | 35% | 10% | 0.5-1.5 | PGL95-148.01.01-E3S10 | Copper stain 2% |
| | | | | Rusty sandy ash, metal | 20% | | | | Moderat layering |
| | | | | wood charcol | 20% | | | | Sand/charcol horizons |
| | | | | Metal | 10% | | | | Very warm |
| | | | | Slag | 10% | | | | |
| | | | | Other | 5% | | | | |
| | | | 1.5-3.5+ | Dk. gray sandy ash | 30% | 10% | 1.5-2.5 | PGL95-148.01.01-E3S9 | Copper stain 2% |
| | | | | Rusty sandy ash, metal | 50% | | 2.5-3.5 | PGL95-148.01.01-E3S8 | Moderat layering |
| | | | | Wood, charcol | 5% | | | | Sand/charcol horizons |
| | | | | Stones | 5% | | | | Generally uniform |
| | | | | Slag | 5% | | | | Very warm |
| | | | | Other | 5% | | | | |
| | | | 5.0-5.4 | Med. brn. gray sandy ash | 70% | 10% | Grab (5m) | PGL95-148.01.01-E3S7 | Very warm |
| | | | | Rusty metal | 10% | | | | |
| | | | | Wood, charcol | 10% | | | | |
| | | | | Slag | 5% | | | | |
| | | | | Stones | 5% | | | | |
| East | E4 | 4.2 | 0.0-0.2 | Sand cap (minor hogfuel) | | | | | No basement |
| | | | 0.2-4.2 | Dk. gray sand ash | 45% | 10% | 0.2-1.2 | PGL95-148.01.01-E4S14 | On south edge of pile. |
| | | | | Rusty metal/ash | 25% | | 1.2-2.2 | PGL95-148.01.01-E4S13 | Profile 2.5 m. into bank |
| | | | | Brown sandy ash | 10% | | 2.2-3.2 | PGL95-148.01.01-E4S12 | Copper stain 2-5% |
| | | | | Slag | 10% | | 3.2-4.2 | PGL95-148.01.01-E4S11 | Warm |
| | | | | Stones | 5% | | 0.3-1.3 | MAR-148-DWT-E4-S36 | |
| | | | | Other | 5% | | | | |

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## Powell River Incinerator Bottom Ash Sampling
## Trench Profiles and Sample Descriptions

| Pile | Trench No. | Total Depth (from top) (m) | Profile Interval (m) | Description | | Percent Coarse (0.03m) | Sample Interval (m) | Sample No. | Comments |
|---|---|---|---|---|---|---|---|---|---|
| East | E5 | 3.5 | 0.0-0.5 | Sand cap | | | | | No basement |
| | | | 0.5-3.5 | Dk. gray sand ash | 45% | 10% | 1.5-2.5 | PGL95-148.01.01-E5S16 | On south edge of pile. |
| | | | | Rusty metal/ash | 25% | | 2.5-3.5 | PGL95-148.01.01-E5S15 | Profile 2.0 m. into bank |
| | | | | Mottled brown sandy ash | 10% | | 0.5-1.4 | MAR-148-DWT-E5-S35 | Copper stain 2% |
| | | | | Slag | 10% | | | | Very warm to hot. |
| | | | | Stones | 5% | | | | |
| | | | | Other | 5% | | | | |
| East | E6 | 3.1 | 0.0-0.8 | Hogfuel | | | | | No basement |
| | | | 0.8-1.0 | Sand cap | | | | | |
| | | | 1.0-3.1 | Dk. gray sand ash | 45% | 10% | 1.0-2.0 | PGL95-148.01.01-E6S18 | Copper stain 2% |
| | | | | Rusty metal/ash | 25% | | 2.0-3.0 | PGL95-148.01.01-E6S17 | Very warm to hot. |
| | | | | Brown sandy ash | 10% | | | | Slag to 0.3 m. |
| | | | | Slag | 10% | | | | |
| | | | | Stones | 5% | | | | |
| | | | | Other | 5% | | | | |
| | | | 3.1 | Large boulder | | | | | |
| East | E7 | 9.5 | 0.0-4.5 | As decribed in E4 and E5 | | | | | Site excavated |
| | | | 4.5-7.5 | Dk. gray sand ash | 45% | 10% | | | from base of pile from |
| | | | | Rusty metal/ash | 25% | | | | 4.5 to 9.5 m measured |
| | | | | Brown sandy ash | 10% | | | | form the top down. |
| | | | | Slag | 10% | | | | 2% copper stain |
| | | | | Stones | 5% | | | | Warm |
| | | | | Other | 5% | | | | |
| | | | 7.5-8.0 | Asphalt roofing | | | | | |
| | | | 8.0-8.7 | Brown ash and roofing | | | | | |
| | | | 8.7-9.0 | Gypsum | | | | | |
| | | | 9.0-9.5 | Basement | | | | | |

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## Powell River Incinerator Bottom Ash Sampling
## Trench Profiles and Sample Descriptions

| Pile | Trench No. | Total Depth (from top) (m) | Profile Interval (m) | Description | | Percent Coarse (0.03m) | Sample Interval (m) | Sample No. | Comments |
|---|---|---|---|---|---|---|---|---|---|
| East | E8 | 3.5 | 0.0-0.5 | Sand cap | | | | | No basement |
| | | | 0.5-3.5 | Dk. gray sand ash | 45% | 10% | 0.5-1.5 | PGL95-148.01.01-E8S21 | 2% copper stain |
| | | | | Rusty metal/ash | 25% | | 1.5-2.5 | PGL95-148.01.01-E8S20 | Warm |
| | | | | Brown sandy ash | 10% | | 2.5-3.5 | PGL95-148.01.01-E8S19 | 0.1m band sand @1.0 m |
| | | | | Slag | 10% | | | | |
| | | | | Stones | 5% | | | | |
| | | | | Other | 5% | | | | |
| East | E9 | 3.5 | 0.0-0.3 | Sand cap | | | | | No basement |
| | | | 0.3-3.5 | Gray black sandy ash | 70% | 10% | 1.5-2.5 | PGL95-148.01.01-E9S22 | 2% copper stain |
| | | | | Rusty ash, metal | 10% | | 0.3-1.2 | MAR-148-DWT-E9-S34 | Cool |
| | | | | Wood, charcol | 10% | | | | |
| | | | | Stones | 5% | | | | |
| | | | | Other | 10% | | | | |
| East | E10 | 3 | 0.0-0.2 | Hogfuel | | | | | No basement |
| | | | 0.2-1.0 | Layered sand cap and ash | | | | | |
| | | | 1.0-2.0 | Dark gray ash/rusty metal | 80% | 5% | 1.0-2.0 | PGL95-148.01.01-E10S24 | |
| | | | | Gray sandy ash | 10% | | | | |
| | | | | Wood, stones, other | 10% | | | | |
| | | | 2.0-3.0 | Dk. gray sand ash | 45% | 10% | 2.0-3.0 | PGL95-148.01.01-E10S23 | 2% copper stain |
| | | | | Rusty metal/ash | 25% | | | | |
| | | | | Brown sandy ash | 10% | | | | |
| | | | | Slag | 10% | | | | |
| | | | | Stones | 5% | | | | |
| | | | | Other | 5% | | | | |

