

# **2021 Groundwater and Soil Vapour Monitoring Report Great West Adventure Park North Half of Section 17-038-27 W4M**



PRESENTED TO  
**City of Red Deer**

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## EXECUTIVE SUMMARY

The City of Red Deer (The City) retained Tetra Tech Canada Inc. (Tetra Tech) to conduct the 2021 groundwater and vapour monitoring program at the former landfill located beneath the Great West Adventure Park (GWAP), located within Lot 1 MR Plan 8322386, within the north half of Section 17-038-27 W4M, in Red Deer, Alberta, hereafter referred to as “the site”. The objective of the monitoring program is to confirm potential environmental concerns related to former operations at the site.

The current groundwater monitoring network at the site consists of six monitoring wells (MW-01, MW-02, MW-03, MW-04, MW-05, and an on-site groundwater well for the BMX Club). The BMX Club well is not used as a source of potable water but used for dust control and watering grass. The current vapour monitoring network consists of three vapour monitoring wells (VW-01, VW-02, and VW-03); VW-03 was installed in 2021.

Tetra Tech’s scope of work for the 2021 monitoring and sampling program at the GWAP site included conducting semi-annual events of groundwater and vapour monitoring, and annual groundwater sampling at MW-02 and the BMX Club well, reviewing and updating previous recommendations for the site, and preparing an annual report. The analytical groundwater parameters included pH, electrical conductivity (EC), major ions, total dissolved solids (TDS), nutrients, and dissolved metals.

Key findings of the 2021 environmental monitoring program and conclusions include the following:

- The groundwater elevations in 2021 were consistent with the 2019 results and the inferred groundwater flow direction was to the northeast. The average horizontal hydraulic gradients at the site were 0.003 m/m in July 2021 and November 2021. This is consistent with observations made historically. Groundwater elevations in 2021 were overall slightly lower than the groundwater elevations measured previously in 2019.
- In 2021, the groundwater analytical results from MW-02 were similar to 2019 with concentrations of TDS, chloride, dissolved arsenic, dissolved iron, and dissolved manganese exceeding the Tier 1 Guidelines. The measured concentrations of TDS, chloride, dissolved iron, and dissolved manganese were generally consistent with previous results and are interpreted to reflect natural groundwater quality.
- The chloride concentration at MW-02 in 2021 (290 mg/L) was greater than the Tier 1 Guideline and increased from the 2019 chloride concentration (233 mg/L). Chloride concentrations previously measured in 2019 were greatest at up-gradient well MW-01 and are likely due to road salt use in the area and are not necessarily related to landfill impacts.
- The concentration of dissolved arsenic was greater than the Tier 1 Guideline at MW-02. The dissolved arsenic concentration measured at MW-02 in 2021 (0.00880 mg/L) was marginally greater than the guideline for the protection of freshwater aquatic life (0.005 mg/L) and consistent with concentrations measured in 2019. The dissolved arsenic concentrations are interpreted to not be of concern.
- The BMX Club well is not used as a source of potable water but used for dust control and watering grass. The water quality of the BMX Club well was similar to the water quality of the on-site monitoring wells with concentrations of TDS, chloride and dissolved manganese exceeding the Tier 1 Guidelines. Overall, groundwater quality at the BMX well was very similar to shallow groundwater quality in the area (particularly MW-03) despite being installed in a deeper unit (greater than 30 m deep). There are no obvious leachate impacts in this well based on the sampling results.
- Methane concentrations measured in headspace of the groundwater monitoring wells and at the soil vapour probes, including the results of newly installed probe VW-03 near Riverbend Village Apartments, were consistent with results obtained in 2013 and 2019 and do not indicate obvious impacts related to the buried wastes. Methane concentrations measured during the first two monitoring events at newly installed VW-03 were

non-detect. The results suggest that the risk for vapour migration from the site to the Riverbend Village Apartments is low.

Ongoing risk management is recommended, including the following risk management elements.

- Ongoing Monitoring:
  - Continuation of a groundwater or vapour monitoring program is not warranted; however, the vapour and groundwater monitoring wells should be maintained for potential future assessments. It is recommended to conduct an annual site check to verify site drainage and the integrity of the landfill cover, monitoring wells, and vapour probes.
- Risk Management:
  - In consideration that buried waste remains beneath the site, and as recommended in the risk management plan (RMP) prepared by Tiamat Environmental Consultants Ltd. (Tiamat) in 2014, the risk management approach for the site should be periodically reviewed and updated, if necessary. A review of the mitigative measures completed in the 2019 groundwater and soil vapour monitoring report is included in Appendix B.
- Administrative Actions:
  - Utilize the revised generic mitigative measures when evaluating applications for development within the setback variance.
  - Regarding land development applications within the regulated setback to the east, across the Red Deer River, the river is considered a natural barrier and vapour migrating from the site to future developments is not considered to be a concern.
  - Ensure that the site is clearly identified within The City's Land Use Bylaw and appropriate administrative requirements are met for the site in accordance with The City's policies.

Further to the above recommendations, the site remains an historical landfill. It presently appears to be well maintained and capped. The City should review this status on an ongoing basis to ensure that the cover remains intact and drainage remains positive; repairs or maintenance should be undertaken as required to maintain the site.

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## LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of The City of Red Deer and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than The City of Red Deer, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in Appendix A or Contractual Terms and Conditions executed by both parties.

## 1.0 INTRODUCTION

The City of Red Deer (The City) retained Tetra Tech Canada Inc. (Tetra Tech) to conduct the 2021 groundwater and vapour monitoring at the former landfill located beneath the Great West Adventure Park (GWAP), located within Lot 1 MR Plan 8322386, within the north half of Section 17-038-27 W4M, in Red Deer, Alberta, hereafter referred to as the site. The objective of the monitoring program is to identify potential environmental concerns related to former operations at the site.

In 2019, Tetra Tech conducted groundwater and soil vapour monitoring and sampling to identify potential environmental concerns related to former operations at the site. The results were presented and discussed in the 2019 Groundwater and Soil Vapour Monitoring Report – Great West Adventure Park (Tetra Tech 2020). Key findings and recommendations of the 2019 monitoring program are summarized in Section 1.1, and the objectives and scope for the 2021 monitoring program are presented in Section 1.2.

The field components of the monitoring program were completed under Tetra Tech's detailed work plans encompassing the scope of work outlined in Section 1.2 below. The current report was completed under Tetra Tech's Limitations on the Use of this Document for conducting environmental work. A copy of these conditions is provided in Appendix A.

### 1.1 2019 Report – Key Findings and Recommendations

The 2019 report identified no significant impacts related to the former landfill operations at most monitoring well locations. However, the presence of residual impacts in the groundwater and buried landfill waste remaining beneath the site require ongoing risk management. Key findings included:

- The groundwater elevations in 2019 indicated that the inferred groundwater flow direction was to the northeast and towards the Red Deer River.
- Parameters that exceeded the Alberta Tier 1 Soil and Groundwater Remediation Guidelines (Tier 1 Guidelines) at one or more groundwater monitoring wells in 2019 included total dissolved solids (TDS), chloride, and dissolved metals including aluminum, arsenic, cadmium, copper, iron, manganese, and selenium. The measured concentrations of these parameters were generally consistent with previous results and background/up-gradient concentrations and may reflect natural groundwater quality or may be elevated due to inadequate filtration. Possible exceptions are the dissolved metal concentrations at MW-02, in particular cadmium and arsenic.
- The estimated risks and hazards associated with the soil vapour samples collected in December 2019 did not exceed the corresponding target risk and hazard levels.

Based on these findings, the recommendations for the 2021 monitoring program were as follows:

- For due diligence, based on the presence of buried waste and proximity of the apartments, confirmation of soil vapour concentrations in the northeast area of the site is recommended with installation of one additional vapour monitoring probe between the waste footprint and the apartments.
- Conduct annual groundwater sampling at MW-02 to confirm the dissolved metal concentrations measured in 2019.
- Determine the status of the Red Deer BMX Club water well located at the site. Confirm if the water well is being used, the purpose of the well, and the water quality.



## 1.2 Scope of Work

Based on the 2019 findings and recommendations (Tetra Tech 2020), the 2021 monitoring program scope of work was outlined in the proposal titled 2021 Work Scope and Cost Estimate and was sent to the City of Red Deer on March 2, 2021 (Tetra Tech 2021). The work conducted in 2021 included the following activities:

- Installing a new vapour well along the north boundary of the site (VW-03) prior to the spring monitoring event.
- Conducting semi-annual events of groundwater and vapour monitoring, including measuring headspace vapours and groundwater levels within each monitoring well and observing monitoring well integrity.
- Determining the status of the Red Deer BMX Club water well located at the site. Confirming if the water well is being used, the purpose of the well, and the water quality.
- Conducting annual groundwater sampling of the BMX Club well (if present) and groundwater monitoring well MW-02 by:
  - Purging monitoring wells until practically dry or until a minimum of three well volumes had been removed and allowing the water levels in the wells to recover.
  - Measuring field parameters (pH, electrical conductivity [EC], and water temperature) at the time of sampling.
  - Collecting groundwater samples from each well and submitting the samples for chemical analyses.
- Conducting monitoring well repairs, as required.
- Preparing an annual report summarizing the field activities undertaken for the year, interpreting the groundwater and soil vapour monitoring results, interpreting the groundwater analytical results, and providing recommendations for future monitoring activities at the site.

In the proposal titled 2021 Work Scope and Cost Estimate (Tetra Tech 2021), Tetra Tech recommended semi-annual monitoring of groundwater well headspaces for methane as a useful screening tool in the absence of vapour wells in other areas of the site. Subsequently, while headspace methane monitoring was conducted in 2021, headspace monitoring for volatile organic compounds (VOCs) and combustible vapour concentrations (CVCs) was not conducted.

## 2.0 BACKGROUND INFORMATION

### 2.1 General Information

The site is located within the north half of Section 17-038-27 W4M, within Lot 1 MR Plan 8322386. The site is zoned P1 – Parks and Recreation and is located within the community of Riverside Meadows. The site is located on the west bank of the Red Deer River, east of Kerry Wood Drive and North of Taylor Drive. The Red Deer River is adjacent to the southeastern portion of the site and flows in a northeasterly direction. A general site location plan is shown on Figure 1. The site has been developed and includes a BMX biking track, a small building, a parking lot, a boat launch, and a pedestrian/biking trail. The surrounding land use consists of residential housing, Fairview Elementary School, as well as commercial land use. Natural areas of the site consist of grasses and trees. Figure 2 shows the site location with surrounding land use. Additional information on the site history, historical groundwater monitoring investigations, geology, and hydrogeology can be found in Appendix B. Cross-sections that

were prepared using the wells previously installed at the site in 2013 are included in Appendix C (from Tiamat Environmental Consultants Ltd. [Tiamat] 2014).

## 2.2 2019 – Conceptual Site Model Summary

The selection of comparative guidelines is based on the conceptual site model (CSM), which outlines the rationale for the selection of applicable exposure pathways and receptors at the site. This evaluation is based on guidance presented in the Alberta Tier 1 Guidelines (Alberta Environment and Parks [AEP] 2019). The CSM that was developed for the site in the 2019 groundwater and soil vapour monitoring report (Tetra Tech 2020) included the following items:

- Description of any identified environmental issues including a description of processes or activities undertaken at or near the site and a listing of chemicals of potential concern (COPCs) identified in earlier investigations.
- Description of known and reported historical releases, including locations and status of any subsequent environmental site assessments (ESAs) and remediation.
- Identification of applicable exposure pathways and receptors.

The CSM is summarized in the table below.

### Summary of Exposure Pathways and Receptors for Soil and Groundwater

Release Mechanism	COPC	Migration Pathway	Potential Receptor
Leachate infiltration into foundation or through cover.	Inorganic parameters and nutrients, metals, petroleum hydrocarbons (PHCs), VOCs, and other indicator parameters (i.e., biological oxygen demand [BOD] and chemical oxygen demand [COD]).	Direct soil contact.	Human users of the parkland; ecological plants and soil invertebrates.
		Migration to groundwater users (water wells); migration to the Red Deer River via groundwater.	Domestic use aquifer (DUA) drinking water; freshwater aquatic life in the Red Deer River.
		Nutrient and energy cycling.	Microbial functioning of the soil.
Landfill gas (LFG) emissions.	VOCs, methane, benzene, toluene, ethylbenzene, and xylenes (BTEX), PHC fractions, and siloxanes.	Vapour inhalation.	Human users of the parkland; inhabitants of buildings near the parkland.

As recommended by AEP, the soil vapour results obtained during the 2019 investigation were compared to the Canadian Council of Minister of the Environment’s (CCME’s) document A Protocol for the Derivation of Soil Vapour Quality Guidelines for Protection of Human Exposures Via Inhalation of Vapours (CCME 2014). To determine the appropriate guidelines to compare the vapour sampling results to, indoor air risk calculations were undertaken and methane explosive risks were evaluated.

The CSM determined that the most applicable guidelines for groundwater and vapour results for the site were:

- Groundwater concentrations at the site were compared to the Alberta Tier 1 Guidelines under residential land use for coarse-grained soils (AEP 2019).
- Soil vapour analytical results were compared to A Protocol for the Derivation of Soil Vapour Quality Guidelines for Protection of Human Exposures Via Inhalation of Vapours under residential land use for both slab-on-grade and basement for coarse-grained soils (CCME 2014).

## 2.3 Monitoring Well Network

The groundwater monitoring network at the site consists of five monitoring wells (MW-01 to MW-05). Monitoring wells were in good condition during the 2021 events. All of the monitoring wells are screened to the bottom of the well through the native sand and gravel into the shale bedrock. MW-03 is also screened through sand fill. Monitoring well completion details are summarized in Table 1.

During the July 2021 monitoring event, the Red Deer BMX Club water well was located near the club house. The well appeared to be used on a regular basis and is equipped with a submersible pump. From talking to members of the BMX Club, it was determined that the BMX Club well is not used as a source of potable water but used for dust control and watering grass. A water well driller's report is currently not available for the well. The depth of the BMX Club well was not determined but was deeper than the length of the water level indicator that was used (greater than 30 m).

The vapour monitoring network consists of three vapour monitoring wells; VW-01 located near the north end of the site, VW-02 in the southwest corner of the site, and VW-03 located in the northeast portion of the site near the Riverbend Village Apartments. Vapour monitoring well VW-03 was installed in 2021. The vapour wells were in good condition during the 2021 monitoring events.

Groundwater and vapour monitoring well locations are shown on Figure 2. Borehole logs for all monitoring wells and vapour wells are attached in Appendix F.

## 3.0 FIELD METHODOLOGY

### 3.1 Groundwater Monitoring and Sampling

A discussion of the methods used for the groundwater monitoring and sampling fieldwork and laboratory testing is presented in the following section. In 2021, Tetra Tech conducted groundwater monitoring on July 7 and November 20. Groundwater sampling was conducted on November 23, 2021.

#### 3.1.1 Groundwater Monitoring and Sampling Methodology

Groundwater monitoring consisted of measuring methane in monitoring well headspaces, and static groundwater levels in each monitoring well using an electronic water level indicator semi-annually (July and November).

The methodology for groundwater monitoring and sampling included the following:

- Observing the integrity of each well and noting drainage and site conditions near the well that may have an effect on monitoring results or groundwater quality.
- Measuring the methane headspace concentrations in each well using an RKI Eagle Hydrocarbon Surveyor II (RKI Eagle) calibrated to methane.
- Measuring liquid levels in each monitoring well with an interface probe and recording total depths confirming absence of non-aqueous phase liquids (NAPL).
- Recording of field data on standardized forms as documented in Tetra Tech standard operating practices.
- Purging each monitoring well requiring sampling using dedicated polyethylene bailers or Waterra tubing with inertial pump foot valves of at least three well volumes of water, or until the well was practically dry.

- The BMX Club well is equipped with a submersible pump; water was allowed to run through the tap for 30 seconds prior to sampling.

Following the completion of groundwater monitoring and purging, groundwater samples were collected from the required wells using the procedures identified below:

- Groundwater samples were collected from one monitoring well (MW-02) and the BMX Club well. Samples were collected and placed into appropriate laboratory supplied, sterile glass and plastic vials and bottles for the required analytical package. Samples were filtered and/or preserved in the field, as required.
- Field measurements were taken for pH, EC, and temperature at the time of sampling.
- Samples were submitted in coolers with ice to ALS Laboratory Group (ALS) in Calgary, Alberta for laboratory analysis under chain-of-custody (COC) documentation.

### 3.1.2 Groundwater Analytical Program

The analytical program for the groundwater monitoring wells was developed based on the recommendations in Section 1.1 and is summarized below:

- Routine water chemistry parameters and dissolved metals.
- Ammonia.
- Phosphorus.

## 3.2 Vapour Well Installation

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On May 3, 2021, a new vapour well (VW-03) was installed using a tracked drill rig and solid stem augers along the northeast site boundary near monitoring well MW-04 to monitor LFG vapour near the Riverbend Village Apartments. The vapour well was installed with 19 mm diameter polyvinyl chloride (PVC) pipe to a depth of 3.5 m below grade (mbg) and screened with 19 mm slotted PVC pipe from 2.0 mbg to 3.5 mbg. Free water was not observed in the borehole during the installation of the vapour well and materials were noted as dry. The borehole log of VW-03 is attached in Appendix F.

## 3.3 Vapour Monitoring Program

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A discussion of the methods used for the fieldwork is presented in the following sections. In 2021, Tetra Tech conducted vapour monitoring on July 9 and November 20.

### 3.3.1 Vapour Monitoring Methodology

Monitoring at the vapour monitoring probes (19 mm diameter) consisted of measuring and recording soil gas pressure, composition (methane, carbon dioxide, oxygen, hydrogen sulphide, and balance) on a percent volumetric basis, and groundwater elevation semi-annually (July and November).

The soil vapour probes were inspected for visible signs of damage and the position of the sampling labcock was noted. Soil gas pressure was recorded using a digital manometer. Once the soil gas pressure was recorded, the soil gas probes were purged of three well volumes of vapour with the GEM 5000 Analyzer (GEM), or until readings stabilized.

After purging, gas composition measurements for methane, carbon dioxide, oxygen, balance gas, and hydrogen sulphide were recorded using the GEM analyzer. After recording soil gas concentrations, the probe/well depths and water levels were measured to confirm the water level within the probe was beneath the screen portion of the soil gas probes (i.e., the probe was not blinded).

After monitoring, the soil vapour probes sampling ports were returned to the closed position and the well was securely locked.

## 4.0 RESULTS AND DISCUSSION

This section presents the results of the fieldwork conducted in 2021 at GWAP and discussions of these results.

### 4.1 Well Headspace Monitoring

The headspace vapour concentrations for 2021 are presented in Table 1 (groundwater wells) and Table 4 (soil vapour probes). Based on the style of installation, different monitoring methodologies were utilized; however, the instruments utilized were each calibrated to methane. The headspace methane concentrations for the groundwater monitoring wells were measured with an RKI Eagle and the soil vapour probes were measured with a GEM. The RKI Eagle detection limit ranges from 5 parts per million (ppm) to 100% of the lower explosive limit (LEL). For methane, 500 ppm is equivalent to 1% LEL; 20% LEL is equivalent to 1% Gas. The GEM has a higher upper range of detection; however, it is less accurate at low (ppm) levels.

In 2021, the water level for all groundwater monitoring wells and soil vapour wells were not above the monitoring screens; therefore, no wells were blinded, and the vapour measurements are representative for in-situ soil vapours.

During the July 2021 monitoring event, methane headspace concentrations at the groundwater wells (measured using the RKI Eagle) ranged from 25 ppm at MW-05 to 250 ppm at MW-03. During the November 2021 monitoring event, methane headspace concentrations at the groundwater wells ranged from less than the instrument detection limit at MW-04 to 290 ppm at MW-02. The highest methane concentration measured in groundwater monitoring well headspaces at the site was 290 ppm at MW-04 in November 2021 and that measurement is equivalent to 0.03% Gas.

Methane concentrations (measured using the GEM) at vapour wells VW-01, VW-02, and VW-03 were less than the instrument detection limit during both monitoring events in 2021. Wellhead pressures at the vapour wells were negligible during both monitoring events in 2021. Carbon monoxide was detected at VW-03 in July 2021 (1.0%); however, the concentration was less than the instrument detection limit in November 2021. Concentrations of carbon dioxide, oxygen, and the balance gas were consistent during both monitoring events and the concentrations measured in 2019.

Overall, methane concentrations measured in headspace of the groundwater monitoring wells and at the soil vapour probes, including the results of newly installed probe VW-03 near Riverbend Village Apartments, are consistent with results obtained in 2013 and 2019 and do not indicate obvious impacts related to the buried wastes. Methane concentrations measured during the first two monitoring events at newly installed VW-03 were non-detect. The results suggest that the risk for vapour migration from the site to the Riverbend Village Apartments is low.

In 2021, since the headspace vapour measurements were consistent with 2019 results, soil vapour sampling was not warranted; therefore, hazard quotients were not updated and the 2019 hazard quotient results and mitigative measures are still applicable to the site. The hazard quotient results and mitigative measures from the 2019 groundwater and soil vapour monitoring report are included in Appendix B.

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## 4.2 Groundwater Elevations

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The measured groundwater levels and calculated groundwater elevations for 2021 are presented in Table 1.

Figure 3 presents the groundwater elevation trends (hydrographs) for the groundwater monitoring wells. Figure 3 shows that groundwater elevations decreased at all monitoring wells in 2021 from the groundwater elevations measured in 2019 and prior.

The average depth to groundwater in the monitoring wells was 2.78 mbg in July 2021 and 3.03 mbg in November 2021. The contoured elevations for the monitoring wells suggest the groundwater flow was to the northeast in July 2021 and November 2021. The groundwater elevations and interpreted elevation contours are shown on Figure 4 and Figure 5, respectively, for July 2021 and November 2021 events. The inferred groundwater flow in 2013 and 2019 was also to the northeast (Tiamat 2014; Tetra Tech 2020).

It is unknown at what depth the BMX Club well is screened but the well's depth is greater than 30 m. In July, the depth to groundwater level was similar to the shallow monitoring wells. Although the well elevation is not surveyed, the measured water level suggests there is no obvious downward vertical gradient at the site.

The average horizontal gradients were 0.003 m/m in July 2021 and November 2021.

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## 4.3 Groundwater Field Parameters

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Field measurements for pH, EC, and temperature at MW-02 in November 2021 are shown in Table 2. A discussion of the results of the field tests is summarized in this section.

Groundwater temperature at MW-02 was 6.80°C, the pH value was 6.99, and the field EC measurement was 1,210 µs/cm. The field pH and field EC measurements were less than the laboratory measured results and differed considerably, which may be due to differences in sample temperatures and limitations of field equipment.

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## 4.4 Laboratory Results

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The groundwater analytical data for 2021 are summarized in Table 2. The 2021 laboratory analytical reports are included in Appendix D and historical analytical results are included in Appendix E.

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### 4.4.1 Groundwater Monitoring Well MW-02

In November 2021, the TDS concentration at MW-02 was 1,090 mg/L and greater than the Tier 1 Guideline (500 mg/L). Historical TDS concentrations were greater than the Tier 1 Guidelines at all wells on site in 2013 and 2019. Elevated TDS concentrations often occur in groundwater as a result of the dissolution of naturally occurring salts in the glacial tills of Alberta, and do not necessarily indicate groundwater quality impact related to the former operations at the site.

