Dawson Creek Groundwater and Surface Water Impact Assessment

Peace River Regional District

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[Compliance statement]

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1. Introduction

GHD has prepared the following Groundwater and Surface Water Assessment Report (Report) for the Peace River Regional District (PRRD) in support of the Dawson Creek Landfill (Site) closure. The location of the landfill is presented on Figure 1, a Site plan is presented on Figure 2.

1.1 Background

The Dawson Creek Landfill is located approximately 4 kilometres (km) east of the City of Dawson Creek. The landfill is located just south of Highway 49 and north of Dawson Creek.

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 1997, ownership of the landfill was transferred to the PRRD.

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 until January 1, 2020. Historically, the clean fill was placed at the crest of the landfill and pushed down slope.

1.2 Assessment Approach

This assessment was undertaken to evaluate groundwater and surface water quality at the Site and assess any impacts related to landfill leachate migration to the receiving groundwater and surface water environments under existing conditions.

The purpose of the impact assessment is to support the conceptual design of the cover rehabilitation program, specifically to determine the level of design needed to reduce leachate generation and improve water quality within the receiving environments.

The following points describe the approach used to complete this assessment:

- The physical setting of the Site was investigated using historical stratigraphic logs. The physical setting is described in terms of subsurface geology and hydrogeology to define the presence and movement of groundwater through the subsurface.
- Groundwater and surface water quality outside the landfill footprint is characterized by samples collected from monitoring wells and surface water courses in the vicinity of the landfill. The sampling program includes the collection of groundwater and surface water samples from "background" locations.
- Leachate indicator parameters were selected based on historical Site groundwater and surface water quality data.
- The groundwater and surface water analytical results for the leachate indicator parameters were assessed and compared to background groundwater and upstream surface water quality to identify potential landfill-related water quality impacts.
- A conceptual Site model was developed to describe existing conditions, the Site physical setting, receptors, compliance locations, and how the Site interacts with the surrounding environment (i.e., pathways from contaminant source to receptor).
- A Hydrologic Evaluation Landfill Performance (HELP) model was created to estimate leachate generation rates and leachate impacted groundwater discharge to the receiving environment under existing conditions.
- Hydraulic monitoring data was used to prepare an annual water balance for the landfill. This water balance was prepared for the purposes of understanding the quantitative movement of groundwater through the Site.

– Assessment of risks to the receiving environment and potential engineered mitigation measures (e.g., low-permeable final cover).

1.3 Regulatory Setting

The appropriate groundwater standards to apply to the Site depend on the current and future groundwater and surface water uses and the potential for groundwater or surface water at the Site to flow to surface water bodies that support aquatic life.

The BC Ministry of Environment and Climate Change Strategy (ENV), formerly the BC MOE, document Protocol 21 for Contaminated Sites: Water Use Determination (Protocol 21) (ENV, 2020) provides the criteria for selecting the appropriate standards to apply to water quality results.

Based on GHD's experience and the guidance provided in Protocol 21, the BC Contaminated Sites Regulation (CSR) and Approved and Working Water Quality Guidelines (WQG) provide an appropriate benchmark for evaluating groundwater and surface water quality at the Site. The following describes the water quality standards that should be used to assess water quality at the Site moving forward and the rationale for using those standards.

Protocol 21 specifies that Aquatic Life (AW) standards apply to sites located within a 500 metre (m) radius of a surface water body. Dawson Creek is located approximately 50 m south of the Site. Therefore, CSR AW standards apply to groundwater at the Site.

To exclude the application of the Drinking Water (DW) standards from the Site, Protocol 21 indicates that there must be no groundwater wells used for drinking water purposes located with a 500 m radius from the Site, and there cannot be a viable aquifer on Site to protect future drinking water use. The Site is underlain primarily by glaciolacustrine clay and till which overly Aquifers 851 and 593. Aquifer 851 is a confined sand and gravel aquifer, and Aquifer 593 is a fractured sedimentary bedrock aquifer. Based on these observations, the CSR DW standards should conservatively apply to groundwater at the Site unless an additional hydrogeologic characterization demonstrates that the surficial soils act as an effective confining layer.

Analytical results for surface water samples are compared to the BC WQGs for the protection of drinking water (DW) and freshwater aquatic life (FWAL).

WQGs include both short term minimum/maximum (STM) (instantaneous) and long-term average (LTA) (30 day mean) guidelines and may apply to dissolved or total parameter concentrations. The long-term average (LTA) guidelines are generally more stringent than the short-term minimum/maximum (STM) guidelines. WQGs are also often dependent on background conditions, hardness, chloride, calcium pH, and/or temperature.

Based on the surface water sampling frequency and methodology conducted at the Site, STM WQGs for total concentrations apply.

2. Field Investigations

Field investigations to assess existing conditions at the landfill were completed by GHD in May 2020 and September 2022. During the Site visits, the following observations were made:

– 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 observed on southwest slope.

3. Site Physical Setting

3.1 Climate

The climate of the Dawson Creek area is characterized by mild, wet summers and cold, dry winters. According to the data collected at the Dawson Creek Airport weather station (Climate ID 1182285), which is located approximately 1 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% 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 Site 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 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 to the southeast corner of the Site.

3.3 Site 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 associated with a former glacial lake and glacial till. Sand and gravel were encountered within a historical, cut off, meander of Dawson Creek. Historical photography shows that the cutoff meander, present in 1964, is in a horseshoe shape beneath the landfill footprint.

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. Available historical borehole logs are presented in Appendix A.

3.4 Hydrogeology

Two regional aquifers underly 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 the primary source of recharge for this aquifer. Aquifer 593 is a bedrock aquifer comprised primarily of shale with some sandstone of the Kaskapau Formation. Aquifer 593 has moderate vulnerability and productivity.

Five monitoring wells (MW) are installed within the overburden at the Site. 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 was completed at Site monitoring wells by AGRA earth and Environmental (AGRA) in 1999, a summary of the hydraulic conductivity estimates is presented in Table 3.1, below. The hydraulic conductivities at the Site range between 3 x 10^{-9} m/sec in the high plasticity clay to 1 x 10^{-4} m/sec in the gravel of the old creek meander at DC-98-1. Based on the high hydraulic conductivity measured at DC-98-1, the cut off meander of Dawson Creek likely provides a preferential pathway for leachate migration directly to Dawson Creek.

Table 3.1 Site Hydraulic Conductivity Estimates

Location	Stratigraphy	Hydraulic Conductivity (m/sec)	Reference
DC-BH101	Clay	5 x 10^{-9}	(Matrix Solutions, 2018)
DC-95-1	Clay and Clay Till	1 x 10^{-7}	(AGRA Earth and Environmental, 1999)
DC-98-5	Clay Till	5 x 10^{-6}	
DC-98-2	Clay w sand	5 x 10^{-7}	
DC-98-1	Gravel Layer	1 x 10^{-4}	
MP99-1A	High Plastic Clay	3 x 10^{-8}	
MP99-1B	High Plastic Clay	3 x 10^{-9}	
MP99-2	High Plastic Clay	3 x 10^{-9}	

Based on the groundwater elevation data provided in annual reports for the Site, 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 m AMSL to the north, to approximately 630 m AMSL 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.

For reference, the 2021 water level data (2021 Annual Monitoring Report, Matrix Solutions Inc.) are provided in Appendix C (Table 5a).

A horizontal groundwater flow velocity in the clay and clay till is estimated to range from 0.01 to 22 metres per year (m/yr). Based on a horizontal gradient of 0.05 m/m (average 2021 groundwater elevations at DC-BH101 and DC-98-3), a range of hydraulic conductivity values between of 5 x 10^{-6} m/sec (DC-98-5) and 3 x 10^{-9} (MP99-1B and MP99-2) and an estimated effective porosity of 0.35 representative of clay till (Spitz & Moreno, 1966). Using a geometric mean hydraulic conductivity of 6.4 x 10^{-8} m/sec, a horizontal groundwater flow velocity of 0.29 m/year is estimated.

Groundwater monitoring wells and flow direction are presented on Figure 5.

3.5 Estimated Leachate Generation Rate

Leachate generation at the landfill was estimated using the HELP model. To estimate an overall leachate generation rate for the landfill, leachate generation was modeled for both the landfill plateau and side slopes. Leachate generation was assumed to be the rate at which leachate percolated through the clay till underlying the landfill.

Leachate generation was modeled for two scenarios: the first model assumed a low permeability cover (1.0 x 10^{-9} m/sec), representing properly moisture-conditioned and compacted cover material with minimal deterioration; and the second model assumed a medium permeability cover (1.0 x 10^{-7} m/sec), representing a conservative estimate for the effective permeability of the existing cover at the Landfill. Both scenarios potentially conform to the landfill cover material requirements set out in the 2016 BC Landfill Criteria for Municipal Solid Waste (Criteria).

The HELP model inputs are summarized below, and leachate generation rates calculated from the HELP models are presented in Table 3.2, below. The estimated leachate generation rates reported in the 2012 Dawson Creek Landfill

Hydrogeologic Assessment (AECOM, 2012) are presented in Table 3.2 for comparison. As summarized below, the results of the medium permeability cover are generally comparable to previous estimates made by AECOM. It is recommended that test pitting and soil sampling be completed to accurately determine hydraulic conductivity and thickness of landfill cover.

Leachate generation rates estimated by GHD and HELP model inputs and results are presented in Appendix B.

HELP Model Assumptions/Inputs:

Slopes: 27% side slopes; 1% plateau

Topsoil Thickness: 15 cm

Cover thickness: 60 cm

Cover hydraulic conductivity: 1.0 x 10^{-9} m/sec (Low permeability)

Cover hydraulic conductivity: 1.0 x 10^{-7} m/sec (Medium permeability)

Landfill Plateau area: 3.125 Hectares (Ha)

Landfill Side Slopes Area: 3.125 Ha

Total Landfill Area: 6.25 Ha

Table 3.2 HELP Model Leachate Generation Rates

HELP Model Simulation	Precipitation (m^3/year)	Leachate Generation Rate (m^3/year)	Runoff (m^3/year)	Evapotranspiration (m^3/year)
AECOM, 2012 (Low Rate)	28,892	3,285	-	-
AECOM, 2012 (High Rate)	28,892	6,242	-	-
GHD, 2023 (Low Permeability)	28,892	631	6,368	21,902
GHD, 2023 (Medium Permeability)	28,892	5,197	5,107	18,597

4. Water Quality Monitoring

4.1 Environmental Monitoring Program

The purpose of the water quality monitoring program is to characterize groundwater and surface water quality at the Site and assess water quality impacts resulting from landfill leachate migration. Groundwater quality is assessed at four monitoring locations located upgradient, cross-gradient, and downgradient of the landfill waste footprint. The following groundwater monitoring wells are included in the current environmental monitoring program:

– DC-BH101 (Upgradient)
– DC-95-2 (Cross-Gradient)
– DC-19-1 (Downgradient)
– DC-98-1 (Downgradient)

Surface water quality is assessed at four monitoring locations located upstream, midstream, and downstream of the landfill. The following surface water monitoring locations are included in the current environmental monitoring program:

– DC-SW6 (Upstream)
– DC-SW4 (Midstream)

– DC-SW2 (Midstream)
– DC-SW7 (Downstream)

The locations of the groundwater monitoring wells and surface water monitoring locations are illustrated on Figure 5. Appendix C, Table 5a (2021 Annual Monitoring Report, Matrix Solutions Inc.) includes a summary of the well completion details where available.

Surface water monitoring location DC-SW4 is located on an oxbow adjacent to the main channel of Dawson Creek. Based on historical satellite imagery of the Site, the oxbow does not appear to have a perennial hydraulic connection to the main channel of Dawson Creek. Because this monitoring location does not represent surface water quality in Dawson Creek, it was not considered in this assessment.

The groundwater and surface water monitoring and sampling program were completed by SLR Consulting Ltd. Between 2015-2017, and by Matrix Solutions Inc. from 2018 to 2022.

As part of the monitoring program, groundwater, and surface water samples are collected and analyzed for a comprehensive list of field parameters, general chemistry, nutrients, metals, hydrogen sulfide, hydrocarbons and extractable petroleum hydrocarbons (EPH). The analytical results from the 2021 Annual Monitoring Report prepared by Matrix Solutions Inc. along with the selected comparative criteria are presented in Appendix C (Tables 5b – 5j). The groundwater samples have been compared to the CSR DW and AW criteria and the Surface Water samples have been compared to the WQG DW and FAW criteria. Historical concentrations of leachate indicator parameters and concentration trend analysis from the 2021 Annual Monitoring Report prepared by Matrix Solutions Inc. are presented in Appendix D.

4.2 Groundwater Quality

4.2.1 Background Groundwater Quality

Monitoring wells DC-BH101 is located immediately upgradient of the Landfill approximately 10 m northwest of the waste footprint. DC-BH101 is screened within till/clay unit. Based on the location of this well and historical water quality, it is considered to be representative of background groundwater quality that has not been affected by landfill related impacts. Elevated concentrations of groundwater analytical parameters observed at DC-BH101 are interpreted to be representative of natural conditions and/or impacts from off-Site related activities occurring upgradient of the Site.

4.2.2 Leachate Quality and Quantity

Matrix Solutions Inc. determined that data documenting leachate concentrations beneath the Site is not available. Leachate indicator parameters for the landfill are assumed to be sodium, chloride, sulphate, boron, iron, and manganese based on leachate water quality from other landfills in the Peace River Regional District.

4.2.3 Groundwater Quality Impact Assessment

Impacts to groundwater from landfill leachate are clearly apparent at the downgradient monitoring wells, where concentrations of leachate indicator parameters chloride and boron (Appendix C) are observed at significantly higher levels than in upgradient and cross-gradient groundwater. Concentrations of ammonia, arsenic, cobalt, iron, and manganese are also observed at significantly higher levels in downgradient groundwater than in upgradient and cross-gradient groundwater.

A summary of the analytical parameters reported at concentrations in excess of their applicable groundwater quality standards between 2018 and 2021 are presented in Table 4.1, below. Please note that the exceeding parameters listed below are summarized from the historical reports prepared by others.

Table 4.1 2018-2021 Groundwater Quality – Analytes Exceeding Applicable Water Quality Standards.

Year	DC-BH101 (Upgradient)	DC-95-2 (Cross-Gradient)	DC-19-1 (Downgradient)	DC-98-1 (Downgradient)
2018	Na, SO_4, Li, Sr, U,	Na, SO_4, S^{2-} as H_2S, Co, Li, Sr	--	Na, Cl, SO_4, NH_3-N, As, Co, Fe, Li, Mn, Sr
2019	Na, SO_4, Li, Sr, U,	Na, SO_4, Co, Li, Mn, Sr	Na, Cl, Co, Li, Mn, Sr, U	Na, Cl, NH3-N, As, Co, Fe, Li, Mn, Sr
2020	Na, SO_4, Li, Sr, U	Na, SO_4, Co, Li, Mn, Sr	Na, Cl, SO_4, Co, Li, Mn, Sr, U	Na, Cl, SO_4, NH_3-N, S^{2-} as H_2S, As, Co, Fe, Mn
2021	Na, SO_4, Li, Sr, U	Na, SO_4, Co, Li, Mn, Sr	Na, SO_4, Co, Li, Mn, Sr, U	Na, Cl, NH3-N, As, Co, Fe, Li, Mn, Sr

Notes:
-- - data not collected
** - no analytes in sample exceeded both applicable standards and background concentrations.
Criteria applied: BC CSR: AW and DW; BC WQG: AW, DW, WW, IW, and LW

It should be noted that the concentrations of sodium, sulphate, lithium, and strontium at the background well are frequently higher than concentrations reported at the cross-gradient DC-95-2 and downgradient well DC-19-1. Concentrations of lithium and strontium are occasionally higher in background when compared to DC-98-1. As shown above the number of parameters in excess of their applicable standards is greater at the downgradient most monitoring well. DC-98-1 is screened within the cut off meander of Dawson Creek and provides worst-case landfill impacts.

Based on the historical data, concentrations of leachate indicator parameters in downgradient groundwater appear to have been stable for several years. These observations indicate that while impacts to groundwater from landfill leachate are present, and resulting in exceedances of applicable groundwater quality standards, they do not appear to be worsening.

While groundwater quality concentrations have stabilized, it is recommended that monitoring and reporting continue to ensure that groundwater quality remains at current concentrations or decrease over time.

4.3 Surface Water Quality

4.3.1 Background Surface Water Quality

Surface water monitoring location DC-SW6 is located in the main channel of Dawson Creek approximately 200 m upstream of the landfill waste footprint. Based on the location of this monitoring location and historical water quality results, it is considered to be representative of upstream surface water quality that has not been affected by landfill related impacts. Background surface water quality in Dawson Creek is known to be impacted by the wastewater treatment plant, which is located upstream from the landfill and contributes a large proportion of surface water flow to the creek (AECOM, 2012). Elevated concentrations of surface water analytical parameters observed at DC-SW6 are interpreted to be representative of natural conditions and/or impacts from the wastewater treatment plant.

4.4 Surface Water Quality Impact Assessment

Based on the historical surface water quality data (Appendix C), impacts to surface water quality in Dawson Creek from landfill leachate appear to be present but limited. Concentrations of chloride, sulphate, chromium, iron, and manganese have generally been similar, or higher in concentration at the upstream monitoring location (DC-SW6) compared to the mid- and downstream locations (DC-SW2 and DC-SW7). Concentrations of these parameters exceed BC WQGs at the upstream monitoring location. This indicates that the elevated concentrations of these parameters in surface water are related to activities upstream of the landfill.

Concentrations of sodium and boron show seasonal variations, with elevated concentrations observed at the mid- and downstream locations relative to background surface water, indicating that leachate impacted groundwater is likely discharging to Dawson Creek during the summer and fall. Based on the historical data and trend analyses completed by Matrix (Matrix, 2022) (Appendices C and D), concentrations of boron and sodium in Dawson Creek are well below the BC WQGs and show no overall increasing trend.

The midstream (SW2) and downstream (SW7) surface water monitoring points are located downstream of the confluence of the former meander and Dawson Creek. Water quality at these points are good representatives of worst-case leachate impacted groundwater discharging to Dawson Creek. As described above, the landfill is having some influence on surface water quality but is not significant in comparison to upstream impacts. Thus, worst-case groundwater discharge is not having a significant influence on surface water quality.

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). Reported exceedances of the applicable surface water quality standards between 2017 and 2021 are presented in Table 4.2.

Table 4.2 2017-2021 Surface Water Quality – Analytes Exceeding Applicable Water Quality Standards

Year	DC-SW6 (Upstream)	DC-SW2 (Midstream)	DC-SW7 (Downstream)
2017	Conductivity, total dissolved solids, sulphide, faecal coliforms, aluminum, chromium, iron, manganese,	Conductivity, total dissolved solids, sulphide, faecal coliforms, aluminum, beryllium, chromium, iron, manganese	Conductivity, total dissolved solids, faecal coliforms, chromium, manganese
2018	Temperature, field pH, field dissolved oxygen, chloride, total phosphorous, iron, e.coli	Field pH, field dissolved oxygen, lab pH, e.coli	Field pH, field dissolved oxygen, lab pH, chloride, ammonia-nitrogen, total phosphorous,
2019	Temperature, chloride, ammonia-nitrogen, total phosphorous, iron, faecal coliforms	Temperature, chloride, nitrite-nitrogen, total phosphorous, faecal coliforms	Temperature, field dissolved oxygen, chloride, nitrite-nitrogen, total phosphorous, faecal coliforms
2020	Temperature, field dissolved oxygen, ammonia-nitrogen, total phosphorous, iron, faecal coliforms	Chloride, ammonia-nitrogen, total phosphorous, iron	Temperature, ammonia-nitrogen, total phosphorous
2021	Temperature, chloride, sulphide, total phosphorus, cobalt, iron, manganese, faecal coliforms	Temperature, field dissolved oxygen, chloride, ammonia-nitrogen, total phosphorus, arsenic, cobalt, iron, manganese	Chloride, ammonia-nitrogen, total phosphorus, cobalt, iron, manganese

5. Conceptual Site Model

Based on the available regional and Site-specific information, the following Conceptual Site model has been developed:

– The Site is located south of highway 49 and immediately north of Dawson Creek. The Site slopes to the south towards Dawson Creek.
– The landfill received municipal solid waste and animal waste between 1974-2002 and received clean fill until 2020. The Site now operates as a transfer station.
– Groundwater elevations measured at monitoring wells across the Site indicate that groundwater flow is to the south toward Dawson Creek.
– The surficial geology underlying the Site consists of glaciolacustrine deposits of laminated to massive clay and glacial till which act as a barrier to groundwater migration.

- There is a historical cut off meander of Dawson Creek beneath the landfill footprint. The meander is characterized by sand and gravel and notably higher permeability and hydraulic conductivity than the surrounding glaciolacustrine deposits. The meander is interpreted to be preferential pathway for leachate migration. Leachate generated in the landfill would preferentially flow through the more permeable sand and gravel and discharge into Dawson Creek.

– Leachate generation for the landfill under the existing conditions of the final cover is estimated to be between 631 to 5,197 m^3 per year.
– Background groundwater quality at the Site (DC-BH101) is characterized by elevated concentrations of sodium, sulphate, lithium, strontium, and uranium which have been consistently observed at concentrations exceeding the applicable groundwater quality standards at the Site. The elevated concentrations of these parameters are interpreted to be representative of natural conditions and/or impacts resulting from off-Site activities upgradient of the landfill.
– Downgradient groundwater quality at the Site (DC-19-1 and DC-98-1 is characterized by elevated concentrations (i.e., elevated above background groundwater quality) of chloride, ammonia, H_2S, arsenic, boron, cobalt, iron, and manganese, which are interpreted to represent impacts from landfill leachate.
    - Monitoring well DC-98-1, is located within the Dawson Creek meander. Thus, water quality result represent worse-case migration of leachate impacts through the preferential pathway.
    - Concentration versus time plots show that groundwater impacts have been stable for a number of years.
– Surface water quality in Dawson Creek is affected by wastewater effluent from the wastewater treatment plant located upstream from the Site.
    - The midstream (SW2) and downstream (SW7) surface water monitoring points are located downstream of the confluence of the former meander and Dawson Creek. Water quality at these points are good representatives of worst-case leachate impacts discharging to Dawson Creek.
– A comparison between upstream, midstream, and downstream water quality shows that landfill is having some influence on water quality in Dawson Creek; however, concentrations of landfill derived analytes are not greater than BC WQG (sodium and boron). It is 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).

6. Water Balance Model

GHD developed a generalized water balance model to quantitatively estimate the movement of groundwater and leachate through the Site. In order to develop the water balance model, the Site was divided into three areas: upgradient of the landfill, the landfill footprint, and downgradient of the landfill. The following describes the water inputs and outputs considered for each of the three areas.

Area 1 – Upgradient of the Landfill

Area 1 represents the area directly north or upgradient of the landfill. Water input into Area 1 consists of the infiltration of precipitation and groundwater flow from further upgradient. Water output from Area 1 consists of groundwater flux through the glaciolacustrine deposits and beneath the landfill footprint.

Area 2 – Landfill Footprint

Area 2 represents the landfill footprint. The water inputs to Area 2 include groundwater flux from upgradient and infiltration of precipitation over the landfill footprint (i.e., leachate generation). The amount of infiltration into the landfill is based on existing conditions including landfill cover soil, vegetative coverage, evaporative zone depth, slope, and waste thickness. The rate of leachate generation was estimated using the HELP model as described in Section 3.5.

Water output from Area 2 consists of leachate impacted groundwater flux to Area 3 as well as evapotranspiration of precipitation falling onto the landfill mound. It is likely that much of the leachate flux from Area 2 would flow through the former Dawson Creek meander.

Area 3 – Downgradient

Area 3 represents the area downgradient of the landfill footprint. The water inputs to Area 3 include infiltration of precipitation, and flux from Area 2. Water output from Area 3 consists of discharge to Dawson Creek, runoff of precipitation into Dawson Creek, and evapotranspiration.

Dawson Creek Meander

Sand and gravel were encountered within the cut off meander of Dawson Creek. The hydraulic conductivities in the sand and gravel is estimated to be on the order of 1 x 10^{-4} m/sec (measured at DC-98-1). Based on the hydraulic conductivity, the old creek meander of Dawson Creek likely provides a preferential pathway for leachate migration directly to Dawson Creek. It is likely that leachate impacted groundwater from Area 2, discharges into the meander which is hydraulically connected to Dawson Creek; however, the horizontal groundwater velocity within the clay and clayey till material would limit discharge into the meander. Some infiltration of precipitation would occur into the meander which would further dilute impacts originating from Area 2. Because the receptor of groundwater discharge within the meander is still Dawson Creek, this area has not been considered separately from Area 3.

6.1 Calculation Methodology and Key Inputs

The following sections provide descriptions of the key methodologies and inputs used in creating the water balance model. Appendix E provides the detailed step-by-step calculations used in the model as well as the data used to complete those calculations. Simplified calculations are presented in each subsection.

6.1.1 Area 1 – Upgradient of Landfill

The groundwater flux flowing across the boundary of Area 1 can be calculated using Darcy's Law and is expressed by the following equation:

$$Q_1 = K \times A \times i$$

Where:

Q_1= flux or flow across the width of the landfill footprint within Area 1 (m^3/year)

K = hydraulic conductivity (m/sec)

A = Cross-sectional area through which groundwater is flowing (m^2)

i = hydraulic gradient or change in hydraulic head over a distance (between DC-BH101 and DC-98-3) (m/m)

Where the cross-sectional area is calculated by the following:

$$A = L \times D$$

Where:

L = length of the landfill footprint which is perpendicular to groundwater flow (m)

D = the saturated thickness of the underlying aquifer (m)

Groundwater influx from Area 1 was estimated based on the following:

– An average horizontal gradient of 0.05 m/m. This value was calculated based on the May 19, July 14, and October 6, 2021, groundwater elevations measured at DC-BH101 and DC-98-3.
– The upgradient length of the landfill footprint which is perpendicular to groundwater flow is estimated to be approximately 256 m.
– The assumed saturated thickness of the aquifer underlying the landfill is estimated to be approximately 12 m based on the average 2021 observed groundwater elevation at DC-BH101 relative to the elevation of Dawson Creek.
– A geometric mean hydraulic conductivity of 6.4×10^{-8} m/sec based on the hydraulic conductivity estimates from MW95-1, MW98-5, MW98-2, MW99-1A/B, and MW99-2.

The groundwater flux from Area 1 (Q_1) entering Area 2 was calculated to be 300 m^3 per year.

Calculations:

$$\begin{aligned} Q_1 &= K \times A \times i \\ &= 6.3 \times 10^{-8}\, m/s \times (256 \times 12.0)\, m^2 \times 0.05\, m/m \times 31536000\, s/yr \\ &= 300\, m^3/yr \end{aligned}$$

Detailed step-by-step calculations of the entire water balance, including the flux from Area 1, are included in Appendix E.

6.1.2 Area 2 – Landfill Footprint

A portion of the precipitation that falls onto the landfill infiltrates and generates leachate, which then mixes with groundwater and follows the natural groundwater flow direction. Leachate generation from the landfill footprint (Q_2) was estimated using the HELP Model described in Section 3.5.

Leachate generation under existing conditions was estimated to be between 631 and 5,197 m^3 per year ($Q_{2\ Low\ Permeability}$ and $Q_{2\ Medium\ Permeability}$).

Outflow from Area 2 into Area 3 ($Q_3 = Q_1 + Q_2$) is estimated to be between 931 and 5,497 m^3 per year.

Calculations:

$$\begin{aligned} Q_{3\ Low\ Permeability} &= Q_1 + Q_{2\ Low} \\ &= 300\, m^3/yr + 631\, m^3/yr \\ &= 931\, m^3/yr \\ Q_{3\ Medium\ Permeability} &= Q_1 + Q_{2\ Med} \\ &= 300\, m^3/yr + 5197\, m^3/yr \\ &= 5497\, m^3/yr \end{aligned}$$

6.1.3 Area 3 – Downgradient

A portion of the precipitation falling onto the area downgradient of the landfill will infiltrate through the subsurface and mix with the groundwater flow from Area 2. Groundwater recharge flux from downgradient precipitation was estimated by multiplying the precipitation infiltration rate by area downgradient of the landfill. The infiltration rate for Dawson Creek area was obtained from Protocol 2 for Contaminates Sites (2017)[1]. The area downgradient of the landfill was estimated to be approximately 15,000 m^2. Based on the Dawson Creek infiltration rate of 80 mm/yr, the flux of precipitation infiltration downgradient of the landfill is estimated to be 1200 m^3/yr (Q_4).

The groundwater flux leaving Area 3 ($Q_5 = Q_3 + Q_4$) was calculated to be between 2,131 and 6,697 m^3 per year. This value is representative of the upgradient groundwater flux that mixes with leachate and downgradient precipitation that

[1] Protocol 2 for Contaminated Sites, 2017. Ministry of Environment and Climate Change Strategy

discharges into Dawson Creek. The clean stormwater runoff from Area 3 would also enter Dawson Creek but would not adversely influence groundwater quality.

This is estimate is shows that leachate is between 30 and 78% of the volume discharging into the creek (based on a low or medium permeable cover material). Given the contrast in permeability between the clayey soils and sand and gravel, it is likely that much of this discharge is occurring within the former Dawson Creek meander.

Calculations:

$$Q_{5\,Low} = Q_{3\,Low} + Q_4$$
$$= 931\ m^3/yr + 1200\ m^3/yr$$
$$= 2131\ m^3/yr$$

$$Q_{5\,High} = Q_{3\,Med} + Q_4$$
$$= 5497\ m^3/yr + 1200\ m^3/yr$$
$$= 6697\ m^3/yr$$

7. Conclusions

Site Physical Setting

– The Site is located south of Highway 49 and north of Dawson Creek

– Based on Site inspections, the following observations have been made:

- 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 observed on southwest slope

Site Hydrogeology

– Groundwater levels and quality is monitored at wells DC-98-5, DC-BH101, DC-95-2, DC-98-1, and DC-98-3, installed upgradient, cross-gradient, and downgradient of the landfill within the overburden

– Groundwater elevations at the Site range from approximately 643 m AMSL to the north, to approximately 630 m AMSL to the south.

– Groundwater at the Site flows to the south, following local topography and towards Dawson Creek.

– Hydraulic conductivity in the overburden has been estimated to range from 3 x 10^{-9} to 1 x 10^{-6} m/sec in the clay till and 1 x 10^{-4} m/sec in the sand and gravel in the old creek meander of Dawson Creek

– The contrast in hydraulic conductivity between the clay till and creek meander will result in a preferential pathway for groundwater and leachate to flow to Dawson Creek

Groundwater Quality

– At the downgradient monitoring wells DC-19-1 and DC-98-1, concentrations of chloride, boron, ammonia, H_2S, arsenic, cobalt, iron, and manganese are elevated compared to upgradient and cross-gradient groundwater and exceed CSR DW and/or FWAL water quality standards.

– Based on the historical data, concentrations of leachate indicator parameters in downgradient groundwater appear to be stable indicating that the presence of leachate is not worsening over time.

Surface Water Quality

– Background surface water quality in Dawson Creek is known to be impacted by the wastewater treatment plant, which is located upstream from the landfill and contributes a large proportion of surface water flow to the creek
– Elevated concentrations of surface water analytical parameters observed in Dawson Creek are interpreted to be representative of natural conditions and/or impacts from the wastewater treatment plant
– Concentrations of leachate indicator parameters in surface water within Dawson Creek are generally similar or higher at monitoring locations upstream of the landfill compared to mid-stream and down-stream locations
– Groundwater impacted by leachate discharges into Dawson Creek in the summer and fall as indicated by elevated concentrations of sodium and boron at downstream surface water monitoring locations.
– Boron and sodium concentrations in Dawson Creek are well below the applicable water quality standards and show no increasing trends, indicating that groundwater recharge is not adversely affecting freshwater aquatic life in Dawson Creek.
– The landfill is not adversely impacting freshwater aquatic life in Dawson Creek.