## Powell River Incinerator Bottom Ash Sampling
## Trench Profiles and Sample Descriptions

| Pile | Trench No. | Total Depth (from top) (m) | Profile Interval (m) | Description | | Percent Coarse (0.03m) | Sample Interval (m) | Sample No. | Comments |
|---|---|---|---|---|---|---|---|---|---|
| West | W11 | 2.3 | 0.0-0.3<br>0.3-2.3<br><br><br><br><br>2.3 | Sand cap<br>Med gray sandy ash<br>Rusty sandy ash<br>Metal<br>Stones<br>Other<br>Basement | <br>65%<br>20%<br>5%<br>5%<br>5% | 15% | 0.3-1.3<br>1.3-2.3 | PGL95-148.01.01-W11S26<br>PGL95-148.01.01-W11S25 | 2% copper stain<br>Cool |
| West | W12 | 4.0 | 0.0-0.3<br>0.3-2.3 | Sand cap<br>Dk. gray sandy ash<br>Rusty sandy ash<br>Metal<br>Stones<br>Slag (very coarse)<br>Other | 55%<br>20%<br>5%<br>5%<br>10%<br>5% | 20% | 2.0-3.0<br>Grab (slag)<br>1.1-2.1 | PGL95-148.01.01-W12S27<br>PGL95-148.01.01-S34<br>MAR-148-DWT-W12-S38 | No basement<br>2.5 cut in east bank<br>2% copper stain<br>Cool |
| West | W13 | 3.0 | 0.0-3.0 | Dk. gray sandy ash<br>Rusty sandy ash<br>Stones<br>Slag (very coarse)<br>Other, charcol | 65%<br>10%<br>5%<br>10%<br>5% | 20% | 0.0-1.0<br>1.0-2.0<br>2.0-3.0<br>2.0-3.0 | PGL95-148.01.01-W13S30<br>PGL95-148.01.01-W13S29<br>PGL95-148.01.01-W13S28<br>MAR-148-DWT-W13-S39 | No basement<br>2.5 cut in east bank<br>2% copper stain<br>Cool |
| West | W14 | 2.8 | 0.0-0.1<br>0.1-2.8<br><br><br><br><br>2.8 | Sand cap<br>Dk. gray sandy ash<br>Rusty sandy ash<br>Stones<br>Slag (very coarse)<br>Other, charcol<br>Basement | <br>70%<br>10%<br>5%<br>5%<br>5% | 20% | 0.0-1.0<br>1.0-2.0<br>2.0-3.0 | PGL95-148.01.01-W13S33<br>PGL95-148.01.01-W13S32<br>PGL95-148.01.01-W13S31 | 2% copper stain<br>Cool |

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## APPENDIX 2
## LABORATORY REPORTS

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# Analysis Report

CANTEST

**REPORT ON:** Results of Testing

**REPORTED TO:**
Pottinger Gaherty Ltd.
Environmental Consultants
Suite 1100
1130 West Pender Street
Vancouver, B.C.
V6E 4A4

Att'n: Mr. David Tupper

**PROJECT NUMBER:** 148.00.02

**NUMBER OF SAMPLES:** 10

**REPORT DATE:** October 30, 1995

**DATE SUBMITTED:** October 3, 1995

**GROUP NUMBER:** 5100314

**SAMPLE TYPE:** Soil & Ash

**TEST METHODS:**

**Cadmium in Soil** - analysis was performed using background-corrected Flame Atomic Absorption Spectrophotometry.

**Mercury in Soil** - analysis was performed using Cold Vapour Atomic Absorption Spectrophotometry.

**Lead in Soil** - analysis was performed using background-corrected Flame Atomic Absorption Spectrophotometry.

**Metals in Soil** - Undried representative samples were digested with a mixture of nitric acid and hydrochloric acid ("Aqua Regia"). Analysis was performed using Inductively Coupled Argon Plasma Spectroscopy (ICAP) or by specific techniques as described. Moisture was determined gravimetrically at 105 C on a separate sample portion.

**Selenium in Soil** - analysis was performed using Zeeman background-corrected Graphite Furnace Atomic Absorption Spectrophotometry.

**TEST RESULTS:**

(See following pages)

CAN TEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

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# Analysis Report

CANTEST

CanTest Ltd
Professional
Analytical
Services

1523 West 3rd Ave
Vancouver, BC
V6J 1J8

Fax: 604 731 2386

Tel: 604 734 7276

1 800 665 8566

**REPORT ON:** Analysis of Soil Samples

**REPORTED TO:**
Pottinger Gaherty Ltd.
Environmental Consultants
Suite 1100
1130 West Pender Street
Vancouver, B.C.
V6E 4A4

Att'n: Mr. David Tupper

**PROJECT NUMBER:** 148.00.02

**NUMBER OF SAMPLES:** 10

**REPORT DATE:** October 30, 1995

**DATE SUBMITTED:** October 3, 1995

**GROUP NUMBER:** 5100314

**SAMPLE TYPE:** Soil & Ash

**C.M.C.S. LEVEL B SUMMARY:**

"Criteria for Managing Contaminated Sites in British Columbia (CMCS)", B.C. Environment, Draft 6, November 1989.

| CLIENT SAMPLE ID | STATUS |
|---|---|
| PGL95-148 .00.02-E 2S4 | Unacceptable |
| PGL95-148 .00.02-E 2S6 | Unacceptable |
| PGL95-148 .00.02-E 3S8 | Unacceptable |
| PGL95-148 .00.02-E 3S9 | Unacceptable |
| PGL95-148 .00.02-E 4S12 | Unacceptable |
| PGL95-148 .00.02-E 5S15 | Unacceptable |
| PGL95-148 .00.02-W 11S25 | Unacceptable |
| PGL95-148 .00.02-W 13S28 | Unacceptable |
| PGL95-148 .00.02-W 14s32 | Unacceptable |
| PGL95-148 .00.02-S 34 | Unacceptable |

**C.M.C.S. LEVEL C SUMMARY:**

"Criteria for Managing Contaminated Sites in British Columbia (CMCS)", B.C. Environment, Draft 6, November 1989.

| CLIENT SAMPLE ID | STATUS |
|---|---|
| PGL95-148 .00.02-E 2S4 | Unacceptable |
| PGL95-148 .00.02-E 2S6 | Unacceptable |
| PGL95-148 .00.02-E 3S8 | Unacceptable |
| PGL95-148 .00.02-E 3S9 | Acceptable |
| PGL95-148 .00.02-E 4S12 | Unacceptable |
| PGL95-148 .00.02-E 5S15 | Unacceptable |

(Continued)

CAN TEST LTD.

Richard

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Pottinger Gah. , Ltd.

REPORT DATE: October 30, 1995

GROUP NUMBER: 5100314

CANTEST

CMCS Level B Criteria in Soil

| CLIENT SAMPLE IDENTIFICATION: | | PGL95-148 .00.02-E 2S4 | PGL95-148 .00.02-E 2S6 | PGL95-148 .00.02-E 3S8 | PGL95-148 .00.02-E 3S9 | | |
|---|---|---|---|---|---|---|---|
| DATE SAMPLED: | | Sep 28/95 | Sep 28/95 | Sep 28/95 | Sep 28/95 | C.M.C.S. LEVEL B | UNITS |
| CAN TEST ID: | | 510030054 | 510030055 | 510030056 | 510030057 | | |
| **Metals Analysis** | | | | | | | |
| Moisture | | 13.7 | 9.86 | 15.4 | 7.33 | - | % |
| Arsenic | As | < 30 | < 30 | < 30 | < 30 | 30 | µg/g |
| Barium | Ba | 187 | 144 | 195 | 87 | 500 | µg/g |
| Cadmium | Cd | 2.5 | 1.7 | 2.1 | **6.0 X** | 5 | µg/g |
| Chromium | Cr | 69 | 44 | 45 | 22 | 250 | µg/g |
| Cobalt | Co | 7 | 6 | 6 | 3 | 50 | µg/g |
| Copper | Cu | **884 X** | **640 X** | **1080 X** | **306 X** | 100 | µg/g |
| Lead | Pb | **1700 X** | **727 X** | 245 | 135 | 500 | µg/g |
| Mercury | Hg | 0.072 | 0.022 | 0.029 | 0.057 | 2 | µg/g |
| Molybdenum | Mo | < 4 | < 4 | 7 | 5 | 10 | µg/g |
| Nickel | Ni | 45 | 58 | 59 | 19 | 100 | µg/g |
| Selenium | Se | < 3 | < 3 | < 3 | < 3 | 3 | µg/g |
| Silver | Ag | < 2 | < 2 | < 2 | < 2 | 20 | µg/g |
| Tin | Sn | **147 X** | **68 X** | **76 X** | 24 | 50 | µg/g |
| Zinc | Zn | **1670 X** | **1510 X** | **3670 X** | **1250 X** | 500 | µg/g |
| Aluminum | Al | 20900 | 15900 | 19400 | 9700 | - | µg/g |
| Antimony | Sb | < 10 | < 10 | < 10 | < 10 | - | µg/g |
| Beryllium | Be | < 1 | < 1 | < 1 | < 1 | - | µg/g |
| Boron | B | 64 | 48 | 47 | 25 | - | µg/g |
| Calcium | Ca | 26300 | 21300 | 21000 | 10000 | - | µg/g |
| Iron | Fe | 89700 | 59200 | 60000 | 24100 | - | µg/g |
| Magnesium | Mg | 2930 | 2190 | 3460 | 3440 | - | µg/g |
| Manganese | Mn | 726 | 631 | 602 | 393 | - | µg/g |
| Phosphorus | PO4 | 6870 | 5360 | 7180 | 3690 | - | µg/g |
| Sodium | Na | 2200 | 1950 | 2390 | 815 | - | µg/g |
| Strontium | Sr | 93 | 68 | 89 | 39 | - | µg/g |
| Titanium | Ti | 374 | 279 | 396 | 262 | - | µg/g |
| Vanadium | V | 26 | 19 | 27 | 20 | - | µg/g |

% = percent
< = Less than detection limit
**X** = Result is greater than C.M.C.S. LEVEL B

µg/g = micrograms per gram, on a dry weight basis.

