Dawson Creek Landfill Closure Plan and Assessment

Peace River Regional District

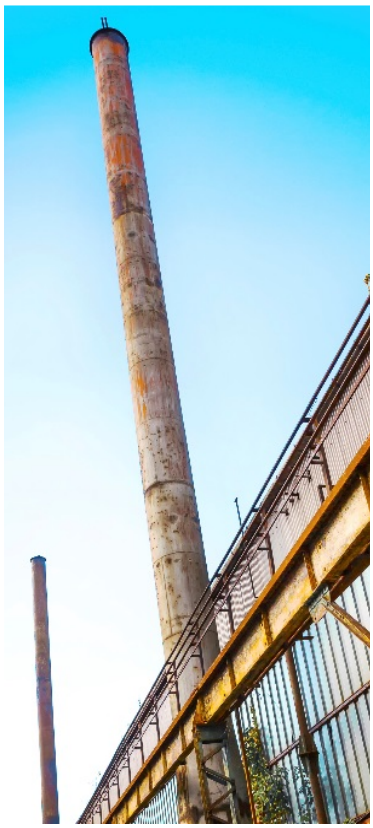


Table of Contents

Figure Index (following text)

Table Index

Table Index (following text)

Appendix Index

1. Introduction

GHD was retained by the Peace River Regional District (PRRD) to prepare a Landfill Closure Plan and Assessment for the Dawson Creek closed landfill located at 829 Highway 49, Dawson Creek, British Columbia (BC). The landfill is authorized under Permit 2212 dated January 8, 2020 (Appendix A) issued by the Ministry of Environment and Climate Change (ENV). The Site location is shown on Figure 1, and the Site plan is shown on Figure 2.

The solid waste operations that form the Site today include the closed landfill footprint (landfill), and a transfer station, as shown on Figure 2. For the purposes of this report, the landfill closure assessment and plan have been completed on the landfill only.

GHD has completed the Landfill Closure Plan following the requirements outlined under Section 4.5 of the Permit and Section 10.3.4 of the Landfill Criteria for Municipal Solid Waste (BC ENV, June 2016). Table 1 provides a summary of the Permit Section 4.5 requirements.

2. Site History

The Dawson Creek closed landfill opened in 1974 (SLR consultning (Canada), 2018) and Permit 2212 (permit) was first issued on October 7, 1974. The permit authorized the discharge of municipal solid waste to the landfill, animal refuse to a carcass pit, and the operation of controlled open burning for wood waste. The landfill was constructed over a historical meander of Dawson Creek, which is approximately 20 metres (m) thick and infilled with fluvial sand and gravel. Waste was placed from the pre-existing north bank of Dawson Creek near Highway 49, to the south towards the existing creek.

In 1998, AGRA Earth and Environmental (AGRA) reported that leachate seeps were observed at the Site and a leachate management plan was developed. Additionally, slope instability concerns for the Site have been documented since the late 1990s. Geotechnical instrumentation was installed to measure slope stability in circa 1997. The geotechnical instrumentation has been read annually or biennially since it was installed.

From at least 2019, the PRRD completed voluntary post-closure groundwater monitoring and reporting to the ENV.

The landfill stopped receiving waste between 2000 and 2002. After closure, the Site continued to operate as a transfer station and waste was redirected to the Bessborough Landfill. Additionally, the Site received clean fill material up until January 1, 2020. Historically, the clean fill was placed at the crest of the landfill and pushed down slope by the contractors using the Site.

The permit was amended on January 8, 2020, to reflect the current state of the closed landfill and add two new clauses including annual reporting and a landfill closure plan. Groundwater and surface water monitoring is expected to continue.

Aerial photographs of the Site were requested from Environmental Risk Information Services (ERIS) and the University of British Columbia (UBC) Geographic Information Centre to determine additional information regarding historical landfill operations. The aerial photographs are provided in

Appendix B. Ten aerial photographs were available, which illustrate the Site conditions in 1964, 1966, 1970, 1977, 1981, 1984, 1987, 1990, 1996, and 2007. In the photographs from 1964 to 1970, the Site was undeveloped. In 1977 and 1981, evidence of road development and excavation/soil disturbance (i.e., landfill footprint) at the Site was apparent in the northern half of the Site. From 1984 and 1987, the landfill footprint increased slightly, and excavation and stockpiling can be observed. In 1990, the landfill footprint had expanded to the south, towards the existing creek. In 1996, the landfill footprint occupied the majority of the Site. In 2007, vegetation covered approximately 40 percent (%) of the previously disturbed area indicating that the landfill was in the post-closure phase.

3. Site Physical Setting

3.1 Climate

The climate near Dawson Creek is characterized by mild, wet summers and cold, dry winters. According to the data collected at the Dawson Creek A weather station (Climate ID 1182285), which is located approximately 1 kilometre (km) south of the Site and is in the same biogeoclimatic zone (Boreal White and Black Spruce) as the landfill, the area receives on average 453.2 millimetres (mm) of precipitation per year (307.2 mm is rainfall and 172.2 cm is snowfall). Precipitation is highly seasonal with 62 percent of total annual precipitation occurring from May to September. The daily average temperature is 1.9 degrees Celsius (°C) and ranges from -13.2 °C in January to 15.5 °C in July. The 1981 to 2010 Canadian Climate Normals data recorded at the Dawson Creek A climate station is presented on Figure 3.

3.2 Topography and Drainage

Topography and drainage features are shown on Figure 4. The Site slopes to the south from an elevation of approximately 650 metres above mean sea level (m AMSL) in the northern portion of Site to approximately 630 m AMSL in the southern portion of the Site. Regional topography near the Site slopes towards Dawson Creek.

Precipitation falling onto the landfill either infiltrates into the subsurface and recharges the vegetative cover or flows as overland runoff. Runoff either flows down the landfill side slopes in a west-southwest direction toward Dawson Creek or is captured by the runoff collection ditches constructed around the perimeter of the landfill. The collection ditches discharge clean stormwater into a retention pond located in the southeast corner of the Site.

Dawson Creek is present along the southern boundary of the Site. A recent flood assessment study estimated that the creek can rise by over 4 m from the base flow elevation during a 1:200-year return period storm event.

3.3 Geology

Based on the results of previous drilling investigations, overburden geology underlying the Site can be described as glaciolacustrine deposits of laminated to massive clay and glacial till. Overburden deposits were interpreted to be associated with a former glacial lake. Sand and gravel were encountered as part of the cut off meander of Dawson Creek. Bedrock was encountered in the

northwest area of Site at a depth of approximately 29.5 metres below ground surface (mbgs). Bedrock is of the Kaskapau Formation of the Smokey Group and is Upper Cretaceous in age. The Kaskapau Formation is characterized by fine clastic sedimentary rock, including mudstones, siltstones, and shale. Borehole logs from previous investigations are presented in Appendix C.

3.4 Hydrogeology

Two regional aquifers underlie the Site as identified by iMapBC. Aquifer 851 is a confined overburden aquifer comprised of glacial sand and gravel deposits. This aquifer has moderate productivity and low vulnerability and is overlain by a confining layer of low porosity clay. Precipitation and infiltration from surface water bodies are estimated to be the primary source of recharge for the aquifer. Aquifer 593 is a bedrock aquifer comprised primarily of shale with some sandstone of the Kaskapau Formation. The aquifer has moderate vulnerability and productivity, and precipitation is estimated to be its primary source of recharge.

Five monitoring wells (MW) are installed within the overburden aquifer on the Site. Well DC-95-1 was destroyed within the last few years due to flooding of Dawson Creek. This well was recommended to be replaced by Matrix during the 2019 annual report titled *2019 Groundwater and Surface Water Monitoring Sampling Program* (Matrix Solutions Inc., February 2020). Wells DC-98-5 and DC-BH101 are located upgradient to the north of the landfill and well DC-95-2 is located cross-gradient to the east. Wells DC-98-1 and DC-98-3 are located downgradient to the southeast and southwest, respectively. Well DC-98-1 was installed within sand and gravel of the old creek meander of Dawson Creek. Other wells were installed within the glaciolacustrine clay and till deposits. Waste was placed on top of clay and clay till (AECOM, 2012).

Hydraulic conductivity testing has been completed on Site. Generally, the hydraulic conductivity in the clay till was found to be approximately 4.59×10^{-7} cm/s (SLR, 2016). The sand and gravel in the old creek meander of Dawson Creek was found to have a hydraulic conductivity at approximately 1×10^{-1} cm/s. The old creek meander of Dawson Creek provides a preferential pathway for leachate migration directly to Dawson Creek.

Based on the 2019 well data provided in previous annual reports, the depth of shallow groundwater ranges from approximately 10 to 14 mbgs (at wells DC-98-5 and DC-BH101 to the north) and 1 to 2 mbgs (at well DC-95-1 near Dawson Creek). Elevations of shallow groundwater ranges from approximately 643 mAMSL to the north, to approximately 630 mAMSL to the south. Groundwater elevations to the south are similar to elevations in Dawson Creek. Local groundwater flows to the south, following local topography and towards Dawson Creek.

A horizontal groundwater flow velocity of 0.06 metres per year (m/yr) was calculated for the clay till based on a horizontal gradient of 0.03 m/m (May 2019 water levels at DC-BH101 [642.28 mAMSL] and DC-98-3 [632.34 mAMSL]), an average hydraulic conductivity of 1×10^{-7} cm/s and an estimated porosity of 0.5 percent. Groundwater monitoring wells and flow direction is presented on Figure 5.

It is expected that the groundwater flow velocity would be significantly higher within the sand and gravel of the old creek meander for Dawson Creek. The groundwater flow velocity could not be accurately estimated within the old creek meander because well borehole logs and installation data are not available. However, the hydraulic conductivity of the gravel within the old creek meander was was estimated to be approximately 1×10^{-1} cm/s. It can be assumed that the groundwater velocity

would be multiple orders of magnitude faster in the creek meander compared to the glaciolacustrine clay and till.

SLR reported that the landfill contributes less than 0.1% to stream flow in Dawson Creek and accounts for 0.08% to 0.54% mass loading to the stream (SLR, 2018).

3.5 Surrounding Land Use

The lands surrounding the Site to the north and east are designated as agricultural land reserves (ALR) used for farming. The municipal boundary for the City of Dawson Creek is to the south and west of the Site. A number of commercial properties are located within in the municipal boundary to the east, and sewage treatment lagoons are located to the south. Agricultural land reserve and land zoned I-2 for General Industrial Use, is located to the east of the Site. Land to the North is zoned P-2 for civic, assembly, and institutional use.

There are two residences within 500 m of the Site, one approximately 65 m north (up-gradient), and the other approximately 150 northwest (up-gradient).There are no well sites within a 500 m radius of the Site. The nearest groundwater well is approximately 770 m to the west (cross-gradient).

The nearest aquatic receiving environment is Dawson Creek, which is located adjacent south of the Site. A number of unnamed streams and tributaries to Dawson Creek are also located within a 1 km radius of the Site.

4. Closed Landfill Design

4.1 Final Cover

Final cover was placed on the landfill between 2000 and 2002. It was reported in an Earth Tech letter (Mareese Keane, 2003) from 2003 that the final cover would be sourced locally from a large building construction. The final cover was intended to include a drainage layer below the clay to avoid leachate breakouts.

On May 28, 2020, GHD completed a walkthrough of the Site with the PRRD and confirmed that the current final cover includes:

- Topsoil with sufficient thickness and quality to support vegetation except where recent soil was deposited at the top of slope. Where present, vegetative cover is well established and is dominated by grass (Poacea ssp.), and dandelion (Taraxacum officinale).
- Possible geosynthetic layer overlying waste with the exception of the southeast side slope where exposed waste is present.
- Common fill layer with sufficient thickness to support surface water runoff.
- Erosion prevention controls include vegetative cover and 3:1 landfill side slopes.
- Visual evidence of differential settlement was observed including a large crack at the toe of slope along the west side of the landfill and sloughing on the south landfill side slope.

Photos taken during the Site walkthrough are presented in Appendix D.

4.2 Vector Controls

The landfill is not expected to attract vectors or wildlife due to the placement of final cover across the majority of the landfill. There have been no recorded occurrence or indication vectors or wildlife on Site (e.g., burrows, digging marks, etc.) including along the southeast side slope where exposed waste was observed. If vector and wildlife become problematic, measures will be taken to ensure the protection of the wildlife and the environment.

4.3 Estimate of Waste Landfilled

Based on local census data and the British Columbia average municipal solid waste disposal rates for the PRRD, GHD estimated an average waste disposal of 9,636 tonnes/year over an assumed 26 to 28-year lifespan, and a final total landfilled waste of approximately 250,538 to 269,799 tonnes.The estimate of waste landfilled was calculated using the following equation:

Waste Landfilled = (Disposal Rate x Population) / 1000

Where:

Waste Landfilled (tonnes): the amount of waste discharged to the landfill in tonnes per year.

Disposal Rate (kg/person): Annual municipal solid waste disposed per person for the PRRD from 1990 to 2018, published by the ENV. Per-person disposal rate is an estimate of how many kilograms of solid waste each BC resident sends to a landfill or other disposal site in a given year. The PRRD disposal rates between 1992 and 1996 were not published within the ENV dataset. To account for the data gaps, the 1991 disposal rate was used for 1992, 1993, 1994, and 1995 rates.

Population (): The number of people residing within Dawson Creek from 1974 to 2006, as published by Statistic Canada. Populations between census years were inferred based on population growth rates.

4.4 Lifespan Analysis

The landfill was closed between 2000 and 2002. The 25-year post-closure period ends in 2027.

4.5 Proposed End Use

Currently the proposed end use for the Site is undeveloped land in support of transfer station operations.

5. Existing Conditions

On May 28, 2020, GHD completed a walkthrough of the Site with the PRRD to assess the existing condition of the landfill. The following observations

- Slope inclinometers are present on Site.
- Loose soil mounds were found at the landfill plateau.

- Uncompacted cover soil with no vegetation was found at the top of the west side slope of the landfill.
- Ponded surface water was found at the southwest toe of the landfill.
- Visual evidence of differential settlement was observed including a large crack at the toe of slope along the west side of the landfill and sloughing on the south landfill side slope.
- Scattered litter such as scrap metal and concrete were observed at the west side of the landfill.
- Exposed waste was observed at the southeast side slope of the landfill.
- Exposed geosynthetics near pond on southwest slope.

6. Leachate Generation and Migration Potential

The following section presents a qualitative review of potential leachate derived impacts to the environmental receptors in the vicinity of the Site. The leachate generation potential and the attenuation capacity of the Site are assessed to identify contaminant transport pathways and determine the potential for off-Site migration.

6.1 Leachate Generation

The leachate generation rate for the Site can be estimated using the Water Balance Method (WBM) published in the textbook titled *Solid Waste Landfill Engineering and Design* (McBean et al., 1995) and adopted by the United States Environmental Protection Agency (EPA, 2005). This method is based on the principle of conservation of mass by determining the major segments of precipitation that detract from percolation (e.g. interception by vegetation). Following the WBM, a Site-specific leachate generation rate or potential can be estimated using the equation and inputs provided below.

Simplified WBM equation:

Infiltration = Precipitation – Surface Runoff – Soil Moisture Storage – Evapotranspiration

Site-specific inputs:

- Average monthly temperatures
- Site latitude
- Average monthly precipitation in inches of water
- Landfill surface conditions
- Soil and vegetation type for final cover

The WBM results are summarized in Figure 6. As shown on Figure 6, approximately 12.7 millimetres (mm) or 3 percent of the annual precipitation was estimated to percolate through the landfill cover to generate leachate. Leachate generation at the Site is estimated to be approximately 1016 cubic metres (m^3) per year based on a waste footprint area of 80,000 m^2 (8 hectares) and the estimated annual leachate generation rate of 0.0127 m (12.7 mm). The Site has a low leachate generation potential relative to other closed landfills in BC.

