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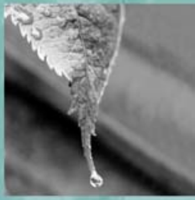

knowledge and research

Uranium Anomalies in Shallow Groundwater Near Bonnyville, Alberta

Alberta Innovates -Technology Futures, Alberta Environment
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March 2010

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***Submitted To*:**

Alberta Environment

and

Beaver River Watershed Alliance

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March 2010

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EXECUTIVE SUMMARY

Elevated dissolved uranium (U) concentrations were measured from groundwater in five water wells within the Cold Lake - Beaver River Basin. Alberta Innovates - Technology Futures (AITF) was contacted to investigate U concentrations in groundwater from water wells within the basin and to develop a better understanding of the source and mechanisms controlling U concentrations in groundwater. Possible sources of U for water wells in the study area include:

- Weathering and oxidation of naturally occurring primary/secondary U minerals in the native sediments.
- Over-pumping of water wells, causing oxidation of naturally occurring U minerals.
- Agricultural application of fertilizers containing trace amounts U.
- Contamination from produced water from energy wells.
- Anthropogenic U from surface spreading of drill cuttings.
- Poorly completed water wells causing mixing between water bearing units.
- Poor groundwater sampling procedures leading to cross-contamination between samples.

Field investigations were conducted at two sites (Site 1 and Site 2) located within the study area during October and November 2009. Data collected from existing private waters wells, new piezometers installed as part of this project, sediment surveys and energy wells in the area were used to develop a conceptual model for the source of U concentrations in groundwater. The new piezometers included a background piezometer (to characterize groundwater geochemistry without any potential impact from existing water wells) and bundle piezometers (allowing depth specific sampling of groundwater).

The sampling conducted in the fall of 2009 showed:

- Elevated concentrations of U in the groundwater at the two sites investigated exceed the Guidelines for Canadian Drinking Water Quality, with the highest concentration of U occurring in the shallowest aquifers.
- U concentrations are increasing in groundwater over time in all previously existing water wells located on Site 1 (Resident A's) property.
- U concentrations in groundwater are decreasing over time in all existing water wells located on Site 2.
- The main source of elevated U concentration in groundwater observed in deeper aquifers is a result of poorly completed wells causing oxidizing conditions due to mixing between the upper and lower aquifers.

Both sites have clear correlations between dissolved U concentrations and redox conditions with groundwater from wells with oxidizing conditions having higher U concentrations, and groundwater with reducing conditions having lower U concentrations. These trends, combined with the low concentrations of U in fields with fertilizer or drill cutting applications, and the lack of U in local produced water is consistent with the source of U being the weathering of overlying clay till deposits. The results of the 2009 field campaign gave new insights into the source of U at the two sites, including:

- There is no indication that produced water for the energy wells adjacent to Sites 1 and 2 are contributing to elevated U concentrations in the groundwater. U concentrations in the produced water are significantly lower than U concentrations measured in most water wells. This is supported by volatile and extractable priority pollutants which are present in the produced water but not detected in the resident wells at Sites 1 and 2.
- The low concentration of U in sediments from the field where fertilizer was applied indicates that fertilizing is not a source of U.
- The low concentration of U in sediments from the field where applied drill cuttings were sprayed indicates that this was not a source of elevated U to the groundwater.
- The presence of dissolved U concentrations from a shallow background monitoring well installed at Site 1 located away from any influences from existing wells suggests a natural source of U in local overlying sediments.
- The primary source of dissolved U in the aquifers is likely due to weathering of the overlying clay/till deposits. U concentrations in both solid phase sediments and in the dissolved phase in groundwater at Site 1 are consistent with this explanation. This suggests that elevated U concentrations in shallow groundwater could be a regional problem.

The results of this study show that redox conditions are the main control on dissolved U concentrations in groundwater in this area. Groundwater from wells with oxidizing conditions (higher DO and Eh) contains higher dissolved U concentration then wells with reducing conditions, regardless of depth. Geochemical modeling has also given some insight into the controls on U mobility. Secondary carbonate and Fe oxyhydroxide mineral phases are at equilibrium with the groundwater and could be controlling the concentration of U in the groundwater. Whole rock analyses of the secondary carbonate and Fe oxyhydroxide mineral phases collected from two wells at Site 1 contain U concentrations suggesting that U is removed from solution through co-precipitation or sorption reactions.

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1 INTRODUCTION

Elevated dissolved uranium (U) concentrations were measured from groundwater in five water wells within the Cold Lake - Beaver River Basin. The Beaver River Watershed Alliance and Alberta Environment were interested in conducting a detailed study to address this issue of elevated U concentrations. Alberta Innovates - Technology Futures (AITF), formally the Alberta Research Council, was contacted to investigate U concentrations in groundwater from water wells within the Cold Lake – Beaver River Basin and to develop a better understanding of the source and mechanisms controlling U concentrations in groundwater.

Objectives of this study included:

- Resampling of existing wells in the area using more rigorous in-field sampling methods than were previously employed in order to properly measure redox conditions which are key controls on U mobility.
- Resampling of existing wells using very stringent field preservation protocols to ensure representative samples were obtained.
- Installation of new wells adjacent to existing wells to better capture changes in water geochemistry with changes in lithology with depth.
- The collection of groundwater and sediment samples from various sources to determine the sources and control of U in groundwater in the area.

2 BACKGROUND

Nearly all rock and soil contains small concentrations of uranium (Appleton, 2007). Uranium is a naturally occurring radioactive element that is widely dispersed in the earth's crust at levels of approximately 2–4 ppm by weight (Stegnar and Benedik, 2001). Lower concentrations of uranium are found in basic rocks, while acidic rocks contain higher uranium concentrations (Storkinger, 1981). In groundwater, uranium is essentially detected everywhere (Graham, 1964; USEPA, 2000.). The Alberta Geological Survey tested sediment samples from Quaternary cores in the Bonneville area and found uranium concentrations ranged from 3-5 ppm by weight (Andriashek, 2000).

Weathering processes such as wind and water erosion, and dissolution and precipitation reactions with uranium in rock and soil redistribute far more uranium in the environment than mining and nuclear fuel industries Gavrilescuet al., 2009. However, those industries may release large quantities of uranium from point-source locations in the form of contaminated groundwater/surface water discharging from tailings impoundments and airborne releases directly from nuclear facilities.

Uranium is recognized by the World Health Organization as a potentially harmful constituent in drinking water and has proposed a drinking water standard of 15 µg L^{-1}. Heath Canada recommends the U limit in drinking water to not exceed 20 µg L^{-1}. In Canada elevated concentrations of U in groundwater, caused by non-anthropogenic influences, have been reported in Manitoba (Betcher et al., 1988), Southern Alberta (Ivanovich et al. 1991) and Saskatchewan (Ranville et al., 2007). Concern over dissolved U is shown by numerous studies that demonstrate the chemical toxicity of U to the kidneys and by the potential for additional radiotoxicity effects in humans (Wrenn, et al., 1987).

Within the natural environment, uranium is mainly found in valance states of (IV) and (VI). Under reducing conditions, U is in the (IV) valence state and present primarily in a stable mineral form such as uraninite [UO_2]. However, abiotic and biological processes in soils transform U through oxidation reactions converting U(IV) (insoluble) to the U(VI) (soluble) uranyl ion, [UO_2^{2+}] through the following reaction:

$$U^{4+} + \frac{1}{2}O_2 + H_2O \rightarrow UO_2^{2+} + 2H^+$$

Uranium is at least 10,000 times more soluble in its oxidized (VI) state and likewise highly soluble in shallow oxidized ground water (Ingebritsen and Sanford 1998). In solution, uranium exist predominantly as UO_2^{2+} and as soluble carbonate complexes $(UO_2)_2CO_3(OH)^{3-}$, $UO_2CO_3^{\circ}$, $UO_2(CO_3)_2^{2-}$, $UO_2(CO_3)_3^{4-}$ and possibly $(UO_2)_3(CO_3)_6^{6-}$ in the presence of carbonate-containing waters (Ciavatta et al., 1981; Duff and Amrhein, 1996). In oxidized environments with a pH between 7 and 8, the aqueous complex $[UO_2(CO_3)_2]^{2-}$ is the predominant form of uranium (Gavrilescuet al., 2009). Numerous investigations of the adsorption of uranium on soils and minerals have shown that carbonate complexing appreciably reduces adsorption of uranium leading to its release from soils (Waite, et al., 1994; Pabalan and Turne, 1997; Pabalan, et al., 1998). An increase of alkalinity or pH enhances desorption of dissolved uranium (Langmuir, 1978). Uranyl hydroxy complexes such as $UO_2(OH)^+$ and $(UO_2)_3(OH)^{5+}$ may also form, but generally in smaller amounts except at high temperature or in carbonate-depleted alkaline water (Gavrilescuet al., 2009).

In addition to dissolved carbonate complexes, uranium can also form stable complexes through sorption and precipitation processes (Hsi and Langmuir, 1985; Echevarria et al., 2001; Curtis et al., 2004; Logue et al., 2004). Uranium sorption is influenced by the pH, alkalinity, and dissolved U concentrations. Uranyl is adsorbed to ferric oxyhydroxides such as goethite, ferrihydrite, amorphous ferric oxyhydroxide, and hematite, which forms natural iron coatings on aquifer material (Hsi and Langmuir, 1985; Duff and Amrhein, 1996; Logue et al., 2004) and colloidal magnetite (Missana et al., 2003). Uranyl may also form other naturally occurring inorganic and organic complexes with phosphates (Brendler et al., 1995), vanadiaum (Tetsu et al., 2009) and silicates (Pearcy et al., 1995). Complexes with sulfate (Gupta and Singh, 2005), fluoride and possibly chloride are potentially important uranyl species where concentrations of these anions are high, but their stability is considerably less than the carbonate and phosphate complexes (Grenthe et al., 1992).

Adsorbed U(VI) may be reduced by mobile reductants such as H_2S or CH_4 (Langmuir 1978). However, U tends to remain in its soluble (VI) valence state during sorption and is then released back into groundwater in its soluble valence when sorption is reversed (Fiedor et al. 1998).

Uranium in mining environments form secondary U(VI) mineral phases that play an important role in the attenuation of dissolved uranium (Tetsu et al., 2009). Although secondary U(IV) minerals exist, most groundwaters are undersaturated with respect to these mineral phases (eg. Ivanovich et al. 1991).

In general, the highest concentration of dissolved U is found in the oxidized zone of the aquifer. As groundwater conditions become reduced, dissolved U concentration decreases due to sorption and precipitation reactions. Deep aquifer systems are recognizable by a constant low U concentration (Figure 1).

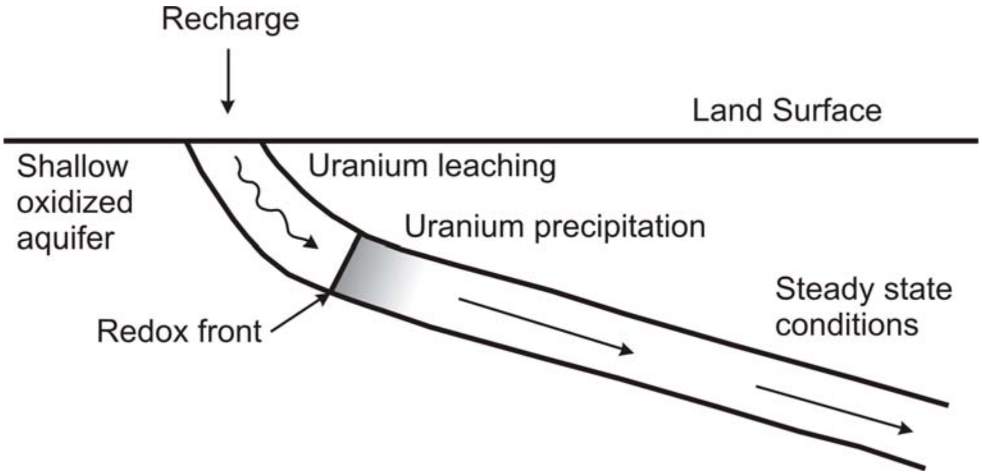


Figure 1: Schematic of uranium concentration distribution along a groundwater flow path. (Revised from Ivanovich et al., 1991).

Possible sources of uranium that have been postulated for water wells in the study area include:

- The weathering and oxidation of naturally occurring primary/secondary uranium minerals within the unsaturated zone of the tills overlying the sand aquifers.
- The over-pumping of water well, introducing oxygen into the drawdown cone of previously saturated sediments, causing oxidation of naturally occurring primary/secondary uranium minerals.
- Agricultural application of fertilizers containing trace amounts uranium.
- Contamination from produced water from energy wells that contains dissolved concentrations of uranium.
- Anthropogenic uranium from surface spreading of drill cuttings.
- Poorly completed water wells causing mixing between water bearing units.
- Poor groundwater sampling procedures leading to cross-contamination between samples.

2.1 Site 1 Location

The study sites are located near Bonnyville, Alberta (Figure 2). Site 1 (3-15-061-05 W4M) and Site 2 (NE-22-063-05 W4M) are located approximately 22 km apart. The area lies within the Eastern Alberta Plains and Mostoos Hills Upland regional Physiographic units. Both study sites are within the Eastern Alberta Plains and have an elevation typically below 600 m

(Atlas of Alberta, 1969). The area is glaciated with relief ranging from flat to hummocky. The two sites lie within the Beaver Lowlands, a flat to gently rolling till plain (Andriashek and Fenton, 1989).

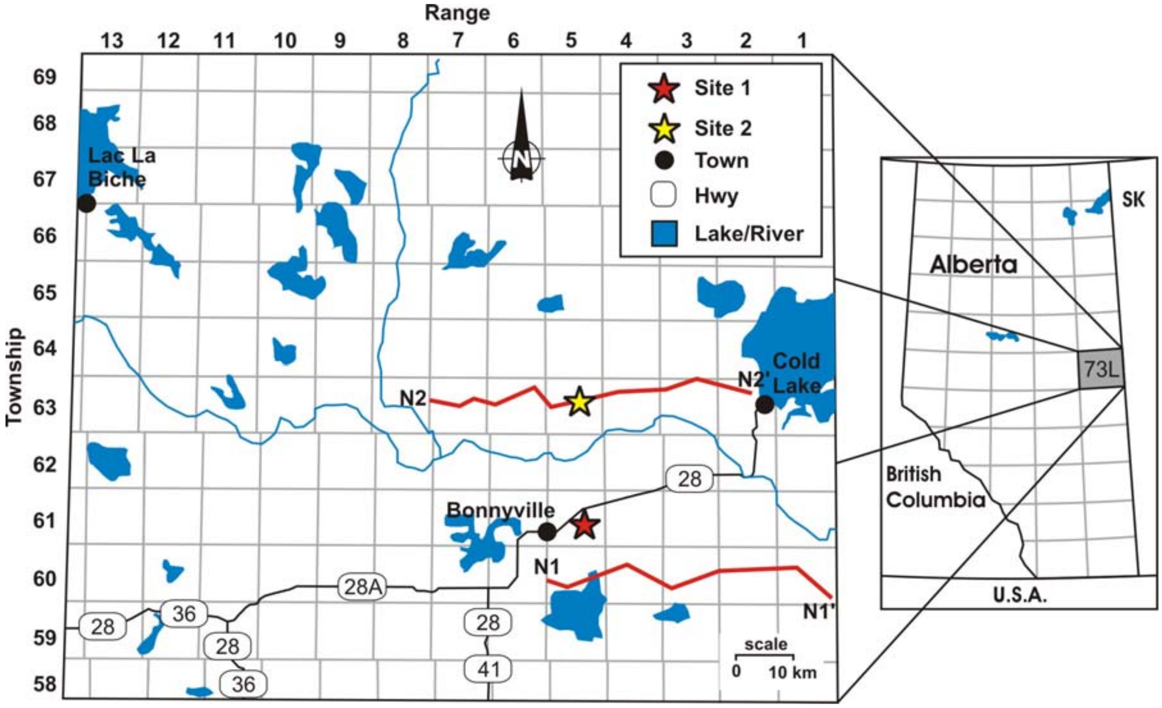


Figure 2: Map showing locations of Site 1 and Site 2 and stratigraphic cross section locations (red lines).

The climate of the area is Dfb, based on the Köppen classification; long cool summers with severe winters. The mean annual precipitation in 433 mm and potential evapotranspiration is 508 mm per year (Hydrogeological Consultants Ltd., 2002).

Site 1 is located approximately 2 km east of Bonnyville Alberta (Figure 2). The property is flat in topography and bounded by Hwy 659 to the south, farm land to the north and east, and commercial property to the west. Approximately 300 m to the north of the site is an energy well battery. At the battery crude oil is separated from impurities. Water produced from the separation process (processed water) is stored in tanks then periodically emptied into tanker trucks and hauled offsite. There are five water wells located at Site 1 over two residential properties. Three water wells are located on Resident A's property (Well 1, Well 2 and Well 3); and the adjacent property to the west has two water wells (Well 4 and Well 5). Limited information was available on the dimensions and depths of the wells. The groundwater beneath Site 1 flows from south to north (Hydrogeological Consultants Ltd. 2007), towards the energy well battery. Geochemical data provided by Alberta Environment for the Wells 1, 2 and 3 show that the groundwater from these wells contain elevated U concentrations exceeding the current Canadian Drinking Water Quality Limits.

During the drilling of an energy well in 2005, approximately 240 m NE of the property, drilling waste was spread across a field using land spray practices. Land spray involves disposing drill cuttings and drill mud as a spray while drilling to disperse the waste over a wide area. All chemical and physical parameters of the AEUB's Directive 50 must be met prior to the commencement of land spry operations. There must also be no visible hydrocarbon sheen on the waste prior to spraying.

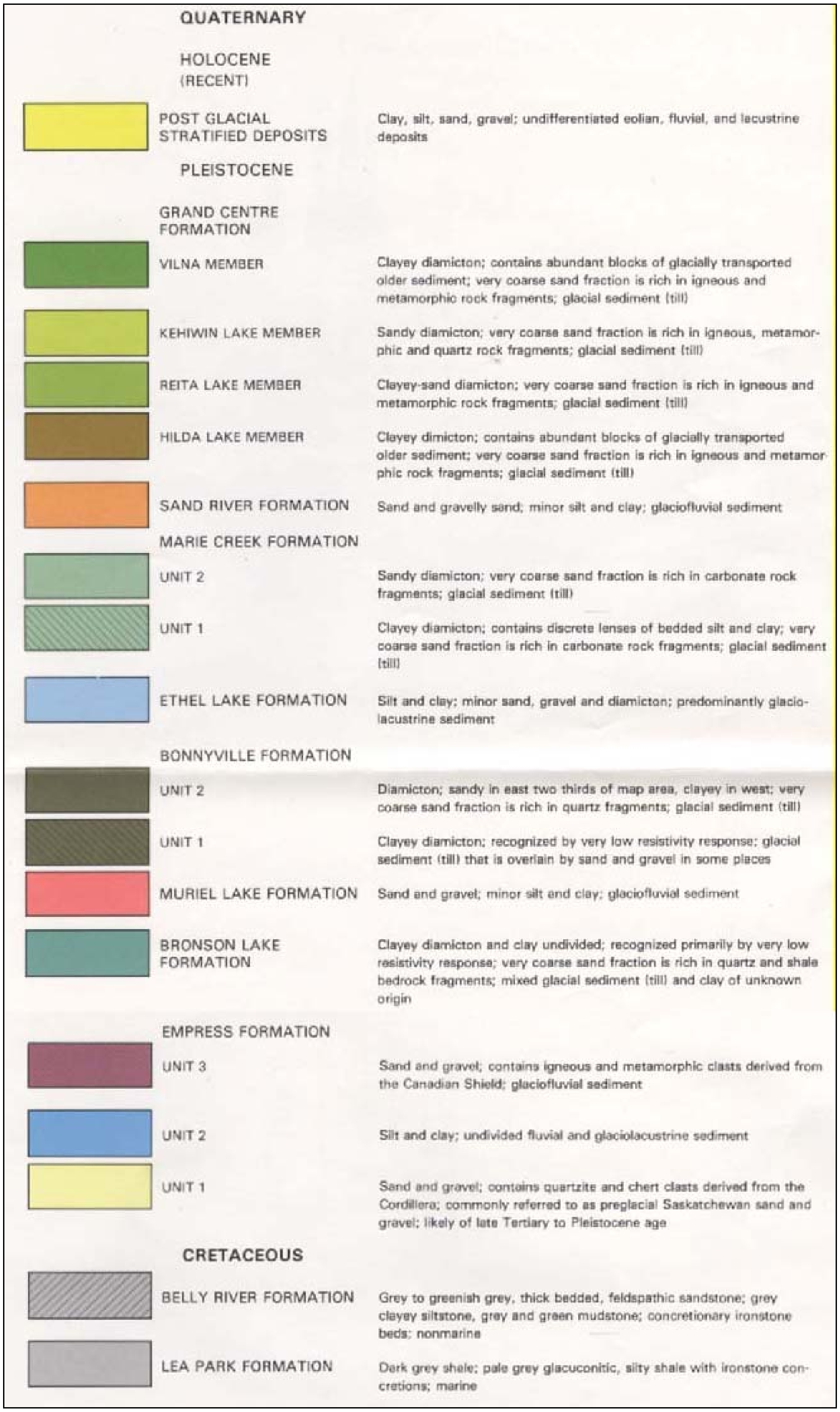
2.2 Site 2 Location

Site 2 is located approximately 23 km NE of Bonnyville, Alberta (Figure 2). The property has hummocky like terrain with the south portion in a topographic low, rising in elevation to the north of the property. The property is bounded by Range Road 452 to the west, a forested marsh area to the south and farmland to the north and east. The farmland is used for hay crops and cattle grazing. On the south portion of the property there are three wells of interest (Well 1, Well 2 and Well 3). The wells are located near a pond of standing water that collects surface water drainage from the surrounding area. Well 1 and 2 are located adjacent to a cattle feed lot. Approximately 280 m north and up-gradient of Well 1 is an energy well battery. Also up-gradient 125 m NW of Well 1 is a field where fertilizer was previously applied. Assuming that groundwater follows the local topography, groundwater in the area would flow from north to south. Geochemical data provided by Alberta Environment for the Wells 1, 2 and 3 show that the groundwater from Wells 1 and 3 contain elevated U concentrations exceeding the current Canadian Drinking Water Quality Limits.

3 GEOLOGY

The overburden geology of the area is described by Andriashek and Fenton (1989). The stratigraphy (Figure 3) and till description come from their work. Cross sections close to the Site 1 and Site 2 properties are shown in Figures 4 and 5 respectively.

In the vicinity of both the Site 1 and Site 2 properties the surficial materials appear to be the Reita Lake Member of the Grand Centre Formation. This clayey-sand diamicton till was deposited during the last major glaciation. This is underlain by the Hilda Lake Member of the Grand Centre Formation, a clayey diamicton.