---

REPORTED TO: Pottinger Gahı , Ltd.

REPORT DATE: October 30, 1995

GROUP NUMBER: 5100314

CANTEST

CMCS Level B Criteria in Soil

| CLIENT SAMPLE IDENTIFICATION: | | PGL95-148 .00.02-E 4S12 | PGL95-148 .00.02-E 5S15 | PGL95-148 .00.02-W 11S25 | PGL95-148 .00.02-W 13S28 | | |
|---|---|---|---|---|---|---|---|
| DATE SAMPLED: | | Sep 28/95 | Sep 28/95 | Sep 28/95 | Sep 28/95 | C.M.C.S. LEVEL B | UNITS |
| CAN TEST ID: | | 510030058 | 510030059 | 510030060 | 510030061 | | |
| **Metals Analysis** | | | | | | | |
| Moisture | | 13.2 | 9.62 | 12.4 | 18.3 | - | % |
| Arsenic | As | < 30 | < 30 | < 30 | < 30 | 30 | µg/g |
| Barium | Ba | 206 | 175 | 166 | 107 | 500 | µg/g |
| Cadmium | Cd | 1.8 | 2.9 | 2.4 | 1.5 | 5 | µg/g |
| Chromium | Cr | 44 | 35 | 43 | 33 | 250 | µg/g |
| Cobalt | Co | 6 | 6 | 5 | 5 | 50 | µg/g |
| Copper | Cu | **3630 X** | **1280 X** | **1610 X** | **295 X** | 100 | µg/g |
| Lead | Pb | 368 | 500 | 195 | **2410 X** | 500 | µg/g |
| Mercury | Hg | 0.016 | 0.040 | 0.024 | 0.084 | 2 | µg/g |
| Molybdenum | Mo | < 4 | < 4 | 5 | < 4 | 10 | µg/g |
| Nickel | Ni | 87 | 75 | 58 | 28 | 100 | µg/g |
| Selenium | Se | < 3 | < 3 | < 3 | < 3 | 3 | µg/g |
| Silver | Ag | < 2 | < 2 | < 2 | < 2 | 20 | µg/g |
| Tin | Sn | **52 X** | **58 X** | **99 X** | 28 | 50 | µg/g |
| Zinc | Zn | **1900 X** | **1700 X** | **1360 X** | **19000 X** | 500 | µg/g |
| Aluminum | Al | 26700 | 14400 | 14300 | 28700 | - | µg/g |
| Antimony | Sb | < 10 | < 10 | < 10 | < 10 | - | µg/g |
| Beryllium | Be | < 1 | < 1 | < 1 | < 1 | - | µg/g |
| Boron | B | 66 | 48 | 123 | 63 | - | µg/g |
| Calcium | Ca | 27500 | 26200 | 24600 | 20400 | - | µg/g |
| Iron | Fe | 65000 | 58400 | 63600 | 33400 | - | µg/g |
| Magnesium | Mg | 6120 | 3320 | 2880 | 4340 | - | µg/g |
| Manganese | Mn | 754 | 536 | 629 | 533 | - | µg/g |
| Phosphorus | PO4 | 4410 | 4330 | 5100 | 5000 | - | µg/g |
| Sodium | Na | 2480 | 2290 | 2490 | 1820 | - | µg/g |
| Strontium | Sr | 107 | 94 | 86 | 112 | - | µg/g |
| Titanium | Ti | 740 | 390 | 361 | 600 | - | µg/g |
| Vanadium | V | 33 | 30 | 25 | 34 | - | µg/g |

% = percent
< = Less than detection limit
**X** = Result is greater than C.M.C.S. LEVEL B

µg/g = micrograms per gram, on a dry weight basis.

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REPORTED TO: Pottinger Gah. , Ltd.

REPORT DATE: October 30, 1995

GROUP NUMBER: 5100314

CANTEST

CMCS Level C Criteria in Soil

| CLIENT SAMPLE IDENTIFICATION: | | PGL95-148 .00.02-E 2S4 | PGL95-148 .00.02-E 2S6 | PGL95-148 .00.02-E 3S8 | PGL95-148 .00.02-E 3S9 | | |
|---|---|---|---|---|---|---|---|
| DATE SAMPLED: | | Sep 28/95 | Sep 28/95 | Sep 28/95 | Sep 28/95 | C.M.C.S. LEVEL C | UNITS |
| CAN TEST ID: | | 510030054 | 510030055 | 510030056 | 510030057 | | |
| **Metals Analysis** | | | | | | | |
| Moisture | | 13.7 | 9.86 | 15.4 | 7.33 | - | % |
| Arsenic | As | < 30 | < 30 | < 30 | < 30 | 50 | µg/g |
| Barium | Ba | 187 | 144 | 195 | 87 | 2000 | µg/g |
| Cadmium | Cd | 2.5 | 1.7 | 2.1 | 6.0 | 20 | µg/g |
| Chromium | Cr | 69 | 44 | 45 | 22 | 800 | µg/g |
| Cobalt | Co | 7 | 6 | 6 | 3 | 300 | µg/g |
| Copper | Cu | **884 X** | **640 X** | **1080 X** | 306 | 500 | µg/g |
| Lead | Pb | **1700 X** | 727 | 245 | 135 | 1000 | µg/g |
| Mercury | Hg | 0.072 | 0.022 | 0.029 | 0.057 | 10 | µg/g |
| Molybdenum | Mo | < 4 | < 4 | 7 | 5 | 40 | µg/g |
| Nickel | Ni | 45 | 58 | 59 | 19 | 500 | µg/g |
| Selenium | Se | < 3 | < 3 | < 3 | < 3 | 10 | µg/g |
| Silver | Ag | < 2 | < 2 | < 2 | < 2 | 40 | µg/g |
| Tin | Sn | 147 | 68 | 76 | 24 | 300 | µg/g |
| Zinc | Zn | **1670 X** | **1510 X** | **3670 X** | 1250 | 1500 | µg/g |
| Aluminum | Al | 20900 | 15900 | 19400 | 9700 | - | µg/g |
| Antimony | Sb | < 10 | < 10 | < 10 | < 10 | - | µg/g |
| Beryllium | Be | < 1 | < 1 | < 1 | < 1 | - | µg/g |
| Boron | B | 64 | 48 | 47 | 25 | - | µg/g |
| Calcium | Ca | 26300 | 21300 | 21000 | 10000 | - | µg/g |
| Iron | Fe | 89700 | 59200 | 60000 | 24100 | - | µg/g |
| Magnesium | Mg | 2930 | 2190 | 3460 | 3440 | - | µg/g |
| Manganese | Mn | 726 | 631 | 602 | 393 | - | µg/g |
| Phosphorus | PO4 | 6870 | 5360 | 7180 | 3690 | - | µg/g |
| Sodium | Na | 2200 | 1950 | 2390 | 815 | - | µg/g |
| Strontium | Sr | 93 | 68 | 89 | 39 | - | µg/g |
| Titanium | Ti | 374 | 279 | 396 | 262 | - | µg/g |
| Vanadium | V | 26 | 19 | 27 | 20 | - | µg/g |

% = percent
< = Less than detection limit
**X** = Result is greater than C.M.C.S. LEVEL C

µg/g = micrograms per gram, on a dry weight basis.