6.2 Leachate Migration and Attenuation

The migration of contaminants from waste to groundwater will occur through three stages:

- Leachate generation resulting from the release of contaminants from refuse into infiltrating water
- Leachate contaminant transport through the underlying soil or unsaturated zone
- Leachate contaminant transport through the underlying aquifer or saturated zone

During leachate migration, attenuation occurs as contaminants move through soil and groundwater and are subject to physical, chemical, and biological processes that result in reduction of contaminant concentrations.

In the unsaturated zone, filtration, oxidation/reduction, precipitation, adsorption and biological degradation processes occur in the unsaturated zone. These processes reduce contaminant levels before reaching the groundwater table. Based on the 2019 environmental monitoring program results (Matrix), the average unsaturated zone across the Site is approximately 1 to 14 m in thickness. The unsaturated zone underlying the Site can be characterized as thin indicating that processes to reduce contaminant levels before reaching the groundwater table is assumed low.

Once leachate has migrated below the water table, leachate contaminants will predominantly migrate by advection, dispersion and diffusion. Leachate constituents are primarily reduced by diffusion and dispersion, however the other attenuation mechanisms listed above can still occur although to a much lesser extent.

6.2.1 Attenuation Mechanisms

The following section briefly describe the attenuation mechanisms specific to the Site within the subsurface that would affect the rate and transport of leachate contaminants.

Advection

Advection is the movement of solutes due to motion of flowing groundwater. Based on the very low groundwater velocity of 0.06 m/yr (see Section 3.4) within the glaciolacustrine clay and till, leachate solutes have migrated approximately 1.5 m over the landfill's 26-year lifespan. The groundwater flow rate can increase or decrease by dispersion, diffusion or adsorption of contaminants to soil.

Note that there is an old creek meander from Dawson Creek that runs under the landfill. The hydraulic conductivity of the creek meander was estimated to be approximately $1x10^{-4}$ m/s, compared to a hydraulic conductivity of approximately $1x10^{-7}$ m/s in the glaciolacustrine clay and till. The groundwater velocity in the creek meander cannot be estimated but it is assumed to be significantly faster than within the clay and till. The creek meander provides a preferential pathway for leachate migration to Dawson Creek.

Sorption and Ion Exchange

Adsorption represents a collection of processes that remove contaminants in or onto solid soil surfaces. Cation exchange capacity (CEC) is a measurement of the soil's ability to hold cations (positive ions) by electrical attraction to clay particles and organic matter, which have negatively

charged surfaces. The CEC of the soil is dependent on the amount of clay and organic matter, as well as the type of clay particles present in the soil matrix.

The CEC for soil in Dawson Creek varies across the Site due to the variation in soil type. Based on the available information on geological characterization (refer to Section 3.3), the surficial soils are primarily of glaciolacustrine clay and till, with sand and gravel within the old creek meander. Typical CEC values, at a pH of 7, are 40 to 80 meq/100 g for 2:1 clays (montmorillonite minerals) and 5 to 20 meq/100 g for 1:1 clays (kaolinite minerals) (McBean et al., 1995).

For the purpose of this report, it is assumed that the CEC is moderate between 20 to 40 meq/100 g due to the type and presence of clay underlying the Site.

Hydrodynamic Dispersion and Diffusion

Hydrodynamic dispersion and diffusion are the processes where leachate contaminants spread out from the expected horizontal flow path and results in the dilution of the leachate solutes. Dispersion is the process of mechanical mixing with uncontaminated water and diffusion is the process of chemical mixing across concentration gradients. As a result of the low groundwater velocity calculated for the Site, the effects of dispersion and diffusion are negligible indicating that the leachate plume is relatively narrow and will not exceed the width of the landfill. Dispersion within the old creek meander is expected to be limited to the channelized sands and gravel.

Biodegradation

Aerobic and anaerobic degradation processes occur as biodegradable organic materials pass through the soil and is typically the dominate attenuation process. Since the landfill has been closed for at least 18 years, leachate strength and the availability of nutrients is poor due to the continuous degradation of landfilled waste.

6.2.2 Summary

Based on the above, the potential for leachate migration and natural attenuation is high within the sands and gravel of the old creek meander, which provides a preferential pathway for leachate transport to Dawson Creek. Limited information is available on the creek meander. The degree of leachate transport to Dawson Creek is monitored through surface water sampling (described in Section 6.3).

The potential for leachate migration within the clay and till over the remainder of the Site would be low largely due to the amount and considerable thickness of silts and clays underlying the landfill. This geologic setting provides a low rate of leachate/groundwater movement.

6.3 Groundwater and Surface Water Quality

The groundwater and surface water quality on Site is monitored three times per year in spring, summer, and fall by Matric Solutions Inc. (Matrix). Based on the 2019 monitoring report, landfill derived impacts are present in groundwater and surface water. Groundwater is currently monitored at five monitoring wells on-Site (Figure 5). Surface water is monitored at four locations within Dawson Creek to the south of the landfill.

Within the last five years (2015 to 2019), groundwater has exceeded the applicable standards at least once for ammonia, nitrate, phenols, chloride, sulphide, sulphate, boron, magnesium, manganese, sodium, arsenic, iron, uranium, cadmium, cobalt, lithium, nickel, strontium, and thallium. Benzene was also detected at well DC-98-1. Landfill-related impacts to groundwater are observed. Generally, well BH-98-1 shows the highest concentrations and most frequent exceedances of applicable standards. Well BH-98-1 is screened within the sand and gravel of the old creek meander, which provides evidence that leachate is migrating within this channel. Well BH-98-1 was recently destroyed by a flood in Dawson Creek, and it was recommended that PRRD replaces this well. In the latest 2019 annual monitoring report by Matrix, it was recommended the current groundwater monitoring program continue.

Surface water concentrations have also been reported above the BC Working and Approved Water Quality Guidelines (WQG) within the last five years. Parameters with elevated concentrations include dissolved oxygen (DO), electrical conductivity (EC), chloride, sulphide, sulphate, nitrate, ammonia, alkalinity, phosphorus, pH, sulphide, total dissolved solids (TDS), beryllium, cadmium, chromium, iron, manganese, aluminum, arsenic, cadmium, vanadium, fecal coliforms, and E. Coli. Landfill-related impacts to surface water are observed. Matrix recommended that the current surface water monitoring program continue.

7. Landfill Gas Generation Potential

Landfill gas generation was estimated for the landfill using the Scholl Canyon Model to quantify the peak methane generated annually. The model is recommended by the ENV to evaluate landfill gas generation and emission rates for the purpose of assessing potential landfill gas impacts (BC Ministry of Environment, 2009).

Use of the model requires two major Site-specific inputs to calculate theoretical methane generation rates:

1. The methane generation potential, Lo, which represents the total potential yield of methane from a mass of waste (m^3 of methane per tonne of waste). The Lo value is dependent on the composition of waste, and in particular, the fraction of organic matter present.

   For the purposes of this report, it is assumed that one third of waste is relatively inert, a third is moderately decomposable, and a third is decomposable.

2. The methane generation rate, k, which represents the first-order biodegradation rate at which methane is generated following waste placement. This constant is influenced by moisture content, the availability of nutrients, pH, and temperature. For determining the value of k, average annual precipitation data should be used.

   The area near Dawson Creek receives on average 453.2 mm of precipitation per year (see Section 3.1), which equates to the following k values: 0.01 for relatively inert waste, 0.02 for moderately decomposable waste, and 0.05 for decomposable waste.

Based on the assumptions above, the model estimates the rate of landfill gas generation in 2020 to be 188.0 tonnes of methane per year. Supporting calculations are presented in Appendix E.

8. Human Health and Environment Risk Evaluation

The evaluation presented below evaluates whether the closed landfill poses acceptable or unacceptable risks to human health and the environment. Per Protocol 13, Screening Level Risk Assessment (SLRA), if a contaminated site is deemed to have no unacceptable risks (i.e., pass the SLRA), then the site is considered to satisfy the risk-based matrix standards of the BC Contaminated Site Regulation, BC Reg. 375/96 (CSR). Using Protocol 13 as a guide, and the known physical, engineered and leachate characteristics of the Site, GHD provided rationale as to whether the existing conditions of the closed landfill poses no unacceptable risks.

Table 8.1 lists each of the potential exposure pathways, as defined by both Protocol 13 and the CSR Section 3.1 matrix standards site-specific factors. Both human and environmental protection exposure scenarios were evaluated.

Table 8.1 Risk Evaluation for the Dawson Creek Closed Landfill

Pathway	Receptor	Risk Evaluation
Human Exposure Scenarios		
Exposure to Contaminated Soils or Waste– Intake of contaminated soil or waste (i.e., ingestion, dermal, dust inhalation, vapour inhalation)	Human – Public, Trespasser, Site Worker	The exposure pathway for human exposure to waste possible due to: • The presence of exposed waste on the southeast landfill side slope Once the waste has been covered, exposure will be eliminated by: • Final cover eliminates the exposure pathway for ground surface to be uncovered and waste to be exposed at surface. Final cover provides a barrier to prevent contact with waste. • The Site is private property with a gate securing the Site entrance. **Based on the above, the human health exposure pathway by ingestion is complete for the public, trespasser or public worker. Therefore, an unacceptable risk to human health exist.**
Exposure to Contaminated Groundwater – Groundwater used for drinking water	Human	The exposure pathways for groundwater used for drinking water becoming contaminated by leachate exists based on the following: • Dawson Creek is located to the south of the Site and may be used for drinking water. • The groundwater velocity underlying the Site is estimated at 0.06 m/yr in the glaciolacustrine clay and till. Groundwater velocity is estimated to be significantly faster in the old creek meander, which acts as a preferential pathway for leachate migration to Dawson Creek.

Pathway	Receptor	Risk Evaluation
		• Groundwater flow also exists within the old creek meander for Dawson Creek, which has a hydraulic conductivity of approximately $1x10^{-4}$ m/s indicating that this aquifer is a potential future drinking water source. • Groundwater impacts are observed on Site and surface water impacts are observed in Dawson Creek. • Groundwater and surface water concentration have recently exceeded BC CSR drinking water (DW), aquatic life (AW), livestock (LW), irrigation (IW), and/or wildlife (WW) standards **Based on the above, the human health (drinking water) exposure pathway is complete. Therefore, an unacceptable risk to human health exists.**
Exposure to Landfill Gas – Inhalation and/or Explosive Atmosphere	Human – Public, Trespasser, Site Worker	The exposure pathways for landfill gas migration may not be eliminated based on the following: • Significant potential landfill gas generation due to a total waste landfilled in exceedance of 100,000 tonnes. • The rate of landfill gas production is estimated to be 188.0 tonnes of methane per year in 2020. • Structures with concrete foundations are located north of the Site. Although, no preferential pathways leading from the landfill footprint to the off-Site structures (i.e. no utility trenches) have been identified, higher permeable soils may be present between the landfill and the neighboring property. **Based on the above, the human health and safety exposure pathway for landfill gas is potentially complete. A landfill gas perimeter probe monitoring program should be initiated to assess whether landfill gas is migrating in the soils adjacent to the Site.**
Environmental Exposure Scenarios		
Terrestrial Exposure to Contaminated Soil – Toxicity to Soil invertebrates and plants	Terrestrial	The exposure pathway for terrestrial exposure to contaminated soil and waste is possible due to: • The presence of exposed waste on the southwest side slope. Once the waste has been covered, exposure will be limited due to:

Pathway	Receptor	Risk Evaluation
		• The placement of final cover eliminates any contact between the waste and ground surface. • There have been no occurrences or indication of vectors or wildlife on-Site (e.g. burrows, digging marks). • Annual final cover monitoring will be completed by the PRRD during the post-closure period (see Section 11) to ensure the integrity of the final cover is maintained. **Based on the above, the terrestrial exposure pathway is present. Therefore, an unacceptable ecological risk exists until the litter and stockpile has been removed.**
	Invertebrates and plants	The exposure pathway for invertebrates and plants is possible due to: • Exposed waste on the southwest side slope. Once the exposed waste has been covered, the exposure pathway will be eliminated by: • Placement of final cover eliminates any contact between waste and ground surface and provides a barrier for the potential for invertebrates to come into contact with waste or waste beneath the geosynthetic where placed.. • Planting of specific non-deep rooting plants within the topsoil providing soil stability and limiting the potential for plants to break through the geosynthetic layer. • Annual final cover monitoring and erosion and settlement monitoring will be completed by the PRRD during the post-closure period (see Section 11) to ensure the integrity of the final cover is maintained. **Based on the above, the invertebrates and plants exposure pathway is complete. Therefore, an unacceptable ecological risk exists.**
Exposure of livestock to contaminated soil and groundwater – Livestock ingesting soil and fodder, and groundwater used for livestock watering.	Livestock	Livestock exposure is limited by the placement of final cover eliminating any contact between waste and ground surface and providing a barrier for the potential for livestock to come into contact with waste or waste beneath the geosynthetics where placed. An exposure pathway for livestock exists based on: • The groundwater quality and surface water quality within Dawson Creek shows landfill-related impacts.

Pathway	Receptor	Risk Evaluation
		• Surface water concentrations have recently exceeded BC CSR livestock (LW), irrigation (IW), and wildlife (WW) standards **Based on the above, the livestock exposure pathway to groundwater used for livestock watering is complete. Therefore, an unacceptable environmental risk exists.**
Exposure of aquatic biota to contaminated groundwater – Groundwater flow to surface water used by aquatic life	Aquatic Biota	Aquatic biota exposure exists from the following: • Dawson Creek is located in close proximity to the landfill to the south of the Site. • An old sand/gravel creek meander for Dawson Creek exists below the landfill, which acts as a preferential pathway for leachate migration to Dawson Creek. • Surface water quality within Dawson Creek shows landfill-related impacts with observation from multiple parameters exceeded BC CSR drinking water (DW), aquatic life (AW), livestock (LW), irrigation (IW), and/or wildlife (WW) standards. • Groundwater quality on Site shows landfill related impacts. • It is recommended that the current groundwater and surface water monitoring program continue. **Based on the above, the aquatic biota (surface water) exposure pathway is complete. Therefore, an unacceptable ecological risk exists.**

Based on the information presented in Table 8.1, all of the human and ecological exposure pathways exist. Therefore, the landfill poses unacceptable risk to human and environmental health in its current state. The Site can be classified as high risk.

9. Conclusions

Based on the Site physical setting, landfill closure design, and human and environmental risk evaluation, the following conclusions are made:

Site Setting

- Dawson Creek is located adjacent and south of the landfill.
- The Site is underlain primarily by glaciolacustrine clay and till. These soils act as a confining layer to overburden Aquifer 851, which is located beneath the Site. In addition, due to the physical characteristics of the soil, these surficial clays do not support a single-family domestic water supply well, and there are no drinking water wells located within a 500 m radius of the Site.

- An old creek meander for Dawson Creek exists below the landfill, consisting of sand and gravel. These soils act as a preferential pathway for leachate from the landfill to Dawson Creek.
- The groundwater flow rate is low at 0.06 m/yr in the glaciolacustrine clay and till. Groundwater flows in a southerly direction.

Landfill Closure

- The landfill was closed between 2000 and 2002. The Site currently operates as a transfer station.
- The 2020 Permit amendment was initiated by the ENV to update the format, make necessary adjustments to reflect the current state of the closed landfill, and add two new clauses including annual reporting and a landfill closure plan.

  Based on the existing conditions of the Site, the landfill cover appears to be discontinuous likely from differential settlement of the landfilled waste as indicated by the observed cracking and sloughing of soil.
- As presented in Table 1, Landfill Closure Plan Status, this report satisfies Permit Condition 4.5.