Leachate Generation Rate

– Leachate generation at the landfill was estimated using the HELP model for two scenarios
    - The first model assumed a low permeability cover (1.0×10^{-9} m/sec), representing properly moisture-conditioned and compacted cover material with minimal deterioration
    - The second model assumed a medium permeability cover (1.0×10^{-7} m/sec), representing a conservative estimate for the effective permeability of the existing cover at the Landfill
– Based on the two scenarios, the leachate generation for the landfill was estimated to be between 631 and 5,197 m^3 per year

Water Balance Model

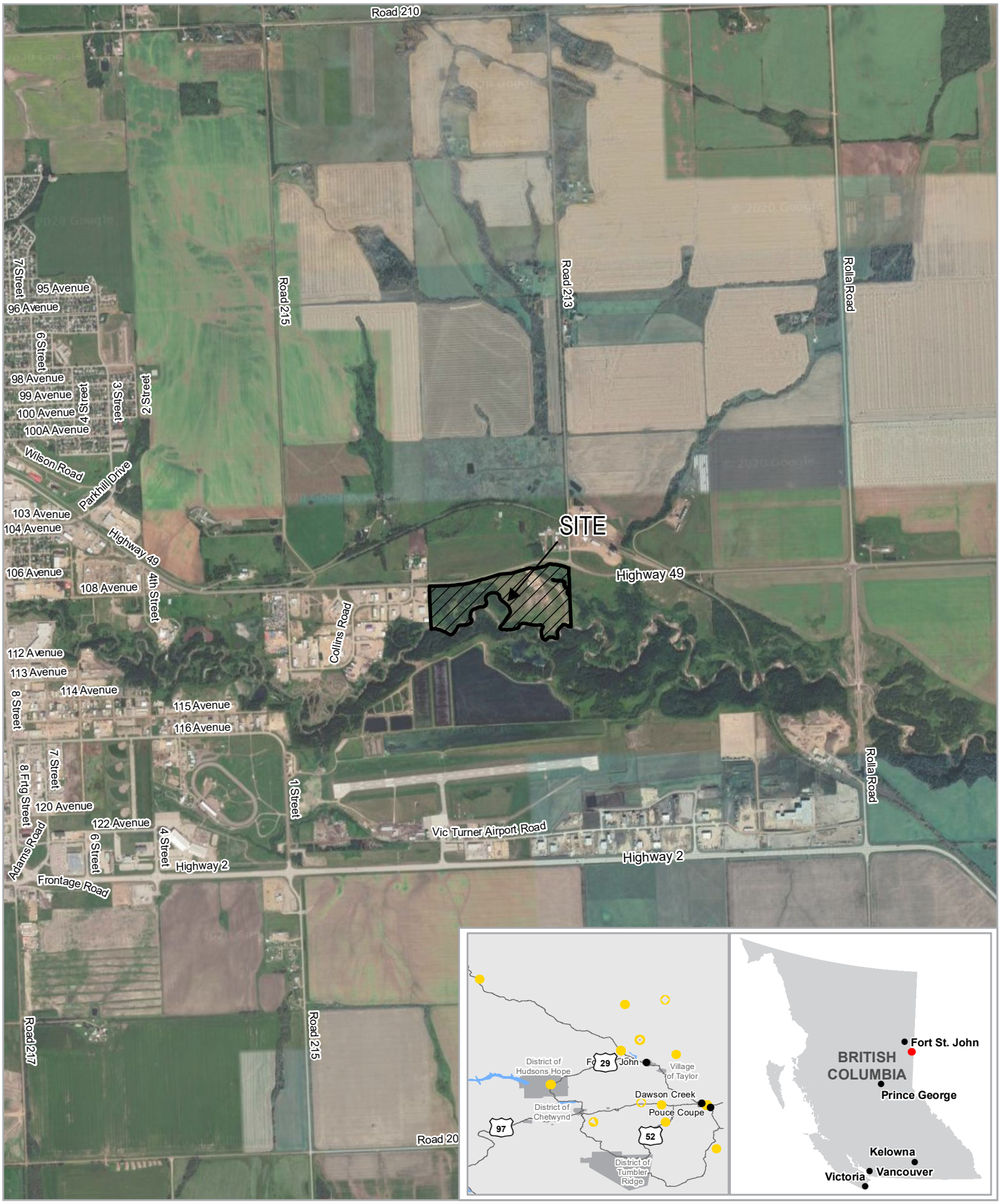
– A water balance model for the Site to quantitatively estimate the movement of groundwater and leachate through the Site was completed
– The model considered groundwater flow from upgradient of the landfill, leachate generated within the landfill footprint using a HELP model, and precipitation falling downgradient of the landfill footprint
– The groundwater discharge into Dawson Creek is estimated to be between 2,131 and 6,697 m^3 per year

8. Recommendations

Based on the findings of this Report, the following recommendations are made:

– Test pitting needed to determine hydraulic conductivity and thickness of landfill cover. This can be used to confirm the results of the HELP model and confirm leachate generation rates
– Continue monitoring groundwater and surface water quality at the Site
– Implement cover rehabilitation measures described in the Cover Rehabilitation report (GHD, 2023)

Figures



Paper Size ANSI A

0 200 400 600 800

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 10N

N

GHD

DAWSON CREEK LANDFILL CLOSURE PLAN AND ASSESSMENT
DAWSON CREEK, BC
PEACE RIVER REGIONAL DISTRICT

Project No. **11213132**
Revision No. **-**
Date **Oct 20, 2020**

SITE LOCATION PLAN

FIGURE 1

Q:\GIS\PROJECTS\11213000s\11213132\Layouts\202008_RPT\11213132_202007_RPT013_GIS001.MXD

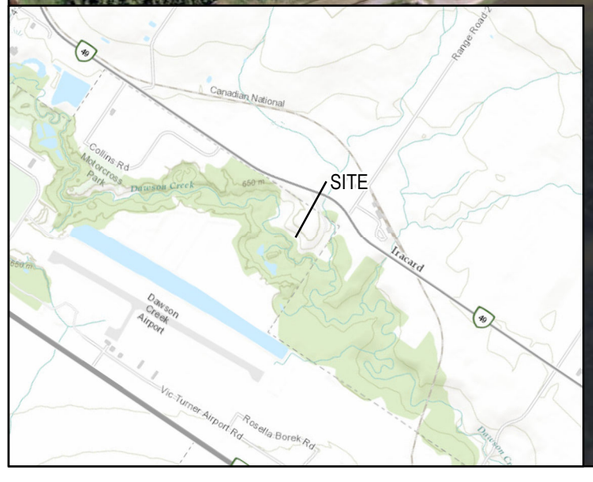
Data source: gOOGLE eARTH iMAGERY, VARIOUS DATES - Accessed 2020

SITE BOUNDARY

APPROXIMATE LIMIT OF WASTE

APPROXIMATE LOCATION OF OLD CREEK MEANDER

SITE



Paper Size ANSI B

0 50 100

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 10N

N

GHD

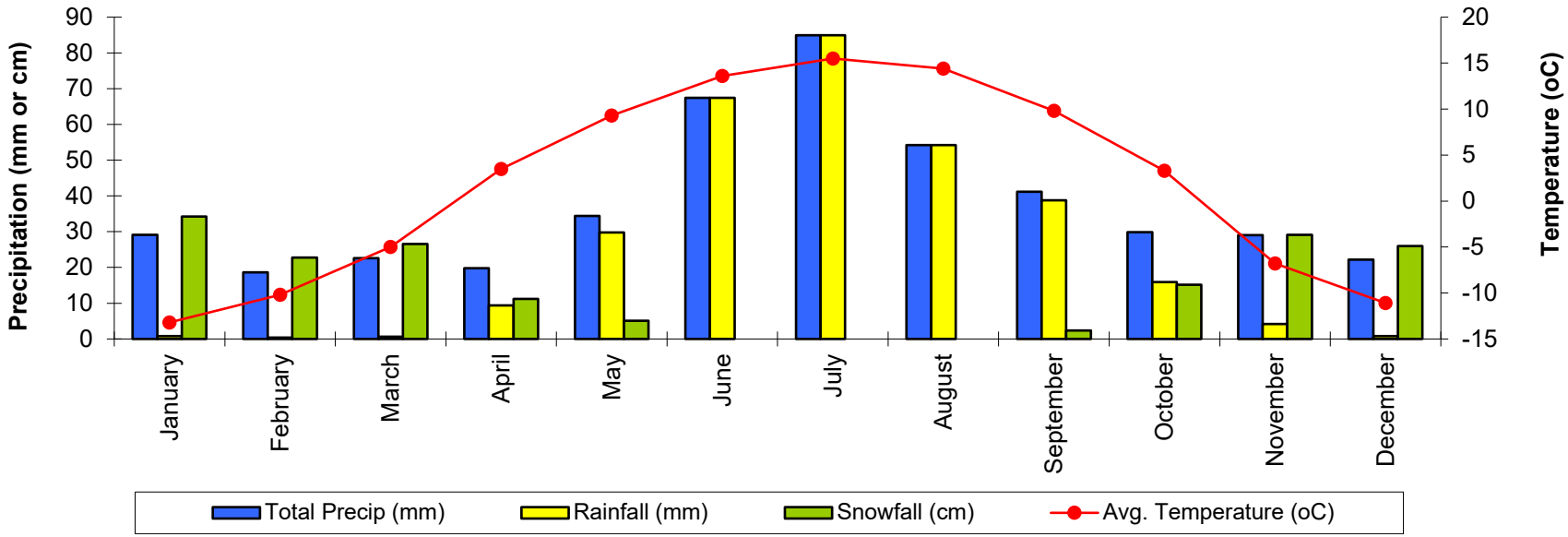
DAWSON CREEK
BRITISH COLUMBIA
GROUNDWATER AND SURFACE WATER IMPACT ASSESSMENT

SITE PLAN

Project No. **11213132**
Revision No. **-**
Date **Sep 1, 2023**

FIGURE 2

Q:\GIS\PROJECTS\11213000s\1213132\Layouts\202208_RPT001\11213132_202208_RPT001_GIS005.mxd
Print date: 01 Sep 2023 - 15:33



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**

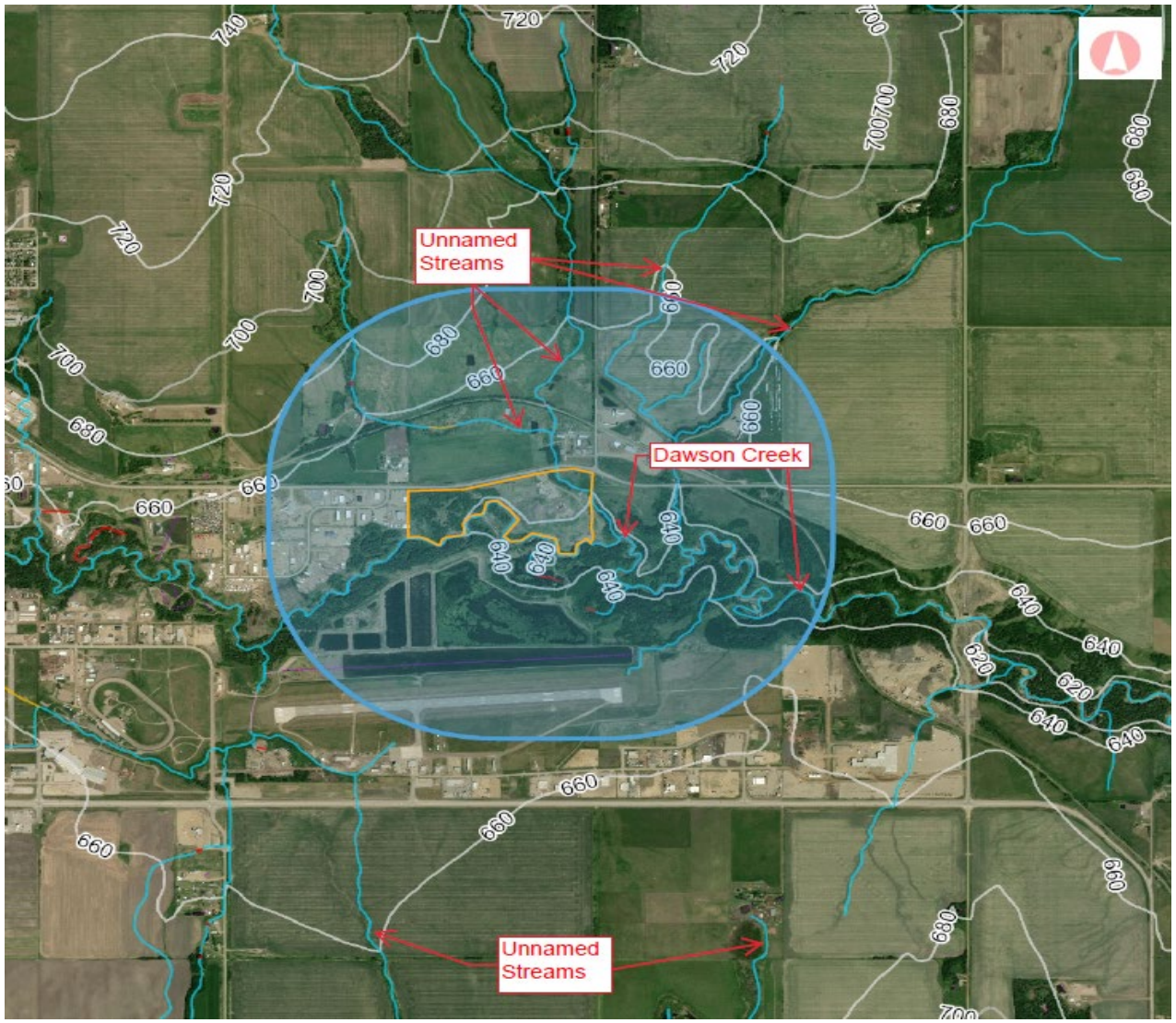
Notes:

(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
GROUNDWATER AND SURFACEWATER IMPACT 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

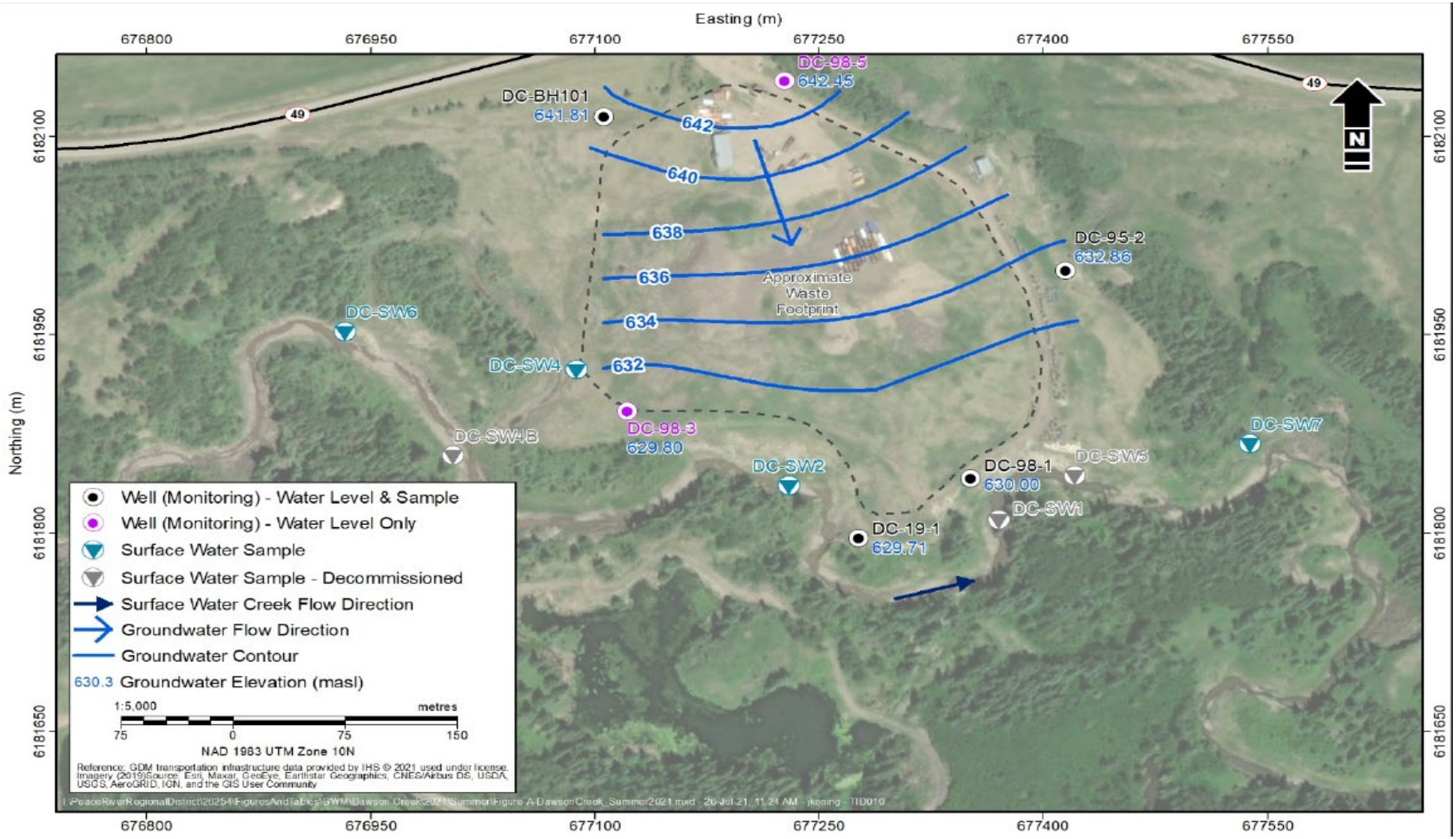
FIGURE 4

TOPOGRAPHY AND DRAINAGE WITHIN 1KM

GROUNDWATER AND SURFACEWATER IMPACT ASSESSMENT

DAWSON CREEK, BC

Peace River Regional District



Source: 2021 Groundwater and Surface Water Monitoring and Sampling Program, Peace River Regional District Landfill Sites, Peace River Regional District, Dawson Creek BC. By Matrix Solutions Inc, March, 2022.

FIGURE 5
GROUNDWATER FLOW DIRECTION
GROUNDWATER AND SURFACEWATER IMPACT ASSESSMENT
DAWSON CREEK, BC
Peace River Regional District

Appendices

Appendix A

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

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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

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REVIEWED BY: AGK
Fig. No:

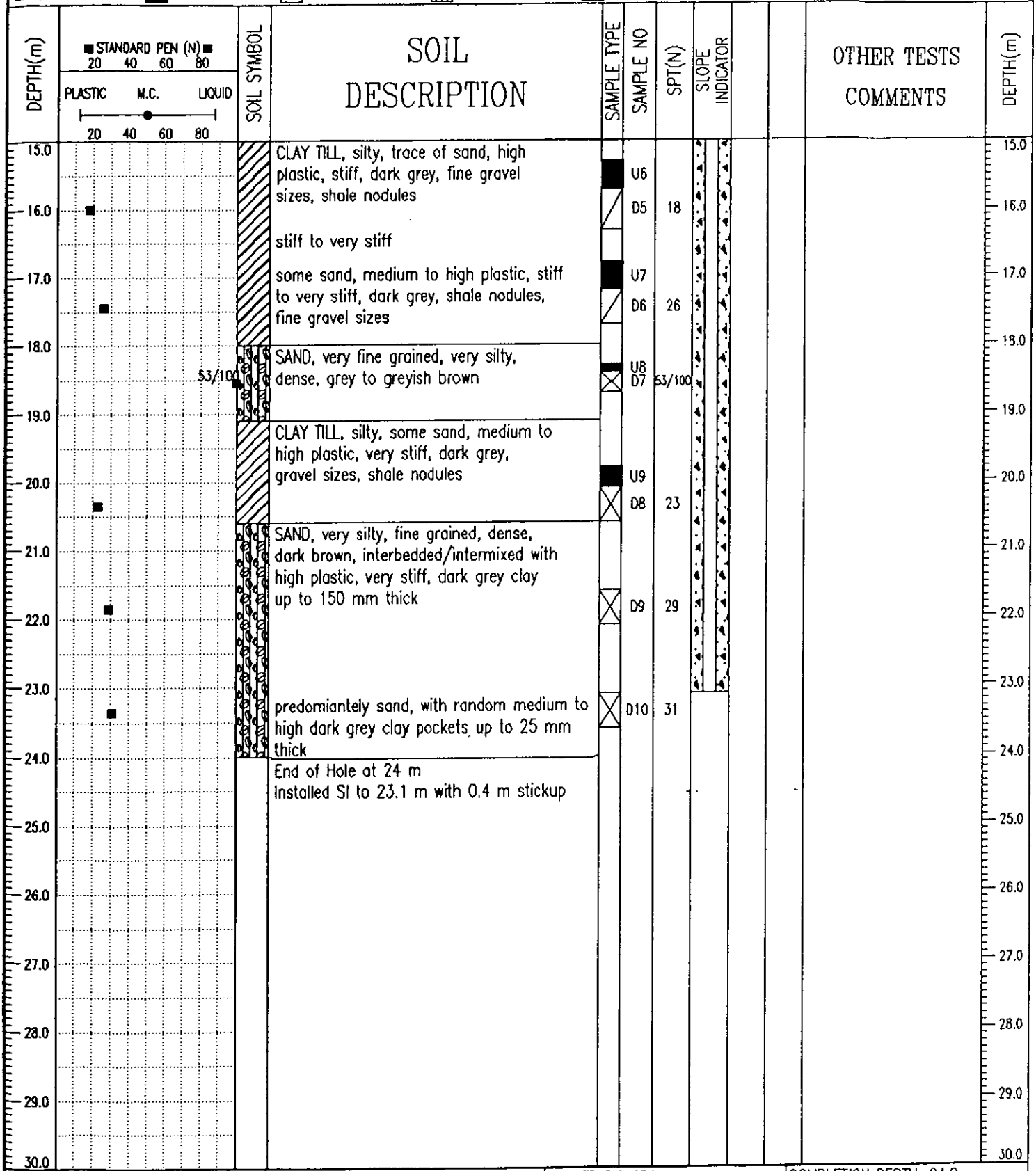
COMPLETION DEPTH: 24.0 m
COMPLETE: 98/04/14

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



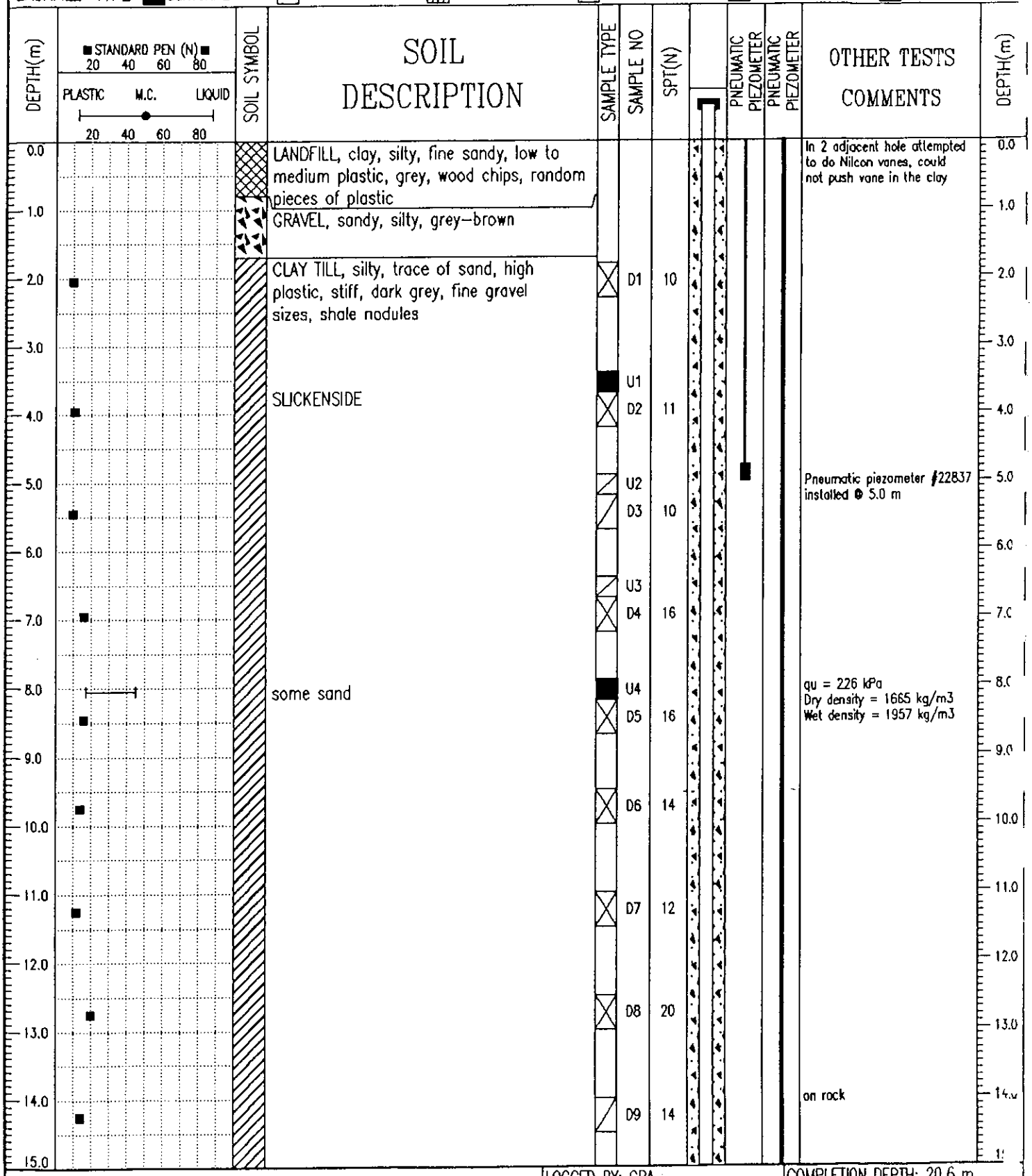
AGRA Earth & Environmental Limited Edmonton, Alberta	LOGGED BY: CRA	COMPLETION DEPTH: 24.0 m
	REVIEWED BY: AGK	COMPLETE: 98/04/14
	Fig. No:	Page 2 of 2

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

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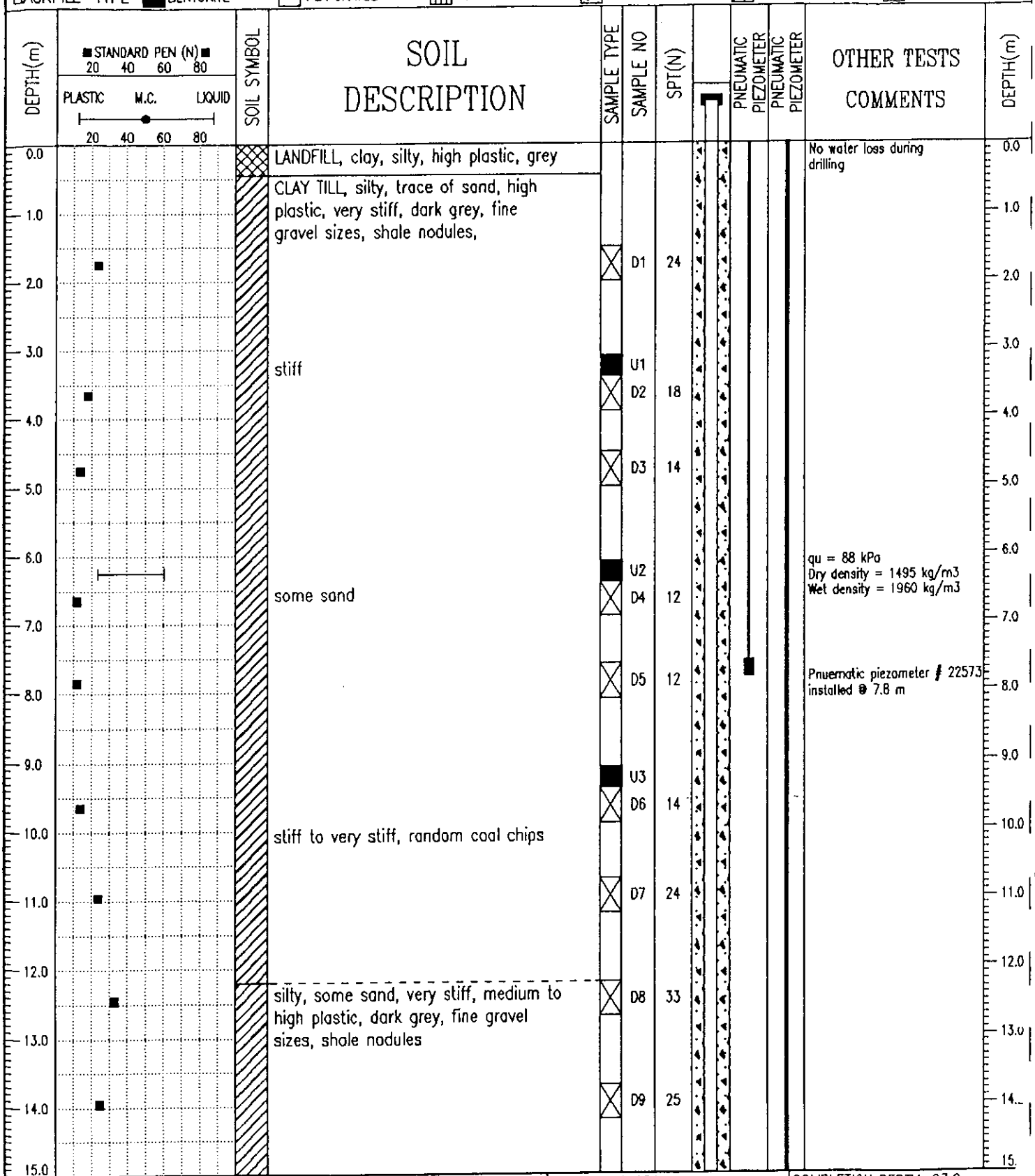
LOGGED BY: CRA | COMPLETION DEPTH: 20.6 m
REVIEWED BY: AGK | COMPLETE: 98/04/16
Fig. No: | Page 2 of 2

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

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

16.0

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

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

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

20.0 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

21.0

22.0

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

24.0

25.0

26.0

27.0

28.0

29.0

30.0

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

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LOGGED BY: CRA | COMPLETION DEPTH: 23.0 m
REVIEWED BY: AGK | COMPLETE: 98/04/17
Fig. No: | 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						

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

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

98/05/26 TETRA4 (TSAM)

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 B

HELP Model Inputs and Results

APPENDIX B - TABLE 1
SUMMARY OF HELP MODEL INPUTS AND RESULTS
Dawson Creek Landfill

	Low Permeability		***Medium Permeability***	
	Side Slopes	***Plateau***	***Unlined***	***Lined***
Layer 1				
Layer Type	Vert. Perc.	Vert. Perc.	Vert. Perc.	Vert. Perc.
Material Description	Topsoil (Silty CLAY with Gravel)	Topsoil (Silty CLAY with Gravel)	Topsoil (Silty CLAY with Gravel)	Topsoil (Silty CLAY with Gravel)
Material Texture Number	12	12	12	12
Effective Saturated Hydraulic Conductivity (cm/s)	4.2×10^{-5}	4.2×10^{-5}	4.2×10^{-5}	4.2×10^{-5}
Thickness (centimetres)	15	15	15	15
Layer 2				
Layer Type	Barrier Soil	Barrier Soil	Barrier Soil	Barrier Soil
Material Description	Compacted Clay	Compacted Clay	Compacted Clay	Compacted Clay
Material Texture Number	16	16	0	0
Effective Saturated Hydraulic Conductivity (cm/s)	1.0×10^{-7}	1.0×10^{-7}	1.0×10^{-5}	1.0×10^{-5}
Thickness (centimetres)	60	60	60	60
Layer 3				
Layer Type	Vert. Perc.	Vert. Perc.	Vert. Perc.	Vert. Perc.
Material Description	MSW	MSW	MSW	MSW
Material Texture Number	18	18	18	18
Effective Saturated Hydraulic Conductivity (cm/s)	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
Thickness (centimetres)	1000	1000	1000	1000
Layer 4				
Layer Type	Barrier Soil	Barrier Soil	Barrier Soil	Barrier Soil
Material Description	Clay Till	Clay Till	Clay Till	Clay Till
Material Texture Number	0	0	0	0
Effective Saturated Hydraulic Conductivity (cm/s)	4.6×10^{-7}	4.6×10^{-7}	4.6×10^{-7}	4.6×10^{-7}
Thickness (centimetres)	680	680	680	680
Slope	26.8%	0.6%	26.8%	0.6%
SCS Curve Number	85	95.2	85	95.2
Evaporative Depth Zone (centimetres)	15	15	15	15
Annual Averages (millimetres)				
Precipitation	462.27	462.27	462.27	462.27
Runoff	98.80	105.00	82.25	81.17
Evapotranspiration	355.53	345.35	304.54	290.59
Percolation/Leakage Through Barrier Layer	8.13	12.06	75.65	90.64
Average Head on Top of Barrier Layer	0.01	0.01	25.65	33.01
Change in Water Storage	-0.19	-0.15	-0.17	-0.14

Notes:

A material texture number of zero indicates that the design parameters are user specified, rather than default HELP3 Model data.

```
**********************************************************************************
**********************************************************************************
**                                                                              **
**                                                                              **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                    USAE WATERWAYS EXPERIMENT STATION                         **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                              **
**                                                                              **
**********************************************************************************
**********************************************************************************


PRECIPITATION DATA FILE:    C:\DC\DC1PP.D4
TEMPERATURE DATA FILE:      C:\DC\DC1TM.D7
SOLAR RADIATION DATA FILE:  C:\DC\DC1SLRD.D13
EVAPOTRANSPIRATION DATA:    C:\DC\DC1ET.D11
SOIL AND DESIGN DATA FILE:  C:\DC\DC1SOIL.D10
OUTPUT DATA FILE:           C:\DC\DC1OUT.OUT


TIME:   8:27     DATE:   4/14/2023


**********************************************************************************

     TITLE:  11213132 DAWSON CREEK LANDFILL - SIDE SLOPE, LOW PERM

**********************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     15.00   CM
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3059 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	60.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1000.00	CM
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	680.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.459999995000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 27.% AND A SLOPE LENGTH OF 35. METERS.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	15.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	4.589	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.065	CM

LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.150	CM
INITIAL SNOW WATER	=	2.347	CM
INITIAL WATER IN LAYER MATERIALS	=	612.569	CM
TOTAL INITIAL WATER	=	614.915	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DAWSON CREEK BC

STATION LATITUDE	=	55.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	130	
END OF GROWING SEASON (JULIAN DATE)	=	270	
EVAPORATIVE ZONE DEPTH	=	15.0	CM
AVERAGE ANNUAL WIND SPEED	=	13.50	KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.50	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.60	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	47.80	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	62.10	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.1	18.6	22.6	19.8	34.4	67.4
84.9	54.2	41.2	29.9	29.0	22.2

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-13.2	-10.2	-5.0	3.5	9.3	13.6
15.5	14.4	9.8	3.3	-6.8	-11.1

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON
AND STATION LATITUDE = 55.70 DEGREES

****

AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	28.86	18.95	23.80	19.61	37.19	62.22
	89.06	64.74	40.37	28.36	27.14	21.97
STD. DEVIATIONS	12.14	8.28	10.13	9.57	19.12	40.72
	67.03	45.32	21.33	16.31	13.33	7.81
RUNOFF						
TOTALS	0.000	0.209	14.767	29.057	6.924	5.932
	27.889	10.323	1.962	0.893	0.772	0.070
STD. DEVIATIONS	0.000	1.091	17.808	25.228	9.744	11.192
	44.999	20.217	6.708	2.942	2.227	0.409
EVAPOTRANSPIRATION						
TOTALS	11.586	13.410	17.848	11.366	48.760	59.301
	56.588	56.018	33.485	20.146	14.105	12.913
STD. DEVIATIONS	1.994	2.286	2.820	6.990	17.488	32.079
	30.484	32.584	18.251	9.092	3.617	1.920
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0000	0.0461	0.2875	1.4146	0.8734
	0.6246	0.7460	0.9621	1.3393	1.2947	0.5441
STD. DEVIATIONS	0.0000	0.0000	0.2075	0.4846	0.7780	0.6666
	0.4684	0.5943	0.8473	1.2239	1.3247	0.7512
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0461	0.2875	1.4146	0.8734
	0.6246	0.7460	0.9621	1.3393	1.2947	0.5441
STD. DEVIATIONS	0.0000	0.0000	0.2075	0.4846	0.7780	0.6666
	0.4684	0.5943	0.8473	1.2239	1.3247	0.7512

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.0000	0.0000	0.0036	0.2282	2.2081	1.4713
	1.3651	1.6217	1.6411	2.4808	1.4829	0.1228
STD. DEVIATIONS	0.0000	0.0000	0.0200	0.5304	1.4031	1.3729

	1.1728	1.4555	1.9536	3.3158	2.1012	0.2073

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0000	0.0003	0.0015	0.0010
	0.0007	0.0008	0.0011	0.0014	0.0014	0.0006
STD. DEVIATIONS	0.0000	0.0000	0.0002	0.0005	0.0008	0.0007
	0.0005	0.0006	0.0009	0.0013	0.0015	0.0008

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	MM		CU. METERS	PERCENT
PRECIPITATION	462.27	(101.696)	4622.7	100.00
RUNOFF	98.800	(56.9422)	988.00	21.373
EVAPOTRANSPIRATION	355.526	(68.1341)	3555.26	76.909
PERCOLATION/LEAKAGE THROUGH LAYER 2	8.13248	(3.39671)	81.325	1.75925
AVERAGE HEAD ON TOP OF LAYER 2	10.521	(5.543)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	8.13248	(3.39671)	81.325	1.75925
AVERAGE HEAD ON TOP OF LAYER 4	0.007	(0.003)		
CHANGE IN WATER STORAGE	-0.189	(0.9685)	-1.89	-0.041

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(MM)	(CU. METERS)
PRECIPITATION	156.70	1567.000
RUNOFF	135.109	1351.0894
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.107998	1.07998
AVERAGE HEAD ON TOP OF LAYER 2	150.000	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.107998	1.07998
AVERAGE HEAD ON TOP OF LAYER 4	0.036	
SNOW WATER	135.25	1352.4823

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4710
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2100

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(CM)	(VOL/VOL)
1	3.4683	0.2312
2	25.6200	0.4270
3	292.0000	0.2920
4	290.3600	0.4270
SNOW WATER	1.578	

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**               HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                  **
**                 HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                     USAE WATERWAYS EXPERIMENT STATION                        **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:    C:\DC\DC2PP.D4
TEMPERATURE DATA FILE:      C:\DC\DC2TM.D7
SOLAR RADIATION DATA FILE:  C:\DC\DC2SLRD.D13
EVAPOTRANSPIRATION DATA:    C:\DC\DC2ET.D11
SOIL AND DESIGN DATA FILE:  C:\DC\DC2SOIL.D10
OUTPUT DATA FILE:           C:\DC\DC2OUT.OUT


TIME:   8:45     DATE:   4/14/2023


**********************************************************************************

     TITLE:  11213132 DAWSON CREEK LANDFILL - PLATEAU, LOW PERM

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
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                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     15.00   CM
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2925 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC


                                  LAYER  2
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TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	60.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1000.00	CM
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	680.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.449999987000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 25. METERS.

SCS RUNOFF CURVE NUMBER	=	95.20	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	15.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	4.388	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.065	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.150	CM
INITIAL SNOW WATER	=	2.347	CM

INITIAL WATER IN LAYER MATERIALS	=	612.368	CM
TOTAL INITIAL WATER	=	614.715	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DAWSON CREEK BC

STATION LATITUDE	=	55.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	130	
END OF GROWING SEASON (JULIAN DATE)	=	270	
EVAPORATIVE ZONE DEPTH	=	15.0	CM
AVERAGE ANNUAL WIND SPEED	=	13.50	KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.50	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.60	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	47.80	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	62.10	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.1	18.6	22.6	19.8	34.4	67.4
84.9	54.2	41.2	29.9	29.0	22.2

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-13.2	-10.2	-5.0	3.5	9.3	13.6
15.5	14.4	9.8	3.3	-6.8	-11.1

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON
AND STATION LATITUDE = 55.70 DEGREES

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	28.86	18.95	23.80	19.61	37.19	62.22
	89.06	64.74	40.37	28.36	27.14	21.97
STD. DEVIATIONS	12.14	8.28	10.13	9.57	19.12	40.72
	67.03	45.32	21.33	16.31	13.33	7.81
RUNOFF						
TOTALS	0.000	0.129	10.459	23.802	6.664	9.188
	32.066	16.446	4.376	1.285	0.544	0.038
STD. DEVIATIONS	0.000	0.615	14.752	22.907	7.960	11.643
	41.314	21.150	6.861	2.742	1.673	0.229
EVAPOTRANSPIRATION						
TOTALS	11.577	13.395	17.982	13.750	55.358	49.242
	52.797	49.393	32.430	22.072	14.441	12.917
STD. DEVIATIONS	1.985	2.272	2.571	8.653	17.283	30.805
	30.046	31.976	20.219	10.540	3.662	1.930
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0009	0.0025	0.3933	1.9395	1.5288	0.9814
	1.1726	1.2863	1.3260	1.4830	1.3465	0.6037
STD. DEVIATIONS	0.0065	0.0185	0.6951	1.0449	0.6685	0.8016
	0.7221	0.8006	0.9466	1.1929	1.3318	0.8420
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0009	0.0025	0.3933	1.9395	1.5288	0.9814
	1.1726	1.2863	1.3260	1.4830	1.3465	0.6037
STD. DEVIATIONS	0.0065	0.0185	0.6951	1.0449	0.6685	0.8016
	0.7221	0.8006	0.9466	1.1929	1.3318	0.8420

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.0000	0.0003	0.5262	2.8888	2.7893	1.4391
	1.9902	2.4503	2.3111	2.5865	1.5313	0.1517
STD. DEVIATIONS	0.0001	0.0023	1.0216	2.0909	1.4552	1.4532
	1.4320	1.8627	2.2696	3.1417	2.1432	0.2614

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0004	0.0021	0.0016	0.0011
	0.0012	0.0014	0.0015	0.0016	0.0015	0.0006
STD. DEVIATIONS	0.0000	0.0000	0.0007	0.0011	0.0007	0.0009
	0.0008	0.0009	0.0010	0.0013	0.0015	0.0009

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	MM		CU. METERS	PERCENT
PRECIPITATION	462.27	(101.696)	4622.7	100.00
RUNOFF	104.996	(52.0383)	1049.96	22.713
EVAPOTRANSPIRATION	345.354	(65.3345)	3453.54	74.708
PERCOLATION/LEAKAGE THROUGH LAYER 2	12.06452	(3.59003)	120.645	2.60985
AVERAGE HEAD ON TOP OF LAYER 2	15.554	(5.648)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	12.06452	(3.59003)	120.645	2.60985
AVERAGE HEAD ON TOP OF LAYER 4	0.011	(0.003)		
CHANGE IN WATER STORAGE	-0.146	(0.9700)	-1.46	-0.032

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(MM)	(CU. METERS)
PRECIPITATION	156.70	1567.000
RUNOFF	103.222	1032.2169
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.107998	1.07998
AVERAGE HEAD ON TOP OF LAYER 2	150.000	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.107998	1.07998
AVERAGE HEAD ON TOP OF LAYER 4	0.036	
SNOW WATER	135.25	1352.4823

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4710
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2100

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(CM)	(VOL/VOL)
1	3.6996	0.2466
2	25.6200	0.4270
3	292.0000	0.2920
4	290.3600	0.4270
SNOW WATER	1.578	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                    USAE WATERWAYS EXPERIMENT STATION                         **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:    C:\DC\DC1PP.D4
TEMPERATURE DATA FILE:      C:\DC\DC1TM.D7
SOLAR RADIATION DATA FILE:  C:\DC\DC1SLRD.D13
EVAPOTRANSPIRATION DATA:    C:\DC\DC1ET.D11
SOIL AND DESIGN DATA FILE:  C:\DC\DC3SOIL.D10
OUTPUT DATA FILE:           C:\DC\DC3OUT.OUT


TIME:   9: 7     DATE:   4/14/2023


**********************************************************************************

     TITLE:  11213132 DAWSON CREEK LANDFILL - SIDE SLOPE, MED PERM