---

REPORTED TO: Pottinger Gahı , Ltd.

REPORT DATE: October 30, 1995

GROUP NUMBER: 5100314

CANTEST

CMCS Level C Criteria in Soil

| CLIENT SAMPLE IDENTIFICATION: | | PGL95-148 .00.02-E 4S12 | PGL95-148 .00.02-E 5S15 | PGL95-148 .00.02-W 11S25 | PGL95-148 .00.02-W 13S28 | | |
|---|---|---|---|---|---|---|---|
| DATE SAMPLED: | | Sep 28/95 | Sep 28/95 | Sep 28/95 | Sep 28/95 | C.M.C.S. LEVEL C | UNITS |
| CAN TEST ID: | | 510030058 | 510030059 | 510030060 | 510030061 | | |
| **Metals Analysis** | | | | | | | |
| Moisture | | 13.2 | 9.62 | 12.4 | 18.3 | - | % |
| Arsenic | As | < 30 | < 30 | < 30 | < 30 | 50 | µg/g |
| Barium | Ba | 206 | 175 | 166 | 107 | 2000 | µg/g |
| Cadmium | Cd | 1.8 | 2.9 | 2.4 | 1.5 | 20 | µg/g |
| Chromium | Cr | 44 | 35 | 43 | 33 | 800 | µg/g |
| Cobalt | Co | 6 | 6 | 5 | 5 | 300 | µg/g |
| Copper | Cu | **3630 X** | **1280 X** | **1610 X** | 295 | 500 | µg/g |
| Lead | Pb | 368 | 500 | 195 | **2410 X** | 1000 | µg/g |
| Mercury | Hg | 0.016 | 0.040 | 0.024 | 0.084 | 10 | µg/g |
| Molybdenum | Mo | < 4 | < 4 | 5 | < 4 | 40 | µg/g |
| Nickel | Ni | 87 | 75 | 58 | 28 | 500 | µg/g |
| Selenium | Se | < 3 | < 3 | < 3 | < 3 | 10 | µg/g |
| Silver | Ag | < 2 | < 2 | < 2 | < 2 | 40 | µg/g |
| Tin | Sn | 52 | 58 | 99 | 28 | 300 | µg/g |
| Zinc | Zn | **1900 X** | **1700 X** | 1360 | **19000 X** | 1500 | µg/g |
| Aluminum | Al | 26700 | 14400 | 14300 | 28700 | - | µg/g |
| Antimony | Sb | < 10 | < 10 | < 10 | < 10 | - | µg/g |
| Beryllium | Be | < 1 | < 1 | < 1 | < 1 | - | µg/g |
| Boron | B | 66 | 48 | 123 | 63 | - | µg/g |
| Calcium | Ca | 27500 | 26200 | 24600 | 20400 | - | µg/g |
| Iron | Fe | 65000 | 58400 | 63600 | 33400 | - | µg/g |
| Magnesium | Mg | 6120 | 3320 | 2880 | 4340 | - | µg/g |
| Manganese | Mn | 754 | 536 | 629 | 533 | - | µg/g |
| Phosphorus | PO4 | 4410 | 4330 | 5100 | 5000 | - | µg/g |
| Sodium | Na | 2480 | 2290 | 2490 | 1820 | - | µg/g |
| Strontium | Sr | 107 | 94 | 86 | 112 | - | µg/g |
| Titanium | Ti | 740 | 390 | 361 | 600 | - | µg/g |
| Vanadium | V | 33 | 30 | 25 | 34 | - | µg/g |

% = percent
< = Less than detection limit
**X** = Result is greater than C.M.C.S. LEVEL C

µg/g = micrograms per gram, on a dry weight basis.

**REPORTED TO:** Pottinger Gah , Ltd.

**REPORT DATE:** October 30, 1995

**GROUP NUMBER:** 5100314

**CMCS Level C Criteria in Soil**

| CLIENT SAMPLE IDENTIFICATION: | | PGL95-148 .00.02-W 14s32 | PGL95-148 .00.02-S 34 | | |
|---|---|---|---|---|---|
| DATE SAMPLED: | | Sep 28/95 | Sep 28/95 | C.M.C.S. LEVEL C | UNITS |
| CAN TEST ID: | | 510030062 | 510030063 | | |
| **Metals Analysis** | | | | | |
| Moisture | | 24.1 | 0.82 | - | % |
| Arsenic | As | < 30 | < 30 | 50 | µg/g |
| Barium | Ba | 237 | 3400 X | 2000 | µg/g |
| Cadmium | Cd | 1.6 | < 0.25 | 20 | µg/g |
| Chromium | Cr | 35 | 122 | 800 | µg/g |
| Cobalt | Co | 6 | 7 | 300 | µg/g |
| Copper | Cu | 1100 X | 4030 X | 500 | µg/g |
| Lead | Pb | 333 | 175 | 1000 | µg/g |
| Mercury | Hg | 0.15 | 0.001 | 10 | µg/g |
| Molybdenum | Mo | 4 | 16 | 40 | µg/g |
| Nickel | Ni | 27 | 43 | 500 | µg/g |
| Selenium | Se | < 3 | < 3 | 10 | µg/g |
| Silver | Ag | < 2 | < 2 | 40 | µg/g |
| Tin | Sn | 21 | 131 | 300 | µg/g |
| Zinc | Zn | 1190 | 1600 X | 1500 | µg/g |
| Aluminum | Al | 11700 | 19300 | - | µg/g |
| Antimony | Sb | < 10 | < 10 | - | µg/g |
| Beryllium | Be | < 1 | < 1 | - | µg/g |
| Boron | B | 49 | 183 | - | µg/g |
| Calcium | Ca | 20400 | 27100 | - | µg/g |
| Iron | Fe | 32600 | 119000 | - | µg/g |
| Magnesium | Mg | 3220 | 2060 | - | µg/g |
| Manganese | Mn | 496 | 1380 | - | µg/g |
| Phosphorus | PO4 | 5760 | 5990 | - | µg/g |
| Sodium | Na | 1990 | 19500 | - | µg/g |
| Strontium | Sr | 97 | 105 | - | µg/g |
| Titanium | Ti | 400 | 392 | - | µg/g |
| Vanadium | V | 26 | 19 | - | µg/g |

% = percent
< = Less than detection limit
X = Result is greater than C.M.C.S. LEVEL C

µg/g = micrograms per gram, on a dry weight basis.

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**REPORTED TO:** Pottinger Ga y Ltd.

**REPORT DATE:** October 30, 1995

**GROUP NUMBER:** 5100314

**C.M.C.S. LEVEL C SUMMARY:** (Continued)

| CLIENT SAMPLE ID | STATUS |
|---|---|
| PGL95-148 .00.02-W 11S25 | Unacceptable |
| PGL95-148 .00.02-W 13S28 | Unacceptable |
| PGL95-148 .00.02-W 14s32 | Unacceptable |
| PGL95-148 .00.02-S 34 | Unacceptable |

**TEST METHODS:**

**Cadmium in Soil** - analysis was performed using background-corrected Flame Atomic Absorption Spectrophotometry.

**Mercury in Soil** - analysis was performed using Cold Vapour Atomic Absorption Spectrophotometry.

**Lead in Soil** - analysis was performed using background-corrected Flame Atomic Absorption Spectrophotometry.

**Metals in Soil** - Undried representative samples were digested with a mixture of nitric acid and hydrochloric acid ("Aqua Regia"). Analysis was performed using Inductively Coupled Argon Plasma Spectroscopy (ICAP) or by specific techniques as described. Moisture was determined gravimetrically at 105 C on a separate sample portion.

**Selenium in Soil** - analysis was performed using Zeeman background-corrected Graphite Furnace Atomic Absorption Spectrophotometry.

**TEST RESULTS:**

(See following pages)

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**REPORTED TO:** Pottinger Gah , Ltd.