Risk Evaluation

- Leachate generation at the Site is estimated to be approximately 1,016 m^3 per year. This is a medium leachate generation rate relative to other closed landfills in BC.
- The potential for leachate migration is high within the sands and gravel of the old creek meander, which provides a preferential pathway for leachate transport to Dawson Creek. The potential for leachate migration vertically within the clay and till over the remainder of the Site is low largely due to the amount and considerable thickness of silts and clays underlying the landfill.
- Groundwater and surface water quality shows landfill-related impacts, with multiple parameters concentrations reported above the applicable CSR standards.
- The rate of landfill gas production is estimated to be 188.0 tonnes of methane per year in 2020, which is high relative to the other closed landfills in the PRRD. The potential for landfill gas migration in the soils around the landfill footprint exists and a soil gas monitoring program should be developed in order to evaluate the potential for soil gas migration.
- Based on the information presented in Table 8.1, all of the human and environmental exposure pathways exist. The Site can be classified as high risk.

10. Recommendations

Based on the conclusions in Section 9, the following recommendations are made:

- Remove the scattered litter and cover exposed waste on the landfill.
- Develop a cover rehabilitation program to ensure a continuous presence of final cover over the waste and a minimum grade of 5 percent. The final cover rehabilitation program should include

an assessment of whether the final cover requires armouring below the 1:200-year return period elevation of Dawson Creek.

- Complete a focused risk assessment on the impact of leachate migration from the landfill, through the creek meander to Dawson Creek.
- Establish a soil gas monitoring program at the north property boundary.
- Replace well BH-98-1 as recommended by Matrix.
- Continue to perform the current groundwater and surface water monitoring program, as recommended by Matrix.

11. Monitoring Plan and Design

As outlined in Table 11.1, the monitoring plan for the remaining post-closure period of 7 years includes erosion and settlement, groundwater, surface water, and landfill gas monitoring, and the development of a design concept and detailed design for final cover rehabilitation.

Table 11.1 2020–2027 Monitoring Plan

Component	Frequency	Description
Final cover	Ongoing	Development of a design concept and detailed design for final cover rehabilitation.
Erosion and settlement	Annually	Complete Site inspection for visual evidence of erosion, settlement, slope movement, and occurrence of leachate seeps with the potential for failure of the final cover. Visual observations may include tensions cracks, slumps, preferential settlement, vegetation stress, cover soil erosion, etc.
Groundwater/leachate	Triannually	Continue the current groundwater monitoring program as recommended in the 2019 Annual Operations and Monitoring Report.
Surface water	Triannually	Continue the current surface water sampling program as recommended in the 2019 Annual Operations and Monitoring Report.
Landfill gas	Triannually	Install and monitor two to three soil gas probes on the northern property line for the presence of methane.

12. References

BC Ministry of Environment. (2009). *Landfill Gas Generation Assessment Procedures Guidelines.* BC Ministry of Environment.

Edward A. McBean, F. A. (1995). *Solid Waste Landfill Engineering and Design.* Prentice Hall PTR.

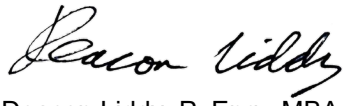
Environmental Protection Agency (EPA). (2005, August). Retrieved from Example Moisture Mass Balance Calculations for Bioreactor Landfills: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9101V4IJ.TXT

iMapBC. (2018, August). Retrieved from Government of British Columbia: https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc
Mareese Keane, P. (2003). *Landfill Surface Water Monitoring Program, Attention Mr. Larry Gardner, Environmental Protection Officer.*
Matrix Solutions Inc. (February 2020). *2019 Groundwater and Surface Water Monitoring and Sampling Program, Peace River Regional District Landfill Sites.*
Provincial Agricultural Land Commission (ALC). (2014). Retrieved from ALR & Maps: https://www.alc.gov.bc.ca/alc/content/alr-maps
SLR consultning (Canada). (2018). *2017 Groundwater and Surface Water Monitoring and Sampling Program, Peace River Regional District Landfill Sites.*
UMA Engineering Ltd. and EBA Engineering Consultants Ltd. (1997). *Landfill Closure Plan Ten Rural Sites.* Edmonton.

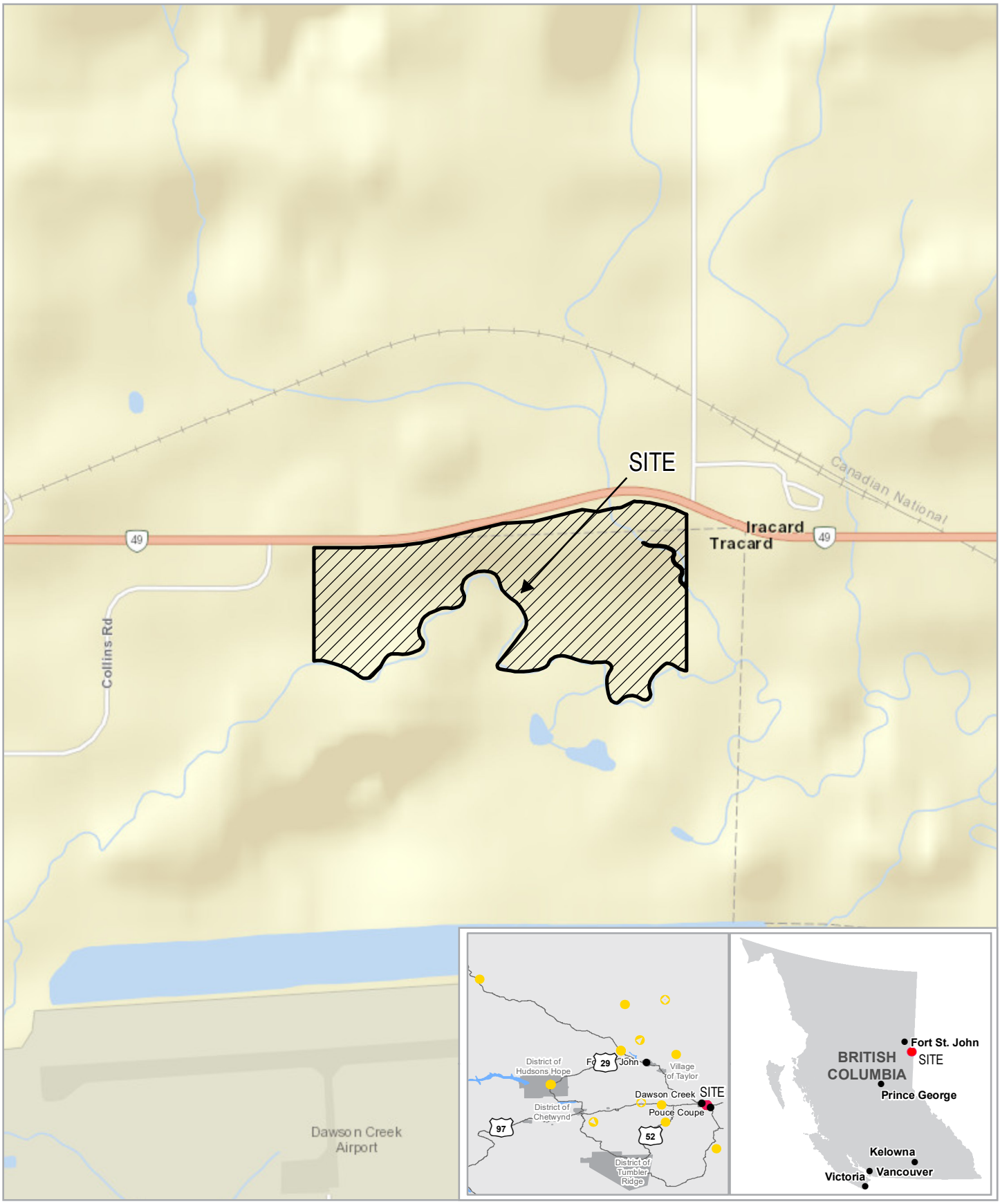
All of Which is Respectfully Submitted,

GHD

Rose Marie Rocca, P. Geo



Deacon Liddy, P. Eng., MBA



Paper Size ANSI A

0 130 260 390 520

Meters

Map Projection: Mercator Auxiliary Sphere
Horizontal Datum: WGS 1984
Grid: WGS 1984 Web Mercator Auxiliary Sphere

N

GHD

DAWSON CREEK LANDFILL CLOSURE REPORT
DAWSON CREEK, BC
PEACE RIVER REGIONAL DISTRICT
DAWSON CREEK LANDFILL CLOSURE REPORT

Project No. **11213132**
Revision No. **-**
Date **Aug 21, 2020**

SITE LOCATION MAP

FIGURE 1

Q:\GIS\PROJECTS\11213000s\11213132\Layouts\202008_RPT000\11213132_202008_RPT000_GIS001.mxd, Report 13

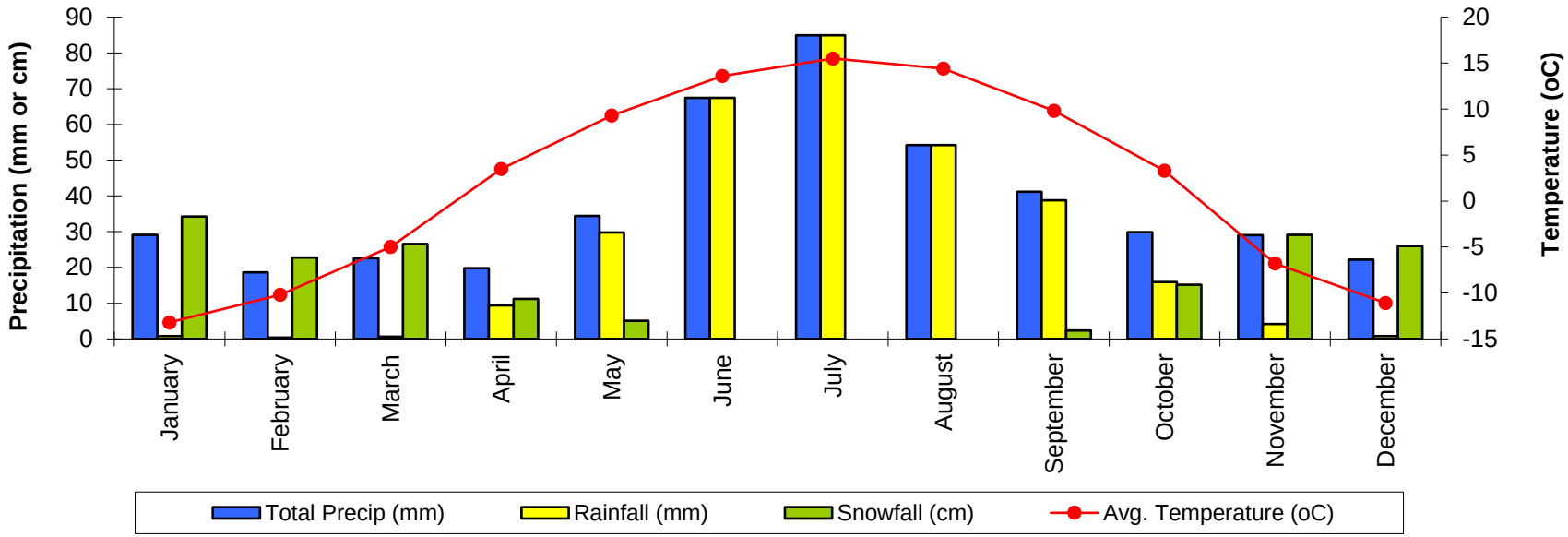
Data source: ESRI Topogrpahic basemapping, Accessed 2020

Source: Google Earth accessed October 2020

Site Boundary

Approximate Limit of Waste

FIGURE 2
SITE PLAN
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



Month	Daily Average Temperature (Celsius)[1]	Daily Maximum Temperature (Celsius)[1]	Daily Minimum Temperature (Celsius)[1]	Rainfall (mm)[1]	Snowfall (cm)[1][2]	Precipation (mm)[2]
January	-13.2	-7.2	-19	0.8	34.2	29.1
February	-10.2	-3.9	-16.5	0.4	22.8	18.6
March	-5	0.9	-10.9	0.6	26.6	22.6
April	3.5	10	-3.1	9.4	11.2	19.8
May	9.3	16.4	2.1	29.8	5.1	34.4
June	13.6	20.1	6.9	67.4	0	67.4
July	15.5	22.2	8.9	84.9	0	84.9
August	14.4	21.5	7.2	54.2	0	54.2
September	9.8	16.2	3.3	38.8	2.4	41.2
October	3.3	9	-2.4	15.9	15.2	29.9
November	-6.8	-1.5	-12.2	4.2	29.1	29
December	-11.1	-5.3	-16.8	0.8	26	22.2
Annual	**1.9**	**8.2**	**-4.4**	**307**	**173**	**453.2**

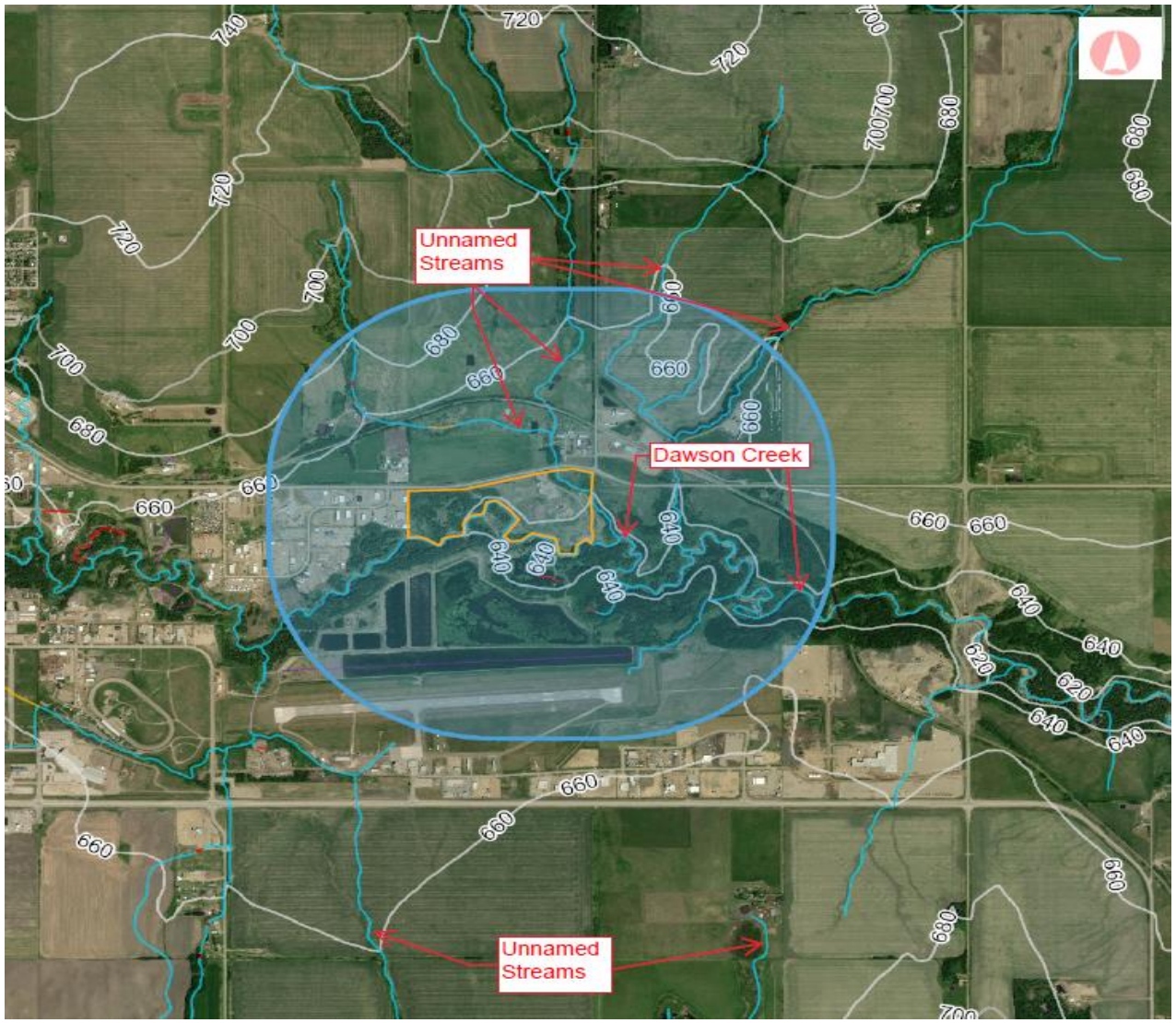
Notes:

(1) Source: Environment Canada: Climate Normals - Dawson Creek A (Station No. 1182285), 1981 - 2010

(2) 1 cm of snowfall corresponds to 1 mm of precipation

Approximate Dawson Creek Landfill Site Latitude 55°45'04"N

FIGURE 3
CLIMATE DATA
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



FWA - Stream Network - Lines

- Stream - Main Flow
- Stream - Secondary Flow
- Wetland - Main Flow
- Wetland - Secondary Flow
- Lake Skeleton - Main Flow
- Lake Skeleton - Secondary Flow
- Lake Arm Skeleton - Secondary Flow
- River Skeleton - Main Flow
- River Skeleton - Secondary Flow
- Flow Connector
- Isolated Waterbody Skeleton - Main flow
- Underground Connector - Main Flow

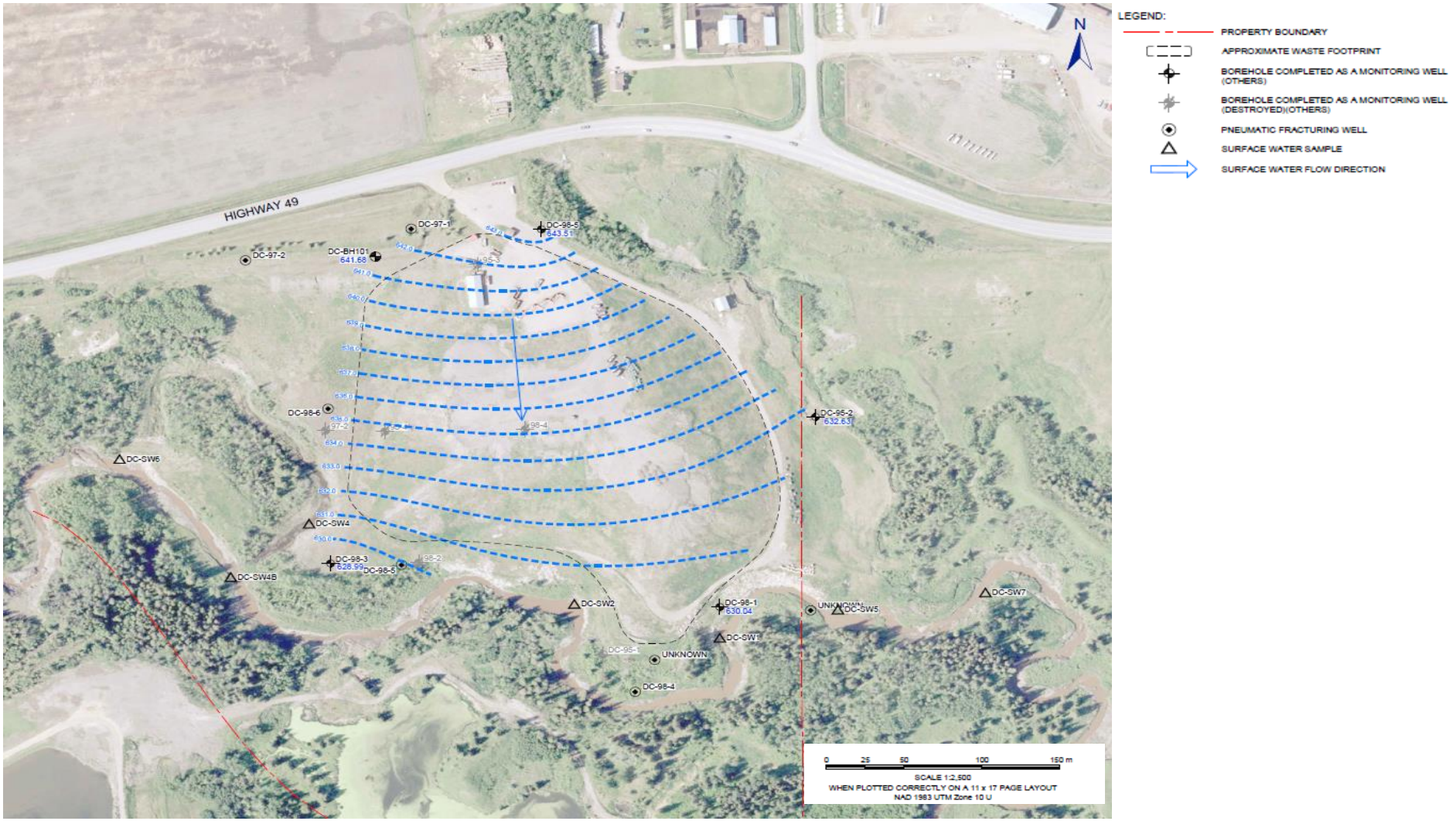
- 1km Radius
- Site Boundary

0 1.02 2.03 km

1: 50,000

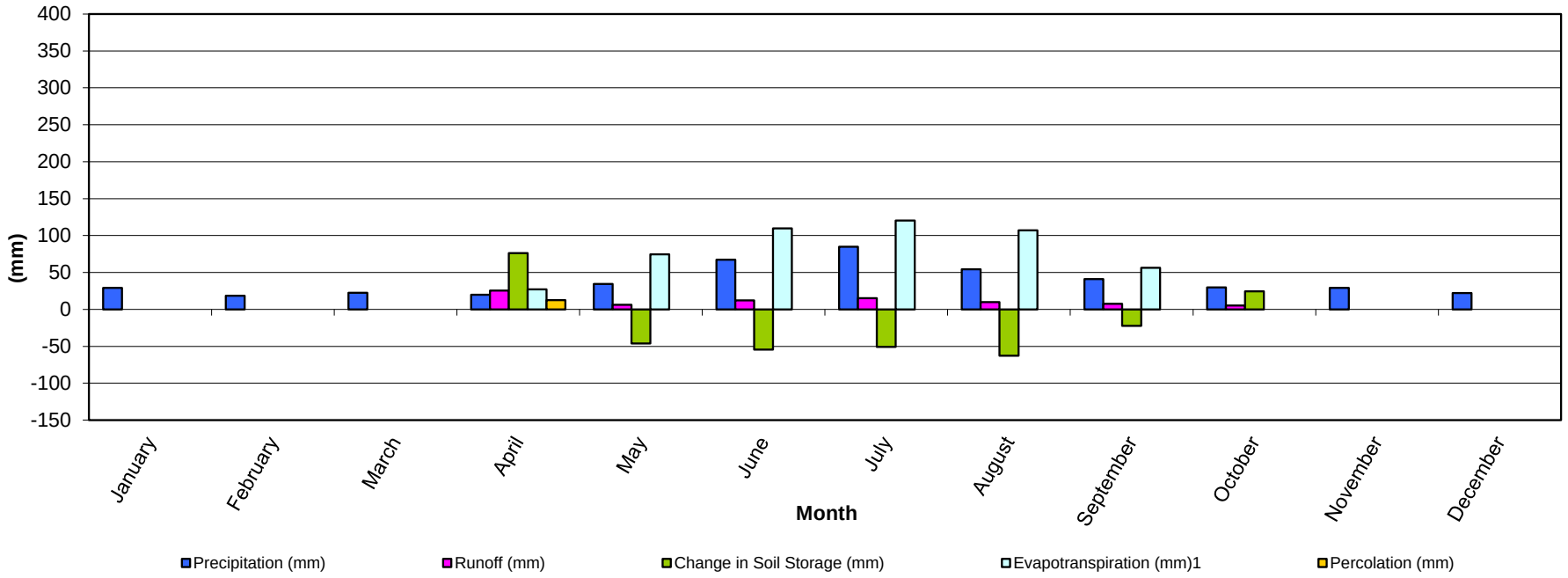
Source: iMap B.C. accessed June 2020

FIGURE 4
TOPOGRAPHY AND DRAINAGE WITHIN 1KM
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



Source: 2017 Groundwater and Surface Water Monitoring and Sampling Program, Peace River Regional District Landfill Sites, Peace River Regional District, Dawson Creek BC, submitted by SLR Consulting (Canada) Ltd, September 13, 2018

FIGURE 5
GROUNDWATER FLOW DIRECTION
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (mm)	29.1	18.6	22.6	19.8	34.4	67.4	84.9	54.2	41.2	29.9	29.0	22.2	453.3
Runoff (mm)	0.0	0.0	0.0	25.4	6.2	12.1	15.3	9.8	7.4	5.4	0.0	0.0	81.6
Change in Soil Storage (mm)	0	0	0	76.2	-46.2265	-54.3913	-50.7	-62.7	-22.5	24.5	0.0	0	0
Evapotranspiration (mm)[1]	0.0	0.0	0.0	27.1	74.5	109.7	120.4	107.2	56.3	0.0	0.0	0.0	495.1
Percolation (mm)	0.0	0.0	0.0	12.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7

Source: Environment Canada: Climate Normals - Dawson Creek A (Station No. 1182285), 1981 - 2010

(1) - Evapotranspiration was estimated using daylight calculations from: NOAA Global Monitoring Laboratory. *Solar Calculation Details.* Accessed July 22, 2020.

FIGURE 6

WATER BALANCE METHOD RESULTS

DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT

DAWSON CREEK, BC

Peace River Regional District

Landfill Closure Plan Status Form
Dawson Creek Landfill Closure Plan and Assessment
Dawson Creek, BC
PRRD

Condition Number	Condition Description	Compliant? (Yes/No/ND)	Action Taken
4.5	The Permittee must submit to the Director a Closure Plan Assessment prepared by an independent Qualified Professional by September 1st, 2021.	Yes	N/A - Closure Plan herein.
4.5 (a)	The Closure Plan Assessment must include the proposed end-use of the landfill after closure;	Yes	N/A - Refer to Section 4.5 of the Closure Plan report.
4.5 (b)	The Closure Plan Assessment must include the estimated and/or anticipated total volume and tonnes of waste received at the landfill during operations, and life of the landfill (i.e., closure date);	Yes	N/A - Refer to Section 4.3 of the Closure Plan report.
4.5 (c)	The Closure Plan Assessment must include the current final cover on site, including, the thickness and permeability of barrier layers and drainage layers, and information on topsoil, vegetative cover and erosion prevention controls;	Yes	N/A - Refer to Section 4.1 of the Closure Plan report.
4.5 (d)	The Closure Plan Assessment must include the current description of procedures for alternative waste disposal facilities;	Yes	N/A - The landfill stopped receiving waste between 2000 and 2002.
4.5 (e)	The Closure Plan Assessment must include the rodent and nuisance wildlife control procedures;	Yes	N/A - Refer to Section 4.2 of the Closure Plan report.
4.5 (f)	The Closure Plan Assessment must include a comprehensive monitoring plan, including groundwater monitoring, surface water monitoring, landfill gas monitoring, leachate monitoring, final cover monitoring, and erosion and settlement monitoring, for a minimum post-closure period of 25 years;	Yes	N/A - Refer to Section 11 of the Closure Plan report.
4.5 (g)	The Closure Plan Assessment must include a plan for operation of any required pollution abatement engineering works, such as leachate collection and treatment systems, for a minimum post-closure period of 25 years (if applicable)	Yes	N/A - The Site is a closed natural attenuation landfill.
4.5 (h)	The Closure Plan Assessment must include an estimated cost, updated annually, to carry out closure and post-closure activities for a minimum period of 25 years.	Yes	N/A - Refer to Section 11 of the Closure Plan report.

Appendices

Appendix A
Permit PR-2212

January 8, 2020

Tracking Number: 389445
Authorization Number: 2212

REGISTERED MAIL

PEACE RIVER REGIONAL DISTRICT
PO BOX 810
Dawson Creek, BC V1G 4H8

Dear Permittee:

Enclosed is Amended Permit 2212 issued under the provisions of the *Environmental Management Act*. Your attention is respectfully directed to the terms and conditions outlined in the permit. An annual fee will be determined according to the Permit Fees Regulation.

This permit does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority rests with the permittee. This permit is issued pursuant to the provisions of the *Environmental Management Act* to ensure compliance with Section 120(3) of that statute, which makes it an offence to discharge waste, from a prescribed industry or activity, without proper authorization. It is also the responsibility of the permittee to ensure that all activities conducted under this authorization are carried out with regard to the rights of third parties and comply with other applicable legislation that may be in force.

When a spill occurs, or there is an imminent risk of one occurring, the responsible person must ensure that it is reported in accordance with the Spill Reporting Regulation. Additional information on spill reporting requirements is available at gov.bc.ca/reportaspill

The Director may require the Permittee to repair, remove, or add to existing works, or to construct new works, and to submit plans and specifications for works specified in this authorization.

The Director may require the Permittee to conduct additional monitoring, and may specify procedures for monitoring, analysis, and procedures or requirements respecting the handling, treatment, transportation, discharge or storage of waste.

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

Ministry of Environment and Climate Change Strategy
Environmental Protection Division
Suite 325 - 1011 4th Avenue
Prince George BC V2L 3H9
Authorizations - North Region
Telephone: (250) 565-6135
Facsimile: (250) 565-6629

Administration of this permit will be carried out by staff from the Environmental Protection Division's Regional Operations Branch. Plans, data and reports pertinent to the operational certificate are to be submitted by email or electronic transfer to the Director, designated Officer, or as further instructed. To meet the reporting requirements in a form and manner acceptable to the Director, reports and notifications related to the administration of this operational certificate must be submitted electronically to the following ministry email addresses:

- EnvAuthorizationsReporting@gov.bc.ca for monitoring and annual reports

- EnvironmentalCompliance@gov.bc.ca for non-compliance reports.

For further information about how to submit data and reports, please refer to http://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/data-and-report-submissions.

For more information about how the Ministry will assesses compliance with your permit please refer to gov.bc.ca/environmentalcompliance.

For more information about how to make changes to your permit and to access waste discharge amendment forms and guidance, please refer to gov.bc.ca/wastedischarge-authorizations.

Yours truly,

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE STRATEGY

PERMIT

2212

Under the Provisions of the Environmental Management Act

Pursuant to the Approved Peace River Regional District Solid Waste Management Plan

PEACE RIVER REGIONAL DISTRICT
Dawson Creek, BC V1G 4H8

is authorized to discharge of municipal solid waste to ground at a landfill located at Dawson Creek, British Columbia, subject to the requirements listed below. Contravention of any of these requirements is a violation of the *Environmental Management Act* and may lead to prosecution.

This Authorization supersedes and replaces all previous versions of Permit 7319 issued under Section 14 of the *Environmental Management Act*.

GLOSSARY

"Facility" means: a landfill operation located at Dawson Creek, British Columbia.

"**Officer: means:** An Officer as defined by Section 1(1) of the *Environmental Management Act*.

"Qualified Professional " means: a person who:

(a) Is an engineer, scientist or technologist specializing in a particular applied science or technology;

(b) Is registered in British Columbia with a professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization;

(c) Through suitable education, experience, accreditation and knowledge respecting solid waste management and related engineering disciplines for the management of leachate, surface water, ground water, storm

Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

water, and landfill gas and other specialist disciplines, may reasonably be relied upon to provide advice within his or her area of expertise and to carry out duties or functions in those areas; and

(d) Provides the completed Declaration of Competency and Conflict of Interest Disclosure Statements.

All documents submitted to the Director by a Qualified Professional must be signed by the author(s).