	QUATERNARY	
	HOLOCENE (RECENT)	
🟨	POST GLACIAL STRATIFIED DEPOSITS	Clay, silt, sand, gravel; undifferentiated eolian, fluvial, and lacustrine deposits
	PLEISTOCENE	
	GRAND CENTRE FORMATION	
🟩	VILNA MEMBER	Clayey diamicton; contains abundant blocks of glacially transported older sediment; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
🟩	KEHIWIN LAKE MEMBER	Sandy diamicton; very coarse sand fraction is rich in igneous, metamorphic and quartz rock fragments; glacial sediment (till)
🟩	REITA LAKE MEMBER	Clayey-sand diamicton; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
🟫	HILDA LAKE MEMBER	Clayey dimicton; contains abundant blocks of glacially transported older sediment; very coarse sand fraction is rich in igneous and metamorphic rock fragments; glacial sediment (till)
🟧	SAND RIVER FORMATION	Sand and gravelly sand; minor silt and clay; glaciofluvial sediment
	MARIE CREEK FORMATION	
🟩	UNIT 2	Sandy diamicton; very coarse sand fraction is rich in carbonate rock fragments; glacial sediment (till)
▨	UNIT 1	Clayey diamicton; contains discrete lenses of bedded silt and clay; very coarse sand fraction is rich in carbonate rock fragments; glacial sediment (till)
🟦	ETHEL LAKE FORMATION	Silt and clay; minor sand, gravel and diamicton; predominantly glaciolacustrine sediment
	BONNYVILLE FORMATION	
⬛	UNIT 2	Diamicton; sandy in east two thirds of map area, clayey in west; very coarse sand fraction is rich in quartz fragments; glacial sediment (till)
▨	UNIT 1	Clayey diamicton; recognized by very low resistivity response; glacial sediment (till) that is overlain by sand and gravel in some places
🟥	MURIEL LAKE FORMATION	Sand and gravel; minor silt and clay; glaciofluvial sediment
🟦	BRONSON LAKE FORMATION	Clayey diamicton and clay undivided; recognized primarily by very low resistivity response; very coarse sand fraction is rich in quartz and shale bedrock fragments; mixed glacial sediment (till) and clay of unknown origin
	EMPRESS FORMATION	
🟪	UNIT 3	Sand and gravel; contains igneous and metamorphic clasts derived from the Canadian Shield; glaciofluvial sediment
🟦	UNIT 2	Silt and clay; undivided fluvial and glaciolacustrine sediment
🟨	UNIT 1	Sand and gravel; contains quartzite and chert clasts derived from the Cordillera; commonly referred to as preglacial Saskatchewan sand and gravel; likely of late Tertiary to Pleistocene age
	CRETACEOUS	
▨	BELLY RIVER FORMATION	Grey to greenish grey, thick bedded, feldspathic sandstone; grey clayey siltstone, grey and green mudstone; concretionary ironstone beds; nonmarine
⬜	LEA PARK FORMATION	Dark grey shale; pale grey glacuconitic, silty shale with ironstone concretions; marine

Figure 3: Stratigraphy of the Sand River map area (from Andriashek and Fenton, 1989)

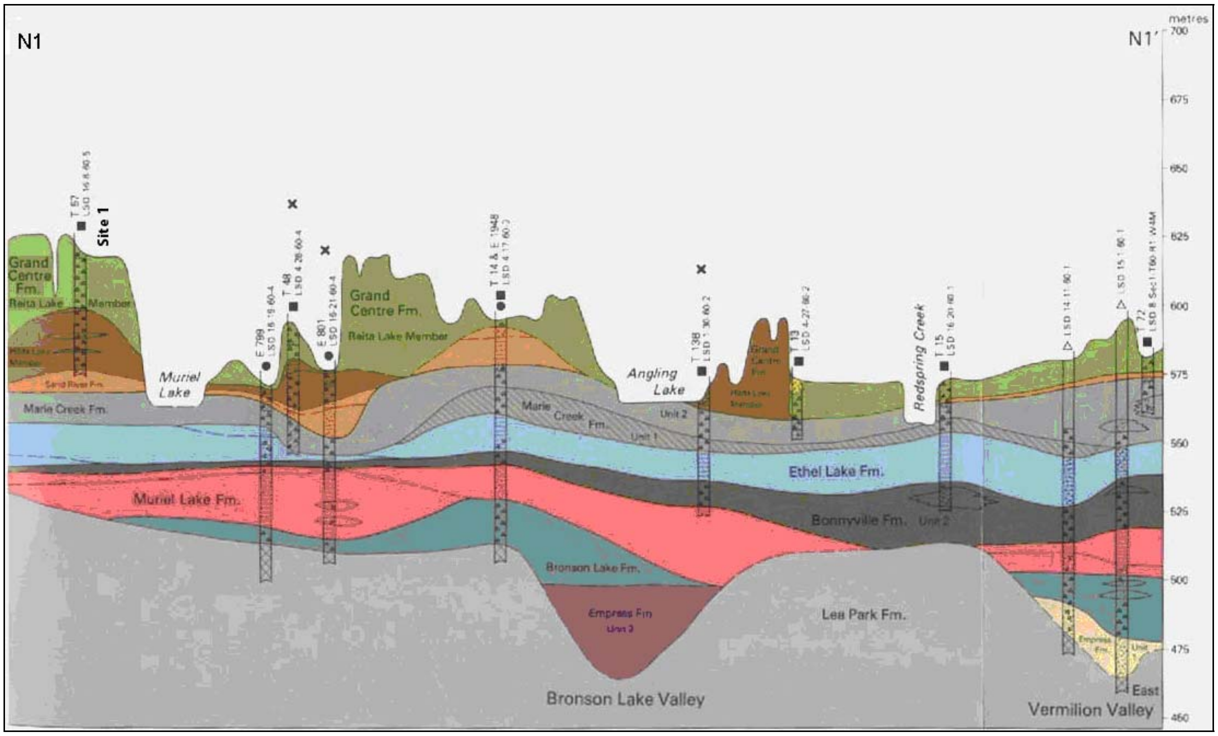


Figure 4: Cross section close to Site 1 (From Andriashek and Fenton, 1989).

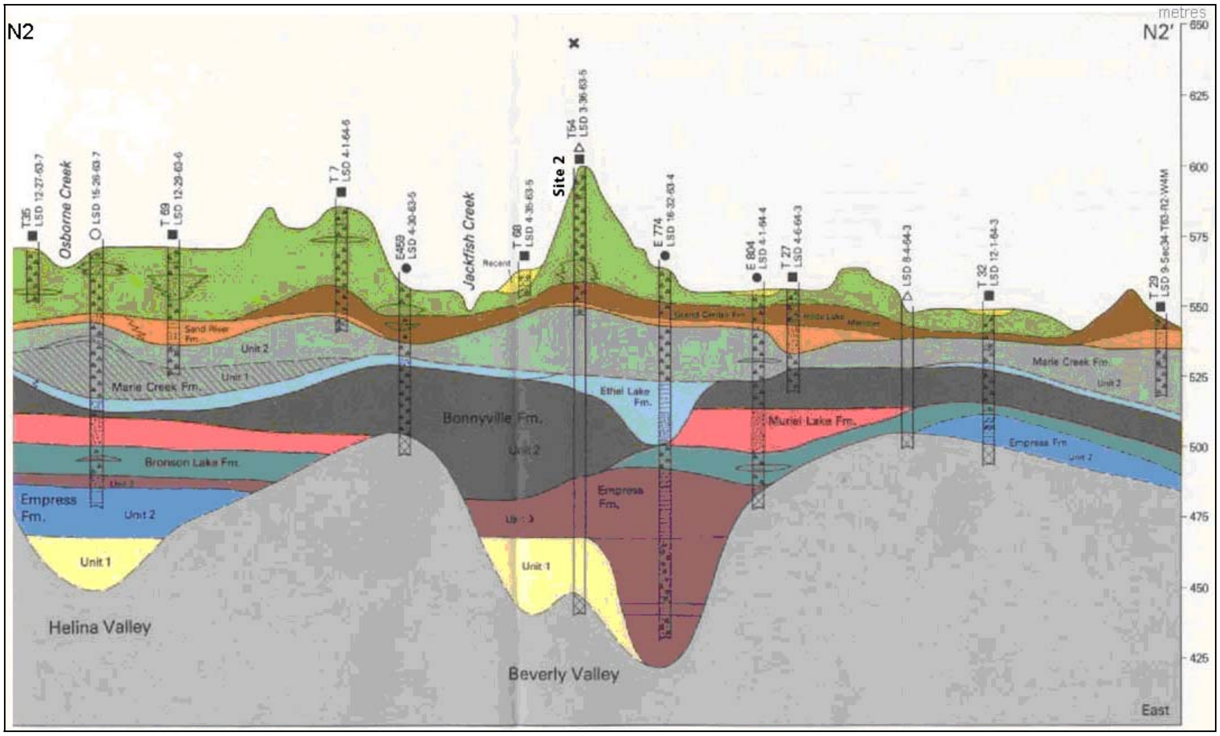


Figure 5: Cross section close to Site 2 (From Andriashek and Fenton, 1989).

The Grand Centre Formation is underlain by the Sand River Formation, an unconsolidated sand and gravelly sand with minor silt and clay of glaciofluvial origin. The Sand River Formation is in turn underlain by the Marie Creek Formation, with Unit 2 (a sandy diamicton till) being present beneath both properties. Below this is the Ethel Lake Formation, an unconsolidated silt and clay with minor sand, gravel and diamicton of glaciolacustrine origin. This is underlain by the Bonnyville Formation till. At the both properties only the Unit 2, a sandy diamicton till, is present. Below this is the Muriel Lake Formation, a sand and gravel of glaciofluvial origin. This unit is not present beneath the Site 1 property.

At Site 2 the Bronson Lake Formation is underlain by Units 1 and 3 of the Empress Formation, both of which are sand and gravel units of glaciofluvial origin. The Empress Formation is not present below the Site 1 property.

At both sites the Quaternary overburden is underlain by Cretaceous age Lea Park Formation, a dark grey shale and silty shale of marine origin.

4 METHODS

This study involved two separate field investigations:

- October 26 to October 30, 2009: The initial field investigation was to visit the two sites of interest and locate all water wells. Physical measurements from each well were recorded along with the collection of groundwater samples. Produced water from Canadian Natural Resources Ltd. (CNRL) energy wells were sampled from a battery located adjacent to each property. Sediment samples were collected from adjacent fields.
- November 23 to November 28, 2009: The second field visit involved installing a bundle piezometer nest and background piezometer at each site. During drilling, borehole logs were recorded and soil samples were collected. Groundwater samples were collected from all new piezometers. Water levels were measured from all water wells and piezometers.

4.1 Groundwater Sampling

Groundwater was collected from wells using a peristaltic pump and ¼-inch diameter polyethylene tubing. New tubing was used for each well to prevent cross-contamination. All wells were purged and allowed to recover prior to sampling. Measurements of pH, Eh, temperature, electrical conductivity and dissolved oxygen (DO) were made in the field using a Hydrolab with all probes sealed in a flow-through cell to prevent any alterations from reactions with atmospheric O_2. It was not possible to measure DO concentrations from the new piezometers due to a malfunctioning probe. All probes in the Hydrolab were calibrated prior to sampling. Water samples were collected when pH and Eh values were stable. From each well and the CNRL batteries, samples were collected for dissolved metals, total metals, routine analysis, dissolved organic carbon (DOC), nutrients (PO_4, NO_2, NO_3, NH_3), stable isotopes $\delta^{18}O$, $\delta^{2}H$, and $\delta^{13}C_{DIC}$. Nutrient and DOC samples were not collected from the two CNRL batteries. All water samples were filtered with 0.45 µm cellulose filters with the exception of total metals and $\delta^{13}C$. Samples were preserved in the field with trace grade acids immediately after collection (HNO_3 for metals; HCl for DOC, H_2SO_4 for nutrients). Water samples were refrigerated until they were analyzed. During sampling procedures, sterile gloves were worn and changed between each well location.

Dissolved H_2S concentrations were determined on 25 mL samples from each well using a Hach DR2010 spectrometer following the methylene blue procedure (SMEWW, 1992). Measurements of alkalinity were made on in the field on filtered samples using a Hach digital titrator and bromcresol green / methyl red indicator and with 0.16 *N* H_2SO_4.

Unfiltered water samples were collected from the two CNRL batteries and Well 1 from Site 1 and Well 1 from Site 2 for the analyses of volatile priority pollutants (VPP) and extractable priority pollutants (EPP).

All samples were immediately shipped to the AITF laboratory in Vegreville, AB, except sample for isotopic analyses, which were shipped to the AITF laboratory in Victoria, BC.

4.2 Piezometer Installation

Piezometers were installed by Core Drilling Environmental and Geotechnical Services using a C-311 auger rig. Boreholes were drilled with 6-inch hollow stem augers and advances to the desired depth. During drilling of the bundle piezometers, sediment samples were collected using a split spoon or sampled off of the auger. Samples were collected every 0.25 cm over the first 2 m of drilling then at 0.5 m intervals for the remaining depths. Samples were immediately frozen after collection due to the subzero outside temperature. When the desired depth was reached, 1-inch threaded PVC piezometers were installed into the annulus of the hollow stem auger. Factory slotted well screens wrapped with geotextile fastened with plastic tie straps were screwed onto the 1-inch PVC piezometer and installed over each water-bearing unit. The screened areas were backfilled with filter sand to 6-inches above the screened interval and capped with 12-inches of bentonite chips. The borehole was backfilled with drill cuttings until near the next water-bearing unit, then a 12-inch layer of bentonite chips were installed to isolate each unit. Well completion involved backfilling the borehole with bentonite chips from a depth of 10-ft (3 m) to surface.

Background monitoring wells at each site were installed into the uppermost water-bearing units using 6-inch hollow stem augers. Piezometers were installed following the same methods as above except they were constructed from 2-inch PVC threaded pipe. Lockable well covers were installed over all piezometers to restrict access and ensure protection.

4.3 Sediment Sampling

Sediment samples were collected from the field where drill cuttings had been applied to the surface near Site 1 and the field near Site 2 that had applied fertilizer. Samples were collected from the upper 0.5 m of the soil horizon using a method similar to Starr and Ingleton (1992). A 2-inch aluminum core tube was driven to depth using a Pionjar rock drill (Figure 6). The core tube was then extracted from the ground, capped then frozen until they were analyzed. Three cores, approximately 0.5 m long, were collected from each location. In the laboratory a composite sample was made from each core and a subsample was microwave digested in 5 mL nitric acid, 2 mL hydrogen peroxide and 1.5 mL hydrofluoric acid. Following total digestion, samples were diluted and total total concentrations for U, Fe, Al, As, Ca, Mg, Na, K and PO_4 were measured using an ICP-MS.

During the monitoring well installation sediment samples were collected from discrete depths and analyzed using the same total digestion method as above.

Figure 6: Core collection using a pionjar drill from the field applied drill cuttings (left) and the field applied fertilizer (right).

Secondary mineral precipitates were observed at Site 1 and collected to determine if U was precipitating or co-precipitating with the mineral phases. A secondary mineral phase that had formed on the surface of a water tap was collected from Resident A's Well 1. While sampling Well 4 on Resident B's property, the pump tubing was lowered to the bottom of the well and a red iron-like secondary precipitate was collected. The plumbing in Residents 2's house had recently been replaced, so no scaling was observed on any of the plumbing fixtures. Secondary precipitate samples were digested and analyzed for total U, Ca, Mg, Fe, Cu, Zn, Al, As and Mn, using the same digestion method as described above. No secondary mineral phases were observed from the wells or plumbing fixtures at Site 2.

4.4 Geochemical Modeling

The geochemical model MINTEQA2 (Allison, 1991), developed by the United States Environmental Protection Agency, was used to understand secondary mineral phases that may be controlling dissolved uranium concentrations in groundwater sampled from Site 1 and Site 2 water wells. MINTEQA2 is an equilibrium/mass-transfer model that calculates saturation indices (SI) for discrete mineral phases. A SI value >0 suggests that the water is supersaturated with respect to the mineral phase and may precipitate; a SI value <0 suggests that the water is undersaturated with respect to the mineral phase will not precipitate; and a SI value near zero indicates that the water is at equilibrium with respect to the mineral phase. The database of MINTEQA2 was modified to make it consistent with that of WATEQ4F (Ball and Nordstrom, 1991). Additional solubility data for Co (Papelis et al., 1988), PO_4 (Baker et al., 1998) and siderite (Ptacek, 1992) was also incorporated into the database. The WATEQ4F thermodynamic database of also contains dissolved U species and

U minerals. MINTEQA2 allows oxidation–reduction potentials (ORP) be entered as measured Eh.

5 RESULTS AND DISCUSSION

5.1 Site 1

Table 1 is a summary of well locations and details from all water wells located on Site 1. A detailed table of groundwater chemistry measured from each water well can be found in Appendix A

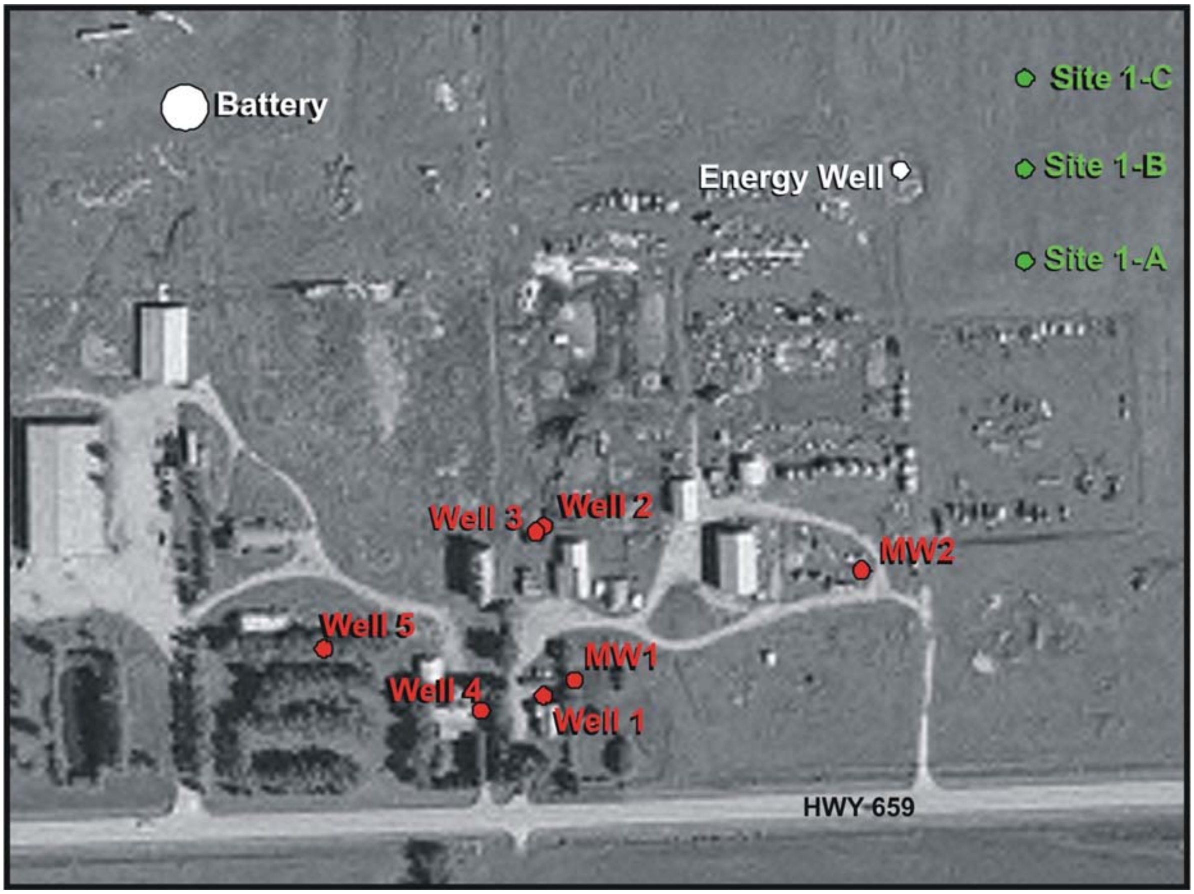


Figure 7: Aerial view of Site 1 showing the locations of water wells, monitoring wells, battery, energy well and soil sampling locations in the field containing land sprayed drill cuttings.

Table 1: Site 1 water well details. mbgl represents meters below ground level.

Location	North	West	Date Drilled/Dug	Casing Type	Casing Diameter	Casing Stick Up (m)	Depth (mbgl)	Water Level (mbgl) 27/10/2009	Water Level (mbgl) 28/11/2009
MW1-1	54.26855	110.67294	2009	PVC	1-inch (2.54 cm)	0.85	7.545		4.63
MW1-2	54.26855	110.67294	2009	CPVC	1/2-inch (1.27 cm)	0.89	9.405		4.61
MW1-3	54.26855	110.67294	2009	PVC	1-inch (2.54 cm)	0.9	13.92		4.60
MW2	54.26891	110.67104	2009	PVC	2-inch (5.08 cm)	0.89	7.16		2.64
Well 1	54.26843	110.67318	1913	concrete culvert	75 cm	0.46	6.685	4.03	4.14
Well 2	54.26901	110.67313	1930	concrete	122 cm x 132 cm	0.05	7.41 (12.15)	4.92	n/a
Well 3	54.26905	110.67308	1972	PVC	4-inch (10.16 cm)	0.18	21.45	4.41	4.40
Well 4	54.26831	110.67361	unknown	Steel culvert	2-ft (61 cm)	0.25	10.14	4.46	4.47
Well 5	54.26863	110.67442	unknown	Steel culvert	79 cm	0.44	24.76	4.00	4.12

5.1.1 Resident A Water Wells

There are three water wells located on the property of Resident A (Figure 7).

Well 1: AENV GIC # 0204326

Well 1 is located 1 m from Resident A's house and used for domestic purposes (Figure 8). The well was hand dug through clay in 1913 to a depth of 6.69 m, intersecting a brown saturated sand unit. The well casing is constructed from a 0.75 m ID x 0.90 m OD concrete culvert with a stick up of 0.46 m above ground surface. The well is equipped with a submersible pump that is piped to the house at a depth of 1.88 m. Water levels in the well were measured at 4.03 m and 4.14 m on October 27, 2009 and November 28, 2009, respectively.

Figure 8: Well 1 located at Site 1.

Previous sampling of Well 1 indicated that concentrations of U, SO_4, NO_3 and other parameters have increased over time (Table 2). Groundwater samples collected during this study indicate that this trend is continuing. From 2007 to 2009, U concentrations increased from 125 $\mu g\ L^{-1}$ to 151 $\mu g\ L^{-1}$ and SO_4 concentrations increased by almost 100 $mg\ L^{-1}$. Since sampling of Well 1 started in 1984, the concentration of many parameters in the groundwater has almost doubled. Elevated NO_3 concentrations along with the presence of total coliforms suggested that Well 1 could be receiving effluent from a local septic tank, livestock waste or agricultural practices.

Table 2: Selected geochemical parameter in groundwater measured in Well 1 from 1984 to 2009.

Date	U (μg L^{-1})	EC (μS cm^{-1})	SO_4 (mg L^{-1})	Cl (mg L^{-1})	NO_3 (mg L^{-1})	Total Coliforms (CFU)
1984	n/a	2130	295	135	n/a	n/a
2005	89	3050	481	242	69.8	57
2007	125	3860	519	328	105	n/a
2009	151	3910	612	256	97.8	n/a

Well 2: AENV GIC # 0204325

Well 2 is located 69 m north of Well 1 and used for stock purposes (Figure 9). A cattle feed lot is located a few meters north of the well. The well was hand dug through clay in 1930 to a depth of 7.4 m, intersecting a brown saturated sand unit. The well was later deepened at an unknown date to 12.15 m by drilling an open hole through the well bottom using a power auger. The upper well casing is constructed from a 1.22 m ID x 1.32 m ID (1.75 m OD x 1.82 m OD) concrete rectangle, with a stick up of 0.05 m above ground surface. At a depth of 1.78 m, there is a deteriorated wooden platform covering the well with a small hole to allow access for a jet pump that is piped to an adjacent barn. A 2-inch (5.1 cm) galvanized steel pipe lines the borehole between 7.4 m and 12.15 m. The pipe was not sealed between the bore hole and casing. Water level in the well was measured at 4.92 m on October 27, 2009. The surface of the well is covered by creosote treated railroad ties.

Figure 9: Well 2 located at Site 1

Image to the left shows the railroad ties used to cover the well. To the right is an inside view of the well showing the suspended wood floor and drop pipe. Note the feedlot in the background.