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     15.00   CM
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3042 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	60.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1000.00	CM
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	680.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.459999995000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 27.% AND A SLOPE LENGTH OF 35. METERS.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	15.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	4.563	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.065	CM

LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.150	CM
INITIAL SNOW WATER	=	2.347	CM
INITIAL WATER IN LAYER MATERIALS	=	612.543	CM
TOTAL INITIAL WATER	=	614.890	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DAWSON CREEK BC

STATION LATITUDE	=	55.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	130	
END OF GROWING SEASON (JULIAN DATE)	=	270	
EVAPORATIVE ZONE DEPTH	=	15.0	CM
AVERAGE ANNUAL WIND SPEED	=	13.50	KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.50	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.60	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	47.80	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	62.10	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.1	18.6	22.6	19.8	34.4	67.4
84.9	54.2	41.2	29.9	29.0	22.2

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-13.2	-10.2	-5.0	3.5	9.3	13.6
15.5	14.4	9.8	3.3	-6.8	-11.1

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON
AND STATION LATITUDE = 55.70 DEGREES

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	28.86	18.95	23.80	19.61	37.19	62.22
	89.06	64.74	40.37	28.36	27.14	21.97
STD. DEVIATIONS	12.14	8.28	10.13	9.57	19.12	40.72
	67.03	45.32	21.33	16.31	13.33	7.81
RUNOFF						
TOTALS	0.000	0.181	13.778	28.044	6.468	3.229
	23.112	6.326	0.551	0.009	0.514	0.039
STD. DEVIATIONS	0.000	0.912	16.854	25.152	9.157	7.681
	40.188	14.335	3.458	0.062	1.616	0.317
EVAPOTRANSPIRATION						
TOTALS	11.586	13.410	17.850	10.993	38.605	47.728
	44.557	44.395	29.247	19.248	14.007	12.912
STD. DEVIATIONS	1.994	2.286	2.799	6.309	15.877	25.446
	22.231	25.244	15.315	9.071	3.688	1.920
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0000	0.0000	2.0600	11.5229	12.7969
	19.1095	16.8903	7.5467	5.0983	0.6468	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	4.3290	5.8156	13.6926
	16.5111	16.1300	9.9598	7.9466	2.5067	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	3.3693	1.6321	0.8469	0.6039	7.9666	8.4859
	8.4698	9.9121	10.3306	10.1246	7.9491	5.9585
STD. DEVIATIONS	5.2296	3.6866	2.7724	2.1592	2.6270	3.7182
	4.4464	4.1787	3.5179	4.2518	5.1792	5.7891

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.0000	0.0000	0.0000	0.0410	0.2062	0.2455
	0.4545	0.3564	0.1229	0.0415	0.0062	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0926	0.1214	0.3192

	0.4438	0.4343	0.2301	0.0776	0.0336	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	1.2566	0.6046	0.2801	0.1549	1.0782	1.3723
	2.5840	4.8923	6.3005	5.5687	4.2117	2.4750
STD. DEVIATIONS	2.9405	2.0729	1.4050	0.8727	0.7065	1.2797
	2.8317	4.4379	5.4351	5.4218	4.9547	3.9872

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	MM		CU. METERS	PERCENT
PRECIPITATION	462.27	(101.696)	4622.7	100.00
RUNOFF	82.250	(51.3747)	822.50	17.793
EVAPOTRANSPIRATION	304.539	(54.7062)	3045.39	65.879
PERCOLATION/LEAKAGE THROUGH LAYER 2	75.67147	(30.26457)	756.715	16.36958
AVERAGE HEAD ON TOP OF LAYER 2	1.229	(0.595)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	75.64935	(25.13580)	756.493	16.36479
AVERAGE HEAD ON TOP OF LAYER 4	25.649	(22.422)		
CHANGE IN WATER STORAGE	-0.169	(1.1578)	-1.69	-0.037

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(MM)	(CU. METERS)
PRECIPITATION	156.70	1567.000
RUNOFF	124.417	1244.1724
PERCOLATION/LEAKAGE THROUGH LAYER 2	10.799844	107.99844
AVERAGE HEAD ON TOP OF LAYER 2	150.000	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.413274	4.13274
AVERAGE HEAD ON TOP OF LAYER 4	271.025	
SNOW WATER	135.25	1352.4823

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4710
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2100

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(CM)	(VOL/VOL)
1	3.4229	0.2282
2	25.6200	0.4270
3	292.2212	0.2922
4	290.3600	0.4270
SNOW WATER	1.578	

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** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) **
** DEVELOPED BY ENVIRONMENTAL LABORATORY **
** USAE WATERWAYS EXPERIMENT STATION **
** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
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PRECIPITATION DATA FILE: C:\DC\DC2PP.D4
TEMPERATURE DATA FILE: C:\DC\DC2TM.D7
SOLAR RADIATION DATA FILE: C:\DC\DC2SLRD.D13
EVAPOTRANSPIRATION DATA: C:\DC\DC2ET.D11
SOIL AND DESIGN DATA FILE: C:\DC\DC4SOIL.D10
OUTPUT DATA FILE: C:\DC\DC4OUT.OUT

TIME: 9:21 DATE: 4/14/2023

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TITLE: 11213132 DAWSON CREEK LANDFILL - PLATEAU, MED PERM

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 12

THICKNESS	=	15.00	CM
POROSITY	=	0.4710	VOL/VOL
FIELD CAPACITY	=	0.3420	VOL/VOL
WILTING POINT	=	0.2100	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2830	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.419999997000E-04	CM/SEC

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	60.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1000.00	CM
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	680.00	CM
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.449999987000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 25. METERS.

SCS RUNOFF CURVE NUMBER	=	95.20	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	15.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	4.245	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.065	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.150	CM
INITIAL SNOW WATER	=	2.347	CM

INITIAL WATER IN LAYER MATERIALS	=	612.225	CM
TOTAL INITIAL WATER	=	614.572	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DAWSON CREEK BC

STATION LATITUDE	=	55.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	130	
END OF GROWING SEASON (JULIAN DATE)	=	270	
EVAPORATIVE ZONE DEPTH	=	15.0	CM
AVERAGE ANNUAL WIND SPEED	=	13.50	KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.50	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.60	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	47.80	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	62.10	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.1	18.6	22.6	19.8	34.4	67.4
84.9	54.2	41.2	29.9	29.0	22.2

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-13.2	-10.2	-5.0	3.5	9.3	13.6
15.5	14.4	9.8	3.3	-6.8	-11.1

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SPOKANE WASHINGTON
AND STATION LATITUDE = 55.70 DEGREES

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	28.86	18.95	23.80	19.61	37.19	62.22
	89.06	64.74	40.37	28.36	27.14	21.97
STD. DEVIATIONS	12.14	8.28	10.13	9.57	19.12	40.72
	67.03	45.32	21.33	16.31	13.33	7.81
RUNOFF						
TOTALS	0.000	0.106	7.927	16.990	4.661	7.959
	27.298	12.118	3.086	0.675	0.326	0.025
STD. DEVIATIONS	0.000	0.532	9.829	15.599	5.270	9.404
	34.799	14.510	4.063	1.068	0.944	0.200
EVAPOTRANSPIRATION						
TOTALS	11.586	13.410	17.822	11.000	40.376	42.588
	40.705	38.357	27.499	20.118	14.222	12.910
STD. DEVIATIONS	1.994	2.286	2.810	6.929	15.953	25.799
	22.076	24.521	16.821	10.110	3.675	1.922
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0000	2.8901	12.6396	15.2791	9.9834
	19.3918	17.2927	7.9557	4.5624	0.6492	0.0000
STD. DEVIATIONS	0.0000	0.0000	6.3632	11.9841	8.7909	10.7628
	16.3568	15.8089	8.7977	6.8449	2.2673	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	3.8498	1.6956	1.7818	6.0526	10.6107	10.4192
	9.5867	10.5408	10.8703	11.1086	8.3844	5.7433
STD. DEVIATIONS	5.3414	3.7523	3.4981	4.3014	2.5187	2.6666
	3.9420	3.3682	2.4405	2.9361	4.7344	5.7013

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.0000	0.0000	0.0212	0.1655	0.2731	0.1672
	0.4734	0.3425	0.0953	0.0352	0.0052	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0878	0.2777	0.1587	0.2377
	0.5034	0.4228	0.1593	0.0677	0.0226	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	1.4502	0.7337	0.4047	1.1796	3.1384	3.2340
	3.4879	5.6494	7.0419	6.1199	4.4695	2.7067
STD. DEVIATIONS	3.2039	2.3376	1.6144	1.8854	2.6962	2.6520
	3.1436	4.1198	5.2119	5.4347	5.1835	4.2577

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	MM		CU. METERS	PERCENT
PRECIPITATION	462.27	(101.696)	4622.7	100.00
RUNOFF	81.171	(42.1197)	811.71	17.559
EVAPOTRANSPIRATION	290.592	(52.4513)	2905.92	62.862
PERCOLATION/LEAKAGE THROUGH LAYER 2	90.64408	(29.06356)	906.441	19.60852
AVERAGE HEAD ON TOP OF LAYER 2	1.316	(0.591)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	90.64403	(22.39571)	906.440	19.60851
AVERAGE HEAD ON TOP OF LAYER 4	33.013	(25.443)		
CHANGE IN WATER STORAGE	-0.138	(1.1440)	-1.38	-0.030

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(MM)	(CU. METERS)
PRECIPITATION	156.70	1567.000
RUNOFF	97.884	978.8351
PERCOLATION/LEAKAGE THROUGH LAYER 2	10.799844	107.99844
AVERAGE HEAD ON TOP OF LAYER 2	150.000	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.404161	4.04161
AVERAGE HEAD ON TOP OF LAYER 4	268.776	
SNOW WATER	135.25	1352.4823

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4710
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2100

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(CM)	(VOL/VOL)
1	3.6380	0.2425
2	25.6200	0.4270
3	292.0000	0.2920
4	290.3600	0.4270
SNOW WATER	1.578	

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Appendix C

Analytical Results (2021 Annual Monitoring Report)

TABLE 5a

Monitoring Well Summary

Peace River Regional District

PRRD Landfill - Dawson Creek

Monitoring Well	Elevation[g] (masl)					Depth (m)											Hydraulic Conductivity (m/s)	Method	Stratigraphy of Screened Interval
			19-May-21	14-Jul-21	06-Oct-21			19-May-21			14-Jul-21			06-Oct-21					
	Ground Surface	Top of Casing	Water Level	Water Level	Water Level	Grnd. to Top of Screen	Grnd. to Base of Screen	Top of Casing to Water	Grnd. to Water	Product Thickness (cm)	Top of Casing to Water	Grnd. to Water	Product Thickness (cm)	Top of Casing to Water	Grnd. to Water	Product Thickness (cm)			
DC-95-1	---	631.54	decommissioned			---	---	---	---	---	---	---	---	---	---	---	1E-07	---	---
DC-19-1	630.92	631.84	630.08	629.71	629.35	1.5	3.0	1.77	0.84	ND	2.13	1.21	ND	2.50	1.57	ND	---	---	clay
DC-95-2	635.86	636.55	632.84	632.86	632.85	---	---	3.70	3.02	ND	3.69	3.00	ND	3.70	3.01	ND	---	---	---
DC-98-1	631.59	632.53	630.26	630.00	630.01	---	---	2.27	1.33	ND	2.52	1.59	ND	2.52	1.58	ND	1E-04	---	---
DC-98-2	---	---	decommissioned			---	---	---	---	---	---	---	---	---	---	---	5E-07	---	---
DC-98-3	633.74	634.55	629.80	629.80	629.85	---	---	4.75	3.94	ND	4.76	3.94	ND	4.70	3.89	ND	---	---	---
DC-98-5	652.36	653.18	641.16	642.45	648.63	---	---	12.03	11.20	ND	10.73	9.91	ND	4.56	3.73	ND	5E-06	---	---
DC-99-1A	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3E-09	---	---
DC-99-1B	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	8E-09	---	---
DC-99-2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3E-08	---	---
DC-BH101	651.83	652.78	643.01	641.81	641.14	13.2	15.8	9.77	8.82	ND	10.96	10.02	ND	11.63	10.69	ND	---	---	till/clay

Notes:

^ - water level measured July 4, 2019

g - elevations are geodetic

masl - metres above sea level

--- - not available

ND - not detected

TABLE 5b

Groundwater Quality Results - Field Parameters

Peace River Regional District

PRRD Landfill - Dawson Creek

Monitoring Well	Sample Date	MSI Sample Number	Temp °C	Field pH	Field EC^{25} µS/cm	Field DO mg/L	ORP mV
DC-19-1	19-May-21	26254210519071	2.1	5.8	3905	9.3	180