Chloride is often considered a useful parameter to assess groundwater quality impacts associated with landfills, as chloride is generally present in elevated concentrations in leachate and is a mobile and conservative (non-reactive) ion. Chloride does not enter into reactions as a non-reactive ion, does not adsorb significantly onto mineral surfaces, or form complexes with other ions. The chloride concentration at MW-02 in 2021 (290 mg/L) was greater than the Tier 1 Guideline and increased from the 2019 chloride concentration at MW-02 (233 mg/L). As stated in the 2019 groundwater and soil vapour monitoring report (Tetra Tech 2020), chloride concentrations were greatest at

up-gradient well MW-01 and are likely due to road salt use in the area and are not necessarily related to landfill impacts.

Iron and manganese are redox-sensitive parameters that can help determine whether the groundwater quality is affected by biodegradation reactions, for instance related to landfill leachate. The biodegradation process leads to a low redox status, which will dissolve iron and manganese oxides present in soil and increase concentrations in groundwater. The dissolved iron and dissolved manganese concentrations were greater than the Tier 1 Guidelines at MW-02 in 2021. The dissolved iron concentration at MW-02 increased from 2019 (6.80 mg/L) to 2021 (12.1 mg/L) and dissolved manganese marginally decreased in 2021 from 2019.

The concentration of dissolved boron, which is often present in landfill leachate, was an order of magnitude less than the guideline at MW-02 and the concentration in 2021 was consistent with the 2019 results.

The concentration of dissolved arsenic was greater than the Tier 1 Guideline at MW-02. The dissolved arsenic concentration measured at MW-02 in 2021 (0.00880 mg/L) was marginally greater than the guideline for the protection of freshwater aquatic life (0.005 mg/L). Arsenic is known to be strongly adsorbed onto iron(hydr)oxides, and when manganese and iron dissolve, arsenic will also go into solution (Hem 1992). The concentration of arsenic at MW-02 is likely correlated to the presence of dissolved iron. It is anticipated that if groundwater with the concentrations measured at MW-02 would enter the Red Deer River, two processes would drastically reduce the concentrations of dissolved arsenic. The first process is that instant dilution would occur as the Red Deer River is not a stagnant waterbody with a year-round average flow rate of approximately 75 m<sup>3</sup>/s (Government of Alberta 2022). The second process is that there is oxygen in the Red Deer River water and precipitation of iron near the riverbank would create an adsorbing surface for arsenic. These processes and the relative minor guideline exceedances for dissolved arsenic concentrations in 2019 and 2021 suggest that the arsenic concentrations in groundwater are not of concern.

#### 4.4.2 BMX Club Well

During the July 2021 monitoring event, field staff were able to talk to BMX club members and found out that the BMX Club well still exists. It is not used as a source of potable water but used for dust control and watering the grass. The BMX Club well was sampled on July 12, 2021.

The water quality of the BMX Club well was similar to the water quality of the on-site monitoring wells with concentrations of TDS, chloride, and dissolved manganese exceeding the Tier 1 Guidelines. Concentrations of TDS, chloride, and dissolved manganese were similar to that of the on-site groundwater wells. Overall, groundwater quality at BMX Club well was very similar to shallow groundwater quality in the area (particularly MW-03) despite being installed in a deeper unit (greater than 30 m deep). However, dissolved iron concentrations were non-detect and there is no evidence of leachate impacts in this well based on the sampling results.

### 4.5 Quality Assurance/Quality Control Methods

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#### 4.5.1 Methods

Tetra Tech's quality assurance/quality control (QA/QC) procedures include reviewing the data collected for precision and accuracy and following the appropriate field protocols.

The field procedures for QA/QC involved:

- Changing nitrile gloves between sample collections;

- Using sample containers provided by the laboratory;
- Cleaning monitoring and sampling tools between sample locations;
- Filling sample containers for PHC analysis with no headspace (air) when the containers were closed;
- Collecting a duplicate groundwater sample during the sampling program; and
- Documenting field procedures and sampling activities.

## 4.5.2 Results

The QA/QC results are included in Table 3. The duplicate sample was submitted for analysis of the same parameters as the original sample.

The duplicate analysis is compared by relative percent difference (RPD). The RPD is calculated using the following equation:

$$RPD = \frac{(V_1 - V_2)}{\frac{(V_1 + V_2)}{2}} * 100\%$$

Where:

$V_1$  = Parent Sample

$V_2$  = Duplicate Sample

Chemical parameters were considered as having passed the QA/QC reproducibility procedure if the RPD was less than or equal to 20%, indicating a close correlation between the sample-duplicate pair.

RPD values were not calculated if one or both of the sample-duplicate concentrations were between the reportable detection limit (RDL) and five times the RDL. In these cases, chemical parameters were still considered as having passed the QA/QC reproducibility procedure if the sample duplicate concentration difference was less than one RDL value.

Duplicate RPDs were greater than 20% for ammonia (64%) and dissolved cadmium (30%). The reason for the variation is unclear; however, it does not affect the results evaluation. Based on the QA/QC results, the sample methods and results are overall considered acceptable.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

Key findings of the 2021 environmental monitoring program and conclusions include the following:

- The groundwater elevations in 2021 were consistent with the 2019 results and the inferred groundwater flow direction was to the northeast. The average horizontal hydraulic gradients at the site were 0.003 m/m in July 2021 and November 2021. This is consistent with observations made historically. Groundwater elevations in 2021 were overall slightly lower than the groundwater elevations measured previously in 2019.
- In 2021, the groundwater analytical results from MW-02 were similar to 2019 with concentrations of TDS, chloride, dissolved arsenic, dissolved iron, and dissolved manganese exceeding the Tier 1 Guidelines. The measured concentrations of TDS, chloride, dissolved iron, and dissolved manganese were generally consistent with previous results and are interpreted to reflect natural groundwater quality.



- The chloride concentration at MW-02 in 2021 (290 mg/L) was greater than the Tier 1 Guideline and increased from the 2019 chloride concentration (233 mg/L). Chloride concentrations previously measured in 2019 were greatest at up-gradient well MW-01 and are likely due to road salt use in the area and are not necessarily related to landfill impacts.
- The concentration of dissolved arsenic was greater than the Tier 1 Guideline at MW-02. The dissolved arsenic concentration measured at MW-02 in 2021 (0.00880 mg/L) was marginally greater than the guideline for the protection of freshwater aquatic life (0.005 mg/L) and consistent with concentrations measured in 2019. The dissolved arsenic concentrations are interpreted to not be of concern.
- The BMX Club well is not used as a source of potable water but used for dust control and watering grass. The water quality of the BMX Club well was similar to the water quality of the on-site monitoring wells with concentrations of TDS, chloride and dissolved manganese exceeding the Tier 1 Guidelines. Overall, groundwater quality at the BMX well was very similar to shallow groundwater quality in the area (particularly MW-03) despite being installed in a deeper unit (greater than 30 m deep). There are no obvious leachate impacts in this well based on the sampling results.
- Methane concentrations measured in headspace of the groundwater monitoring wells and at the soil vapour probes, including the results of newly installed probe VW-03 near Riverbend Village Apartments, were consistent with results obtained in 2013 and 2019 and do not indicate obvious impacts related to the buried waste. Methane concentrations measured during the first two monitoring events at newly installed VW-03 were non-detect. The results suggest that the risk for vapour migration from the site to the Riverbend Village Apartments is low.

Ongoing risk management is recommended, including the following risk management elements.

- Ongoing Monitoring:
  - Continuation of a groundwater or vapour monitoring program is not warranted; however, the vapour and groundwater monitoring wells should be maintained for potential future assessments. It is recommended to conduct an annual site check to verify site drainage and the integrity of the landfill cover, monitoring wells, and vapour probes.
- Risk Management:
  - In consideration that buried waste remains beneath the site, and as recommended in the risk management plan (RMP) prepared by Tiamat in 2014, the risk management approach for the site should be periodically reviewed and updated, if necessary. A review of the mitigative measures completed in the 2019 groundwater and soil vapour monitoring report (Tetra Tech 2020) is included in Appendix B.
- Administrative Actions:
  - Utilize the revised generic mitigative measures when evaluating applications for development within the setback variance.
  - Regarding land development applications within the regulated setback to the east, across the Red Deer River, the river is considered a natural barrier and vapour migrating from the site to future developments is not considered to be a concern.
  - Ensure that the site is clearly identified within The City's Land Use Bylaw and appropriate administrative requirements are met for the site in accordance with The City's policies.

Further to the above recommendations, the site remains an historical landfill. It presently appears to be well maintained and capped. The City should review this status on an ongoing basis to ensure that the cover remains intact and drainage remains positive; repairs or maintenance should be undertaken as required to maintain the site.

## 6.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,  
Tetra Tech Canada Inc.



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Prepared by:  
Ryan Miller, B.Sc.  
Environmental Scientist  
Solid Waste Management Practice  
Direct Line: 403.723.6232  
Ryan.Miller@tetrattech.com

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Reviewed by:  
Frans Hettinga, B.Sc.  
Principal Specialist  
Solid Waste Management Practice  
Direct Line: 403.723.6860  
Frans.Hettinga@tetrattech.com

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Reviewed by:  
Sean D. Buckles, M.Sc., P.Eng.  
Senior Project Engineer- Team Lead  
Solid Waste Management Practice  
Direct Line: 403.723.6876  
Sean.Buckles@tetrattech.com

<p><b>PERMIT TO PRACTICE TETRA TECH CANADA INC.</b></p> <p>RM SIGNATURE: _____</p> <p>RM APEGA ID #: _____</p> <p>DATE: _____</p> <p><b>PERMIT NUMBER: P013774</b> The Association of Professional Engineers and Geoscientists of Alberta (APEGA)</p>
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/dm:lc

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- Tetra Tech Canada Inc. 2020. 2019 Groundwater and Soil Vapour Monitoring Report – Great West Adventure Park. Prepared for The City of Red Deer. July 24, 2020. Project Number: 704-SWM.SWOP04071-01.001.
- Tetra Tech Canada Inc. 2021 Work Scope and Cost Estimate – Red Deer Pre-1972 Landfills. Prepared for The City of Red Deer. March 2021. Project Number: 704-PSWM.SWOP04071-01.

## TABLES

Table 1	Groundwater Monitoring Results
Table 2	Groundwater Analytical Results
Table 3	Groundwater Quality Assurance/Quality Control Analytical Results
Table 4	Soil Vapour Monitoring Results

**Table 1: Groundwater Monitoring Results**

Monitoring Well		MW-01	MW-02	MW-03	MW-04	MW-05
Total Drilled Depth (m)		4.3	4.3	3.7	4.4	5.5
Top of Screened Interval (mbg)		1.3	1.3	1.0	1.4	2.5
Bottom of Screened Interval (mbg)		4.3	4.3	3.7	4.4	5.5
Stick up (m)		0.86	-0.08	0.99	0.73	0.83
Ground Elevation (m)		853.81	852.77	852.75	852.76	854.31
TPC Elevation (m)		854.67	852.68	853.74	853.48	855.13
Depth to Groundwater (mBTPC)	Aug-13	1.99	2.00	1.51	2.61	3.34
	Jun-19	3.51	2.28	2.98	3.25	4.23
	Dec-19	3.76	2.36	3.18	3.10	4.22
	Jul-21	3.66	2.44	3.13	3.54	4.46
	Nov-21	3.89	2.73	3.39	3.87	4.59
Groundwater Elevation (m)	Aug-13	852.68	850.68	852.23	850.87	851.79
	Jun-19	851.16	850.40	850.76	850.24	850.91
	Dec-19	850.91	850.33	850.56	850.38	850.92
	Jul-21	851.01	850.25	850.61	849.94	850.68
	Nov-21	850.77	849.95	850.35	849.61	850.54
Volatile Organic Compounds* (VOCs) (ppm)	Jun-19	ND	ND	1	ND	1
	Dec-19	ND	ND	ND	ND	ND
Combustible Vapour Concentrations* (CVCs) (ppm)	Jun-19	45	270	300	115	0
	Dec-19	10	10	35	5	5
Methane Concentrations** (ppm)	Jul-21	35	140	250	230	25
	Nov-21	5	290	5	ND	5

**Notes:**

mbg - Metres below grade.

mBTPC - Metres below top of plastic pipe casing.

ND - Non-detect.

\* Measured using an RKI Eagle II calibrated to hexane and isobutylene operated in methane-elimination mode.

\*\* - Measured using an RKI Eagle II calibrated to methane.

Table 2: Groundwater Analytical Results

Parameter	Unit	Tier 1 Guideline <sup>1,2</sup>	MW-01	MW-02		MW-03	MW-04	MW-05	BMX CLUB WELL	
			5-Dec-2019	5-Dec-2019	23-Nov-2021	23-Nov-2021 DUP	5-Dec-2019	5-Dec-2019	5-Dec-2019	12-Jul-2021
<b>Field Testing</b>										
Field Temperature	°C	-	4.25	5.52	6.80	-	3.82	4.03	2.44	-
Field Electric Conductivity	µS/cm	-	757	1,058	1,210	-	957	846	753	-
Field pH	pH Units	6.5 to 8.5	<b>6.15</b>	7.68	6.99	-	7.37	7.32	7.98	-
<b>Routine</b>										
pH	pH Units	6.5 to 8.5	7.62	7.72	7.39	7.14	7.71	7.68	7.76	7.42
Electrical Conductivity (EC)	µS/cm	-	1,590	1,590	1,800	1,800	1,560	1,290	1,220	1,630
Total Dissolved Solids (TDS)	mg/L	500	<b>923</b>	<b>965</b>	<b>1,090</b>	<b>1,090</b>	<b>951</b>	<b>823</b>	<b>765</b>	<b>974</b>
Hardness as CaCO <sub>3</sub>	mg/L	-	611	638	647	640	635	581	512	644
Alkalinity (total as CaCO <sub>3</sub> )	mg/L	-	427	560	578	587	520	441	492	581
Bicarbonate	mg/L	-	521	683	705	716	634	538	600	709
Carbonate	mg/L	-	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0
Hydroxide	mg/L	-	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0
Calcium	mg/L	-	173	177	177	176	178	166	144	168
Magnesium	mg/L	-	43.4	47.7	49.9	48.7	46.3	40.4	37	54.5
Potassium	mg/L	-	4.04	4.85	5.00	4.98	4.34	4.17	4.27	4.96
Sodium	mg/L	200	114	112	140	136	114	96.9	101	127
Chloride	mg/L	120	<b>267</b>	<b>233</b>	<b>290</b>	<b>290</b>	<b>234</b>	<b>162</b>	<b>141</b>	<b>231</b>
Fluoride	mg/L	1.5	<0.10	<0.10	0.132	0.138	<0.10	<0.10	<0.10	<0.10
Phosphorus - Total	mg/L	-	1.27	12.5	-	-	4.26	1.33	6.69	-
Sulphate	mg/L	429 <sup>3</sup>	65.1	54.6	47.5	47.2	62.8	87.5	42.7	40.2
Ionic Balance	N/A	-	99.2	94.1	101	101.5	97.1	105	100	97.8
<b>Nutrients</b>										
Ammonia as N	mg/L	1.152 to 110 <sup>6</sup>	0.231	0.338	0.730	1.42	0.174	<0.050	0.082	0.550
Nitrate (as NO <sub>3</sub> -N)	mg/L	3	<0.10	<0.10	<0.100	<0.100	<0.10	<0.10	0.24	<0.10
Nitrite (as NO <sub>2</sub> -N)	mg/L	0.20 <sup>4</sup>	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrate and Nitrite (as N)	mg/L	-	<0.11	<0.11	-	-	<0.11	0.24	<0.11	<0.11
Total Kjeldahl Nitrogen (TKN)	mg/L	-	3.1	40.9	-	-	5.1	2.3	11.3	-
<b>Carbon</b>										
Dissolved Organic Carbon (DOC)	mg/L	-	9.9	7.8	-	-	6.9	4.0	5.3	12.0
<b>Dissolved Metals</b>										
Aluminum	mg/L	0.026 to 0.050 <sup>5</sup>	0.0112	0.0157	<0.0050	<0.0050	<0.0050	0.0024	<b>0.248</b>	<0.0010
Antimony	mg/L	0.006	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00011	0.00021	<0.0001
Arsenic	mg/L	0.005	0.00208	<b>0.00679</b>	<b>0.00880</b>	<b>0.00828</b>	0.00415	0.00019	0.00084	0.00043
Barium	mg/L	1	0.224	0.257	0.458	0.448	0.239	0.122	0.151	0.221
Beryllium	mg/L	-	-	-	<0.000100	<0.000100	-	-	-	-
Bismuth	mg/L	-	-	-	<0.000250	<0.000250	-	-	-	-
Boron	mg/L	1.5	0.057	0.067	0.069	0.069	0.157	0.091	0.052	0.096
Cadmium	mg/L	0.00037 <sup>3</sup>	0.000049	<b>0.00377</b>	0.000150	0.000203	0.000035	0.00012	<b>0.00219</b>	<0.000050
Chromium	mg/L	0.05	<0.00050	<0.00050	<0.00250	<0.00250	<0.00050	<0.00010	0.00067	<0.00010
Cobalt	mg/L	-	-	-	0.00178	0.00177	-	-	-	-
Copper	mg/L	0.007	<0.0010	<0.0010	<0.00100	<0.00100	<0.0010	0.00277	<b>0.00823</b>	<0.00020
Iron	mg/L	0.3	<b>7.59</b>	<b>6.80</b>	<b>12.1</b>	<b>11.8</b>	<b>4.52</b>	<0.010	<b>0.45</b>	<0.010
Lead	mg/L	0.0070 <sup>3</sup>	<0.00025	<0.00025	<0.000250	<0.000250	<0.00025	0.000066	0.000738	<0.000050
Lithium	mg/L	-	-	-	0.0280	0.0288	-	-	-	-
Manganese	mg/L	0.05	<b>1.96</b>	<b>1.56</b>	<b>1.44</b>	<b>1.39</b>	<b>0.822</b>	0.00576	<b>0.0975</b>	<b>0.657</b>
Mercury	mg/L	0.000005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum	mg/L	-	-	-	0.00157	0.00161	-	-	-	-
Nickel	mg/L	0.208 to 0.253 <sup>3</sup>	0.0082	0.0064	0.00425	0.00397	0.0042	0.00195	0.00327	0.00177
Phosphorus	mg/L	-	-	-	<0.250	<0.250	-	-	-	-
Selenium	mg/L	0.002	<0.00025	<0.00025	<0.000250	<0.000250	<0.00025	<b>0.00357</b>	<b>0.00273</b>	<0.000050
Silicon	mg/L	-	-	-	7.67	7.44	-	-	-	-
Silver	mg/L	0.0001	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000010	<0.000010	<0.000010
Strontium	mg/L	-	-	-	1.26	1.26	-	-	-	-
Sulphur	mg/L	-	-	-	16.0	14.6	-	-	-	-
Thallium	mg/L	-	-	-	<0.000050	<0.000050	-	-	-	-
Tin	mg/L	-	-	-	<0.00050	<0.00050	-	-	-	-
Titanium	mg/L	-	-	-	<0.00150	<0.00150	-	-	-	-
Uranium	mg/L	0.015	0.00449	0.00243	0.00164	0.00163	0.00205	0.00351	0.00436	0.00136
Vanadium	mg/L	-	-	-	<0.00250	<0.00250	-	-	-	-
Zinc	mg/L	0.03	<0.0050	0.0161	0.0069	0.0084	<0.0050	0.0017	0.007	0.0138
Zirconium	mg/L	-	-	-	<0.00100	<0.00100	-	-	-	-

**Notes:**

<sup>1</sup> Alberta Environment and Parks (AEP). 2019. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Land Policy Branch, Policy and Planning Division. 198 pp. Referenced guidelines are for coarse-textured soils under Residential/Parkland land use.

<sup>2</sup> Alberta Environment and Parks (AEP). Environmental Quality Guidelines for Alberta Surface Waters. March 2018. Table 1 Surface water quality guidelines for the protection of freshwater aquatic life (PAL). Most conservative values applied (chronic or acute).

<sup>3</sup> Guideline varies with hardness. Values shown based on site hardness range of 512 mg/L to 647 mg/L.

<sup>4</sup> Guideline varies with chloride. Values shown based on site chloride range of 141 mg/L to 290 mg/L.

<sup>5</sup> Guideline varies with pH. Values shown based on site pH range of 6.15 to 7.98.

<sup>6</sup> Guideline varies with pH and temperature. Values shown based on pH range of 6.15 to 7.98 and temperature range of 2.44°C to 6.80°C.

"-" No applicable guideline or not analyzed.

"ND" Non-detected.

**BOLD** - Greater than Tier 1 Guideline.

N/A - Not applicable.





**Table 3: Groundwater Quality Assurance/Quality Control Analytical Results**

Parameter	Unit	RDL	MW-02	Duplicate	RPD (%)
			23-Nov-2021	23-Nov-2021	
<b>Routine</b>					
pH	pH Units	0.1	7.39	7.14	3
Electrical Conductivity (EC)	µS/cm	1	1800	1800	0
Total Dissolved Solids (TDS)	mg/L	1	1090	1090	0
Hardness as CaCO <sub>3</sub>	mg/L	0.6	647	640	1
Alkalinity (total as CaCO <sub>3</sub> )	mg/L	1	578	587	2
Bicarbonate	mg/L	1	705	716	2
Carbonate	mg/L	1	<1.0	<1.0	-
Hydroxide	mg/L	1	<1.0	<1.0	-
Calcium	mg/L	0.25	177	176	1
Magnesium	mg/L	0.5	49.9	48.7	2
Potassium	mg/L	0.5	5.00	4.98	0.4
Sodium	mg/L	0.25	140	136	3
Chloride	mg/L	2.5	290	290	0
Fluoride	mg/L	0.1	0.132	0.138	-
Sulphate	mg/L	1.5	47.5	47.2	1
Anions Total	meq/L	0.1	20.7	20.9	1
Cations Total	meq/L	0.1	19.7	19.4	2
Ionic Balance	N/A	0.01	2.48	3.72	-
<b>Nutrients</b>					
Ammonia as N	mg/L	0.05	0.730	1.42	<b>64</b>
Nitrate (as NO <sub>3</sub> -N)	mg/L	0.1	<0.100	<0.100	-
Nitrite (as NO <sub>2</sub> -N)	mg/L	0.05	<0.050	<0.050	-
<b>Dissolved Metals</b>					
Aluminum	mg/L	0.005	<0.0050	<0.0050	-
Antimony	mg/L	0.0005	<0.00050	<0.00050	-
Arsenic	mg/L	0.0005	0.00880	0.00828	6
Barium	mg/L	0.0005	0.458	0.448	2
Beryllium	mg/L	0.0001	<0.000100	<0.000100	-
Bismuth	mg/L	0.00025	<0.000250	<0.000250	-
Boron	mg/L	0.05	0.069	0.069	-
Cadmium	mg/L	0.000025	0.000150	0.000203	<b>30</b>
Chromium	mg/L	0.0025	<0.00250	<0.00250	-
Cobalt	mg/L	0.0005	0.00178	0.00177	-
Copper	mg/L	0.001	<0.00100	<0.00100	-
Iron	mg/L	0.05	12.1	11.8	3
Lead	mg/L	0.00025	<0.000250	<0.000250	-
Lithium	mg/L	0.005	0.0280	0.0288	3
Manganese	mg/L	0.0005	1.44	1.39	4
Mercury	mg/L	0.000005	<0.0000050	<0.0000050	-
Molybdenum	mg/L	0.00025	0.00157	0.00161	3
Nickel	mg/L	0.0025	0.00425	0.00397	-
Phosphorus	mg/L	0.25	<0.250	<0.250	-
Selenium	mg/L	0.00025	<0.000250	<0.000250	-
Silicon	mg/L	0.25	7.67	7.44	3
Silver	mg/L	0.00005	<0.000050	<0.000050	-
Strontium	mg/L	0.001	1.26	1.26	0
Sulphur	mg/L	2.5	16.0	14.6	9
Thallium	mg/L	0.00005	<0.000050	<0.000050	-
Tin	mg/L	0.0005	<0.00050	<0.00050	-
Titanium	mg/L	0.0015	<0.00150	<0.00150	-
Uranium	mg/L	0.00005	0.00164	0.00163	1
Vanadium	mg/L	0.0025	<0.00250	<0.00250	-
Zinc	mg/L	0.005	0.0069	0.0084	-
Zirconium	mg/L	0.001	<0.00100	<0.00100	-

**Notes:**

RDL - Reportable detection limit.