"Regulatory Document" means: any document that the Operational Certificate holder is required to provide to the Director or the Province pursuant to: (i) this Authorization; (ii) any regulation made under the *Environmental Management Act* that regulates the Facility described in this Authorization or the discharge of waste from that Facility; or (iii) any order issued under the *Environmental Management Act* directed against the Operational Certificate holder that is related to the Facility described in this Authorization or the discharge of waste from that Facility

1. AUTHORIZED DISCHARGES

1.1 Authorized Source

This section applies to the discharge of refuse to a landfill. The site reference number for this discharge is E210867.

1.1.1 The maximum rate of discharge is zero (0) cubic metres per day.

1.1.2 The characteristics of the waste which may be discharged are those of typical municipal solid waste.

1.1.3 The discharge is authorized from authorized works, which are a landfill, a carcass pit and related appurtenances approximately located as shown on the attached Site Plan.

1.1.4 The location of the facilities from which the discharge is authorized to originate is the northeast ¼ of Section 12, Township 78, Range 15, W6M, Peace River Land District approximately as shown on the Site Plan. (≈56.3946 N, -121.1383 W)

Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

2. GENERAL REQUIREMENTS

2.1 Maintenance of Works and Emergency Procedures

All works must be complete and intact.

The Permittee must regularly inspect the Authorized Works and maintain them in good working order.

The Director may require the Permittee to reduce or suspend operations until the Authorized Works have been restored, and/or corrective steps have been taken to prevent unauthorized discharges.

In the event of an emergency or other condition which prevents normal operation of the Authorized Works or leads to an unauthorized discharge, the Permittee must take remedial action immediately to restore the normal operation of the Authorized Works and to prevent any unauthorized discharges. The Permittee must immediately report the emergency or other condition and the remedial action that has and will be taken to the EnvironmentalCompliance@gov.bc.ca email address or as otherwise instructed by the Director.

2.2 Bypasses

The Permittee must not allow any discharge authorized by this authorization to bypass the Authorized Works, except with the prior written approval of the Director.

2.3 General Provisions

Where this Authorization provides that the Director may require an action to be carried out, the Permittee must carry out the action in accordance with the requirements of the Director.

3. OPERATIONAL REQUIREMENTS

3.1 Site Preparation and Restoration

3.1.1 The Permittee must ensure that the site is made inaccessible to the public to prevent unauthorized dumping.

Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

3.1.2 The Permittee must provide surface water diversionary works, firebreaks and site restoration to the satisfaction of the Director.

3.1.3 The Permittee must inspect the landfill site a minimum of annually for any potential berm or slope failures or leachate. The inspection records must be included in the annual report.

3.2 Wildlife Nuisance

The Director may require the Permittee to construct or modify works, or follow specific operating instructions, if the Director is of the opinion that there is a possibility of nuisance or hazard being caused by bears or other animals that are attracted to the site.

3.3 Open Burning Prohibition

The Permittee must not allow the open burning of waste at the site caused by any means, including a deliberate or accidental action by the Permittee or others. The Permittee must immediately extinguish all fires of this nature and notify the Director within 24 hours.

3.4 Groundwater Impacts

3.4.1 The Permittee must not impact groundwater at the property boundary (or as otherwise specified by the Director) by leachate beyond levels specified by the Director.

3.4.2 The Permittee must continue to conduct a ground water and surface water monitoring program that is satisfactory to the Director.

3.5 Sampling Procedures

The Permittee must carry out sampling in accordance with the procedures described in the "British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 2013 Edition (Permittee)" or most recent edition, or by alternative procedures as authorized by the Director.

A copy of the above manual is available on the Ministry web page at https://www2.gov.bc.ca/gov/content/environment/research-monitoring-

Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual

3.6 **Analytical Procedures**

The Permittee must carry out analyses in accordance with procedures described in the "British Columbia Laboratory Manual (2015 Permittee Edition)", or the most recent edition or by alternative procedures as authorized by the Director.

A copy of the above manual is available on the Ministry web page at https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual.

4. **REPORTING REQUIREMENTS**

The Permittee must maintain records of all monitoring data and must submit the results of water sampling analysis in an electronic format suitable for entry into the provincial database system known as EMS.

The Permittee must submit all data required to be submitted under this section by email to the Ministry's Routine Environmental Reporting Submission Mailbox (RERSM) at envauthorizationsreporting@gov.bc.ca or as otherwise instructed by the Director. For guidelines on how to properly name the files and email subject lines or for more information visit the Ministry website: https://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/data-and-report-submissions/routine-environmental-reporting-submission-mailbox

4.1 **Annual Reporting**

The Permittee must, by June 30th each year, submit to the Director an Annual Report for the previous calendar year. The report must contain at least the following information if applicable:

a) the type and tonnage of waste received, transferred, recycled and discharged for the proceeding such calendar year; "if no waste is received, this must be noted in the annual report"

Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

b) occurrences or observations of wildlife, including burrowing/scavenging (medium and large carnivores) at the facility;

c) the results of all monitoring programs as specified in this Authorization. The Permittee must ensure that data interpretation and trend analysis, as well as an evaluation of the impacts of the discharges on the receiving environment in the previous year, is included in such results and carried out by a Qualified Professional;

d) the methods and amounts of leachate collection, treatment and disposal, if applicable;

e) any unauthorized dumping; and

f) results from annually inspection for any potential berm or slope failures or leachate.

4.2 Non-compliance Notification

The Permittee must immediately notify the Director or designate by email at EnvironmentalCompliance@gov.bc.ca, or as otherwise instructed by the Director of any non-compliance with the requirements of this Authorization and take remedial action to remedy any effects of such non-compliance.

The Permittee must provide the Director with written confirmation of all such non-compliance events, including available test results within 24 hours of the original notification by email at EnvironmentalCompliance@gov.bc.ca, or as otherwise instructed by the Director.

4.3 Non-compliance Reporting

If the Permittee fails to comply with any of the requirements of this Authorization, the Permittee must, within 30 days of such non-compliance, submit to the director a written report that includes, but is not necessarily limited to, the following:

a) all relevant test results obtained by the Permittee related to the non-compliance,

b) an explanation of the most probable cause(s) of the non-compliance, and

c) a description of remedial action planned and/or taken by the Permittee to prevent similar non-compliance(s) in the future.

The Permittee must submit all non-compliance reporting required to be submitted under this section by email to the Ministry's Compliance Reporting Submission Mailbox (CRSM) at EnvironmentalCompliance@gov.bc.ca or as otherwise instructed by the Director. For guidelines on how to report a non-compliance or for more information visit the Ministry website: https://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/data-and-report-submissions/compliance-reporting-mailbox

4.4 Spill Reporting

The Permittee must immediately report all spills to the environment (as defined in the Spill Reporting Regulation) in accordance with the Spill Reporting Regulation, which among other things, requires notification to Emergency Management BC at 1-800-663-3456

4.5 Landfill Closure Plan

The Permittee must submit to the Director a Closure Plan Assessment prepared by an independent Qualified Professional by September 1st, 2021. The Closure Plan Assessment must, as a minimum, include the following:

a) proposed end-use of the landfill after closure;
b) estimated and/or anticipated total volume and tonnes of waste received at the landfill during operations, and life of the landfill (i.e. closure date);
c) current final cover on site, including, the thickness and permeability of barrier layers and drainage layers, and information on topsoil, vegetative cover and erosion prevention controls;
d) current description of procedures for alternative waste disposal facilities;
e) rodent and nuisance wildlife control procedures;
f) a comprehensive monitoring plan, including groundwater monitoring, surface water monitoring, landfill gas monitoring, leachate monitoring, final cover monitoring, and erosion and settlement monitoring, for a minimum post-closure period of 25 years;
g) if applicable, a plan for operation of any required pollution abatement engineering works, such as leachate collection and treatment systems, for a minimum post-closure period of 25 years; and

Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

h) an estimated cost, updated annually, to carry out closure and post-closure activities for a minimum period of 25 years.

4.6 **Site Decommissioning**

In accordance with Section 40 of the *Environmental Management Act* and Part 2 of the Contaminated Sites Regulation, the Permittee must submit a site profile to the manager at least 10 days prior to decommissioning the facilities authorized in Section 1.

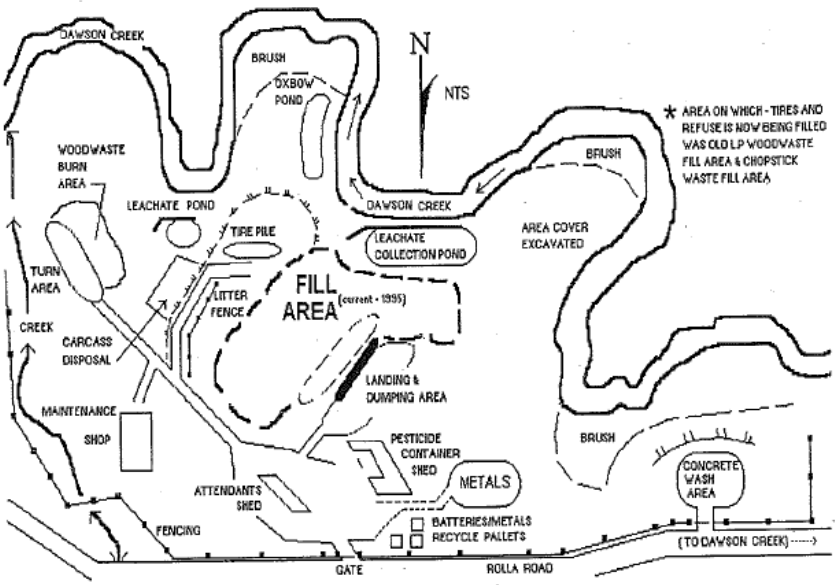
5. **PUBLICATION OF DOCUMENTS**

The Ministry of Environment and Climate Change Strategy publishes Regulatory Documents on its website for the purpose of research, public education and to provide transparency in the administration of environmental laws. The Permittee acknowledges that the Province may publish any Regulatory Documents submitted by the Permittee excluding information that would be exempted from disclosure if the document was disclosed pursuant to a request under section 5 of the Freedom of Information and Protection of Privacy Act, and the Permittee consents to such publication by the Province.

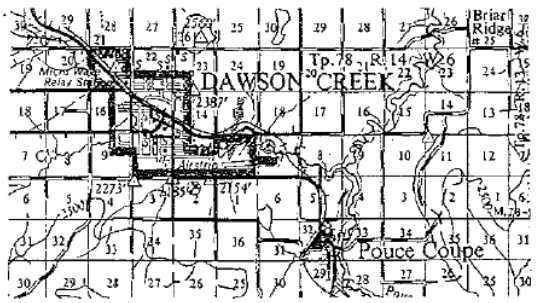
Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

SITE PLAN A



Location Map



Date issued: October 7, 1974
Date amended: January 8, 2020
(most recent)

Peter D. Lawrie
for Director, *Environmental Management Act*
Authorizations - North Region