**REPORT DATE:** January 11, 1996

**GROUP NUMBER:** 5122917

**LEP Metals in Leachate**

| CLIENT SAMPLE IDENTIFICATION: | | PGL95-148. 00.02 E2-S4 | PGL95-148. 00.02 E3-S8 | PGL95-148. 00.02 W13-S28 | PGL95-148. 00.02 S-34 | L.E.P. METALS CRITERIA | UNITS |
|---|---|---|---|---|---|---|---|
| CAN TEST ID: | | 512290064 | 512290065 | 512290066 | 512290067 | | |
| Moisture | | 13.7 | 15.4 | 18.3 | 0.82 | - | % |
| Weight of sample extracted | | 57.9 | 59.1 | 61.2 | 50.4 | - | g |
| Initial pH | | 9.03 | 8.40 | 8.78 | 10.04 | - | pH units |
| Volume 0.5 N acetic acid added | | 132 | 110 | 135 | 14.5 | - | mL |
| Final pH | | 4.94 | 4.91 | 4.91 | 4.98 | - | pH units |
| **Metals Analysis** | | | | | | | |
| Arsenic | As | < 0.75 | < 0.75 | < 0.75 | < 0.75 | 5 | mg/L |
| Barium | Ba | 0.68 | 0.49 | 0.71 | 0.16 | 100 | mg/L |
| Boron | B | 0.37 | 0.29 | 0.44 | 0.14 | 500 | mg/L |
| Cadmium | Cd | 0.06 | 0.05 | < 0.05 | < 0.05 | 0.5 | mg/L |
| Chromium | Cr | < 0.05 | < 0.05 | < 0.05 | < 0.05 | 5 | mg/L |
| Copper | Cu | 9.8 | 7.8 | 0.44 | 2.9 | 100 | mg/L |
| Lead | Pb | 1.2 | 0.8 | 0.3 | < 0.1 | 5 | mg/L |
| Mercury | Hg | < 0.005 | < 0.005 | < 0.005 | < 0.005 | 0.1 | mg/L |
| Selenium | Se | < 0.25 | < 0.25 | < 0.25 | < 0.25 | 1 | mg/L |
| Silver | Ag | < 0.5 | < 0.5 | < 0.5 | < 0.5 | 5 | mg/L |
| Zinc | Zn | 36 | 44 | 25 | 1.8 | 500 | mg/L |
| Aluminum | Al | 4.0 | 5.5 | 2.1 | 0.5 | - | mg/L |
| Antimony | Sb | < 0.3 | < 0.3 | < 0.3 | < 0.3 | - | mg/L |
| Beryllium | Be | < 0.005 | < 0.005 | < 0.005 | < 0.005 | - | mg/L |
| Bismuth | Bi | < 1 | < 1 | < 1 | < 1 | - | mg/L |
| Calcium | Ca | 832 | 590 | 707 | 53 | - | mg/L |
| Cobalt | Co | < 0.05 | < 0.05 | < 0.05 | < 0.05 | - | mg/L |
| Iron | Fe | 0.33 | 0.44 | < 0.1 | 62 | - | mg/L |
| Magnesium | Mg | 14 | 22 | 23 | 1.5 | - | mg/L |
| Manganese | Mn | 6.5 | 9.9 | 4.0 | 0.73 | - | mg/L |
| Molybdenum | Mo | < 0.1 | < 0.1 | < 0.1 | < 0.1 | - | mg/L |
| Nickel | Ni | 0.16 | 0.32 | 0.19 | 0.27 | - | mg/L |
| Phosphorus | PO4 | < 1 | < 1 | < 1 | < 1 | - | mg/L |
| Silicon | SiO2 | 36.8 | 29 | 48 | 23 | - | mg/L |
| Sodium | Na | 18.7 | 19 | 22 | 34 | - | mg/L |
| Strontium | Sr | 2.3 | 1.7 | 2.6 | 0.13 | - | mg/L |
| Tin | Sn | < 0.1 | < 0.1 | < 0.1 | < 0.1 | - | mg/L |
| Titanium | Ti | < 0.01 | < 0.01 | < 0.01 | < 0.01 | - | mg/L |
| Vanadium | V | < 0.05 | < 0.05 | < 0.05 | < 0.05 | - | mg/L |

% = percent
mL = milliliters
< = Less than detection limit

g = grams
mg/L = milligrams per liter

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# A ysis Report

CanTest Ltd

Professional
Analytical
Services

1523 West 3rd Ave
Vancouver, BC
V6J 1J8

Fax: 604 731 2386

Tel: 604 734 7276

1 800 665 8566

**REPORT ON:** Analysis of Soil

**REPORTED TO:** Pottinger Gaherty Ltd.
Environmental Consultants
Suite 1100
1130 West Pender Street
Vancouver, B.C.
V6E 4A4

Att'n: Project Manager

**PROJECT NUMBER:** 148.01.01

**NUMBER OF SAMPLES:** 6

**REPORT DATE:** March 11, 1996

**DATE SUBMITTED:** March 5, 1996

**GROUP NUMBER:** 6030511

**SAMPLE TYPE:** Soil

**TEST METHODS:**

**Polynuclear Aromatic Hydrocarbons** - were determined with methodology based upon U.S. EPA Methods 625/8270, involving extraction, clean-up steps, and analysis using GC/MS.

**Polychlorinated Biphenyls** - were determined with methodology based upon U.S. EPA Methods 608/8080, involving extraction, clean-up steps, and analysis using GC/ECD. Aroclors 1242, 1248, 1254 and 1260 were included.

**TEST RESULTS:**

(See following pages)

CAN TEST LTD.

Matthew Hartley, M.Sc.
Supervisor, Trace Organics

**REPORTED TO:** Pottinger Gahe , Ltd.

CANTEST

**REPORT DATE:** March 11, 1996

**GROUP NUMBER:** 6030511

### Polycyclic Aromatic Hydrocarbons in Soil

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-D WT-E9-S34 | MAR4-148-D WT-E5-S35 | MAR4-148-D WT-E4-S36 | MAR4-148-D WT-E1-S37 | |
|---|---|---|---|---|---|
| DATE SAMPLED: | Mar 4/96 | Mar 4/96 | Mar 4/96 | Mar 4/96 | |
| CAN TEST ID: | 603050071 | 603050078 | 603050079 | 603050080 | DETECTION LIMIT |
| ANALYSIS DATE: | Mar 10/96 | Mar 10/96 | Mar 10/96 | Mar 10/96 | |
| **Low Molecular Weight PAH's** | | | | | |
| Naphthalene | 0.09 | 0.07 | 0.07 | 0.26 | 0.05 |
| Acenaphthylene | < | < | < | < | 0.05 |
| Acenaphthene | < | < | < | < | 0.05 |
| Fluorene | < | < | < | 0.07 | 0.05 |
| Phenanthrene | 0.19 | 0.06 | 0.11 | 0.40 | 0.05 |
| Anthracene | < | < | < | 0.08 | 0.05 |
| Total LMW-PAH's | 0.28 | 0.13 | 0.18 | 0.81 | 0.05 |
| **High Molecular Weight PAH's** | | | | | |
| Fluoranthene | 0.12 | < | 0.06 | 0.22 | 0.05 |
| Pyrene | 0.12 | < | 0.07 | 0.37 | 0.05 |
| Benzo(a)anthracene | < | < | < | 0.07 | 0.05 |
| Chrysene | 0.06 | < | < | 0.11 | 0.05 |
| Benzo(b)fluoranthene | 0.06 | < | < | < | 0.05 |
| Benzo(k)fluoranthene | < | < | < | < | 0.05 |
| Benzo(a)pyrene | < | < | < | < | 0.05 |
| Indeno(1,2,3-c,d)pyrene | < | < | < | < | 0.05 |
| Dibenz(a,h)anthracene | < | < | < | < | 0.05 |
| Benzo(g,h,i)perylene | < | < | < | < | 0.05 |
| Total HMW-PAH's | 0.37 | < | 0.13 | 0.77 | 0.05 |
| Total PAH's | 0.65 | 0.13 | 0.31 | 1.58 | 0.05 |

Results expressed as micrograms per gram, on a dry weight basis. (µg/g)
< = Less than detection limit
NOTE: Benzo(b)fluoranthene and Benzo(k)fluoranthene reported as total.

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**REPORTED TO:** Pottinger Gahe , Ltd.