RPD - Relative Percentage Difference calculated as  $RPD(\%) = \frac{|V1-V2|}{(V1+V2)/2} * 100$  where V1, V2 = concentrations of parent and duplicate sample, respectively.

"-" Indicates RPD not calculated. RPDs have only been considered where both concentrations are greater than 5 times the RDL.

N/A - Not applicable.

**BOLD** - RPD value greater than 20%.

**Table 4: Soil Vapour Monitoring Results**

Parameter	Gas Well											
	VW-01					VW-02					VW-03	
	Aug-13	Jun-19	Dec-19	Jul-21	Nov-21	Aug-13	Jun-19	Dec-19	Jul-21	Nov-21	Jul-21	Nov-21
Pressure (kPa) <sup>1</sup>	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
CH <sub>4</sub> (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO (ppm) <sup>2</sup>		0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	1.0	0.0
CO <sub>2</sub> (%)	2.1	2.7	0.3	1.8	1.8	1.7	0.0	0.1	0.6	0.7	5.5	7.0
O <sub>2</sub> (%)	13.4	17.5	21.0	18.5	21.3	19.9	20.1	22.2	20.1	22.6	14.3	17.2
Balance (% v/v)	84.6	79.8	78.7	79.7	76.9	78.5	79.8	77.7	79.3	76.8	80.2	75.8
Static Water Level (mbtoc) <sup>3</sup>	-	Dry	Dry	Dry	Dry	-	Dry	Dry	Dry	Dry	Dry	Dry
Depth to Bottom (m) <sup>4</sup>	3.70	3.36	3.51	3.44	4.44	2.70	3.37	3.50	3.37	3.37	3.46	3.41
Screen Interval Top (m)	2.7					2.4					2.0	
Screen Interval Bottom (m)	3.0					2.7					3.5	
Stick up (m)	0.76	0.63	0.68	0.69	0.62	1.08	0.96	1.06	1.06	1.04	0.00	0.00

**Notes:**

<sup>1</sup> Kpa - Kilopascal.

<sup>2</sup> ppm - Parts per million.

<sup>3</sup> mbtoc - Meters below top of casing.

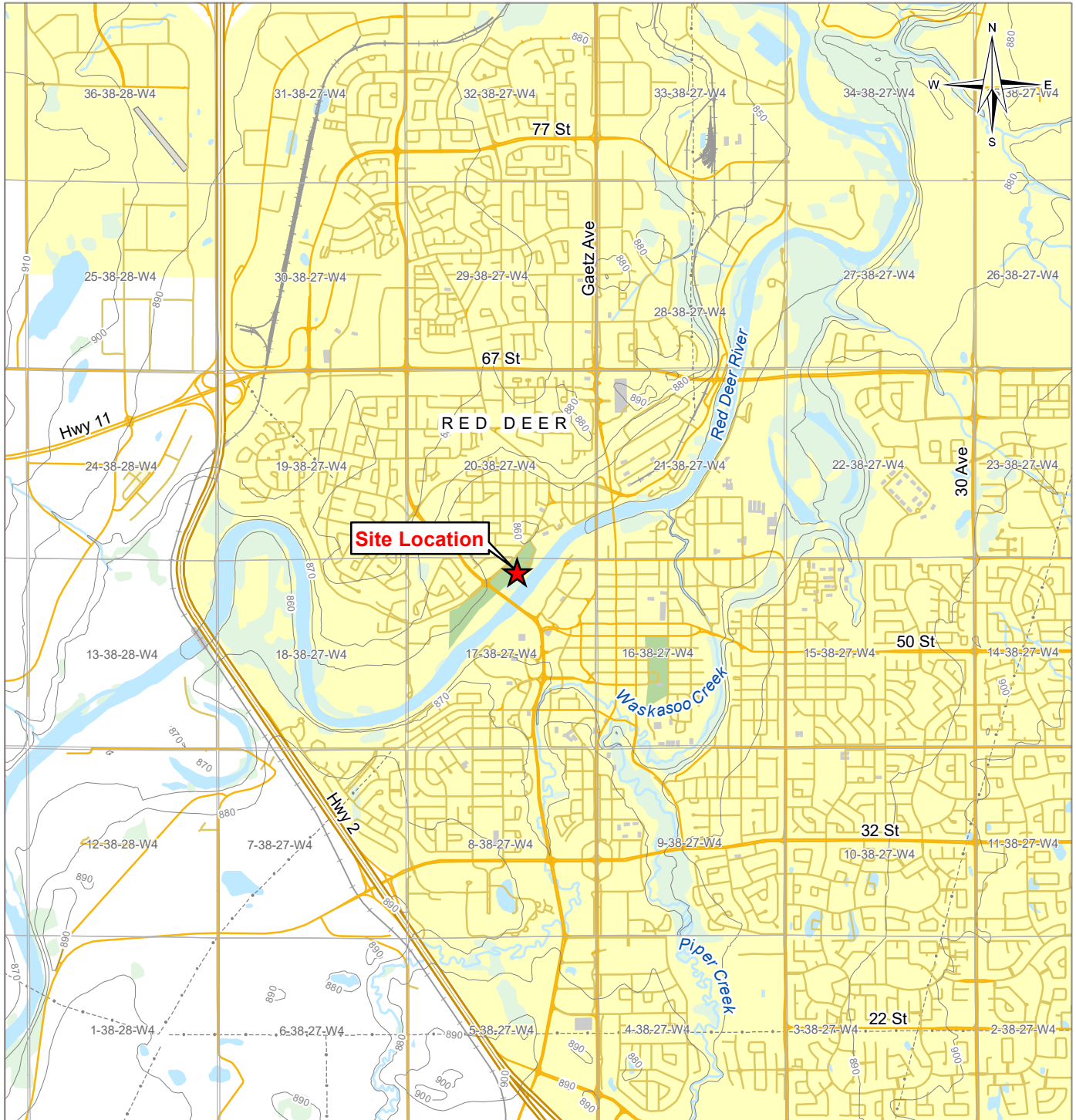
<sup>4</sup> m - Metres.

N/A - Not applicable - well can not be accessed to obtain measurement.

## FIGURES

Figure 1	Site Location Plan
Figure 2	Site Plan and Surrounding Land Use
Figure 3	Historical Groundwater Elevations (Groundwater Monitoring Wells)
Figure 4	Groundwater Elevation Contours – July 2021
Figure 5	Groundwater Elevation Contours – November 2021

C:\Edmonton\GIS\ISOLID\_WASTE\SWOP\SWOP04071-02\Figure1\_SiteLocation.mxd modified 2022-06-14 by stephanie.leusink



**LEGEND**

- Site Location
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Power Line
- Runway
- Building
- Park
- Residential Area
- Contour (10 m)
- Watercourse
- Waterbody
- Wooded Area
- Urban Area

**NOTES**  
Base data source: CanVec 1:50,000.

**STATUS**  
ISSUED FOR USE





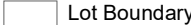

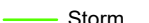


**2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT GREAT WEST ADVENTURE PARK**

**Site Location Plan**

<b>PROJECTION</b> 3TM 114	<b>DATUM</b> NAD83	<b>CLIENT</b> THE CITY OF Red Deer
Scale: 1:50,000 Kilometres		
<b>FILE NO.</b> SWOP04071-02_Figure1_SiteLocation.mxd		
<b>OFFICE</b> Tl-EDM	<b>DWN MRV</b>	<b>CKD SL</b>
<b>DATE</b> June 14, 2022	<b>APVD RM</b>	<b>REV</b> 0
<b>PROJECT NO.</b> SWM.SWOP04071-02.001		<b>Figure 1</b>



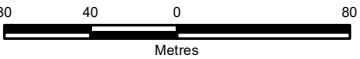
**LEGEND**

-  Monitoring Well
-  Vapour Well
-  Historic Waste Disposal  
(Provided by Tiamat, 2014)
-  Site Boundary
-  Lot Boundary
- Utilities**
-  Electrical
-  Sanitary
-  Storm
-  Water



**NOTES**  
 Base data source: Imagery provided by ESRI; City of Red Deer (2020)  
 Roads from City of Red Deer Open Data, 2018  
 Utilities provided by City of Red Deer.  
 Locations have not been field verified, and should not be used for construction or other intrusive field activities.

**STATUS**  
 ISSUED FOR USE

Scale: 1:3,500



Metres

<b>PROJECTION</b> 3TM 114	<b>DATUM</b> NAD83
<b>FILE NO.</b> SWOP04071-02_Figure2_LandUse.mxd	
<b>CLIENT</b>	
	

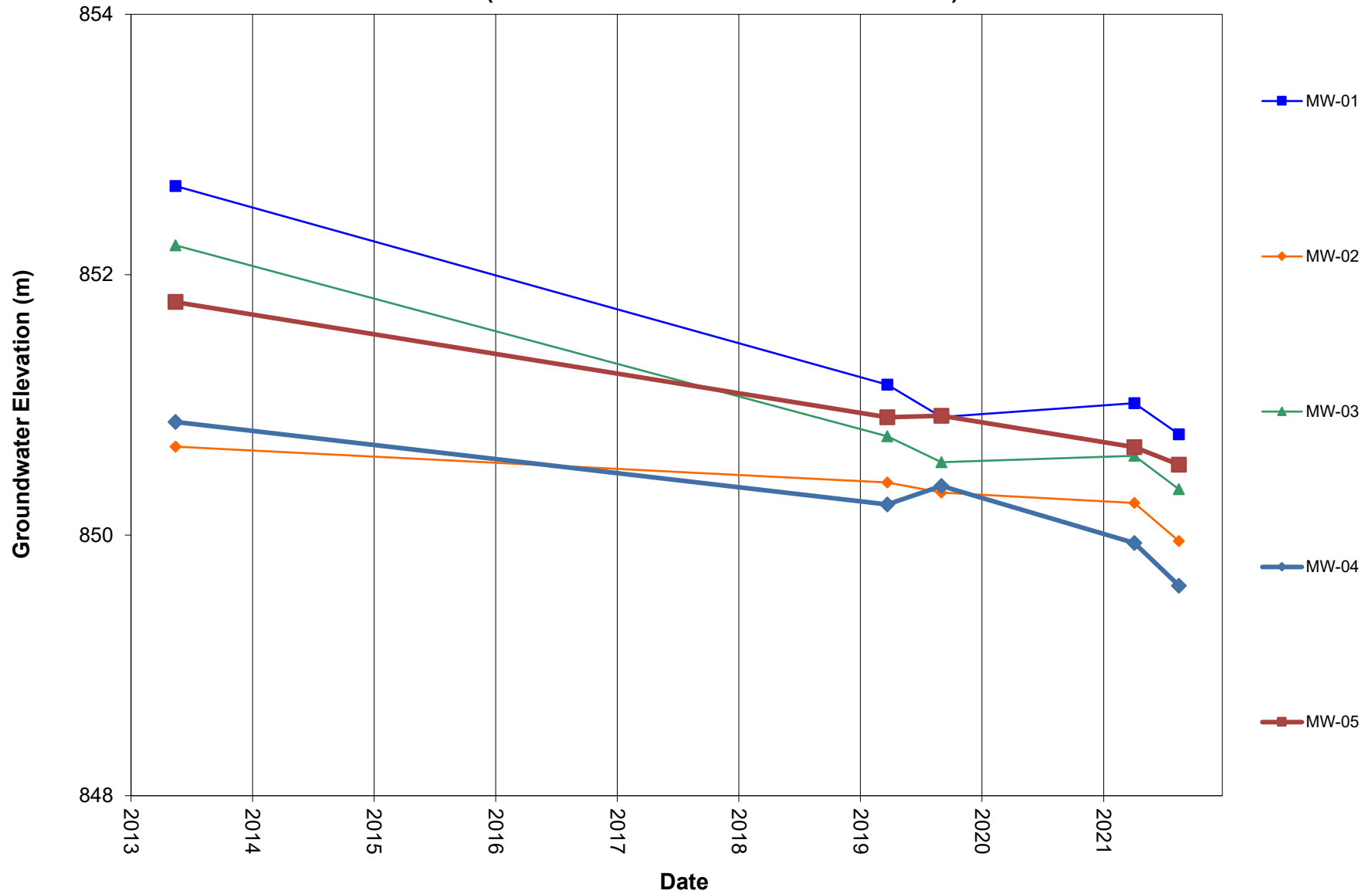
**2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT  
 GREAT WEST ADVENTURE PARK**

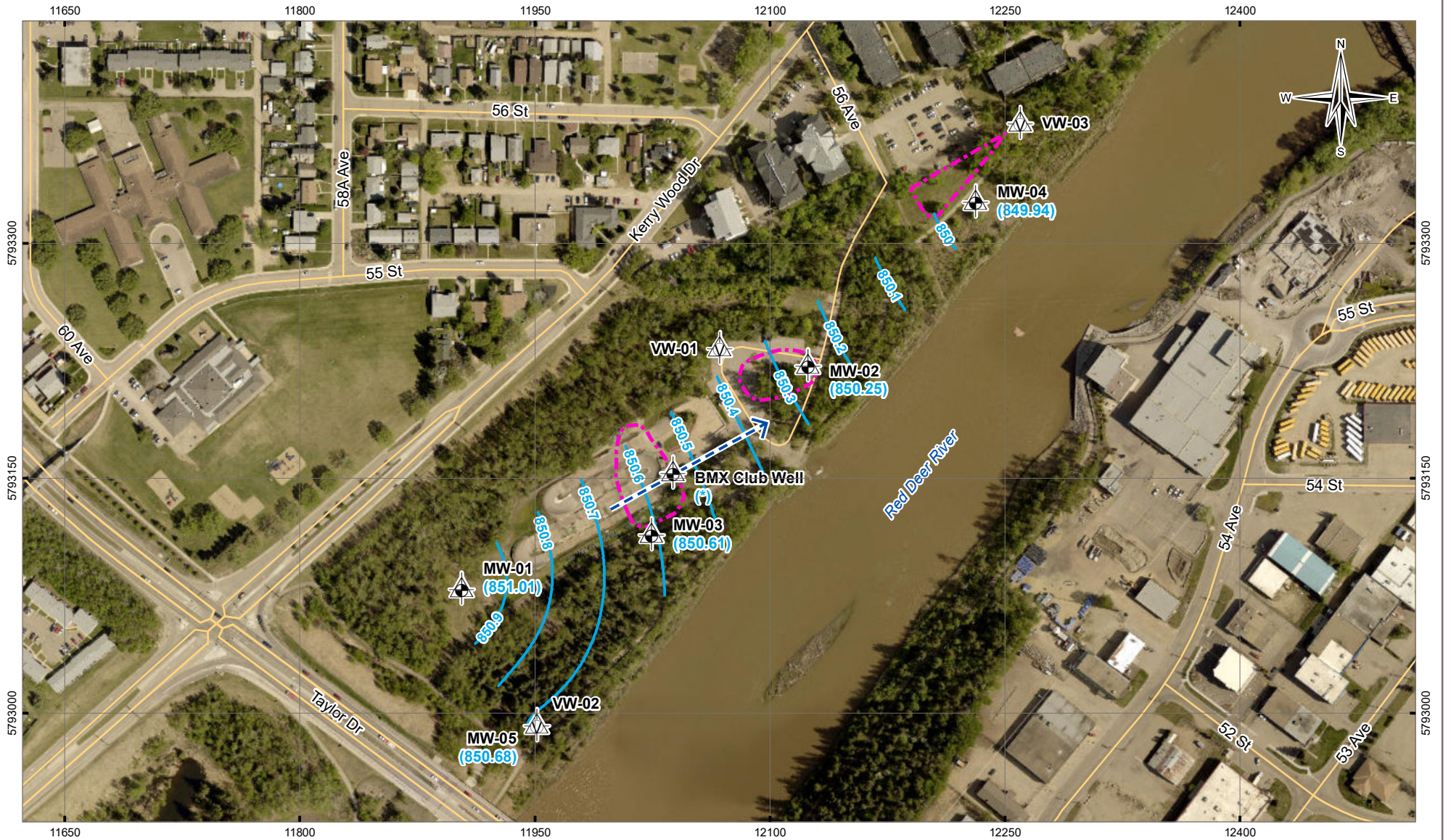
**Site Plan and  
 Surrounding Land Use**

<b>OFFICE</b> TL-EDM	<b>DWN MRV</b> MRV	<b>CKD SL</b> SL	<b>APVD RM</b> RM	<b>REV</b> 0
<b>DATE</b> June 14, 2022	<b>PROJECT NO.</b> SWM.SWOP04071-02.001			






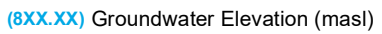

**Figure 2**

**FIGURE 3**  
**HISTORICAL GROUNDWATER ELEVATIONS**  
**(GROUNDWATER MONITORING WELLS)**



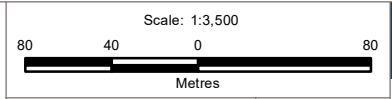


**LEGEND**

-  Monitoring Well
-  Vapour Well
-  Inferred Groundwater Flow Direction
-  Groundwater Elevation Contour (0.1 masl)
-  Road
-  (8XX.XX) Groundwater Elevation (masl)
-  Historic Waste Disposal (Provided by Tiamat, 2014)

**NOTES**  
 Base data source: Imagery provided by ESRI; City of Red Deer (2020)  
 Roads from City of Red Deer Open Data, 2018  
 masl - metres above sea level  
 \* - not measured

**STATUS**  
 ISSUED FOR USE



**PROJECTION**  
 3TM 114

**DATUM**  
 NAD83

**FILE NO.**  
 SWOP04071-02\_Figure4\_GW\_July2021.mxd

**CLIENT**

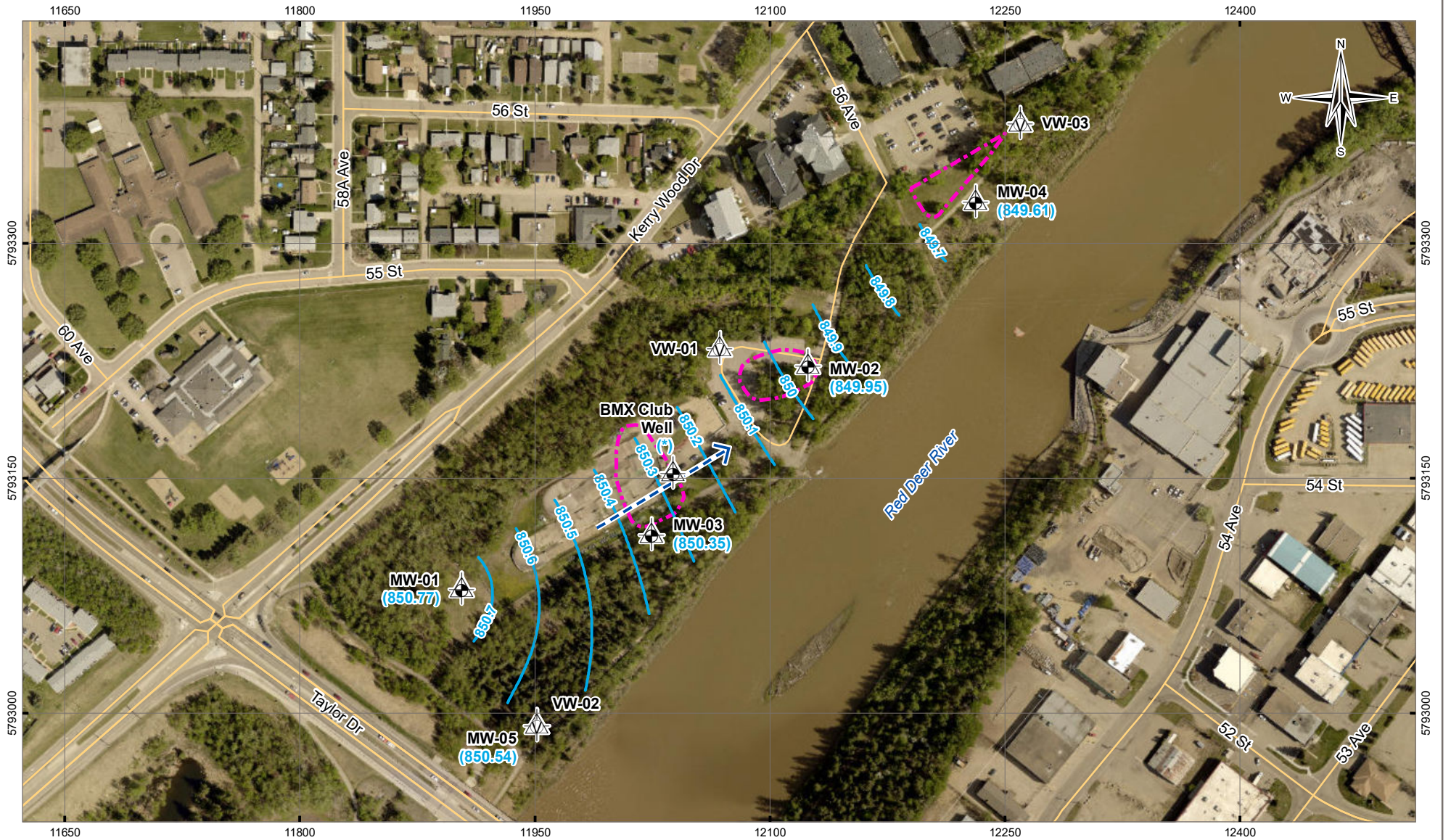



**2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT  
 GREAT WEST ADVENTURE PARK**

**Groundwater Elevation Contours  
 July 2021**

<b>OFFICE</b> TL-EDM	<b>DWN</b> MRV	<b>CKD</b> SL	<b>APVD</b> RM	<b>REV</b> 0
<b>DATE</b> June 14, 2022	<b>PROJECT NO.</b> SWM.SWOP04071-02.001			

**Figure 4**

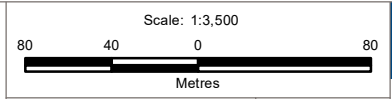


**LEGEND**

- Monitoring Well
- Vapour Well
- Inferred Groundwater Flow Direction
- Groundwater Elevation Contour (0.1 masl)
- Road
- Historic Waste Disposal (Provided by Tiamat, 2014)
- (8XX.XX)** Groundwater Elevation (masl)

**NOTES**  
 Base data source: Imagery provided by ESRI; City of Red Deer (2020)  
 Roads from City of Red Deer Open Data, 2018  
 masl - metres above sea level  
 \* - not measured

**STATUS**  
 ISSUED FOR USE



**PROJECTION**  
 3TM 114

**DATUM**  
 NAD83

**FILE NO.**  
 SWOP04071-02\_Figure5\_GW\_Nov2021.mxd



**2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT  
 GREAT WEST ADVENTURE PARK**

**Groundwater Elevation Contours  
 November 2021**

<b>OFFICE</b> TL-EDM	<b>DWN MRV</b> MRV	<b>CKD SL</b> SL	<b>APVD RM</b> RM	<b>REV</b> 0
<b>DATE</b> June 14, 2022	<b>PROJECT NO.</b> SWM.SWOP04071-02.001			

**Figure 5**



## APPENDIX A

### TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

# LIMITATIONS ON USE OF THIS DOCUMENT

## GEOENVIRONMENTAL

### 1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

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The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

### 1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

### 1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner

consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

### 1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

### 1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

### 1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

### 1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

## APPENDIX B

### SITE HISTORY, HISTORICAL INFORMATION, AND SITE SETTING

## 1.0 SITE HISTORY

The following section summarizes the history of the site and was developed for the 2019 groundwater and soil vapour monitoring report<sup>1</sup>.