DC-19-1	14-Jul-21	26254210714212	8.2	6.7	5500	1.4	55
DC-19-1	05-Oct-21	26254211005311	7.3	6.7	3836	0.5	-68
DC-95-2	19-May-21	26254210519073	4.4	6.0	3609	6.5	9
DC-95-2	14-Jul-21	26254210714213	6.9	6.5	4995	1.1	30
DC-95-2	05-Oct-21	26254211005313	6.0	6.7	4032	4.3	120
DC-98-1	19-May-21	26254210519072	2.8	5.9	4381	8.0	-80
DC-98-1	14-Jul-21	26254210714211	7.2	6.9	5906	1.5	-115
DC-98-1	05-Oct-21	26254211005312	7.4	6.8	4136	0.8	-29
DC-98-3	05-Oct-21	WL only	---	---	---	---	---
DC-98-5	05-Oct-21	WL only	---	---	---	---	---
DC-BH101	19-May-21	26254210519074	8.7	6.0	4099	6.4	203
DC-BH101	14-Jul-21	26254210714214	11.6	6.9	3582	7.2	208
DC-BH101	05-Oct-21	26254211005314	5.4	7.5	3868	---	130
B.C. CSR 375/96 - Freshwater Aquatic Standards*			**NS**	**NS**	**NS**	**NS**	**NS**
B.C. CSR 375/96 - Drinking Water Standards*			**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

NS - not specified

^{25} - field EC corrected to 25°C

* - *Contaminated Sites Regulation 375/96* (Province of British Columbia February 2021)

Italics - indicates value does not meet applicable standards

TABLE 5c

Groundwater Quality Results - General and Inorganic Parameters

Peace River Regional District

PRRD Landfill - Dawson Creek

Monitoring Well	Sample Date	MSI Sample Number	pH	EC µS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	NO_2-N mg/L	NO_3-N mg/L	NO_2+NO_3-N mg/L	NH_3-N mg/L	Total PO_4-P mg/L	Orthophosphate mg/L	Sulphide as S mg/L	Sulphide as H_2S mg/L	T-Alkalinity mg/L	HCO_3 mg/L	Hardness mg/L	TDS mg/L	Phenol mg/L
DC-19-1	19-May-21	26254210519071	7.10	4150	554	227	***297***	9.7	173	***1860***	<0.020	<0.05	<0.07	<0.025	<0.05	<0.01	<0.002	<0.002	621	757	2320	3490	<0.001
DC-19-1	14-Jul-21	26254210714212	6.98	4220	523	216	***262***	11	214	***1840***	<0.020	<0.05	<0.07	<0.025	<0.05	<0.01	<0.002	<0.002	635	775	2200	3450	<0.001
DC-19-1	05-Oct-21	26254211005311	6.82	4170	603	207	***236***	18	235	***1800***	<0.020	<0.05	<0.07	0.273	0.06	<0.01	0.002	0.002	670	816	2360	3500	<0.001
DC-95-2	19-May-21	26254210519073	7.12	3850	551	190	***261***	9.3	15.1	***1960***	<0.020	<0.05	<0.07	1.26	0.06	<0.01	<0.002	<0.002	543	663	2160	3310	0.001
DC-95-2	14-Jul-21	26254210714213	7.17	3740	512	176	***241***	8.4	14.6	***1920***	<0.020	<0.05	<0.07	1.3	<0.05	<0.01	<0.002	<0.002	538	655	2000	3200	<0.001
DC-95-2	05-Oct-21	26254211005313	6.99	3860	547	188	***259***	9.3	14.1	***2090***	<0.020	<0.05	<0.07	1.44	0.08	<0.01	0.002	0.002	503	613	2140	3410	<0.001
DC-98-1	19-May-21	26254210519072	7.01	4620	421	256	***343***	148	***307***	***504***	<0.020	<0.05	<0.07	***31.2***	0.26	<0.01	0.008	0.009	1950	2380	2100	3180	0.003
DC-98-1	14-Jul-21	26254210714211	7.01	4520	320	237	***334***	160	***311***	340	<0.020	<0.05	<0.07	***23.4***	0.26	<0.01	0.003	0.003	1860	2270	1770	2840	0.005
DC-98-1	05-Oct-21	26254211005312	6.93	4560	419	238	***313***	120	***330***	***616***	<0.020	<0.05	<0.07	***31.7***	0.27	<0.01	0.005	0.005	2050	2500	2020	3300	0.001
DC-BH101	19-May-21	26254210519074	7.18	4480	577	244	***341***	9.6	7.6	***2380***	<0.020	0.97	0.97	0.191	0.09	0.02	<0.002	<0.002	562	685	2440	3900	<0.001
DC-BH101	14-Jul-21	26254210714214	7.26	4270	539	237	***317***	8.8	7.7	***2370***	<0.020	0.97	0.97	0.081	<0.05	0.02	<0.002	<0.002	531	648	2320	3800	<0.001
DC-BH101	05-Oct-21	26254211005314	6.91	4260	545	253	***319***	9	7.6	***2480***	<0.020	2.6	2.6	0.032	0.09	<0.01	0.002	0.002	519	633	2400	3920	<0.001
B.C. CSR 375/96 - Freshwater Aquatic Standards*			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1500**	**H**	**Cl**	**400[amph]**	**400[amph]**	**pH/T**	**NS**	**NS**	**NS**	**0.02**	**NS**	**NS**	**NS**	**NS**	**2**
B.C. CSR 375/96 - Drinking Water Standards*			**NS**	**NS**	**NS**	**NS**	**200[HH]**	**NS**	**250[TAO]**	**500[TAO]**	**1**	**10**	**10**	**NS**	**NS**	**NS**	**NS**	**0.05[TAO]**	**NS**	**NS**	**NS**	**NS**	**1**

Notes:

NS - not specified

Cl - dependent on chloride value

H - standard level is dependent on hardness value

[amph] - standard may not protect all amphibians

[HH] - standard is specific to protection of human health

pH/T - standard pH and temperature dependant, 10°C is assumed, see B.C. CSR for standard information

[TAO] - standard to protect against taste and odour concerns

* - *Contaminated Sites Regulation 375/96* (Province of British Columbia February 2021)

Italics - indicates value does not meet applicable standards

TABLE 5d

Groundwater Quality Results - Dissolved Metals

Peace River Regional District
PRRD Landfill - Dawson Creek

Monitoring Well	Sample Date	MSI Sample Number	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mn mg/L	Hg mg/L	Mo mg/L	Ni mg/L	Se mg/L	Si mg/L	Ag mg/L	Sr mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L
DC-19-1	19-May-21	26254210519071	0.014	<0.0010	<0.0010	0.02	<0.0005	<0.0020	0.19	0.00007	<0.0020	0.0008	<0.005	0.30	<0.0005	*0.17*	0.593	<0.000005	<0.005	0.022	<0.0010	5.11	<0.00005	2.49	<0.00030	<0.005	<0.0020	*0.022*	<0.0005	0.013	<0.005
DC-19-1	14-Jul-21	26254210714212	0.065	<0.0010	<0.0010	0.03	<0.0005	<0.0020	0.3	0.00009	<0.0020	*0.002*	<0.005	0.84	<0.0005	*0.18*	1.34	<0.000005	<0.005	0.029	<0.0010	6.09	<0.00005	*2.74*	<0.00030	<0.005	<0.0020	*0.021*	0.0007	0.007	<0.005
DC-19-1	05-Oct-21	26254211005311	<0.01	<0.001	0.002	0.04	<0.0005	<0.002	0.43	<0.00005	<0.002	*0.0068*	<0.005	4.90	<0.0005	*0.16*	*2.70*	<0.000005	<0.005	0.032	<0.001	7.68	<0.00005	*3.27*	<0.0003	<0.005	<0.002	0.017	<0.0005	0.045	<0.005
DC-95-2	19-May-21	26254210519073	<0.01	<0.0010	<0.0010	0.01	<0.0005	<0.0020	0.44	<0.00005	<0.0020	*0.007*	<0.005	0.85	<0.0005	*0.17*	*1.72*	<0.000005	<0.005	0.011	<0.0010	6.58	<0.00005	*4.36*	<0.00030	<0.005	<0.0020	0.014	<0.0005	0.009	<0.005
DC-95-2	14-Jul-21	26254210714213	<0.01	<0.0010	<0.0010	0.01	<0.0005	<0.0020	0.45	0.00005	<0.0020	*0.0067*	<0.005	1.40	<0.0005	*0.17*	*1.52*	<0.000005	<0.005	0.0095	<0.0010	6.48	<0.00005	*4.08*	<0.00030	<0.005	<0.0020	0.016	<0.0005	0.006	<0.005
DC-95-2	05-Oct-21	26254211005313	<0.01	<0.001	<0.001	0.01	<0.0005	<0.002	0.41	<0.00005	<0.002	*0.004*	<0.005	1.50	<0.0005	*0.16*	*1.55*	<0.000005	<0.005	0.0075	<0.001	6.65	<0.00005	*4.17*	<0.0003	<0.005	<0.002	0.014	<0.0005	0.007	<0.005
DC-98-1	19-May-21	26254210519072	0.043	<0.0010	*0.031*	0.31	<0.0005	<0.0020	1.52	<0.00005	<0.0020	*0.026*	<0.005	*62.2*	<0.0005	*0.14*	*2.46*	<0.000005	<0.005	0.044	<0.0010	7.95	<0.00005	*2.91*	<0.00030	<0.005	<0.0020	0.0091	0.003	0.007	0.008
DC-98-1	14-Jul-21	26254210714211	0.031	<0.0010	*0.031*	0.35	<0.0005	<0.0020	1.8	<0.00005	<0.0020	*0.025*	<0.005	*60.4*	<0.0005	*0.11*	*1.68*	<0.000005	<0.005	0.044	<0.0010	7.53	<0.00005	*2.52*	<0.00030	<0.005	<0.0020	0.008	0.003	0.006	0.01
DC-98-1	05-Oct-21	26254211005312	0.025	<0.001	*0.035*	0.26	<0.0005	<0.002	1.5	<0.00005	<0.002	*0.025*	<0.005	*55.60*	<0.0005	*0.15*	*2.73*	<0.000005	<0.005	0.046	<0.001	7.88	<0.00005	*3.17*	<0.0003	<0.005	<0.002	0.011	0.002	0.005	0.008
DC-BH101	19-May-21	26254210519074	0.086	<0.0010	<0.0010	0.02	<0.0005	<0.0020	0.3	0.0004	<0.0020	0.0006	0.006	0.20	0.0006	*0.21*	0.50	<0.000005	<0.005	0.017	<0.0010	5.97	<0.00005	*4.88*	<0.00030	<0.005	0.0053	*0.045*	<0.0005	0.017	<0.005
DC-BH101	14-Jul-21	26254210714214	0.025	<0.0010	<0.0010	0.01	<0.0005	<0.0020	0.31	0.0002	<0.0020	<0.0005	<0.005	<0.05	<0.0005	*0.22*	0.17	<0.000005	<0.005	0.011	<0.0010	5.84	<0.00005	*4.86*	<0.00030	<0.005	<0.0020	*0.0524*	0.0006	0.007	<0.005
DC-BH101	05-Oct-21	26254211005314	<0.01	<0.001	<0.001	0.01	<0.0005	<0.002	0.3	0.0024	<0.002	<0.0005	<0.005	<0.05	<0.0005	*0.21*	<0.02	0.000006	<0.005	0.0088	<0.001	6.04	<0.00005	*4.73*	<0.0003	<0.005	<0.002	*0.044*	<0.0005	0.013	<0.005
B.C. CSR 375/96 - Freshwater Aquatic Standards*			**NS**	**0.09**	**0.05**	**10**	**0.0015**	**NS**	**12**	**H**	**0.01^{Cr6}**	**0.04**	**H**	**NS**	**H**	**NS**	**NS**	**0.00025**	**10**	**H**	**0.02**	**NS**	**H**	**NS**	**0.003**	**NS**	**1**	**0.085**	**NS**	**H**	**NS**
B.C. CSR 375/96 - Drinking Water Standards*			**9.5^{HH}**	**0.006**	**0.01**	**1**	**0.008**	**NS**	**5**	**0.005**	**0.05^{Cr6}**	**0.001**	**1.5$^{HH, WT}$**	**6.5$^{HH, IC2, WT}$**	**0.01**	**0.008**	**1.5$^{HH, IC2, WT}$**	**0.001**	**0.25**	**0.08**	**0.01**	**NS**	**0.02**	**2.5**	**NS**	**2.5**	**NS**	**0.02**	**0.02**	**3^{HH}**	**NS**

Notes:

NS - not specified
H - standard level is dependent on hardness value
^{Cr6} - guideline value for Cr(VI)
^{HH} - standard is specific to protection of human health
^{IC2} - standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2
^{WT} - standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.
* - *Contaminated Sites Regulation 375/96* (Province of British Columbia February 2021)
Italics - indicates value does not meet applicable standards

TABLE 5e

Groundwater Quality Results - Hydrocarbons

Peace River Regional District

PRRD Landfill - Dawson Creek

Monitoring Well	Sample Date	MSI Sample Number	Benzene mg/L	Toluene mg/L	Ethylbenzene mg/L	Xylenes mg/L	Styrene mg/L	VPHw mg/L	VHw (C_6-C_{10}) mg/L	EPHw (C_{10}-C_{19}) mg/L	EPHw (C_{19}-C_{32}) mg/L
DC-19-1	19-May-21	26254210519071	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
DC-95-2	19-May-21	26254210519073	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
DC-98-1	19-May-21	26254210519072	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
DC-BH101	19-May-21	26254210519074	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
B.C. CSR 375/96 - Freshwater Aquatic Standards**			**0.4**	**0.005**	**2**	**0.3**	**0.72**	**1.5**	**15^{IWU}**	**5^{IWU}**	**NS**
B.C. CSR 375/96 - Drinking Water Standards**			**0.005**	**0.06^{WT}**	**0.14^{WT}**	**0.09**	**0.8**	**NS**	**15^{IWU}**	**5^{IWU}**	**NS**

Notes:

NS - not specified

^{IWU} - standard is applicable to all sites, irrespective of water use

^{WT} - standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

** - *Contaminated Sites Regulation 375/96* (Province of British Columbia February 2021)

VPHw - does not include BTEX

VHw (C_6-C_{10}) - includes BTEX

Italics - indicates value does not meet applicable standards

TABLE 5f

Surface Water Quality Results - Field Parameters

Peace River Regional District

PRRD Landfill - Dawson Creek

Sample Point	Sample Date	MSI Sample Number	Temp °C	Field pH	Field EC^{25} µS/cm	Field DO mg/L	ORP mV	Field Turbidity NTU
DC-SW2	19-May-21	26254210519077	*17.1* DW	8.57	583	8.85	160	90.77
DC-SW2	14-Jul-21	26254210714219	*22.7* DW	8.84	*1277* Irr	10.28	118	68.86
DC-SW2	05-Oct-21	26254211005316	4	8.65	*1062* Irr	*1.2* FAL	126	23.89
DC-SW4	19-May-21	26254210519078	---	---	---	---	---	---
DC-SW4	14-Jul-21	dry	---	---	---	---	---	---
DC-SW4	05-Oct-21	dry	---	---	---	---	---	---
DC-SW6	19-May-21	26254210519076	*17.0* DW	7.94	586	8.64	152	83.83
DC-SW6	14-Jul-21	26254210714218	*23.6* DW	8.28	*2012* Irr	9.59	125	21.49
DC-SW6	05-Oct-21	26254211005318	2.9	8.19	*962* Irr	9.69	128	37.5
DC-SW7	19-May-21	26254210519075	*16.7* DW	8.29	671	9.53	167	88.56
DC-SW7	14-Jul-21	26254210714217	*22.7* DW	9.2 Irr	*1038* Irr	10.2	149	25.95
DC-SW7	05-Oct-21	26254211005317	3.7	9.3 Irr	*1188* Irr	10.5	135	18.01
B.C. Approved WQG - Drinking Water (DW)^{BCSW1}			**15^{AO}**	**NS**	**NS**	**NS**	**NS**	**narrative**
B.C. Approved WQG - Freshwater Aquatic Life (FAL)^{BCSW2}			**narrative^{mean}**	**narrative^{mean}**	**NS**	**<8^{mean,LS}**	**NS**	**narrative**
B.C. Approved WQG - Irrigation Water (Irr)^{BCSW2}			**natural^{mean}**	**5.0-9.5^{mean}**	**NS**	**NS**	**NS**	**narrative**
B.C. Approved WQG - Livestock Water (LW)^{BCSW2}			**natural^{mean}**	**5.0-9.5^{mean}**	**NS**	**NS**	**NS**	**narrative**
B.C. Approved WQG - Wildlife Water (WW)^{BCSW2}			**natural^{mean}**	**NS**	**NS**	**NS**	**NS**	**narrative**
B.C. Working WQG - Freshwater Aquatic Life (FAL)^{BCSW4}			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Irrigation Water (Irr)^{BCSW4}			**NS**	**NS**	**700^{mean,crop}**	**NS**	**NS**	**NS**