Appendix B
Aerial Photographs

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

1964 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

1966 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

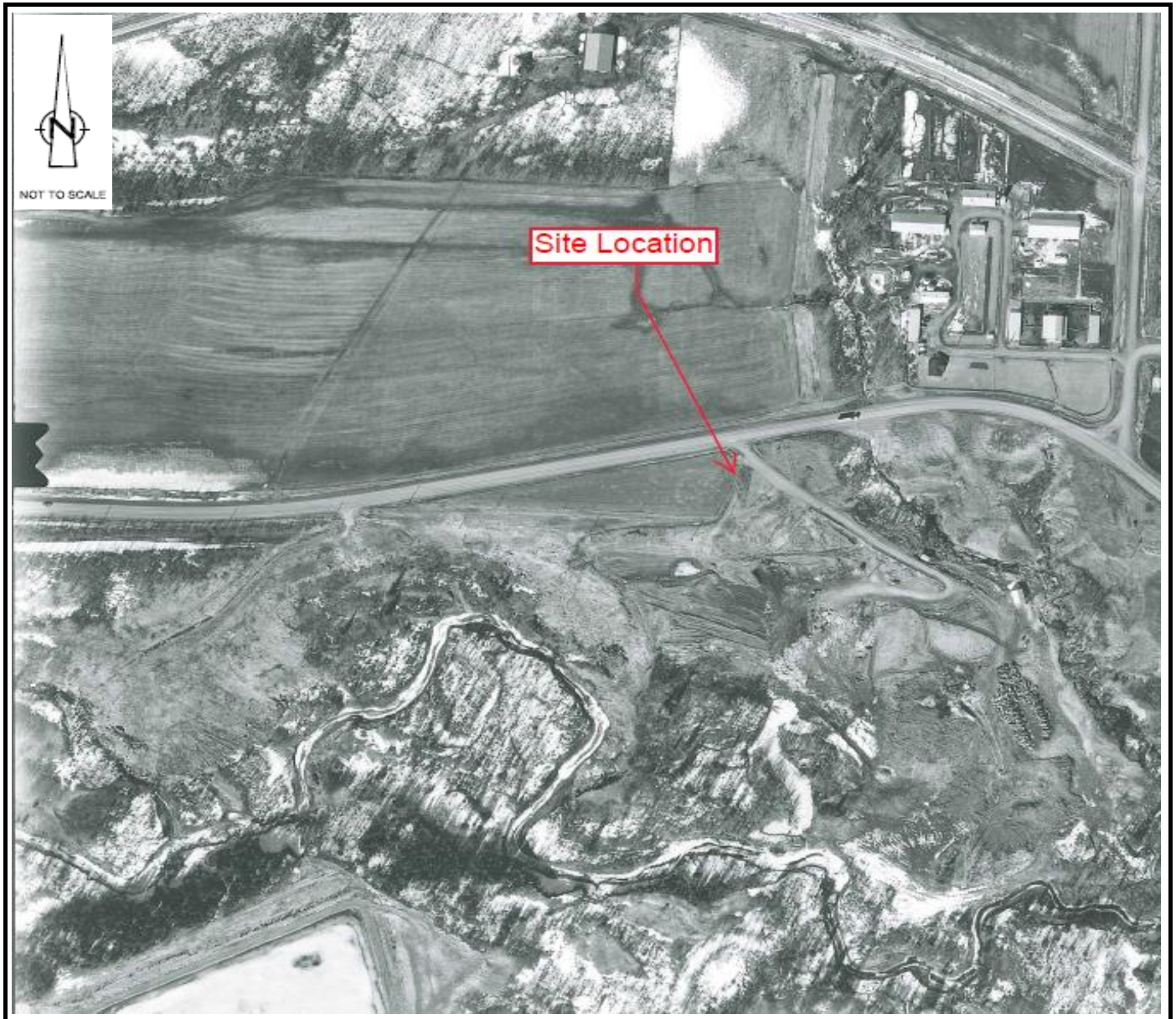
PHOTOLOG

1970 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

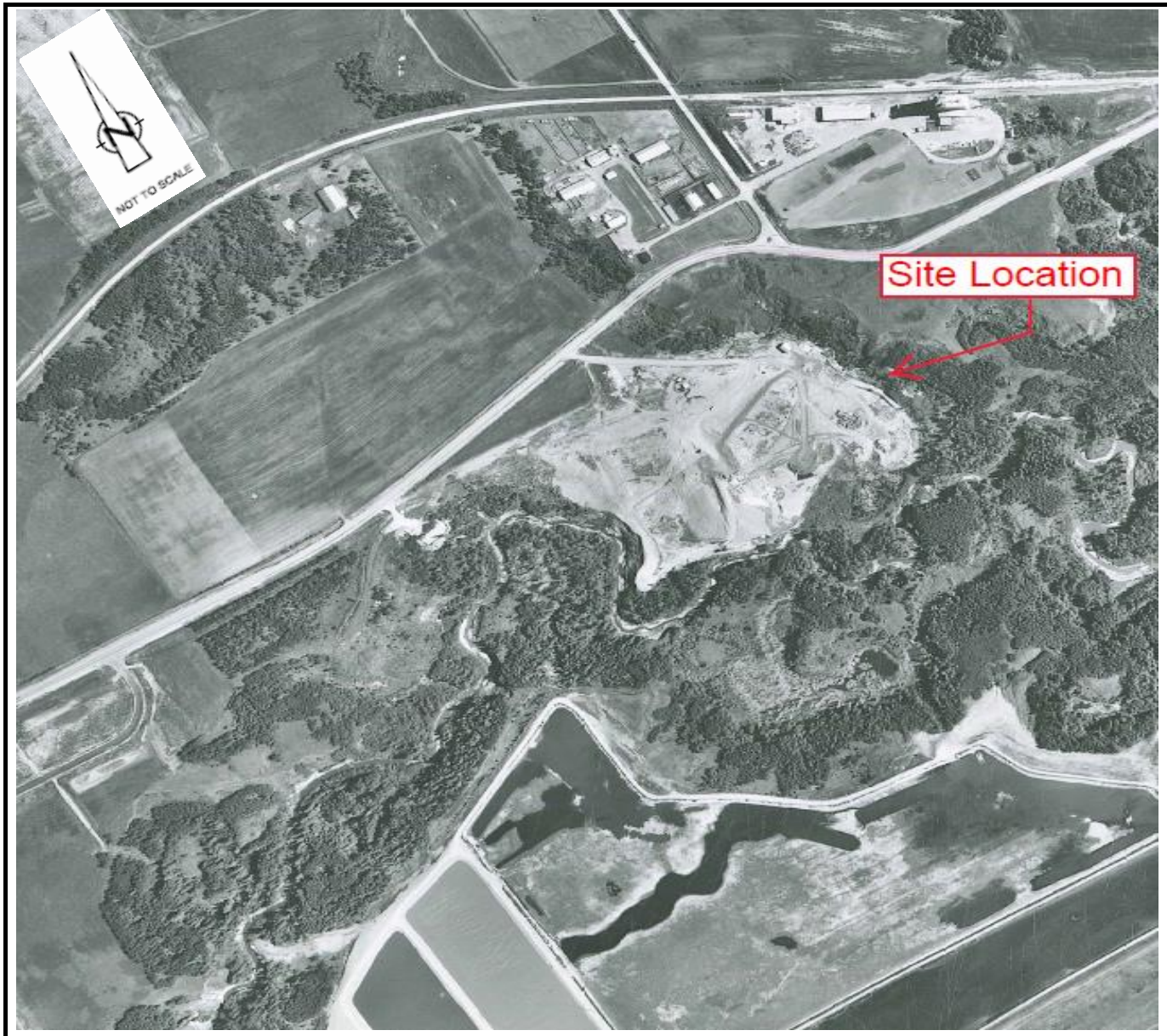
1977 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

1981 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

1984 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

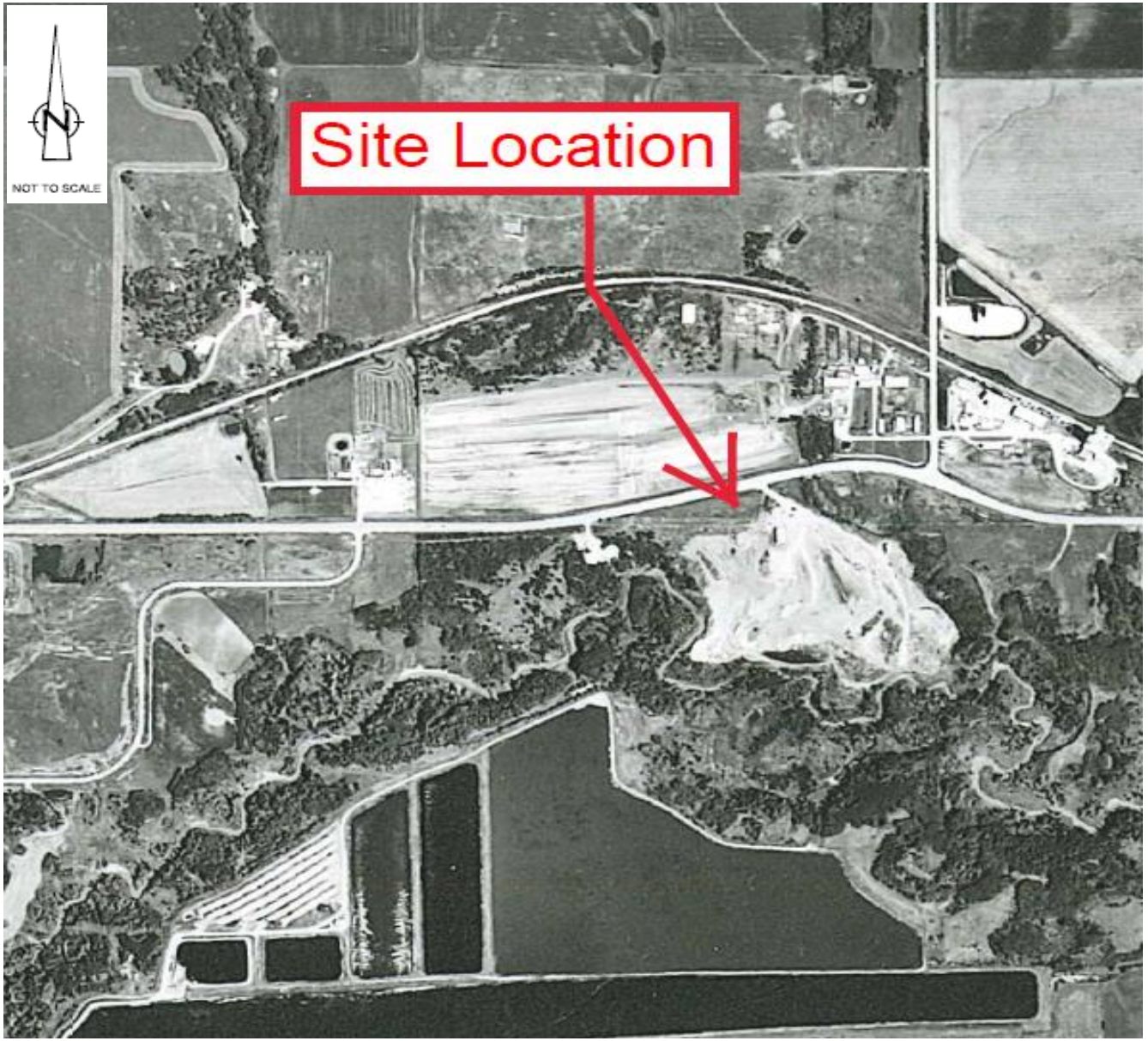
PHOTOLOG

1987 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

1990 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District



SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

1996 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

SOURCE: UBC GEOGRAPHICAL INFORMATION CENTER

PHOTOLOG

2007 AERIAL PHOTOGRAPH
DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

Appendix C
Borehole Logs

CITY OF DAWSON CREEK	DAWSON CREEK LANDFILL	BOREHOLE NO: 97-1
	NE 1/2 SECTION 12 TWP 78 RGE 15 W6M	PROJECT NO: EG08201
MAYHEW 1000 TRUCK/ WET ROTARY		ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m) | ■ STANDARD PEN (N) ■ 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL

SOIL DESCRIPTION

SAMPLE TYPE | SAMPLE NO | SPT(N) | SLOPE INDICATOR

OTHER TESTS COMMENTS

DEPTH(m)

DEPTH(m)	SOIL DESCRIPTION	SAMPLE NO	OTHER TESTS COMMENTS
0.0	GRAVEL FILL, silty, sandy, brown loose to compact		
3.0	CLAY, varved, silty, high plastic, stiff, grey to greyish brown, laminated with low to medium plastic pockets	U1	U1 Z = 3.1 5o 3.4 m varved clay, grey/brown, thin varves (1 to 4 mm)
5.0	dark grey, with brown-grey medium plastic laminations, random salt crystals	U2	U2 Z = 5.5 to 5.8 m varved clay, grey/brown some inclined of 20 degrees; 4" stone lamination
8.0	stiff to very stiff, gypsum crystals	U3	U3 Z = 8.5 to 8.8 m varved clay, siltier, gypsum crystals
12.0	CLAY, silty, some sand, very stiff, medium to high plastic, dark grey, fine gravel sizes, gypsum crystals	U4	U4 Z = 11.6 to 11.9 m some laminations 1/4" and 1" pockets
15.0	medium plastic, sandstone nodules	U5	U5 Z = 14.6 to 15.0 m lacustrine clay
18.0	medium-high plastic, grey, fine gravel sizes to random cobble Z = 18.6 - 18.9 m cobbles CLAY, silty, some fine sand, stiff, medium plastic, grey, silt partings	U6	U6 Z = 17.7 to 18.1 m damaged, recovery, one 4" stone, some clay
20.0		U7	Pneumatic piezometer #21678 installed at 20.2 m (see Note 1) U7 Z = 20.7 to 21.1 m lacustrine clay; very wet
24.0	stiff, medium-high plastic, grey	U8	U8 Z = 23.8 to 24.2 m lacustrine clay
25.0	CLAY TILL, silty, trace of sand, stiff to	C1	C1 Recovery = 83 %

AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA/AGK	COMPLETION DEPTH: 43.0 m
	REVIEWED BY: AGK	COMPLETE: 97/06/18
	Fig. No:	Page 1 of 2

98/06/23 11:02PM (25MW)

CITY OF DAWSON CREEK	DAWSON CREEK LANDFILL	BOREHOLE NO: 97-1
	NE 1/2 SECTION 12 TWP 78 RGE 15 W6M	PROJECT NO: EG08201
MAYHEW 1000 TRUCK/ WET ROTARY		ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m)	■ STANDARD PEN (N) ■ 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	SLOPE INDICATOR	OTHER TESTS COMMENTS	DEPTH(m)
25.0			very stiff, medium-high plastic, grey, slickensided, fine gravel sizes (friable shale, green/grey, some siltstone, poorly cemented grey sandstone, gypsum crystals); amount of gravel sizes increases with depth		C1				25.0
26.0					C2			C2 Recovery = 83 %	26.0
27.0									27.0
28.0					C3			C3 Recovery = 109 %	28.0
29.0			1" layer cobbles, fine sand						29.0
30.0			Various planar/non-planar slickensides		C4			C4 Recovery = 46 % (Pump Water pressure build up due to hole squeezing, causing core to washed out)	30.0
31.0			CLAY, silty, medium to high plastic, stiff to very stiff, grey, fine silt laminations or partings						31.0
32.0			very silty, some fine sand, low plastic,		C5			C5 Recovery = 70 %	32.0
33.0			silty, medium to high plastic, grey, random rust stains, laminations and slickensides, all @ 255 degrees to axis						33.0
34.0			intermixed/interbedded with low plastic silty clay or clayey sand beds or partings						34.0
35.0					C6			C6 Recovery = 59 %	35.0
36.0									36.0
37.0			partial slickensides, discontinuous, planar, some striation (20 to 55 degrees) in higher plastic clay; intermixed with fluvial sand/silt beds/partings, indistinct bedding		C7			C7 Recovery = 67 %	37.0
38.0									38.0
39.0			Wet, gypsum crystals, thin fine/sand lamination, slickensided below sand slickensides (20 to 35 degrees), planar, slightly striated		C8			C8 Recovery = 77 %	39.0
40.0			fine sand/silt partings						40.0
41.0			lamination rust stains and slickensides at subhorizontal		C9			C9 Recovery = 67 %	41.0
42.0					C10			Pneumatic piezometer #21674 installed at 41.2 m (See Note 1) C10 Recovery = 56 %	42.0
43.0			End of Hole at 43.0 m No water loss during drilling						43.0
44.0									44.0
45.0			Note 1: Instalation: piezo tip in sand pack sock, strapped to SI casing and grouted in with tremie pipe						45.0
46.0									46.0
47.0									47.0
48.0									48.0
49.0									49.0
50.0									50.0

AGRA Earth & Environmental Limited
Edmonton, Alberta

LOGGED BY: CRA/AGK
REVIEWED BY: AGK
Fig. No:

COMPLETION DEPTH: 43.0 m
COMPLETE: 97/06/18

98/06/23 11:02PM (2SAW)

CITY OF DAWSON CRREK	DAWSON CREEK LANDFILL	BOREHOLE NO: 97-2
	NE 1/2 SECTION 12 TWP 78 RGE 15 W6M	PROJECT NO: EG08201
MAYHEW 1000 TRUCK/ WET ROTARY		ELEVATION:

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND

DEPTH(m)	STANDARD PEN (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	SLOPE INDICATOR	OTHER TESTS COMMENTS	DEPTH(m)
0.0			CLAY, silty, trace of sand, stiff, medium to high plastic, dark grey with brown mottles or laminations, laminated thin water-like, random gravel sizes						0.0
1.0									1.0
2.0									2.0
3.0			dark grey		U1			U1 Z = 3.1 to 3.5 m clay, well defined laminations, some high plastic laminations (1 to 3 mm), some fine gravel sizes	3.0
4.0									4.0
5.0									5.0
6.0			stiff, gypsum crystals, some laminations		U2			U2 Z = 5.5 to 5.8 m Clay, laminated, medium plastic, gypsum crystals, relatively dry	6.0
7.0									7.0
8.0									8.0
9.0			sizes		U3			U3 Z = 8.5 to 8.8 m clay, massive, silty, medium to low plastic, relatively dry	9.0
10.0			massive, medium to low plastic						10.0
11.0									11.0
12.0			medium plastic		U4			U4 Z = 11.6 to 11.9 clay, massive, dark grey, medium plastic, relatively dry	12.0
13.0			CLAY TILL, silty, trace of sand, medium to high plastic, stiff, dark grey, random gravel sizes, gypsum crystals						13.0
14.0								U5 Z = 11.6 to 11.9 m	14.0
15.0					U5			Pneumatic piezometer #21683 at 14.7 m (see Note 1)	15.0
16.0			medium plastic, sandy, stiff, grey, random high plastic clay zones, fine gravel sizes		C1			C1 Recovery = 100 %	16.0
17.0									17.0
18.0			slickensides 45 to 70 degrees		C2			C2 Recovery = 95 %	18.0
19.0			medium-high plastic, some sand, stiff, dark grey, random high plastic clay, fine gravel sizes						19.0
20.0					C3			C3 Recovery = 89 %	20.0
21.0			softer, high plastic, numerous slickensides						21.0
22.0					C4			C4 No Recovery	22.0
23.0									23.0
24.0			higher plastic, clay zones, slickensides		C5			C5 Recovery = 100 %	24.0
25.0					C6			C6 Recovery = 80 %	25.0

AGRA Earth & Environmental Limited
Edmonton, Alberta

LOGGED BY: CRA/AGK	COMPLETION DEPTH: 41.5 m
REVIEWED BY: AGK	COMPLETE: 97/06/21
Fig. No:	Page 1 of 2

98/06/23 11:02PM (2sdw)

CITY OF DAWSON CRREK	DAWSON CREEK LANDFILL	BOREHOLE NO: 97-2
	NE 1/2 SECTION 12 TWP 78 RGE 15 W6M	PROJECT NO: EG08201
MAYHEW 1000 TRUCK/ WET ROTARY		ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m)	STANDARD PEN (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	SLOPE INDICATOR	OTHER TESTS COMMENTS	DEPTH(m)
25.0			silt partings, slickensides		C6				25.0
26.0			slickenside						26.0
27.0			shale nodules		C7			C7 Recovery = 41 %	27.0
28.0			high plastic, very stiff, grey, shale nodules, cobbles, gypsum crystals, brown, silt laminations, drier		C8			C8 Recovery = 83 %	28.0
29.0									29.0
30.0			CLAY SHALE, badly weathered, silty, low to medium plastic, hard, grey, with thin horizontal yellowish-grey to rust colored laminations?, very friable, fissile		C9			C9 Recovery = 94% Pneumatic piezometer #21675 at 31 m (see Note 1)	30.0
31.0									31.0
32.0					C10			C10 Recovery = 83 %	32.0
33.0									33.0
34.0			harder, well-cemented shale zones, but very friable, rust stained, breaks easily along various directions		C11			C11 Recovery = 83 %	34.0
35.0									35.0
36.0					C12			C12 Recovery = 90 %	36.0
37.0									37.0
38.0					C13			C13 Recovery = 89 %	38.0
39.0									39.0
40.0			medium plastic, harder shale, dark grey-brown, breaks easily along planes in all direction		C14			C14 Recovery = 95 %	40.0
41.0									41.0
42.0			End of Hole at 41.5 m No water loss during drilling						42.0
43.0									43.0
44.0									44.0
45.0			Note 1: Installation: piezo tip in sand pack sock, strapped to SI casing and grouted in with tremie pipe						45.0
46.0									46.0
47.0									47.0
48.0									48.0
49.0									49.0
50.0									50