Municipal records indicate that the waste disposal at the site occurred between approximately 1923 and 1947 (approximately 24 years). This would indicate that the estimated age of the waste material would be approximately 73 to 97 years old. Records indicate that the municipal solid waste (MSW) was disposed of after gravel mining in the area which was associated with a former commercial timber business.

Historical MSW disposal was identified during the Phase II environmental site assessment<sup>2</sup> (ESA) beneath a portion of the BMX track and a portion of the public parking lot. A separate waste area was identified off site, adjacent to the Riverbend Village apartments parking lot to the northeast. Estimated waste areas are identified on Figure 2. The MSW encountered during the Phase II ESA was a mixture of plastics, paper, metal, wires, and glass amongst a mix of sand, clay, and gravels. The Phase II ESA estimated the total area of buried waste at approximately 3,970 m<sup>2</sup>, to a maximum depth of 4.6 m below ground surface (mbgs). The largest footprint of waste is estimated to be located underneath the BMX track facility.

Results of the 2014 Phase II ESA<sup>2</sup> indicated that surface materials of sod, sand, and loam were overlying clay, sand, and gravel fill material. The fill was estimated to be 0.6 m to 6.6 m deep. Waste was encountered at six testholes and was typically under a thin layer of sod. The deepest waste was encountered at TH-11 and TH-12, at 4.6 mbgs and 5.5 mbgs and overlying native clay and sand. These testholes were located in the central area of the BMX track. The cross-sections completed by Tiamat Environmental Consultants Ltd.<sup>2</sup> (Tiamat) indicate that where encountered, the top of the shale bedrock was found at approximately 5 mbgs.

## 2.0 HISTORICAL GROUNDWATER MONITORING AND INVESTIGATION SUMMARY

In 2014, Tiamat completed a Phase II ESA<sup>2</sup>, which consisted of advancing 23 testholes ranging from 2.7 m below grade (mbg) to 6.6 mbg. Waste was observed in six of the testholes during the drilling program. Five monitoring wells were installed (MW-01 to MW-05) along with two soil vapour wells (VW-01 and VW-02). In August 2013, groundwater monitoring and sampling was completed at all monitoring wells.

Previous reports prepared by Tiamat for the site include the following:

- Phase I Environmental Site Assessment, Historic Waste Disposal Site, Great West Adventure Park, The City of Red Deer. September 24, 2013<sup>3</sup>.
- Phase II Environmental Site Assessment, Historic Waste Disposal Site, Great West Adventure Park, The City of Red Deer. February 12, 2014<sup>1</sup>.

<sup>1</sup> Tetra Tech Canada Inc. 2020. 2019 Groundwater and Soil Vapour Monitoring Report – Great West Adventure Park. Prepared for The City of Red Deer. July 2020. Project Number: 704-SWM.SWOP04071-01.001.

<sup>2</sup> Tiamat Environmental Consultants Ltd. 2014. Phase II Environmental Site Assessment, Historic Waste Disposal Site, Great West Adventure Park, The City of Red Deer. February 12, 2014.

<sup>3</sup> Tiamat Environmental Consultants Ltd. 2013. Phase I Environmental Site Assessment, Historic Waste Disposal Site, Great West Adventure Park, The City of Red Deer. September 24, 2013.

- Environmental Risk Management Plan, Historic Waste Disposal Site, Great West Adventure Park, The City of Red Deer. December 3, 2014<sup>4</sup>.

The results of the Phase II ESA conducted by Tiamat in 2014 indicated the following:

- Historical records indicate the present configuration of the site has been unchanged. The site is currently zoned as a municipal reserve (1MR).
- Historical information suggests the disposal of household sanitary waste materials started pre-1923 until 1947 by the Village of North Red Deer. Other available information suggested that disposal activity commenced on or about 1916 and ended by 1947. After that, the village or North Red Deer was amalgamated within the City in January 1948.
- At the time of the report preparation, records indicated there were not any outstanding environmental concerns with the site.
- The historical waste disposal areas have been redeveloped as public recreational activities, green spaces, and a multi-family apartment building. Presently, there are no obvious activities on the adjacent lands that are interpreted as an environmental concern relative to the site.

The recommendations of the program were as follows, as identified in the Phase II ESA<sup>2</sup>:

- Continue to monitor groundwater elevations and soil vapour data biannually for one hydrogeological cycle.
- Determine if surface water sampling should be included to predict groundwater flow patterns and the impacts of potential leachate could have on the Red Deer River water quality.
- Collect an additional set of soil vapour and groundwater analytical data, groundwater elevations, and volatile headspace measurement during the winter months to determine seasonal changes in soil vapour concentrations.
- Review the results of the soil vapour sampling with the Riverbend Village Apartments and install an additional soil vapour and groundwater monitoring well within the proximity of the apartments to determine potential risk to the apartment building tenants.
- Review all new data and update the site risk management plan (RMP) with all new information and findings.

The recommendations of the RMP<sup>4</sup> were as follows:

- A risk review should be completed for the site using the updated groundwater analytical data. The review should be based on river flow, geometry and characteristics to determine if the City of Red Deer Waste Treatment Plant (WTP) is susceptible to any effects from the historical waste disposal. The WTP is located northeast of the site, across the river.
- The above findings should be reviewed with the WTP to determine if leachate constituents could impact the WTP.
- Information in the preliminary quantitative risk assessment (PQRA) should be updated as new site information is obtained.

---

<sup>4</sup> Tiamat Environmental Consultants Ltd. 2014. Environmental Risk Management Plan, Historic Waste Disposal Sites, Great West Adventure Park, The City of Red Deer. December 3, 2014.

- A review of the RMP should be completed when the PQRA information is updated, if there are changes to the chemicals of potential concern (COPCs).
- The RMP should be reviewed and updated at five-year intervals.

## 3.0 SITE SETTING

The following section presents an overview of the regional and local setting for the site.

### 3.1 Geology

The following sections summarize the regional and local geology.

#### 3.1.1 Geological Setting and Stratigraphy

The City and site are located within the Red Deer River drainage basin with principal drainage via the Red Deer River located east of the site. The river has incised the uplands with gentle slopes to the east and west of the river in the vicinity of the site.

The geology in the river valley is characterized by fluvial surficial sediments deposited by the Red Deer River, overlying shale and sandstone bedrock of the Paskapoo Formation.

Key elements of the geological setting are presented below from Tiamat's 2013 Phase I ESA report<sup>3</sup>:

*"The fertile black soil in the region (Penhold Loam) is of alluvial lacustrine origin. The Penhold Loam is a well-drained fine sandy loam classified as Chernozemic. It is generally stone free and in natural areas, is typically 1.5 m thick, more or less.*

*The Quaternary deposits consist of drift deposits of clay, silt, gravel and sand. Published information indicates the banks of the Red Deer River comprise of dirty gravel with thickness ranging from 6 to 12 m, more or less.*

*In the valley, lies preglacial Saskatchewan gravels and sand. Terrace gravels hydraulically connected to the Red Deer River are a known resource of groundwater. Surficial soils comprise largely of poorly to moderately sorted sand, silt and gravel with a varying amount of clay. The fluvial sediments generally have obscure bedding planes. Medium to coarse sized gravel with cross-bedded sand have been documented.*

*The Tertiary bedrock consists of sequences of alternating shales and sandstones of the Paskapoo Formation. The Paskapoo Formation underlies the gravel sediments. This non-marine bedrock is composed of mudstone, siltstone and sandstone. The formation of the Rocky Mountains subjected the Paskapoo Formation to a regional stress-induced fracture pattern."*

#### 3.1.2 Local Geology

Based on the Phase II ESA results, GWAP consisted of 0.6 m to 6.6 m of fill material, consisting of a mixture of sod, sand and loam, overlying clay, sand, and gravel. Testholes with observed waste consisted of up to 4.6 m of waste, with often minimal soil cover on top. Waste material was situated on top of a native clay and sand layer, overlying a shale bedrock, encountered between 2.6 m to 5.8 m depths. Monitoring wells MW-01 to MW-05 at the site are screened through multiple stratigraphy's, including sand fill, native sand and gravel, and shale bedrock.

## 3.2 Hydrogeology

The following sections summarize the regional and local hydrogeology.

### 3.2.1 Regional Hydrogeology

The regional hydrogeology is most influenced by the presence of the river sediments situated within the valley along the Red Deer River and a bedrock valley trending north-northeast in the vicinity of the site.

Key elements of the hydrogeological setting are presented below from Tiamat's 2013 Phase I ESA report<sup>3</sup>:

*"A significant buried valley and aquifer resource trending northeastward through the city has been partially mapped and lies in the SE 28-38-27 W4M (MacKenzie Trail and Riverside). This buried valley extends to a depth of 21 m, more or less and may extend to the south into north portions of 21-28-27 W4M. Mapping by the Alberta Geological Survey<sup>5</sup> indicates that the valley could be beneath the site, however the width of the valley is not defined.*

*The dominant type of near-surface groundwater in the Paskapoo Formation in the area of assessment is sodium bicarbonate. Notable concentrations of sodium sulphate type groundwater have also been reported. The quality of groundwater for potable use is generally suitable to depths of 300 m on the west side of Red Deer and decreases to 90 m, more or less in the east.*

*Areas of recharge (downward flow) in unsaturated heterogeneous sediments include most areas above the river and creek valleys, whereas; the river valleys will generally exhibit discharge. The distribution of groundwater in the area can also be influenced by the local geology, topographic relief, areas of artesian flow, springs and reasonable yielding water source wells.*

*Numerous permanent surface water features within The City of Red Deer and vicinity include Red Deer River, Waskasoo Creek, Gaetz Lakes, Hazlett Lake, Bower Ponds (result of formerly mining gravel resources), various sloughs in the fringe areas of the city and an assortment of other smaller creeks and springs.*

The regional groundwater flow is expected to follow the bedrock topography and will be influenced by the varying distribution of sediments in the river valley, which will have been deposited in various historical channels since filled in under varying depositional environments. Further, the river is in hydrologic connection with the adjacent sediments; therefore, seasonal changes in river stage will affect the local groundwater flow patterns (magnitude and direction). In seasons of higher river flow, bank storage will occur whereas in seasons of lower flow (such as late summer/fall), the storage will be released.

### 3.2.2 Local Hydrogeology

The Red Deer River is located on the southeast side of the site and flows in a northerly direction. Shallow groundwater is assumed to flow parallel to or towards the river.

<sup>5</sup> Andriashek, L. comp. 2018. Thalwegs of Bedrock Valleys, Alberta (GIS data, line features); Alberta Energy Regulator, AER/AGS Digital Data 2018-0001.

### 3.3 Groundwater Resource Usage

A 2019 search of the Alberta Water Well Database for groundwater users within a 1 km radius of the site, identified 18 groundwater wells; 8 of the wells are listed as for domestic use, 1 is listed as for industrial use, 1 is listed as other, and 8 are listed as for unknown use, 7 of which have been decommissioned<sup>6</sup>.

The nearest water well is located on site and is indicated to be drilled to 7.5 mbg; however, measurements in 2021 suggest that it is greater than 30 mbg. The well was drilled in 1986 and was donated to the Red Deer BMX club. The proposed well use is listed as other. According to BMX club members, it is not used as a source of potable water but used for dust control and watering the grass. The water wells within a 1 km radius of site range from 7.5 mbg to 58 mbg. The status and use of the surrounding groundwater wells were not confirmed and they were not field verified.

## 4.0 HAZARD QUOTIENTS

### 4.1 2019 Hazard Quotient Calculations

Using the soil vapour screening levels described in the 2019 groundwater and soil monitoring report<sup>1</sup> and the soil vapour sampling results, estimated cancer risks (for carcinogens) and estimated hazard quotients (HQs; for non-carcinogens) were calculated for the site.

Estimated risks were calculated by dividing the soil vapour concentration by the corresponding soil vapour screening level for carcinogenic effects and multiplying the ratio by the target risk level of  $1 \times 10^{-5}$ . Similarly, the estimated HQs represent the soil vapour concentration divided by the corresponding soil vapour screening level for non-carcinogenic effects.

For this evaluation, target risk and hazard levels were determined in accordance with Alberta Tier 2 Guidelines. For carcinogens, the target risk level is  $1 \times 10^{-5}$ , as this value is considered by Health Canada to represent a negligible risk. For non-carcinogens a target hazard level of 1 is used as potential exposures that result in hazard indices equal to or less than 1 signify negligible potential for adverse health effects. Each sampling location was screened individually for every chemical detected.

The risk levels for carcinogens in the samples collected ranged between  $4.9 \times 10^{-7}$  and  $6.3 \times 10^{-7}$ . The hazard levels identified in the samples collected for the non-carcinogens ranged between 0.004 and 0.024.

The estimated risks and hazards associated with the soil vapour samples collected in December 2019 did not exceed the corresponding target risk and hazard levels in any of the samples collected.

### 4.2 Review of the 2014 Hazard Quotients from the Risk Management Plan

The following section is a review of the 2014 RMP<sup>4</sup> for the site that was completed by Tiamat. The review of the 2014 RMP was completed for the 2019 groundwater and soil vapour monitoring report<sup>1</sup>.

The 2014 RMP presented a proposed site-specific environmental RMP as a tool to assist with the review of future subdivision applications on lands lying within the regulated setback distance from the site (300 m). The focus was on potential ingress of soil gas for COPCs with a HQ greater than 1.0. Residential land use was considered most

<sup>6</sup> Alberta Environment and Parks. 2019. Water Well Database. [http://www.telusgeomatics.com/tgpub/ag\\_water/](http://www.telusgeomatics.com/tgpub/ag_water/).



sensitive, and exposure ratings for other land uses (e.g., school, public institutions, commercial complexes) were considered to not be greater than residential; however, unique exceptions would have to be reviewed and addressed on a site-specific basis<sup>4</sup>. Further, underground utility workers and subsurface utility infrastructure were considered relevant to potential exposure.

The 2014 RMP applied a 10x factor of safety to the HQs to address uncertainties. HQs from the RMP ranged up to 566 (including the 10x factor of safety). Based on these, the RMP then provided recommended generic mitigative measures based on the calculated HQs, ranging from passive to active measures, recognizing that the ultimate approach would require a design professional for the proposed development.

Following the 2014 RMP, CCME released the document A Protocol for the Derivation of Soil Vapour Quality Guidelines for Protection of Human Exposures Via Inhalation of Vapours<sup>7</sup>, designed to provide guidance for developing site-appropriate soil vapour quality guidelines. The guidelines developed using the methods outlined in the CCME document were used for this current study and are included with the vapour sampling results in Table 4. HQs were calculated using estimated dose (based on concentrations measured at the site) and divided by tolerable daily intake. Soil vapour concentrations from the Phase II ESA conducted in 2013 were not compared to soil vapour quality guidelines; however, spot checks of five target compounds with the highest HQs in the 2013 work (benzene, tetrachloroethylene, chloromethane, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene) identified that none of the 2013 concentrations would have unacceptable HQs using the updated CCME methodology.

The 2014 RMP was prepared concurrent to RMPs at several other former City landfills, and a common set of mitigative measures was applied based on the HQs. Subsequent to the 2014 RMP and to the release of the CCME Protocol document, The City undertook additional assessment at another former City Landfill (Montfort); as part of that work, their consultant XCG Consulting Limited (XCG) revised the 2014 RMP criteria ranges for each generic mitigative measure category to include a cancer risk range to allow comparison of the 2014 RMP ranges with the HQ and cancer risks calculated by XCG<sup>8</sup>. From that work, XCG identified the following generic mitigative measures for developments within a 300 m setback of these landfills (based on Tiamat<sup>4</sup>), and these have been adopted for this site:

### Passive Measures

1. Passive Measures – Level A: for Cancer Risk of  $> 1E^{-5}$  and  $< 5E^{-5}$  and/or HQ  $> 0.2$  and  $< 1$ .  
Compacted clay liner with a minimum thickness of 1m and confirmed maximum hydraulic conductivity of  $10^{-6}$  cm/sec.
2. Passive Measures – Level B: for Cancer Risk of  $> 5E^{-5}$  and  $< 5E^{-4}$  and/or HQ  $> 1$  and  $< 5$ .  
Synthetic liner with type of material, thickness and installation details dependent on the design professional.
3. Passive Measures – Level C: for Cancer Risk of  $> 5E^{-4}$  and  $< 1E^{-3}$  and/or HQ  $> 5$  and  $< 50$ .  
Passive sub-slab depressurization (SSD) system with a minimum depressurization of 4 Pa to 10 Pa. In some instances (such as a pervious subgrade), the actual depressurization necessary may require an active SSD or alternative active ventilation system.

---

<sup>7</sup> Canadian Council of Ministers of the Environment. 2014. A Protocol for the Derivation of Soil Vapour Quality Guidelines for Exposure Protection of Human Exposures via Inhalation of Vapours. Available online: <http://ceqg-rcqe.ccme.ca/en/index.html#void>.

<sup>8</sup> XCG Consulting Limited, 2018. Vapour Intrusion Assessment and Environmental Monitoring Report, prepared for the City of Red Deer's Montfort Landfill.

## Active Measures

Field verify the presence of the identified chemicals of concern and other potential chemicals in the soil gas state at the development site. If confirmed, determine the most appropriate manner to prevent soil vapour intrusion.

1. Active Measures – Level D: for Cancer Risk of  $> 1E^{-3}$  and  $< 2E^{-3}$  and/or HQ values  $>50$  and  $<100$ .

Active SSD must be configured to compensate for depressurization of the building and have adequate negative pressure gradients across the entire footprint of the foundation.

2. Active Measures - Level E: for Cancer Risk of  $>2E^{-3}$  and/or HQ values  $>100$ .

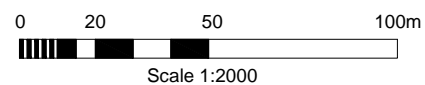
Installation of geomembrane and active soil vapour extraction with system fault notification alarm.

Based on the 2019 program, the greatest HQ calculated for the site was 0.008 (vs target hazard level of 0.2) and the greatest estimated cancer risk was  $6.3 \times 10^{-7}$  (vs target Risk of  $1.0 \times 10^{-5}$ ). While development at the site is not currently proposed, for illustrative purposes, based on these HQ and cancer risk levels calculated from the 2019 vapour data, no passive or active measures would be required for the site. It is noted that even if the 10x factor of safety is applied, mitigative measures would still not be required. It should also be noted that assumptions made in the calculations of HQs and cancer risk above are inherently conservative; therefore, applying a factor of safety is not needed.

Future applications for development within the setback are subject to review by The City. The developer's team would be responsible for reviewing and verifying the available data relative to their proposed development. The mitigative measures presented above are generic and can be used as a general guide for expectations by The City; ultimately, the developer's design engineer would be responsible for developing measures specific to the intended development based on the above or an appropriate equivalent. Protection of workers (e.g., construction and utility) should form part of any development plan.

## APPENDIX C

### CROSS-SECTIONS (TIAMAT 2014)



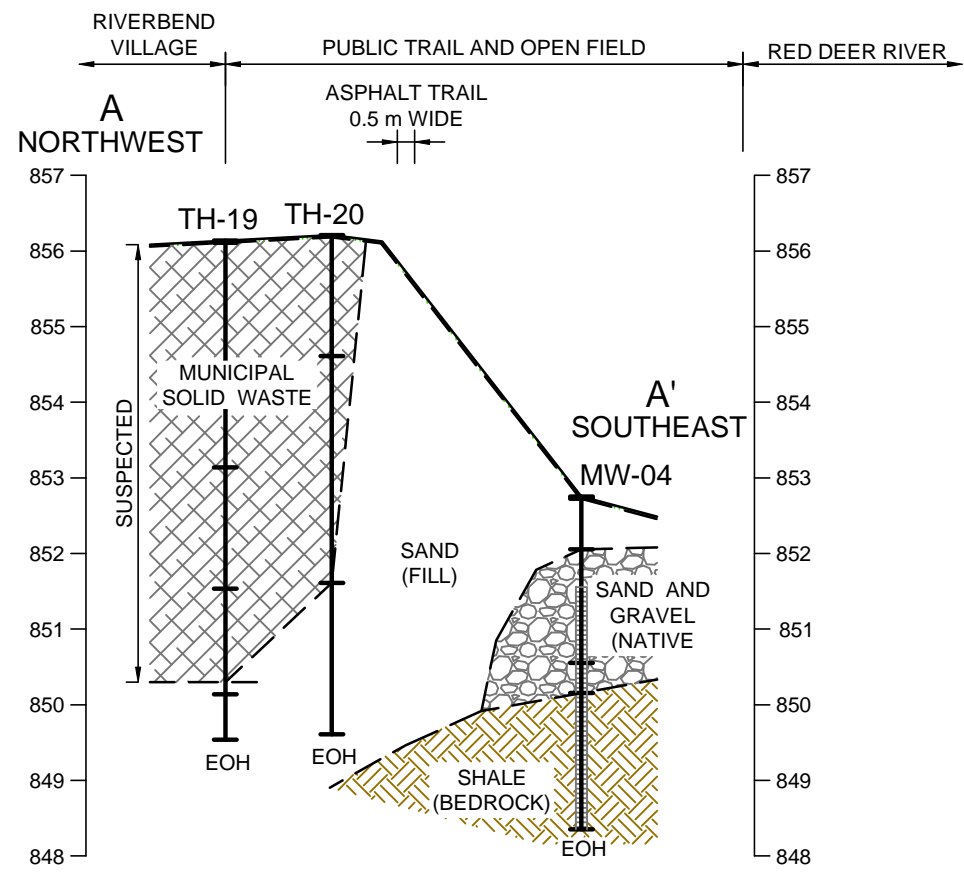
PHASE II TEST LOCATIONS  
 MW-## GROUNDWATER MONITORING WELL (5)  
 TH-## TESTHOLE (16)  
 VW-## SOIL VAPOUR MONITORING WELL (2)  
 REFER TO TABLE 1 FOR TESTHOLE INFORMATION

LEGEND  
 HISTORIC WASTE DISPOSAL LOT BOUNDARY  
 CROSS SECTION LOCATION  
 ELECTRICAL  
 SANITARY  
 STORM  
 WATER

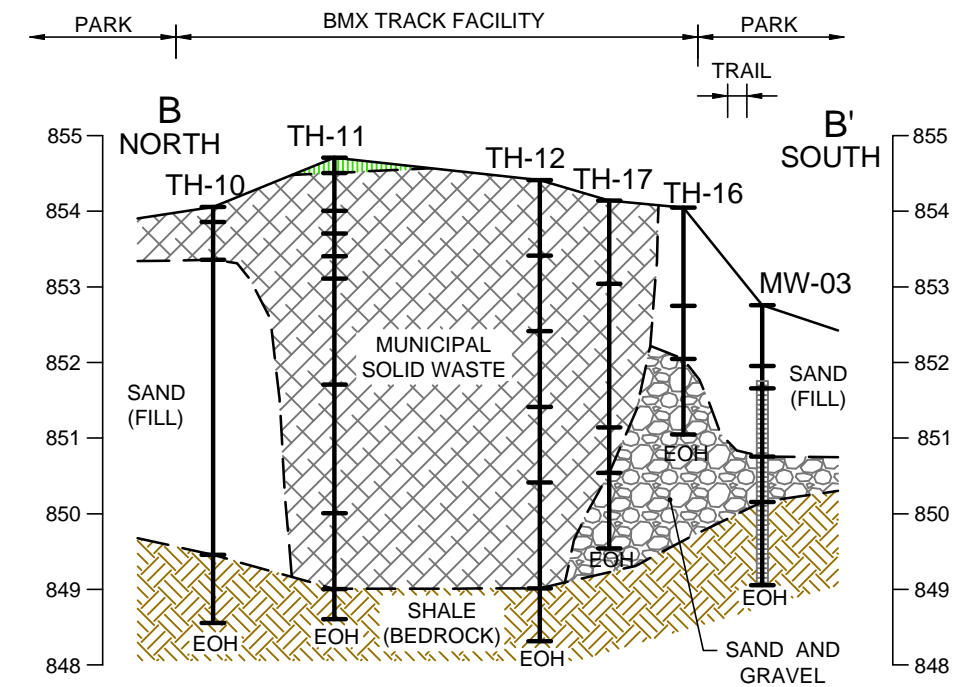
NOTE:  
 LOCATION OF BURIED UTILITIES ARE APPROXIMATE.  
 ACTUAL LOCATIONS OF THE SHALLOW UTILITIES  
 AND ANY OTHER UTILITIES SHOULD BE VERIFIED  
 PRIOR TO ANY GROUND DISTURBANCE ACTIVITY.