B.C. Working WQG - Livestock Water (LW)^{BCSW4}			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Wildlife Water (WW)^{BCSW4}			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

--- - not analyzed

NS - not specified

25 - field EC corrected to 25°C

AO - aesthetic objective

mean - 30-day mean; calculated from at least 5 weekly samples taken in a period of 30 days

crop - guideline level is crop and soil dependent; criterion shown is most stringent value

LS - guideline is dependent upon life stage; criterion shown is most stringent value

narrative - see applicable guidelines for further details

natural - temperature should not change more than + or - 1 deg C from natural ambient background.

BCSW1 - *Source Drinking Water Quality Guidelines* (B.C. ENV 2020)

BCSW2 - *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

BCSW4 - *British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

Italics - indicates value does not meet Working Water Quality Guidelines

Italics - indicates value does not meet Approved Water Quality Guidelines

TABLE 5g

Surface Water Quality Results - General and Inorganic Parameters

Peace River Regional District

PRRD Landfill - Dawson Creek

Sample Point	Sample Date	MSI Sample Number	Lab pH	Lab EC µS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	NO_2-N mg/L	NO_3-N mg/L	NO_2/NO_3-N mg/L	NH_3-N mg/L	PO_4-P-T mg/L	Orthophosphate mg/L	Sulphide as S mg/L	Sulphide as H_2S mg/L	T-Alkalinity mg/L	HCO_3 mg/L	Hardness mg/L	TDS mg/L	TSS mg/L	Phenols mg/L
DC-SW2	19-May-21	26254210519077	8.4	625	61.1	26.8	30.5	7.2	35.3	150	<0.005	0.03	0.03	<0.025	*0.24* DW,FAL	0.06	<0.002	<0.002	131	143	263	390	57	0.001
DC-SW2	14-Jul-21	26254210714219	8.72	*1120* Irr	75.5	44.2	88.6	11.1	*124* Irr	196	<0.005	0.04	0.04	0.026	*0.58* DW,FAL	0.41	*0.004* FAL	*0.004* FAL	229	241	371	*677* Irr	29	<0.001
DC-SW2	05-Oct-21	26254211005316	8.44	*1140* Irr	72.9	47.8	96.8	17.1	*128* Irr	137	0.058	1.43	1.49	*0.149* FAL	*1.08* DW,FAL	1.01	*0.004* FAL	*0.004* FAL	277	317	379	*667* Irr	27	<0.001
DC-SW4	19-May-21	26254210519078	7.54	*2800* Irr	398	146	165	13.0	*135* Irr	*1220* DW,FAL,LW	<0.020	<0.05	<0.07	<0.025	*0.05* DW,FAL	<0.01	0.002	0.002	335	408	1600	*2280* Irr,LW	9	<0.001
DC-SW6	19-May-21	26254210519076	7.92	597	59.2	25.6	25.1	6.2	28.5	154	<0.005	0.02	0.02	<0.025	*0.15* DW,FAL	<0.01	<0.002	<0.002	113	138	253	366	51	0.001
DC-SW6	14-Jul-21	26254210714218	8.31	*1760* Irr	162	82	117	10.2	*175* FAL,Irr	*482* FAL	<0.005	<0.01	<0.01	<0.025	<0.05	<0.01	0.002	0.002	242	295	742	*1170* Irr,LW	14	<0.001
DC-SW6	05-Oct-21	26254211005318	8.06	*916* Irr	82.5	37	57.5	4.8	87.8	215	<0.005	0.01	0.01	<0.025	<0.05	<0.01	0.002	0.002	136	166	358	*566* Irr	21	0.002
DC-SW7	19-May-21	26254210519075	8.37	628	61.6	26.8	31	7.4	35.3	151	<0.005	0.03	0.03	0.043	*0.24* DW,FAL	0.06	0.002	0.002	129	143	264	391	59	<0.001
DC-SW7	14-Jul-21	26254210714217	8.97	*1000* Irr	61	41.7	91.8	16.1	*117* Irr	127	<0.005	0.09	0.09	*0.105* FAL	*0.86* DW,FAL	0.7	*0.006* FAL	*0.006* FAL	233	215	324	*595* Irr	26	<0.001
DC-SW7	05-Oct-21	26254211005317	8.53	*1160* Irr	71.6	49	106	19.6	*137* Irr	121	0.092	2.02	2.11	*0.32* FAL	*1.23* DW,FAL	1.12	*0.005* FAL	*0.005* FAL	294	322	380	*682* Irr	9	<0.001
B.C. Approved WQG - Drinking Water (DW)[BCSW1]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**250[AO]**	**500[AO]**	**1[MAC]**	**10[MAC]**	**NS**	**NS**	**0.01[L,AO]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Approved WQG - Freshwater Aquatic Life (FAL)[BCSW2]			**narrative[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**150[mean]**	**H[SO4,mean]**	**Cl[mean]**	**3[mean]**	**NS**	**pH/T[mean]**	**0.005-0.015[L]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**narrative**	**0.05[ST]**
B.C. Approved WQG - Irrigation Water (Irr)[BCSW2]			**5.0-9.5[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**100[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**narrative**	**NS**
B.C. Approved WQG - Livestock Water (LW)[BCSW2]			**5.0-9.5[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**600[mean]**	**1000[mean]**	**10[ST]**	**100[ST]**	**100[ST]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**narrative**	**NS**
B.C. Approved WQG - Wildlife Water (WW)[BCSW2]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**600[mean]**	**NS**	**10[ST]**	**100[ST]**	**100[ST]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**narrative**	**NS**
B.C. Working WQG - Freshwater Aquatic Life (FAL)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.002**	**0.002**	**narrative**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Irrigation Water (Irr)[BCSW4]			**NS**	**700[mean,crop]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**500[mean,crop]**	**NS**
B.C. Working WQG - Livestock Water (LW)[BCSW4]			**NS**	**NS**	**1000[mean]**	**NS**	**NS**	**NS**	**NS**	**1000[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1000[mean]**	**NS**
B.C. Working WQG - Wildlife Water (WW)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

NS - not specified

animal - guideline level is animal dependent; criterion shown is most stringent value

AO - aesthetic objective

mean - 30-day mean; calculated from at least 5 weekly samples taken in a period of 30 days

crop - guideline level is crop and soil dependent; criterion shown is most stringent value

Cl - dependent on chloride value

H - dependent on hardness value

L - guideline applies to lakes only

MAC - maximum acceptable concentration

narrative - see applicable guidelines for further details

pH/T - dependent on pH and temperature values, most stringent guideline of 0.102 mg/L applied, see applicable guideline for further details

SO4 - guideline level is hardness dependent; hardness values greater than 250 mg/L need to be determined based on site water

BCSW1 - *Source Drinking Water Quality Guidelines* (B.C. ENV 2020)

BCSW2 - *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

BCSW4 - *British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

Italics - indicates value does not meet Working Water Quality Guidelines

Italics - indicates value does not meet Approved Water Quality Guidelines

TABLE 5h

Surface Water Quality Results - Total Metals

Peace River Regional District

PRRD Landfill - Dawson Creek

Sample Point	Sample Date	MSI Sample Number	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Cr mg/L	Cr3+ ^ mg/L	Cr6+ ^ mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mn mg/L	Hg mg/L	Mo mg/L	Ni mg/L	Se mg/L	Si mg/L	Ag mg/L	Sr mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L
DC-SW2	19-May-21	26254210519077	1.03	0.0003	0.00232	0.0859	0.00007	<0.0001	0.07	0.00007	*0.0018* FAL	<0.0005	<0.01	*0.0016* DW	0.0055	*2.87* DW,FAL	0.0013	0.0128	*0.0807* DW	0.00001	0.00093	0.0112	0.0004	2.36	<0.00005	0.204	0.00001	<0.0001	0.0108	0.0012	0.0044	0.0181	0.0009
DC-SW2	14-Jul-21	26254210714219	0.846	0.0005	*0.00547* FAL	0.0605	<0.00005	<0.0001	0.231	0.00004	*0.0016* FAL	---	---	*0.0019* DW	0.0033	*1.73* DW,FAL	0.001	0.0281	*0.0983* DW	<0.000005	0.00211	0.0143	0.0005	2.31	<0.00005	0.355	0.00002	<0.0001	0.016	0.00231	0.0054	0.0086	0.0011
DC-SW2	05-Oct-21	26254211005316	0.251	0.0005	0.00403	0.0337	<0.00005	<0.0001	0.26	0.00003	0.0006	<0.0005	<0.01	*0.0017* DW	0.0026	*0.728* DW	0.0004	0.0297	*0.0801* DW	<0.000005	0.00199	0.015	0.0003	0.92	<0.00005	0.362	<0.00001	<0.0001	0.0043	0.00179	0.0035	0.0096	<0.0005
DC-SW4	19-May-21	26254210519078	0.037	<0.0002	0.00091	0.0342	<0.00010	<0.0002	0.466	<0.00002	<0.0010	<0.0005	<0.01	0.0009	0.001	*0.758* DW	<0.0002	0.0509	*0.677* DW,Irr	<0.000005	0.00097	0.0065	0.0003	3.04	<0.00010	1.58	<0.00002	<0.0002	<0.0010	0.00695	<0.0002	<0.0020	<0.0010
DC-SW6	19-May-21	26254210519076	1.24	0.0003	0.00239	0.093	0.00008	<0.0001	0.049	0.00007	*0.0023* FAL	<0.0005	<0.01	*0.0016* DW	0.006	*3.46* DW,FAL	0.0015	0.012	*0.0842* DW	0.000009	0.00096	0.011	0.0004	3.37	<0.00005	0.198	0.00002	<0.0001	0.0144	0.00116	0.0053	0.0193	0.001
DC-SW6	14-Jul-21	26254210714218	0.393	0.0004	0.00143	0.0972	<0.00005	<0.0001	0.114	0.00004	0.0008	---	---	0.0006	0.0042	*0.383* DW	0.0003	0.0345	*0.0662* DW	<0.000005	0.0028	0.0067	0.0007	1.29	<0.00005	0.723	0.00004	<0.0001	0.019	0.00581	0.0017	0.005	0.0008
DC-SW6	05-Oct-21	26254211005318	0.494	0.0002	0.00087	0.0578	<0.00005	<0.0001	0.053	0.00003	*0.0012* FAL	<0.0005	<0.01	0.0006	0.0033	*0.779* DW	0.0005	0.0179	*0.0382* DW	<0.000005	0.00167	0.0065	0.0003	1.26	<0.00005	0.415	0.00002	<0.0001	0.0156	0.00197	0.0021	0.0073	0.0012
DC-SW7	19-May-21	26254210519075	1.14	0.0003	0.00246	0.0862	0.00009	<0.0001	0.07	0.00006	*0.002* FAL	<0.0005	<0.01	*0.0016* DW	0.0055	*3.11* DW,FAL	0.0014	0.0134	*0.0859* DW	0.00001	0.00101	0.011	0.0004	3.54	<0.00005	0.204	0.00002	<0.0001	0.0134	0.00123	0.0048	0.0167	0.0009
DC-SW7	14-Jul-21	26254210714217	0.402	0.0005	0.00484	0.0382	<0.00005	<0.0001	0.277	0.00002	0.0008	---	---	*0.0014* DW	0.0016	*0.814* DW	0.0004	0.026	*0.0636* DW	<0.000005	0.00172	0.0139	0.0005	0.88	<0.00005	0.281	<0.00001	<0.0001	0.0085	0.00141	0.0034	0.0053	0.0006
DC-SW7	05-Oct-21	26254211005317	0.128	0.0005	0.00423	0.0284	<0.00005	<0.0001	0.29	0.00002	<0.0005	<0.0005	<0.01	*0.0017* DW	0.0015	*0.435* DW	0.0002	0.0303	*0.0743* DW	<0.000005	0.00196	0.0154	0.0004	0.65	<0.00005	0.343	<0.00001	<0.0001	0.0024	0.00172	0.0036	0.005	<0.0005
B.C. Approved WQG - Drinking Water (DW)[BCSW1]			**9.5[MAC]**	**0.006[MAC]**	**0.01[MAC]**	**NS**	**NS**	**NS**	**5[MAC]**	**0.005[MAC]**	**0.05[MAC]**	**NS**	**NS**	**0.001[MAC]**	**1[AO]**	**0.3[AO]**	**0.005[MAC]**	**NS**	**0.02[AO]**	**0.001[MAC]**	**0.088[MAC]**	**0.08[MAC]**	**0.01[MAC]**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.02[MAC]**	**NS**	**3[MAC]**	**NS**
B.C. Approved WQG - Freshwater Aquatic Life (FAL)[BCSW2]			**NS[DM]**	**NS**	**0.005[ST]**	**NS**	**NS**	**NS**	**1.2[mean]**	**NS[DM]**	**NS**	**NS**	**NS**	**0.004[mean]**	**NS[DM]**	**1.0[ST]**	**H[mean]**	**NS**	**H[mean]**	**MeHg[mean]**	**7.6[mean]**	**NS**	**0.001[mean]**	**NS**	**H[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**H[mean]**	**NS**
B.C. Approved WQG - Irrigation Water (Irr)[BCSW2]			**5**	**NS**	**0.1[ST]**	**NS**	**NS**	**NS**	**0.5[mean,crop]**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.2[ST]**	**NS**	**0.2[ST]**	**NS**	**NS**	**0.002[ST]**	**0.01[mean,crop]**	**NS**	**0.01[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**soil pH**	**NS**
B.C. Approved WQG - Livestock Water (LW)[BCSW2]			**5**	**NS**	**0.025[ST]**	**NS**	**NS**	**NS**	**5[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.3[mean]**	**NS**	**0.1[ST]**	**NS**	**NS**	**0.003[ST]**	**0.016**	**NS**	**0.03[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**2[mean]**	**NS**
B.C. Approved WQG - Wildlife Water (WW)[BCSW2]			**5**	**NS**	**0.025[ST]**	**NS**	**NS**	**NS**	**5[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.3[mean]**	**NS**	**0.1[ST]**	**NS**	**NS**	**MeHg[mean]**	**0.034**	**NS**	**0.002[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Freshwater Aquatic Life (FAL)[BCSW4]			**NS**	**0.009[mean,Sb3]**	**NS**	**1[mean]**	**0.00013[mean]**	**NS**	**NS**	**NS**	**0.001[mean,Cr6]**	**0.0089[Cr3]**	**0.001[Cr6]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**H[mean]**	**NS**	**NS**	**NS**	**NS**	**0.0008[mean,Riv]**	**NS**	**NS**	**0.0085[mean]**	**NS**	**NS**	**NS**
B.C. Working WQG - Irrigation Water (Irr)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**0.1[mean]**	**NS**	**NS**	**0.0051[ST]**	**0.0049[mean,Cr3]**	**0.0049[Cr3]**	**0.008[Cr6]**	**0.05[mean,CU]**	**NS**	**NS**	**NS**	**0.75[mean,crop]**	**0.2[mean]**	**NS**	**NS**	**0.2[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.01[mean]**	**0.1[mean]**	**NS**	**NS**