CANTEST

**REPORT DATE:** March 11, 1996

**GROUP NUMBER:** 6030511

### Polycyclic Aromatic Hydrocarbons in Soil

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-D WT-W12-S38 | MAR4-148-D WT-W13-S39 | |
|---|---|---|---|
| DATE SAMPLED: | Mar 4/96 | Mar 4/96 | |
| CAN TEST ID: | 603050081 | 603050082 | DETECTION LIMIT |
| ANALYSIS DATE: | Mar 10/96 | Mar 10/96 | |
| **Low Molecular Weight PAH's** | | | |
| Naphthalene | < | 0.13 | 0.05 |
| Acenaphthylene | < | < | 0.05 |
| Acenaphthene | < | < | 0.05 |
| Fluorene | < | < | 0.05 |
| Phenanthrene | 0.08 | 0.16 | 0.05 |
| Anthracene | < | < | 0.05 |
| Total LMW-PAH's | 0.08 | 0.30 | 0.05 |
| **High Molecular Weight PAH's** | | | |
| Fluoranthene | 0.06 | 0.05 | 0.05 |
| Pyrene | 0.06 | 0.06 | 0.05 |
| Benzo(a)anthracene | < | < | 0.05 |
| Chrysene | < | < | 0.05 |
| Benzo(b)fluoranthene | < | < | 0.05 |
| Benzo(k)fluoranthene | < | < | 0.05 |
| Benzo(a)pyrene | < | < | 0.05 |
| Indeno(1,2,3-c,d)pyrene | < | < | 0.05 |
| Dibenz(a,h)anthracene | < | < | 0.05 |
| Benzo(g,h,i)perylene | < | < | 0.05 |
| Total HMW-PAH's | 0.12 | 0.11 | 0.05 |
| Total PAH's | 0.20 | 0.41 | 0.05 |

Results expressed as micrograms per gram, on a dry weight basis. (µg/g)
< = Less than detection limit

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**REPORTED TO:** Pottinger Gahe , Ltd.

CANTEST

**REPORT DATE:** March 11, 1996

**GROUP NUMBER:** 6030511

### Polychlorinated Biphenyls in Soil

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-D WT-E9-S34 | MAR4-148-D WT-E5-S35 | MAR4-148-D WT-E4-S36 | MAR4-148-D WT-E1-S37 | |
|---|---|---|---|---|---|
| DATE SAMPLED: | Mar 4/96 | Mar 4/96 | Mar 4/96 | Mar 4/96 | DETECTION LIMIT |
| CAN TEST ID: | 603050071 | 603050078 | 603050079 | 603050080 | |
| Arochlor 1242 | < | < | < | < | 0.03 |
| Arochlor 1248 | < | < | < | < | 0.03 |
| Arochlor 1254 | < | < | < | < | 0.03 |
| Arochlor 1260 | < | < | < | < | 0.03 |

Results expressed as micrograms per gram, on a dry weight basis. (µg/g)
< = Less than detection limit

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**REPORTED TO:** Pottinger Gahe. , Ltd.

CANTEST

**REPORT DATE:** March 11, 1996

**GROUP NUMBER:** 6030511

### Polychlorinated Biphenyls in Soil

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-D WT-W12-S38 | MAR4-148-D WT-W13-S39 | |
|---|---|---|---|
| DATE SAMPLED: | Mar 4/96 | Mar 4/96 | DETECTION LIMIT |
| CAN TEST ID: | 603050081 | 603050082 | |
| Arochlor 1242 | < | < | 0.03 |
| Arochlor 1248 | < | < | 0.03 |
| Arochlor 1254 | < | < | 0.03 |
| Arochlor 1260 | < | < | 0.03 |

Results expressed as micrograms per gram, on a dry weight basis. (µg/g)
< = Less than detection limit

DLUT

# Analysis Report

CANTEST

CanTest Ltd

Professional
Analytical
Services

1523 West 3rd Ave
Vancouver, BC
V6J 1J8

Fax: 604 731 2386

Tel: 604 734 7276

1 800 665 8566

**REPORT ON:** Results of Analysis

**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited
Suite 1100 - 1130 W. Pender St.
Vancouver, B.C.
V6E 4A4

Attention: Dave Tupper

**PROJECT NUMBER:** 148.01.01

**NUMBER OF SAMPLES:** 6

**REPORT DATE:** March 28, 1996

**DATE SUBMITTED:** March 5, 1996

**FILE NUMBER:** 5800 K

**SAMPLE TYPE:** Soil

**SAMPLE IDENTIFICATION:**

The samples were submitted as shown under the "Results of Testing".

**METHODS OF TESTING:**

**Polychlorinated Dibenzodioxins and Dibenzofurans** - were determined with methodology based upon U.S. EPA Methods 8290 involving extraction, clean-up steps, and analysis using High Resolution GC/MS.

Analyses for polychlorinated dibenzodioxins and dibenzofurans were not performed by CANTEST LTD. but sublet to another laboratory on the client's behalf.

**RESULTS OF TESTING:**

See the following pages.

CANTEST LTD.

M. Hartley

Matthew Hartley, M.Sc.
Supervisor, Organic Testing

MH/wm
D:\ORGANICS\REPORTS\PGL5800.DOC

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CANTEST

**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited

**REPORT DATE:** March 28, 1996

**FILE NUMBER:** 5800 K

### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-DWT-E9-S34 | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| CANTEST ID: | 5800K-1 | | | |
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | 0.9308 | 0.1076 | 170 | 90 |
| 1,2,3,7,8-PENTA CDD | 4.1528 | 0.0934 | 110 | 94 |
| 1,2,3,4,7,8-HEXA CDD | 4.6408 | 0.0645 | 80 | 71 |
| 1,2,3,6,7,8-HEXA CDD | 23.9890 | 0.0857 | 120 | 93 |
| 1,2,3,7,8,9-HEXA CDD | 19.9812 | 0.0746 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | 122.0471 | 0.3398 | 110 | 76 |
| OCTA CDD | 274.2914 | 12.1472 | 170 | 58 |
| TOTAL TETRA CDD | 80.9391 | 0.1076 | | |
| TOTAL PENTA CDD | 98.6285 | 0.0934 | | |
| TOTAL HEXA CDD | 244.4573 | 0.0741 | | |
| TOTAL HEPTA CDD | 239.2122 | 0.3398 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | 46.2841 | 0.0963 | 120 | 109 |
| 1,2,3,7,8-PENTA CDF | 8.3816 | 0.1030 | 110 | 103 |
| 2,3,4,7,8-PENTA CDF | 14.3438 | 0.0850 | 100 | 100 |
| 1,2,3,4,7,8-HEXA CDF | 50.1053 | 0.0654 | 100 | 88 |
| 1,2,3,6,7,8-HEXA CDF | 17.2957 | 0.1436 | 110 | 73 |
| 2,3,4,6,7,8-HEXA CDF | 21.3252 | 0.1638 | 100 | 71 |
| 1,2,3,7,8,9-HEXA CDF | 3.5673 | 0.1147 | 90 | 75 |
| 1,2,3,4,6,7,8-HEPTA CDF | 75.8402 | 0.1655 | 120 | 102 |
| 1,2,3,4,7,8,9-HEPTA CDF | 5.8591 | 0.2441 | 100 | 76 |
| OCTA CDF | 123.6609 | 5.1113 | | |
| TOTAL TETRA CDF | 134.0644 | 0.0963 | | |
| TOTAL PENTA CDF | 232.3972 | 0.0932 | | |
| TOTAL HEXA CDF | 174.1153 | 0.1195 | | |
| TOTAL HEPTA CDF | 136.9550 | 0.1982 | | |
| TOTAL TOXIC EQUIVALENCY | | 31.752 | | |

Results reported as ng/Kg (nanograms per kilogram)

CDD * = Chloro dibenzo-p-dioxin
CDF ** = Chloro dibenzofuran.
MDL = Method Detection Limit
ND = Not Detected
pg = Picograms
% = Percent