CLIENT: THE CITY OF RED DEER  
 PROJECT: PHASE II ESA HISTORIC WASTE DISPOSAL SITES  
 GREAT WEST PTN NW AND NE 17-38-27 W4M  
 TITLE: PHASE II ESA TEST LOCATIONS AND  
 INTERPRETED EXTENT OF WASTE

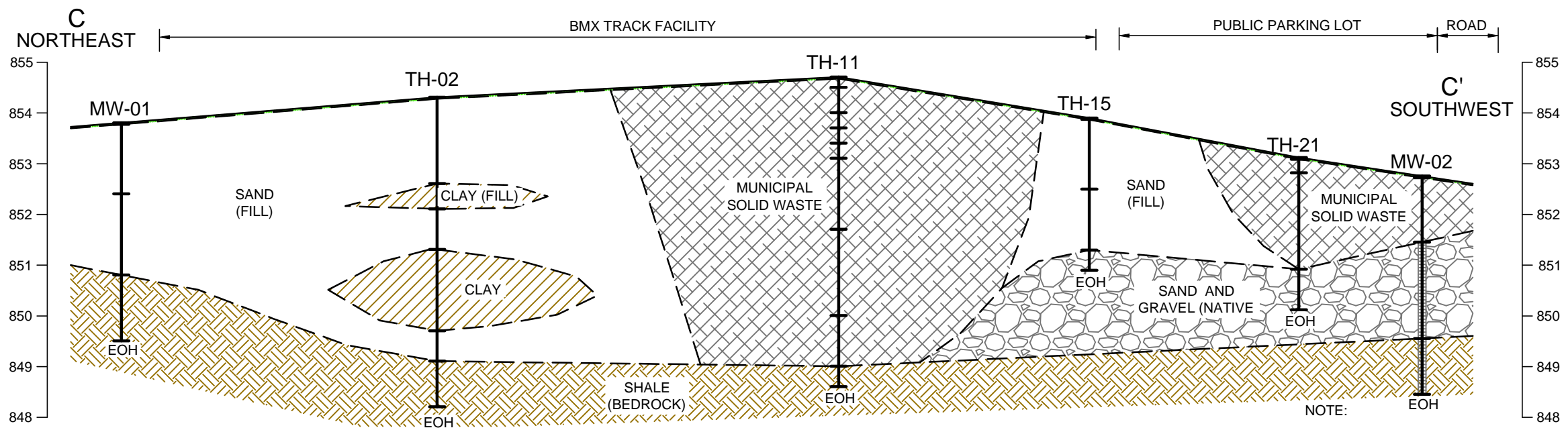
Tiamat Environmental Consultants Ltd.  
 SCALE: 1 : 2000  
 DATE: April 10/14  
 PROJECT NO.: 12-435  
 DRAWN BY: LCH  
 CHECKED BY: LTM  
 CAD FILE NO.: Phase II ESA v1.04.dwg  
 FIGURE NO.: FIGURE 2



TRaverse ADJACENT TO RIVERBEND VILLAGE

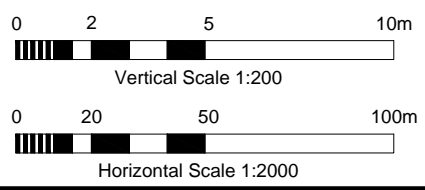


TRaverse OF BMX TRACK FACILITY



LONGITUDINAL OF BMX TRACK FACILITY

NOTE: THE GEOLOGIC AND STRATIGRAPHIC SECTIONS SHOWN ON THIS DRAWING ARE INTERPRETED FROM BOREHOLE LOGS. STRATIGRAPHY IS KNOWN WITH CERTAINTY ONLY AT THE BOREHOLE LOCATIONS. ACTUAL STRATIGRAPHY AND GEOLOGIC CONDITIONS BETWEEN BOREHOLES MAY VARY FROM THAT INDICATED ON THIS DRAWING.



CLIENT:	THE CITY OF RED DEER						
PROJECT:	ENVIRONMENTAL RISK MANAGEMENT PLAN HISTORIC WASTE DISPOSAL SITE GREAT WEST ADVENTURE PARK SITE						
TITLE:	CROSS SECTIONS A - A', B -B' AND C - C'						
SCALE:	AS SHOWN	DATE:	MAR. 14/14	PROJECT NO.:	12-435	FIGURE NO.:	FIGURE 3
DRAWN BY:	LCH	CHECKED BY:	LTM	CAD FILE NO.:	SECTIONS V1.00		

## APPENDIX D

### LABORATORY ANALYTICAL REPORTS



## CERTIFICATE OF ANALYSIS

**Work Order** : **CG2105962**  
**Client** : **Tetra Tech Canada Inc.**  
**Contact** : Darby Madalena  
**Address** : 115 - 200 Rivercrest Dr SE  
Calgary AB Canada T2C 2X5  
**Telephone** : 403 203 3355  
**Project** : SWM.SWOP04071-02.001  
**PO** : SWM.SWOP04071-02.001  
**C-O-C number** : Great West Adventure  
**Sampler** : Ryan Miller  
**Site** : ----  
**Quote number** : Q71650 City of Red Deer Pre-1972 Landfill Monitoring  
**No. of samples received** : 2  
**No. of samples analysed** : 2

**Page** : 1 of 4  
**Laboratory** : Calgary - Environmental  
**Account Manager** : Milica Papic  
**Address** : 2559 29th Street NE  
Calgary AB Canada T1Y 7B5  
**Telephone** : +1 403 407 1800  
**Date Samples Received** : 24-Nov-2021 09:35  
**Date Analysis Commenced** : 24-Nov-2021  
**Issue Date** : 01-Dec-2021 16:39

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

### Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Laboratory Department</i>
Anthony Calero	Team Leader - Inorganics	Inorganics, Calgary, Alberta
Daniel Ching	Lab Analyst	Metals, Calgary, Alberta
Mackenzie Lamoureux	Lab Assistant	Metals, Calgary, Alberta
Parker Sgarbossa	Laboratory Analyst	Inorganics, Calgary, Alberta
Sara Niroomand		Inorganics, Calgary, Alberta
Sara Niroomand		Metals, Calgary, Alberta
Shirley Li		Metals, Calgary, Alberta
Vladka Stamenova	Analyst	Inorganics, Calgary, Alberta



## General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances  
LOR: Limit of Reporting (detection limit).

<i>Unit</i>	<i>Description</i>
-	No Unit
%	percent
µS/cm	Microsiemens per centimetre
meq/L	milliequivalents per litre
mg/L	milligrams per litre
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

## Qualifiers

<i>Qualifier</i>	<i>Description</i>
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.





## Analytical Results

Sub-Matrix: Water					Client sample ID	MW-02	Duplicate	----	----	----
(Matrix: Water)					Client sampling date / time	23-Nov-2021 14:15	23-Nov-2021	----	----	----
Analyte	CAS Number	Method	LOR	Unit	CG2105962-001	CG2105962-002	-----	-----	-----	
					Result	Result	----	----	----	
<b>Physical Tests</b>										
alkalinity, bicarbonate (as HCO3)	71-52-3	E290	1.0	mg/L	705	716	----	----	----	
alkalinity, carbonate (as CO3)	3812-32-6	E290	1.0	mg/L	<1.0	<1.0	----	----	----	
alkalinity, hydroxide (as OH)	14280-30-9	E290	1.0	mg/L	<1.0	<1.0	----	----	----	
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	578	587	----	----	----	
conductivity	----	E100	1.0	µS/cm	1800	1800	----	----	----	
hardness (as CaCO3), dissolved	----	EC100	0.60	mg/L	647	640	----	----	----	
pH	----	E108	0.10	pH units	7.39	7.14	----	----	----	
solids, total dissolved [TDS], calculated	----	EC103	1.0	mg/L	1090	1090	----	----	----	
<b>Anions and Nutrients</b>										
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.730	1.42	----	----	----	
chloride	16887-00-6	E235.Cl	0.50	mg/L	290	290	----	----	----	
fluoride	16984-48-8	E235.F	0.020	mg/L	0.132	0.138	----	----	----	
nitrate (as N)	14797-55-8	E235.NO3	0.020	mg/L	<0.100 <sup>DLDS</sup>	<0.100 <sup>DLDS</sup>	----	----	----	
nitrite (as N)	14797-65-0	E235.NO2	0.010	mg/L	<0.050 <sup>DLDS</sup>	<0.050 <sup>DLDS</sup>	----	----	----	
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	47.5	47.2	----	----	----	
<b>Ion Balance</b>										
anion sum	----	EC101	0.10	meq/L	20.7	20.9	----	----	----	
cation sum	----	EC101	0.10	meq/L	19.7	19.4	----	----	----	
ion balance (cation-anion difference)	----	EC101	0.010	%	2.48	3.72	----	----	----	
<b>Dissolved Metals</b>										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0050 <sup>DLDS</sup>	<0.0050 <sup>DLDS</sup>	----	----	----	
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00050 <sup>DLDS</sup>	<0.00050 <sup>DLDS</sup>	----	----	----	
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00880	0.00828	----	----	----	
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.458	0.448	----	----	----	
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000100 <sup>DLDS</sup>	<0.000100 <sup>DLDS</sup>	----	----	----	
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000250 <sup>DLDS</sup>	<0.000250 <sup>DLDS</sup>	----	----	----	
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.069	0.069	----	----	----	
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.000150	0.000203	----	----	----	
calcium, dissolved	7440-70-2	E421	0.050	mg/L	177	176	----	----	----	
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00250 <sup>DLDS</sup>	<0.00250 <sup>DLDS</sup>	----	----	----	



## Analytical Results

Sub-Matrix: Water (Matrix: Water)					Client sample ID	MW-02	Duplicate	---	---	---
Client sampling date / time					23-Nov-2021 14:15	23-Nov-2021	---	---	---	
Analyte	CAS Number	Method	LOR	Unit	CG2105962-001	CG2105962-002	-----	-----	-----	
					Result	Result	---	---	---	
<b>Dissolved Metals</b>										
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00178	0.00177	---	---	---	
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00100 <sup>DLDS</sup>	<0.00100 <sup>DLDS</sup>	---	---	---	
iron, dissolved	7439-89-6	E421	0.010	mg/L	12.1	11.8	---	---	---	
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000250 <sup>DLDS</sup>	<0.000250 <sup>DLDS</sup>	---	---	---	
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0280	0.0288	---	---	---	
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	49.9	48.7	---	---	---	
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	1.44	1.39	---	---	---	
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	---	---	---	
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00157	0.00161	---	---	---	
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00425	0.00397	---	---	---	
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.250 <sup>DLDS</sup>	<0.250 <sup>DLDS</sup>	---	---	---	
potassium, dissolved	7440-09-7	E421	0.100	mg/L	5.00	4.98	---	---	---	
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000250 <sup>DLDS</sup>	<0.000250 <sup>DLDS</sup>	---	---	---	
silicon, dissolved	7440-21-3	E421	0.050	mg/L	7.67	7.44	---	---	---	
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000050 <sup>DLDS</sup>	<0.000050 <sup>DLDS</sup>	---	---	---	
sodium, dissolved	17341-25-2	E421	0.050	mg/L	140	136	---	---	---	
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.26	1.26	---	---	---	
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	16.0	14.6	---	---	---	
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000050 <sup>DLDS</sup>	<0.000050 <sup>DLDS</sup>	---	---	---	
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00050 <sup>DLDS</sup>	<0.00050 <sup>DLDS</sup>	---	---	---	
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00150 <sup>DLDS</sup>	<0.00150 <sup>DLDS</sup>	---	---	---	
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00164	0.00163	---	---	---	
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00250 <sup>DLDS</sup>	<0.00250 <sup>DLDS</sup>	---	---	---	
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0069	0.0084	---	---	---	
zirconium, dissolved	7440-67-7	E421	0.00020	mg/L	<0.00100 <sup>DLDS</sup>	<0.00100 <sup>DLDS</sup>	---	---	---	
dissolved mercury filtration location	---	EP509	-	-	Field	Field	---	---	---	
dissolved metals filtration location	---	EP421	-	-	Field	Field	---	---	---	

Please refer to the General Comments section for an explanation of any qualifiers detected.

## QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: <b>CG2105962</b>	Page	: 1 of 8
Client	: <b>Tetra Tech Canada Inc.</b>	Laboratory	: Calgary - Environmental
Contact	: Darby Madalena	Account Manager	: Milica Pasic
Address	: 115 - 200 Rivercrest Dr SE Calgary AB Canada T2C 2X5	Address	: 2559 29th Street NE Calgary, Alberta Canada T1Y 7B5
Telephone	: 403 203 3355	Telephone	: +1 403 407 1800
Project	: SWM.SWOP04071-02.001	Date Samples Received	: 24-Nov-2021 09:35
PO	: SWM.SWOP04071-02.001	Issue Date	: 01-Dec-2021 16:39
C-O-C number	: Great West Adventure		
Sampler	: Ryan Miller		
Site	: ----		
Quote number	: Q71650 City of Red Deer Pre-1972 Landfill Monitoring		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

### Key

- Anonymous:** Refers to samples which are not part of this work order, but which formed part of the QC process lot.  
**CAS Number:** Chemical Abstracts Services number is a unique identifier assigned to discrete substances.  
**DQO:** Data Quality Objective.  
**LOR:** Limit of Reporting (detection limit).  
**RPD:** Relative Percent Difference.

## Summary of Outliers

### **Outliers : Quality Control Samples**

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

### **Outliers: Reference Material (RM) Samples**

- No Reference Material (RM) Sample outliers occur.

### **Outliers : Analysis Holding Time Compliance (Breaches)**

- Analysis Holding Time Outliers exist - please see following pages for full details.

### **Outliers : Frequency of Quality Control Samples**

- No Quality Control Sample Frequency Outliers occur.



## Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water** Evaluation: \* = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times		Eval	Analysis Date	Holding Times		Eval
				Rec	Actual			Rec	Actual	
<b>Anions and Nutrients : Ammonia by Fluorescence</b>										
<b>Amber glass total (sulfuric acid)</b> Duplicate	E298	23-Nov-2021	29-Nov-2021	----	----		29-Nov-2021	28 days	6 days	✓
<b>Anions and Nutrients : Ammonia by Fluorescence</b>										
<b>Amber glass total (sulfuric acid)</b> MW-02	E298	23-Nov-2021	29-Nov-2021	----	----		29-Nov-2021	28 days	6 days	✓
<b>Anions and Nutrients : Chloride in Water by IC</b>										
<b>HDPE</b> Duplicate	E235.Cl	23-Nov-2021	----	----	----		25-Nov-2021	28 days	2 days	✓
<b>Anions and Nutrients : Chloride in Water by IC</b>										
<b>HDPE</b> MW-02	E235.Cl	23-Nov-2021	----	----	----		25-Nov-2021	28 days	2 days	✓
<b>Anions and Nutrients : Fluoride in Water by IC</b>										
<b>HDPE</b> Duplicate	E235.F	23-Nov-2021	----	----	----		25-Nov-2021	28 days	2 days	✓
<b>Anions and Nutrients : Fluoride in Water by IC</b>										
<b>HDPE</b> MW-02	E235.F	23-Nov-2021	----	----	----		25-Nov-2021	28 days	2 days	✓
<b>Anions and Nutrients : Nitrate in Water by IC</b>										
<b>HDPE</b> Duplicate	E235.NO3	23-Nov-2021	----	----	----		25-Nov-2021	3 days	2 days	✓



Matrix: **Water** Evaluation: ✖ = Holding time exceedance ; ✔ = Within Holding Time

Analyte Group Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis				
			Preparation Date	Holding Times		Eval	Analysis Date	Holding Times		Eval	
				Rec	Actual			Rec	Actual		
<b>Anions and Nutrients : Nitrate in Water by IC</b>											
HDPE MW-02	E235.NO3	23-Nov-2021	----	----	----		25-Nov-2021	3 days	2 days	✔	
<b>Anions and Nutrients : Nitrite in Water by IC</b>											
HDPE Duplicate	E235.NO2	23-Nov-2021	----	----	----		25-Nov-2021	3 days	2 days	✔	
<b>Anions and Nutrients : Nitrite in Water by IC</b>											
HDPE MW-02	E235.NO2	23-Nov-2021	----	----	----		25-Nov-2021	3 days	2 days	✔	
<b>Anions and Nutrients : Sulfate in Water by IC</b>											
HDPE Duplicate	E235.SO4	23-Nov-2021	----	----	----		25-Nov-2021	28 days	2 days	✔	
<b>Anions and Nutrients : Sulfate in Water by IC</b>											
HDPE MW-02	E235.SO4	23-Nov-2021	----	----	----		25-Nov-2021	28 days	2 days	✔	
<b>Dissolved Metals : Dissolved Mercury in Water by CVAAS</b>											
Glass vial dissolved (hydrochloric acid) Duplicate	E509	23-Nov-2021	25-Nov-2021	----	----		25-Nov-2021	28 days	2 days	✔	
<b>Dissolved Metals : Dissolved Mercury in Water by CVAAS</b>											
Glass vial dissolved (hydrochloric acid) MW-02	E509	23-Nov-2021	25-Nov-2021	----	----		25-Nov-2021	28 days	2 days	✔	
<b>Dissolved Metals : Dissolved Metals in Water by CRC ICPMS</b>											
HDPE dissolved (nitric acid) Duplicate	E421	23-Nov-2021	30-Nov-2021	----	----		30-Nov-2021	180 days	7 days	✔	
<b>Dissolved Metals : Dissolved Metals in Water by CRC ICPMS</b>											
HDPE dissolved (nitric acid) MW-02	E421	23-Nov-2021	30-Nov-2021	----	----		30-Nov-2021	180 days	7 days	✔	



Matrix: **Water** Evaluation: \* = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times		Eval	Analysis Date	Holding Times		Eval
				Rec	Actual			Rec	Actual	
<b>Physical Tests : Alkalinity Species by Titration</b>										
HDPE Duplicate	E290	23-Nov-2021	----	----	----		26-Nov-2021	14 days	3 days	✓
<b>Physical Tests : Alkalinity Species by Titration</b>										
HDPE MW-02	E290	23-Nov-2021	----	----	----		26-Nov-2021	14 days	3 days	✓
<b>Physical Tests : Conductivity in Water</b>										
HDPE Duplicate	E100	23-Nov-2021	----	----	----		26-Nov-2021	28 days	3 days	✓
<b>Physical Tests : Conductivity in Water</b>										
HDPE MW-02	E100	23-Nov-2021	----	----	----		26-Nov-2021	28 days	3 days	✓
<b>Physical Tests : pH by Meter</b>										
HDPE MW-02	E108	23-Nov-2021	----	----	----		26-Nov-2021	0.25 hrs	68 hrs	* EHTR-FM
<b>Physical Tests : pH by Meter</b>										
HDPE Duplicate	E108	23-Nov-2021	----	----	----		26-Nov-2021	0.25 hrs	70 hrs	* EHTR-FM

**Legend & Qualifier Definitions**

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended  
 Rec. HT: ALS recommended hold time (see units).



## Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✖ = QC frequency outside specification; ✔ = QC frequency within specification.