B.C. Working WQG - Livestock Water (LW)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**0.1[mean]**	**NS**	**NS**	**0.080[ST]**	**0.05[mean,Cr3,Cr6]**	**0.05[Cr3]**	**0.05[Cr6]**	**1[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.2[mean]**	**0.1[mean]**	**NS**	**NS**
B.C. Working WQG - Wildlife Water (WW)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

NS - not specified

[AO] - aesthetic objective

[mean] - 30-day mean; calculated from at least 5 weekly samples taken in a period of 30 days

[Cr3] - guideline is for total Cr^{3+}

[Cr6] - guideline is for total Cr^{6+}

[crop] - guideline level is crop-dependent; criterion shown is most stringent value

[CU] - continuous or intermittent use on all soils, see applicable guideline for further details

[DM] - guideline available for dissolved metal

H - guideline is hardness dependent

[MAC] - maximum acceptable concentration

[ST] - short-term acute guideline

MeHg - guideline dependent upon concentration of MeHg (assumed to be ≤0.5 % where no value provided); see applicable guideline for further details

[Riv] - 30-day average, site-specific objective for the lower Columbia River, BC

[Sb3] - guideline is for Sb^{3+}

soil pH - guideline is dependent upon soil pH

[^] - there is no acid digestion method available to recover speciated chromium, these soluble analytes are reported as dissolved

[BCSW1] - *Source Drinking Water Quality Guidelines* (B.C. ENV 2020)

[BCSW2] - *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

[BCSW4] - *British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

Italics - indicates value does not meet Working Water Quality Guidelines

Italics - indicates value does not meet Approved Water Quality Guidelines

TABLE 5i

Surface Water Quality Results - Hydrocarbons

Peace River Regional District
PRRD Landfill - Dawson Creek

Sample Point	Sample Date	MSI Sample Number	Benzene mg/L	Toluene mg/L	Ethylbenzene mg/L	Xylenes mg/L	Styrene mg/L	VPHw (C_6-C_{10}) mg/L	VHw (C_6-C_{10}) mg/L	EPHw (C_{10}-C_{19}) mg/L	EPHw (C_{19}-C_{32}) mg/L
DC-SW2	19-May-21	26254210519077	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
DC-SW4	19-May-21	26254210519078	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
DC-SW6	19-May-21	26254210519076	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
DC-SW7	19-May-21	26254210519075	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.05	<0.05	<0.2	<0.2
B.C. Approved WQG - Drinking Water (DW)[BCSW1]			**0.005[MAC]**	**0.024[AO]**	**0.0016[AO]**	**0.02[AO]**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Approved WQG - Freshwater Aquatic Life (FAL)[BCSW2]			**0.04[mean]**	**0.0005[mean]**	**0.2[mean]**	**0.03[mean]**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Approved WQG - Irrigation Water (Irr)[BCSW2]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Approved WQG - Livestock Water (LW)[BCSW2]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Approved WQG - Wildlife Water (WW)[BCSW2]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Freshwater Aquatic Life (FAL)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**0.072**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Irrigation Water (Irr)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Livestock Water (LW)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
B.C. Working WQG - Wildlife Water (WW)[BCSW4]			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

NS - not specified
AO - aesthetic objective
mean - 30-day mean; calculated from at least 5 weekly samples taken in a period of 30 days
MAC - maximum acceptable concentration
VPHw (C_6-C_{10}) - does not include BTEX
BCSW1 - *Source Drinking Water Quality Guidelines* (B.C. ENV 2020)
BCSW2 - *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)
BCSW4 - *British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)
Italics - indicates value does not meet Working Water Quality Guidelines
Italics - indicates value does not meet Approved Water Quality Guidelines

TABLE 5j

Surface Water Quality Results - Microbiological Parameters

Peace River Regional District

PRRD Landfill - Dawson Creek

Sample Point	Sample Date	MSI Sample Number	Faecal Coliforms CFU/100mL	Total Coliforms CFU/100mL
DC-SW2	19-May-21	26254210519077	*10* LW	70
DC-SW2	14-Jul-21	26254210714219	*100* DW,FAL,LW	100
DC-SW2	05-Oct-21	26254211005316	*160* DW,FAL,LW	190
DC-SW4	19-May-21	26254210519078	<10	330
DC-SW6	19-May-21	26254210519076	*40* DW,FAL,LW	500
DC-SW6	14-Jul-21	26254210714218	<10	20
DC-SW6	05-Oct-21	26254211005318	*10* LW	60
DC-SW7	19-May-21	26254210519075	*20* DW,FAL,LW	180
DC-SW7	14-Jul-21	26254210714217	*80* DW,FAL,LW	80
DC-SW7	05-Oct-21	26254211005317	*3000* DW,FAL,Irr,LW	3000
B.C. Approved WQG - Drinking Water (DW)[BCSW1]			**10[MAC]**	**NS**
B.C. Approved WQG - Freshwater Aquatic Life (FAL)[BCSW2]			**14[mean,shell]**	**NS**
B.C. Approved WQG - Irrigation Water (Irr)[BCSW2]			**200[geo,irr]**	**NS**
B.C. Approved WQG - Livestock Water (LW)[BCSW2]			**0[animal]**	**NS**
B.C. Approved WQG - Wildlife Water (WW)[BCSW2]			**NS**	**NS**
B.C. Working WQG - Freshwater Aquatic Life (FAL)[BCSW4]			**NS**	**NS**
B.C. Working WQG - Irrigation Water (Irr)[BCSW4]			**NS**	**NS**
B.C. Working WQG - Livestock Water (LW)[BCSW4]			**NS**	**NS**
B.C. Working WQG - Wildlife Water (WW)[BCSW4]			**NS**	**NS**

Notes:

CFU - colony forming units

NS - not specified

mean - 30-day mean; calculated from at least 5 weekly samples taken in a period of 30 days

animal - guideline level is enclosure-dependent; criterion shown is most stringent value

geo - geometric mean

MAC - maximum acceptable concentration

shell - shelfish harvesting

BCSW1 - *Source Drinking Water Quality Guidelines* (B.C. ENV 2020)

BCSW2 - *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

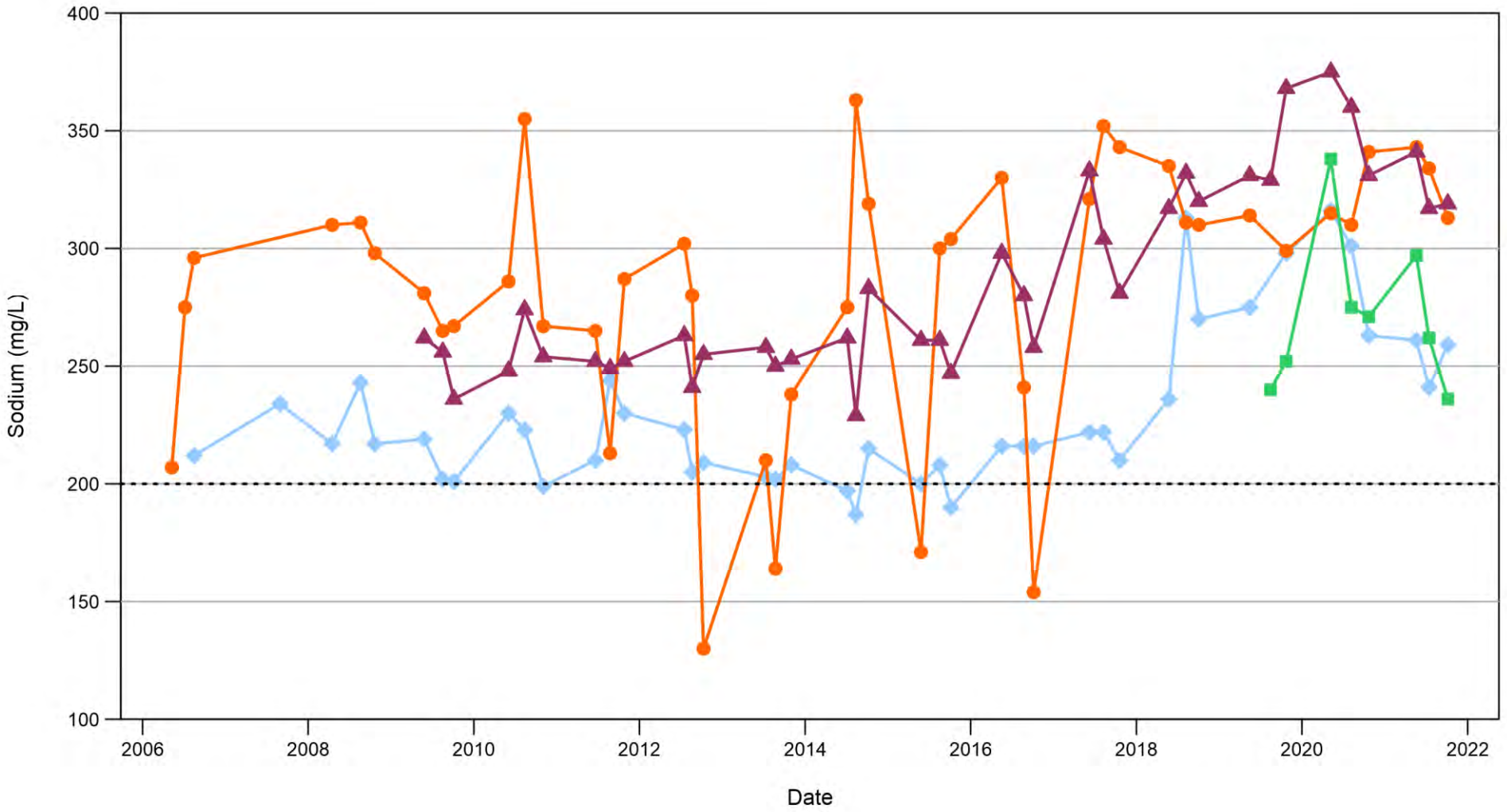
BCSW4 - *British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (B.C. ENV 2021)

Italics - indicates value does not meet Working Water Quality Guidelines

Italics - indicates value does not meet Approved Water Quality guidelines, resampling is recommended to confirm the presence of coliforms

Appendix D

Historical groundwater and Surface Water Concentration Versus Time Plots (2021 Annual Monitoring Report)



DC-95-2
DC-98-1
DC-BH101
DC-19-1

B.C. CSR 375/96 - Drinking Water Standards (2021) = 200 mg/L

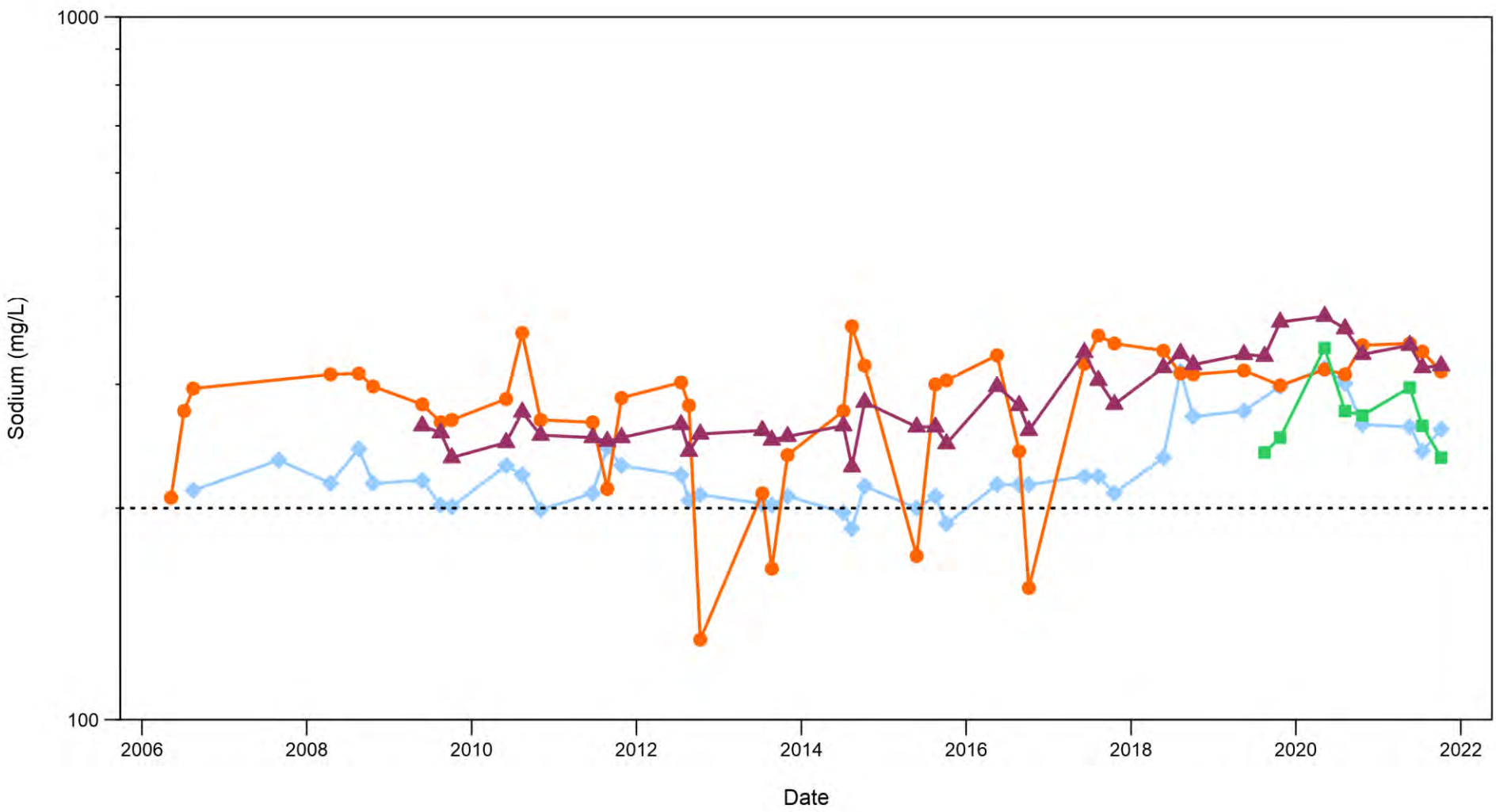
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Sodium Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5a



DC-95-2
DC-98-1
DC-BH101
DC-19-1

B.C. CSR 375/96 - Drinking Water Standards (2021) = 200 mg/L

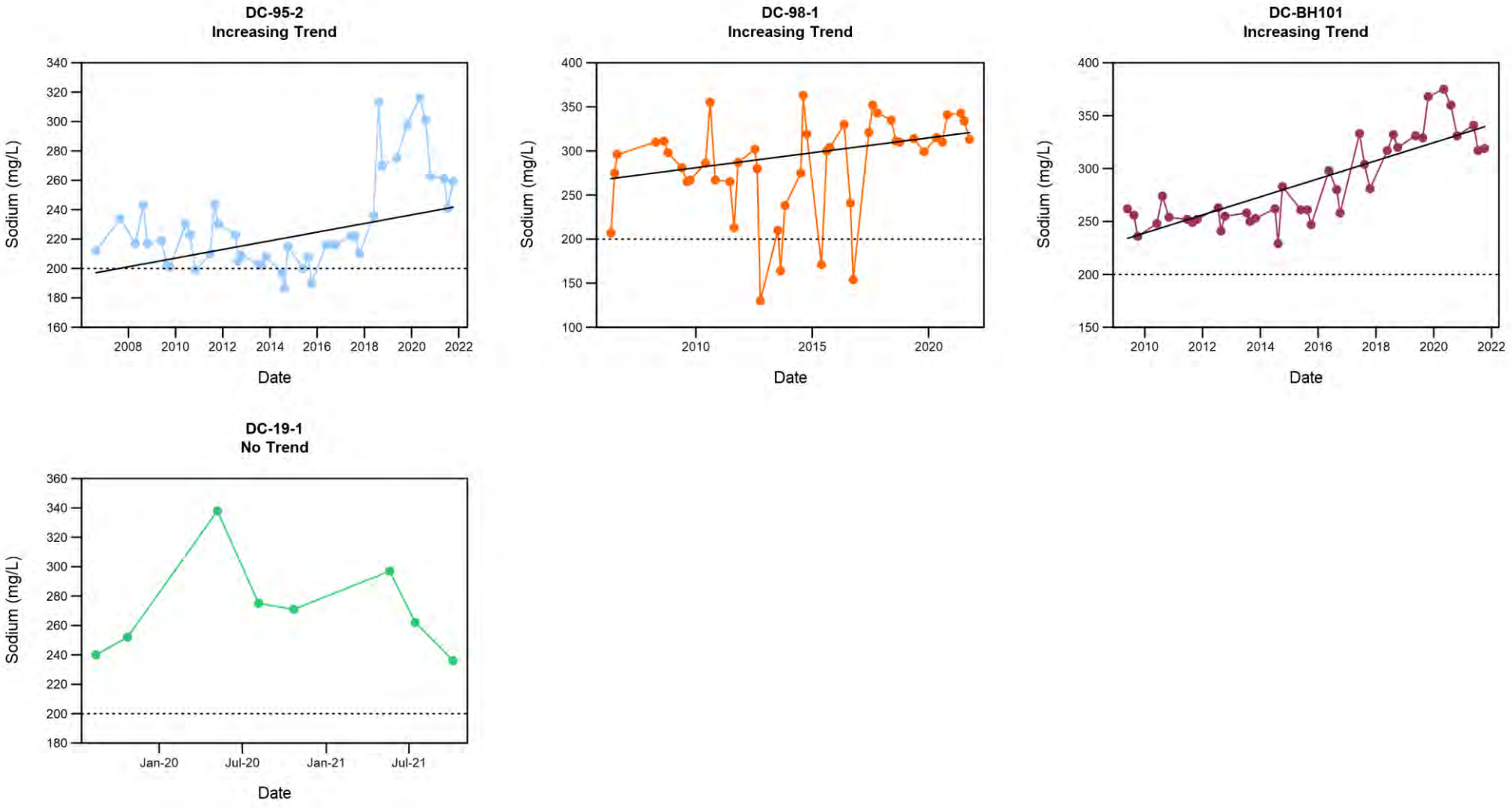
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Sodium Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5a



Sodium
Sen slope
B.C. CSR 375/96 - Drinking Water Standards (2021) = 200 mg/L

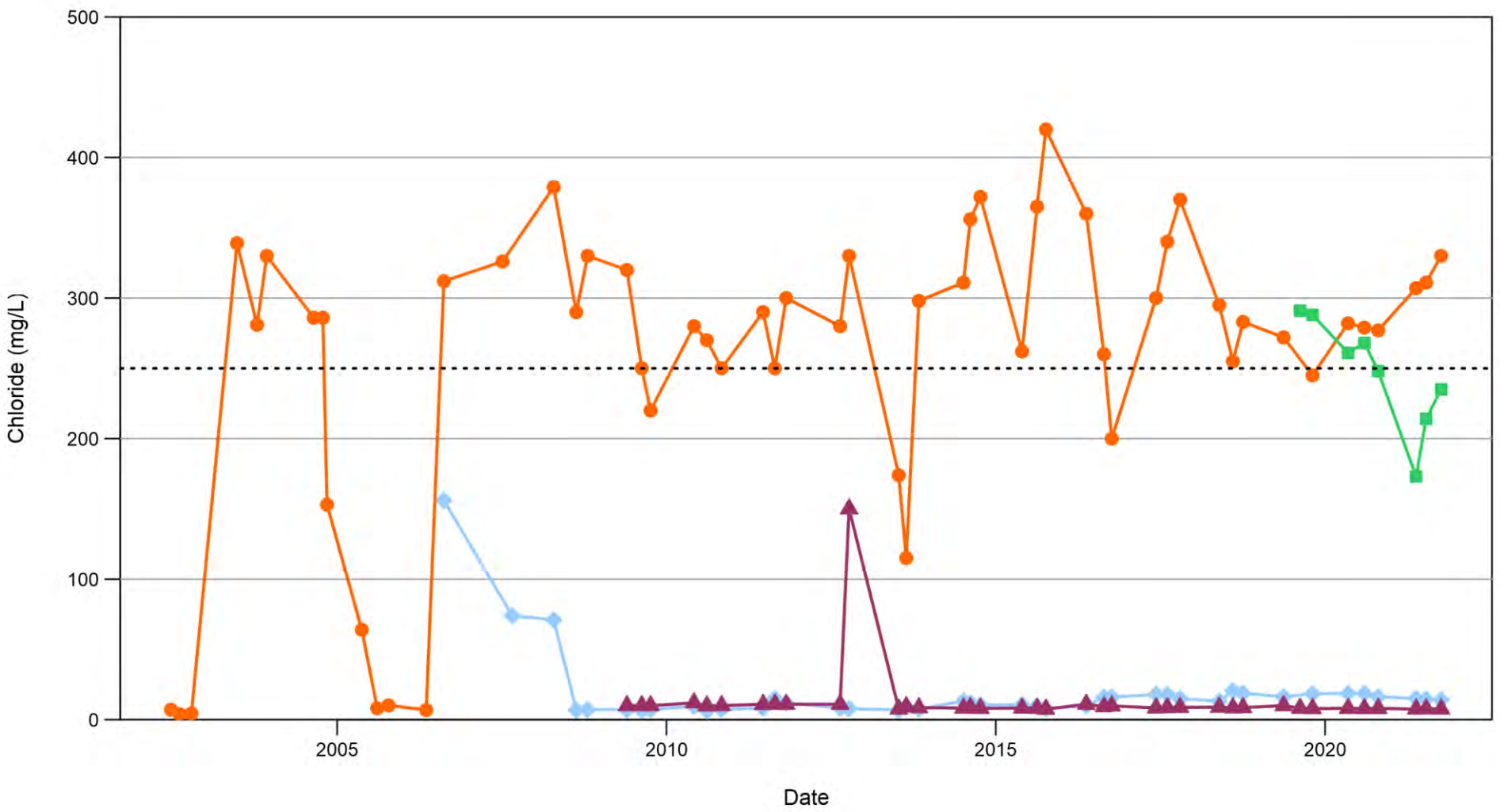
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Groundwater Sodium

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5b



DC-95-2
DC-98-1
DC-BH101
DC-19-1

B.C. CSR 375/96 - Drinking Water Standards (2021) = 250 mg/L

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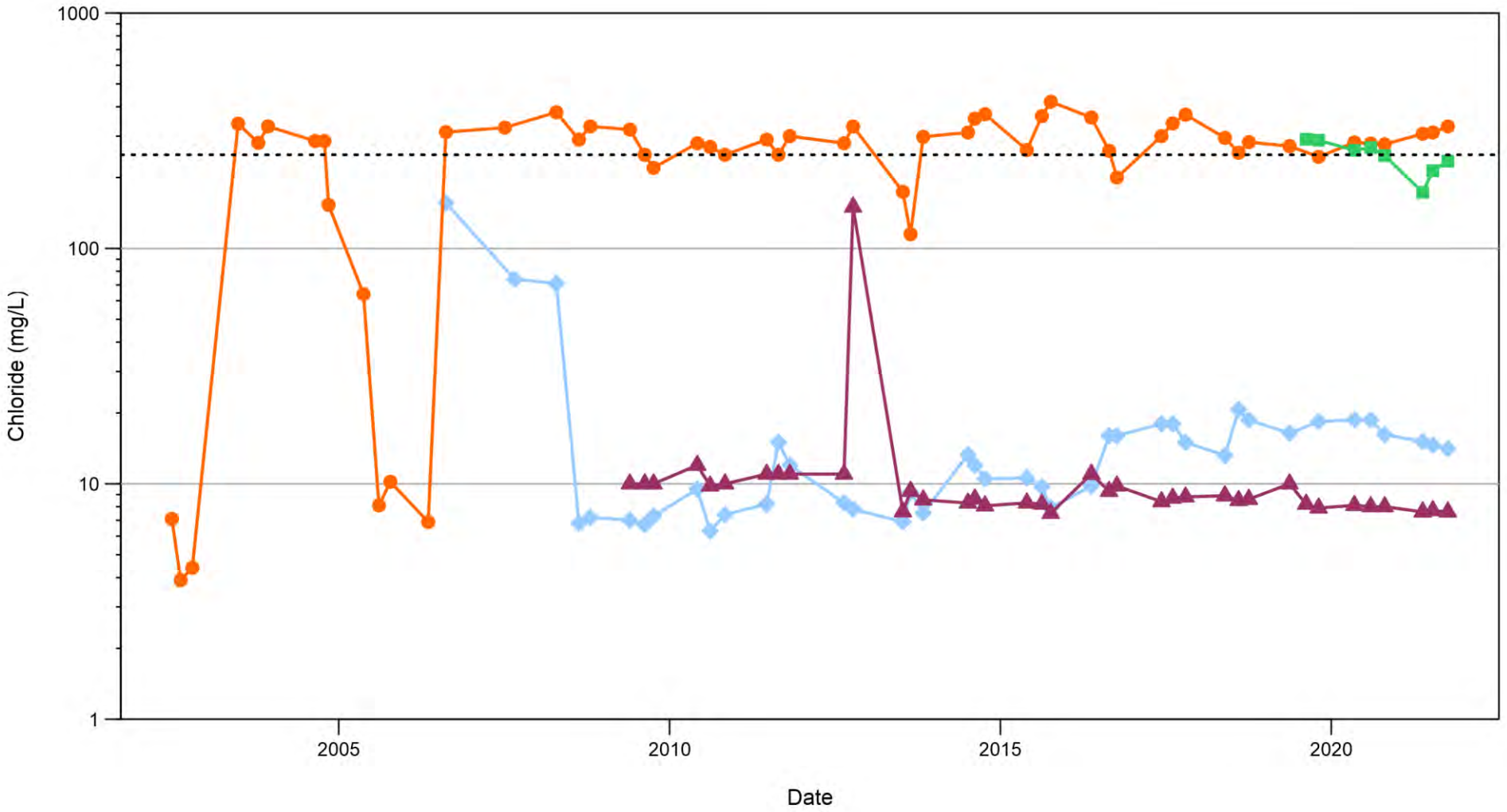
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Chloride Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5c



DC-95-2
DC-98-1
DC-BH101
DC-19-1

B.C. CSR 375/96 - Drinking Water Standards (2021) = 250 mg/L

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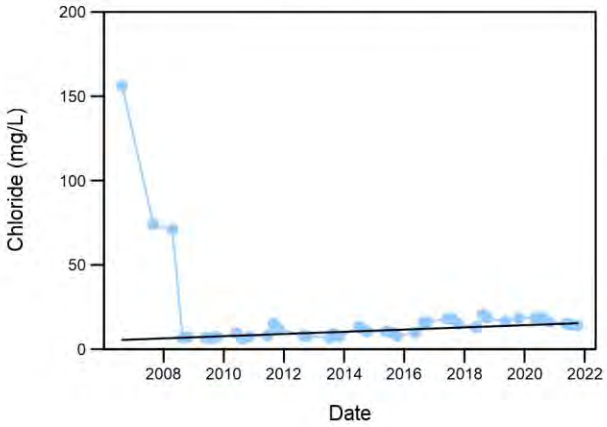
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Chloride Concentrations

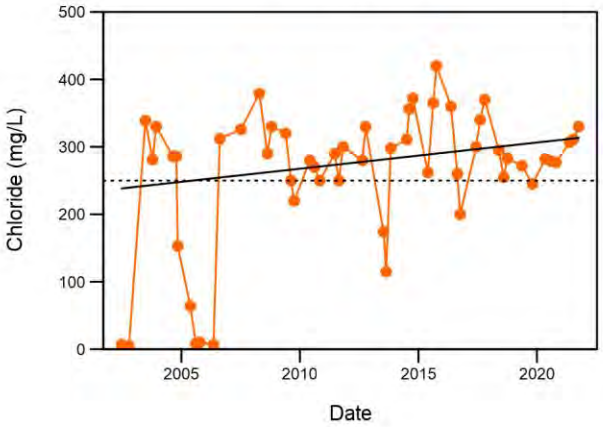
Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5c

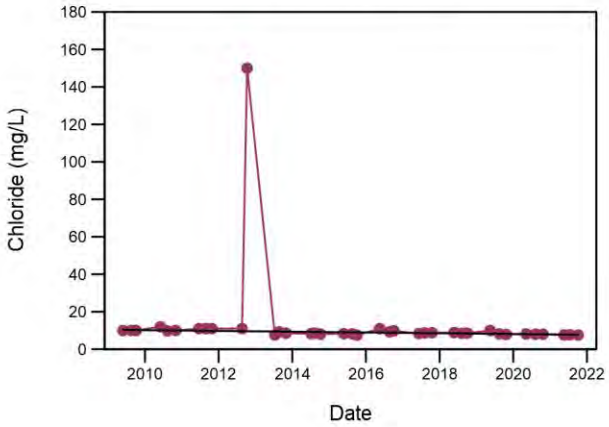
DC-95-2
Increasing Trend



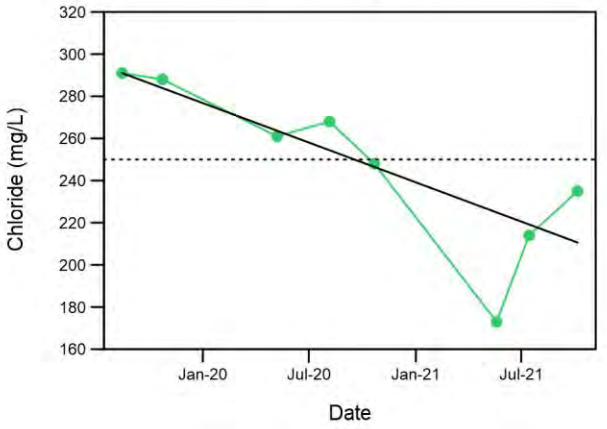
DC-98-1
Increasing Trend



DC-BH101
Decreasing Trend



DC-19-1
Decreasing Trend



Chloride
Sen slope
B.C. CSR 375/96 - Drinking Water Standards (2021) = 250 mg/L

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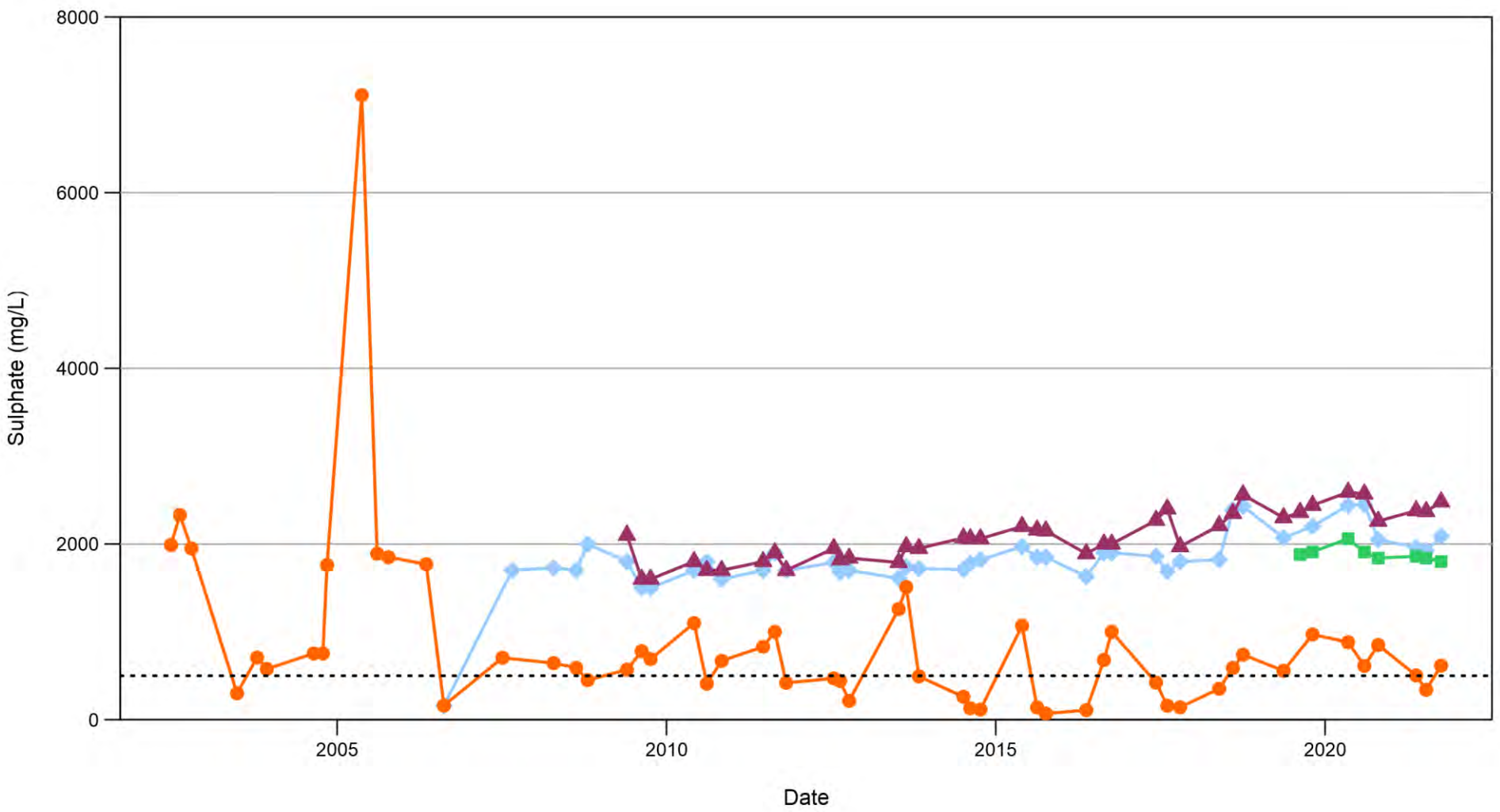
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Groundwater Chloride

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5d



DC-95-2
DC-98-1
DC-BH101
DC-19-1

B.C. CSR 375/96 - Drinking Water Standards (2021) = 500 mg/L

Matrix Solutions Inc.
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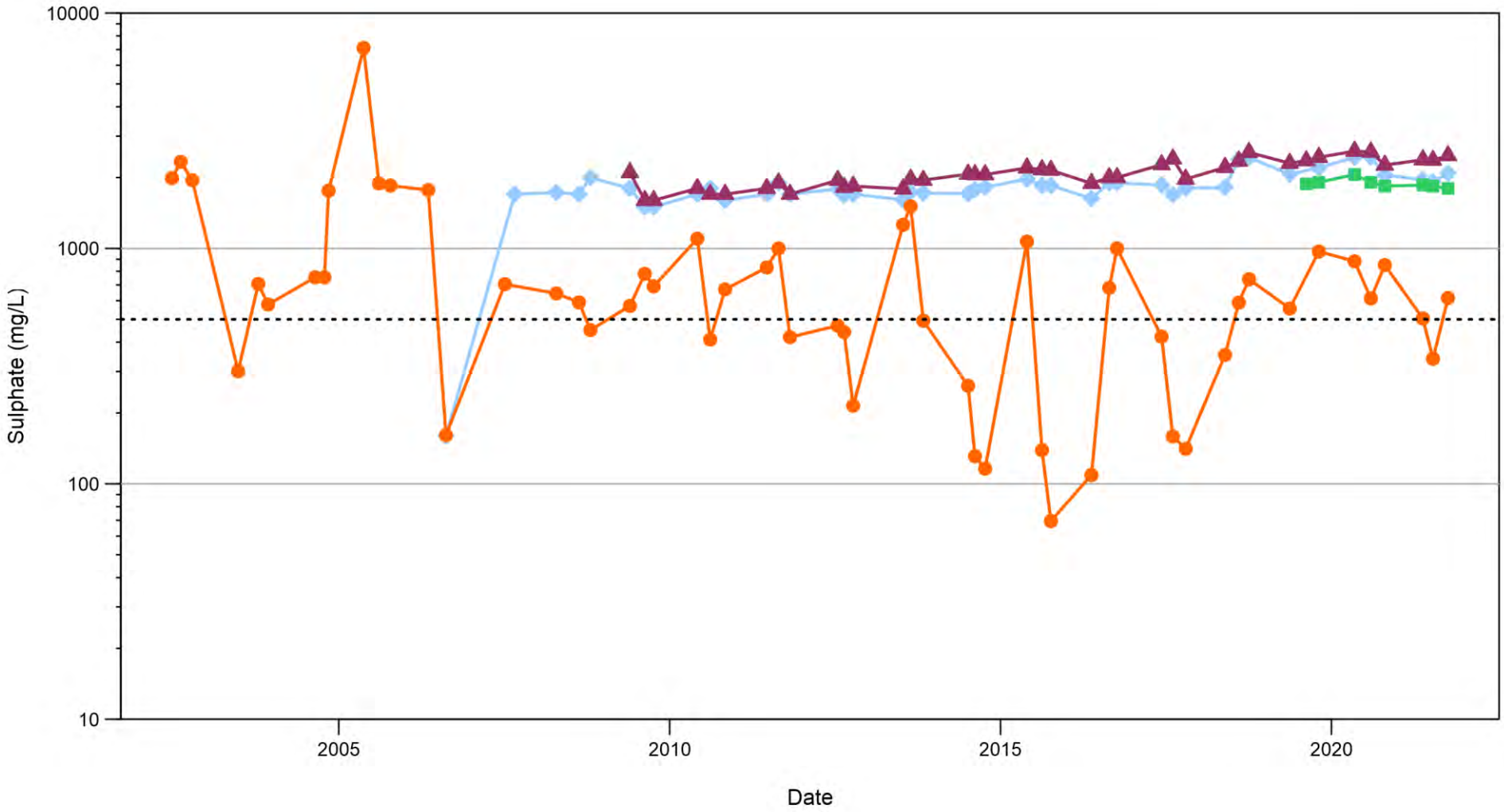
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Sulphate Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5e



DC-95-2
DC-98-1
DC-BH101
DC-19-1

B.C. CSR 375/96 - Drinking Water Standards (2021) = 500 mg/L

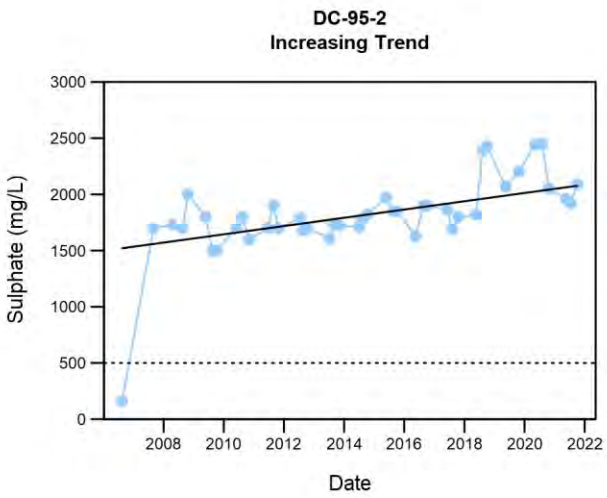
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

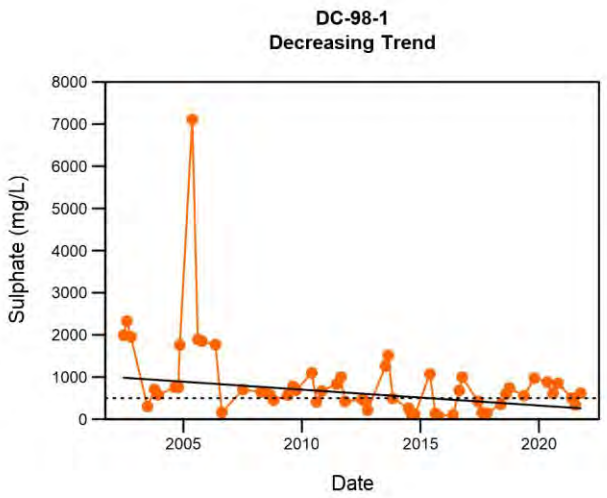
Peace River Regional District
Dawson Creek Landfill

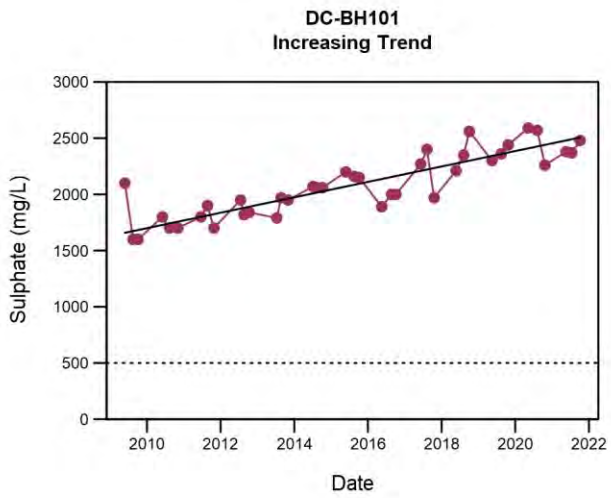
Historical Groundwater Sulphate Concentrations

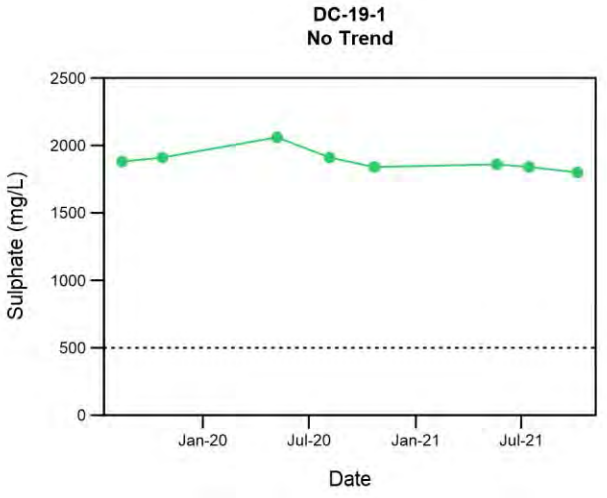
Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5e









Sulphate
Sen slope
B.C. CSR 375/96 - Drinking Water Standards (2021) = 500 mg/L

Matrix Solutions Inc.
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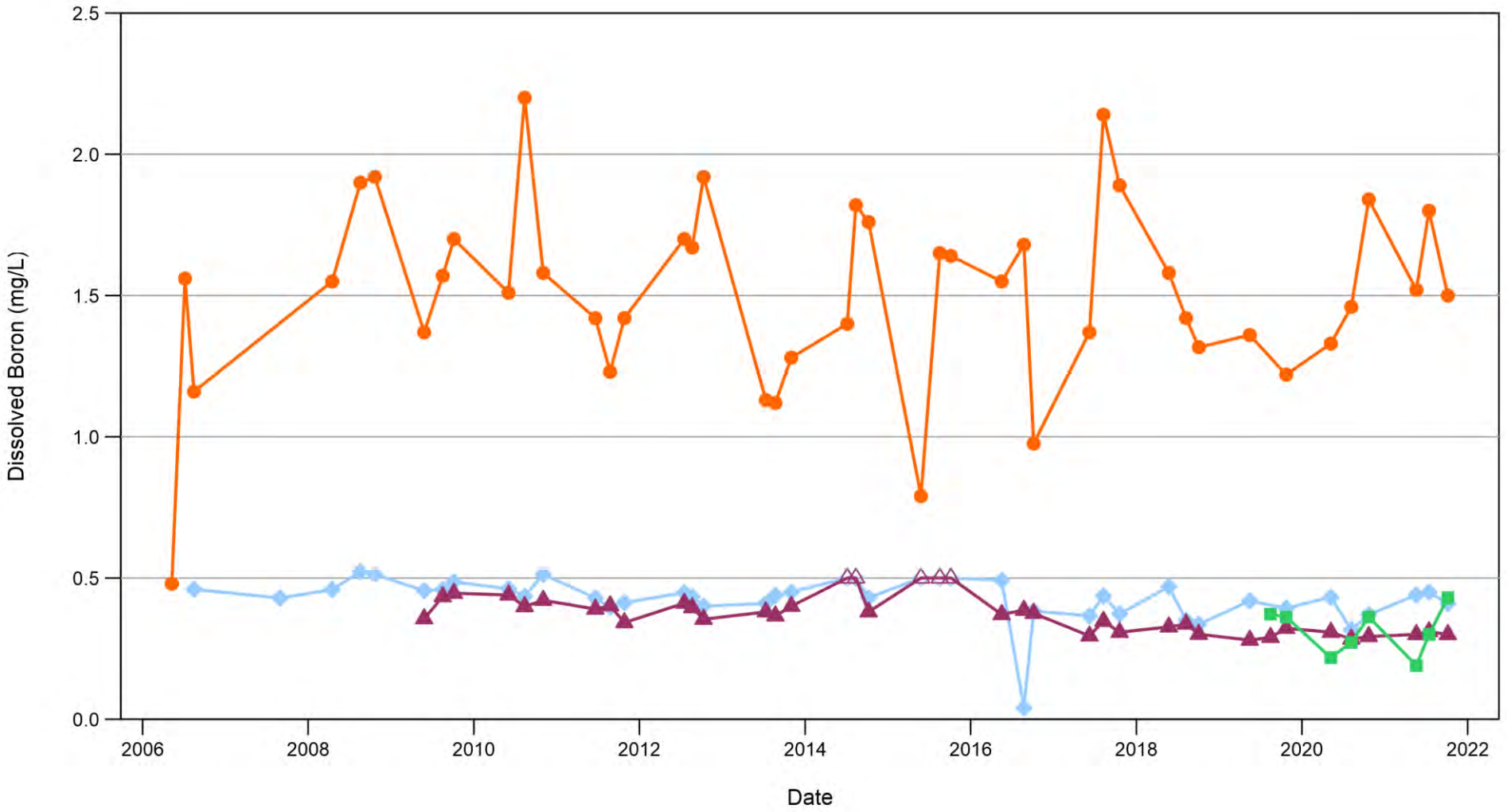
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Groundwater Sulphate

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5f



DC-95-2
DC-98-1
DC-BH101
DC-19-1

Non Detect (Open Symbol)
B.C. CSR 375/96 - Drinking Water Standards (2021) = 5 mg/L

Matrix Solutions Inc.
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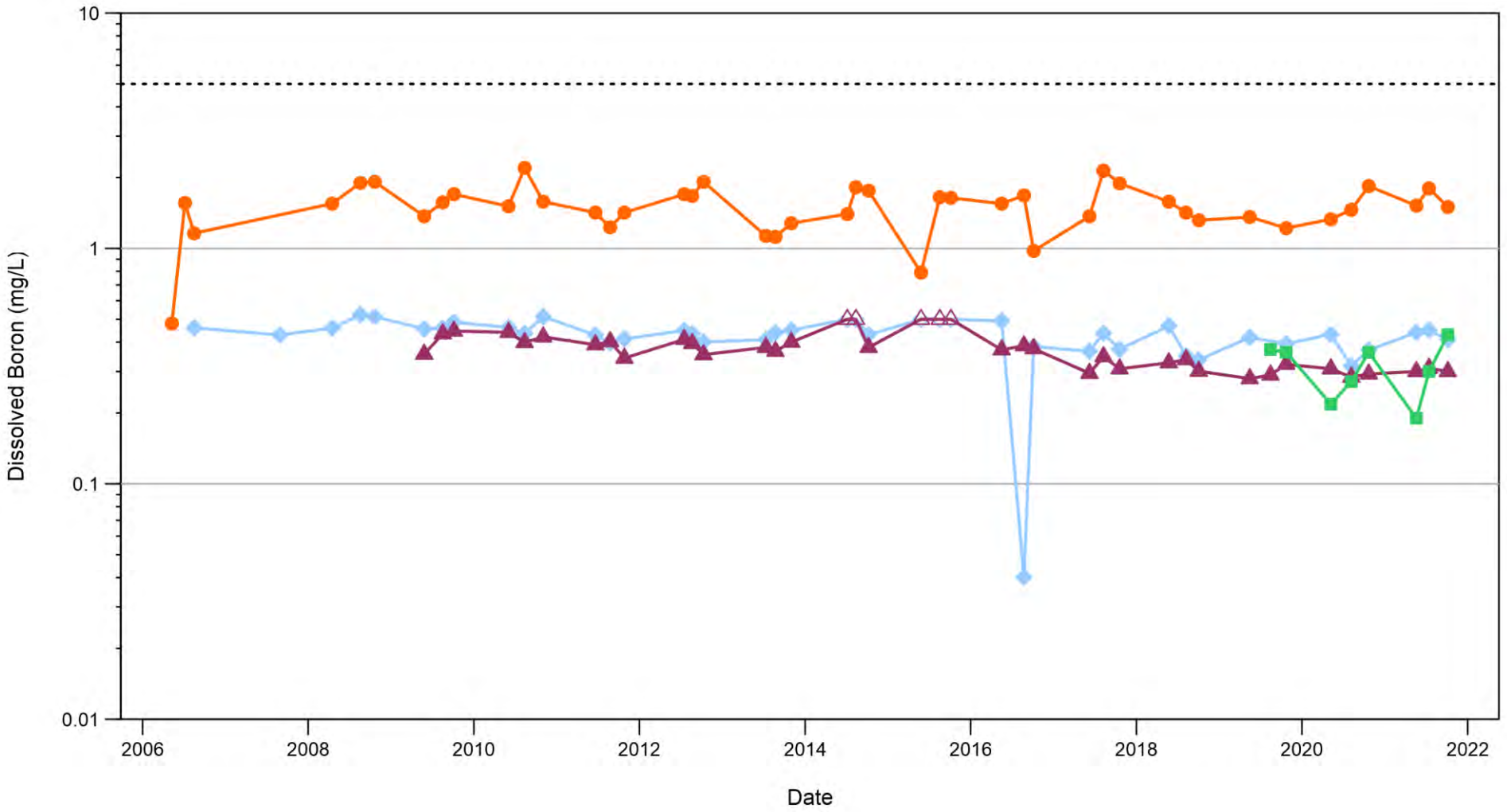
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Dissolved Boron Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5g



DC-95-2
DC-98-1
DC-BH101
DC-19-1

Non Detect (Open Symbol)
B.C. CSR 375/96 - Drinking Water Standards (2021) = 5 mg/L

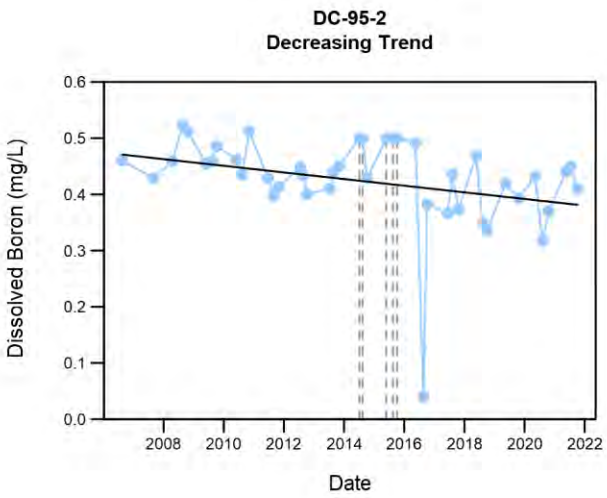
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

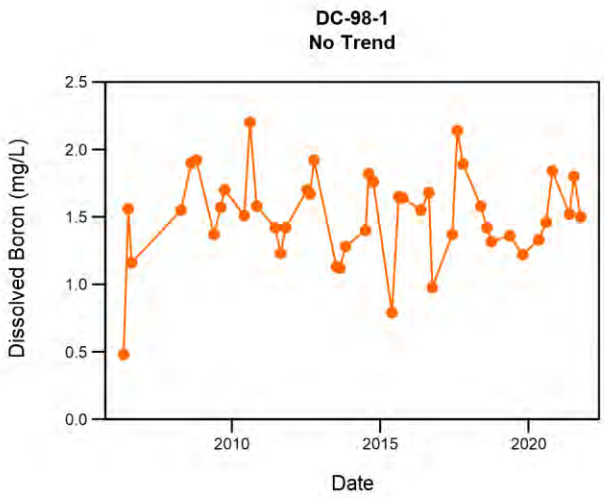
Peace River Regional District
Dawson Creek Landfill

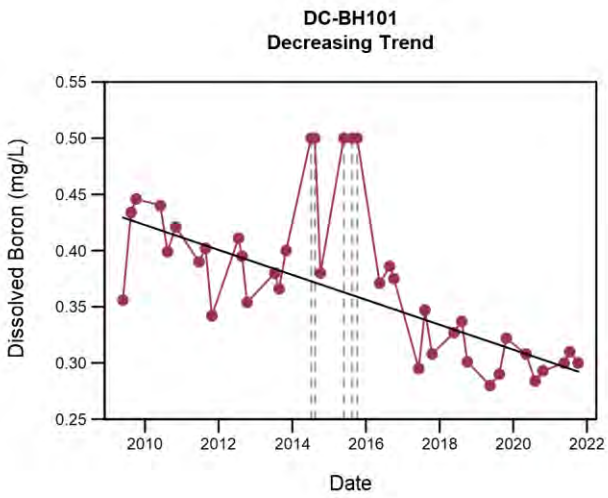
Historical Groundwater Dissolved Boron Concentrations

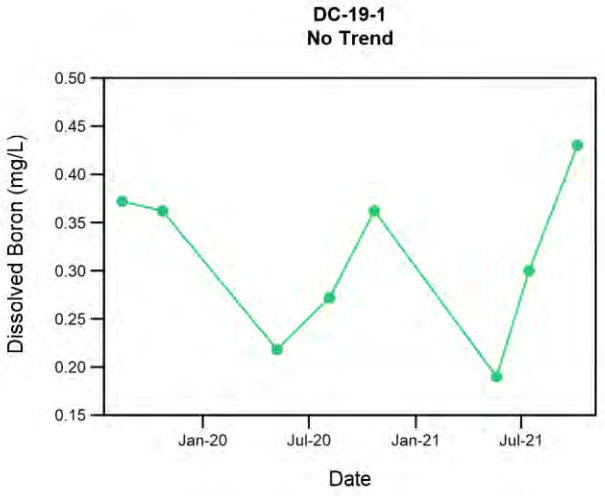
Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5g









- Dissolved Boron
- Values below detection limit (DL)
- Sen slope
- B.C. CSR 375/96 - Drinking Water Standards (2021) = 5 mg/L

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

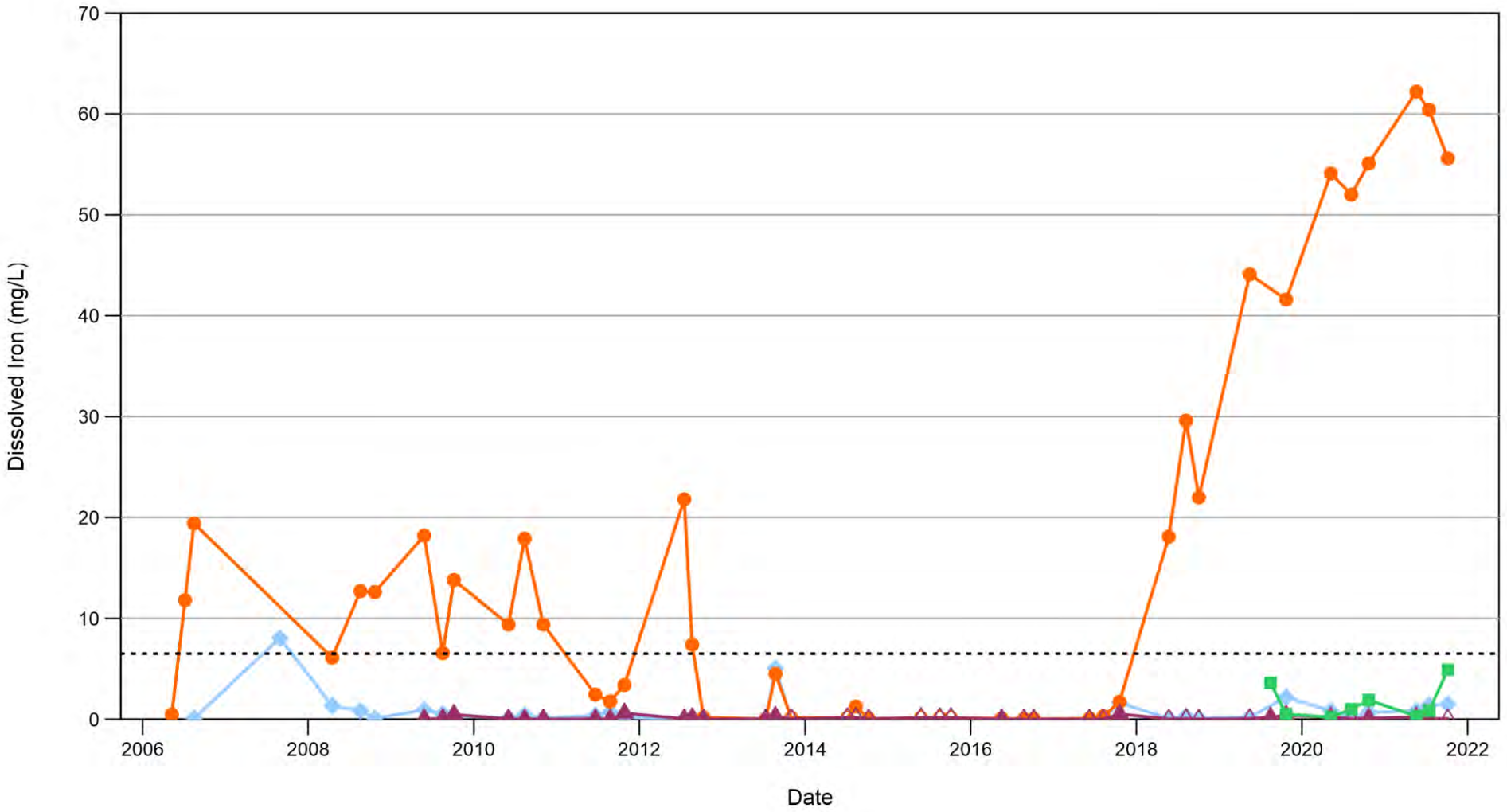
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Groundwater Dissolved Boron

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5h

F:/26254/502/2021/EDS/Dawson Creek/Trend Analysis/GW/GraphAll_2021114_16188.pdf - 2021-11-04 - adellej



DC-95-2
DC-98-1
DC-BH101
DC-19-1

Non Detect (Open Symbol)
B.C. CSR 375/96 - Drinking Water Standards (2021) = 6.5 mg/L

Matrix Solutions Inc.
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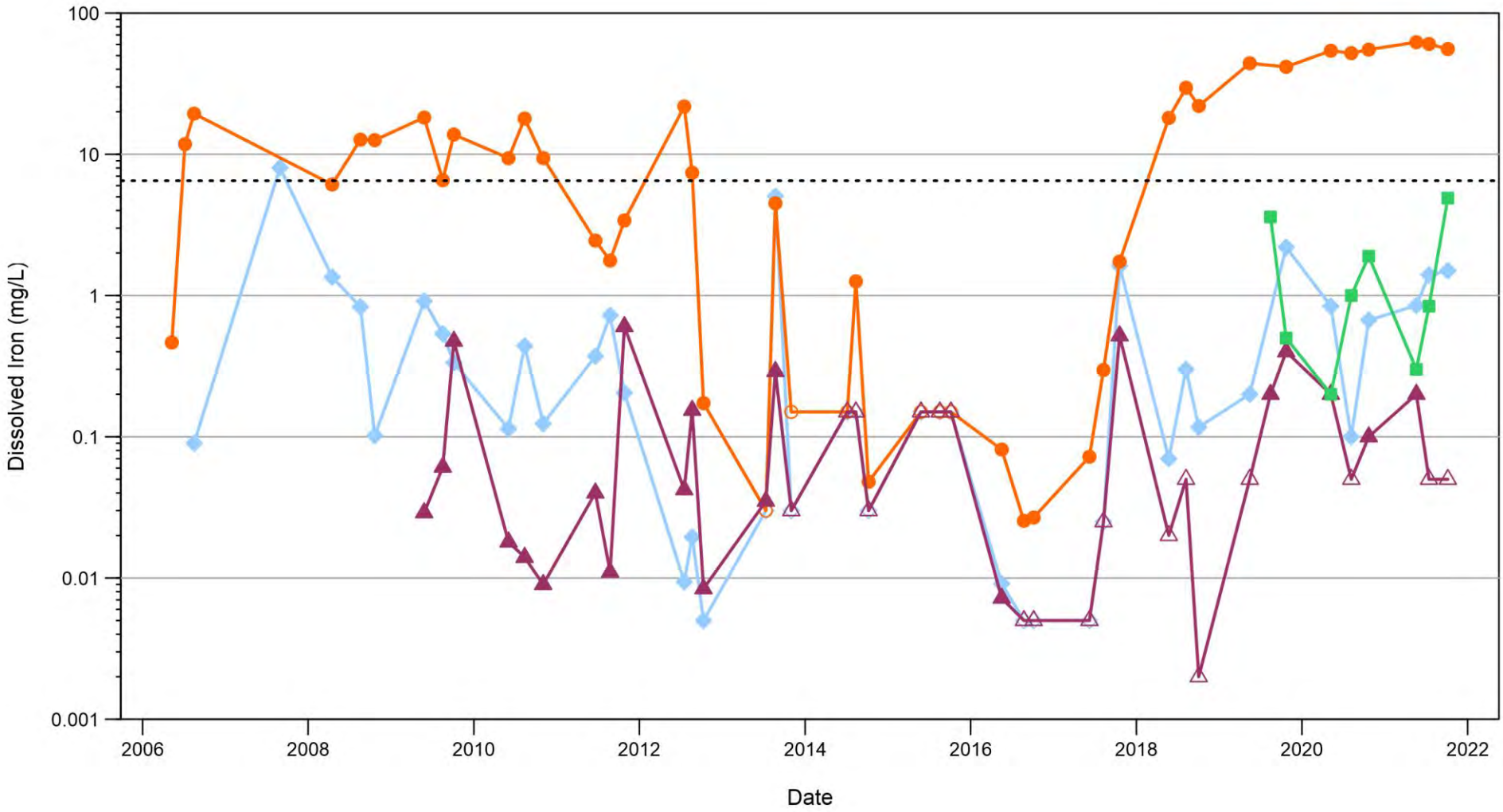
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Dissolved Iron Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5i



DC-95-2
DC-98-1
DC-BH101
DC-19-1

Non Detect (Open Symbol)
B.C. CSR 375/96 - Drinking Water Standards (2021) = 6.5 mg/L

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

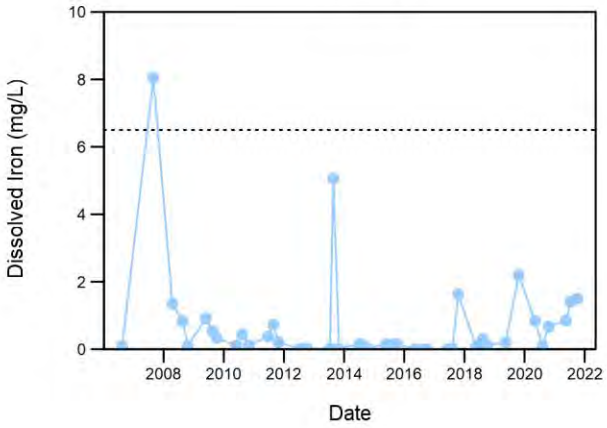
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Dissolved Iron Concentrations

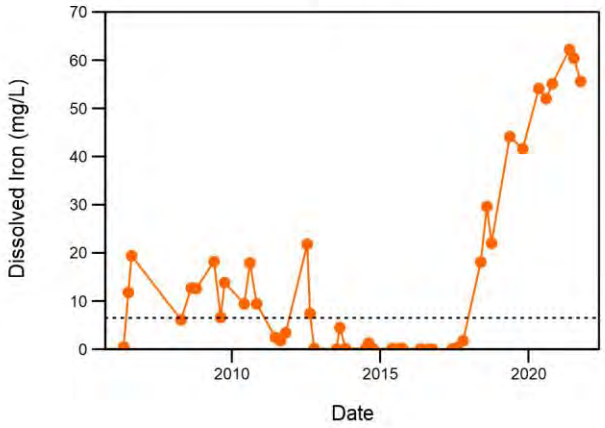
Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5i

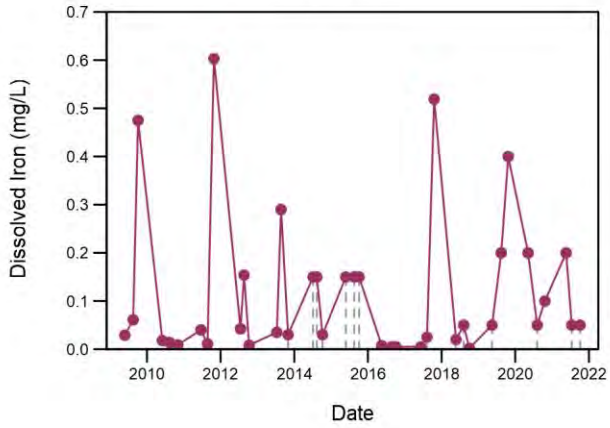
DC-95-2
No Trend



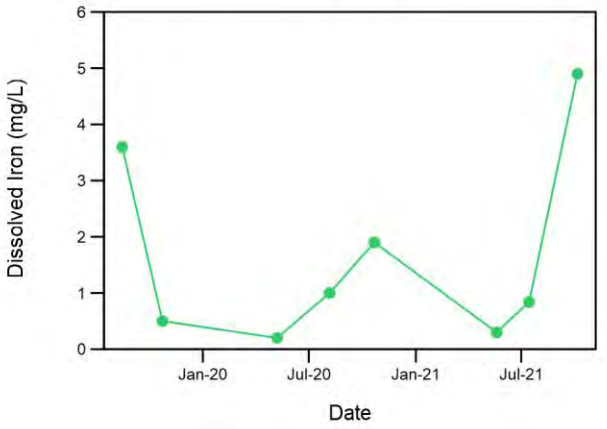
DC-98-1
No Trend



DC-BH101
No Trend



DC-19-1
No Trend



Dissolved Iron
Values below detection limit (DL)
B.C. CSR 375/96 - Drinking Water Standards (2021) = 6.5 mg/L

Matrix Solutions Inc.
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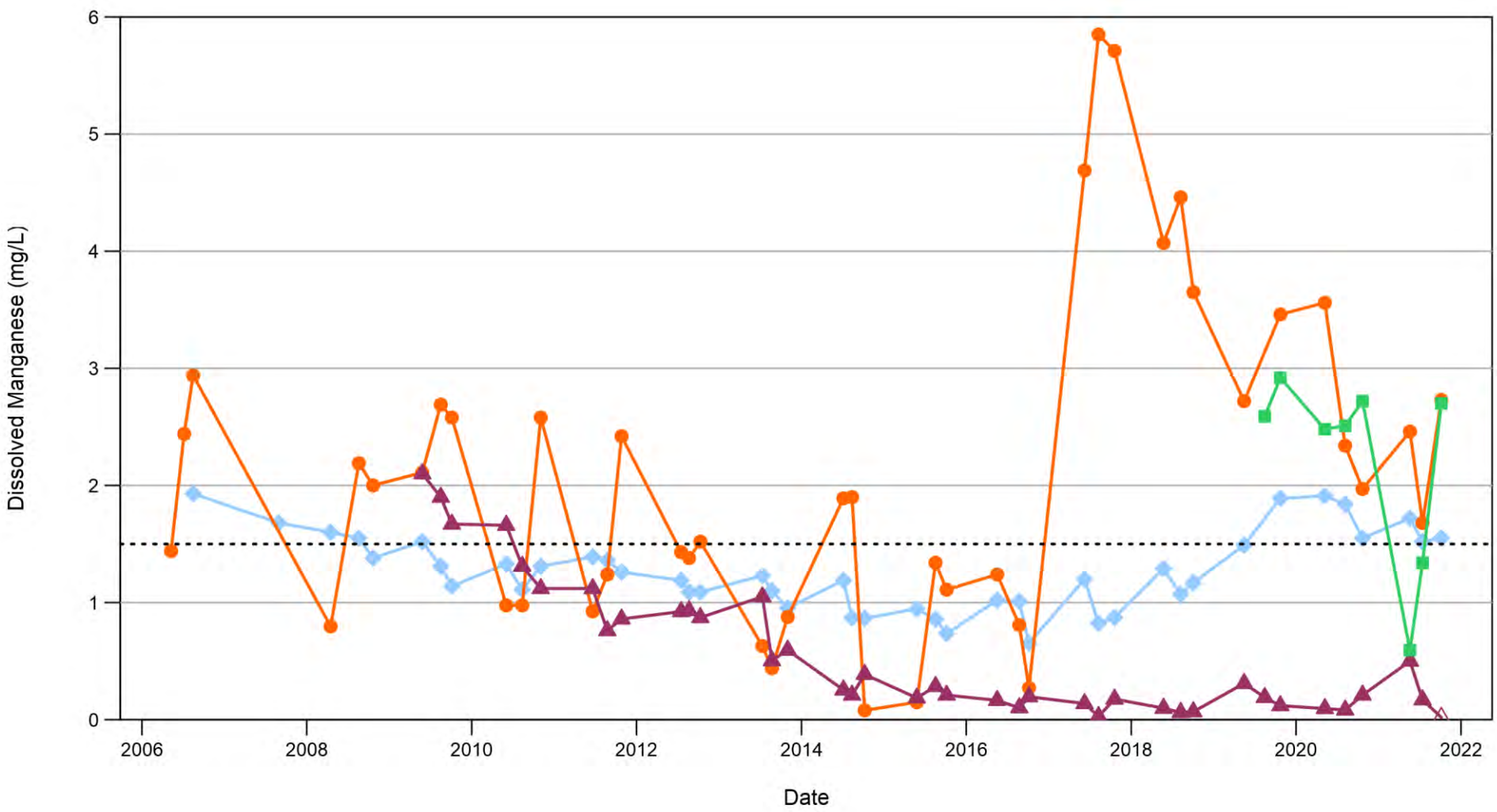