Groundwater collected from Well 2 has elevated concentrations of U, Cl and NO_3 (Table 3). The concentration of U has increased from 63 µg L^{-1} in 2005 to 75 µg L^{-1} in 2009. Electrical conductivity, SO_4 and Cl have also shown a significant increase in concentrations since 2005. Elevated NO_3 concentrations along with the presence of total coliforms suggested that Well 2 could be receiving effluent from a local septic tank, livestock waste or agricultural practices.

Table 3: Selected geochemical parameter in groundwater measured in Well 2 during 2005 and 2009.

Date	U (µg L^{-1})	EC (µS cm^{-1})	SO_4 (mg L^{-1})	Cl (mg L^{-1})	NO_3 (mg L^{-1})	Total Coliforms (CFU)
2005	63	2930	240	365	24.3	14
2009	75	3980	359	625	21.7	n/a

Well 3: No AENV GIC #

Well 3 is located 67 m north of Well 1 (2 m SW from Well 2) and used for stock purposes (Figure 10). A cattle feed lot is located a few meter north of Well 3. The well was drilled to a depth of 21.45 m in 1972 using a mud rotary drilling rig, intersecting a saturated sand unit. The well casing is constructed from a 4-inch (10.2 cm) PVC and installed over the entire length of the borehole. There is no seal between the bore hole and casing. The casing stick up is 0.18 m above ground surface and protected by an outer 6-inch (15.2 cm) casing. Water is extracted from the well using an air lift system. Water levels in the well were measured at 4.41m and 4.40 m on October 27, 2009 and November 28, 2009, respectively.

Groundwater collected from Well 3 shows an increase in U, EC, SO_4 and Cl since 2005 (Table 4). Uranium concentrations are elevated at 40 µg L^{-1} above the Canadian Drinking Quality Guidelines. Elevated NO_3 concentrations along with the presence of total coliforms suggested that Well 3 could be receiving effluent from a local septic tank, livestock waste or agricultural practices.

Figure 10: Image to the left shows Well 3 and image on the right shows the well relative to Well 2.

Table 4: Selected geochemical parameter in groundwater measured in Well 3 during 2005 and 2009.

Date	U (µg L^{-1})	EC (µS cm^{-1})	SO_4 (mg L^{-1})	Cl (mg L^{-1})	NO_3 (mg L^{-1})	Total Coliforms (CFU)
2005	60	2940	240	359	24.3	12
2009	68	3988	367	573	23.1	n/a

5.1.2 Resident B Water Wells

There are two water wells located on the property of Resident B (Figure 7).

Well 4: No AENV GIC #

Well 4 is located 31 m west of Well 1 and used for domestic purposes by Resident B (Figure 11). The well was hand dug to a depth of 10.14 m. The surface casing of the well is constricted from a 0.64 m ID x 0.75 m OD concrete casing with a stick up of 0.25 m. The well is covered by a concrete lid. At a depth of 0.72 m below the top of casing (BTOC), the well is cased to depth with a 0.61 m diameter galvanized steel culvert. The well is equipped with a submersible pump that is piped to the house at a depth of 2.06 m BTOC. Water levels in the well were measured at 4.46 m and 4.47 m on October 27, 2009 and November 28, 2009, respectively.

Figure 11: Well 4 located on Site 1.

Water samples have not been collected from Well 4 in the past. Analyses of groundwater collected from the Well 4 during this study shows that it contains slightly elevated U concentrations at 26 µg L^{-1}. The concentration of Cl and SO_4 are 120 mg L^{-1} and 319 mg L^{-1}, respectively. The measured concentration of NO_3 in the groundwater was 0.9 mg L^{-1}.

Well 5: No AENV GIC #

Well 5 is located 85 m NW of Well 1 and used for domestic purposes by the neighboring commercial property west of Site 1 (Figure 12). The well was bored to a depth of 24.76 m. The well casing is constructed from a 0.79 m diameter galvanized steel culvert with a stick up of 0.44 m above ground surface. The well is equipped with a submersible pump that is piped to the adjacent property. Water levels in the well were measured at 4.00 m and 4.12 m on October 27, 2009 and November 28, 2009, respectively.

Figure 12: Well 5 located on Site 1.

Water samples have not been collected from Well 5 in the past. The concentration of dissolved U was 4 µg L^{-1}, below the Canadian Drinking Water Quality Guidelines. The concentration of Cl and SO_4 were 20 mg L^{-1} and 277 mg L^{-1}, respectively. The concentration of NO_3 in the groundwater was below detection limits.

5.1.3 New Monitoring Well Installed in 2009

Two monitoring wells were installed on Site 1:

- a bundle piezometer and
- a background monitoring piezometer.

Both piezometers are located on the property of Resident A (Figure 7). The bundle piezometer (MW1) was installed near Well 1 and the monitoring piezometer (MW2) was installed at a location that would not be influenced by the pumping of any existing wells.

During the installation of MW1, sediment stratigraphy was recorded and samples were collected (see Appendix B for a detailed description of well log). Brown oxidized clay/till was observed to a depth of 5.8 m. The clay/till in this layer consisted of clay with some silt lenses, pebbles and the occasional boulder. Within the upper meter, vugs containing white powdery minerals were observed. Below 1 m vugs with red iron-like minerals and iron staining along possible fractures were observed to a depth of 5 m. At a depth of 5.8 m, there was a sharp transition from brown oxidized clay to grey stiff clay. A brown fine to medium grained water-bearing sand was present from 6.4 to 6.7 m followed by grey clay (Figure 13). A second water-bearing unit composed of a medium to course grain grey sand was observed from 9.15 to 9.76 m (Figure 12). Dense grey clay extended from 9.76 m to 12.2 m. A third water –bearing unit, consisting of a grey silty sand was observed from 12.2 to 13.7 m. Grey clay was encountered from 13.7 to 15.2 m at which point drilling was terminated. One-inch diameter piezometers were installed over the upper and lower water-bearing units and a ½-inch CPVC piezometer was installed over the middle water-bearing unit, following procedures described in the method section (Figure 14).

Figure 13: Image to the left shows the fine saturated brown sand collected from the first water bearing unit (6.4-6.7 m). To the right shows a medium to course grain saturated grey sand collected from the second water bearing unit (9.2-9.8 m). Rectangles in the scale card are 2 x 5 cm.

Figure 14: Image to the left shows the installation of MW1 on Site 1. Image to the right shows the completed well with the house of Resident 1 in the background.

During the installation of MW2, clay was observed to extend from surface to a depth of 5.5 m at which point a brown fine to medium grain water-bearing sand unit encountered to a depth of 6.4 m. The sand unit was underlain by grey clay. A 2-inch monitoring well was installed across the sand unit (Figure 15).

Figure 15: Image to the left shows the installation of MW2 on Site 1. Image to the right shows the completed well.

Water levels measured from MW1-1,2,3 show that there is a 3 cm head difference between MW1-1 and MW1-3, indicating a slight downward vertical gradient between the three aquifers (Table 1).

Figure 16 shows a depth profile of geochemistry from piezometer bundle MW1. Results show that U concentrations slightly exceed drinking water guidelines with concentrations of 23, 21 and 27 $\mu g\ L^{-1}$ in piezometers MW1-1,-2,-3, respectively. The concentration of U is relatively constant between the three aquifers. Other parameters such as TDS, EC, major cations and SO_4 have the highest concentrations in the upper aquifer however, Cl and NO_3 are elevated in the lower aquifer suggesting that this aquifer may be impacted by an anthropogenic source(s).

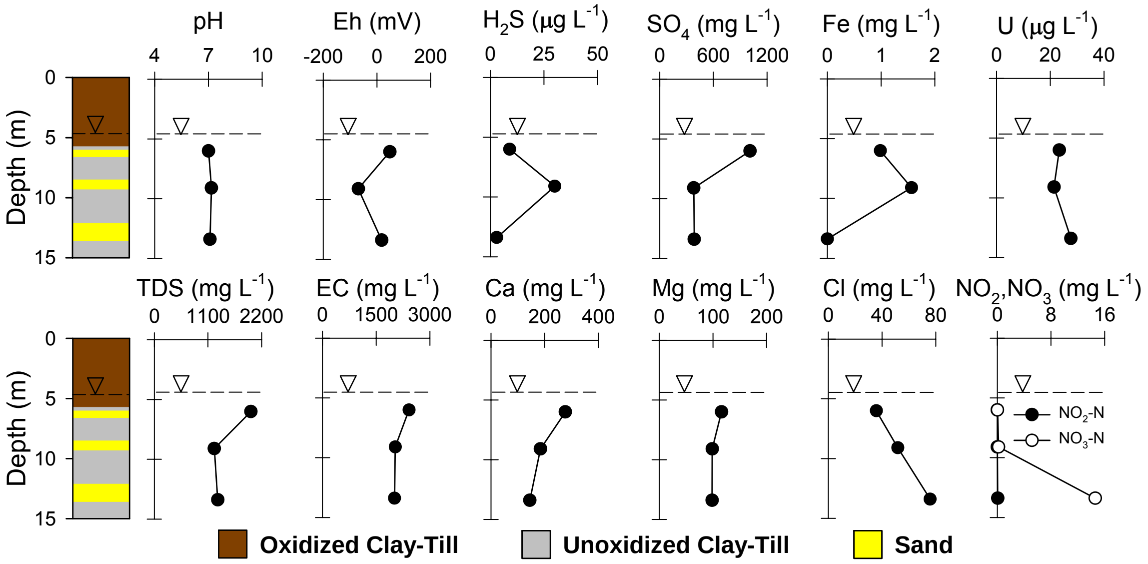


Figure 16: Profile of stratigraphy and groundwater chemistry from MW1, Site 1. The dashed line with inverted triangle represents the water table.

Groundwater sampled from the background well, MW2, contained dissolved U concentrations of 81.6 µg L^{-1}, exceeding drinking water guidelines. However other parameters such as nitrogen, SO_4, Cl and EC are lower than other wells completed in this unit (Appendix A).

5.1.4 Geochemical Trends

Site 1 contains four water bearing units at depths of approximately 7 m (aquifer 1), 9.5 m aquifer 2), 13 m (aquifer 3) and 23 m (aquifer 4). It was no possible to measure absolute elevation at each well therefore the exact depth to the aquifer varies between well locations. Well 1, MW1-1 and MW2 are completed in the aquifer 1; Well 4 and MW1-2 are completed in aquifer 2; MW1-3 is completed in aquifer 3 and Well 5 is completed in aquifer 4. Well 2 is screened over aquifer 1, 2 and 3, and Well 3 is screened over all aquifers.

Figure 17 show a comparison of selected ion concentrations from all wells grouped into the appropriate aquifers. Aquifer 1 shows considerable difference in concentrations between wells, with well 1 exhibiting the highest concentration of U and other parameters. This might be due to the fact that Well 1 is almost a century old and continual pumping over this time period may have created a significant drawdown cone exposing potential U-bearing minerals to oxidation. Well 1 is also a poorly completed large diameter well with the potential of oxygen diffusion into the exposed walls of the well.

Wells installed in aquifer 2 show little variability in U concentrations and other parameters. This suggests that the wells are likely properly completed.

Aquifer 3 shows a large difference in concentration between the two well installed. MW1-2 contains lower concentration of U and other parameters. MW1-2 was screened over the aquifer and sealed with bentonite to isolate the aquifer from other water bearing units. Well

2 was screened over aquifer 1, 2 and 3. Water from aquifer 1 and 2 is likely mixing with aquifer 3 causing the elevated concentration of U and other parameters. Poorly completed wells causing the mixing of U from upper water-bearing units has been documented by McCall et al. (2009).

Aquifer 4 also shows a large difference in concentration between the two well installed. Well 5 contains low concentrations of U and other parameters. There is no information on well completion details for Well 5 but it does appear to be isolated from the overlying shallow aquifers. Well 3 was screened over aquifer 1, 2, 3 and 4. Water from aquifer 1, 2, 3 and 4 is likely mixing causing the elevated concentration of U and other parameters. Wells 2 and 3 are located only a few meters apart and have similar dissolved U concentrations suggesting that these wells are mixing with a similar source.

The correlation between dissolved U concentrations and redox conditions is clearly seen in Figure 17. Groundwater from wells with a high Eh (oxidizing conditions) contains higher concentrations of U, whereas groundwater with a low Eh (reducing conditions) contains lower concentrations of U. Uranium is highly soluble in shallow oxidized ground water (Ingebritsen and Sanford 1998) but becomes less mobile under reducing conditions due to sorption and precipitation reactions (Ivanovich et al., 1991). There is a similar trend between redox and NO_3/NH_3 concentrations. Under oxidizing conditions NO_3 is dominating, however under reducing conditions, NH_3 is more prevalent.

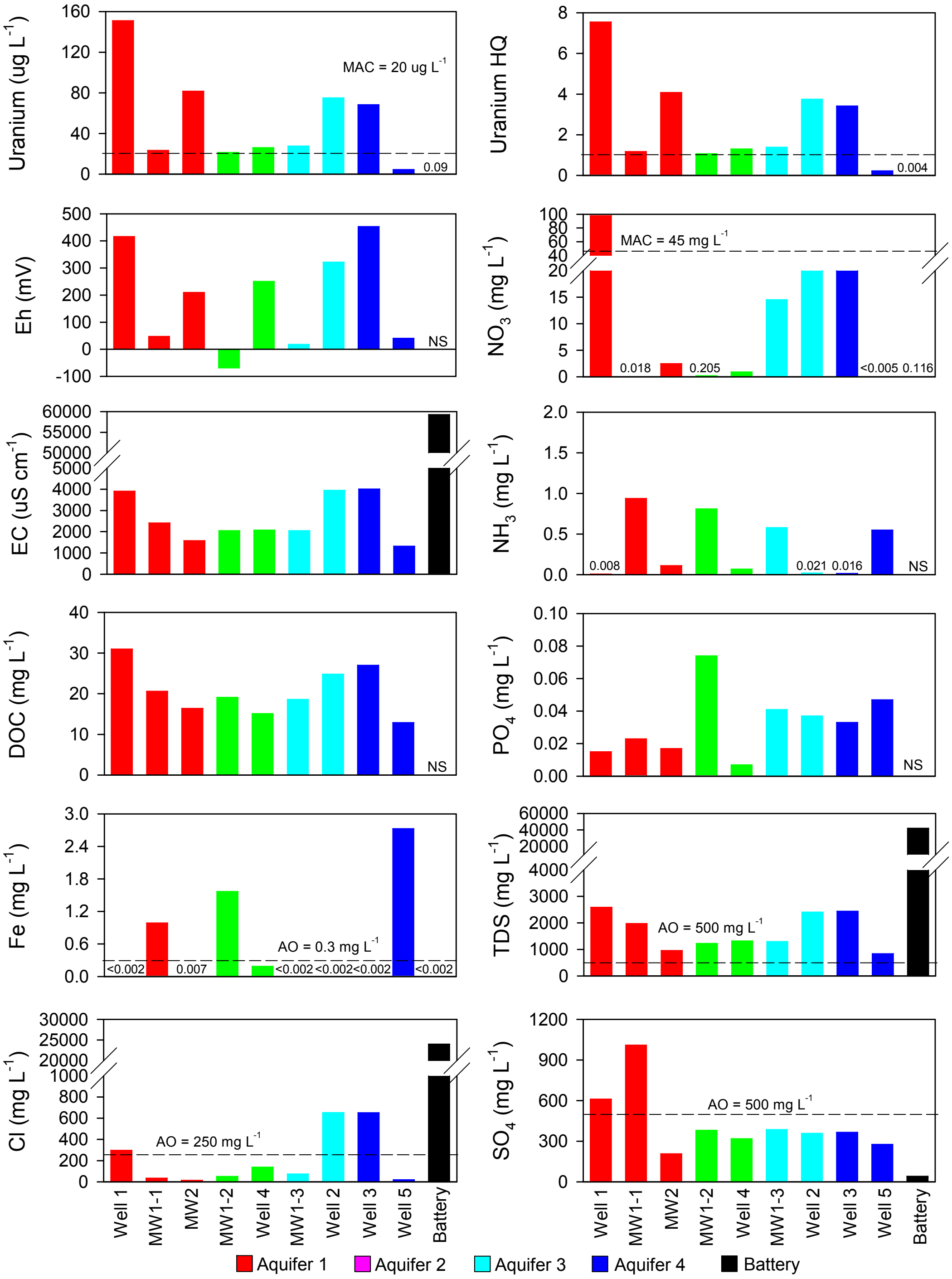


Figure 17: Bar graph showing the concentration of dissolved ions in the groundwater from each well on Site 1.

Wells are grouped according to the aquifers they a completed in. Uranium HQ represents the Uranium Hazard Quotient which is a calculation of the measured U concentration divided by the interim maximum allowable concentration (IMAC) U concentration. A value of 1 indicates the concentration of U is at IMAC. Values above 1 show how many time the concentration exceeds the IMAC. NS - Not Sampled.

It should be noted that all wells were sampled for both dissolved metals and total metals. With respect to U, there was little difference between dissolved U and total recoverable U (See Appendix A).

5.2 Site 2

Table 5 is a summary of well locations and details from all water wells located on Site 2. A detailed table of groundwater chemistry measured from each water well can be found in Appendix A.

Figure 18: Aerial view of Site 2 showing the locations of water wells, monitoring wells, battery and soil sampling locations in the field containing land applied fertilizer.

Table 5: Site 2 well details.

Location	North	West	Date Drilled/Dug	Casing Type	Casing Diameter	Casing Stick Up (m)	Depth (mbgl)	Water Level (mbgl) 27/10/2009	Water Level (mbgl) 28/11/2009
MW1-1	54.46453	110.67227	2009	CPVC	1/2-inch (1.27 cm)	1.14	1.56		dry
MW1-2	54.46453	110.67227	2009	PVC	1-inch (2.54 cm)	1.14	3.84		1.87
MW1-3	54.46453	110.67227	2009	PVC	1-inch (2.54 cm)	1.14	12.49		8.24
MW2	54.4656	110.67017	2009	PVC	2-inch (5.08 cm)	0.85	10.69		3.69
Well 1	54.46476	110.67207	1932	Steel culvert	74 cm	0.6	12.34	6.03	5.26
Well 2	54.46507	110.67283	unknown	concrete culvert	45 cm	0.8	20.155	4.91	6.29
Well 3	54.46502	110.67281	unknown	Steel culvert	2-ft (61 cm)	0.72	26.76	12.65	22.88

5.2.1 Resident Water Wells

There are three existing water wells located on Site 2 (Figure 18).

Well 1: No AENV GIC #

Well 1 is located 23 m west of the Residents house and used for domestic purposes (Figure 19). The well was hand dug in 1932 to a depth of 7.6 m then deepened in the 1980's to a depth of 12.34 m. The well casing is constructed from a 0.74 m diameter galvanized steel culvert to 7.6 m with a stick up of 0.6 m above ground surface. From 7.6 m to 12.34 m, the well is completed with a wooden casing. No seal was used between the casing and bore-hole. The well is located inside a small building. A submersible pump is installed in the well to provide groundwater to the residence. Water levels in the well were measured at 6.03 m and 5.26 m on October 27, 2009 and November 28, 2009, respectively. Water could be heard draining into the well, likely from a perched water-bearing zone.

Figure 19: Image to the left shows the well shack and image to the right shows Well 1, located on Site 2.

Previous water samples collected from Well 1 show that the groundwater contains elevated concentrations of U exceeding the Canadian Drinking Water Quality Guidelines (Table 6). U concentrations in the groundwater have slightly decreased from 2007 to 2009, however, other parameters such as EC, SO_4 and Cl have decreased significantly. NO_3 concentrations in Well 1 are low (<1 mg L^{-1}), however, numerous empty bleach bottles were surrounding the well suggesting that there may have be bacterial problems in the past (Figure 19).

Table 6: Selected geochemical parameter in groundwater measured in Well 1 during 2007, 2008 and 2009 field sampling.

Date	U (µg L^{-1})	EC (µS cm^{-1})	SO_4 (mg L^{-1})	Cl (mg L^{-1})	NO_3 (mg L^{-1})	DO (%)
2007	35.5	1860	172	50.1	0.4	n/a
2008	37.6	1690	146	47.5	0.3	n/a
2009	29.3	1598	123.5	28.9	0.57	83.7

Well 2: No AENV GIC #

Well 2 is located 70 m NW of Well 1 and used for stock purposes (Figure 20). A cattle feed lot is located immediately north and west of Well 2. The well was drilled to a depth of 20.16 m in the mid 1970's The well casing is constricted from a 0.45 m ID x 0.58 m OD concrete casing to a depth of 3.7 m, with a stick up of 0.80 m. The remainder of the well is completed with a wooden casing to 20 m. No seal was used between the casing and bore-hole. A removable submersible pump is shared between Wells 2 and 3. Water levels in the well were measured at 4.91 m and 6.91 m on October 27, 2009 and November 28, 2009, respectively. The large difference in water levels is likely due to recent pumping of the well.

Figure 20: Image to the left shows Well 2 located on Site 2. To the right shows Well 3 in the foreground and Well 2 in the background.

Groundwater collected from Well 2 shows that concentrations of U have decreased (Table 7). Since 2008 the concentration of U has decreased from 19.1 µg L^{-1} to 13.7 µg L^{-1} in 2009. Electrical conductivity of the groundwater has also shown a decrease since 2008. The presence of dissolved NO_3 (3.7 mg L^{-1}) in the groundwater suggested that the well could be receiving effluent livestock waste or agricultural practices.

Table 7: Selected geochemical parameters in groundwater measured in Well 2 during 2008 and 2009.

Date	U (µg L^{-1})	EC (µS cm^{-1})	SO_4 (mg L^{-1})	Cl (mg L^{-1})	NO_3 (mg L^{-1})	DO (%)
2008	19.1	2390	n/a	n/a	n/a	n/a
2009	13.7	2215	166	200	3.69	14.7

Well 3: AENV GIC # 0216248

Well 3 is located 63 m NW of Well 1 (7.45 m south of Well 2) and used for stock purposes (Figure 21). A cattle feed lot is located north and immediately west of Well 3. The well was drilled to a depth of 26.76 m sometime during the 1980's. The well casing is constructed from a 0.61 m diameter galvanized steel casing with a stick up of 0.72 m. A removable submersible pump is shared between Wells 3 and 2. Well 3 is completed in a poor yield aquifer that historically has a low water level. Groundwater from Well 2 is routinely pumped into Well 3 as an artificial storage reservoir. Water is then pumped to cattle feed lots. Water levels in the well were measured at 12.65 m and 22.88 m on October 27, 2009 and November 28, 2009, respectively. The significant difference in water levels is likely due to recent pumping of groundwater from Well 2 into Well 3 or the over pumping of Well 3.

Figure 21: Well 5, located on Site 1.

The pumping of groundwater from Well 2 into Well 3 makes it difficult to distinguish whether water is being sampled from the deeper formation or from Well 2. However, U concentrations in Well 3 exceed the Canadian Drinking Water Quality Guidelines, whereas U concentrations in Well 2 are below guidelines. During sampling in 2009, DO concentrations were measured a 92 % suggesting that water from Well 2 was likely injected prior to sampling (Table 8.). Injecting oxygen-rich water into the deeper aquifer could lead to the mobilization of uranium. The well casings for Wells 1 and 2 were not sealed between water-bearing units which suggest that cascading between the units could also be occurring resulting elevated dissolved U concentrations.

Table 8: Selected geochemical parameter in groundwater measured in Well 3 during 2008 and 2009.