Quality Control Sample Type	Method	QC Lot #	Count		Frequency (%)		Evaluation
			QC	Regular	Actual	Expected	
<b>Analytical Methods</b>							
<b>Laboratory Duplicates (DUP)</b>							
Alkalinity Species by Titration	E290	353411	1	20	5.0	5.0	✔
Ammonia by Fluorescence	E298	355294	1	20	5.0	5.0	✔
Chloride in Water by IC	E235.Cl	352270	1	13	7.6	5.0	✔
Conductivity in Water	E100	353409	1	20	5.0	5.0	✔
Dissolved Mercury in Water by CVAAS	E509	352552	1	2	50.0	5.0	✔
Dissolved Metals in Water by CRC ICPMS	E421	355649	1	19	5.2	5.0	✔
Fluoride in Water by IC	E235.F	352271	1	13	7.6	5.0	✔
Nitrate in Water by IC	E235.NO3	352273	1	15	6.6	5.0	✔
Nitrite in Water by IC	E235.NO2	352272	1	13	7.6	5.0	✔
pH by Meter	E108	353410	1	20	5.0	5.0	✔
Sulfate in Water by IC	E235.SO4	352274	1	13	7.6	5.0	✔
<b>Laboratory Control Samples (LCS)</b>							
Alkalinity Species by Titration	E290	353411	1	20	5.0	5.0	✔
Ammonia by Fluorescence	E298	355294	1	20	5.0	5.0	✔
Chloride in Water by IC	E235.Cl	352270	1	13	7.6	5.0	✔
Conductivity in Water	E100	353409	1	20	5.0	5.0	✔
Dissolved Mercury in Water by CVAAS	E509	352552	1	2	50.0	5.0	✔
Dissolved Metals in Water by CRC ICPMS	E421	355649	1	19	5.2	5.0	✔
Fluoride in Water by IC	E235.F	352271	1	13	7.6	5.0	✔
Nitrate in Water by IC	E235.NO3	352273	1	15	6.6	5.0	✔
Nitrite in Water by IC	E235.NO2	352272	1	13	7.6	5.0	✔
pH by Meter	E108	353410	1	20	5.0	5.0	✔
Sulfate in Water by IC	E235.SO4	352274	1	13	7.6	5.0	✔
<b>Method Blanks (MB)</b>							
Alkalinity Species by Titration	E290	353411	1	20	5.0	5.0	✔
Ammonia by Fluorescence	E298	355294	1	20	5.0	5.0	✔
Chloride in Water by IC	E235.Cl	352270	1	13	7.6	5.0	✔
Conductivity in Water	E100	353409	1	20	5.0	5.0	✔
Dissolved Mercury in Water by CVAAS	E509	352552	1	2	50.0	5.0	✔
Dissolved Metals in Water by CRC ICPMS	E421	355649	1	19	5.2	5.0	✔
Fluoride in Water by IC	E235.F	352271	1	13	7.6	5.0	✔
Nitrate in Water by IC	E235.NO3	352273	1	15	6.6	5.0	✔
Nitrite in Water by IC	E235.NO2	352272	1	13	7.6	5.0	✔
Sulfate in Water by IC	E235.SO4	352274	1	13	7.6	5.0	✔
<b>Matrix Spikes (MS)</b>							
Ammonia by Fluorescence	E298	355294	1	20	5.0	5.0	✔
Chloride in Water by IC	E235.Cl	352270	1	13	7.6	5.0	✔



Matrix: **Water** Evaluation: \* = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type	Method	QC Lot #	Count		Frequency (%)		
			QC	Regular	Actual	Expected	Evaluation
<i>Analytical Methods</i>							
<b>Matrix Spikes (MS) - Continued</b>							
Dissolved Mercury in Water by CVAAS	E509	352552	1	2	50.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	355649	1	19	5.2	5.0	✓
Fluoride in Water by IC	E235.F	352271	1	13	7.6	5.0	✓
Nitrate in Water by IC	E235.NO3	352273	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	352272	1	13	7.6	5.0	✓
Sulfate in Water by IC	E235.SO4	352274	1	13	7.6	5.0	✓





## Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Calgary - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Calgary - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Chloride in Water by IC	E235.Cl Calgary - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Calgary - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC	E235.NO2 Calgary - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC	E235.NO3 Calgary - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Sulfate in Water by IC	E235.SO4 Calgary - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Alkalinity Species by Titration	E290 Calgary - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Calgary - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Dissolved Metals in Water by CRC ICPMS	E421 Calgary - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS.  Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Mercury in Water by CVAAS	E509 Calgary - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Dissolved Hardness (Calculated)	EC100 Calgary - Environmental	Water	APHA 2340B	"Hardness (as CaCO <sub>3</sub> ), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO <sub>3</sub> equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.



<i>Analytical Methods</i>	<i>Method / Lab</i>	<i>Matrix</i>	<i>Method Reference</i>	<i>Method Descriptions</i>
Ion Balance using Dissolved Metals	EC101 Calgary - Environmental	Water	APHA 1030E	Cation Sum, Anion Sum, and Ion Balance are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Dissolved species are used where available. Minor ions are included where data is present. Ion Balance cannot be calculated accurately for waters with very low electrical conductivity (EC).
TDS in Water (Calculation)	EC103 Calgary - Environmental	Water	APHA 1030E (mod)	Total Dissolved Solids is calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Dissolved species are used where available. Minor ions are included where data is present.
<i>Preparation Methods</i>	<i>Method / Lab</i>	<i>Matrix</i>	<i>Method Reference</i>	<i>Method Descriptions</i>
Preparation for Ammonia	EP298 Calgary - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Dissolved Metals Water Filtration	EP421 Calgary - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO <sub>3</sub> .
Dissolved Mercury Water Filtration	EP509 Calgary - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.



## QUALITY CONTROL REPORT

Work Order : **CG2105962**

Page : 1 of 10

Client : Tetra Tech Canada Inc.  
 Contact : Darby Madalena  
 Address : 115 - 200 Rivercrest Dr SE  
 Calgary AB Canada T2C 2X5  
 Telephone : 403 203 3355  
 Project : SWM.SWOP04071-02.001  
 PO : SWM.SWOP04071-02.001  
 C-O-C number : Great West Adventure  
 Sampler : Ryan Miller  
 Site : ----  
 Quote number : Q71650 City of Red Deer Pre-1972 Landfill Monitoring  
 No. of samples received : 2  
 No. of samples analysed : 2

Laboratory : Calgary - Environmental  
 Account Manager : Milica Papic  
 Address : 2559 29th Street NE  
 Calgary, Alberta Canada T1Y 7B5  
 Telephone : +1 403 407 1800  
 Date Samples Received : 24-Nov-2021 09:35  
 Date Analysis Commenced : 24-Nov-2021  
 Issue Date : 01-Dec-2021 16:40

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

### Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	Position	Laboratory Department
Anthony Calero	Team Leader - Inorganics	Inorganics, Calgary, Alberta
Daniel Ching	Lab Analyst	Metals, Calgary, Alberta
Mackenzie Lamoureux	Lab Assistant	Metals, Calgary, Alberta
Parker Sgarbossa	Laboratory Analyst	Inorganics, Calgary, Alberta
Sara Niroomand		Inorganics, Calgary, Alberta
Sara Niroomand		Metals, Calgary, Alberta
Shirley Li		Metals, Calgary, Alberta
Vladka Stamenova	Analyst	Inorganics, Calgary, Alberta

Page : 2 of 10  
Work Order : CG2105962  
Client : Tetra Tech Canada Inc.  
Project : SWM.SWOP04071-02.001

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## General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.

CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.

DQO = Data Quality Objective.

LOR = Limit of Reporting (detection limit).

RPD = Relative Percentage Difference

# = Indicates a QC result that did not meet the ALS DQO.



### Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: <b>Water</b>					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
<b>Physical Tests (QC Lot: 353409)</b>											
CG2105960-004	Anonymous	conductivity	----	E100	2.0	µS/cm	452	447	1.11%	10%	----
<b>Physical Tests (QC Lot: 353410)</b>											
CG2105960-004	Anonymous	pH	----	E108	0.10	pH units	7.77	7.78	0.129%	4%	----
<b>Physical Tests (QC Lot: 353411)</b>											
CG2105960-004	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	248	246	0.648%	20%	----
<b>Anions and Nutrients (QC Lot: 352270)</b>											
CG2105961-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	127	124	2.09%	20%	----
<b>Anions and Nutrients (QC Lot: 352271)</b>											
CG2105961-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
<b>Anions and Nutrients (QC Lot: 352272)</b>											
CG2105961-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
<b>Anions and Nutrients (QC Lot: 352273)</b>											
CG2105961-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3	0.100	mg/L	18.6	18.3	2.02%	20%	----
<b>Anions and Nutrients (QC Lot: 352274)</b>											
CG2105961-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	126	123	2.35%	20%	----
<b>Anions and Nutrients (QC Lot: 355294)</b>											
CG2105961-004	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0250	mg/L	1.73	1.72	0.682%	20%	----
<b>Dissolved Metals (QC Lot: 352552)</b>											
CG2105962-001	MW-02	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
<b>Dissolved Metals (QC Lot: 355649)</b>											
CG2106049-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00050	mg/L	0.00086	0.00085	0.000006	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00050	mg/L	0.0273	0.0264	3.02%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.100	mg/L	<0.100 µg/L	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0250	mg/L	0.827 µg/L	0.000802	3.01%	20%	----
		calcium, dissolved	7440-70-2	E421	0.250	mg/L	303	301	0.629%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.50	mg/L	<0.50 µg/L	<0.00050	0	Diff <2x LOR	----



Sub-Matrix: **Water**

Laboratory Duplicate (DUP) Report

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
<b>Dissolved Metals (QC Lot: 355649) - continued</b>											
CG2106049-001	Anonymous	copper, dissolved	7440-50-8	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0050	mg/L	0.0185	0.0181	0.0004	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0250	mg/L	208	205	1.29%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00050	mg/L	0.00580	0.00590	1.78%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000250	mg/L	0.00216	0.00203	0.000129	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00250	mg/L	0.0294	0.0289	1.55%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.250	mg/L	2.88	2.85	1.11%	20%	----
		selenium, dissolved	7782-49-2	E421	0.250	mg/L	252 µg/L	0.253	0.383%	20%	----
		silicon, dissolved	7440-21-3	E421	0.250	mg/L	3.12	3.11	0.372%	20%	----
		silver, dissolved	7440-22-4	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.250	mg/L	1.91	1.87	0.035	Diff <2x LOR	----
		strontium, dissolved	7440-24-6	E421	0.00100	mg/L	0.170	0.170	0.0726%	20%	----
		sulfur, dissolved	7704-34-9	E421	2.50	mg/L	390	398	1.91%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00150	mg/L	<0.00150	<0.00150	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000050	mg/L	0.0139	0.0138	0.645%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0050	mg/L	0.0493	0.0487	0.0006	Diff <2x LOR	----
		zirconium, dissolved	7440-67-7	E421	0.00150	mg/L	<0.00150	<0.00150	0	Diff <2x LOR	----



## Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

### Sub-Matrix: Water

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
<b>Physical Tests (QCLot: 353409)</b>						
conductivity	----	E100	1	µS/cm	<1.0	----
<b>Physical Tests (QCLot: 353411)</b>						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
<b>Anions and Nutrients (QCLot: 352270)</b>						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
<b>Anions and Nutrients (QCLot: 352271)</b>						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
<b>Anions and Nutrients (QCLot: 352272)</b>						
nitrite (as N)	14797-65-0	E235.NO2	0.01	mg/L	<0.010	----
<b>Anions and Nutrients (QCLot: 352273)</b>						
nitrate (as N)	14797-55-8	E235.NO3	0.02	mg/L	<0.020	----
<b>Anions and Nutrients (QCLot: 352274)</b>						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
<b>Anions and Nutrients (QCLot: 355294)</b>						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
<b>Dissolved Metals (QCLot: 352552)</b>						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
<b>Dissolved Metals (QCLot: 355649)</b>						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----



Sub-Matrix: Water

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
<b>Dissolved Metals (QCLot: 355649) - continued</b>						
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	<0.50	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
zirconium, dissolved	7440-67-7	E421	0.0002	mg/L	<0.00020	----





## Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
Analyte	CAS Number	Method	LOR	Unit	Spike	Recovery (%)	Recovery Limits (%)		Qualifier
					Concentration	LCS	Low	High	
<b>Physical Tests (QCLot: 353409)</b>									
conductivity	---	E100	1	µS/cm	146.9 µS/cm	97.7	90.0	110	---
<b>Physical Tests (QCLot: 353410)</b>									
pH	---	E108	---	pH units	7 pH units	100	98.6	101	---
<b>Physical Tests (QCLot: 353411)</b>									
alkalinity, total (as CaCO3)	---	E290	1	mg/L	500 mg/L	112	85.0	115	---
<b>Anions and Nutrients (QCLot: 352270)</b>									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	---
<b>Anions and Nutrients (QCLot: 352271)</b>									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	100	90.0	110	---
<b>Anions and Nutrients (QCLot: 352272)</b>									
nitrite (as N)	14797-65-0	E235.NO2	0.01	mg/L	0.5 mg/L	101	90.0	110	---
<b>Anions and Nutrients (QCLot: 352273)</b>									
nitrate (as N)	14797-55-8	E235.NO3	0.02	mg/L	2.5 mg/L	102	90.0	110	---
<b>Anions and Nutrients (QCLot: 352274)</b>									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	---
<b>Anions and Nutrients (QCLot: 355294)</b>									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	92.3	85.0	115	---
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	88.0	80.0	120	---
<b>Dissolved Metals (QCLot: 355649)</b>									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	96.4	80.0	120	---
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	110	80.0	120	---
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	94.6	80.0	120	---
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.5	80.0	120	---
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	94.0	80.0	120	---
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	100	80.0	120	---
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.1	80.0	120	---
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.9	80.0	120	---
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	97.2	80.0	120	---
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.4	80.0	120	---
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	98.3	80.0	120	---
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	98.0	80.0	120	---
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	97.0	80.0	120	---



Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		Qualifier
					Concentration	LCS	Low	High	
<b>Dissolved Metals (QCLot: 355649) - continued</b>									
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	99.0	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	94.5	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	95.5	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	99.2	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	96.0	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	97.9	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	98.4	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	97.7	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	99.0	60.0	140	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.5	80.0	120	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	50 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	100	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	97.6	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	97.4	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	98.7	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	94.2	80.0	120	----
zirconium, dissolved	7440-67-7	E421	0.0002	mg/L	0.1 mg/L	103	80.0	120	----



### Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		Qualifier
					Concentration	Target	MS	Low	High	
<b>Anions and Nutrients (QCLot: 352270)</b>										
CG2105966-006	Anonymous	chloride	16887-00-6	E235.Cl	106 mg/L	100 mg/L	106	75.0	125	----
<b>Anions and Nutrients (QCLot: 352271)</b>										
CG2105966-006	Anonymous	fluoride	16984-48-8	E235.F	1.04 mg/L	1 mg/L	104	75.0	125	----
<b>Anions and Nutrients (QCLot: 352272)</b>										
CG2105966-006	Anonymous	nitrite (as N)	14797-65-0	E235.NO2	0.530 mg/L	0.5 mg/L	106	75.0	125	----
<b>Anions and Nutrients (QCLot: 352273)</b>										
CG2105966-006	Anonymous	nitrate (as N)	14797-55-8	E235.NO3	2.64 mg/L	2.5 mg/L	106	75.0	125	----
<b>Anions and Nutrients (QCLot: 352274)</b>										
CG2105966-006	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	107 mg/L	100 mg/L	107	75.0	125	----
<b>Anions and Nutrients (QCLot: 355294)</b>										
CG2105961-005	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	----
<b>Dissolved Metals (QCLot: 352552)</b>										
CG2105962-002	Duplicate	mercury, dissolved	7439-97-6	E509	0.0000818 mg/L	0.0001 mg/L	81.8	70.0	130	----
<b>Dissolved Metals (QCLot: 355649)</b>										
CG2106049-002	Anonymous	aluminum, dissolved	7429-90-5	E421	1.81 mg/L	2 mg/L	90.5	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.213 mg/L	0.2 mg/L	106	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.179 mg/L	0.2 mg/L	89.3	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.178 mg/L	0.2 mg/L	89.1	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.345 mg/L	0.4 mg/L	86.2	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0918 mg/L	0.1 mg/L	91.8	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.931 mg/L	1 mg/L	93.1	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.0385 mg/L	0.04 mg/L	96.4	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	40 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.369 mg/L	0.4 mg/L	92.2	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.180 mg/L	0.2 mg/L	89.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.181 mg/L	0.2 mg/L	90.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	18.5 mg/L	20 mg/L	92.7	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.188 mg/L	0.2 mg/L	94.0	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.863 mg/L	1 mg/L	86.3	70.0	130	----



Sub-Matrix: **Water**

					<i>Matrix Spike (MS) Report</i>					
					<i>Spike</i>		<i>Recovery (%)</i>	<i>Recovery Limits (%)</i>		
<i>Laboratory sample ID</i>	<i>Client sample ID</i>	<i>Analyte</i>	<i>CAS Number</i>	<i>Method</i>	<i>Concentration</i>	<i>Target</i>	<i>MS</i>	<i>Low</i>	<i>High</i>	<i>Qualifier</i>
<b>Dissolved Metals (QCLot: 355649) - continued</b>										
CG2106049-002	Anonymous	magnesium, dissolved	7439-95-4	E421	ND mg/L	10 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.186 mg/L	0.2 mg/L	93.1	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.193 mg/L	0.2 mg/L	96.4	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.360 mg/L	0.4 mg/L	90.1	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	91.5 mg/L	100 mg/L	91.5	70.0	130	----
		potassium, dissolved	7440-09-7	E421	35.5 mg/L	40 mg/L	88.8	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.373 mg/L	0.4 mg/L	93.4	70.0	130	----
		silicon, dissolved	7440-21-3	E421	87.1 mg/L	100 mg/L	87.1	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.0394 mg/L	0.04 mg/L	98.4	70.0	130	----
		sodium, dissolved	17341-25-2	E421	18.0 mg/L	20 mg/L	90.1	70.0	130	----
		strontium, dissolved	7440-24-6	E421	0.189 mg/L	0.2 mg/L	94.7	70.0	130	----
		sulfur, dissolved	7704-34-9	E421	ND mg/L	200 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.0382 mg/L	0.04 mg/L	95.6	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.190 mg/L	0.2 mg/L	94.9	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.369 mg/L	0.4 mg/L	92.3	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.0380 mg/L	0.04 mg/L	94.9	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.913 mg/L	1 mg/L	91.3	70.0	130	----
		zinc, dissolved	7440-66-6	E421	3.64 mg/L	4 mg/L	91.0	70.0	130	----
		zirconium, dissolved	7440-67-7	E421	0.377 mg/L	0.4 mg/L	94.3	70.0	130	----



Report to:			Report Format / Distribution			Service Requested:								
Company: Tetra Tech Canada Inc.			<input type="checkbox"/> Standard <input type="checkbox"/> Other			<input checked="" type="checkbox"/> Regular Service (Default)								
Contact: Darby Madalena			<input checked="" type="checkbox"/> PDF <input checked="" type="checkbox"/> Excel <input type="checkbox"/> Fax			<input type="checkbox"/> Rush Service (2-3 Days)								
Address: 110, 140 Quarry Park Blvd SE, Calgary, AB T2C 3G3			Email 1: darby.madalena@tetrattech.com			<input type="checkbox"/> Priority Service (1 Day or ASAP)								
Phone: 403-723-6867 Fax: 403-203-3301			Email 2:			<input type="checkbox"/> Emergency Service (<1 Day / Wkend) - Contact ALS								
ALS Digital Crosstab results			Analysis Request											
Invoice To: <input checked="" type="checkbox"/> Same as Report			Indicate Bottles: Filtered / Preserved (F/P) →											
Company: SAME AS REPORT			Client / Project Information:			ROU-MET_D-ABT NH3-F Hazardous? Highly Contaminated? Number of Containers								
Contact:			Job #: SWOP04071-02.001											
Address:			PO/AFE: SWOP04071-02.001											
Sample:			Legal Site Description:											
Phone: Fax:			Quote #: Q71650											
Lab Work Order # (lab use only)			ALS Milica Paptic Contact:		Sampler (Initials): Ryan Miller									
Sample #	Sample Identification (This description will appear on the report)		Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)									
MW-02			23-11-21	1415	Water		X	X						
Duplicate			J	-	Water		X	X						
Guidelines / Regulations			Special Instructions / Hazardous Details											
			Dissolved Metals & Hg Field Filtered & Preserved											
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.														
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.														

Relinquished By: Ryan Miller	Date & Time: NOV 24/21	Received By: [Signature]	Date & Time: 24/11/21
Relinquished By: [Signature]	Date & Time: 9:30	Received By: [Signature]	Date & Time: [Blank]

Environmental Division  
Calgary  
Work Order Reference  
**CG2105962**



## APPENDIX E

### HISTORICAL ANALYTICAL RESULTS

**Table 1**  
**Soil Vapour and Groundwater Monitoring Well Elevations**

Test Location	Well Depth (m)	Elevations				Screen Length (m)
		Ground (m)	Top of Pipe (m)	Screen Interval		
				Bottom	Top	
MW-01	4.3	853.806	854.668	849.506	852.506	3.0
MW-02	4.3	852.765	852.682	848.465	851.465	3.0
MW-03	3.7	852.750	853.740	849.050	851.750	2.7
MW-04	4.4	852.755	853.482	848.355	851.355	3.0
MW-05	5.5	854.307	855.132	848.807	851.807	3.0
VW-01	2.7	853.847	854.605	851.147	851.447	0.3
VW-02	2.4	854.338	855.419	851.938	852.238	0.3
TH-01	853.676	--	--	--	--	--
TH-02	854.308	--	--	--	--	--
TH-08	854.207	--	--	--	--	--
TH-09	854.244	--	--	--	--	--
TH-10	854.056	--	--	--	--	--
TH-11	854.706	--	--	--	--	--
TH-12	854.413	--	--	--	--	--
TH-14	853.661	--	--	--	--	--
TH-15	853.898	--	--	--	--	--
TH-16	854.048	--	--	--	--	--
TH-17	854.140	--	--	--	--	--
TH-18	853.369	--	--	--	--	--
TH-19	856.137	--	--	--	--	--
TH-20	856.201	--	--	--	--	--
TH-21	853.119	--	--	--	--	--
TH-23	853.749	--	--	--	--	--

Notes:

- 1) Geodetic elevations are referenced to multiple ASCMs located within The City of Red Deer.
- 2) Datum is ASCM #17988 and #294421.
- 3) MW - Monitoring Well.
- 4) VW - Soil Vapour Well.
- 5) TH - Testhole no well instrumentation.
- 6) NA - Not Applicable.

**Table 2**  
**Site Monitoring Results**

Test Location	Elevations		Groundwater Elevation		Headspace Vapour			
	Ground (m)	Top of Pipe (m)	(m)		09/08/13		Combustible	Volatile
			09/08/13		Combustible	Volatile		
MW-01	853.806	854.668	851.819		155	ND		
MW-02	852.765	852.682	850.762		590	ND		
MW-03	852.750	853.740	851.235		530	ND		
MW-04	852.755	853.482	850.142		135	ND		
MW-05	854.307	855.132	850.965		10	ND		
VW-01	853.847	854.605	--		95	ND		
VW-02	854.338	855.419	--		45	ND		

## Notes:

- 1) Measurement of combustible and volatile vapours by RKI Eagle 2. Combustible vapour sensor calibrated to hexane and photoionization detector calibrated to isobutylene.
- 2) ND - Not Detected, less than the limit of instrument detection.
- 3) -- No value established.



**Table 3A**  
**Analytical Results - Soil - Drill Cuttings (Soil Bag)**

Parameter	Detection Limit	Soil Bag	Class II Landfill Acceptance Criteria
		1 of 1	
pH	0.10	8.47	2-12.5
Flash Point (°C)	30.0	>75	>61
Paint Filter Test	-	PASS	PASS
Total Organic Carbon	0.10	0.69	--
<b><u>TCLP Hydrocarbons</u></b>			
Benzene	0.0050	ND	0.5
Toluene	0.0050	ND	0.5
Ethylbenzene	0.0050	ND	0.5
Xylenes	0.0050	ND	0.5
<b><u>TCLP Metals</u></b>			
Antimony (Sb)	5.0	ND	500
Arsenic (As)	0.20	ND	5
Barium (Ba)	5.0	ND	100
Beryllium (Be)	0.50	ND	5
Boron (B)	5.0	ND	500
Cadmium (Cd)	0.050	ND	1
Chromium (Cr)	0.50	ND	5
Cobalt (Co)	5.0	ND	100
Copper (Cu)	5.0	ND	100
Iron (Fe)	5.0	ND	1,000
Lead (Pb)	0.50	ND	5
Mercury (Hg)	0.010	ND	0.2
Nickel (Ni)	0.50	ND	5
Selenium (Se)	0.20	ND	1
Silver (Ag)	0.50	ND	5
Thallium (Tl)	0.50	ND	5
Uranium (U)	1.0	ND	2
Vanadium (V)	5.0	ND	100
Zinc (Zn)	5.0	ND	500
Zirconium (Zr)	5.0	ND	500

## Notes:

- 1) Applicable Waste Screens process for The City of Red Deer Class II waste management facility.
- 2) Class II Landfill Acceptance Criteria - per Table 2, Part 4 Schedule to the Alberta User Guide for Waste Managers 3/95.
- 3) All units are mg/L unless otherwise stated.
- 4) ND - Not Detected
- 5) Soil Bags were sampled on June 26, 2013.
- 6) For further laboratory information, refer to the specific laboratory report in Appendix A.