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CANTEST

**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited

**REPORT DATE:** March 28, 1996

**FILE NUMBER:** 5800 K

### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-DWT-E5-S35 | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| CANTEST ID: | 5800K-2 | | | |
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | 0.9202 | 0.0933 | 170 | 123 |
| 1,2,3,7,8-PENTA CDD | 3.7360 | 0.0810 | 110 | 115 |
| 1,2,3,4,7,8-HEXA CDD | 2.9941 | 0.0559 | 80 | 96 |
| 1,2,3,6,7,8-HEXA CDD | 9.0798 | 0.0743 | 120 | 90 |
| 1,2,3,7,8,9-HEXA CDD | 10.2199 | 0.0647 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | 45.3675 | 0.2946 | 110 | 74 |
| OCTA CDD | 64.3675 | 10.5329 | 170 | 54 |
| TOTAL TETRA CDD | 126.7488 | 0.0933 | | |
| TOTAL PENTA CDD | 122.0087 | 0.0810 | | |
| TOTAL HEXA CDD | 157.6396 | 0.0643 | | |
| TOTAL HEPTA CDD | 101.4102 | 0.2946 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | 47.0526 | 0.0835 | 120 | 148 |
| 1,2,3,7,8-PENTA CDF | 7.5905 | 0.0893 | 110 | 136 |
| 2,3,4,7,8-PENTA CDF | 13.0350 | 0.0737 | 100 | 131 |
| 1,2,3,4,7,8-HEXA CDF | 37.9611 | 0.0567 | 100 | 101 |
| 1,2,3,6,7,8-HEXA CDF | 14.7237 | 0.1245 | 110 | 79 |
| 2,3,4,6,7,8-HEXA CDF | 17.7542 | 0.1420 | 100 | 83 |
| 1,2,3,7,8,9-HEXA CDF | 1.2540 | 0.0994 | 90 | 80 |
| 1,2,3,4,6,7,8-HEPTA CDF | 71.7395 | 0.1435 | 120 | 83 |
| 1,2,3,4,7,8,9-HEPTA CDF | 5.0804 | 0.2117 | 100 | 74 |
| OCTA CDF | 40.0114 | 4.4320 | | |
| TOTAL TETRA CDF | 276.7798 | 0.0835 | | |
| TOTAL PENTA CDF | 191.6612 | 0.0808 | | |
| TOTAL HEXA CDF | 145.6728 | 0.1037 | | |
| TOTAL HEPTA CDF | 112.6178 | 0.1719 | | |
| TOTAL TOXIC EQUIVALENCY | | 25.115 | | |

Results reported as ng/Kg (nanograms per kilogram)

CDD * = Chloro dibenzo-p-dioxin
CDF ** = Chloro dibenzofuran
MDL = Method Detection Limit
ND = Not Detected
pg = Picograms
% = Percent

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CANTEST

**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited

**REPORT DATE:** March 28, 1996

**FILE NUMBER:** 5800 K

### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-DWT-E4-S36 | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| CANTEST ID: | 5800K-3 | | | |
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | 0.7822 | 0.0878 | 170 | 67 |
| 1,2,3,7,8-PENTA CDD | 2.0340 | 0.0754 | 110 | 69 |
| 1,2,3,4,7,8-HEXA CDD | 1.9501 | 0.0473 | 80 | 78 |
| 1,2,3,6,7,8-HEXA CDD | 6.0228 | 0.0838 | 120 | 80 |
| 1,2,3,7,8,9-HEXA CDD | 8.5867 | 0.0620 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | 38.0735 | 0.3000 | 110 | 72 |
| OCTA CDD | 71.0158 | 11.4414 | 170 | 51 |
| TOTAL TETRA CDD | 42.3685 | 0.0878 | | |
| TOTAL PENTA CDD | 52.9683 | 0.0754 | | |
| TOTAL HEXA CDD | 82.1942 | 0.0616 | | |
| TOTAL HEPTA CDD | 74.4916 | 0.3000 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | 26.0443 | 0.0752 | 120 | 85 |
| 1,2,3,7,8-PENTA CDF | 4.5874 | 0.0811 | 110 | 83 |
| 2,3,4,7,8-PENTA CDF | 7.1846 | 0.0672 | 100 | 79 |
| 1,2,3,4,7,8-HEXA CDF | 21.7650 | 0.0554 | 100 | 84 |
| 1,2,3,6,7,8-HEXA CDF | 7.5749 | 0.1116 | 110 | 80 |
| 2,3,4,6,7,8-HEXA CDF | 9.7314 | 0.1250 | 100 | 77 |
| 1,2,3,7,8,9-HEXA CDF | 0.8247 | 0.0907 | 90 | 74 |
| 1,2,3,4,6,7,8-HEPTA CDF | 36.9132 | 0.1403 | 120 | 76 |
| 1,2,3,4,7,8,9-HEPTA CDF | 2.3608 | 0.2069 | 100 | 78 |
| OCTA CDF | 16.8087 | 4.8144 | | |
| TOTAL TETRA CDF | 136.4224 | 0.0752 | | |
| TOTAL PENTA CDF | 110.8511 | 0.0736 | | |
| TOTAL HEXA CDF | 85.1404 | 0.0952 | | |
| TOTAL HEPTA CDF | 54.7368 | 0.1680 | | |
| TOTAL TOXIC EQUIVALENCY | | 14.732 | | |

Results reported as ng/Kg (nanograms per kilogram)

CDD * = Chloro dibenzo-p-dioxin
CDF ** = Chloro dibenzofuran
MDL = Method Detection Limit
ND = Not Detected
pg = Picograms
% = Percent

**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited

**REPORT DATE:** March 28, 1996

**FILE NUMBER:** 5800 K

### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-DWT-E1-S37 | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| CANTEST ID: | 5800K-4 | | | |
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | 0.7284 | 0.0953 | 170 | 97 |
| 1,2,3,7,8-PENTA CDD | 4.1040 | 0.0818 | 110 | 84 |
| 1,2,3,4,7,8-HEXA CDD | 2.2878 | 0.0513 | 80 | 107 |
| 1,2,3,6,7,8-HEXA CDD | 12.2641 | 0.0910 | 120 | 100 |
| 1,2,3,7,8,9-HEXA CDD | 13.4641 | 0.0673 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | 104.2251 | 0.3257 | 110 | 68 |
| OCTA CDD | 336.3817 | 12.4202 | 170 | 36 |
| TOTAL TETRA CDD | 52.0283 | 0.0953 | | |
| TOTAL PENTA CDD | 75.5996 | 0.0818 | | |
| TOTAL HEXA CDD | 156.1452 | 0.0669 | | |
| TOTAL HEPTA CDD | 246.8489 | 0.3257 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | 28.6632 | 0.0817 | 120 | 124 |
| 1,2,3,7,8-PENTA CDF | 4.8692 | 0.0880 | 110 | 107 |
| 2,3,4,7,8-PENTA CDF | 6.9099 | 0.0730 | 100 | 106 |
| 1,2,3,4,7,8-HEXA CDF | 21.5925 | 0.0601 | 100 | 103 |
| 1,2,3,6,7,8-HEXA CDF | 7.3394 | 0.1211 | 110 | 93 |
| 2,3,4,6,7,8-HEXA CDF | 9.8306 | 0.1357 | 100 | 83 |
| 1,2,3,7,8,9-HEXA CDF | 0.9848 | 0.0985 | 90 | 77 |
| 1,2,3,4,6,7,8-HEPTA CDF | 42.9480 | 0.1523 | 120 | 75 |
| 1,2,3,4,7,8,9-HEPTA CDF | 3.5945 | 0.2247 | 100 | 62 |
| OCTA CDF | 27.2199 | 5.2282 | | |
| TOTAL TETRA CDF | 140.7103 | 0.0817 | | |
| TOTAL PENTA CDF | 115.9249 | 0.0799 | | |
| TOTAL HEXA CDF | 84.0877 | 0.1033 | | |
| TOTAL HEPTA CDF | 69.4020 | 0.1824 | | |
| TOTAL TOXIC EQUIVALENCY | | 17.993 | | |

Results reported as ng/Kg (nanograms per kilogram)

CDD * = Chloro dibenzo-p-dioxin
CDF ** = Chloro dibenzofuran
MDL = Method Detection Limit
ND = Not Detected
pg = Picograms
% = Percent