Date	U (µg L^{-1})	EC (µS cm^{-1})	SO_4 (mg L^{-1})	Cl (mg L^{-1})	NO_3 (mg L^{-1})	DO (%)
2008	28.8	2240	n/a	n/a	n/a	n/a
2009	22.3	1911	226	102	2.32	91.8

5.2.2 New Monitoring Well Installed in 2009

Two monitoring well were installed at Site 2; a bundle piezometer and a background monitoring piezometer (Figure 18). The bundle piezometer (MW1) was installed 8 m from

Well 1 and the monitoring piezometer (MW2) was installed 172 m NE of Well 1 to prevent any influences from the pumping of existing wells.

During the installation of MW1, sediment stratigraphy was recorded and samples were collected (see Appendix B for a detailed description of well log). Brown oxidized clay/till was observed to a depth of 4.9 m. The clay/till in this layer consisted of clay with some silt lenses and some pebbles. A brown saturated silt layer was present between 1.5 m and 1.75 m, and a water-bearing unit consisting of brown saturated sandy silt was encountered between 3 and 3.5 m. At a depth of 4.9 m, there was a sharp transition from brown oxidized clay to grey pebbly clay. A grey fine to medium grained water-bearing sand was encountered from 12 to 12.3 m followed by grey clay. Grey clay was encountered from 12.3 to 13.5 m at which point drilling was terminated. One-inch diameter piezometers were installed over the upper (12 m) and lower (3 m) water-bearing units. A ½-inch CPVC piezometer was installed over the saturated silt layer at a 1.5 m depth but did not produce any water. Piezometers were installed following procedures described in the method section (Figure 22).

Figure 22: Image to the left shows the drilling of MW1 on Site 2. Image to the right shows MW1 with the feed lot and energy well batteries in the background. Well 1 is located 8 m directly to the east of MW1.

During the installation of MW2, clay was observed to extend from surface to a depth of 8.8 m at which point a grey medium grain water-bearing sand unit encountered to a depth of 9.1 m. The sand unit was underlain by grey clay with silty fine sand layers to 10.7 m at which point drilling was terminated. A 2-inch monitoring well was installed across the sand unit (Figure 23).

Figure 23: Image to the left shows the installation of MW2 on Site 2. Image to the right shows the completed well. Note the energy well battery in the background. Also to the north where the cattle are grazing is the fertilizer applied field.

Water levels measured from MW1-2 and -3 shows that there is a significant head difference of 6.37 m between the two aquifers indicating a strong downward vertical gradient (Table 5).

Figure 24 shows a depth profile of geochemistry from piezometer bundle MW1. Results show that U concentrations exceed drinking water guidelines with concentrations of 40.5 and 25.8 µg L^{-1} in piezometers MW1-1 and -2, respectively. Most parameters are more elevated in the upper aquifer.

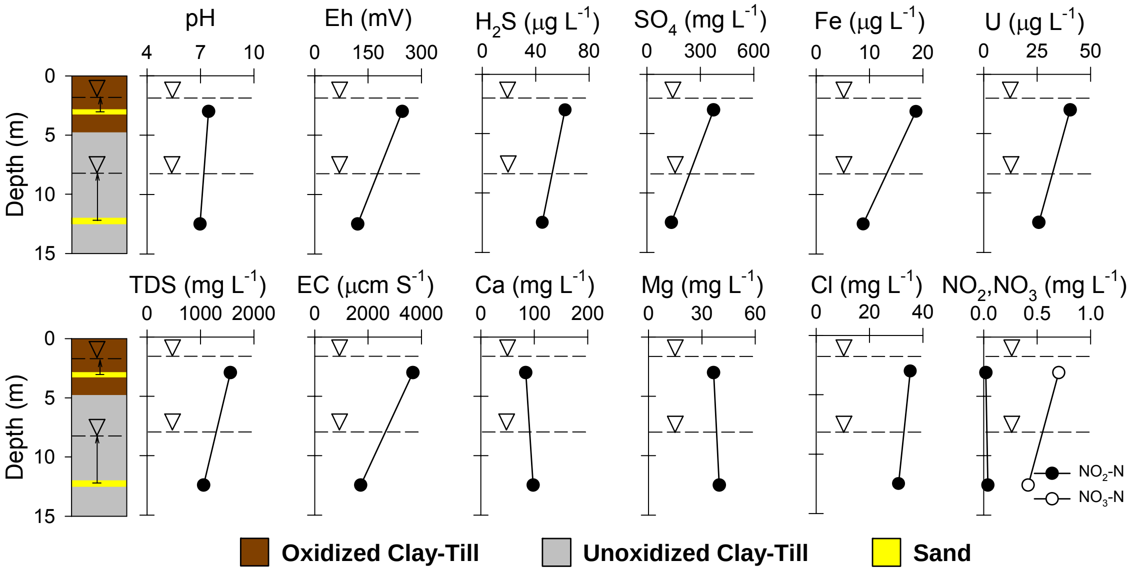


Figure 24: Profile of stratigraphy and groundwater chemistry from MW1, Site 2. The dashed line with inverted triangle represents the water table.

Groundwater sampled from the background well, MW2, contained dissolved U concentrations of 1.8 µg L^{-1}, much lower than groundwater sampled from other wells onsite. Other parameters such as NO$_3$, Cl and EC are also lower than other wells (AppendixA).

5.2.3 Geochemical Trends

Site 2 contains four water bearing units at depths of approximately 3.8 m (aquifer 1), 12 m (aquifer 2), 20 m (aquifer 3) and 26 m (aquifer 4). It was no possible to measure absolute elevation at each well therefore the exact depth to the aquifer varies between well locations. MW1-2 is completed in the aquifer 1; Well 1 and MW1-3 are completed in aquifer 2; Well 2 is completed in aquifer 3 and Well 3 is completed in aquifer 4. Well 1 is screened over aquifer 1 and 2. MW2 is uphill from MW1 and likely completed in aquifer 2, although it is difficult to confirm without actual elevations.

Figure 25 shows a comparison of selected ion concentrations from all wells grouped into the appropriate aquifers. Aquifer 1 exhibiting the highest concentration of U and other parameters. This aquifer is located in the oxidized zone of the clay/till and is relatively close to the surface (3 m).

Wells installed in aquifer 2 show variability in U concentrations and other parameters. Well 1 and MW1-2 are located 8 m apart but show some slight differences in U concentrations and other parameters. Water could be heard draining into Well 1 from a higher elevation. The water draining into Well 1 is likely leakage from aquifer 1 resulting in slightly elevated U concentration. Groundwater from MW2 has low concentration of U and is located a significant distance from the other wells. Aquifer 1 was not encountered during the drilling of MW2.

As discussed previously, water from Well 2 is routinely injected into Well 3. Concentrations between the aquifer 3 and 4 are similar, however aquifer 4 contains elevated U concentrations suggesting that aquifer 4 contains a greater concentration of U. Elevated NO_3 concentrations in aquifers 3 and 4 are likely a result of the adjacent cattle feed lot. Cascading along the well casing and bore-hole could also cause mixing with lower and upper waters.

A correlation between dissolved U concentrations and redox conditions can be seen in Figure 25. Groundwater from wells with a high Eh (oxidizing conditions) contains higher concentrations of U, whereas groundwater with a low Eh (reducing conditions) contains lower concentrations of U. Uranium is highly soluble in shallow oxidized groundwater (Ingebritsen and Sanford 1998) but becomes less mobile under reducing conditions due to sorption and precipitation reactions (Ivanovich et al., 1991). There is a similar trend between redox and NO_3/NH_3 concentrations. Under oxidizing conditions NO_3 is dominating, however under reducing conditions, NH_3 is more prevalent. Measurements of Eh also show that groundwater at Site 2 is more oxidized than groundwater from Site 1.

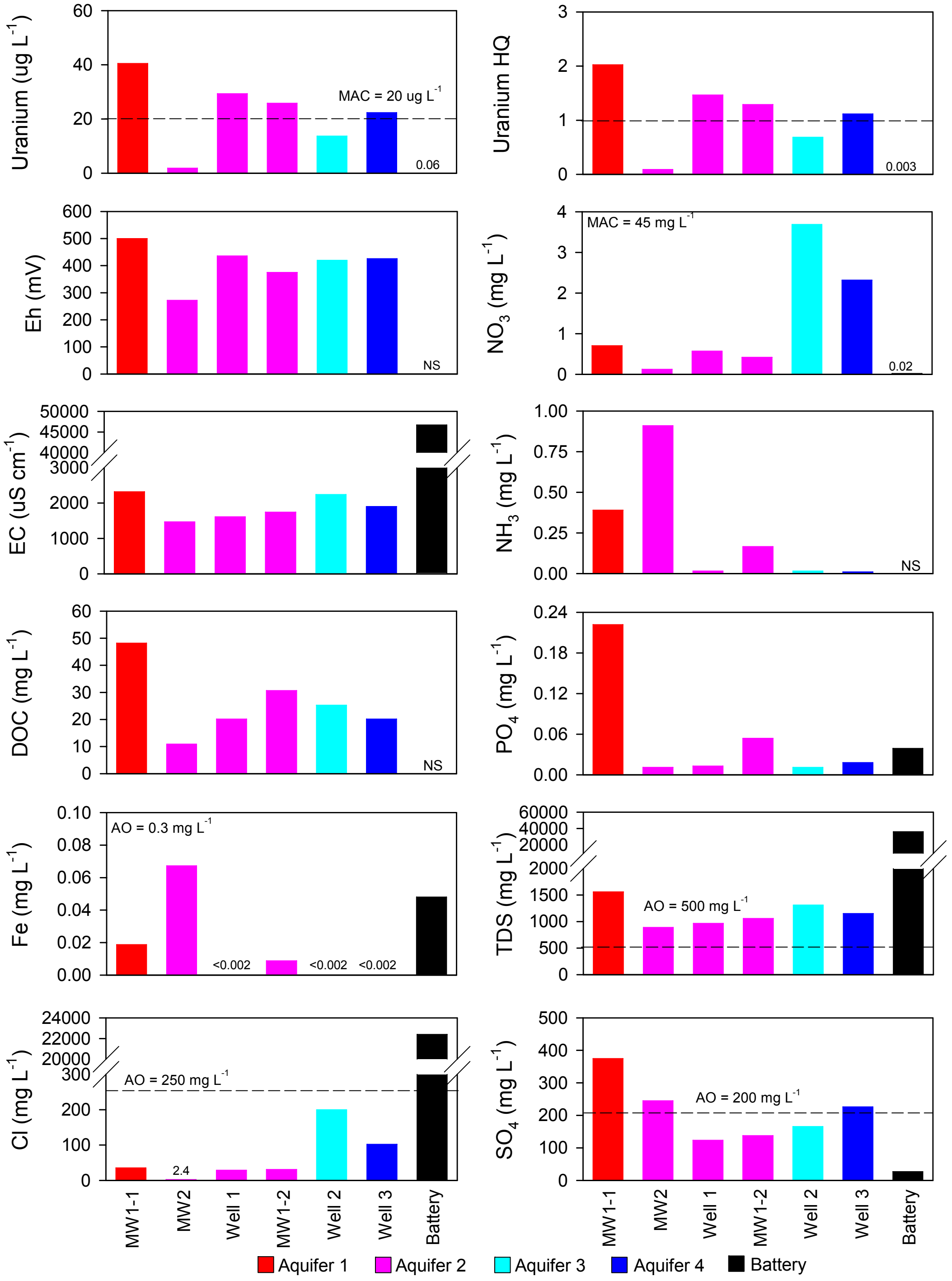


Figure 25: Bar graph showing the concentration of dissolved ions in the groundwater from each well on Site 2.

Wells are grouped according to the aquifers they a completed in. Uranium HQ represents the Uranium Hazard Quotient which is a calculation of the measured U concentration divided by the interim maximum allowable concentration (IMAC) U concentration. A value of zero indicates the concentration of U is at IMAC. Values above 1 show how many time the concentration exceeds the IMAC. NS: Not Sampled.

5.3 Speciation Modeling

Saturation indices were calculated using the geochemical model MINTEQA2. Calculated SI values for and U(VI) minerals carnotite [$K_2(UO_2)_2V_2O_8$], rutherfordine [UO_2CO_3], schoepite [$(UO_2)_8O_2(OH)_{12}$•$12(H_2O)$], tyuyamunite [$Ca(UO_2)_2V_2O_8 \cdot 5\text{-}8(H_2O)$], uranium hydroxide [$UO_3$], and Gummite (mixture of uraninite and secondary U minerals), and U(IV) minerals uraninite [UO_2] and amorphous UO_2, indicates that the groundwater from both the Site 1 and Site 2 water wells are undersaturated with respect to these mineral phases (Tables 10 and 11).

Table 9: Saturation indices for uranium mineral phases from Site 1 groundwaters calculated using MINTEQA2. SI >0-supersaturated; <0-undersaturated; near 0-equilibrium.

Location	Carnotite	Rutherfordine	Schoepite	Tyuyamunite	Crystalline	Gummite	Uraninite	Amorphous
Site 1	$K_2(UO_2)_2V_2O_8$	UO_2CO_3	$(UO_2)_4O(OH)_6$?$6H_2O$	$Ca(UO_2)_2V_2O_8$?$5\text{-}8(H_2O)$	UO_3	sec U(VI)	UO_2	UO_2
Well 1	-3.75	-3.85	-5.05	-3.46	-7.69	-10.54	-18.17	-24.14
Well 2	-3.84	-4.30	-5.51	-3.91	-8.12	-10.95	-18.76	-24.70
Well 3	-4.45	-5.50	-6.11	-4.63	-8.79	-11.67	-20.39	-26.41
Well 4	-4.81	-5.58	-6.07	-4.58	-8.73	-11.59	-20.47	-26.46
Well 5	-4.82	-4.84	-5.84	-4.68	-8.48	-11.33	-18.96	-24.93
MW1-1	-4.34	-4.29	-5.40	-4.40	-8.08	-10.96	-29.13	-35.15
MW1-2	-5.14	-5.56	-6.06	-5.07	-8.76	-11.65	-31.08	-37.12
MW1-3	-3.84	-4.16	-5.34	-3.91	-8.04	-10.93	-28.99	-35.03
MW2	-4.86	-4.87	-5.33	-4.64	-7.99	-10.86	-30.48	-36.49

Table 10: Saturation indices for uranium mineral phases from Site 2 groundwaters calculated using MINTEQA2. SI >0-supersaturated; <0-undersaturated; near 0-equilibrium.

Location	Carnotite	Rutherfordine	Schoepite	Tyuyamunite	Crystalline	Gummite	Uraninite	Amorphous
Site 2	$K_2(UO_2)_2V_2O_8$	UO_2CO_3	$(UO_2)_4O(OH)_6$?$6H_2O$	$Ca(UO_2)_2V_2O_8$?$5\text{-}8(H_2O)$	UO_3	sec U(VI)	UO_2	UO_2
Well 1	-4.68	-5.44	-5.93	-4.74	-8.56	-11.40	-20.41	-26.38
Well 2	-3.82	-4.63	-5.86	-4.47	-8.56	-11.44	-18.73	-24.77
Well 3	-5.24	-5.64	-6.22	-4.95	-8.93	-11.82	-20.41	-26.46
MW1-2	-3.14	-4.19	-5.52	-4.03	-8.26	-11.15	-29.07	-35.14
MW1-3	-4.06	-5.53	-6.12	-4.95	-8.84	-11.72	-31.12	-37.17
MW2	-6.27	-5.22	-6.35	-5.97	-9.04	-11.91	-30.08	-36.10

The dominate U complexes in the groundwater, determined through modeling results, are U hydroxides [$U(OH)^-$] for the U(IV) species, and uranyl carbonates [UO_2CO_3] for the U(VI) species. The relative abundances of these two complexes is 99.9 % bound in the U hydroxide as [$U(OH)_5^{-1}$] for U(IV) and 90 % and 5 % bound in uranyl carbonates [$UO_2(CO_3)_2^{-2}$] and [$UO_2(CO_3)_3^{-4}$] respectively, for U(VI). However, because the water wells are completed at a shallow depth, uranium would be in the (VI) oxidation state therefore, the dominate U species in the groundwater would be uranyl carbonates.

Calculations with MINTEQA2 show that groundwaters at Site 1 and Site 2 are at equilibrium or supersaturated with calcite, dolomite and other carbonate minerals, and Fe oxyhydroxides, suggesting that these phases may act as possible sinks for dissolved U concentrations. (Tables 12 and 13).

Table 11: Saturation indices for secondary mineral phases from Site 1 groundwaters calculated using MINTEQA2. SI >0-supersaturated; <0-undersaturated; near 0-equilibrium.

Location	Calcite $CaCO_3$	Dolomite $CaMg(CO_3)_2$	Magnesite $MgCO_3$	Siderite $FeCO_3$	Rhodochrosite $MnCO_3$	Gypsum $CaSO_4 \cdot 2H_2O$	Gibbsite $Al(OH)_3$	Basaluminite $Al_4(OH)_{10}SO_4$	Jarosite $KFe_3(SO_4)_2(OH)_6$	Ferrihydrite $Fe_2O_3 \cdot 0.5H_2O$	Lepidocrosite γ-FeO(OH)	Goethite α-FeO(OH)
Well 1	-0.01	0.10	-0.40	-3.19	-3.65	-0.80	0.93	1.36	-26.17	-6.40	-2.88	-1.16
Well 2	0.15	0.38	-0.29	-3.13	-1.51	-0.98	0.87	0.47	-26.03	-6.38	-2.86	-1.07
Well 3	0.67	1.40	0.23	-2.55	-2.10	-1.01	1.24	1.65	-22.63	-4.47	-0.95	0.68
Well 4	0.60	1.12	0.01	-0.27	-0.92	-1.02	0.05	-3.49	-15.75	-2.10	1.42	3.11
Well 5	-0.54	-0.95	-0.92	0.17	-1.56	-1.32	0.43	-0.81	-15.88	-2.84	0.68	2.41
MW1-1	-0.11	-0.55	-0.94	-0.11	-0.25	-0.43	0.89	2.08	0.33	2.19	5.71	7.34
MW1-2	0.55	0.85	-0.19	0.44	0.11	-0.90	1.40	2.59	2.77	4.05	7.57	9.16
MW1-3	-0.27	-0.69	-0.91	-1.72	-0.47	-0.98	0.73	1.34	-5.59	0.52	4.04	5.63
MW2	0.41	0.68	-0.24	-1.97	-0.62	-1.28	1.09	0.72	-4.87	1.65	5.17	6.84

Table 12: Saturation indices for secondary mineral phases from Site 2 groundwaters calculated using MINTEQA2. SI >0-supersaturated; <0-undersaturated; near 0-equilibrium.

Location	Calcite $CaCO_3$	Dolomite $CaMg(CO_3)_2$	Magnesite $MgCO_3$	Siderite $FeCO_3$	Rhodochrosite $MnCO_3$	Gypsum $CaSO_4 \cdot 2H_2O$	Gibbsite $Al(OH)_3$	Basaluminite $Al_4(OH)_{10}SO_4$	Jarosite $KFe_3(SO_4)_2(OH)_6$	Ferrihydrite $Fe_2O_3 \cdot 0.5H_2O$	Lepidocrosite γ-FeO(OH)	Goethite α-FeO(OH)
Well 1	0.55	1.01	-0.06	-2.49	-1.48	-1.46	0.52	-2.27	-22.76	-4.32	-0.80	0.93
Well 2	-0.03	-0.29	-0.75	-3.21	-2.89	-1.23	0.64	0.56	-26.59	-6.41	-2.89	-1.29
Well 3	0.62	1.01	-0.09	-2.56	-2.58	-1.12	0.32	-1.85	-23.37	-4.43	-0.91	0.67
MW1-2	-0.41	-1.21	-1.27	-1.78	-1.15	-1.20	2.82	10.09	-5.58	0.32	3.85	5.38
MW1-3	0.41	0.43	-0.47	-1.52	-0.25	-1.49	1.52	2.79	-3.32	1.99	5.51	7.09
MW2	-0.17	-0.88	-1.20	-0.82	-0.86	-1.03	1.48	3.94	-3.33	1.45	4.97	6.60

The secondary precipitate collected at Site 1, Well 1, from the plumbing fixtures effervesced when HCl was applied to the mineral surface indicating that the precipitate is likely a secondary carbonate phase. Total digestion of the secondary precipitate shows that Ca is the dominate cation suggesting that the mineral phase could be poorly crystalline calcite [$CaCO_3$]. Also measured from the total digestion was a significant concentration of U, indicating that some U is precipitating or co-precipitating and being removed from solution (Table 14). The elevated Cu and Zn concentrations are a result of leaching from copper plumbing.

Table 13: Total concentrations extracted from secondary precipitates collected from Site 1 in Well 1 and Well 4.

Location	U mg/kg	Ca mg/kg	Mg mg/kg	Fe mg/kg	Cu mg/kg	Zn mg/kg	Al mg/kg	As mg/kg	Mn mg/kg
Well 1	143	282107	16162	488	19913	3838	183	1.47	328
Well 4	0.59	468	92.9	854	0.44	216	6.32	0.004	2.8

Analysis of the orange secondary precipitate collected from the bottom of Well 4, Site 1, indicates that the dominate ion is iron, suggesting that the precipitate is likely a poorly crystalline Fe-oxyhydroxide mineral phase (Table 14). Concentrations of U were also measureable in the secondary precipitate suggesting that some U is precipitating or co-precipitating and being removed from solution. It has been documented that U in groundwater is adsorbed to ferric oxyhydroxides such as goethite, ferrihydrite and amorphous ferric oxyhydroxide (Hsi and Langmuir, 1985; Duff and Amrhein, 1996; Logue et al., 2004).

The natural removal of U through the precipitation of secondary mineral phases may reduce the concentration of dissolved U in groundwater thereby improving water quality. However, it should be noted that through well rehabilitation methods where acid is used to remove scale from the well and plumbing, U can easily be remobilized into solution, significantly increasing dissolved U concentrations in the water.

6 SOURCES OF URANIUM

6.1 Oxidation Processes

Tills and other overburden sediments may release natural concentrations of uranium minerals as they are eroded. Uranium sources in the till or clay material may include:

- U contained in carbonate rock fragments,,
- Precambrian rock material,
- U adsorbed onto organic material or clay minerals, and
- U contained within the crystal structure of minerals either in Precambrian rock fragments or in detrital minerals in the till/clay deposits (Betcher et al., 1988).

Over 100s to 1000s of years, oxygen diffuses into the soils and oxidized the minerals releasing dissolved ions into the pore water. Over time, meteoric water eventually displaces the pore water downward through pore space and fractures. Although clays tend to have a very low intergranular permeability, frequently they can be fractured and these clays were observed to have thin lenses of silt which may increase the permeability. This process is clearly demonstrated by Ranville, et al. (2007), where glacial till in central Saskatchewan has been weathered between 7 ka and 10 ka. The till has been oxidized to a depth of 4 m, evident from a brown color and fractures. Oxidation of the till at that site resulted in the release of elevated concentrations of dissolved uranium and other ions to the pore water. Where this process occurs, one would expect concentrations of dissolved ions to decrease with depth into the unoxidized zone, due to the absence of oxidizing conditions. Leaching of U and other metals from tills due to surficial weathering has also been observed by Betcher et al. (1988), Ivanovich et al. (1991) and Gilliss, et al., (2004). This weathering process may be the source of U in the groundwaters in the Bonnyville area.