**Table 3B**  
**Analytical Results - Soil - General Indices & Heavy Metals**

Parameters	Units	Detection Limit	TH-17	TH-20	TH-21	Tier 1 Guideline
			@ 3.5 m	@ 3.9 - 4.6 m	@ 2.0 m	
			09/07/13	07/15/2013	07/18/2013	
Chloride (Cl)	mg/kg	6.7 - 10	115	10.6	101	--
Nitrate-N	mg/kg	0.33 - 0.51	ND	ND	ND	--
Nitrite-N	mg/kg	0.33 - 0.51	ND	ND	ND	--
<b>Metals</b>						
Antimony (Sb)	mg/kg	0.20	3.16	0.33	0.39	20
Arsenic (As)	mg/kg	0.20	7.04	4.63	5.92	17
Barium (Ba)	mg/kg	5.0	292	200	262	500
Beryllium (Be)	mg/kg	1.0	ND	ND	ND	5
Cadmium (Cd)	mg/kg	0.50	ND	ND	ND	10
Chromium (Cr)	mg/kg	0.50	16.4	9.55	14.0	64
Cobalt (Co)	mg/kg	1.0	6.3	4.3	6.0	20
Copper (Cu)	mg/kg	2.0	15.2	8.0	14.6	63
Lead (Pb)	mg/kg	5.0	<b>398</b>	6.4	8.1	140
Mercury (Hg)	mg/kg	0.050	ND	ND	ND	6.6
Molybdenum (Mo)	mg/kg	1.0	1.2	ND	ND	4
Nickel (Ni)	mg/kg	2.0	19.3	13.5	19.4	50
Selenium (Se)	mg/kg	0.50	ND	ND	ND	1.0
Silver (Ag)	mg/kg	1.0	ND	ND	ND	20
Thallium (Tl)	mg/kg	0.50	ND	ND	ND	1.0
Tin (Sn)	mg/kg	2.0	ND	ND	ND	5
Uranium (U)	mg/kg	2.0	ND	ND	ND	23
Vanadium (V)	mg/kg	1.0	23.5	17.2	24.2	130
Zinc (Zn)	mg/kg	10	80	78	56	200
Hexavalent Chromium	mg/kg	0.10	ND	ND	ND	0.4
Boron (B), Hot Water Ext.	--	0.10	1.37	1.24	0.34	2

## Notes:

- 1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for residential/parkland land use.
- 2) ND - Not Detected, less than the limit of method detection.
- 3) -- No value established in the reference criteria.
- 4) Bold & Shaded - Exceeds the referenced Alberta Tier 1 and CCME guidelines.
- 5) For further laboratory information, refer to the specific laboratory report in Appendix A.

**Table 3C**  
**Analytical Results - Soil - VOCs**

Parameters	Units	Detection Limit	TH-17	TH-20	TH-21	Tier 1 Guideline
			@ 3.5 m 09/07/13	@ 3.9 - 4.6 m 07/15/2013	@ 2.0 m 07/18/2013	
<b>Hydrocarbons</b>						
F1 (C <sub>6</sub> -C <sub>10</sub> )	mg/kg	10	ND	ND	ND	24
F2 (C <sub>10</sub> -C <sub>16</sub> )	mg/kg	25	ND	ND	ND	130
F3 (C <sub>16</sub> -C <sub>34</sub> )	mg/kg	50	ND	ND	ND	300
F4 (C <sub>34</sub> -C <sub>50</sub> )	mg/kg	50	ND	ND	ND	2,800
Total Hydrocarbons (C <sub>6</sub> -C <sub>50</sub> )	mg/kg	50	ND	ND	ND	--
<b>Volatile Organic Compounds</b>						
Benzene	mg/kg	0.010	ND	ND	ND	0.073
Bromobenzene	mg/kg	0.010	ND	ND	ND	--
Bromochloromethane	mg/kg	0.010	ND	ND	ND	--
Bromodichloromethane	mg/kg	0.010	ND	ND	ND	--
Bromoform	mg/kg	0.010	ND	ND	ND	--
Bromomethane	mg/kg	0.10	ND	ND	ND	--
n-Butylbenzene	mg/kg	0.010 - 0.070	ND	ND	ND	--
sec-Butylbenzene	mg/kg	0.010	ND	ND	ND	--
tert-Butylbenzene	mg/kg	0.010	ND	ND	ND	--
Carbon tetrachloride	mg/kg	0.010	ND	ND	ND	0.00056
Chlorobenzene	mg/kg	0.010	ND	ND	ND	0.018
Dibromochloromethane	mg/kg	0.010	ND	ND	ND	0.27
Chloroethane	mg/kg	0.10	ND	ND	ND	--
Chloroform	mg/kg	0.010	ND	ND	ND	0.001
Chloromethane	mg/kg	0.10	ND	ND	ND	--
2-Chlorotoluene	mg/kg	0.010	ND	ND	ND	--
4-Chlorotoluene	mg/kg	0.010	ND	ND	ND	--
1,2-Dibromo-3-chloropropane	mg/kg	0.010	ND	ND	ND	--
1,2-Dibromoethane	mg/kg	0.010	ND	ND	ND	--
Dibromomethane	mg/kg	0.010	ND	ND	ND	--
1,2-Dichlorobenzene	mg/kg	0.010	ND	ND	ND	0.18
1,3-Dichlorobenzene	mg/kg	0.010	ND	ND	ND	--
1,4-Dichlorobenzene	mg/kg	0.010	ND	ND	ND	0.098
Dichlorodifluoromethane	mg/kg	0.010	ND	ND	ND	--
1,1-Dichloroethane	mg/kg	0.010	ND	ND	ND	--
1,2-Dichloroethane	mg/kg	0.010	ND	ND	ND	0.0027
1,1-Dichloroethene	mg/kg	0.010	ND	ND	ND	0.021
cis-1,2-Dichloroethene	mg/kg	0.010	ND	ND	ND	--
trans-1,2-Dichloroethene	mg/kg	0.010	ND	ND	ND	--
Methylene chloride	mg/kg	0.010	ND	0.013	ND	0.095
1,2-Dichloropropane	mg/kg	0.010	ND	ND	ND	--
1,3-Dichloropropane	mg/kg	0.010	ND	ND	ND	--
2,2-Dichloropropane	mg/kg	0.010	ND	ND	ND	--
1,1-Dichloropropene	mg/kg	0.010	ND	ND	ND	--
cis-1,3-Dichloropropene	mg/kg	0.010	ND	ND	ND	--
trans-1,3-Dichloropropene	mg/kg	0.010	ND	ND	ND	--
Ethylbenzene	mg/kg	0.010	ND	ND	ND	0.21
Hexachlorobutadiene	mg/kg	0.010	ND	ND	ND	0.0067
Isopropylbenzene	mg/kg	0.010	ND	ND	ND	--
p-Isopropyltoluene	mg/kg	0.010	ND	0.019	ND	--
n-Propylbenzene	mg/kg	0.010	ND	ND	ND	--
Styrene	mg/kg	0.010	ND	ND	ND	0.8
1,1,1,2-Tetrachloroethane	mg/kg	0.010	ND	ND	ND	--
1,1,2,2-Tetrachloroethane	mg/kg	0.050	ND	ND	ND	--
Tetrachloroethene	mg/kg	0.010	ND	ND	ND	0.16
Toluene	mg/kg	0.010	0.021	ND	ND	0.49
1,2,3-Trichlorobenzene	mg/kg	0.010	ND	ND	ND	0.26
1,2,4-Trichlorobenzene	mg/kg	0.010 - 0.020	ND	ND	ND	0.23
1,1,1-Trichloroethane	mg/kg	0.010	ND	ND	ND	--
1,1,2-Trichloroethane	mg/kg	0.010	ND	ND	ND	--
Trichloroethene	mg/kg	0.010	ND	ND	ND	0.012
Trichlorofluoromethane	mg/kg	0.010	ND	ND	ND	--
1,2,3-Trichloropropane	mg/kg	0.020	ND	ND	ND	--
1,2,4-Trimethylbenzene	mg/kg	0.010	ND	0.083	ND	--
1,3,5-Trimethylbenzene	mg/kg	0.010	ND	0.027	ND	--
Vinyl chloride	mg/kg	0.20	ND	ND	ND	0.00034
Xylenes	mg/kg	0.1	ND	ND	ND	12

Notes:

- 1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for residential/parkland land use.
- 2) ND - Not Detected, less than the limit of method detection.
- 3) -- No value established in the reference criteria.
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- 5) For further laboratory information, refer to the specific laboratory report in Appendix A.

**Table 4A**  
**Groundwater Indices at Time of Sampling**

<b>Monitoring Well</b>	<b>pH</b>	<b>Electrical Conductivity (µg/cm)</b>	<b>Temperature (°C)</b>	<b>Dissolved Oxygen (mg/L)</b>	<b>Total Dissolved Solid (mg/L)</b>	<b>Redox (±mV)</b>
MW-01	6.84	894	11.4	2.29	786.50	-17.3
MW-02	6.94	672	11.8	1.57	585.00	-65.2
MW-03	6.85	1,206	9.6	0.87	1,111.50	-46.6
MW-04	6.90	1,028	9.2	1.80	955.50	+57.2
MW-05	7.13	1,047	6.8	0.62	1,040.00	-52.2

Notes:

- 1) Samples collected on August 9, 2013
- 2) Groundwater indices measured by YSI Pro Plus multi-meter.

**Table 4B**  
**Analytical Results - Groundwater - General Water Quality**

Parameter	Unit	Detection Limit	MW-01	MW-02	MW-03	MW-04	MW-05	Tier 1 Guideline
			08/09/2013					
<b>General Water Quality</b>								
Biochemical Oxygen Demand	mg/L	2.0	3.4	ND	ND	2.9	ND	--
Chemical Oxygen Demand	mg/L	5.0	260	70	26	190	58	--
Conductivity	µS/cm	1.0	1,200	910	1,800	1,500	1,600	--
pH	Unitless	0.1	7.72	7.84	7.66	7.81	7.85	6.5 - 8.5
Total Organic Carbon (C)	mg/L	0.50	9.4	7.5	4.5	8.4	4.1	--
Dissolved Cadmium (Cd)	µg/L	0.005	NT	NT	0.057	0.058	0.029	--
Total Cadmium (Cd)	µg/L	0.0050	<b>1.1</b>	<b>0.39</b>	<b>0.055</b>	<b>1.5</b>	<b>0.19</b>	0.060*
Alkalinity (CaCO <sub>3</sub> )	mg/L	0.50	460	370	580	500	460	--
Bicarbonate (HCO <sub>3</sub> )	mg/L	0.50	560	450	710	600	560	--
Carbonate (CO <sub>3</sub> )	mg/L	0.50	ND	ND	ND	ND	ND	--
Hydroxide (OH)	mg/L	0.50	ND	ND	ND	ND	ND	--
Sulphates (SO <sub>4</sub> )	mg/L	1.0	140	54	89	130	60	--
Chlorides (Cl)	mg/L	2.0	40	37	190	130	210	--
Total Ammonia (NH <sub>3</sub> -N)	mg/L	0.050	0.26	0.23	0.19	0.11	0.060	1.37*
Total Phosphorus (P)	mg/L	0.030	2.6	0.26	ND	2.2	0.21	--
Total Nitrogen (N)	mg/L	0.050	17	1.6	0.51	18	0.49	--
Total Kjeldahl Nitrogen (TKN)	mg/L	0.50	17	1.6	0.38	17	0.47	--
Nitrite (NO <sub>2</sub> )	mg/L	0.0030	0.0050	ND	0.0070	0.0060	ND	--
Nitrate (NO <sub>3</sub> )	mg/L	0.0030	0.033	ND	0.12	0.58	0.017	--
Nitrate plus Nitrite (N)	mg/L	0.0030	0.038	ND	0.13	0.59	0.017	--
<b>Trace Organics</b>								
Acetic Acid	mg/L	50	NT	NT	ND	ND	ND	--
Formic Acid	mg/L	50	NT	NT	ND	ND	ND	--
Propionic Acid	mg/L	50	NT	NT	ND	ND	ND	--
Adsorbable Organic Halogen	mg/L	0.004	NT	NT	0.090	0.087	0.427	--

Notes:

- 1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for residential land use.
- 2) \* Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) on aquatic life pathway. Canadian Council of Ministers of the Environment (CCME) guidelines are referenced.
- 3) ND - Not Detected, less than the limit of method detection.
- 4) NT - Not Tested.
- 5) -- No value established in the reference criteria.
- 6) Bold & Shaded - Exceeds the referenced Alberta Tier 1 and CCME guidelines.
- 7) For further laboratory information, refer to the specific laboratory report in Appendix A.

**Table 4C**  
**Analytical Results - Groundwater - Metals**

Parameter	Unit	Detection Limit	MW-01	MW-02	MW-03	MW-04	MW-05	Tier 1 Guideline
			08/09/2013					
<b>Total Metals</b>								
Aluminum (Al)	mg/L	0.0030	<b>6.4</b>	<b>5.0</b>	0.037	<b>24</b>	<b>3.4</b>	0.1*
Antimony (Sb)	mg/L	0.00060	0.0011	0.00072	ND	0.0011	0.00064	0.006
Arsenic (As)	mg/L	0.00020	<b>0.014</b>	<b>0.011</b>	<b>0.0067</b>	<b>0.039</b>	0.0047	0.005
Barium (Ba)	mg/L	0.010	0.43	0.39	0.25	<b>1.2</b>	0.26	1
Beryllium (Be)	mg/L	0.0010	ND	ND	ND	0.0024	ND	--
Boron (B)	mg/L	0.020	0.079	0.052	0.20	0.27	0.056	1.5
Calcium (Ca)	mg/L	0.30	260	120	220	440	190	--
Chromium (Cr)	mg/L	0.0010	<b>0.020</b>	<b>0.0082</b>	ND	<b>0.097</b>	<b>0.010</b>	0.001*
Cobalt (Co)	mg/L	0.00030	0.017	0.0053	0.0019	0.028	0.0045	--
Copper (Cu)	mg/L	0.00020	<b>0.038</b>	<b>0.012</b>	0.0011	<b>0.074</b>	<b>0.0098</b>	0.003*
Iron (Fe)	mg/L	0.060	<b>23</b>	<b>12</b>	<b>7.5</b>	<b>83</b>	<b>8.2</b>	0.3
Lead (Pb)	mg/L	0.00020	<b>0.024</b>	<b>0.011</b>	ND	<b>0.044</b>	<b>0.0043</b>	0.004*
Lithium (Li)	mg/L	0.020	0.021	0.021	0.024	0.069	0.031	--
Magnesium (Mg)	mg/L	0.20	46	32	44	110	47	--
Manganese (Mn)	mg/L	0.0040	<b>3.2</b>	<b>1.6</b>	<b>0.66</b>	<b>2.9</b>	<b>0.48</b>	0.05
Molybdenum (Mo)	mg/L	0.00020	0.0045	0.0038	0.0012	0.0071	0.0030	--
Nickel (Ni)	mg/L	0.00050	0.040	0.013	0.0057	0.084	0.013	0.11*
Phosphorus (P)	mg/L	0.10	0.93	0.32	ND	2.6	0.29	--
Potassium (K)	mg/L	0.30	4.8	4.3	4.3	10	5.9	--
Selenium (Se)	mg/L	0.00020	<b>0.0013</b>	0.00062	ND	<b>0.0053</b>	0.00080	0.001
Silicon (Si)	mg/L	0.10	19	18	7.0	58	13	--
Silver (Ag)	mg/L	0.00010	<b>0.00028</b>	ND	ND	<b>0.00071</b>	<b>0.00012</b>	0.0001*
Sodium (Na)	mg/L	0.50	55	54	110	69	110	--
Strontium (Sr)	mg/L	0.020	0.61	0.81	0.94	1.2	0.85	--
Sulphur (S)	mg/L	0.20	39	18	29	42	20	--
Thallium (Tl)	mg/L	0.00020	ND	ND	ND	0.00036	ND	--
Tin (Sn)	mg/L	0.0010	ND	0.0011	ND	0.0021	ND	--
Titanium (Ti)	mg/L	0.0010	0.076	0.10	0.0020	0.21	0.10	--
Uranium (U)	mg/L	0.00010	0.0045	0.0020	0.0030	0.0077	0.0043	0.02
Vanadium (V)	mg/L	0.0010	0.023	0.011	0.0011	0.083	0.011	--
Zinc (Zn)	mg/L	0.0030	<b>0.11</b>	<b>0.062</b>	0.0072	<b>0.25</b>	<b>0.039</b>	0.03
<b>Dissolved Metals</b>								
Aluminum (Al)	mg/L	0.0030	NT	NT	ND	0.0035	ND	--
Antimony (Sb)	mg/L	0.00060	NT	NT	ND	ND	ND	--
Arsenic (As)	mg/L	0.00020	NT	NT	0.0060	0.00022	0.00055	--
Barium (Ba)	mg/L	0.010	NT	NT	0.25	0.13	0.15	--
Beryllium (Be)	mg/L	0.0010	NT	NT	ND	ND	ND	--
Boron (B)	mg/L	0.020	NT	NT	0.18	0.23	0.041	--
Calcium (Ca)	mg/L	0.30	NT	NT	220	200	170	--
Chromium (Cr)	mg/L	0.0010	NT	NT	ND	ND	ND	--
Cobalt (Co)	mg/L	0.00030	NT	NT	0.0015	0.00062	0.0015	--
Copper (Cu)	mg/L	0.00020	NT	NT	0.0018	0.0023	0.0012	--
Iron (Fe)	mg/L	0.060	NT	NT	7.3	ND	0.32	--
Lead (Pb)	mg/L	0.00020	NT	NT	ND	ND	ND	--
Lithium (Li)	mg/L	0.020	NT	NT	0.023	0.027	0.026	--
Magnesium (Mg)	mg/L	0.20	NT	NT	41	44	43	--
Manganese (Mn)	mg/L	0.0040	NT	NT	0.59	0.11	0.31	--
Molybdenum (Mo)	mg/L	0.00020	NT	NT	0.0013	0.00099	0.0023	--
Nickel (Ni)	mg/L	0.00050	NT	NT	0.0049	0.0043	0.0031	--
Phosphorus (P)	mg/L	0.10	NT	NT	ND	ND	ND	--
Potassium (K)	mg/L	0.30	NT	NT	4.2	5.4	5.2	--
Selenium (Se)	mg/L	0.00020	NT	NT	ND	0.0025	0.00031	--
Silicon (Si)	mg/L	0.10	NT	NT	6.2	4.9	4.9	--
Silver (Ag)	mg/L	0.00010	NT	NT	ND	ND	ND	--
Sodium (Na)	mg/L	0.50	NT	NT	100	68	110	--
Strontium (Sr)	mg/L	0.020	NT	NT	0.91	0.91	0.81	--
Sulphur (S)	mg/L	0.20	NT	NT	26	40	19	--
Thallium (Tl)	mg/L	0.00020	NT	NT	ND	ND	ND	--
Tin (Sn)	mg/L	0.0010	NT	NT	ND	ND	ND	--
Titanium (Ti)	mg/L	0.0010	NT	NT	ND	ND	ND	--
Uranium (U)	mg/L	0.00010	NT	NT	0.0027	0.0042	0.0036	--
Vanadium (V)	mg/L	0.0010	NT	NT	ND	ND	ND	--
Zinc (Zn)	mg/L	0.0030	NT	NT	0.0099	0.0041	0.0060	--

Notes:

- 1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for residential land use.
- 2) \* Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) on aquatic life pathway. Canadian Council of Ministers of the Environment (CCME) guidelines are referenced.
- 3) ND - Not Detected, less than the limit of method detection.
- 4) NT - Not Tested.
- 5) - - No value established in the reference criteria.
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- 7) For further laboratory information, refer to specific laboratory report in Appendix A.

**Table 4D**  
**Analytical Results - Groundwater - VOCs**

Parameter	Detection Limit	MW-01	MW-02	MW-03	MW-04	MW-05	Tier 1 Guideline
		08/09/2013					
<b>Volatiles</b>							
Benzene	0.00040	ND	ND	ND	ND	ND	0.005
Toluene	0.00040	ND	ND	ND	ND	ND	0.024
Ethylbenzene	0.00040	ND	ND	ND	ND	ND	0.0024
Xylenes (Total)	0.00080	ND	ND	ND	ND	ND	0.3
F1 (C <sub>6</sub> -C <sub>10</sub> )	0.10	ND	ND	ND	ND	ND	0.81
F2 (C <sub>10</sub> -C <sub>16</sub> )	0.10	ND	ND	ND	ND	ND	1.1
Total Trihalomethanes	0.0020	ND	ND	ND	ND	ND	0.1
Bromodichloromethane	0.00050	ND	ND	ND	ND	ND	--
Bromoform	0.00050	ND	ND	ND	ND	ND	--
Bromomethane	0.0020	ND	ND	ND	ND	ND	--
Carbon tetrachloride	0.00050	ND	ND	ND	ND	ND	0.00056
Chlorobenzene	0.00050	ND	ND	ND	ND	ND	0.0013
Chlorodibromomethane	0.0010	ND	ND	ND	ND	ND	--
Chloroethane	0.0010	ND	ND	ND	ND	ND	--
Chloroform	0.00050	ND	ND	ND	ND	ND	0.0018
Chloromethane	0.0020	ND	ND	ND	ND	ND	--
1,2-dibromoethane	0.00050	ND	ND	ND	ND	ND	--
1,2-dichlorobenzene	0.00050	ND	ND	ND	ND	ND	0.0007
1,3-dichlorobenzene	0.00050	ND	ND	ND	ND	ND	--
1,4-dichlorobenzene	0.00050	ND	ND	ND	ND	ND	0.001
1,1-dichloroethane	0.00050	ND	ND	ND	ND	ND	--
1,2-dichloroethane	0.00050	ND	ND	ND	ND	ND	0.005
1,1-dichloroethene	0.00050	ND	ND	ND	ND	ND	0.014
cis-1,2-dichloroethene	0.00050	ND	ND	ND	ND	ND	--
trans-1,2-dichloroethene	0.00050	ND	ND	ND	ND	ND	--
Dichloromethane	0.0020	ND	ND	ND	ND	ND	0.05
1,2-dichloropropane	0.00050	ND	ND	ND	ND	ND	--
cis-1,3-dichloropropene	0.00050	ND	ND	ND	ND	ND	--
trans-1,3-dichloropropene	0.00050	ND	ND	ND	ND	ND	--
Methyl methacrylate	0.00050	ND	ND	ND	ND	ND	0.47
Methyl-tert-butylether (MTBE)	0.00050	ND	ND	ND	ND	ND	0.015
Styrene	0.00050	ND	ND	ND	ND	ND	0.072
1,1,1,2-tetrachloroethane	0.0020	ND	ND	ND	ND	ND	--
1,1,2,2-tetrachloroethane	0.0020	ND	ND	ND	ND	ND	--
Tetrachloroethene	0.00050	ND	ND	ND	ND	ND	0.03
1,2,3-trichlorobenzene	0.0010	ND	ND	ND	ND	ND	0.008
1,2,4-trichlorobenzene	0.0010	ND	ND	ND	ND	ND	0.015
1,3,5-trichlorobenzene	0.00050	ND	ND	ND	ND	ND	0.014
1,1,1-trichloroethane	0.00050	ND	ND	ND	ND	ND	--
1,1,2-trichloroethane	0.00050	ND	ND	ND	ND	ND	--
Trichloroethene	0.00050	ND	ND	ND	ND	ND	0.005
Trichlorofluoromethane	0.00050	ND	ND	ND	ND	ND	--
1,2,4-trimethylbenzene	0.00050	ND	ND	ND	ND	ND	--
1,3,5-trimethylbenzene	0.00050	ND	ND	ND	ND	ND	--
Vinyl chloride	0.00050	ND	ND	ND	ND	ND	0.0011

Notes:

- 1) Tier 1 Guideline- Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for residential/parkland land use.
- 2) ND - Not Detected, less than the limit of method detection.
- 3) Unless specified all units are mg/L
- 4) -- No value established in the reference criteria.
- 5) Bold & Shaded - Exceeds the referenced Alberta Tier 1 and CCME guidelines.
- 6) For further laboratory information, refer to the specific laboratory report in Appendix A.