---

**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited

**REPORT DATE:** March 28, 1996

**FILE NUMBER:** 5800 K

### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-DWT-W12-S38 | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| CANTEST ID: | 5800K-5 | | | |
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | 1.2488 | 0.0920 | 170 | 90 |
| 1,2,3,7,8-PENTA CDD | 3.2972 | 0.0809 | 110 | 79 |
| 1,2,3,4,7,8-HEXA CDD | 2.9775 | 0.0483 | 80 | 87 |
| 1,2,3,6,7,8-HEXA CDD | 10.2356 | 0.0087 | 120 | 102 |
| 1,2,3,7,8,9-HEXA CDD | 11.2774 | 0.0140 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | 64.5831 | 0.3679 | 110 | 67 |
| OCTA CDD | 242.8014 | 11.6904 | 170 | 41 |
| TOTAL TETRA CDD | 79.2866 | 0.0920 | | |
| TOTAL PENTA CDD | 80.9317 | 0.0809 | | |
| TOTAL HEXA CDD | 146.2203 | 0.0139 | | |
| TOTAL HEPTA CDD | 138.9762 | 0.3679 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | 31.9333 | 0.0787 | 120 | 112 |
| 1,2,3,7,8-PENTA CDF | 5.8590 | 0.0892 | 110 | 102 |
| 2,3,4,7,8-PENTA CDF | 9.4561 | 0.0687 | 100 | 94 |
| 1,2,3,4,7,8-HEXA CDF | 26.5485 | 0.0623 | 100 | 116 |
| 1,2,3,6,7,8-HEXA CDF | 10.7146 | 0.1036 | 110 | 89 |
| 2,3,4,6,7,8-HEXA CDF | 11.7323 | 0.1330 | 100 | 89 |
| 1,2,3,7,8,9-HEXA CDF | 12.7027 | 0.1030 | 90 | 82 |
| 1,2,3,4,6,7,8-HEPTA CDF | 59.1491 | 0.1433 | 120 | 76 |
| 1,2,3,4,7,8,9-HEPTA CDF | 3.5242 | 0.1952 | 100 | 62 |
| OCTA CDF | 56.7591 | 4.9191 | | |
| TOTAL TETRA CDF | 152.0633 | 0.0787 | | |
| TOTAL PENTA CDF | 146.6356 | 0.0777 | | |
| TOTAL HEXA CDF | 105.8698 | 0.0998 | | |
| TOTAL HEPTA CDF | 88.9793 | 0.1659 | | |
| TOTAL TOXIC EQUIVALENCY | | 21.303 | | |

Results reported as ng/Kg (nanograms per kilogram)

CDD * = Chloro dibenzo-p-dioxin
CDF ** = Chloro dibenzofuran
MDL = Method Detection Limit
ND = Not Detected
pg = Picograms
% = Percent

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**REPORTED TO:** Pottinger Gaherty Environmental Consultants Limited

**REPORT DATE:** March 28, 1996

**FILE NUMBER:** 5800 K

### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CLIENT SAMPLE IDENTIFICATION: | MAR4-148-DWT-W13-S39 | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| CANTEST ID: | 5800K-6 | | | |
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | 0.4355 | 0.1465 | 170 | 76 |
| 1,2,3,7,8-PENTA CDD | 1.1346 | 0.1470 | 110 | 76 |
| 1,2,3,4,7,8-HEXA CDD | 1.0607 | 0.1005 | 80 | 75 |
| 1,2,3,6,7,8-HEXA CDD | 5.3430 | 0.1484 | 120 | 91 |
| 1,2,3,7,8,9-HEXA CDD | 4.5667 | 0.1220 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | 23.6493 | 0.6131 | 110 | 65 |
| OCTA CDD | 45.8625 | 23.3809 | 170 | 43 |
| TOTAL TETRA CDD | 21.0049 | 0.1465 | | |
| TOTAL PENTA CDD | 24.7556 | 0.1470 | | |
| TOTAL HEXA CDD | 52.8851 | 0.1213 | | |
| TOTAL HEPTA CDD | 45.5468 | 0.6131 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | 16.0395 | 0.1369 | 120 | 89 |
| 1,2,3,7,8-PENTA CDF | 3.5923 | 0.1289 | 110 | 88 |
| 2,3,4,7,8-PENTA CDF | 4.5393 | 0.1145 | 100 | 87 |
| 1,2,3,4,7,8-HEXA CDF | 9.7085 | 0.1074 | 100 | 87 |
| 1,2,3,6,7,8-HEXA CDF | 3.2567 | 0.1900 | 110 | 91 |
| 2,3,4,6,7,8-HEXA CDF | 3.2245 | 0.2365 | 100 | 78 |
| 1,2,3,7,8,9-HEXA CDF | 1.3904 | 0.1738 | 90 | 69 |
| 1,2,3,4,6,7,8-HEPTA CDF | 15.7655 | 0.2389 | 120 | 75 |
| 1,2,3,4,7,8,9-HEPTA CDF | 1.4802 | 0.5075 | 100 | 65 |
| OCTA CDF | 8.7977 | 9.8382 | | |
| TOTAL TETRA CDF | 66.6579 | 0.1369 | | |
| TOTAL PENTA CDF | 65.3280 | 0.1213 | | |
| TOTAL HEXA CDF | 37.6036 | 0.1761 | | |
| TOTAL HEPTA CDF | 28.0420 | 0.3281 | | |
| TOTAL TOXIC EQUIVALENCY | | 8.375 | | |

Results reported as ng/Kg (nanograms per kilogram)

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### Analysis Report
### Concentration of Polychlorinated Dibenzodioxins and Dibenzofurans

| CANTEST ID: | METHOD BLANK | | % REC OF C13 SURROGATES | |
|---|---|---|---|---|
| | Concentration | MDL | pg Spiked | % Recovery |
| DIOXINS | | | | |
| 2, 3, 7, 8-TETRA CDD * | ND | 0.0347 | 170 | 99 |
| 1,2,3,7,8-PENTA CDD | ND | 0.0330 | 110 | 100 |
| 1,2,3,4,7,8-HEXA CDD | ND | 0.0210 | 80 | 92 |
| 1,2,3,6,7,8-HEXA CDD | ND | 0.0315 | 120 | 92 |
| 1,2,3,7,8,9-HEXA CDD | ND | 0.0257 | | |
| 1,2,3,4,6,7,8-HEPTA CDD | ND | 0.1127 | 110 | 91 |
| OCTA CDD | ND | 3.0216 | 170 | 86 |
| TOTAL TETRA CDD | ND | 0.0347 | | |
| TOTAL PENTA CDD | ND | 0.0330 | | |
| TOTAL HEXA CDD | ND | 0.0255 | | |
| TOTAL HEPTA CDD | ND | 0.1127 | | |
| FURANS | | | | |
| 2,3,7,8-TETRA CDF ** | ND | 0.0349 | 120 | 139 |
| 1,2,3,7,8-PENTA CDF | ND | 0.0368 | 110 | 118 |
| 2,3,4,7,8-PENTA CDF | ND | 0.0287 | 100 | 128 |
| 1,2,3,4,7,8-HEXA CDF | ND | 0.0238 | 100 | 95 |
| 1,2,3,6,7,8-HEXA CDF | ND | 0.0524 | 110 | 87 |
| 2,3,4,6,7,8-HEXA CDF | ND | 0.0533 | 100 | 86 |
| 1,2,3,7,8,9-HEXA CDF | ND | 0.0319 | 90 | 90 |
| 1,2,3,4,6,7,8-HEPTA CDF | ND | 0.0527 | 120 | 92 |
| 1,2,3,4,7,8,9-HEPTA CDF | ND | 0.0777 | 100 | 97 |
| OCTA CDF | ND | 1.2714 | | |
| TOTAL TETRA CDF | ND | 0.0349 | | |
| TOTAL PENTA CDF | ND | 0.0323 | | |
| TOTAL HEXA CDF | ND | 0.0403 | | |
| TOTAL HEPTA CDF | ND | 0.0631 | | |
| TOTAL TOXIC EQUIVALENCY | | 0.1016 | | |

Results reported as ng/Kg (nanograms per kilogram)

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CDF ** = Chloro dibenzofuran
MDL = Method Detection Limit
ND = Not Detected
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% = Percent