Figure 26 shows depth profiles of total metal and major cation concentrations measured in sediment samples. The upper four points represent samples from the weathered clay, the next point is from unweathered clay and the bottom three points are samples from the aquifer material. Overall the plots show lower concentrations of major cations, Al and U in the near surface of the profile increasing in concentration with depth toward the unweathered material. The upper portion of the profile represents a zone of leaching due to the greater susceptibility to oxidation. In this zone, concentrations of major cations, Al and U are low because they have been removed by weathering. With depth, the ingress of oxygen decreases resulting in an underlying zone with increased concentrations of metals and major cations. Uranium concentrations within the aquifer material show an abrupt decrease indicating that the aquifer material contains a lower abundance of U than the overlying clay/till material. Although the average concentration of solid-phase U in the clay/till material is quite low (average 2.07 mg kg^{-1}, range 1.61-2.66 mg kg^{-1}), similar U concentrations in Lake Agassiz clays (average 2.3 mg kg^{-1}) led to U concentrations in the till pore water up to 250 µg L^{-1} and in the underlying sand and gravel aquifers up to 155 µg L^{-1} (Betcher et al., 1988). The lower abundance of U in the actual sand aquifer sediments combined with the elevated concentrations of dissolved U, Na, Mg and SO_4 in groundwater in this unit at Site 1, Well 1, provides a strong indication that elevated U concentrations are due to downward leakage of weathering products from the overlying clay/till unit.

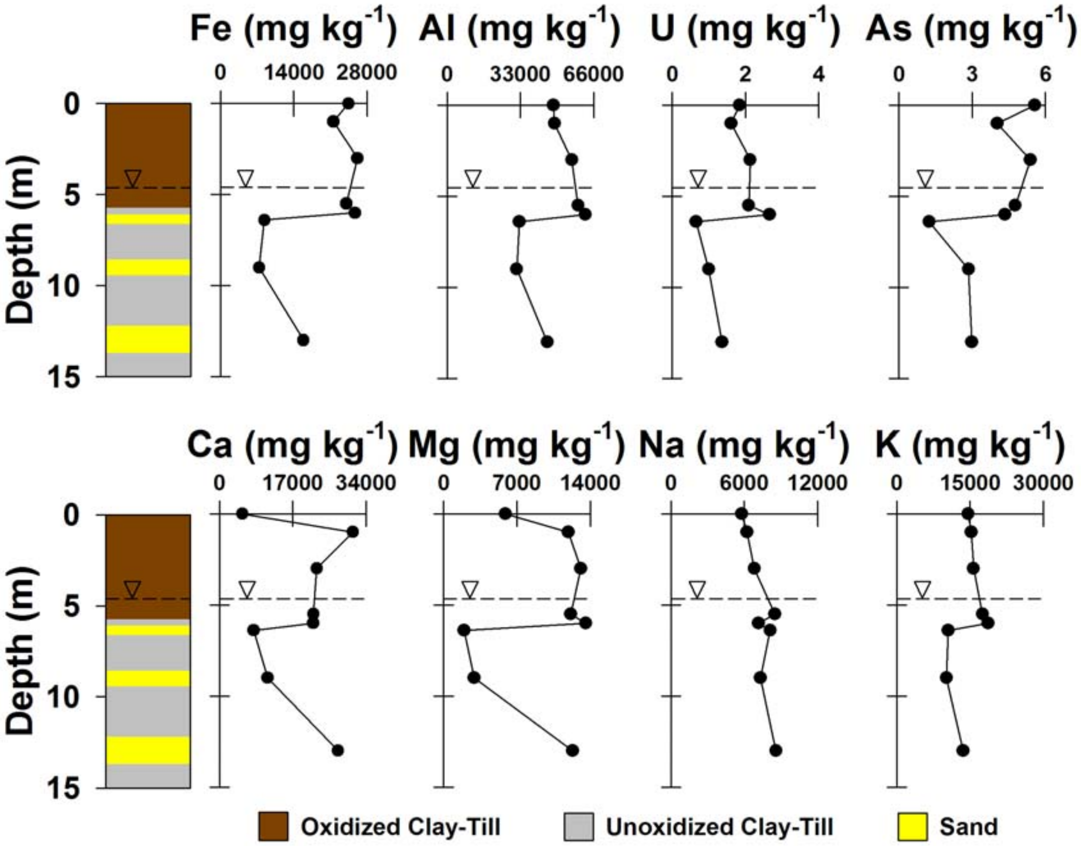


Figure 26: Depth profile showing stratigraphy and total solid concentrations at Site 1, MW1. The dashed line with inverted triangle represents the water table.

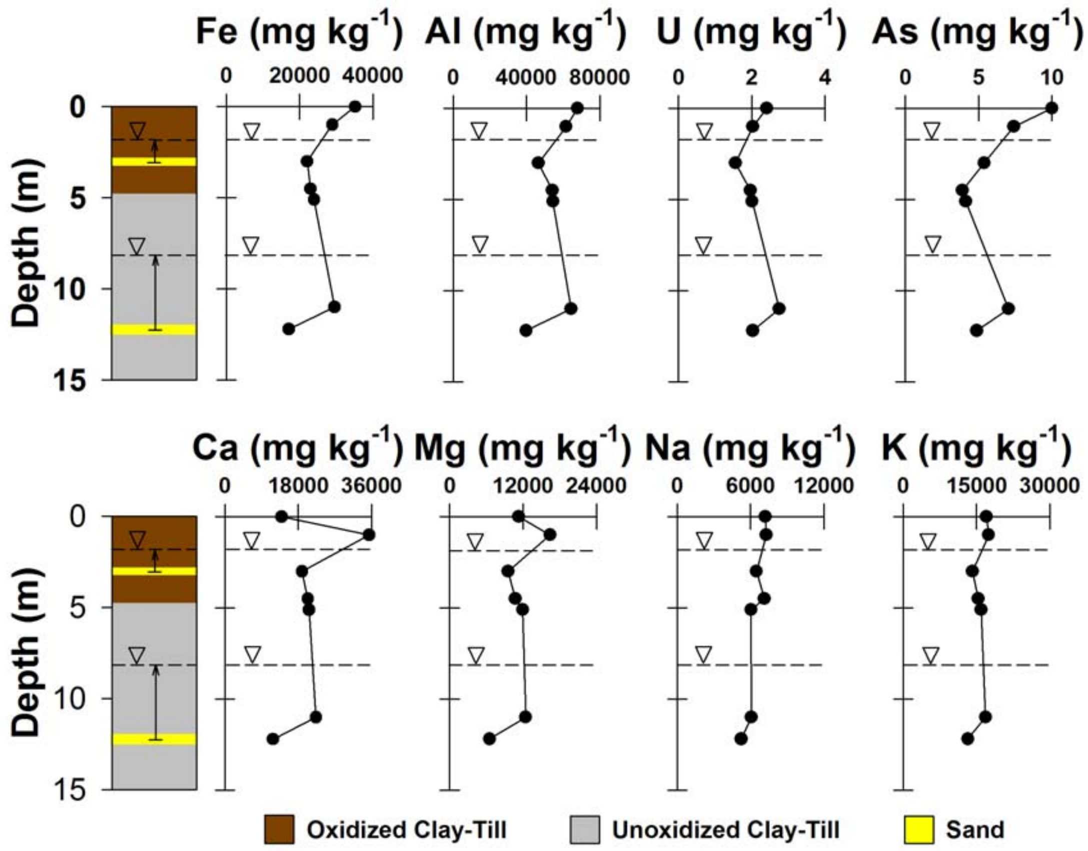


Figure 27: Depth profile showing stratigraphy and total solid concentrations at *<u>Site 2</u>, MW1. The dashed line with inverted triangle represents the water table for the upper and lower aquifers.*

The over-pumping of groundwater may also increase the ingress if oxygen into a water bearing zone. Over-pumping of poorly completed or low yield water wells can create large drawdown cones in the water table, exposing sediments that would normally be saturated to oxygen. This may cause weathered sediments adjacent to the water well to release dissolved concentration of ions to the pore waters. When pumping stops, the water table recovers and mobilizes the dissolved ions. During pumping, poorly completed wells can also cause cascading along the well casing between an upper contaminated aquifer and a deeper aquifer.

6.2 Fertilizers

Uranium is a trace constituent of many phosphate bearing fertilizers and the enrichment of U in fertilizer compared to soils suggests that fertilizer could contribute dissolved U to irrigation drainage (Zielinsli, et al., 1997). Reported U concentrations of 20-200 $\mu g\ g^{-1}$ in fertilizers correlate positively with percentage of P_2O_5 (Spalding and Sackett, 1972), and are comparable to the range of U concentrations found in phosphate rock from all major producing areas of the world (Menzel, 1968). As mentioned in section 2.2, fertilizer was previously applied to a field at Site 2, 125 m NE from Well 1. The field slopes towards wells at Site 2, therefore surface water runoff and groundwater flow from the field is likely directed towards the wells.

Analyses of the three sediment cores collected from the field are shown in table 15. Results show that there are no elevated U concentrations in the upper 0.6 m on the sediments and it is unlikely that a U-bearing fertilizer was applied to the field. The concentration of U in the field sediments is lower than U concentrations in the upper meter of sediments collected from MW1 (Table 15).

Table 14: Metals and major cation concentrations from the total digestion sediments collected from a field with applied fertilizer.

Location	North	West	Depth (m)	U ($mg\ kg^{-1}$)	Ca ($mg\ kg^{-1}$)	Mg ($mg\ kg^{-1}$)	Na ($mg\ kg^{-1}$)	K ($mg\ kg^{-1}$)	Al ($mg\ kg^{-1}$)	Fe ($mg\ kg^{-1}$)	As ($mg\ kg^{-1}$)	PO_4 ($mg\ kg^{-1}$)
Site2-A	54.46606	110.67031	0.59	1.51	5860	3368	6164	13927	41096	18303	3.49	366
Site2-B	54.46700	110.67040	0.59	1.29	7359	3310	5641	13037	40344	17333	3.26	691
Site2-C	54.46439	110.67245	0.6	1.19	7949	3556	6553	12369	38775	17294	4.07	345
MW1	54.46453	110.67227	0-1	2.22	24702	13868	7248	17254	64755	32056	8.71	530

6.3 Land Applied Drill Cuttings

Rocks of Western Canadian Sedimentary Basin contain significant and variable amounts of uranium. There is the potential to mobilize uranium minerals from land applied drill cuttings through oxidation and leaching on the surface. Dissolved uranium could potentially move with infiltrating water down into the water table. As mentioned in section 2.1, land applied drill cuttings were applied to a field at Site 1.

Analyses of the three sediment cores collected from the field are shown in table 16. Results show that there are no elevated U concentrations in the upper 0.6 m on the sediments and it is unlikely that the drill cuttings applied to the field were U-bearing. The concentration of U in the field sediments is similar to U concentrations in the upper meter of sediments collected from MW1 (Table 16).

Table 15: Metals and major cation concentrations from the total digestion sediments collected from a field with applied drill cuttings.

Location	North	West	Depth (m)	U ($mg\ kg^{-1}$)	Ca ($mg\ kg^{-1}$)	Mg ($mg\ kg^{-1}$)	Na ($mg\ kg^{-1}$)	K ($mg\ kg^{-1}$)	Al ($mg\ kg^{-1}$)	Fe ($mg\ kg^{-1}$)	As ($mg\ kg^{-1}$)	PO_4 ($mg\ kg^{-1}$)
Site1-A	54.27001	110.67003	0.43	2.96	6285	5225	5755	14237	49224	22832	4.35	447
Site1-B	54.27071	110.67000	0.56	2.01	6536	5251	6233	15754	51757	23725	4.72	442
Site1-C	54.27146	110.67000	0.59	1.85	10855	7710	6137	14461	49099	21442	4.45	479
MW1	54.26855	110.67294	0-1	1.73	18136	8903	6001	14917	48128	23022	4.80	332

6.4 Processed Water

Petroleum reservoirs can contain uranium in variable concentrations. Uranium in gas, oil or produced water can concentrate in sludges and scales in tubes, lines and equipment. Poorly completed wells or spills may also contribute to surface water and groundwater contamination. Normally, concentrations in produced fluids are not high enough to cause problems from a leaking energy well or facility into the groundwater. In the vicinity of the Site 1 and Site 2 properties, energy wells have oil or oil and gas production from the Grand Rapids Formation from a depth of 500 to 600 m. These wells also have produced water.

At each site, groundwater water was sampled for routine analyses, dissolved metals, total metals, volatile priority pollutants (VPP) and extractable priority pollutants (EPP) from a battery located adjacent to the site and the main water well used for potable water. Samples were collected to determine if the produced water was impacting these wells.

Tables 17 and 18 show only the VPP and EPP where concentrations of organic compounds were detected (Appendix D lists all organic compound analyzed for VPP and EPP). The results in tables 17 and 18 show no correlation between the produced water from the batteries and the Site 1 and 2 wells. In most cases, VPP and EPP concentrations in the water wells are near or below detection and concentrations in the produced water from the batteries are well above detection limits.

Table 16: Site 1 groundwater concentration of volatile priority pollutants and extractable priority pollutants collected from the Well 1 and the Battery adjacent to the site.

Compound Name	Volatile Priority Pollutants (μg/L)		Detection Limit
	Site 1 - Well 1	Site 1 - Battery	
1,2,4-Trimethylbenzene	nd	**23.9**	0.1
1,3,5-Trimethybenzene	nd	**12**	0.1
Benzene	nd	**2530**	0.1
Ethyl benzene	nd	**139**	0.1
Isopropylbenzene	nd	**7.3**	0.1
m,p-Xylene	nd	**1130**	0.1
Toluene	**0.3**	**14300**	0.1
Xylenes	nd	**1390**	0.1
o-Xylene	nd	**260**	0.1

Compound Name	Extractable Priority Pollutants (μg/L)		Detection Limit
	Site 1 - Well 1	Site 1 - Battery	
Butylbenzylphthalate	**0.1**	nd	0.1
Di-n-butylphthalate	**0.4**	nd	0.1
Acenaphthene	nd	**3.9**	0.1
Bis(2-ethylhexyl)phthalate	**0.5**	**56.8**	0.1
Diethyl phthalate	**0.1**	nd	0.1

Table 17: Site 2 groundwater concentration of volatile priority pollutants and extractable priority pollutants collected from the Well 1 and the Battery adjacent to the site.

Compound Name	Volatile Priority Pollutants (µg/L)		Detection Limit
	Site 2 - Well 1	**Site 2 - Battery**	
1,2,4-Trimethylbenzene	nd	**1.1**	0.1
Chloroform	**0.1**	nd	0.1
Ethyl benzene	nd	**10**	0.1
m,p-Xylene	nd	**2.9**	0.1
Trihalomethanes	**0.1**	nd	0.1
Xylenes	nd	**4.6**	0.1
o-Xylene	nd	**1.8**	0.1

Compound Name	Extractable Priority Pollutants (µg/L)		Detection Limit
	Site 2 - Well 1	**Site 2 - Battery**	
Benzo(a)pyrene	nd	**24.3**	0.1
Butylbenzylphthalate	**0.2**	nd	0.1
Di-n-butylphthalate	**0.5**	nd	0.1
Fluorene	nd	**10.9**	0.1
Phenanthrene	nd	**29.4**	0.1
Acenaphthene	nd	**20.7**	0.1
Benzo(a)anthracene	nd	**6.3**	0.1
Bis(2-ethylhexyl)phthalate	**0.8**	nd	0.1
Diethyl phthalate	**0.1**	nd	0.1
Fluroanthene	nd	**25.0**	0.1

Figures 17 and 25 shows the uranium concentration measured in the processed water compared to U concentrations measured from the water wells. In all cases U concentrations are significantly higher in the water wells then those measured from the processed water, indicating that the energy wells are an unlikely source of U.

6.5 Isotope Chemistry

6.5.1 Oxygen and Hydrogen Isotopes of Water (δ^{18}O and δ^{2}H)

The oxygen and hydrogen isotope ratio of water can be used to determine the origin of water in a hydrogeological system. It is possible to differentiate normal meteoric water from water that has undergone significant water/rock interaction and mixing with basinal brines. Oxygen and hydrogen isotopes can be used to identify different water sources that may have mixed with the ambient water, due to pressure and gradient changes caused by pumping energy wells.

A plot of δ^{18}O versus δ^{2}H is presented in Figure 28. The global meteoric water line (GMWL) represents the isotopic composition of precipitation (rain and snow) that falls on the earth. Summer rain is isotopically more enriched (more positive) and plots on the right hand side of the GMWL while winter precipitation is more depleted (negative) and can plot slightly to the left hand side of the GMWL. Also shown on the plot is the local meteoric water line (LMWL) plotted using precipitation data from the International Atomic Energy Agency (IAEA) station located in Edmonton. The isotopic trend of deeper basinal brine water is also shown on Figure 28.

The isotopic signature of water from the residential and monitoring wells on Site 1 and Site 2 all follow the local meteoric water line. This indicates that the origin of the water in these wells is meteoric precipitation. The $\delta^{18}O$ and $\delta^{2}H$ values are shifted slightly to the right of the LMWL indicating that the waters are more evaporated which is expected since Bonnyville is located west of Edmonton. There is no component of basinal brine water in the residential wells. Water collected from the Batteries contains $\delta^{18}O$ and $\delta^{2}H$ values that are more enriched (evaporated) and plot between the LMWL and the brine water signature. The oxygen signatures of brines tend to be isotopically enriched due to evaporation (Hitchon 1969). Therefore the Battery $\delta^{18}O$ and $\delta^{2}H$ water values may represent water that is a mixture of local meteoric water and brine water.

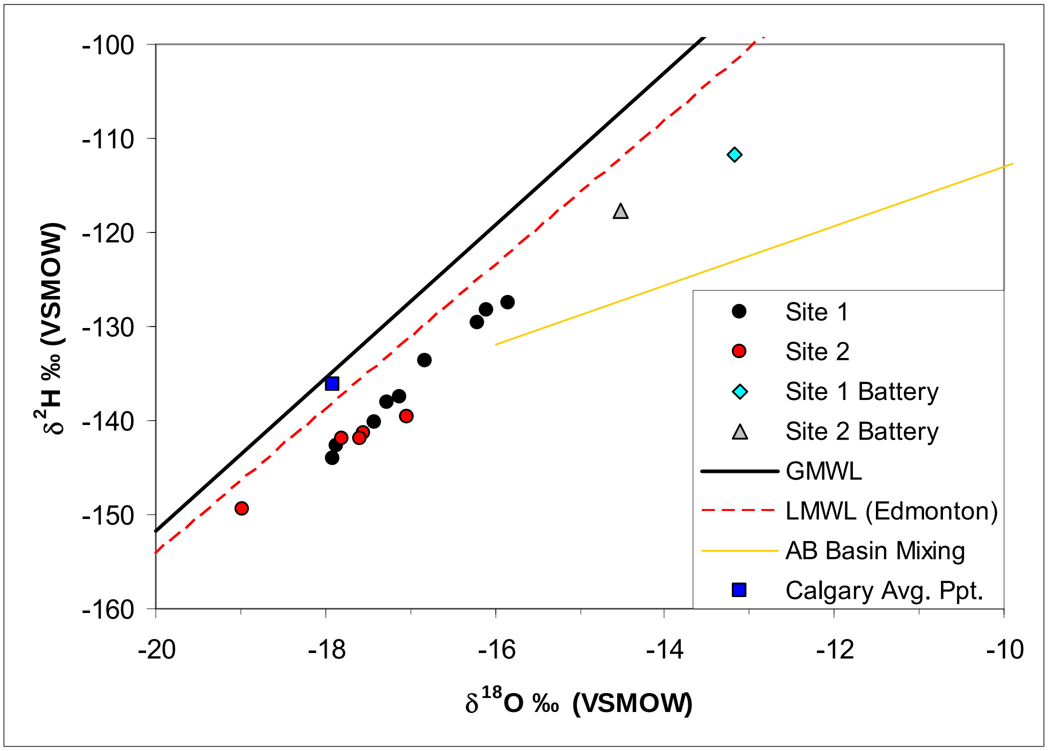


Figure 28: Plot showing $\delta^{2}H$ versus $\delta^{18}O$ measured in groundwater from Sites 1 and 2 and the Batteries. VSMOW – Vienna Standard Mean Ocean Water.

6.5.2 Carbon Isotopes of Dissolved Inorganic Carbon ($\delta^{18}O$ and $\delta^{2}H$)

Carbon isotopes of the DIC in the groundwater were collected from the residential wells and two Batteries. The average $\delta^{13}C$-DIC value for all water wells on Sites 1 and 2 is -14.28 ‰ and shows little variation with a standard deviation of 1.01 ‰. Groundwater typically has a $\delta^{13}C$-DIC signature between -20 to 0 ‰ (Clark and Fritz, 1997). Water collected from the Batteries shows a significant difference in $\delta^{13}C$-DIC signature with values of 4.38 ‰ and 23.80 ‰ from Batteries 1 and 2, respectively (Figure 29). The large difference in $\delta^{13}C$-DIC values between the water wells and produced water from the Batteries indicates that it is unlikely that produced water is mixing with shallow ground water at either Site. If water was mixing between the two water types, one would expect to see a shift towards positive values in the δ13C-DIC signature of the groundwater, however that is not occurring evident from the tightly grouping of the δ13C-DIC values.

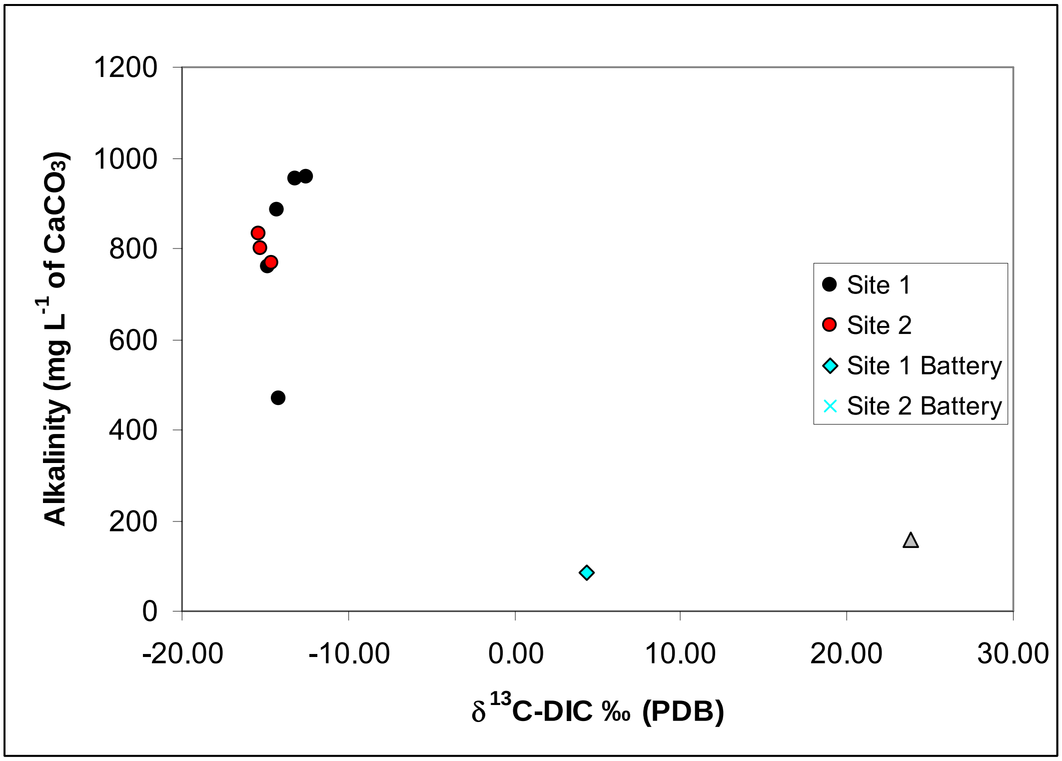


Figure 29: Plot showing alkalinity versus δ^{13}C-DIC measured in groundwater from Sites 1 and 2 and the Batteries. DIC – Dissolved Inorganic Carbon; PDB – Pee Dee Belemnite.