**Table 5A**  
**Summary of Parameters Measured During Sampling of Soil Vapour**

Parameter	Well Diameter	Well Depth	Headspace Volume	Purge Rate	Purge Time	Pressure	
Unit	(mm)	(m)	(cm <sup>3</sup> )	(cm <sup>3</sup> /min)	(min)	Ambient (psi)	Vapour Well (psi)
VW-01	25	3.7	1,816	943.30	6	15.26	15.26
VW-02	25	2.7	1,325	943.30	5.3	15.17	15.19

Notes:

- 1) Measurement of pressure by digital Cole-Parmer absolute pressure gauge.
- 2) Purge time is minimum elapsed time prior to the collection of a soil vapour sample.
- 3) Screen set at base of well.
- 4) Soil vapour sampling was completed Friday, August 9, 2013.



**Table 5B**  
**Analytical Results - Soil Vapour - General Indices**

Parameter	Unit	Detection Limit	VW-01	VW-02
			08/09/2013	
<b><u>Gauge Pressure</u></b>				
Pressure after sampling	psi	--	-5.0	-5.0
Pressure on receipt	psig	--	-2.9	-3.6
<b><u>Fixed Gases</u></b>				
Oxygen	% v/v	0.2	13.4	19.9
Nitrogen	% v/v	0.2	84.6	78.5
Carbon Monoxide	% v/v	0.2	ND	ND
Methane	% v/v	0.2	ND	ND
Carbon Dioxide	% v/v	0.2	2.1	1.7

## Notes:

- 1) Results are from sampling performed on Friday, August 09, 2013.
- 2) ND - Not Detected, less than the limit of method detection.
- 3) -- No value established in the detection limit.
- 4) For further information, the reader should refer to the laboratory report in Appendix A.

**Table 5C**  
**Analytical Results - Soil Vapour - VOCs**

Parameter	Unit	Detection Limit	VW-01	VW-02
			08/09/2013	
<b>Hydrocarbon Fractions</b>				
Aliphatic >C <sub>5</sub> -C <sub>6</sub>	µg/m <sup>3</sup>	5.0	6.1	5.8
Aliphatic >C <sub>6</sub> -C <sub>8</sub>	µg/m <sup>3</sup>	5.0	18.9	20.1
Aliphatic >C <sub>9</sub> -C <sub>10</sub>	µg/m <sup>3</sup>	5.0	34.2	57.8
Aliphatic >C <sub>10</sub> -C <sub>12</sub>	µg/m <sup>3</sup>	5.0	62.9	122
Aliphatic >C <sub>12</sub> -C <sub>16</sub>	µg/m <sup>3</sup>	5.0	10.1	28.0
Aromatic >C <sub>7</sub> -C <sub>8</sub> (TEX Excluded)	µg/m <sup>3</sup>	5.0	ND	ND
Aromatic >C <sub>8</sub> -C <sub>10</sub>	µg/m <sup>3</sup>	5.0	13.6	31.7
Aromatic >C <sub>10</sub> -C <sub>12</sub>	µg/m <sup>3</sup>	5.0	17.0	36.0
Aromatic >C <sub>12</sub> -C <sub>16</sub>	µg/m <sup>3</sup>	5.0	ND	ND
<b>Select Volatile Gases</b>				
Acetylene	ppm	0.21 - 0.22	ND	ND
Ethane	ppm	0.21 - 0.22	ND	0.33
Ethylene	ppm	0.21 - 0.22	ND	ND
Methane	ppm	4.2 - 4.5	32	8.8
n-Butane	ppm	0.42 - 0.45	ND	ND
n-Pentane	ppm	0.21 - 0.22	ND	ND
Propane	ppm	0.21 - 0.22	ND	ND
Propene	ppm	0.21 - 0.22	ND	ND
Propyne	ppm	0.42 - 0.45	ND	ND
<b>Volatile Organic Compounds</b>				
Dichlorodifluoromethane (FREON 12)	ppbv	0.2	0.86	0.73
1,2-Dichlorotetrafluoroethane	ppbv	0.2	ND	ND
Chloromethane	ppbv	0.3	0.56	0.52
Vinyl Chloride	ppbv	0.2	ND	ND
Chloroethane	ppbv	0.3	ND	ND
1,3-Butadiene	ppbv	0.5	ND	ND
Trichlorofluoromethane (FREON 11)	ppbv	0.2	0.32	0.38
Ethanol (ethyl alcohol)	ppbv	4.6 - 9.2	177	331
Trichlorotrifluoroethane	ppbv	0.2	ND	ND
2-propanol	ppbv	3.0	ND	ND
2-Propanone	ppbv	0.8	11.6	15.9
Methyl Ethyl Ketone (2-Butanone)	ppbv	3.0	ND	ND
Methyl Isobutyl Ketone	ppbv	3.2	ND	ND
Methyl Butyl Ketone (2-Hexanone)	ppbv	2.0	ND	ND
Methyl t-butyl ether (MTBE)	ppbv	0.2	ND	0.33
Ethyl Acetate	ppbv	2.2	ND	ND
1,1-Dichloroethylene	ppbv	0.3	ND	ND
cis-1,2-Dichloroethylene	ppbv	0.2	ND	ND
trans-1,2-Dichloroethylene	ppbv	0.2	ND	ND
Methylene Chloride(Dichloromethane)	ppbv	0.8	ND	ND
Chloroform	ppbv	0.3	0.87	0.42
<b>Carbon Tetrachloride</b>	<b>ppbv</b>	<b>0.3</b>	<b>ND</b>	<b>ND</b>
1,1-Dichloroethane	ppbv	0.2	ND	ND
1,2-Dichloroethane	ppbv	0.2	ND	ND
Ethylene Dibromide	ppbv	0.2	ND	ND
1,1,1-Trichloroethane	ppbv	0.3	ND	ND
1,1,2-Trichloroethane	ppbv	0.2	ND	ND
1,1,2,2-Tetrachloroethane	ppbv	0.2	ND	ND
cis-1,3-Dichloropropene	ppbv	0.2	ND	ND
trans-1,3-Dichloropropene	ppbv	0.2	ND	ND
1,2-Dichloropropane	ppbv	0.4	ND	ND
Bromomethane	ppbv	0.2	ND	ND
Bromoform	ppbv	0.2	ND	ND
Bromodichloromethane	ppbv	0.2	ND	ND
Dibromochloromethane	ppbv	0.2	ND	ND
Trichloroethylene	ppbv	3.0	ND	ND
Tetrachloroethylene	ppbv	0.2	3.65	3.17
Benzene	ppbv	0.2	0.71	0.59
Toluene	ppbv	0.2	3.08	3.34
Ethylbenzene	ppbv	0.2	0.44	0.73
p+m-Xylene	ppbv	0.4	1.73	3.28
o-Xylene	ppbv	0.2	0.74	1.33
Styrene	ppbv	0.2	ND	ND
4-ethyltoluene	ppbv	2.2	ND	ND
1,3,5-Trimethylbenzene	ppbv	0.5	ND	0.60
1,2,4-Trimethylbenzene	ppbv	0.5	0.52	0.88
Chlorobenzene	ppbv	0.2	ND	ND
Benzyl chloride	ppbv	1.0	ND	ND
1,3-Dichlorobenzene	ppbv	0.4	ND	ND
1,4-Dichlorobenzene	ppbv	0.4	ND	ND
1,2-Dichlorobenzene	ppbv	0.4	ND	ND
1,2,4-Trichlorobenzene	ppbv	2.0	ND	ND
Hexachlorobutadiene	ppbv	3.0	ND	ND
Hexane	ppbv	0.3	0.72	0.57
Heptane	ppbv	0.3	ND	0.43
Cyclohexane	ppbv	0.2	0.89	ND
Tetrahydrofuran	ppbv	0.4	3.51	6.04
1,4-Dioxane	ppbv	2.0	ND	ND
Xylene (Total)	ppbv	0.6	2.47	4.61
Vinyl Bromide	ppbv	0.2	ND	ND
Propene	ppbv	0.3	ND	ND
2,2,4-Trimethylpentane	ppbv	0.2	0.21	ND
Carbon Disulfide	ppbv	0.5	2.81	1.65
Vinyl Acetate	ppbv	0.2	ND	ND

Notes:

- 1) Results are from sampling performed on Friday, August 09, 2013.
- 2) ND - Not Detected, less than the limit of method detection.
- 3) For further information, the reader should refer to the laboratory report in Appendix A.

**Table 5D**  
**Analytics Results - Soil Vapour - Siloxanes**

Parameter	Detection Limit		VW-01		VW-02	
	mg/m <sup>3</sup>	ppm	08/09/2013			
			mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>	ppm
Trimethylsilyl Fluoride	--		ND	ND	ND	ND
Tetramethylsilane	0.0001	0.0002	ND	ND	ND	ND
Methoxytrimethylsilane	0.0033 - 0.0043	0.0008 - 0.0010	ND	ND	ND	ND
Ethoxytrimethylsilane	0.0032 - 0.0042	0.0007 - 0.0009	ND	ND	ND	ND
Trimethylsilanol	--	--	0.0284	0.0077	0.0077	0.0021
Isopropoxytrimethylsilane	0.0013 - 0.0018	0.0002 - 0.0003	ND	ND	ND	ND
Trimethoxymethyl Silane #	--	--	ND	ND	ND	ND
Hexamethyl Disiloxane - L2	0.0001 - 0.0002	0.0001	ND	ND	ND	ND
Propoxytrimethylsilane	0.0036 - 0.0048	0.0007 - 0.0009	ND	ND	ND	ND
1-Methylbutoxytrimethylsilane *	--	--	ND	ND	ND	ND
Butoxytrimethylsilane *	--	--	ND	ND	ND	ND
Trimethoxyvinyl Silane #	--	--	ND	ND	ND	ND
Hexamethyl Cyclotrisiloxane - D3	--	--	0.0172	0.0019	0.0119	0.0013
Octamethyl Trisiloxane - L3	0.0002 - 0.0003	0.0001	ND	ND	ND	ND
Triethoxyvinyl Silane #	--	--	ND	ND	ND	ND
Triethoxyethyl Silane #	--	--	ND	ND	ND	ND
Octamethyl Cyclotetrasiloxane - D4	--	--	0.0118	0.0010	0.0098	0.0008
Decamethyl Tetrasiloxane - L4	0.0003 - 0.0004	0.0001	ND	ND	ND	ND
Tetraethylsilicate #	--	--	ND	ND	ND	ND
Decamethyl Cyclopentasiloxane - D5	--	--	0.0201	0.0013	0.0644	0.0042
Dodecamethyl Pentasiloxane - L5	0.0031 - 0.0040	0.0002 - 0.0003	ND	ND	ND	ND
Dodecamethyl Cyclohexasiloxane - D6	--	--	0.0422	0.0023	0.0718	0.0040
Sum	--	--	0.1349	0.0169	0.1856	0.0159

Notes:

- 1) Soil vapour samples collected on Friday, August 09, 2013.
- 2) ND - Not Detected, less than the limit of method detection.
- 3) -- No value established in the detection limit.
- 4) V=200 mL, where V is volume of air/gas sampled.
- 5) \* - Semiquantitative (response factor set at 5).
- 6) # - Unstable, poor detectability, commercial standards tested.
- 7) For further information, the reader should refer to the laboratory report in Appendix A.

## APPENDIX F

### BOREHOLE LOGS

<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> MW-01
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> HS Auger
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 853.806 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 07/16/2013

<b>Sample Type:</b> <input checked="" type="checkbox"/> Shelby Tube <input checked="" type="checkbox"/> Split Spoon <input type="checkbox"/> Core <input type="checkbox"/> Disturbed <input type="checkbox"/> No Recovery
<b>Backfill Type:</b> <input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Silica Sand <input type="checkbox"/> Grout <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Bentonite : Sand

**Notes:** Groundwater Monitoring Well is approximately 60 m southwest of TH-02

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Grass (~ 3 cm thick). Loam and sand (fill) - compact, some silt, trace clay, trace fine rounded gravel, trace rootlets, damp, dark olive brown.					
1.0	Sand (fill) - compact, some silt, trace clay, moist, dark olive brown. becomes wet at 1.8 m.					
2.0						
3.0	Sand and gravels (native) - compact, silty, wet, olive brown.					
4.0	End of hole at 4.3 m. 51 mm diameter 3.0 m length 010 PVC screen. Aboveground lockable steel casing set in concrete.					
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						

<b>Tiamat Environmental Consultants Ltd.</b>	Slough :	Completion Depth (m): 4.3
	Depth to Groundwater :	Checked By: LTM
	Logged By: JAL/LTM	Page: 1 of 1

<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> MW-02
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> SS Auger
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 852.765 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 07/08/2013

<b>Sample Type:</b> <input type="checkbox"/> Shelby Tube <input type="checkbox"/> Split Spoon <input type="checkbox"/> Core <input type="checkbox"/> Disturbed <input type="checkbox"/> No Recovery
<b>Backfill Type:</b> <input type="checkbox"/> Bentonite <input type="checkbox"/> Silica Sand <input type="checkbox"/> Grout <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Bentonite : Sand

**Notes:** Groundwater Monitoring Well is located in the central parking lot area, about 70 m northeast of the BMX track

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Grass (~ 3 cm thick). Sand and loam (fill) mixed with MSW - nail, glass fragments, steel, wood debris, loose to compact, some silt, trace fine rounded gravel, moist, dark olive. wet to 0.5 m.					
1.0	Sand and gravel (fill) - loose to compact, silty, trace clay, wet, olive.					
2.0						
3.0	Shale (bedrock) - weak, highly weathered, silty, some clay, wet, grey.					
4.0	End of hole at 4.3 m. 51 mm diameter 3 m length 010 PVC screen. Flush mount bolt-down casing set in concrete.					
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						

<b>Tiamat Environmental Consultants Ltd.</b>	Slough :	Completion Depth (m): 4.3
	Depth to Groundwater :	Checked By: LTM
	Logged By: JAL	Page: 1 of 1

<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> MW-03
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> Direct Push
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 852.750 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 06/08/2013

<b>Sample Type:</b> <input checked="" type="checkbox"/> Shelby Tube <input checked="" type="checkbox"/> Split Spoon <input type="checkbox"/> Core <input type="checkbox"/> Disturbed <input type="checkbox"/> No Recovery
<b>Backfill Type:</b> <input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Silica Sand <input type="checkbox"/> Grout <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Bentonite : Sand

**Notes:** Groundwater Monitoring Well is located south of the walking trail about 130 m northeast of MW-01

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Clay - soft, silty, loamy, trace rootlets, trace sand, moist, olive.					
1.0	Silty clay (fill) - soft to firm, trace sand, trace roots, moist, olive. trace oxides at 1.1 m. Sand (fill) - compact, silty, wet, olive.					
2.0	Gravel (native) - compact, sandy, trace silts, wet, olive.					
3.0	Shale (bedrock) - weak, highly weathered, silty, some clay, damp, grey.					
4.0	End of hole at 3.7 m. 51 mm diameter 2.7 m length 010 PVC screen. Aboveground lockable steel casing set in concrete.					
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						

<b>Tiamat Environmental Consultants Ltd.</b>	Slough :	Completion Depth (m): 3.7
	Depth to Groundwater :	Checked By: LTM
	Logged By: JAL/LTM	Page: 1 of 1

<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> MW-04
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> Direct Push
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 852.755 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 06/08/2013

<b>Sample Type:</b> Shelby Tube  Split Spoon  Core  Disturbed  No Recovery
<b>Backfill Type:</b> Bentonite  Silica Sand  Grout  Pea Gravel  Drill Cuttings  Bentonite : Sand

**Notes:** Groundwater Monitoring Well is located on the north part of the site about 70 m southeast of 56 Avenue and about 20 m north of the Red Deer River

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Grass (~ 3 cm thick). Sand (fill) - compact, loamy, some rootlets, trace gravels, damp, dark olive.					
1.0	Sand and gravel (native) - dense, trace coal, damp, olive. becomes wet at 1.4 m.					
2.0	Gravel (native) - compact, trace sand, trace silt, wet, olive.					
3.0	Shale (bedrock) - weak, highly weathered, silty, some clay, wet, grey.					
4.0	Refusal on shale at 4.4m. End of hole at 4.4 m. 51 mm diameter 3 m length 010 PVC screen. Aboveground lockable steel casing set in concrete.					
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						



<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> MW-05
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> SS Auger
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 854.307 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 07/18/2013

<b>Sample Type:</b> <input type="checkbox"/> Shelby Tube <input type="checkbox"/> Split Spoon <input type="checkbox"/> Core <input type="checkbox"/> Disturbed <input type="checkbox"/> No Recovery
<b>Backfill Type:</b> <input type="checkbox"/> Bentonite <input type="checkbox"/> Silica Sand <input type="checkbox"/> Grout <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Bentonite : Sand

**Notes:** Groundwater Monitoring well is located about 2 m south of VW-02

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Grass (~ 3 cm thick). Loam (fill) - compact, trace rootlets, damp, dark olive.					
	Sand (fill) - compact, loamy, silty, trace rootlets, trace clay, damp, light olive.					
1.0	Sand (native) - compact, some silt, moist, light olive.					
2.0	Sand and gravel (native) - loose, moist, light olive.					
3.0						
4.0						
5.0	Shale (bedrock) - soft, moderately weathered, damp, grey.					
6.0	End of hole at 5.5 m. 51 mm diameter 3 m length 010 PVC screen. Aboveground lockable steel casing set in concrete.					
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						

<b>Tiamat Environmental Consultants Ltd.</b>	Slough :	Completion Depth (m): 5.5
	Depth to Groundwater :	Checked By: LTM
	Logged By: JAL	Page: 1 of 1

<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> VW-01
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> SS Auger
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 853.847 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 06/07/2013

<b>Sample Type:</b> <input checked="" type="checkbox"/> Shelby Tube <input checked="" type="checkbox"/> Split Spoon <input type="checkbox"/> Core <input type="checkbox"/> Disturbed <input type="checkbox"/> No Recovery
<b>Backfill Type:</b> <input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Silica Sand <input type="checkbox"/> Grout <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Bentonite : Sand

**Notes:** Soil Vapour Well is located about 10 m north of the parking lot

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Sand and loam (fill) - compact, trace rootlets, trace fine rounded gravel, moist, dark olive brown.					
1.0	Sand (native) - compact, trace rootlets, moist, light olive brown.					
	Clay - firm, trace rootlets, moist, light olive brown.					
	Sand - compact, trace gravel, trace silt, moist, dark olive brown.					
2.0	Clay - firm, some gravel, moist, dark olive brown.					
3.0	Sand - compact, trace gravel, moist, dark olive brown. becomes wet at 3 m.					
4.0	End of hole at 3.7 m. 25 mm diameter 3 m length 020 PVC screen. Aboveground lockable steel casing set in concrete.					
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						

<b>Tiamat Environmental Consultants Ltd.</b>	Slough :	Completion Depth (m): 3.7
	Depth to Groundwater :	Checked By: LTM
	Logged By: LTM	Page: 1 of 1

<b>PROJECT:</b> Phase II ESA Historic Waste Disposal Sites	<b>BOREHOLE No.:</b> VW-02
<b>PROJECT No.:</b> 12-435	<b>DRILL TYPE:</b> SS Auger
<b>LOCATION:</b> Great West Adventure Park Site	<b>GROUND ELEVATION:</b> 854.338 m
<b>CLIENT:</b> The City of Red Deer	<b>COMPLETION DATE:</b> 06/07/2013

<b>Sample Type:</b> <input checked="" type="checkbox"/> Shelby Tube <input checked="" type="checkbox"/> Split Spoon <input type="checkbox"/> Core <input type="checkbox"/> Disturbed <input type="checkbox"/> No Recovery
<b>Backfill Type:</b> <input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Silica Sand <input type="checkbox"/> Grout <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Bentonite : Sand

**Notes:** Soil Vapour Well is located at approximately 100 m southeast of MW-01

Depth (m)	Soil Description	Sample Type	Sample No.	SPT (N)	Combustible Soil Vapours (ppm)	Well Details
0.0	Loam (fill) - loose, trace rootlets, damp, dark olive brown (~ 15 cm thick). Sand (fill) - compact, silty, trace rootlets, trace loam, silty, light olive.					
1.0						
2.0	Sand and gravel (native) - compact to dense, silty, damp, light olive.					
3.0	End of hole at 2.7 m. 25 mm diameter 0.3 m length 020 PVC screen. Aboveground lockable steel casing set in concrete.					
4.0						
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						

<b>Tiamat Environmental Consultants Ltd.</b>	Slough :	Completion Depth (m): 2.7
	Depth to Groundwater :	Checked By: LTM
	Logged By: LTM	Page: 1 of 1



# Borehole No: VW-03

Project: Vapour Probe Installation

Project No: SWM.SWOP04071-02.008

Location: Great West Adventure Park

Red Deer, Alberta

UTM: 307588 E; 5795367 N; Z 12

Depth (m)	Method	Soil Description	Notes and Comments	VW-03	Depth (ft)
0		CLAY (FILL) - sandy, rootlets, grass, moist, light brown to dark brown	Flush mount	0	0
1	Solid stem auger	CLAY - sandy, some gravel, rounded gravel, dry, dark brown		1	1
2				2	2
3				3	3
4		END OF BOREHOLE (3.5 metres) Vapour Probe installed to 3.5 metres		4	4
5				5	5



Contractor: CP Drilling

Completion Depth: 3.5 m

Equipment Type: Truck mounted

Start Date: 2022 May 3

Logged By: MR

Completion Date: 2022 May 3

Reviewed By: FH

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