AGRA Earth & Environmental Limited
Edmonton, Alberta

LOGGED BY: CRA/AGK
REVIEWED BY: AGK
Fig. No:

COMPLETION DEPTH: 41.5 m
COMPLETE: 97/06/21

98/06/23 11:02PM (2.4M)

CITY OF DAWSON CRREK	DAWSON CREEKK LANDFILL	BOREHOLE NO: 97-3
	NE 1/2 SECTION TWP 78 RGE 15 W6M	PROJECT NO: EG08201
MAYHEW 1000 TRUCK/ WET ROTARY		ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m) | ■ STANDARD PEN (N) ■ 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL

SOIL DESCRIPTION

GARBAGE, large pieces of concrete, metal, and ash, mixed with clay

last circulation; large pieces of concrete

ash mixed with gravel sizes, black to dark grey

CLAY, silty, very soft, squeezing, medium to high plastic, grey, silt/fine sand pockets (too soft to core)

CLAY TILL, silty, trace of sand, medium to high plastic, stiff, grey, fine gravel sizes (attempted to core but hole squeezing causing high pump pressures as well as material form upper hole keep falling in)

End of Hole at 19.6 m
Water level at 1.5 m at completion
Was losing water throughout the drilling of borehole

Note 1: Installation: piezo tip in sand pack sock, stapped to SI casing and grouted in with tremie pipe

SAMPLE TYPE | SAMPLE NO | SPT(N) | SLOPE INDICATOR

OTHER TESTS COMMENTS

U1 Z = 3.1 to 3.4 m

U2 Z = 5.5 to 5.8 m
medium to coarse sand, gravel, silty clay, very wet

U3 Z = 8.5 to 8.8 m
recovery approx. 8", sandy, silty clay, pebbles up to 3/4", very wet, 1/2" metal piece, maximum nail

U4 Z = 11.5 to 11.9 m
clay, sand, gravel very wet, soft, very soft at 11.7 m, drier and stiffer at 11.8 m, 1 large nail @ 11.7 m

U5 Z = 13.4 to 13.8 m
clay till, high plastic, stiff

U6 Z = 14.6 to 14.9 m
clay fill, high plastic stiff to very stiff

U7 Z = 16.2 to 16.6 m
clay fill, high plastic, stiff to very stiff, steel plate 1" x 2" at the bottom

Pneumatic piezometer #21679 at 18.5 m (see note 1)

U9 Z = 19.3 to 19.6 m

DEPTH(m)

AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA REVIEWED BY: AGK Fig. No:	COMPLETION DEPTH: 19.6 m COMPLETE: 97/06/20 Page 1 of 1

98/06/23 11:03PM (25MB)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 – DAWSON CREEK LANDFILL	BOREHOLE NO: 98-4
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND

DEPTH(m) | STANDARD PEN (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL

SOIL DESCRIPTION

LANDFILL, clay, silty, low to medium plastic, mixed with wood, pieces of plastic, some metal

gravel sizes, (maybe bottom of landfill)

(TUBE), soft clay, with gravel sizes, pieces of plastic/glass

CLAY TILL, silty, trace of sand, high plastic, stiff, dark grey, shale nodules and pockets, random gravel sizes

gravel sizes

12/150

SAMPLE TYPE	SAMPLE NO	SPT(N)
	U1	
	U2	
	D1	15
	U3	
	D2	12/150
	U4	
	D3	20
	U5	
	D4	12

PNEUMATIC PIEZOMETER | PNEUMATIC PIEZOMETER

OTHER TESTS COMMENTS

Mixed heavy drilling mud, lossing some water in landfill material

Bit pluggged, pieces of plastic/wood retained in suspension plugged off bit ports

Bit plugged

Bit plugged

Bit plugged

Attempt to push Nilcon vane, no success

Pneumatic piezometer #22571 installed @ 8.6 m

On rock

Pneumatic piezometer #22569 installed @ 13.9 m

DEPTH(m)

0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0

AGRA Earth & Environmental Limited
Edmonton, Alberta

LOGGED BY: CRA
REVIEWED BY: AGK
Fig. No:

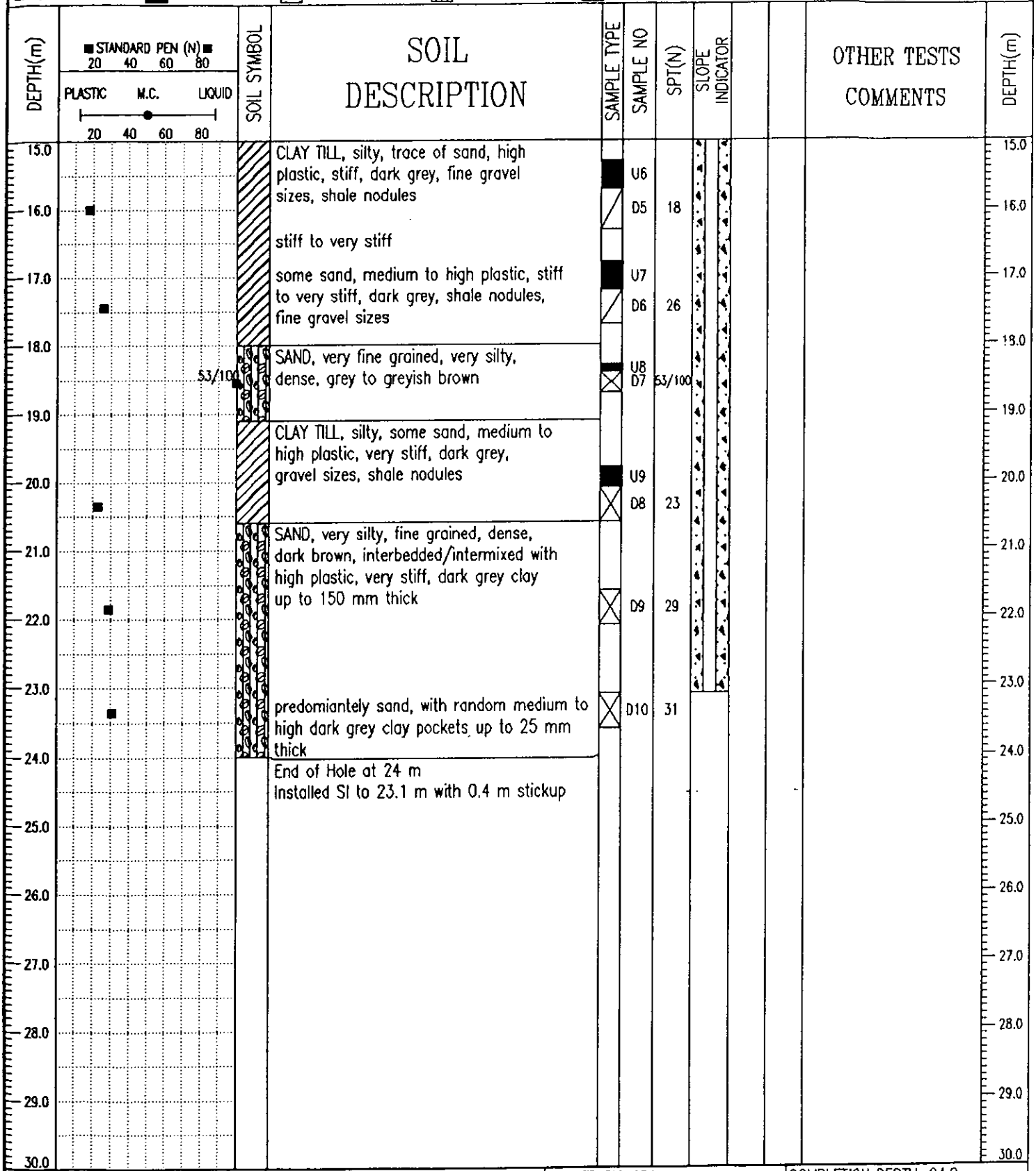
COMPLETION DEPTH: 24.0 m
COMPLETE: 98/04/14

98/06/23 11:21PM (15MM)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 – DAWSON CREEK LANDFILL	BOREHOLE NO: 98-4
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND



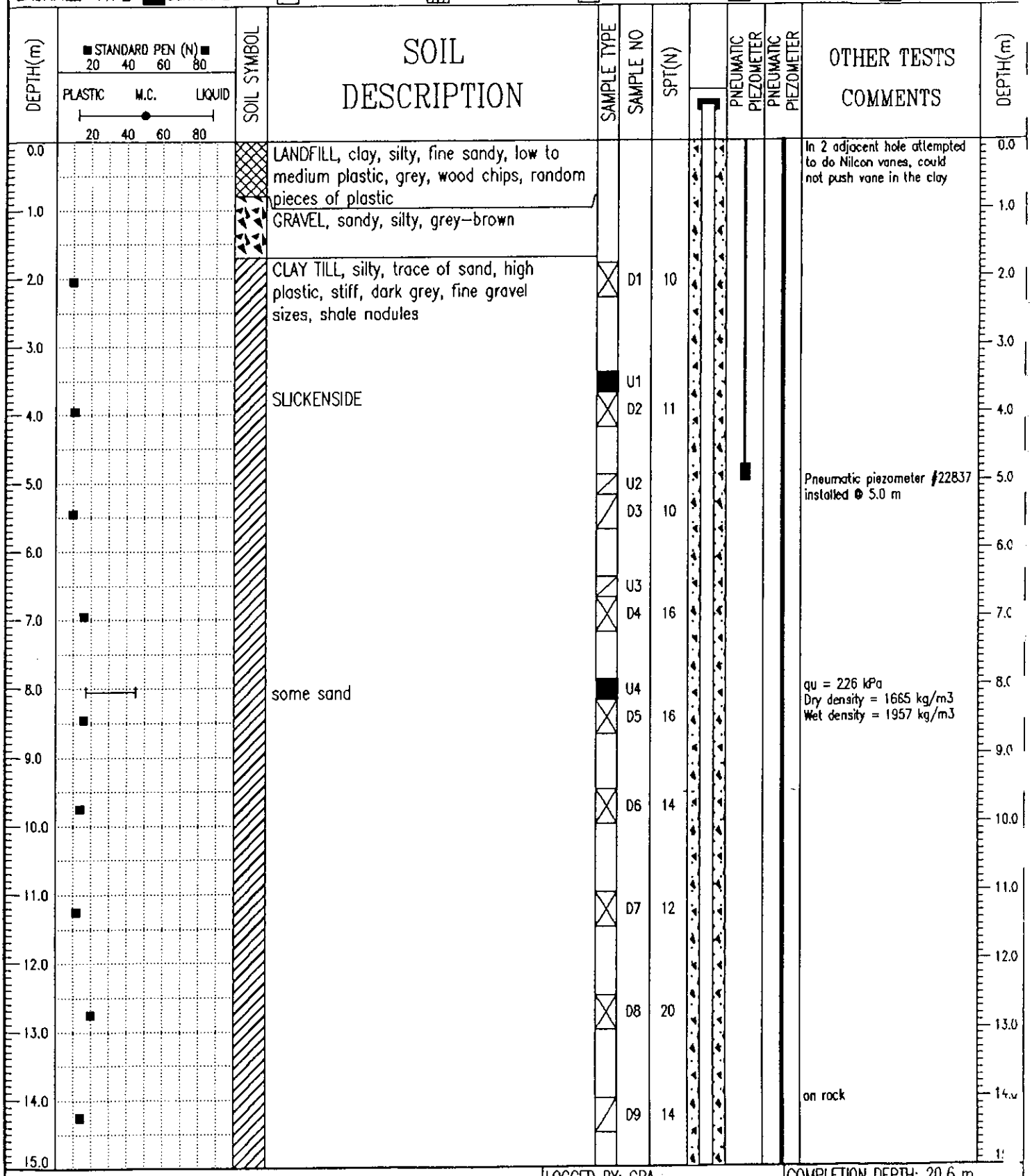
AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA	COMPLETION DEPTH: 24.0 m
	REVIEWED BY: AGK	COMPLETE: 98/04/14
	Fig. No:	Page 2 of 2

98/05/25 11:21PM (15MW)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 – DAWSON CREEK LANDFILL	BOREHOLE NO: 98-5
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND



AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA REVIEWED BY: AGK Fig. No:	COMPLETION DEPTH: 20.6 m COMPLETE: 98/04/16 Page 1 of

98/06/23 11:21PM (1Saw)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 - DAWSON CREEK LANDFILL	BOREHOLE NO: 98-5
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m)	STANDARD PEN (N) 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	SLOPE INDICATOR	PNEUMATIC PIEZOMETER	OTHER TESTS COMMENTS	DEPTH(m)
15.0	■		CLAY TILL, silty, some sand, high plastic, stiff, dark grey, fine gravel sizes, shale nodules,							15.0
16.0	■				D10	15				16.0
17.0	■				D11	16				17.0
18.0										18.0
19.0	■				D12	18				19.0
20.0	■				D13	18		■	Pneumatic piezometer #23161 installed @ 19.7 m	20.0
21.0			End of Hole at 20.6 m Installed SI to 19.8 m with 0.6 m stickup							21.0
22.0										22.0
23.0										23.0
24.0										24.0
25.0										25.0
26.0										26.0
27.0										27.0
28.0										28.0
29.0										29.0
30.0										30.0