7 CONCLUSIONS

The following conclusions were made:

- Current status of area water wells:
  - Elevated concentrations of U in the groundwater at the two sites investigated exceed Guidelines for Canadian Drinking Water Quality. The highest concentration of U occurs in the shallowest aquifers.
  - U concentrations in groundwater are increasing over time in all previously existing water wells located on Site 1, Resident A's property.
  - U concentrations in groundwater are decreasing over time in all existing water wells located on Site 2
  - The main source of elevated U concentration in groundwater observed in deeper aquifers is a result of poorly completed wells causing oxidizing conditions due to mixing between the upper and lower aquifers.

- Source of U:
  - There is no indication that produced water from the energy wells adjacent to Sites 1 and 2 are contributing to elevated U concentrations in the groundwater. U concentrations in the produced water are significantly lower than U concentrations measured in most water wells. Volatile and extractable priority pollutants measured in the produced water were not detected in the resident wells at Sites 1 and 2.
  - Measurements of δ18O, δ2H, and δ13C-DIC from the produced water and groundwater from well on Sites 1 and 2 indicate that there is no mixing between the two water types.
  - The low concentration of solid phase U in sediments from the field where fertilizer was applied indicates that fertilizing is not contributing to elevated U concentrations in the groundwater.
  - The lack of elevated U in sediments from the field where applied drill cuttings were sprayed indicates that this was not a source of elevated U concentrations to the groundwater.
  - The presence of dissolved U concentrations in a shallow background monitoring well installed at Site 1 located away from any influences from existing wells suggests a natural source of U in local shallow sediments.
  - The primary source of U in the aquifers is likely due to weathering of the overlying clay/till deposits. U concentrations in both solid phase sediment concentrations and in the dissolved phase in groundwater at Site 1 are consistent with this explanation. This suggests that elevated U concentrations in shallow groundwater could be a regional problem.

- Controls on U mobility:
  - Redox conditions appear to control dissolved U concentrations in groundwater. Groundwater from wells with oxidizing condition (higher DO and Eh) contain a higher dissolved U concentration then wells with reducing conditions, regardless of depth.
  - Geochemical modeling has given some insight into the controls on U mobility. Secondary carbonate and Fe oxyhydroxide mineral phases are at equilibrium with the groundwater and could be controlling the concentration of U in the groundwater.
  - Whole rock analyses on a secondary carbonate and Fe oxyhydroxide mineral phases collected from two wells at Site 1 contain U concentrations indicating that U is being removed from solution through co-precipitation or sorption reactions.

8 RECOMMENDATIONS

- Elevations should be measured from each well to determine accurate vertical aquifer locations and to calculate the groundwater flow direction.
- In order to fully understand the distribution of dissolved U concentration in the groundwater it is imperative to understand the source of U. A mineralogy study of the archived clay/till material is highly recommended to identify solid-phase sources of U and observe the extent of weathering in the oxidized zone. Understanding the

amount, mineral phase, weathered surfaces and oxidation state of the U would provide knowledge about the stability of the mineral, extent of weathering and may provide insight to future releases of U from the sediments. It would also be beneficial to properly identify the secondary mineral precipitates to understand how U is removed from groundwater through co-precipitation or sorption reactions.

- Other shallow wells in the region should be sampled for U concentrations to determine if elevated U in the shallow groundwater is local or regional.
- Overburden wells in the area completed over multiple aquifers should also be sampled for U concentrations in the groundwater.
- A distilled water extract or squeezing method could be applied to the archived clay/till material to determine the pore water concentration of U with depth.

9 CLOSURE

AITF is pleased to present the findings of this Phase II investigation into the source and controls of uranium in groundwater from the Site 1 and Site 2 wells in the Bonnyville area. We look forward to any comments and discussions.

Sincerely,

Michael Moncur, M.Sc.,
Research Hydrogeologist

10 ACKNOWLEDGMENTS

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APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	$\delta^{18}O$ (‰)	$\delta^{2}H$ (‰)	d-excess (‰)	$\delta^{13}C$ (‰)	pH Field	pH Lab	Eh Field (mV)	$Eh_{corrected}$ Field (mV)	DO Field (mg L^{-1})	H_2S Field (µg L^{-1})
SITE 1											
Well1	10/28/2009	-15.84	-127.55	-0.85	-14.32	6.88	7.8	162	416	23.80	0
Well 2	10/28/2009	-16.21	-129.61	0.07	-13.13	6.74	7.44	68	322	13.9	60
Well 3	10/28/2009	-16.10	-128.36	0.46	-12.48	6.69	7.33	199	453	9.00	11
Well 4	10/28/2009	-17.13	-137.41	-0.36	-14.83	6.85	7.48	-3	251	5.50	9
Well 5	10/28/2009	-17.26	-138.02	0.08	-14.22	7.9	8.15	-213	41	6.00	2
MW1-1	11/27/2009	-17.90	-143.96	-0.75		7.01	7.42	-206	48		9
MW1-2	11/27/2009	-17.88	-142.66	0.36		7.17	7.51	-323	-69		30
MW1-3	11/27/2009	-17.43	-140.10	-0.68		7.09	7.5	-236	18		3
MW2	11/27/2009	-16.81	-133.70	0.82		7.15	7.73	-44	210		42
Battery	10/30/2009	-13.17	-111.73	-6.37	4.38		7.1				
SITE 2											
Well1	10/29/2009	-17.54	-141.44	-1.08	-15.29	7.00	7.81	182	436	83.70	3
Well1 (dup)	10/29/2009						7.64				
Well 2	10/28/2009	-17.59	-141.96	-1.22	-15.32	6.89	7.23	166	420	14.70	3
Well 3	10/29/2009	-17.81	-141.97	0.49	-14.63	7.06	7.58	172	426	91.80	2
MW1-2	11/28/2009	-17.04	-139.69	-3.40		7.46	7.79	246	500		62
MW1-3	11/28/2009	-17.04	-139.65	-3.33		6.98	7.66	121	375	77.30	45
MW2	11/28/2009	-18.98	-149.40	2.45		6.9	7.5	18	272	74.10	8
Battery	10/29/2009	-14.52	-117.70	-1.53	23.80		7.71				
Aesthetic Objectives						6.5-8.5	6.5-8.5				≤50
Maximum Acceptable Concentrations											
CDWQG											

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	EC Field (µS cm^{-1})	EC Lab (µS cm^{-1})	TDS Lab (mg L^{-1})	Hardness Routine (mg L^{-1} $CaCO_3$)	Temp Field (degC)	Alkalinity$_{total}$ Field (mg L^{-1} $CaCO_3$)	Alkalinity$_{total}$ Lab (mg L^{-1} $CaCO_3$)
SITE 1								
Well1	10/28/2009	3910	3910	2590	1600	7.86	632	885
Well 2	10/28/2009	3980	3950	2410	1530	9.50	768	954
Well 3	10/28/2009	3988	4010	2440	1560	5.52	772	959
Well 4	10/28/2009	2069	2080	1320	978	7.04	628	759
Well 5	10/28/2009	1294	1320	845	565	5.34	420	470
MW1-1	11/27/2009	2417	2410	1980	1280	5.62	488	602
MW1-2	11/27/2009	2035	2050	1230	817	4.66	560	663
MW1-3	11/27/2009	2015	2050	1300	735	4.67	528	638
MW2	11/27/2009	1535	1580	960	554	6.38	540	685
Battery	10/30/2009		59300	42100	3010	42.10	152	85.7
SITE 2								
Well1	10/29/2009	1598	1610	973	606	8.19	636	802
Well1 (dup)	10/29/2009		1610	959	526		720	802
Well 2	10/28/2009	2215	2240	1310	846	4.65	656	834
Well 3	10/29/2009	1911	1900	1150	828	4.32		769
MW1-2	11/28/2009	3680	2320	1560	340	3.30	692	933
MW1-3	11/28/2009	1723	1740	1060	369	4.33	664	816
MW2	11/28/2009	1413	1470	887	548	5.60	484	620
Battery	10/29/2009		46700	36200	1680	39		157
Aesthetic Objectives				≤500		≤15		
Maximum Acceptable Concentrations								
CDWQG								

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	P-Alkalinity Routine (mg L^{-1} $CaCO_3$)	Bicarbonate Routine (mg L^{-1})	NH_3-N Nutrient (mg L^{-1})	NO_2-N Routine (mg L^{-1})	NO_3-N Routine (mg L^{-1})	NO_2+NO_3 Routine (mg L^{-1})	Ortho-PO_4-P Nutrient (mg L^{-1})	P Dissolved (µg L^{-1})
SITE 1									
Well1	10/28/2009	<1.0	1080	0.008	0.002	97.798	97.8	0.015	16.2
Well 2	10/28/2009	<1.0	1160	0.021	0.109	21.691	21.8	0.037	57.8
Well 3	10/28/2009	<1.0	1170	0.016	0.028	23.172	23.2	0.033	51.2
Well 4	10/28/2009	<1.0	925	0.07	0.001	0.896	0.897	0.007	6.51
Well 5	10/28/2009	<1.0	572	0.55	<.001	<.005	<.005	0.047	65.4
MW1-1	11/27/2009	<1.0	734	0.94	0.012	0.018	0.03	0.023	
MW1-2	11/27/2009	<1.0	808	0.81	0.003	0.205	0.208	0.074	
MW1-3	11/27/2009	<1.0	778	0.58	0.08	14.52	14.6	0.041	
MW2	11/27/2009	<1.0	835	0.112	0.013	2.477	2.49	0.017	
Battery	10/30/2009	<1.0	104		0.001	0.115	0.116		147
SITE 2									
Well1	10/29/2009	<1.0	978	0.015	<.001	0.194	0.194	0.013	12.2
Well1 (dup)	10/29/2009	<1.0	977		<.001	0.944	0.944	0.013	12.1
Well 2	10/28/2009	<1.0	1020	0.015	0.002	3.688	3.69	0.011	14.4
Well 3	10/29/2009	<1.0	937	0.01	0.001	2.319	2.32	0.018	13.1
MW1-2	11/28/2009	<1.0	1140	0.39	0.021	0.703	0.724	0.222	
MW1-3	11/28/2009	<1.0	995	0.166	0.039	0.417	0.456	0.054	
MW2	11/28/2009	<1.0	756	0.91	0.011	0.122	0.133	0.011	
Battery	10/29/2009	<1.0	192		<.001		0.022	0.039	<.800
Aesthetic Objectives									
Maximum Acceptable Concentrations						45	45		
CDWQG									

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	P Recoverable ($\mu g\ L^{-1}$)	TKN Nutrient ($mg\ L^{-1}$)	DOC Nutrient ($mg\ L^{-1}$)	Silica Routine ($mg\ L^{-1}$)	Si Dissolved ($mg\ L^{-1}$)	Si Recoverable ($mg\ L^{-1}$)	Cl Routine ($mg\ L^{-1}$)	Cl Dissolved ($mg\ L^{-1}$)	Cl Recoverable ($mg\ L^{-1}$)
SITE 1										
Well1	10/28/2009	14.4	1.29	31	21.6	11.1	8.62	298	256	252
Well 2	10/28/2009	52.4	1.94	24.8	14.7	7.85	6.34	653	625	596
Well 3	10/28/2009	58.3	2.48	27	16.8	10.4	9.24	651	573	576
Well 4	10/28/2009	7.6	0.89	15.1	13.9	7.06	6	140	120	126
Well 5	10/28/2009	83.8	1.31	12.9	6.4	3.45	3.06	20.5	20.4	17.6
MW1-1	11/27/2009		1.93	20.6	17.4			35.8	27.9	23.9
MW1-2	11/27/2009		1.98	19.1	16.1			51.8	36.7	36.8
MW1-3	11/27/2009		1.37	18.6	19.8			75.9	50.5	54.1
MW2	11/27/2009		1.17	16.4	16.6			14.8	9.68	10.1
Battery	10/30/2009	163			15.1	3.33	3.44	24000	22500	23100
SITE 2										
Well1	10/29/2009	21.6	1.06	20.2	21.1	12.2	10.2	28.6	21.9	21.7
Well1 (dup)	10/29/2009	10.1			21.1	11.8	9.73	29.2	23.4	21.6
Well 2	10/28/2009	15.5	1.57	25.3	21.2	10.2	8.3	200	169	164
Well 3	10/29/2009	22.3	1.28	20.2	20	12.5	10.5	102	85.3	85.1
MW1-2	11/28/2009		3.12	48.2	16			35.3	23.5	22.3
MW1-3	11/28/2009		1.67	30.7	14.8			30.9	21.2	20.3
MW2	11/28/2009		1.39	10.9	17.1			2.4	1.4	1.48
Battery	10/29/2009	4.59			9.9	2.51	2.79	22400	16900	18100
Aesthetic Objectives								250	250	250
Maximum Acceptable Concentrations										
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	F Routine ($mg\ L^{-1}$)	SO_4 Routine ($mg\ L^{-1}$)	Sulfur Dissolved ($mg\ L^{-1}$)	Sulfur Recoverable ($mg\ L^{-1}$)	Ca Dissolved ($mg\ L^{-1}$)	Ca Extractable ($mg\ L^{-1}$)	Ca Recoverable ($mg\ L^{-1}$)	Mg Extractable ($mg\ L^{-1}$)	Mg Dissolved ($mg\ L^{-1}$)
SITE 1										
Well1	10/28/2009	0.74	612	80.8	77.1	195	189	195	273	106
Well 2	10/28/2009	0.56	359	169	155	228	205	229	247	210
Well 3	10/28/2009	0.6	367	160	161	192	195	196	261	205
Well 4	10/28/2009	0.54	319	135	138	167	174	175	132	120
Well 5	10/28/2009	0.35	277	138	142	72.9	73.1	74.9	92.8	81.1
MW1-1	11/27/2009	0.5	1010			277	321	303	116	
MW1-2	11/27/2009	0.58	381			184	164	183	98.9	
MW1-3	11/27/2009	0.56	387			145	132	148	98.4	
MW2	11/27/2009	0.81	208			114	99.9	107	73.9	
Battery	10/30/2009	0.65	42	1.54	1.59	713	692	757	312	214
SITE 2										
Well1	10/29/2009	0.51	121	64.4	62	124	120	125	74.5	72.4
Well1 (dup)	10/29/2009	0.51	126	265	255	126	102	126	65.8	228
Well 2	10/28/2009	0.31	166	102	101	185	169	187	103	104
Well 3	10/29/2009	0.36	226	67.3	61	174	165	175	101	82.1
MW1-2	11/28/2009	0.69	375			84	75.8	85.8	36.6	
MW1-3	11/28/2009	0.61	138			98	82.1	93.3	39.8	
MW2	11/28/2009	0.17	245			170	143	173	46.4	
Battery	10/29/2009	0.3	27	0.29	1.52	340	355	341	193	118
Aesthetic Objectives			≤500							
Maximum Acceptable Concentrations		1.5								
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Mg Recoverable (mg L^{-1})	K Routine (mg L^{-1})	K Dissolved (mg L^{-1})	K Recoverable (mg L^{-1})	Na Routine (mg L^{-1})	Na Dissolved (mg L^{-1})	Na Recoverable (mg L^{-1})	Ag Dissolved (µg L^{-1})	Ag Recoverable (µg L^{-1})
SITE 1										
Well1	10/28/2009	107	7.7	47	47.5	244	60.6	58.6	0.0077	0.0094
Well 2	10/28/2009	248	19.3	18.1	16.9	257	198	184	0.0202	0.0252
Well 3	10/28/2009	263	19.4	16.8	16.7	272	200	188	0.02	0.0322
Well 4	10/28/2009	133	7.5	6.7	6.86	88.2	53.5	52.5	0.0031	0.0055
Well 5	10/28/2009	93.1	6	5.78	5.9	93.5	53.7	55.3	0.0007	0.0018
MW1-1	11/27/2009		14.3			125			0.008	0.0145
MW1-2	11/27/2009		8.8			127			0.0073	0.0211
MW1-3	11/27/2009		10.6			148			0.0076	0.0133
MW2	11/27/2009		5.6			136			0.0044	0.0234
Battery	10/30/2009	312	80.6	69	73.2	17000	10100	10600	0.089	0.193
SITE 2										
Well1	10/29/2009	74.8	12.9	12.4	12	134	105	104	0.0048	0.0057
Well1 (dup)	10/29/2009	278	13.2	6.52	6.26	137	173	165	0.0055	0.009
Well 2	10/28/2009	105	54.1	5.15	5.05	102	49.2	48.3	0.0078	0.0123
Well 3	10/29/2009	82.5	6.1	12.6	11.6	79.2	122	114	0.0041	0.0061
MW1-2	11/28/2009		48.3			427			0.02	0.0658
MW1-3	11/28/2009		58.8			219			0.0149	0.0413
MW2	11/28/2009		5.3			71.3			0.003	0.0062
Battery	10/29/2009	194	40.7	31.2	31	13100	7020	6980	0.103	0.18
Aesthetic Objectives						≤200	≤200	≤200		
Maximum Acceptable Concentrations										
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Al Dissolved (μg L^{-1})	Al Recoverable (μg L^{-1})	As Dissolved (μg L^{-1})	As Recoverable (μg L^{-1})	B Dissolved (μg L^{-1})	B Recoverable (μg L^{-1})	Ba Dissolved (μg L^{-1})	Ba Recoverable (μg L^{-1})	Be Dissolved (μg L^{-1})
SITE 1										
Well1	10/28/2009	0.959	4.82	2.02	2.28	188	178	70.4	67.5	<.003
Well 2	10/28/2009	0.886	34.6	1.76	1.97	110	103	120	112	<.003
Well 3	10/28/2009	3.97	495	1.83	2.08	106	99.3	117	122	<.003
Well 4	10/28/2009	0.315	2.63	0.88	1.02	104	102	77.8	78.1	<.003
Well 5	10/28/2009	0.345	2.63	0.812	0.629	112	113	20.8	22	<.003
MW1-1	11/27/2009	0.77	282	1.1	0.975	142	148	107	125	<.003
MW1-2	11/27/2009	4.95	1130	1.83	1.78	121	116	79.8	96.4	<.003
MW1-3	11/27/2009	0.459	45.3	3.4	3.06	128	115	137	137	<.003
MW2	11/27/2009	3.01	1970	1.33	1.77	161	144	51.4	65.7	<.003
Battery	10/30/2009	1.63	70.3	66.4	77.8	1650	1730	35500	38000	0.0685
SITE 2										
Well1	10/29/2009	0.483	16.6	1.02	1.02	83.6	82	229	220	<.003
Well1 (dup)	10/29/2009	0.627	25.9	0.992	1.02	89.4	83.9	245	223	<.003
Well 2	10/28/2009	0.408	10.8	0.942	1.14	59.6	56.4	388	369	<.003
Well 3	10/29/2009	0.415	11.5	1.01	1.01	91.3	89.9	115	113	<.003
MW1-2	11/28/2009	58.2	5580	5.38	5.56	93.2	69	209	251	<.003
MW1-3	11/28/2009	6.15	2750	4.28	4.25	73.8	59.2	209	234	0.0065
MW2	11/28/2009	2.94	82.7	12.2	14.9	117	120	136	156	0.0048
Battery	10/29/2009	1.81	67.4	48.1	52.3	2340	2550	18400	18500	0.064
Aesthetic Objectives		100	100							
Maximum Acceptable Concentrations				10	10	5000	5000	1000	1000	
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Be Recoverable (µg L^{-1})	Bi Dissolved (µg L^{-1})	Bi Recoverable (µg L^{-1})	Co Dissolved (µg L^{-1})	Co Recoverable (µg L^{-1})	Cd Dissolved (µg L^{-1})	Cd Recoverable (µg L^{-1})	Cr Dissolved (µg L^{-1})	Cr Recoverable (µg L^{-1})
SITE 1										
Well1	10/28/2009	<.003	0.0027	0.0023	0.214	0.145	0.033	0.0335	5.03	0.737
Well 2	10/28/2009	<.003	0.0083	0.0082	0.558	0.438	0.269	0.166	5.69	1.02
Well 3	10/28/2009	0.0132	0.0129	0.0144	0.845	0.816	0.0642	0.0754	6.75	1.82
Well 4	10/28/2009	<.003	0.0186	0.0122	0.0709	0.019	0.028	0.0257	5.6	0.965
Well 5	10/28/2009	<.003	<.001	0.0016	0.0966	0.0386	0.0112	0.0131	3.02	0.52
MW1-1	11/27/2009	0.0141	0.0014	0.0041	8.27	9.78	0.0608	0.0492	2.21	1.41
MW1-2	11/27/2009	0.0254	0.0026	0.0138	1.86	2.02	0.0382	0.0479	2.46	2.53
MW1-3	11/27/2009	<.003	0.0114	0.0056	4.27	4.42	0.067	0.0666	2.34	1.01
MW2	11/27/2009	0.0425	0.0011	0.0107	1.12	1.83	0.0267	0.0642	1.62	3
Battery	10/30/2009	0.077	0.0209	0.0201	0.407	0.363	0.0856	0.182	1.21	1.67
SITE 2										
Well1	10/29/2009	<.003	<.001	<.001	0.233	0.219	0.0264	0.0285	1.14	0.457
Well1 (dup)	10/29/2009	<.003	0.0021	0.0016	0.306	0.223	0.0257	0.0253	0.879	0.715
Well 2	10/28/2009	<.003	0.0017	0.0013	0.378	0.217	0.0738	0.0647	3.64	0.398
Well 3	10/29/2009	<.003	<.001	<.001	0.134	0.113	0.0328	0.0321	2.69	0.299
MW1-2	11/28/2009	0.101	0.0043	0.0408	1.11	1.92	0.103	0.157	4.03	10.2
MW1-3	11/28/2009	0.0457	0.002	0.0235	1.06	1.6	0.0754	0.116	2.44	10.1
MW2	11/28/2009	0.0038	<.001	0.0015	3.18	3.47	0.0279	0.0324	1.04	0.243
Battery	10/29/2009	0.081	0.0039	0.006	0.719	0.496	0.022	0.0279	1.86	1.92
Aesthetic Objectives										
Maximum Acceptable Concentrations							5	5		
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Cu Dissolved (μg L^{-1})	Cu Recoverable (μg L^{-1})	Fe^{2+} Dissolved (μg L^{-1})	Fe_{total} Dissolved (μg L^{-1})	Fe_{total} Extractable (μg L^{-1})	Fe_{total} Recoverable (μg L^{-1})	Hg Dissolved (μg L^{-1})	Hg Recoverable (μg L^{-1})	Li Dissolved (μg L^{-1})
SITE 1										
Well1	10/28/2009	7.08	6.72	20	<2.00	<2.00	<2.00	<.0100	0.0142	158
Well 2	10/28/2009	16.8	12.4	60	<2.00	55.8	<2.00	0.0129	0.0372	130
Well 3	10/28/2009	13	13.4	10	<2.00	191	187	<.0100	0.0292	125
Well 4	10/28/2009	1.81	1.95	410	188	1080	1690	<.0100	<.0100	69.4
Well 5	10/28/2009	0.634	0.517	2580	2730	2520	3130	0.0155	0.0118	52.4
MW1-1	11/27/2009	1.44	1.99	2010	989	1130	1480			68.3
MW1-2	11/27/2009	2.13	1.76	2330	1570	1810	2220			61.6
MW1-3	11/27/2009	1.01	1.61	40	<2.00	14.6	3			80
MW2	11/27/2009	2.89	4.13	10	7	4.27	1050			93.8
Battery	10/30/2009	9.6	31.2		<2.00	1380	1750	0.166	0.6	1190
SITE 2										
Well1	10/29/2009	6.46	6.52	10	<2.00	76.7	156	<.0100	0.0103	77.3
Well1 (dup)	10/29/2009	6.68	6.7		<2.00	122	171	0.0138	0.0157	82.8
Well 2	10/28/2009	9.67	9.09	0	<2.00	<2.00	<2.00	<.0100	0.0104	100
Well 3	10/29/2009	7.07	6.91	0	<2.00	9.2	<2.00	0.0182	0.0233	88.6
MW1-2	11/28/2009	13	15.4	30	18.7	1770	2950			83.2
MW1-3	11/28/2009	10.3	18.7	20	8.8	1750	1780			64.2
MW2	11/28/2009	1.07	1.95	300	67.2	145	1650			32.8
Battery	10/29/2009	49.2	54.6		48	1310	2080	0.243	0.0902	1130
Aesthetic Objectives		≤1000	≤1000	≤300	≤300	≤300	≤300			
Maximum Acceptable Concentrations								1	1	
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Li Recoverable (µg L^{-1})	Mn Dissolved (µg L^{-1})	Mn Recoverable (µg L^{-1})	Mo Dissolved (µg L^{-1})	Mo Recoverable (µg L^{-1})	Ni Dissolved (µg L^{-1})	Ni Recoverable (µg L^{-1})	Pb Dissolved (µg L^{-1})	Pb Recoverable (µg L^{-1})
SITE 1										
Well1	10/28/2009	148	0.641	7.72	2.97	2.87	0.427	0.415	<.001	0.0115
Well 2	10/28/2009	123	115	103	2.56	2.33	4.9	3.55	0.597	0.765
Well 3	10/28/2009	118	9.33	45.4	1.98	2.04	5.13	5.12	0.0844	1.67
Well 4	10/28/2009	68	134	138	1.97	2.01	<.005	<.005	<.001	0.0955
Well 5	10/28/2009	52.5	144	151	3.69	3.91	<.005	<.005	0.009	<.001
MW1-1	11/27/2009	71.7	3980	4260	20.4	15.9	2.41	2.4	0.0374	0.285
MW1-2	11/27/2009	58.2	1680	1680	13.8	11.7	0.15	0.85	0.208	0.69
MW1-3	11/27/2009	70.1	1980	1950	17.3	17.2	1.72	2.44	0.097	0.6
MW2	11/27/2009	85.6	279	336	7.27	8.3	1.33	2.84	0.0324	0.953
Battery	10/30/2009	1280	1720	1840	34.6	36.7	<.005	<.005	0.003	7.5
SITE 2										
Well1	10/29/2009	77	34	33.8	1.77	1.74	1.51	1.52	<.001	0.0201
Well1 (dup)	10/29/2009	79.3	35.9	33.1	1.82	1.62	1.88	1.57	<.001	0.0194
Well 2	10/28/2009	96.8	5.99	5.82	1.25	1.24	2.91	2.65	0.0278	0.0235
Well 3	10/29/2009	88.4	3.65	3.67	1.42	1.34	0.177	0.314	0.0114	0.0505
MW1-2	11/28/2009	60.3	351	401	25	34.9	12.8	13.5	0.571	7.4
MW1-3	11/28/2009	48.3	606	642	12.3	13.1	10.1	11.3	0.156	4.4
MW2	11/28/2009	33.3	749	775	4.02	4.07	0.02	0.307	0.0411	0.318
Battery	10/29/2009	1180	50.4	55.3	1.11	0.927	<.005	1.27	0.0329	0.119
Aesthetic Objectives			≤50	≤50						
Maximum Acceptable Concentrations										10
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Sb Dissolved (µg L^{-1})	Sb Recoverable (µg L^{-1})	Se Dissolved (µg L^{-1})	Se Recoverable (µg L^{-1})	Sn Dissolved (µg L^{-1})	Sn Recoverable (µg L^{-1})	Sr Dissolved (µg L^{-1})	Sr Recoverable (µg L^{-1})	Th Dissolved (µg L^{-1})
SITE 1										
Well1	10/28/2009	0.239	0.225	15.3	14.5	<.0300	<.0300	1310	1240	0.0004
Well 2	10/28/2009	0.21	0.176	6.57	6.62	<.0300	<.0300	1360	1260	0.0014
Well 3	10/28/2009	0.204	0.206	5.93	6.26	<.0300	<.0300	1240	1220	0.0035
Well 4	10/28/2009	0.0808	0.0763	2.92	3.52	<.0300	<.0300	840	839	0.0018
Well 5	10/28/2009	0.0414	0.04	1.35	0.835	<.0300	<.0300	449	459	<.0003
MW1-1	11/27/2009	0.503	0.386	1.48	1.25	0.0972	0.107	1080	1110	0.0022
MW1-2	11/27/2009	4.3	0.225	1.37	1.61	0.0817	0.177	782	712	0.0026
MW1-3	11/27/2009	0.323	0.304	1.95	2.37	0.0696	0.0821	648	652	0.0046
MW2	11/27/2009	0.273	0.349	14.6	11.6	<.0300	0.3	450	420	0.0042
Battery	10/30/2009	0.685	1.16	248	291	0.031	0.0579	72100	78900	0.0017
SITE 2										
Well1	10/29/2009	0.18	0.184	1.41	1.29	<.0300	<.0300	596	576	0.0008
Well1 (dup)	10/29/2009	0.193	0.173	1.41	1.19	<.0300	<.0300	605	558	0.0006
Well 2	10/28/2009	0.165	0.163	2.7	3.27	<.0300	<.0300	1020	962	0.0008
Well 3	10/29/2009	0.224	0.213	7.15	6.54	<.0300	<.0300	859	835	0.0006
MW1-2	11/28/2009	0.887	1.03	3.03	5.96	2.39	3.67	335	341	0.0369
MW1-3	11/28/2009	0.599	0.791	1.21	1.16	1.3	2.97	333	318	0.007
MW2	11/28/2009	0.214	0.228	0.407	0.37	0.0924	0.495	561	564	0.0014
Battery	10/29/2009	1.42	2.03	181	200	0.0769	0.11	41400	41700	0.0006
Aesthetic Objectives										
Maximum Acceptable Concentrations		10		10	10					
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Th Recoverable (µg L^{-1})	Ti Dissolved (µg L^{-1})	Ti Recoverable (µg L^{-1})	Tl Dissolved (µg L^{-1})	Tl Recoverable (µg L^{-1})	U Dissolved (µg L^{-1})	U Recoverable (µg L^{-1})	V Dissolved (µg L^{-1})	V Recoverable (µg L^{-1})
SITE 1										
Well1	10/28/2009	0.0021	2.46	2.93	0.0144	0.0141	151	146	1.59	0.403
Well 2	10/28/2009	0.0102	2.62	3.06	0.0154	0.0148	75	68.5	1.81	0.582
Well 3	10/28/2009	0.139	3.01	24.3	0.0355	0.0404	68.3	70.6	2.08	1.82
Well 4	10/28/2009	0.0015	1.73	1.79	0.0076	0.008	26	26.6	1.56	0.308
Well 5	10/28/2009	0.0005	1.04	1.19	<.0003	0.0011	4.48	4.75	0.843	0.183
MW1-1	11/27/2009	0.145	2.72	15	0.0023	0.0077	23.4	32.6	0.444	1.08
MW1-2	11/27/2009	0.329	2.81	36.8	0.0016	0.0185	21.4	22.1	0.496	2.76
MW1-3	11/27/2009	0.0167	2.9	5.05	0.0107	0.0081	27.7	28.8	1.31	1.39
MW2	11/27/2009	0.477	2.73	74	0.0135	0.0407	81.6	84.5	0.327	4.2
Battery	10/30/2009	0.0392	6.42	14.9	0.0185	0.0131	0.0855	0.0873	0.92	0.95
SITE 2										
Well1	10/29/2009	0.0057	2.24	2.81	0.0053	0.0068	27.6	26.5	0.425	0.421
Well1 (dup)	10/29/2009	0.0061	2.26	2.79	0.0072	0.0073	31	27.8	0.394	0.484
Well 2	10/28/2009	0.0034	2.42	2.58	0.012	0.0096	13.7	12.6	1.15	0.262
Well 3	10/29/2009	0.0037	2.22	2.43	0.0113	0.0126	22.3	21.7	1.06	0.28
MW1-2	11/28/2009	1.76	5.49	122	0.0192	0.0863	40.5	48.9	1.61	9.52
MW1-3	11/28/2009	0.677	2.68	91.5	0.0083	0.0438	25.8	26.3	0.99	5.72
MW2	11/28/2009	0.0476	2.68	6.97	0.0119	0.0166	1.82	2.01	0.132	0.603
Battery	10/29/2009	0.0921	18.3	24.6	0.008	0.0097	0.0587	0.0156	0.45	0.5
Aesthetic Objectives										
Maximum Acceptable Concentrations							20	20		
CDWQG										