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Groundwater Dissolved Iron

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5j



DC-95-2
DC-98-1
DC-BH101
DC-19-1

Non Detect (Open Symbol)
B.C. CSR 375/96 - Drinking Water Standards (2021) = 1.5 mg/L

Matrix Solutions Inc.
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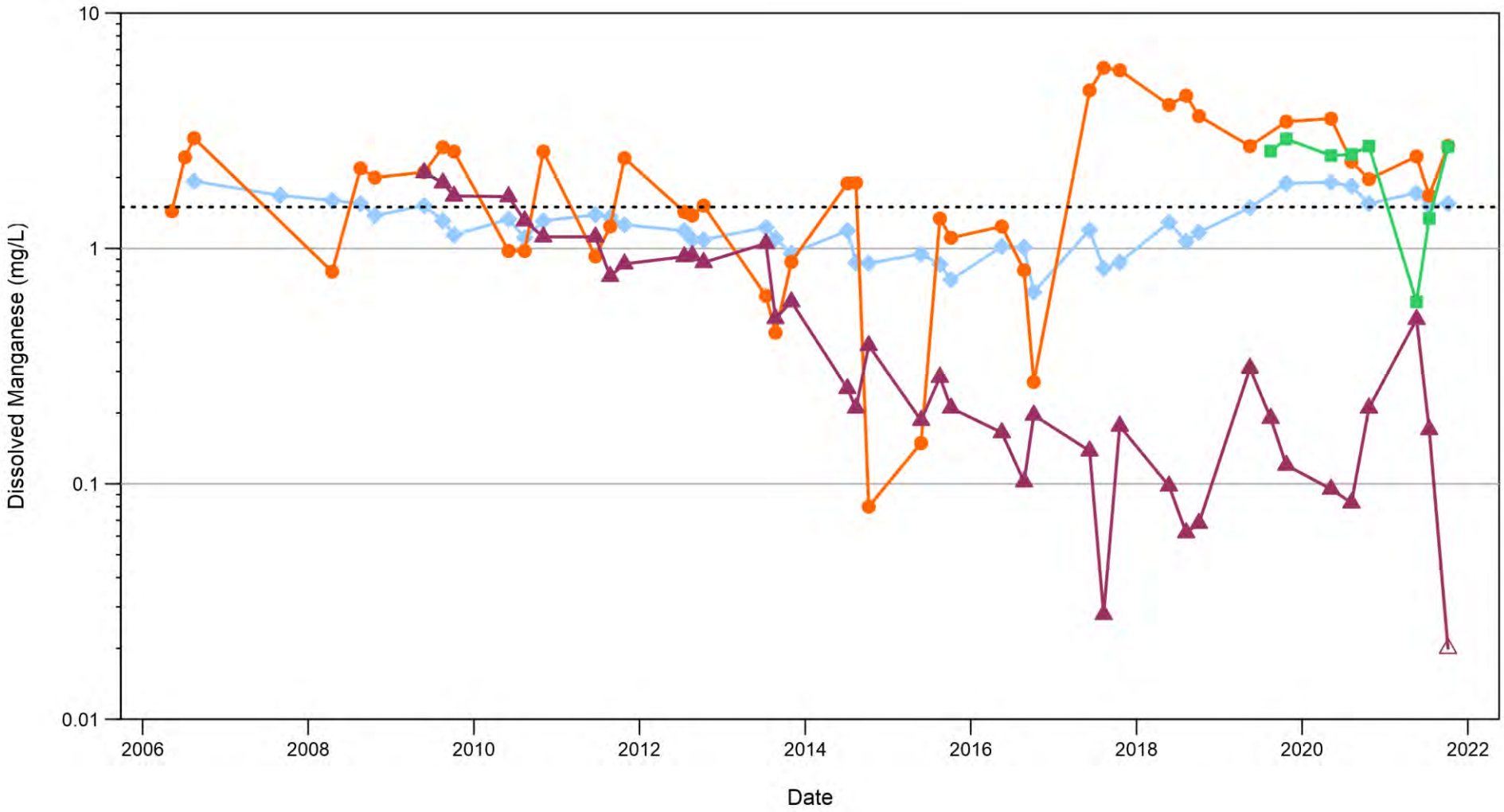
Peace River Regional District
Dawson Creek Landfill

Historical Groundwater Dissolved Manganese Concentrations

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5k



DC-95-2
DC-98-1
DC-BH101
DC-19-1

Non Detect (Open Symbol)
---- B.C. CSR 375/96 - Drinking Water Standards (2021) = 1.5 mg/L

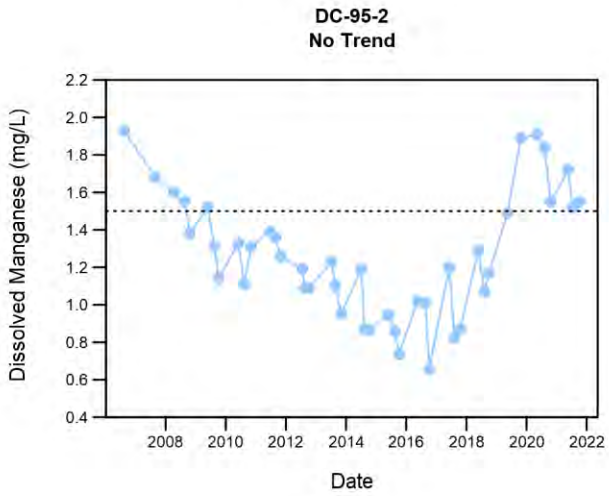
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

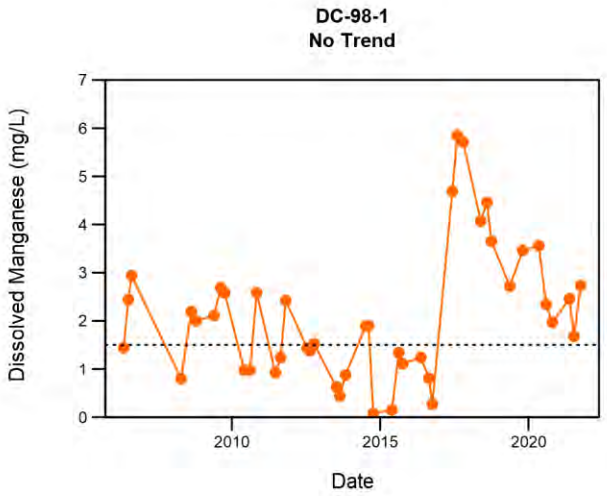
Peace River Regional District
Dawson Creek Landfill

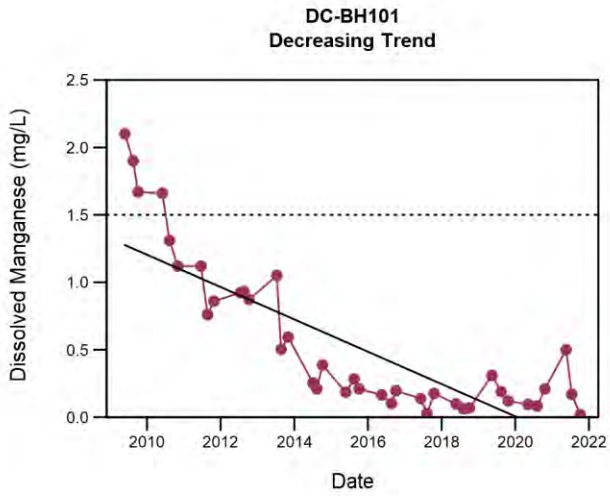
Historical Groundwater Dissolved Manganese Concentrations

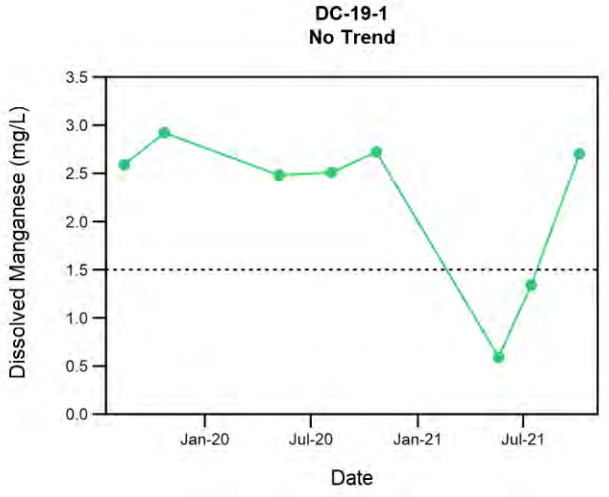
Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5k









- Dissolved Manganese
- Values below detection limit (DL)
- Sen slope
- B.C. CSR 375/96 - Drinking Water Standards (2021) = 1.5 mg/L

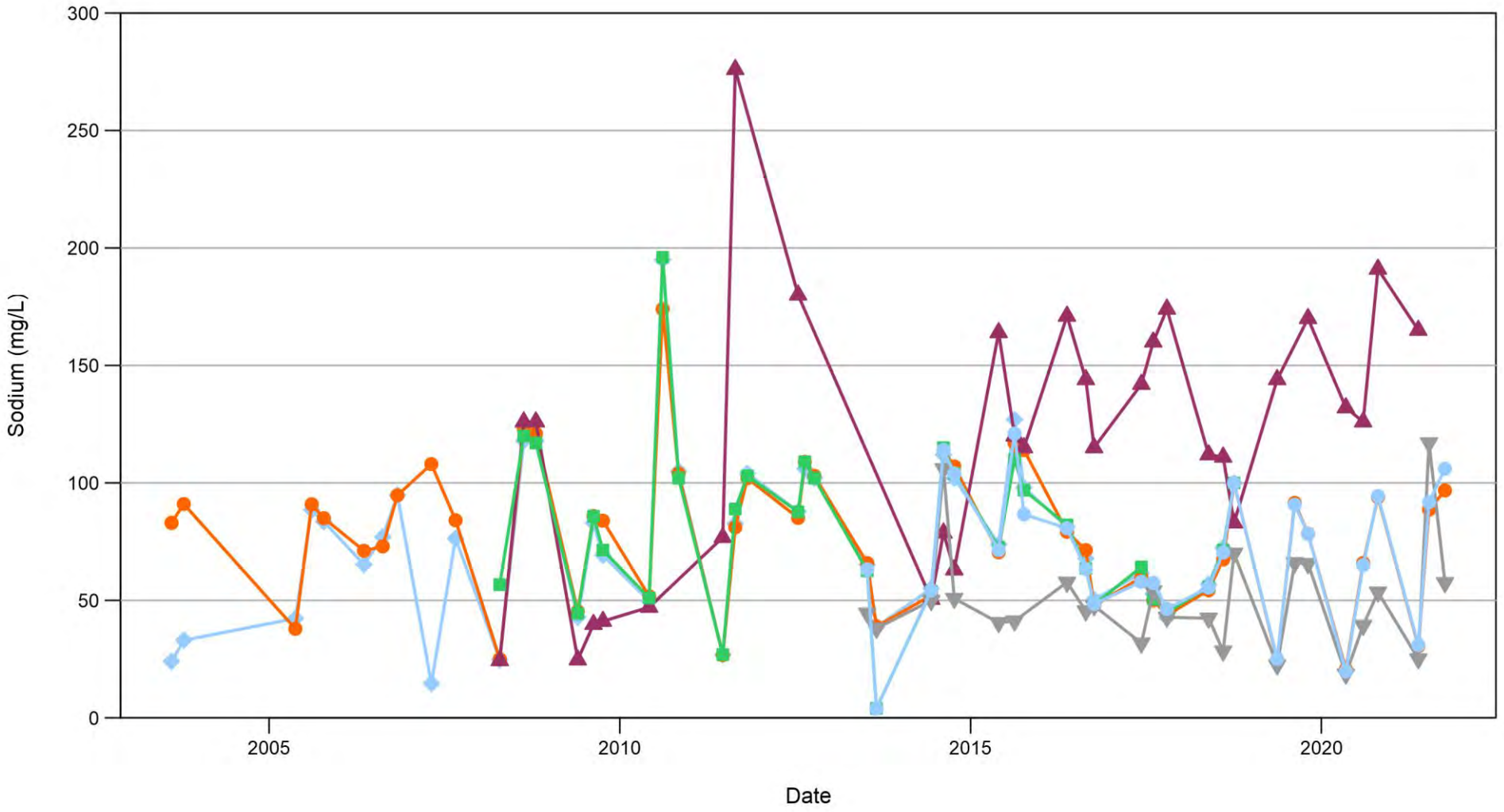
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Groundwater Dissolved Manganese

Date:	Project:	Submitter:	Reviewer:
04 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5I



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

Matrix Solutions Inc.
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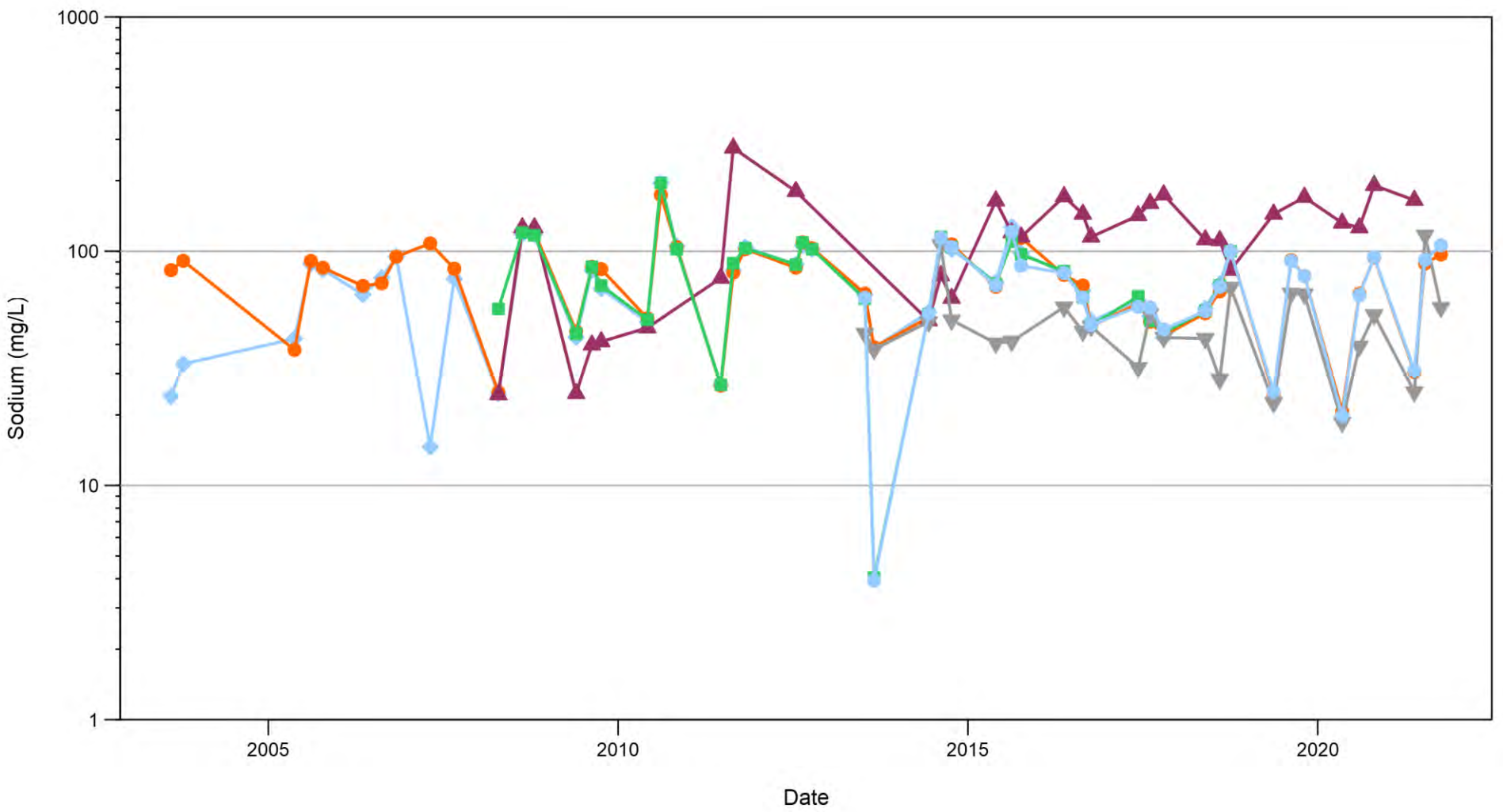
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Sodium Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5m



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

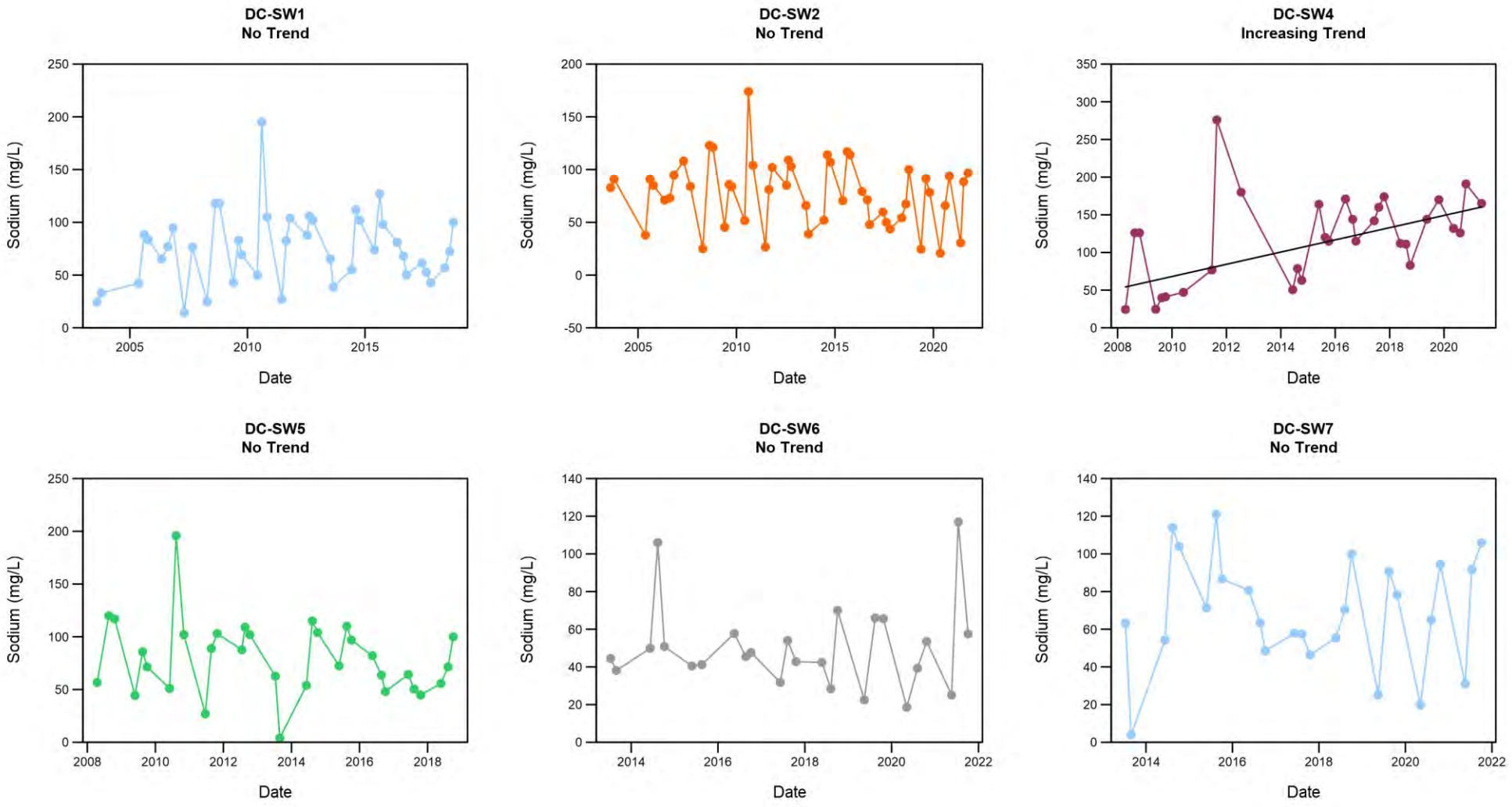
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Sodium Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5m



Matrix Solutions Inc.
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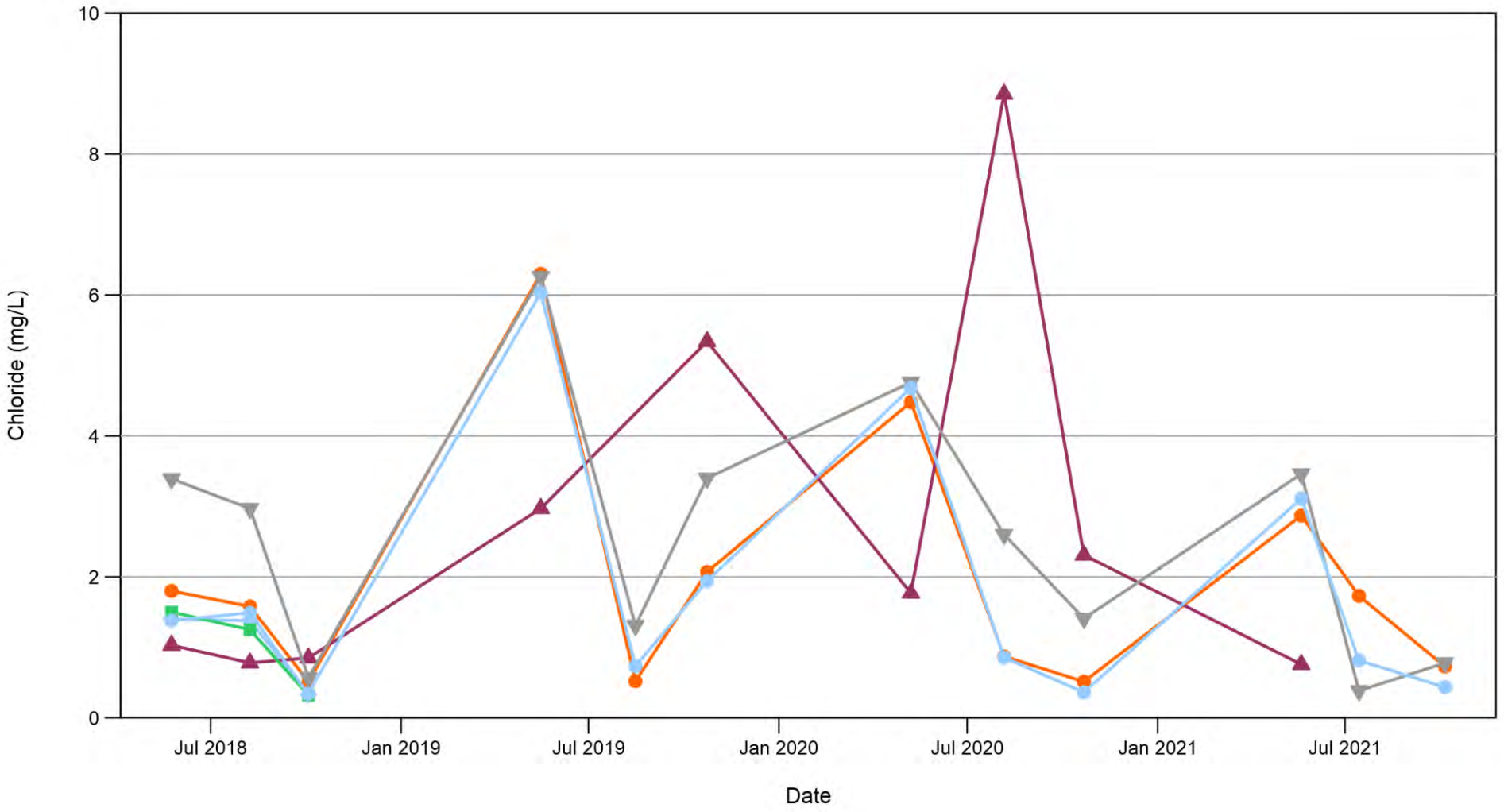
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Sodium

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5n



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Irrigation (2019) = 100 mg/L

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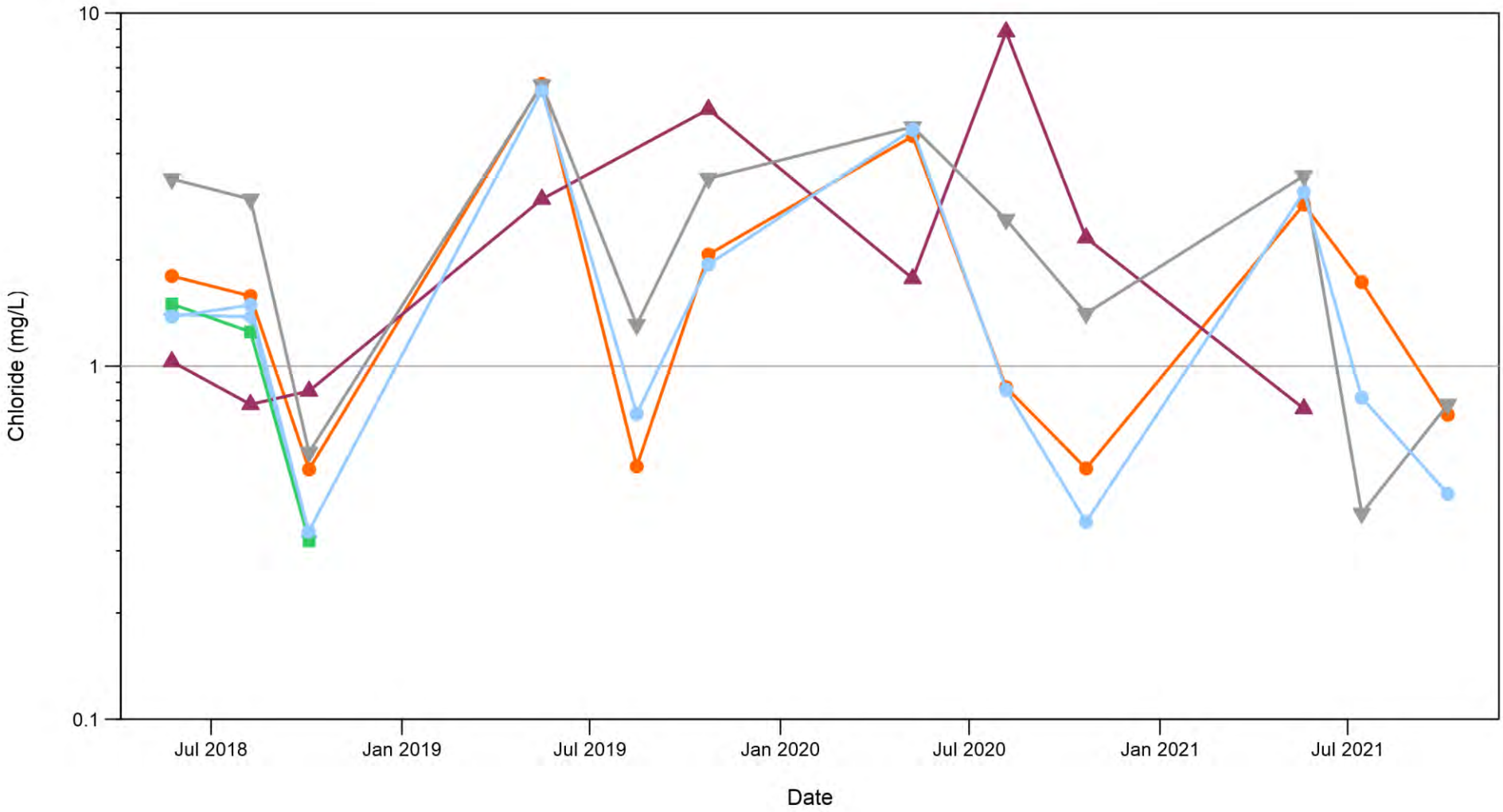
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Chloride Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5o



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Irrigation (2019) = 100 mg/L

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

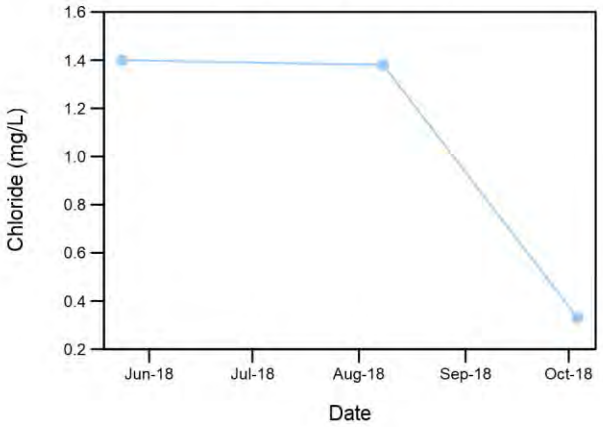
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Chloride Concentrations

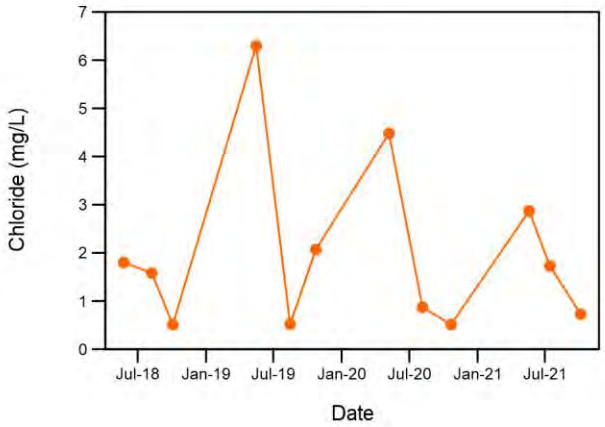
Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5o

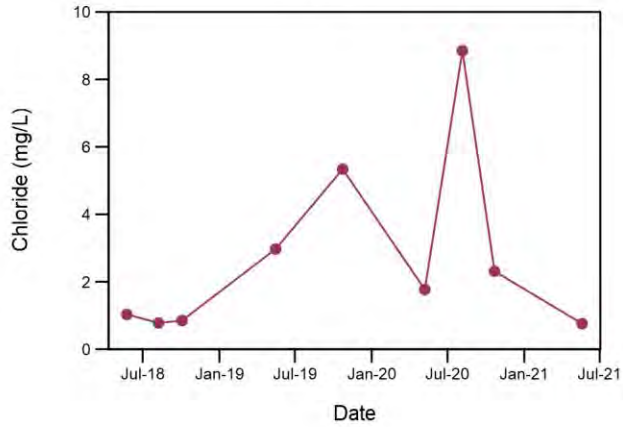
DC-SW1
Insufficient data for analysis



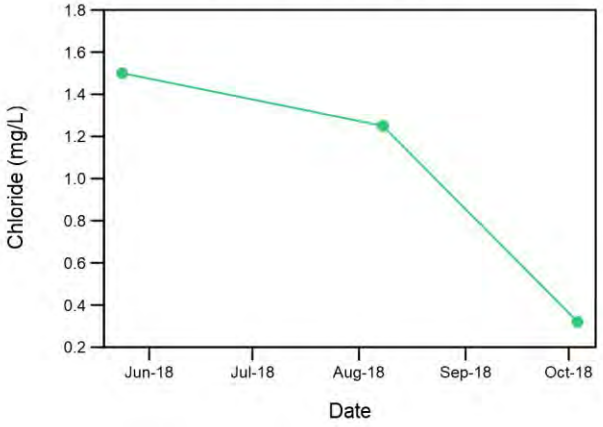
DC-SW2
No Trend



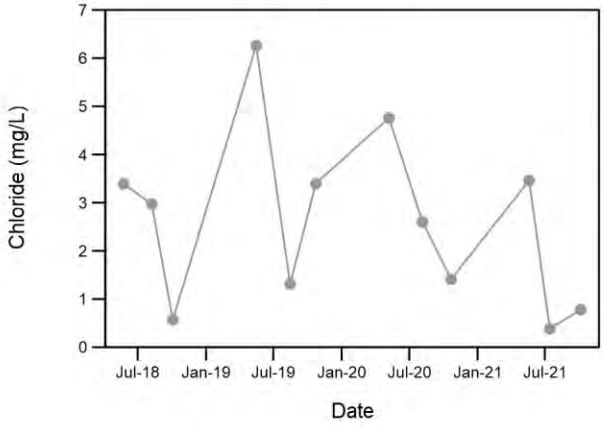
DC-SW4
No Trend



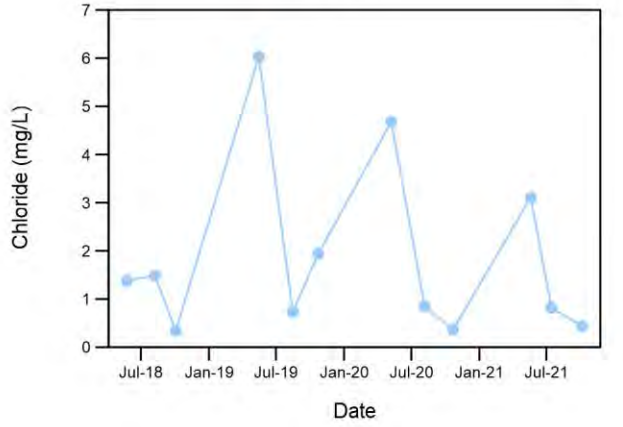
DC-SW5
Insufficient data for analysis



DC-SW6
No Trend



DC-SW7
No Trend



Chloride
B.C. Approved Water Quality Guidelines - Irrigation (2019) = 100 mg/L

Matrix Solutions Inc.
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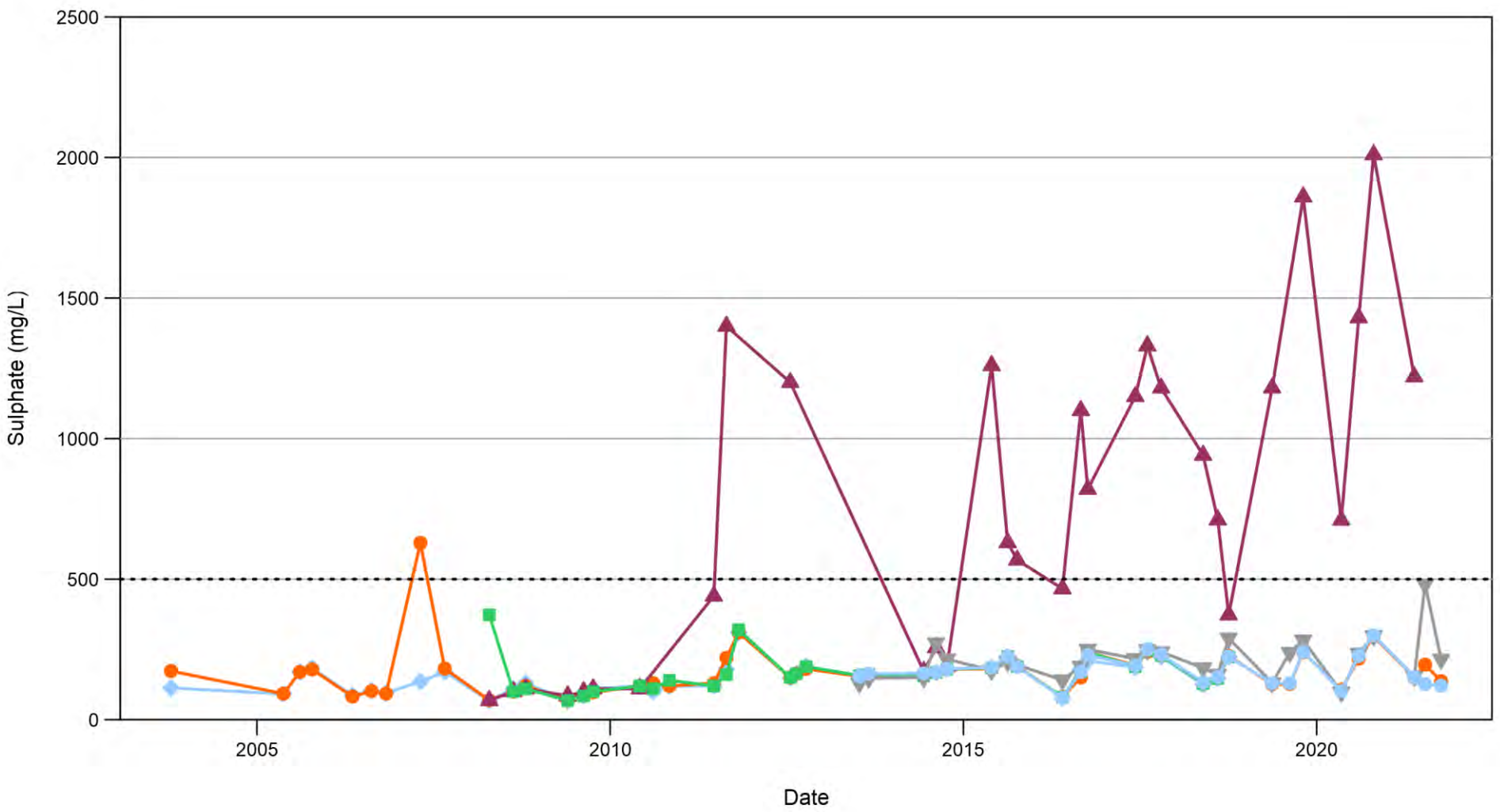
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Chloride

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5p



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 500 mg/L

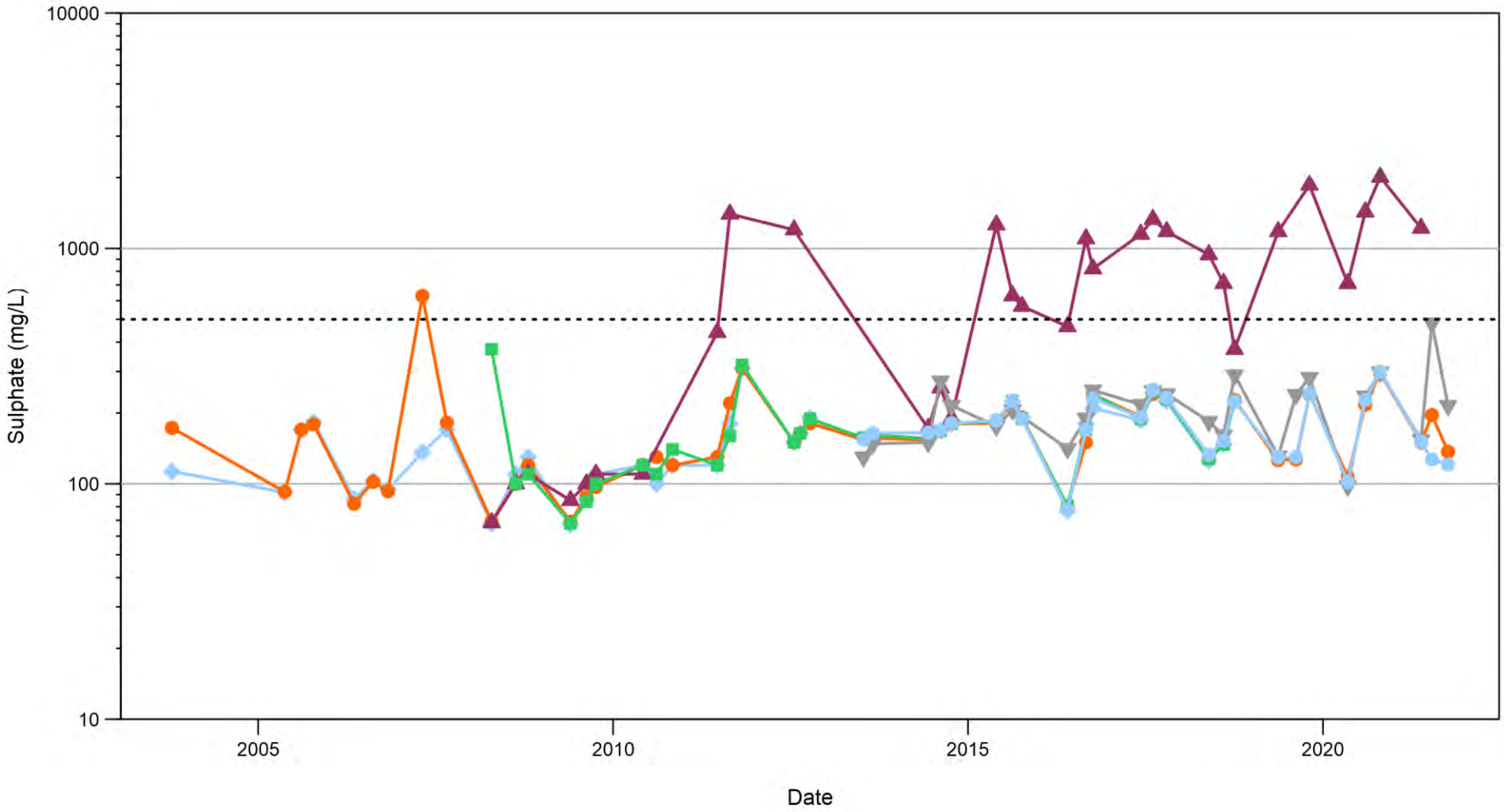
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Sulphate Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5q



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 500 mg/L

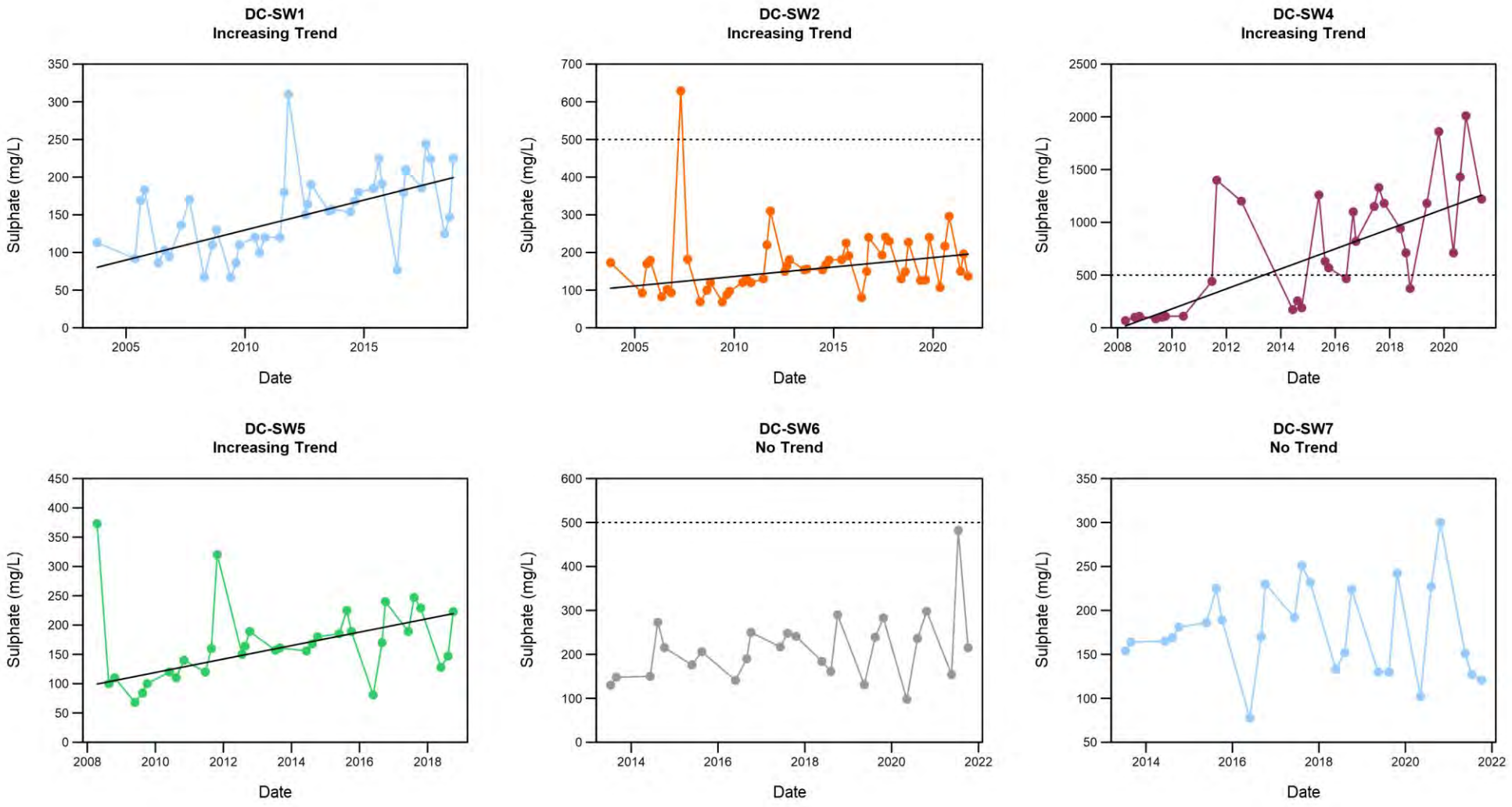
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Sulphate Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5q



Sulphate
Sen slope
B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 500 mg/L

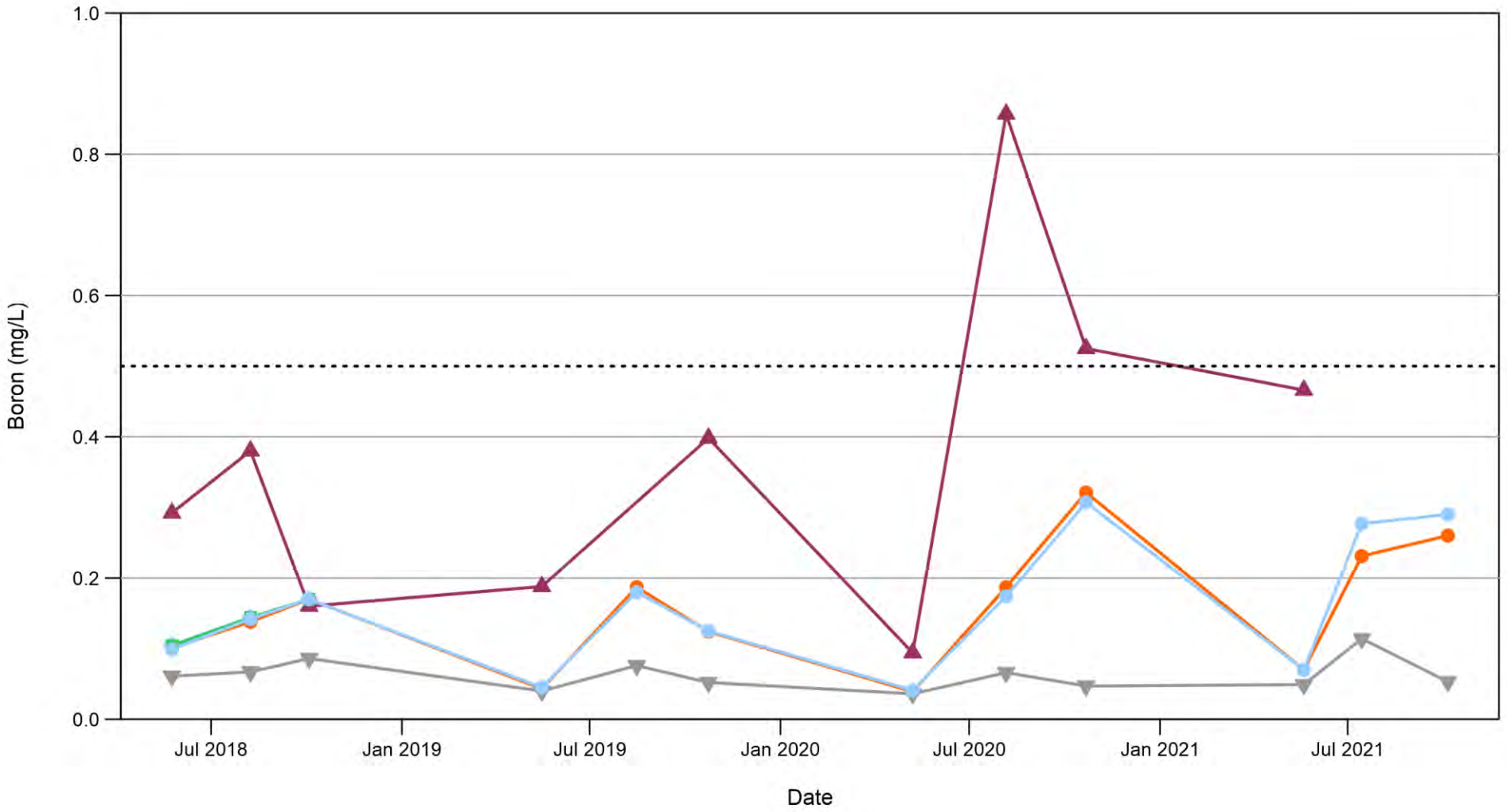
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Sulphate

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5r



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Irrigation (2019) = 0.5 mg/L

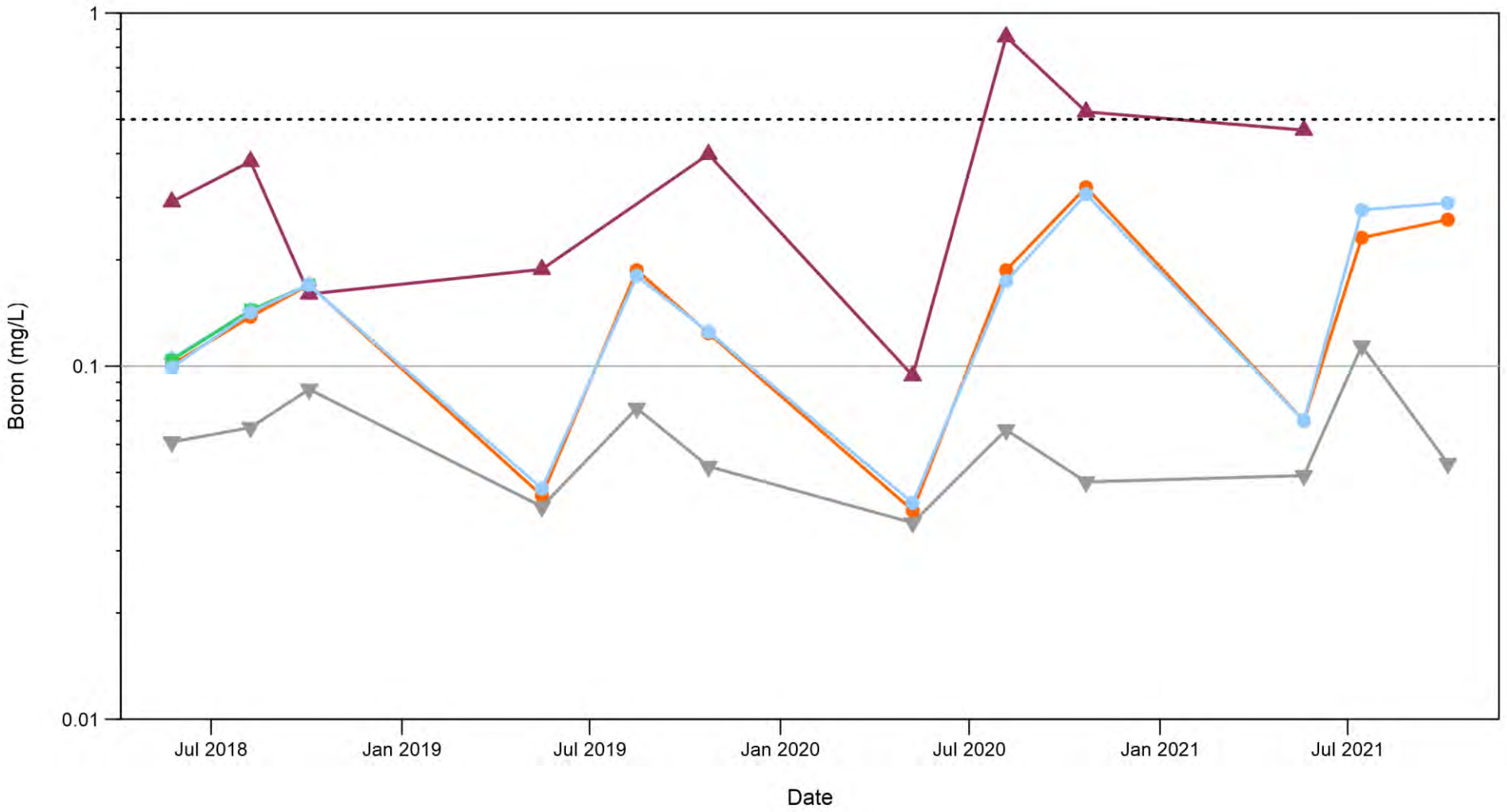
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Boron Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5s



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Irrigation (2019) = 0.5 mg/L

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

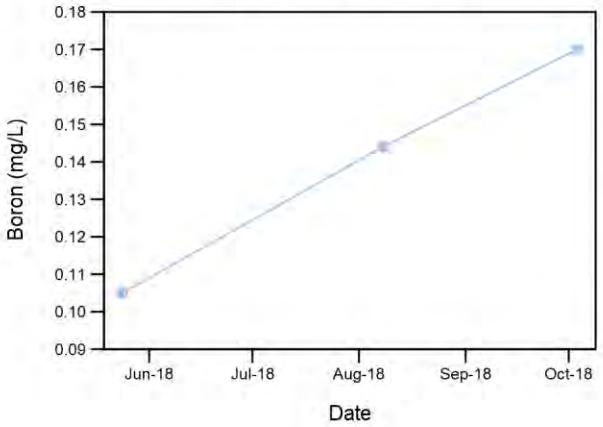
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Boron Concentrations

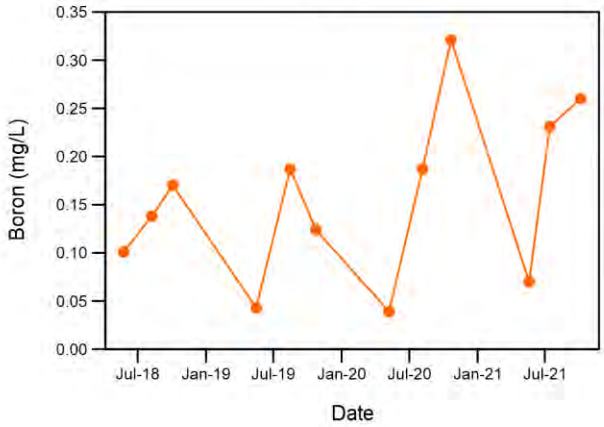
Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5s

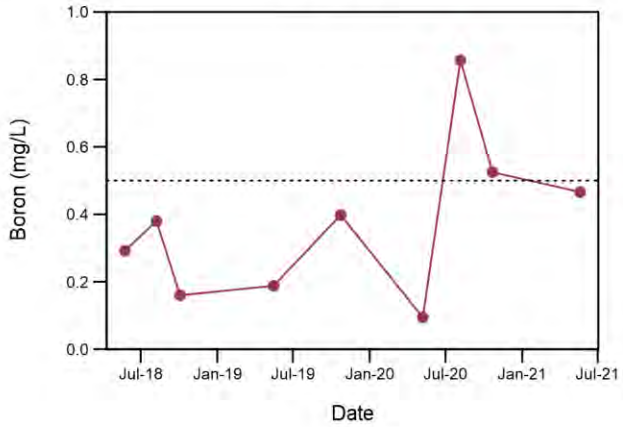
DC-SW1
Insufficient data for analysis



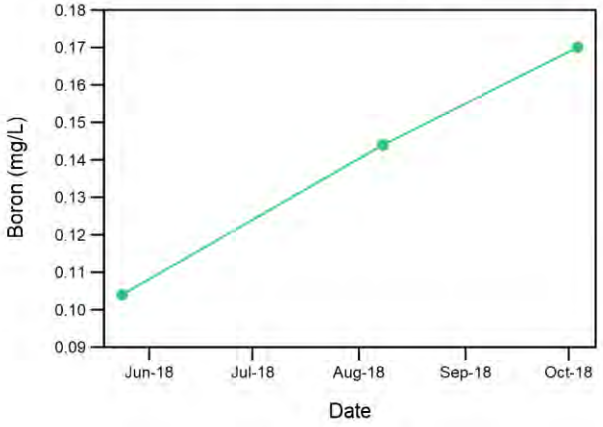
DC-SW2
No Trend



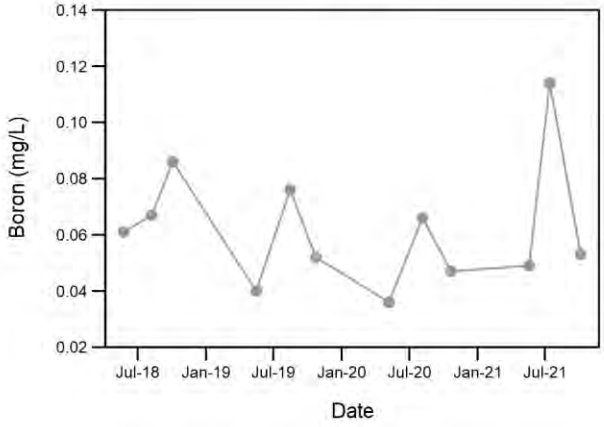
DC-SW4
No Trend



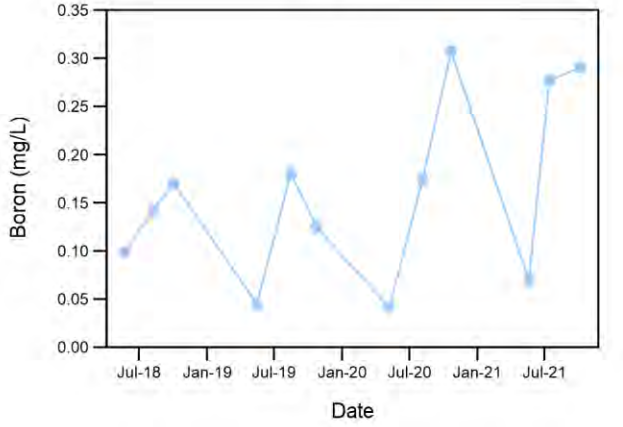
DC-SW5
Insufficient data for analysis



DC-SW6
No Trend



DC-SW7
No Trend



Boron
B.C. Approved Water Quality Guidelines - Irrigation (2019) = 0.5 mg/L

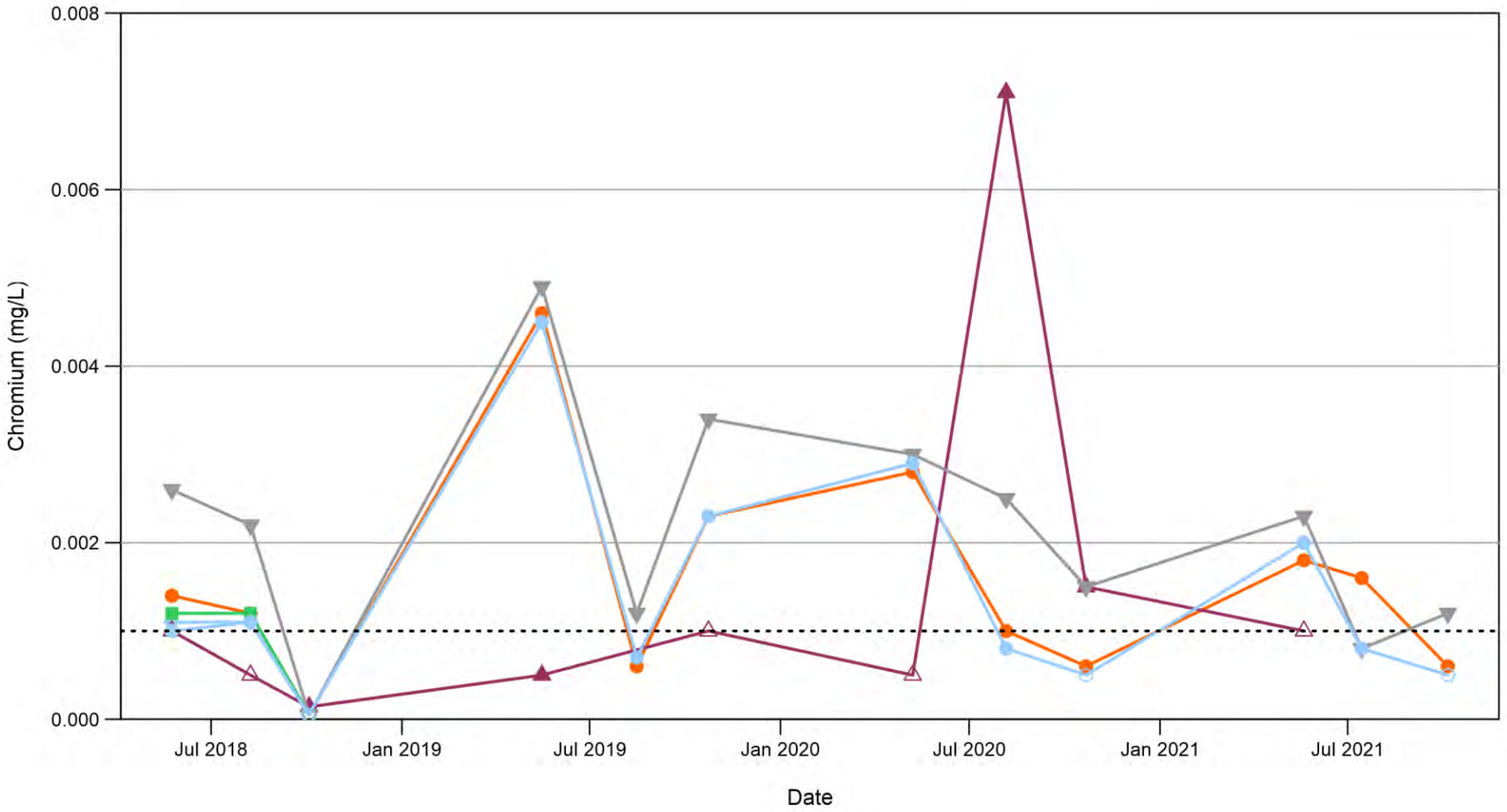
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Boron

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5t



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

Non Detect (Open Symbol)
B.C. Working Water Quality Guidelines - FAL (2021) = 0.001 mg/L

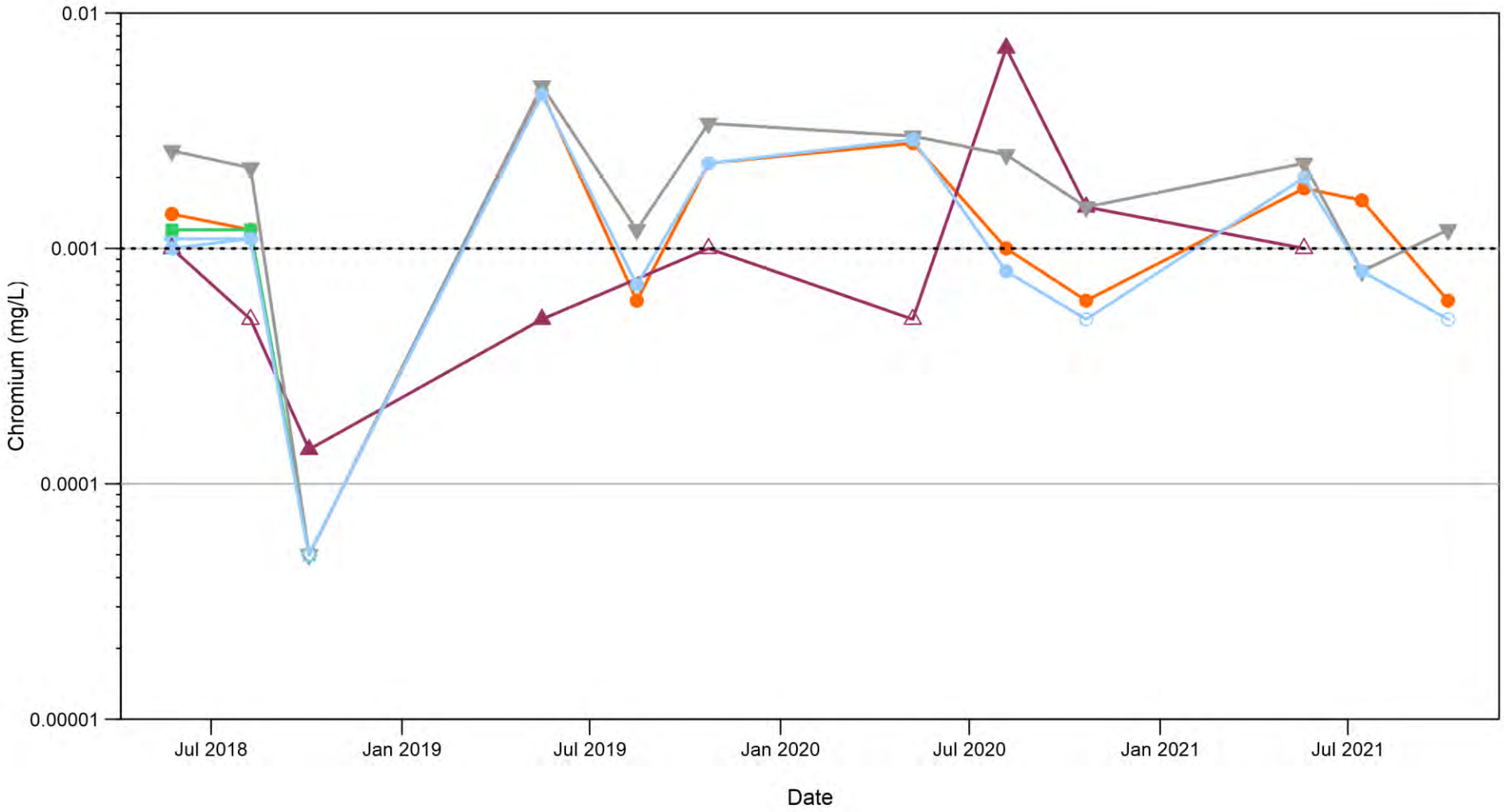
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Chromium Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5u



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

Non Detect (Open Symbol)
B.C. Working Water Quality Guidelines - FAL (2021) = 0.001 mg/L

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

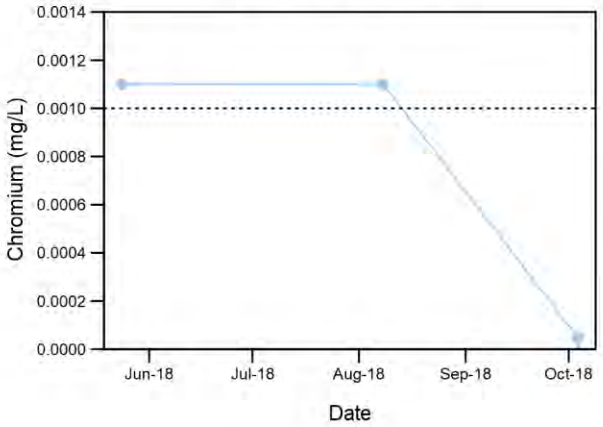
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Chromium Concentrations

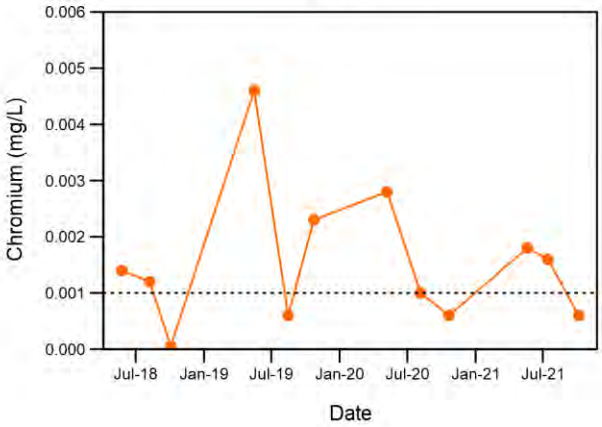
Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5u

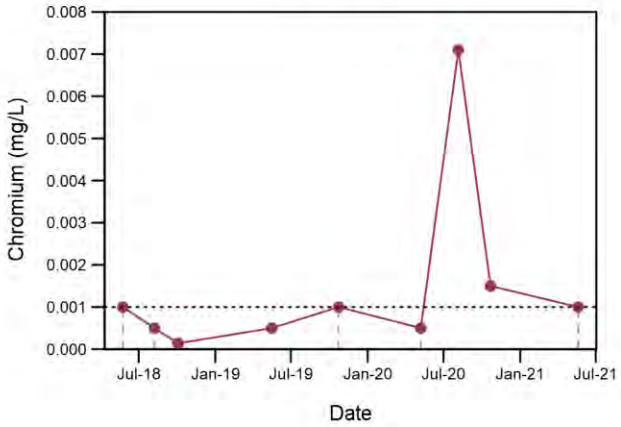
DC-SW1
Insufficient data for analysis



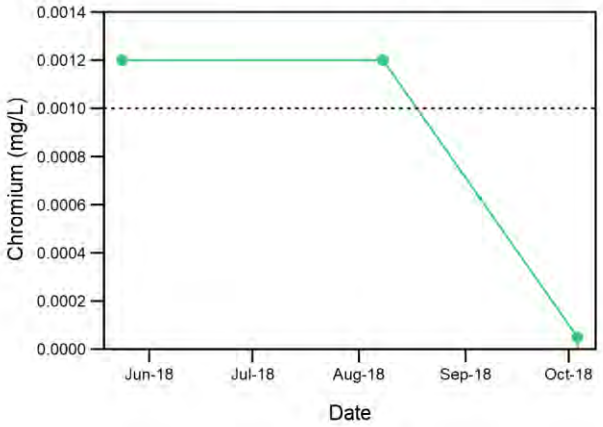
DC-SW2
No Trend



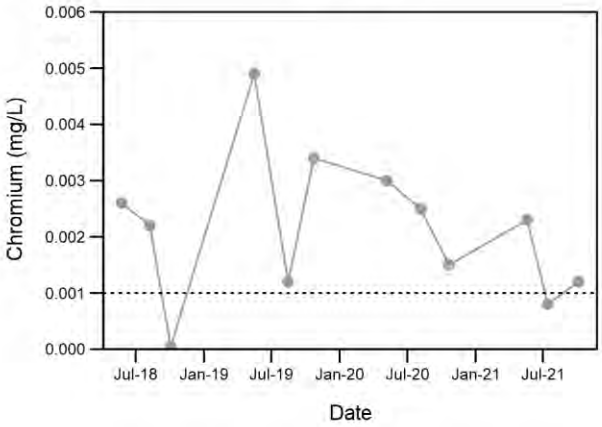
DC-SW4
No Trend



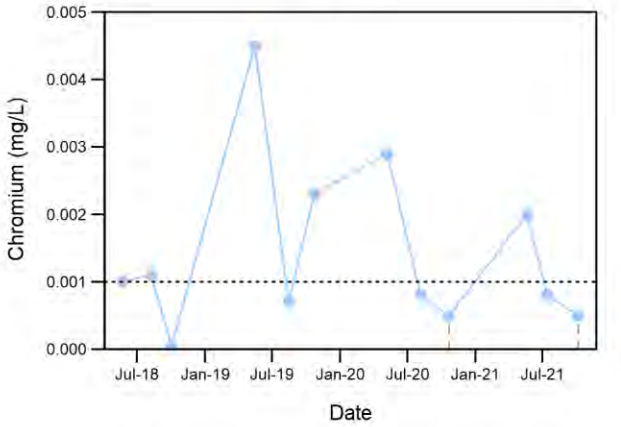
DC-SW5
Insufficient data for analysis



DC-SW6
No Trend



DC-SW7
No Trend



Chromium
Values below detection limit (DL)
B.C. Working Water Quality Guidelines - FAL (2021) = 0.001 mg/L

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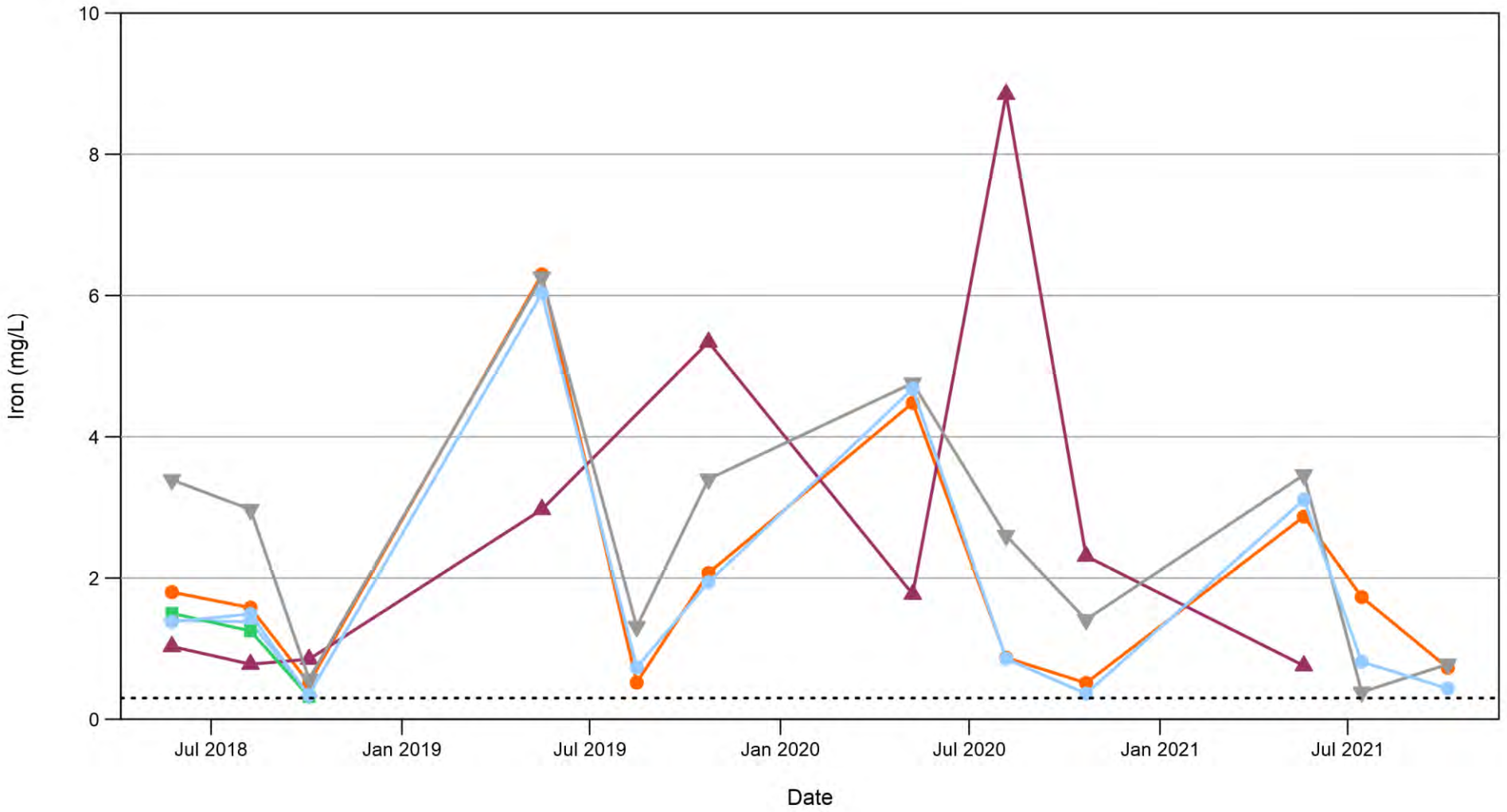
Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Chromium

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5v



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 0.3 mg/L

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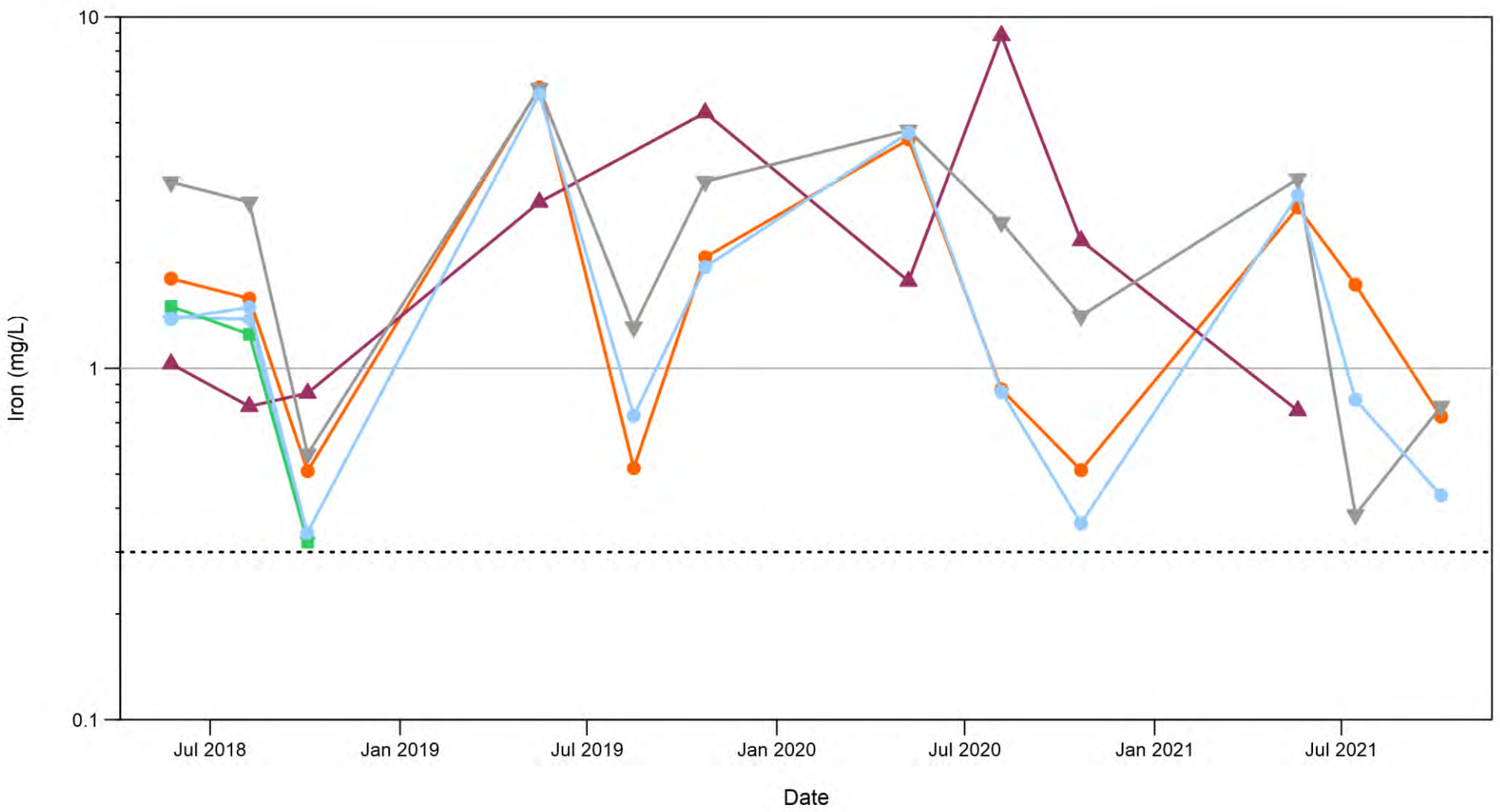
Dawson Creek Landfill

Historical Surface Water Iron Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5w



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 0.3 mg/L

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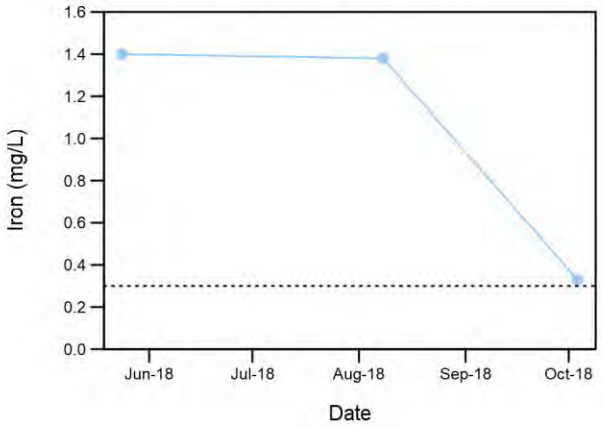
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Iron Concentrations

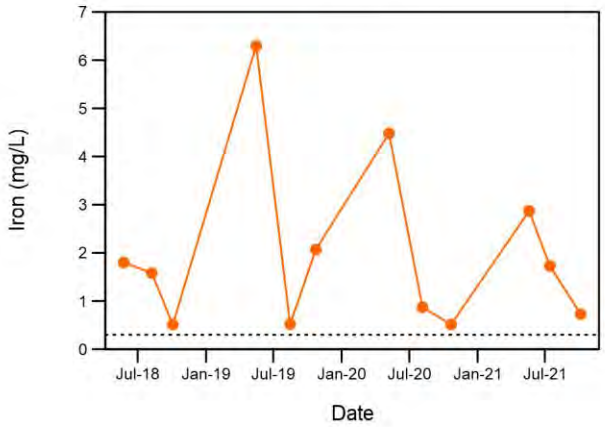
Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5w

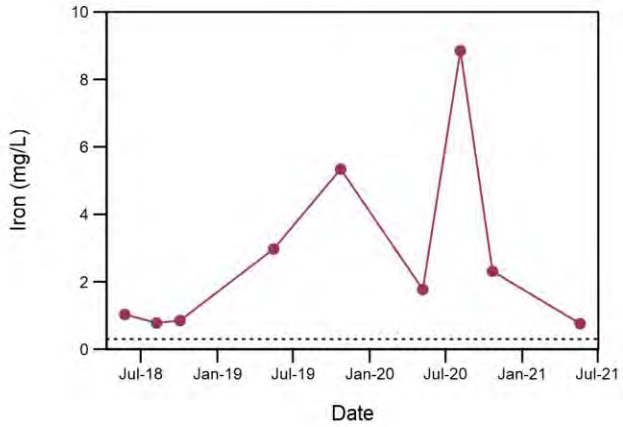
DC-SW1
Insufficient data for analysis



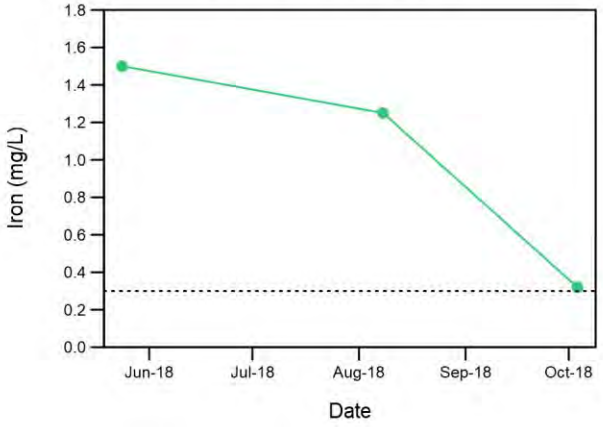
DC-SW2
No Trend



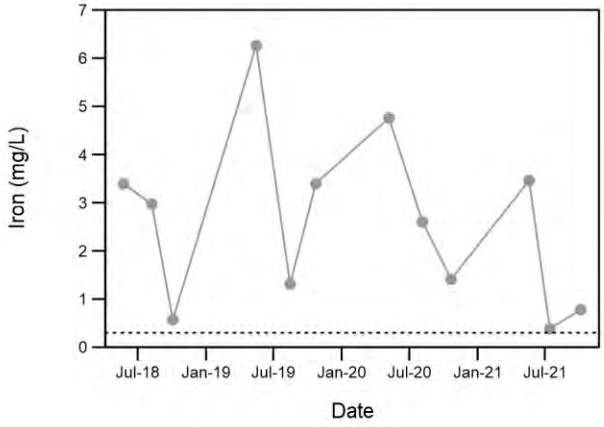
DC-SW4
No Trend



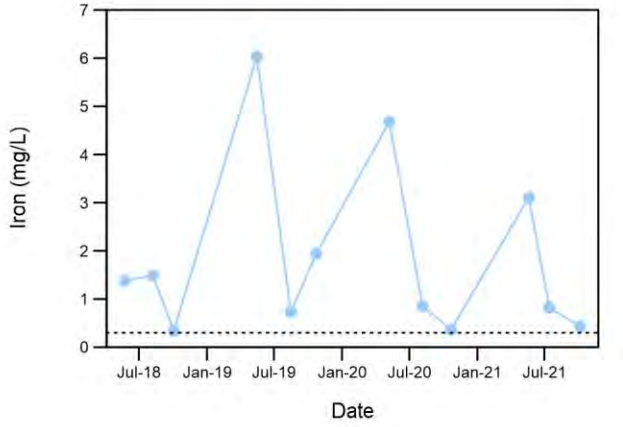
DC-SW5
Insufficient data for analysis



DC-SW6
No Trend



DC-SW7
No Trend



Iron
B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 0.3 mg/L

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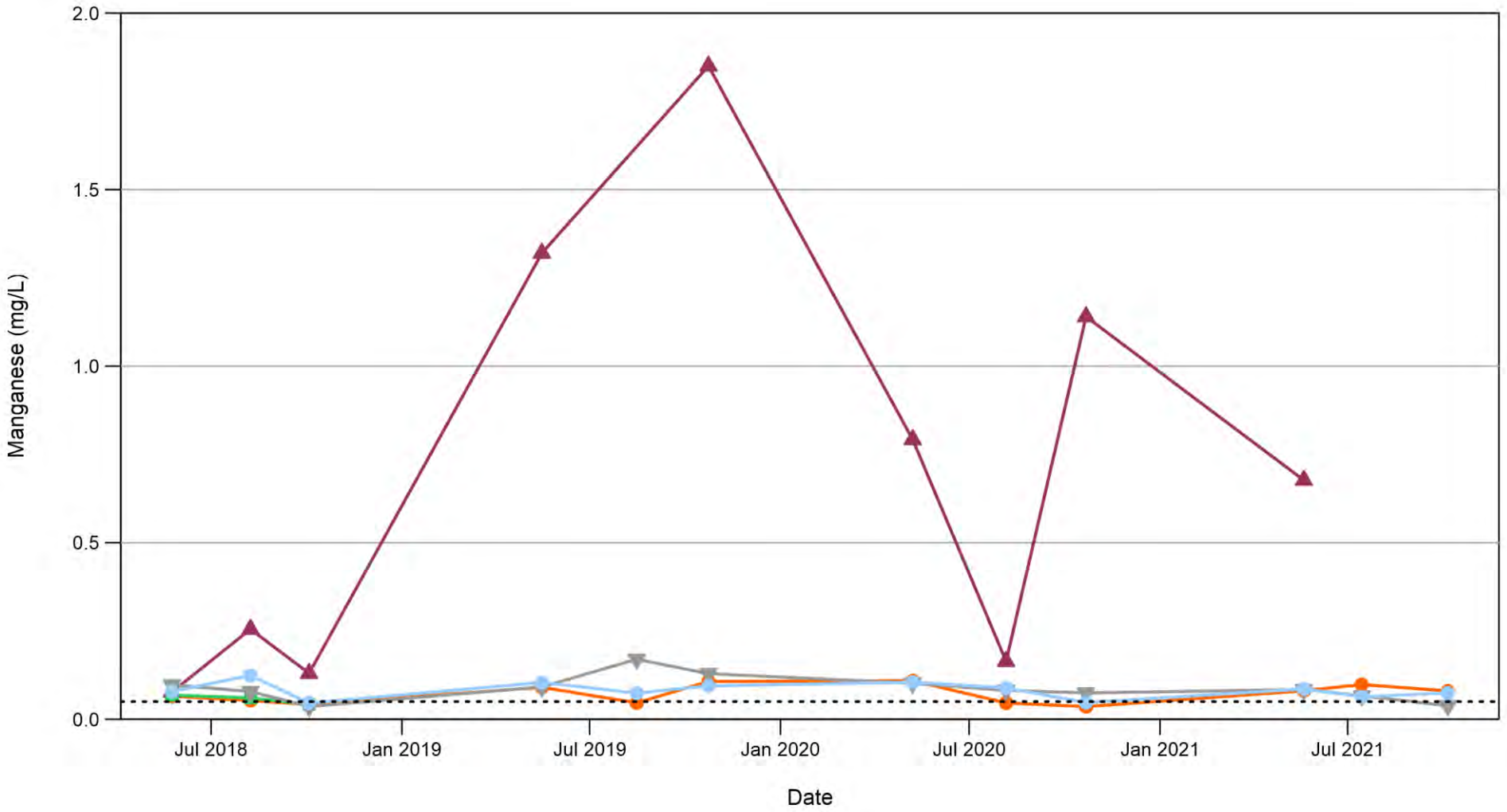
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Iron

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5x



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 0.05 mg/L

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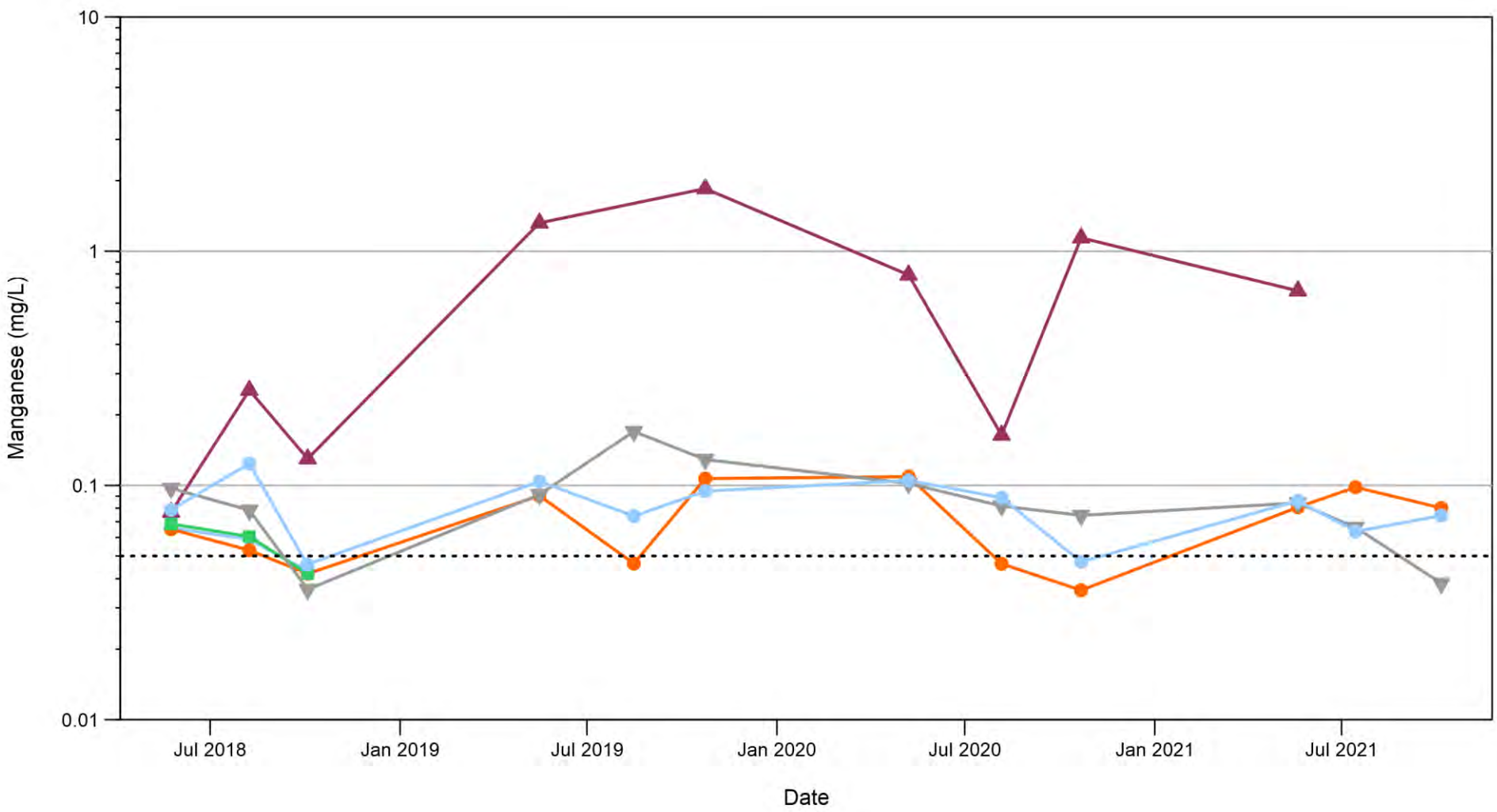
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Manganese Concentrations

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5y



DC-SW1
DC-SW2
DC-SW4
DC-SW5
DC-SW6
DC-SW7

B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 0.05 mg/L

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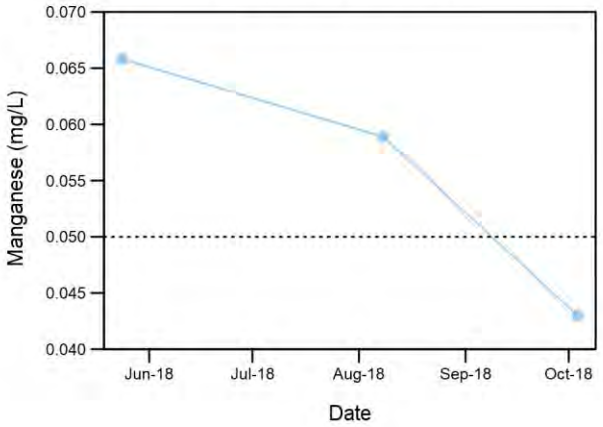
Peace River Regional District
Dawson Creek Landfill

Historical Surface Water Manganese Concentrations

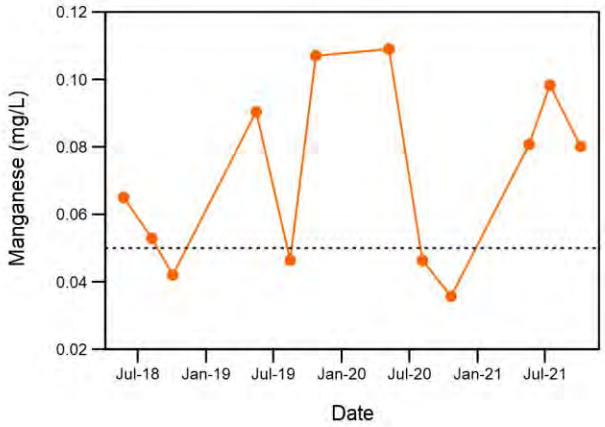
Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5y

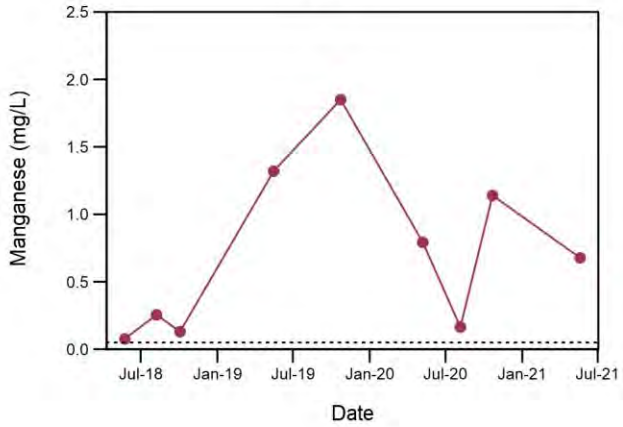
DC-SW1
Insufficient data for analysis



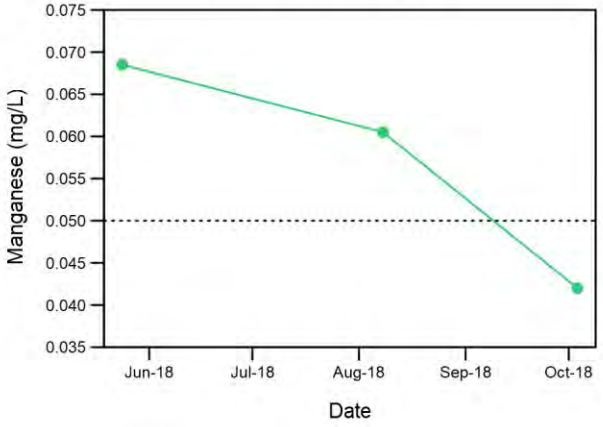
DC-SW2
No Trend



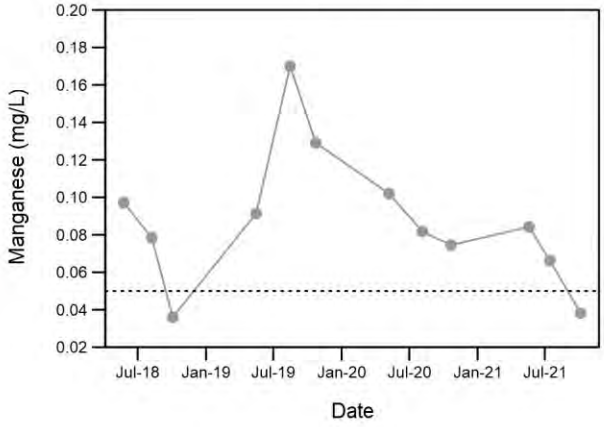
DC-SW4
No Trend



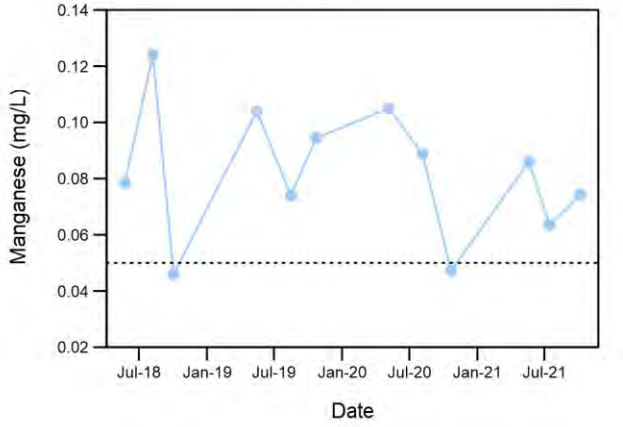
DC-SW5
Insufficient data for analysis



DC-SW6
No Trend



DC-SW7
No Trend



Manganese
B.C. Approved Water Quality Guidelines - Drinking Water (2020) = 0.05 mg/L

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Peace River Regional District
Dawson Creek Landfill

Mann-Kendall Trend Analysis - Surface Water Manganese

Date:	Project:	Submitter:	Reviewer:
23 Nov 2021	26254	C. Bromba	R. Reimer

Figure 5z

Appendix E

Water Balance Model Calculations

Water Balance Model Calculations, Area 1

Calculation of Area 1 Groundwater Influx

Inputs: Groundwater flux from upgradient (Q1)
Output: Flux into Area 2

Upgradient Influx

		Hydraulic Conductivity	
Q = K*A*dh/dl	Location	K (m/s)	Unit
K =	MW95-1	1E-07	Clay and Clay Till
	MW98-5	5E-06	Clay Till
	MW98-2	5E-07	Clay w sand
	MP99-1A	3E-08	high plastic clay
	MP99-1B	3E-09	high plastic clay
	MP99-2	3E-09	high plastic clay

Cross-section area = length (across the landfil area) * thickness of saturated aquifer
length across landfill area = 256 m
average saturated thickness = 12.0 m
Cross-sectional area = 3069 m^2

Geo mean K = 6.4E-08 m/sec
dh/dl = 0.05 m/m

$V_{Average}$ = K*dh/dl / n
8.9E-09 m/sec
0.3 m/yr

Porosity (assumed) 0.35

Groundwater flux from upgradient (Q1) 300 m3/year

Water Balance Model Calculations, Area 2

Calculation of Groundwater Flux out of landfill area

Inputs:			GW flux from Areas 1 (Q1) Leachate generation from landfill (Q2)
Outputs:			Flux into Area 3 (Q3)
Groundwater flux from upgradient (Q1)	300	m3/year	
Leachate Generation (HELP Model - GHD, 2023 (Low Permeability) (Q2 Low)	631	m3/year	
Leachate Generation (HELP Model - GHD, 2023 (Medium Permeability) (Q2 Medium)	5,197	m3/year	
Evapotranspiration (HELP Model - GHD, 2023 (Low Permeability)	21,903	m3/year	
Evapotranspiration (HELP Model - GHD, 2023 (Medium Permeability)	18,598	m3/year	
Runoff (HELP Model - GHD, 2023 (Low Permeability)	6,369	m3/year	
Runoff (HELP Model - GHD, 2023 (Medium Permeability)	5,107	m3/year	
Flux out of landfill area (HELP Model - GHD, 2023 (Q3 - Low Permeability)	**931**	**m3/year**	
Flux out of landfill area (HELP Model - GHD, 2023 (Q3 - Medium Permeability)	**5,497**	**m3/year**	

Water Balance Model Calculations, Area 3

Calculation of Groundwater Flux out of landfill area

Inputs:	Flux from Area 2 (Q3) Infiltration of precipitation downgradient of the landfill (Q4)	
Outputs:	Discharge to Dawson Creek (Q5)	
Flux out of landfill area (HELP Model - GHD, 2023 (Low Permeability) (Q3 Low)	931	m3/year
Flux out of landfill area (HELP Model - GHD, 2023 (Medium Permeability) (Q3 High)	5,497	m3/year
Infiltration rate for Dawson Creek (CSR Protocol 2)	80	mm/year
Downgradient area	15000	m2
Flux from precipitation infiltration (Q4)	1200	m3/year
Flux out of Area 3 - Discharge into Dawson Creek (Q5 Low)	**2,131**	**m3/year**
Flux out of Area 3 - Discharge into Dawson Creek (Q5 High)	**6,697**	**m3/year**

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