AGRA Earth & Environmental Limited
Edmonton, Alberta

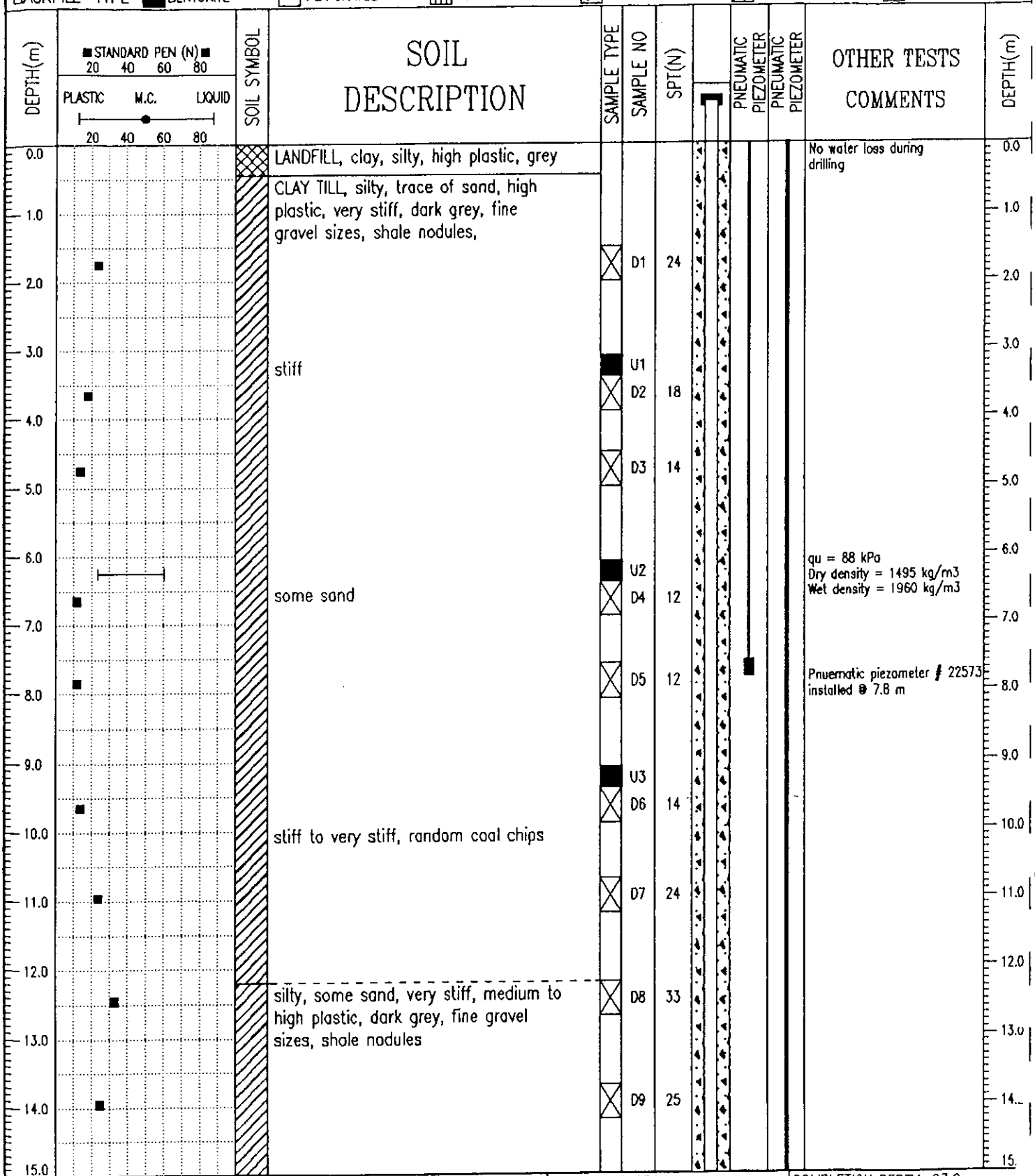
LOGGED BY: CRA | COMPLETION DEPTH: 20.6 m
REVIEWED BY: AGK | COMPLETE: 98/04/16
Fig. No: | Page 2 of 2

98/06/23 11:22PM (1Saw)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 - DAWSON CREEK LANDFILL	BOREHOLE NO: 98-6
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND



AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA REVIEWED BY: AGK Fig. No:	COMPLETION DEPTH: 23.0 m COMPLETE: 98/04/17 Page 1 of 1

98/06/23 11:22PM (15MM)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 - DAWSON CREEK LANDFILL	BOREHOLE NO: 98-6
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m) | ■STANDARD PEN (N)■ 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL

SOIL DESCRIPTION

SAMPLE TYPE	SAMPLE NO	SPT(N)	SLOPE INDICATOR	PNEUMATIC PIEZOMETER	OTHER TESTS COMMENTS
	D10	40			
	D11	42			
	D12	40			
	D13	31			
	D14	28			Pnuematic piezometer #23159 installed @ 21.5 m

CLAY TILL, silty, some sand very stiff to hard, medium to high plastic, dark grey, fine gravel sizes, shale nodules

very fine grained, dense, sand/silt pockets/partings, brown

SAND, very silty, clayey, non to low plastic, dense, brown, random dark grey high plastic clay partings

CLAY TILL, very sandy, silty, low plastic, hard, brown, fine gravel sizes, some rust staining, shale nodules

CLAY, silty, fine sandy, medium to high plastic, very stiff, dark grey, with horizonitally interbedding of light grey to brown, silt/fine sand laminations up to 5 mm thick
fine sand/silt laminations up to 25 mm thick

End of Hole at 23.0 m
Installed SI to 23 m with 0.7 m stickup

DEPTH(m): 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0, 26.0, 27.0, 28.0, 29.0, 30.0

AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA REVIEWED BY: AGK Fig. No:	COMPLETION DEPTH: 23.0 m COMPLETE: 98/04/17 Page 2 of 2

98/06/23 11:29PM (15MW)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 – DAWSON CREEK LANDFILL	BOREHOLE NO: 98-7
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(m) | STANDARD PEN (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL

SOIL DESCRIPTION

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	PNEUMATIC PIEZOMETER	PNEUMATIC PIEZOMETER	OTHER TESTS COMMENTS
0.0						
						Skid hole, on metal
1.0						Skid hole, metal
2.0						
3.0						
						GRAVEL, sandy, silty, black
						CLAY TILL, silty, some sand, stiff, high plastic, dark grey, shale nodules, fine gravel sizes
4.0		D1	12			
		U1				qu = 111 kPa
5.0		D2	11			Dry density = 1882 kg/m3 Wet density = 2204 kg/m3
6.0		U2				firm to stiff
		D3	8			
7.0						Pnuematic piezometer #22570 installed @ 6.9 m
		U3				stiff
8.0		D4	16			
9.0		U4				
		D5	13			
10.0						
11.0		D6	12			
12.0						
		D7	17			medium to high plastic, stiff to very stiff, dark grey,
13.0						
						On rock
14.0		D8	27			
15.0						

AGRA Earth & Environmental Limited
Edmonton, Alberta

LOGGED BY: CRA
REVIEWED BY: AGK
Fig. No:

COMPLETION DEPTH: 23.2 m
COMPLETE: 98/04/18

98/05/26 TEMPLATE (1 SAMPLE)

PEACE RIVER REGIONAL DISTRICT	PHASE 2 – DAWSON CREEK LANDFILL	BOREHOLE NO: 98-7
	NE 1/4 12-78-15-W6M	PROJECT NO: EG08275
CANTERRA 310 TRACK/ WET ROTARY	DAWSON CREEK, BRITISH COLUMBIA	ELEVATION:

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND

DEPTH(m)	STANDARD PEN (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	SLOPE INDICATOR	PNEUMATIC PIEZOMETER	OTHER TESTS COMMENTS	DEPTH(m)
15.0	■		CLAY TILL, silty, some sand, medium to high plastic, stiff to very stiff, dark grey, fine gravel sizes, shale nodules		D9	19				15.0
16.0										16.0
17.0	■		very stiff		D10	22				17.0
18.0										18.0
18.5	■				D11	22				
19.0			SAND, very fine grained, very silty, trace of clay, dense, brown, random high plastic dark grey clay layers/partings							19.0
20.0	■				D12	44				20.0
20.2			CLAY TILL, silty, very sandy, hard, low plastic, brown, fine gravel sizes							
21.0										21.0
21.5	■		CLAY, silty, fine sandy, medium to high platic, dark grey, with thin light grey to brown fine sand/silt partings		D13	40				
22.0									Pnuematic piezometer #23158 installed @ 22.2 m	22.0
23.0										23.0
			End of Hole at 23.2 m Installed SI to 23.2 m with 0.5 m stickup							
24.0										24.0
25.0										25.0
26.0										26.0
27.0										27.0
28.0										28.0
29.0										29.0
30.0										30.0

AGRA Earth & Environmental Limited
Edmonton, Alberta

LOGGED BY: CRA
REVIEWED BY: AGK
Fig. No:

COMPLETION DEPTH: 23.2 m
COMPLETE: 98/04/18

98/06/26 TIETBAM (TSAW)

Appendix D
Photolog

IMG_20200528_131429.jpg

Photo 1 - Main entrance to the landfill through the transfer station.

IMG_20200528_132226.jpg

Photo 2 - Loose soil and steep slopes along the top of slope of the landfill cover. Looking north at center of the site.

Site Photographs

IMG_20200528_132227.jpg

Photo 3 - Loose soil in foreground at the top of the landfill slope. General topography looking southwest from the center of the site.

IMG_20200528_132355.jpg

Photo 4 - General topography looking southwest. Pond shown to left center of photo. Photo taken from center of site.

Site Photographs

IMG_20200528_132526.jpg

Photo 5 - Exposed, loose soil at the top of the landfill's south slope. Looking east.

IMG_20200528_132722.jpg

Photo 6 Pond near toe of southwest landfill slope. Looking east.

Site Photographs

IMG_20200528_132655.jpg

Photo 7 - Exposed geosynthetics near pond on southwest slope.

IMG_20200528_132812.jpg

Photo 8 - Crack in soil observed at toe of slope along west side of landfill may be result of soil creep. Looking northeast.

Site Photographs

IMG_20200528_132816.jpg

Photo 9 - Crack in soil observed at toe of slope along west side of landfill. Looking south.

IMG_20200528_132909.jpg

Photo 10 - Construction debris at west side of landfill. Looking north.

Site Photographs

IMG_20200528_133000.jpg

Photo 11 - West perimeter of site at Dawson Creek.
Looking northwest. Rusted steel debris observed on bank.

IMG_20200528_133132.jpg

Photo 12 - General topography looking northeast at west side of landfill.

Site Photographs

IMG_20200528_133352.jpg

Photo 13 - General topography looking west/southwest away from west side of landfill.

IMG_20200528_133916.jpg

Photo 14 - South side of landfill slope with soil creep observed. Looking north. Monitoring location in foreground.

Site Photographs

IMG_20200528_133607.jpg

Photo 15 - General topography looking east at southeast landfill slopes. Concrete debris pile at mid-ground in center of photo.

IMG_20200528_133830.jpg

Photo 16 - Concrete debris piles at south side of landfill. Looking southwest.

Site Photographs

IMG_20200528_134641.jpg

Photo 17 - Exposed waste on the landfill's southeast side slope. Looking west.

IMG_20200528_134700.jpg

Photo 18 - Concrete debris piles and monitoring location at southeast corner of site. Sparse vegetation around monitoring location was observed. Looking southeast.

Site Photographs

IMG_20200528_134734.jpg

Photo 19 - General topography of the east/southeast slope looking north.

IMG_20200528_134851.jpg

Photo 20 - Access road on southeast corner of site. Bins and materials staged to the right are used by transfer station operations. Looking east.

IMG_20200528_135147.jpg

Photo 21 - General topography of the east landfill side slope.

IMG_20200528_135454.jpg

Photo 22 - Top of landfill area used as storage by transfer station operations. Looking south.

Site Photographs

Appendix E
Landfill Gas Generation Potential Calculations

Landfill Gas Generation Potential Calculations
Dawson Creek Landfill Closure Plan and Assessment

	Relatively Inert	Moderately Decomposable	Decomposable	
Gas Production potential, Lo =	20	120	160	m^3 CH4/tonne
lag time before start of gas production, lag =	1	years		
Historical Data Used (years)	47			
1st Year of Historical Data Used	1974			
4 Years after Reporting Year	2024			
methane (by volume)	50%			
carbon dioxide (by volume)	50%			
methane (density) - 1atm, 25C	0.6557	kg/m^3	(25C,SP)	
carbon dioxide (density)	1.7988	kg/m^3	(25C,SP)	

Year	Year Number	Annual Tonnage (tonnes)	Cumulative Waste-in-place (tonnes)	Waste Tonnage Relatively Inert (tonnes)	Waste Tonnage Moderately Decomposable (tonnes)	Waste Tonnage Decomposable (tonnes)	Methane Generation Rate, k Relatively Inert ($year^{-1}$)	Methane Generation Rate, k Moderately Decomposable ($year^{-1}$)	Methane Generation Rate, k Decomposable ($year^{-1}$)	Annual Methane Production (tonnes/yr)
1974	1	9,636	9,636	3,212	3,212	3,212	0.01	0.02	0.05	0.00
1975	2	9,636	19,272	3,212	3,212	3,212	0.01	0.02	0.05	21.90
1976	3	9,636	28,908	3,212	3,212	3,212	0.01	0.02	0.05	42.90
1977	4	9,636	38,544	3,212	3,212	3,212	0.01	0.02	0.05	63.03
1978	5	9,636	48,180	3,212	3,212	3,212	0.01	0.02	0.05	82.34
1979	6	9,636	57,816	3,212	3,212	3,212	0.01	0.02	0.05	100.86
1980	7	9,636	67,452	3,212	3,212	3,212	0.01	0.02	0.05	118.62
1981	8	9,636	77,088	3,212	3,212	3,212	0.01	0.02	0.05	135.66
1982	9	9,636	86,724	3,212	3,212	3,212	0.01	0.02	0.05	152.02
1983	10	9,636	96,360	3,212	3,212	3,212	0.01	0.02	0.05	167.72
1984	11	9,636	105,996	3,212	3,212	3,212	0.01	0.02	0.05	182.79
1985	12	9,636	115,632	3,212	3,212	3,212	0.01	0.02	0.05	197.26
1986	13	9,636	125,268	3,212	3,212	3,212	0.01	0.02	0.05	211.17
1987	14	9,636	134,904	3,212	3,212	3,212	0.01	0.02	0.05	224.52
1988	15	9,636	144,540	3,212	3,212	3,212	0.01	0.02	0.05	237.35
1989	16	9,636	154,176	3,212	3,212	3,212	0.01	0.02	0.05	230.95
1990	17	9,636	163,812	3,212	3,212	3,212	0.01	0.02	0.05	242.29
1991	18	9,636	173,448	3,212	3,212	3,212	0.01	0.02	0.05	253.24
1992	19	9,636	183,084	3,212	3,212	3,212	0.01	0.02	0.05	263.80
1993	20	9,636	192,720	3,212	3,212	3,212	0.01	0.02	0.05	274.00
1994	21	9,636	202,356	3,212	3,212	3,212	0.01	0.02	0.05	283.84
1995	22	9,636	211,992	3,212	3,212	3,212	0.01	0.02	0.05	293.35
1996	23	9,636	221,628	3,212	3,212	3,212	0.01	0.02	0.05	302.53
1997	24	9,636	231,264	3,212	3,212	3,212	0.01	0.02	0.05	311.40
1998	25	9,636	240,900	3,212	3,212	3,212	0.01	0.02	0.05	319.97
1999	26	9,636	250,536	3,212	3,212	3,212	0.01	0.02	0.05	328.25
2000	27	9,636	260,172	3,212	3,212	3,212	0.01	0.02	0.05	336.25
2001	28	9,636	269,808	3,212	3,212	3,212	0.01	0.02	0.05	343.99
2002	29	0	269,808	0	0	0	0.01	0.02	0.05	351.47
2003	30	0	269,808	0	0	0	0.01	0.02	0.05	338.95
2004	31	0	269,808	0	0	0	0.01	0.02	0.05	326.94
2005	32	0	269,808	0	0	0	0.01	0.02	0.05	315.40
2006	33	0	269,808	0	0	0	0.01	0.02	0.05	304.32
2007	34	0	269,808	0	0	0	0.01	0.02	0.05	293.69
2008	35	0	269,808	0	0	0	0.01	0.02	0.05	283.48
2009	36	0	269,808	0	0	0	0.01	0.02	0.05	273.67
2010	37	0	269,808	0	0	0	0.01	0.02	0.05	264.24
2011	38	0	269,808	0	0	0	0.01	0.02	0.05	255.19
2012	39	0	269,808	0	0	0	0.01	0.02	0.05	246.49
2013	40	0	269,808	0	0	0	0.01	0.02	0.05	238.14
2014	41	0	269,808	0	0	0	0.01	0.02	0.05	230.10
2015	42	0	269,808	0	0	0	0.01	0.02	0.05	222.39
2016	43	0	269,808	0	0	0	0.01	0.02	0.05	214.97
2017	44	0	269,808	0	0	0	0.01	0.02	0.05	207.83
2018	45	0	269,808	0	0	0	0.01	0.02	0.05	200.98
2019	46	0	269,808	0	0	0	0.01	0.02	0.05	194.38
2020	47	0	269,808	0	0	0	0.01	0.02	0.05	188.04

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

Rose Marie Rocca
Rose.Marie.Rocca@ghd.com
604.248.3662

Deacon Liddy
Deacon.Liddy@ghd.com
604.248.3671

www.ghd.com