APPENDIX A

Groundwater Chemistry Site 1 & Site 2

Location	Date	Zn Dissolved (µg L^{-1})	Zn Recoverable (µg L^{-1})	Charge Balance
SITE 1				
Well1	10/28/2009	54.2	52.3	0.93
Well 2	10/28/2009	433	510	0.91
Well 3	10/28/2009	5.24	6.86	0.93
Well 4	10/28/2009	77.3	177	0.91
Well 5	10/28/2009	1.89	9.09	0.99
MW1-1	11/27/2009	50.3	55	0.92
MW1-2	11/27/2009	7.95	8.08	0.98
MW1-3	11/27/2009	52.3	55.8	0.89
MW2	11/27/2009	1.05	5.43	0.92
Battery	10/30/2009	4.77	4.16	1.18
SITE 2				
Well1	10/29/2009	6.78	6.67	0.94
Well1 (dup)	10/29/2009	6.95	6.57	0.86
Well 2	10/28/2009	2.06	1.82	0.87
Well 3	10/29/2009	368	352	0.87
MW1-2	11/28/2009	19.9	28.8	0.97
MW1-3	11/28/2009	13.4	24.7	0.91
MW2	11/28/2009	2.18	3.11	0.81
Battery	10/29/2009	3.36	3.15	0.95
Aesthetic Objectives		5000	5000	
Maximum Acceptable Concentrations				
CDWQG				

APPENDIX B

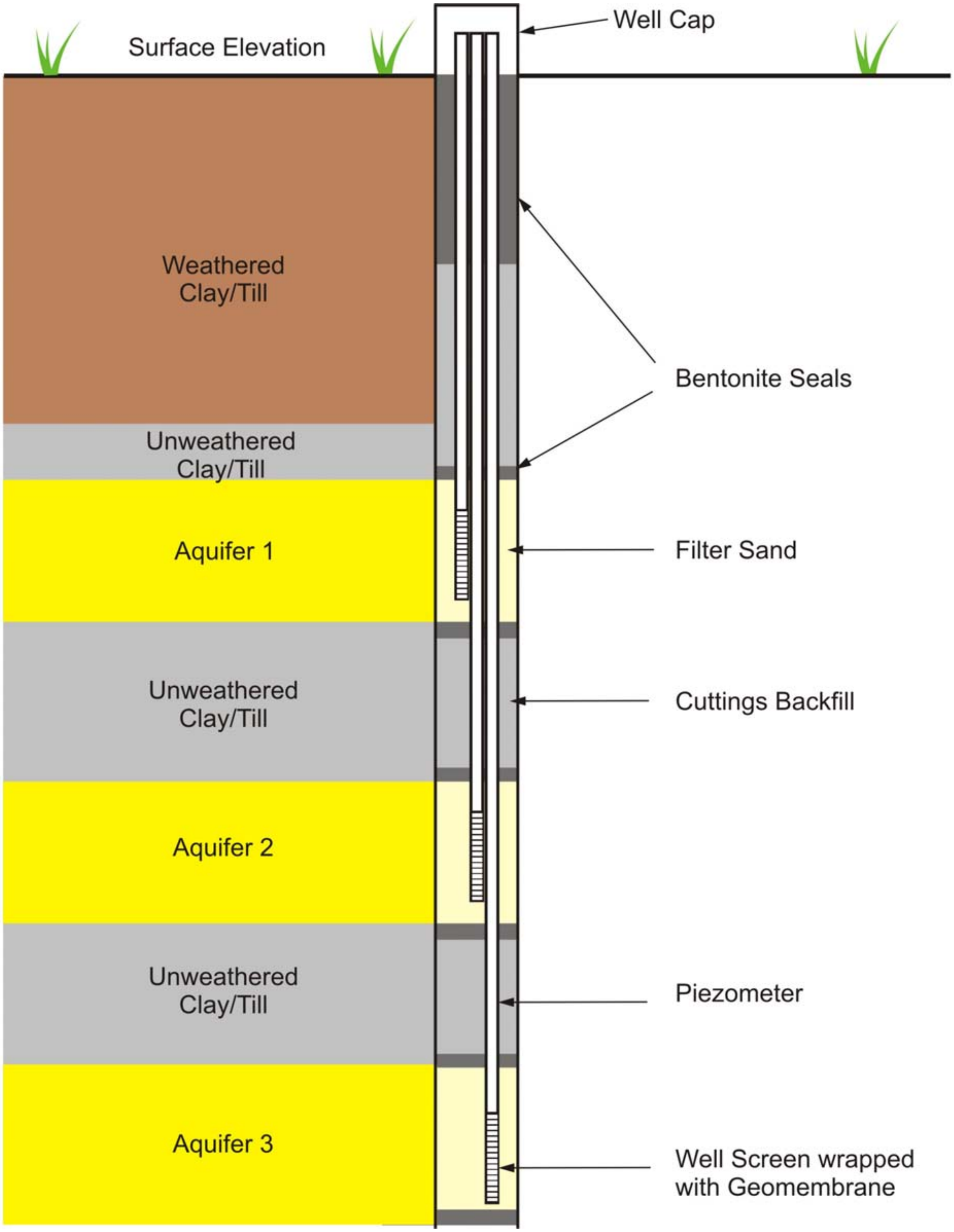
Site 1 & Site 2 Well Logs

Site 1

Depth (m)	Sediment Description
0-0.25	Brown sandy silt with pebbles – very dry.
0.25 - 0.5	Brown silty clay – roots with small pebbles. White precipitates, stiff clumps, more moist then above.
0.50-0.75	Brown sandy silty clay pebbles with white precipitates, clumpy.
0.75-1	Brown stiff clay with thin silt layers (1 mm). Some coarse sand grain in clay.
1-1.25	Brown stiff clay with thin silt layers (1 mm) with some small vugs of Fe precipitates.
1.25-1.5	Brown stiff moist clay with thin silt layers (1 mm), and schist pebbles.
1.5-1.75	Brown stiff clay with ?? thin silt layers (1 mm). Sandy with no pebbles.
1.75-2	Brown silty moist clay with some organics. No silt layers or sand.
2-2.5	Same as above with some coarse sand grains in the clay.
2.5-3	Same as above but moist with dark sand lenses. Angular pebbles also Fe vugs.
3.3.5	Brown clay with some pebbles. Less silt, still some Fe vugs.
3.5-4	Brown clay with red-brown staining and pebbles.
4-4.5	Brown crumbly clay with Fe staining and pebbles.
4.5-5	Same as above but more dry.
5.0-5.5	Same as above but with larger pebbles.
5.5-5.8	Same as above but drier.
5.8	Contact between brown oxidized clay and stiff compact grey clay.
5.8-6.4	Stiff compact grey clay.
6.4-6.7	Brown saturated fine to medium grain sand
6.7-9.15	Dense grey clay.
9.15-9.76	Grey saturated coarse grain sand.
9.75-12.2	Dense dry clay.
12.2-13.7	grey saturated silty grain sand.
13.7-15.2	Grey clay

Site 2 – MW1 Well Log.

Depth (m)	Sediment Description
0-0.25	Brown moist clay – roots.
0.25-0.5	Brown moist clay – some black organics.
0.50-1	Brown moist clay.
1 -1.25	Slight lighter brown moist clay.
1.25-1.5	Brown clay with red staining.
1.50-1.75	Brown silt – saturated.
1.75-2.25	Brown stiff silty clay with some sand and pebbles.
2.25-3	Brown silty clay – no pebbles.
3-3.5	Brown saturated sandy silt.
3.5-3.75	Brown clay.
3.75-4.5	Brown silty clay with pebbles.
4.5-4.9	Brown stiff clay.
4.9	Contact between brown oxidized clay and grey clay.
4.9-5.1	grey sandy clay with pebbles
5.1-5.5	Grey stiff clay.
5.5-6	Grey stiff clay with pockets of brown/red material.
6-7	Grey clay.
7-8.5	Grey soft clay with some sand grains.
8.5-11	Grey clay with some pebbles.
11-12	Grey stiff clay.
12-12.3	Grey fine and medium grain sand.
12.3-13.5	Grey stiff clay.



Idealized well completion diagram for the MW1 bundle peizomewter nests installed at Sites 1 and 2. Diagram not to scale.

APPENDIX C

Total Extractable Metals from Sediments: Site 1:MW1 Site 1: Land Applied Drill Cuttings
Site 2:MW1 Site 2: Land Applied Fertilizer

Location	Depth (m)	Na (mg kg^{-1})	Mg (mg kg^{-1})	U (mg kg^{-1})	Al (mg kg^{-1})	As (mg kg^{-1})	PO_4 (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Fe (mg kg^{-1})
SITE 1 - Bore Hole										
MW1	0	5787	5902	1.84	47837	5.56	336	14582	5324	24458
MW1	1	6214	11903	1.61	48418	4.03	328	15252	30947	21586
MW1	3	6828	13114	2.13	56257	5.39	419	15713	22580	26189
MW1	5.5	8500	12148	2.09	58995	4.77	383	17543	21813	24064
MW1	6	7151	13579	2.66	62269	4.34	395	18681	21774	25711
MW1	6.4	8128	1964	0.652	32511	1.24	161	10542	7927	8409
MW1	9	7319	2920	0.998	31391	2.86	145	10177	11194	7398
MW1	12	8590	12325	1.36	45192	2.99	289	13595	27526	15873
SITE 1 - Land Applied Drill Cuttings										
Site1-A	0-0.50	5755	5225	2.96	49224	4.35	447	14237	6285	22832
Site1-B	0-0.50	6233	5251	2.01	51757	4.72	442	15754	6536	23725
Site1-C	0-0.50	6137	7710	1.85	49099	4.45	479	14461	10855	21442
SITE 2 - Bore Hole										
MW1	0	7204	11300	2.41	67874	10	573	17025	13954	35188
MW1	1	7291	16436	2.03	61635	7.41	487	17483	35450	28924
MW1	3	6479	9536	1.56	46456	5.38	314	14181	18949	22046
MW1	4.5	7132	10718	1.96	54188	3.89	343	15340	20360	22950
MW1	5.1	6031	11946	2.01	54475	4.12	349	15953	20700	23969
MW1	11.5	6074	12437	2.75	64353	7.05	452	16847	22379	29501
MW1	12	5230	6518	2.03	39813	4.88	418	13232	11788	17057
SITE 2 - Land Applied Fertilizer										
Site2-A	0-0.50	6164	3368	1.51	41096	3.49	366	13927	5860	18303
Site2-B	0-0.50	5641	3310	1.29	40344	3.26	691	13037	7359	17333
Site2-C	0-0.50	6553	3556	1.19	38775	4.07	345	12369	7949	17294

APPENDIX D

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3406

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site1-Battery
Matrix :
SmpDate: 30-Oct-09 @ 1000 Samplers..ID1 :
EndDate: @ ..ID2 :

EXTRACTABLE PRIORITY POLLUTANTS
METHOD: IE340 | TimeLines (days)
SCAN: EPP | from sample date

		Max	Actual
Date Received :	4-Nov-09 by: SS	-	5 --
Date Extracted:	10-Nov-09 by: drc	7	11 *
Date Analyzed :	11-Nov-09 by: drc	21	12 ok

Raw DataFile : E3406

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100730	1,2,4-Trichlorobenzene	0.0		.1	.1	100734	1,2-Diphenylhydrazine	0.0		.1	.1
103632	2,3,4,6-Tetrachlorophenol	0.0		.1	.2	100708	2,4,6-Trichlorophenol	0.0		.1	.2
100700	2,4-Dichlorophenol	0.0		.1	.2	100701	2,4-Dimethylphenol	0.0		.2	.2
100703	2,4-Dinitrophenol	0.0		.1	.2	100732	2,4-Dinitrotoluene	0.0		.1	.1
100733	2,6-Dinitrotoluene	0.0		.1	.1	100725	2-Chloronaphthalene	0.0		.1	.1
100699	2-Chlorophenol	0.0		.2	.2	100702	2-Methyl-4,6-dinitrophenol	0.0		.1	.2
100704	2-Nitrophenol	0.0		.1	.2	100738	4-Bromophenyl phenyl ether	0.0		.1	.1
100698	4-Chloro-3-methylphenol	0.0		.1	.2	100742	4-Chlorophenyl phenyl ether	0.0		.1	.1
100705	4-Nitrophenol	0.0		.1	.2	100709	Acenaphthene	3.9	H	.1	.4
100710	Acenaphthylene	0.0		.1	.1	100711	Anthracene	0.0		.1	.1
100731	Benzidine	0.0		.2	.2	100712	Benzo(a)anthracene	0.0		.1	.1
100716	Benzo(a)pyrene	0.0		.1	.2	100713	Benzo(b)fluoranthene	0.0		.1	.1
100715	Benzo(ghi)perylene	0.0		.2	.1	100714	Benzo(k)fluoranthene	0.0		.1	.1
100739	Bis(2-chloroethoxy)methane	0.0		.1	.1	100740	Bis(2-chloroethyl)ether	0.0		.1	.1
100741	Bis(2-chloroisopropyl)ether	0.0		.1	.1	100748	Bis(2-ethylhexyl)phthalate	56.8	H	.1	2.0
100743	Butylbenzylphthalate	0.0		.1	.1	100717	Chrysene	0.0		.1	.1
100744	Di-n-butylphthalate	0.0		.1	.1	100747	Di-n-octyl phthalate	0.0		.1	.1
100718	Dibenzo(ah)anthracene	0.0		.5	.1	100745	Diethyl phthalate	0.0		.1	.1
100746	Dimethyl phthalate	0.0		.1	.1	100719	Fluoranthene	0.0		.1	.1
100720	Fluorene	0.0		.1	.1	100726	Hexachlorobenzene	0.0		.1	.1
100727	Hexachlorobutadiene	0.0		.5	.1	100728	Hexachlorocyclopentadiene	0.0		.1	.1
100729	Hexachloroethane	0.0		.5	.1	100721	Indeno(1,2,3-cd)pyrene	0.0		.1	.1
100749	Isophorone	0.0		.1	.1	100737	N-Nitroso-di-n-propylamine	0.0		.2	.1
100736	N-Nitrosodiphenylamine	0.0		.1	.1	100722	Naphthalene	0.0		.1	.1
100735	Nitrobenzene	0.0		.1	.1	100706	Pentachlorophenol	0.0		.1	.2
100723	Phenanthrene	0.0		.1	.1	100707	Phenol	0.0		.1	.2
100724	Pyrene	0.0		.1	.1						

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.
** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

Date: 13-Nov-09
Contact Person: Grant Prill

mail to:
Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

Please check the mailing information and inform the lab if changes are required.

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3406

EXTRACTABLE PRIORITY POLLUTANTS

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site1-Battery
Matrix :
SmpDate: 30-Oct-09 @ 1000 Samplers..ID1 :
EndDate: @ ..ID2 :

METHOD: IE340 | TimeLines (days)
SCAN: EPP | from sample date

	Max	Actual	
Date Received : 4-Nov-09 by: SS	-	5	--
Date Extracted: 10-Nov-09 by: drc	7	11	*
Date Analyzed : 11-Nov-09 by: drc	21	12	ok

Raw DataFile : E3406

ESTIMATED
CONCENTRATION

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS

No additional compounds reported

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container - No
Inappropriate Temperature - No
Inappropriate Headspace - No
Broken / Leaking Container - No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar

Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"
Please check the mailing information and inform the lab if changes are required.

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3405

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

Contact: Blyth, Alec
SmpNo :
ProjNo :
GrpSmpNo :
StaNo :
StaType:
Comment: Site1-Battery
Matrix :
SmpDate: 30-Oct-09 @ 1000
Samplers..ID1 :
EndDate: @
..ID2 :

	TimeLines (days) from sample date Max	Actual
Date Received : 4-Nov-09 by: SS	-	5 ··
Date Extracted: 17-Nov-09 by: SS	7	18 *
Date Analyzed : 18-Nov-09 by: SS	7	19 *

Raw DataFile : V3405

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100651	1,1,1,2-Tetrachloroethane	0.0		.1	.1	95227	1,1,1-Trichloroethane	0.0		.1	.1
95224	1,1,2,2-Tetrachloroethane	0.0		.1	.1	95228	1,1,2-Trichloroethane	0.0		.1	.1
95214	1,1-Dichloroethane	0.0		.1	.1	95216	1,1-Dichloroethylene	0.0		.1	.1
100645	1,1-Dichloropropylene	0.0		.1	.1	100652	1,2,3-Trichlorobenzene	0.0		.1	.1
100655	1,2,3-Trichloropropane	0.0		.1	.1	100653	1,2,4-Trichlorobenzene	0.0		.1	.1
100656	1,2,4-Trimethylbenzene	23.9	H	.1	.2	100640	1,2-Dibromo-3-chloropropane	0.0		.3	.1
100641	1,2-Dibromoethane	0.0		.1	.1	95211	1,2-Dichlorobenzene	0.0		.1	.1
95215	1,2-Dichloroethane	0.0		.1	.1	95218	1,2-Dichloropropane	0.0		.1	.1
100657	1,3,5-Trimethylbenzene	12.0	H	.1	.2	95212	1,3-Dichlorobenzene	0.0		.1	.1
100644	1,3-Dichloropropane	0.0		.1	.1	95213	1,4-Dichlorobenzene	0.0		.1	.1
100643	2,2-Dichloropropane	0.0		.1	.1	95207	2-Chloroethoxyethylene	0.0		.4	.1
100638	2-Chlorotoluene	0.0		.1	.1	100639	4-Chlorotoluene	0.0		.1	.1
95200	Benzene	2530.0	H	.1	2.0	100634	Bromobenzene	0.0		.1	.1
95201	Bromodichloromethane	0.0		.1	.1	95202	Bromoform	0.0		.5	.1
95203	Bromomethane	0.0		.1	.1	95204	Carbon tetrachloride	0.0		.1	.1
95205	Chlorobenzene	0.0		.1	.1	95206	Chloroethane	0.0		.1	.1
95208	Chloroform	0.0		.1	.1	106204	Chloromethane	0.0		.5	.1
95209	Dibromochloromethane	0.0		.1	.1	95210	Dibromomethane	0.0		.1	.1
95221	Ethyl benzene	139.0	H	.1	2.0	100646	Hexachlorobutadiene	0.0		.3	.1
100647	Isopropylbenzene	7.3	H	.1	.2	102608	MTBE	0.0		.1	.1
95222	Methylene chloride	0.0		2.0	.1	100649	Naphthalene	0.0		.1	.1
95223	Styrene	0.0		.1	.1	100397	TRIHALOMETHANES	0.0		.1	.1
95225	Tetrachloroethylene	0.0		.3	.1	95226	Toluene	14300.0	H	.1	2.0
100654	Trichloroethylene	0.0		.1	.1	95229	Trichlorofluoromethane	0.0		.1	.1
95232	Vinyl chloride	0.0		.5	.1	100407	XYLENES	1390.0	H	.1	2.0
100642	cis-1,2-Dichloroethylene	0.0		.1	.1	95219	cis-1,3-Dichloropropylene	0.0		.3	.1
95234	m,p-Xylene	1130.0	H	.1	2.0	100637	n-Butylbenzene	0.0		.1	.1
100650	n-Propylbenzene	0.0		.1	.1	95233	o-Xylene	260.0	H	.1	2.0
100648	p-Isopropyltoluene	0.0		.1	.1	100635	sec-Butylbenzene	0.0		.1	.1
100636	tert-Butylbenzene	0.0		.1	.1	95217	trans-1,2-Dichloroethylene	0.0		.1	.1
95220	trans-1,3-Dichloropropylene	0.0		.3	.1						

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 19-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3405

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site1-Battery
Matrix :
SmpDate: 30-Oct-09 @ 1000 Samplers..ID1 :
EndDate: @ ..ID2 :

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

		TimeLines (days) from sample date Max	Actual
Date Received :	4-Nov-09 by: SS	-	5 --
Date Extracted:	17-Nov-09 by: SS	7	18 *
Date Analyzed :	18-Nov-09 by: SS	7	19 *

Raw DataFile : V3405

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS	ESTIMATED CONCENTRATION ug/L
Petroleum Hydrocarbons	300

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container	- No
Inappropriate Temperature	- No
Inappropriate Headspace	- No
Broken / Leaking Container	- No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 19-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA
RESEARCH
COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides &

T09- 3405

NOV 0 4 [illegible]

By: SS

R&MD NO:

Form Date: Jan 2007

Contact: Alec Blyth
Phone: 403 210 5345
Fax:
Email:

Quotation:

Results To: ARC
Calgary

Invoice To:

Mailing Address

Sample Information

Sample Location: C - Battery

Sample Date: OCT 30 2009
Month Day Year
1000

Sampled By: AB
Initials

User Sample #:

Sample Type:
- ☑ Ground Water
- ☐ Surface Water
- ☐ Treated Water
- ☐ Sediment
- ☐ Soil
- ☐ Effluent
- ☐ Air
- ☐ Other: Energy Well

Analysis Requested

General Scans
- ☑ VPP
- ☑ EPP
- ☐ PESTE
- ☐

(Expanded List)
- ☐ PAH
- ☐ PPCP
- ☐ RFA
- ☐ GLYPHOSATE
- ☐ THM
- ☐ DRUGA
- ☐ DRUGN
- ☐ NPE
- ☐ Other

Hydrocarbon Scans
- ☐ HCV - volatile
- ☐ HCE - extractable
- ☐ BTEX

Air Analysis Scans
- ☐ VOC
- ☐ RSC
- ☐ C1C4
- ☐ PAH
- ☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

Prior contact with the laboratory is recommended to arrange for sample submissions and requirements. Appropriate sampling procedures for the various analyses are available upon request from the laboratory. An Analysis Request Form should be completed for each sampling event.

Shipping Address:

Alberta Research Council
Hwy 16A & 75 Street
Vegreville, Alberta
T9C 1T4

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3404

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site1-Well 1
Matrix :
SmpDate: 28-Oct-09 @ 1000 Samplers..ID1 :
EndDate: @ ..ID2 :

EXTRACTABLE PRIORITY POLLUTANTS

METHOD: IE340	TimeLines (days) from sample date	
SCAN: EPP	Max	Actual
Date Received : 4-Nov-09 by: SS	-	7 --
Date Extracted: 10-Nov-09 by: drc	7	13 *
Date Analyzed : 11-Nov-09 by: drc	21	14 ok
Raw DataFile : E3404		

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100730	1,2,4-Trichlorobenzene	0.0		.1	.1	100734	1,2-Diphenylhydrazine	0.0		.1	.1
103632	2,3,4,6-Tetrachlorophenol	0.0		.1	.2	100708	2,4,6-Trichlorophenol	0.0		.1	.2
100700	2,4-Dichlorophenol	0.0		.1	.2	100701	2,4-Dimethylphenol	0.0		.2	.2
100703	2,4-Dinitrophenol	0.0		.1	.2	100732	2,4-Dinitrotoluene	0.0		.1	.1
100733	2,6-Dinitrotoluene	0.0		.1	.1	100725	2-Chloronaphthalene	0.0		.1	.1
100699	2-Chlorophenol	0.0		.2	.2	100702	2-Methyl-4,6-dinitrophenol	0.0		.1	.2
100704	2-Nitrophenol	0.0		.1	.2	100738	4-Bromophenyl phenyl ether	0.0		.1	.1
100698	4-Chloro-3-methylphenol	0.0		.1	.2	100742	4-Chlorophenyl phenyl ether	0.0		.1	.1
100705	4-Nitrophenol	0.0		.1	.2	100709	Acenaphthene	0.0		.1	.1
100710	Acenaphthylene	0.0		.1	.1	100711	Anthracene	0.0		.1	.1
100731	Benzidine	0.0		.2	.2	100712	Benzo(a)anthracene	0.0		.1	.1
100716	Benzo(a)pyrene	0.0		.1	.2	100713	Benzo(b)fluoranthene	0.0		.1	.1
100715	Benzo(ghi)perylene	0.0		.2	.1	100714	Benzo(k)fluoranthene	0.0		.1	.1
100739	Bis(2-chloroethoxy)methane	0.0		.1	.1	100740	Bis(2-chloroethyl)ether	0.0		.1	.1
100741	Bis(2-chloroisopropyl)ether	0.0		.1	.1	100748	Bis(2-ethylhexyl)phthalate	.5	H	.1	.1
100743	Butylbenzylphthalate	.1	H	.1	.1	100717	Chrysene	0.0		.1	.1
100744	Di-n-butylphthalate	.4	H	.1	.1	100747	Di-n-octyl phthalate	0.0		.1	.1
100718	Dibenzo(ah)anthracene	0.0		.5	.1	100745	Diethyl phthalate	.1	H	.1	.1
100746	Dimethyl phthalate	0.0		.1	.1	100719	Fluoranthene	0.0		.1	.1
100720	Fluorene	0.0		.1	.1	100726	Hexachlorobenzene	0.0		.1	.1
100727	Hexachlorobutadiene	0.0		.5	.1	100728	Hexachlorocyclopentadiene	0.0		.1	.1
100729	Hexachloroethane	0.0		.5	.1	100721	Indeno(1,2,3-cd)pyrene	0.0		.1	.1
100749	Isophorone	0.0		.1	.1	100737	N-Nitroso-di-n-propylamine	0.0		.2	.1
100736	N-Nitrosodiphenylamine	0.0		.1	.1	100722	Naphthalene	0.0		.1	.1
100735	Nitrobenzene	0.0		.1	.1	100706	Pentachlorophenol	0.0		.1	.2
100723	Phenanthrene	0.0		.1	.1	100707	Phenol	0.0		.1	.2
100724	Pyrene	0.0		.1	.1						

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA RESEARCH COUNCIL   ORGANICS ANALYSIS DATA SHEET   ARC SAMPLE NUMBER: T09-3404

Contact: Blyth, Alec
SmpNo :   ProjNo :   GrpSmpNo :
StaNo :   StaType:
Comment: Site1-Well 1
Matrix :
SmpDate: 28-Oct-09 @ 1000   Samplers..ID1 :
EndDate: @   ..ID2 :

EXTRACTABLE PRIORITY POLLUTANTS
METHOD: IE340
SCAN: EPP

	TimeLines (days) from sample date Max	Actual	
Date Received : 4-Nov-09 by: SS	-	7	..
Date Extracted: 10-Nov-09 by: drc	7	13	*
Date Analyzed : 11-Nov-09 by: drc	21	14	ok

Raw DataFile : E3404

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS	ESTIMATED CONCENTRATION
No additional compounds reported	

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container	- No
Inappropriate Temperature	- No
Inappropriate Headspace	- No
Broken / Leaking Container	- No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
DRC
Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA
RESEARCH
COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides &

T09- 3404
NOV 0 4 2009
By: SS

R&MD NO

Date: Jan 2007

Contact: Alec Blyth	Results To: ARC Calgary
Phone: 403 210 5345	
Fax:	Invoice To:
Email:	
Quotation:	Mailing Address

Sample Information

Sample Location: C - House

Sample Date: OCT (Month) 28 (Day) 2009 (Year) 1000

Sampled By: AB (Initials)

User Sample #:

Sample Type:
- ☑ Ground Water
- ☐ Surface Water
- ☐ Treated Water
- ☐ Sediment
- ☐ Soil
- ☐ Effluent
- ☐ Air
- ☐ Other:

Analysis Requested

General Scans
- ☑ VPP
- ☑ EPP
- ☐ PESTE
- ☐

(Expanded List)
- ☐ PAH
- ☐ PPCP
- ☐ RFA
- ☐ GLYPHOSATE
- ☐ THM
- ☐ DRUGA
- ☐ DRUGN
- ☐ NPE
- ☐ Other

Hydrocarbon Scans
- ☐ HCV - volatile
- ☐ HCE - extractable
- ☐ BTEX

Air Analysis Scans
- ☐ VOC
- ☐ RSC
- ☐ C1C4
- ☐ PAH
- ☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

Prior contact with the laboratory is recommended to arrange for sample submissions and requirements. Appropriate sampling procedures for the various analyses are available upon request from the laboratory. An Analysis Request Form should be completed for each sampling event.

Shipping Address:

Alberta Research Council
Hwy 16A & 75 Street
Vegreville, Alberta
T9C 1T4

ALBERTA RESEARCH COUNCIL   ORGANICS ANALYSIS DATA SHEET   ARC SAMPLE NUMBER: T09-3403

Contact: Blyth, Alec
SmpNo :   ProjNo :   GrpSmpNo :
StaNo :   StaType:
Comment: Site1-Well 1
Matrix :
SmpDate: 28-Oct-09 @ 1000   Samplers..ID1 :
EndDate: @   ..ID2 :

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

	TimeLines (days) from sample date Max	Actual
Date Received : 4-Nov-09 by: SS	-	7 --
Date Extracted: 13-Nov-09 by: SS	7	16 *
Date Analyzed : 14-Nov-09 by: SS	7	17 *

Raw DataFile : V3403

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100651	1,1,1,2-Tetrachloroethane	0.0		.1	.1	95227	1,1,1-Trichloroethane	0.0		.1	.1
95224	1,1,2,2-Tetrachloroethane	0.0		.1	.1	95228	1,1,2-Trichloroethane	0.0		.1	.1
95214	1,1-Dichloroethane	0.0		.1	.1	95216	1,1-Dichloroethylene	0.0		.1	.1
100645	1,1-Dichloropropylene	0.0		.1	.1	100652	1,2,3-Trichlorobenzene	0.0		.1	.1
100655	1,2,3-Trichloropropane	0.0		.1	.1	100653	1,2,4-Trichlorobenzene	0.0		.1	.1
100656	1,2,4-Trimethylbenzene	0.0		.1	.1	100640	1,2-Dibromo-3-chloropropane	0.0		.3	.1
100641	1,2-Dibromoethane	0.0		.1	.1	95211	1,2-Dichlorobenzene	0.0		.1	.1
95215	1,2-Dichloroethane	0.0		.1	.1	95218	1,2-Dichloropropane	0.0		.1	.1
100657	1,3,5-Trimethylbenzene	0.0		.1	.1	95212	1,3-Dichlorobenzene	0.0		.1	.1
100644	1,3-Dichloropropane	0.0		.1	.1	95213	1,4-Dichlorobenzene	0.0		.1	.1
100643	2,2-Dichloropropane	0.0		.1	.1	95207	2-Chloroethoxyethylene	0.0		.4	.1
100638	2-Chlorotoluene	0.0		.1	.1	100639	4-Chlorotoluene	0.0		.1	.1
95200	Benzene	0.0		.1	.1	100634	Bromobenzene	0.0		.1	.1
95201	Bromodichloromethane	0.0		.1	.1	95202	Bromoform	0.0		.5	.1
95203	Bromomethane	0.0		.1	.1	95204	Carbon tetrachloride	0.0		.1	.1
95205	Chlorobenzene	0.0		.1	.1	95206	Chloroethane	0.0		.1	.1
95208	Chloroform	0.0		.1	.1	106204	Chloromethane	0.0		.5	.1
95209	Dibromochloromethane	0.0		.1	.1	95210	Dibromomethane	0.0		.1	.1
95221	Ethyl benzene	0.0		.1	.1	100646	Hexachlorobutadiene	0.0		.3	.1
100647	Isopropylbenzene	0.0		.1	.1	102608	MTBE	0.0		.1	.1
95222	Methylene chloride	0.0		2.0	.1	100649	Naphthalene	0.0		.1	.1
95223	Styrene	0.0		.1	.1	100397	TRIHALOMETHANES	0.0		.1	.1
95225	Tetrachloroethylene	0.0		.3	.1	95226	Toluene	.3	H	.1	.1
100654	Trichloroethylene	0.0		.1	.1	95229	Trichlorofluoromethane	0.0		.1	.1
95232	Vinyl chloride	0.0		.5	.1	100407	XYLENES	0.0		.1	.1
100642	cis-1,2-Dichloroethylene	0.0		.1	.1	95219	cis-1,3-Dichloropropylene	0.0		.3	.1
95234	m,p-Xylene	0.0		.1	.1	100637	n-Butylbenzene	0.0		.1	.1
100650	n-Propylbenzene	0.0		.1	.1	95233	o-Xylene	0.0		.1	.1
100648	p-Isopropyltoluene	0.0		.1	.1	100635	sec-Butylbenzene	0.0		.1	.1
100636	tert-Butylbenzene	0.0		.1	.1	95217	trans-1,2-Dichloroethylene	0.0		.1	.1
95220	trans-1,3-Dichloropropylene	0.0		.3	.1						

Zero (0) values indicate that the analyte is not DETECTED.   MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected   Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 16-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4   (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta   T2L 2A6

ALBERTA RESEARCH COUNCIL
ORGANICS ANALYSIS DATA SHEET
ARC SAMPLE NUMBER: T09-3403

Contact: Blyth, Alec
SmpNo :
ProjNo :
GrpSmpNo :
StaNo :
StaType:
Comment: Site1-Well 1
Matrix :
SmpDate: 28-Oct-09 @ 1000
Samplers..ID1 :
EndDate: @
..ID2 :

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

		TimeLines (days) from sample date Max	Actual	
Date Received :	4-Nov-09 by: SS	-	7	..
Date Extracted:	13-Nov-09 by: SS	7	16	*
Date Analyzed :	14-Nov-09 by: SS	7	17	*

Raw DataFile : V3403

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS	ESTIMATED CONCENTRATION
No additional compounds reported	

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container - No
Inappropriate Temperature - No
Inappropriate Headspace - No
Broken / Leaking Container - No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar

SS

Date: 16-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA RESEARCH COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides & O

T09- 3403
NOV 0 4 2009

R&MD NO:
BY: SS

Form Date: Jan 2007

Contact: Alec Blyth
Phone: 403 210 5345
Fax:
Email:

Quotation:

Results To: ARC
Calgary

Invoice To:

Mailing Address

Sample Information

Sample Location: C - House

Sample Date: Oct 28 2009
Month Day Year
1000

Sampled By: AB
Initials

User Sample #:

Sample Type:
☑ Ground Water
☐ Surface Water
☐ Treated Water
☐ Sediment
☐ Soil
☐ Effluent
☐ Air
☐ Other:

Analysis Requested

General Scans
☑ VPP
☑ EPP
☐ PESTE
☐

(Expanded List)
☐ PAH
☐ PPCP
☐ RFA
☐ GLYPHOSATE
☐ THM
☐ DRUGA
☐ DRUGN
☐ NPE
☐ Other

Hydrocarbon Scans
☐ HCV - volatile
☐ HCE - extractable
☐ BTEX

Air Analysis Scans
☐ VOC
☐ RSC
☐ C1C4
☐ PAH
☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

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Shipping Address:

Alberta Research Council
Hwy 16A & 75 Street
Vegreville, Alberta
T9C 1T4

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3399

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505 | TimeLines (days)
SCAN: VPP | from sample date
| Max Actual

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site2 - Battery
Matrix :
SmpDate: 29-Oct-09 @ 1500 Samplers..ID1 :
EndDate: @ ..ID2 :

		Max	Actual
Date Received :	4-Nov-09 by: SS	-	6 --
Date Extracted:	17-Nov-09 by: SS	7	19 *
Date Analyzed :	18-Nov-09 by: SS	7	20 *

Raw DataFile : V3399

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100651	1,1,1,2-Tetrachloroethane	0.0		.1	.1	95227	1,1,1-Trichloroethane	0.0		.1	.1
95224	1,1,2,2-Tetrachloroethane	0.0		.1	.1	95228	1,1,2-Trichloroethane	0.0		.1	.1
95214	1,1-Dichloroethane	0.0		.1	.1	95216	1,1-Dichloroethylene	0.0		.1	.1
100645	1,1-Dichloropropylene	0.0		.1	.1	100652	1,2,3-Trichlorobenzene	0.0		.1	.1
100655	1,2,3-Trichloropropane	0.0		.1	.1	100653	1,2,4-Trichlorobenzene	0.0		.1	.1
100656	1,2,4-Trimethylbenzene	1.1	H	.1	.2	100640	1,2-Dibromo-3-chloropropane	0.0		.3	.1
100641	1,2-Dibromoethane	0.0		.1	.1	95211	1,2-Dichlorobenzene	0.0		.1	.1
95215	1,2-Dichloroethane	0.0		.1	.1	95218	1,2-Dichloropropane	0.0		.1	.1
100657	1,3,5-Trimethylbenzene	0.0		.1	.1	95212	1,3-Dichlorobenzene	0.0		.1	.1
100644	1,3-Dichloropropane	0.0		.1	.1	95213	1,4-Dichlorobenzene	0.0		.1	.1
100643	2,2-Dichloropropane	0.0		.1	.1	95207	2-Chloroethoxyethylene	0.0		.4	.1
100638	2-Chlorotoluene	0.0		.1	.1	100639	4-Chlorotoluene	0.0		.1	.1
95200	Benzene	0.0		.1	.1	100634	Bromobenzene	0.0		.1	.1
95201	Bromodichloromethane	0.0		.1	.1	95202	Bromoform	0.0		.5	.1
95203	Bromomethane	0.0		.1	.1	95204	Carbon tetrachloride	0.0		.1	.1
95205	Chlorobenzene	0.0		.1	.1	95206	Chloroethane	0.0		.1	.1
95208	Chloroform	0.0		.1	.1	106204	Chloromethane	0.0		.5	.1
95209	Dibromochloromethane	0.0		.1	.1	95210	Dibromomethane	0.0		.1	.1
95221	Ethyl benzene	10.0	H	.1	.2	100646	Hexachlorobutadiene	0.0		.3	.1
100647	Isopropylbenzene	0.0		.1	.1	102608	MTBE	0.0		.1	.1
95222	Methylene chloride	0.0		2.0	.1	100649	Naphthalene	0.0		.1	.1
95223	Styrene	0.0		.1	.1	100397	TRIHALOMETHANES	0.0		.1	.1
95225	Tetrachloroethylene	0.0		.3	.1	95226	Toluene	0.0		.1	.1
100654	Trichloroethylene	0.0		.1	.1	95229	Trichlorofluoromethane	0.0		.1	.1
95232	Vinyl chloride	0.0		.5	.1	100407	XYLENES	4.6	H	.1	.2
100642	cis-1,2-Dichloroethylene	0.0		.1	.1	95219	cis-1,3-Dichloropropylene	0.0		.3	.1
95234	m,p-Xylene	2.9	H	.1	.2	100637	n-Butylbenzene	0.0		.1	.1
100650	n-Propylbenzene	0.0		.1	.1	95233	o-Xylene	1.8	H	.1	.2
100648	p-Isopropyltoluene	0.0		.1	.1	100635	sec-Butylbenzene	0.0		.1	.1
100636	tert-Butylbenzene	0.0		.1	.1	95217	trans-1,2-Dichloroethylene	0.0		.1	.1
95220	trans-1,3-Dichloropropylene	0.0		.3	.1						

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 19-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3399

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site2 - Battery
Matrix :
SmpDate: 29-Oct-09 @ 1500 Samplers..ID1 :
EndDate: @ ..ID2 :

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

		TimeLines (days) from sample date Max	Actual
Date Received :	4-Nov-09 by: SS	-	6 --
Date Extracted:	17-Nov-09 by: SS	7	19 *
Date Analyzed :	18-Nov-09 by: SS	7	20 *
Raw DataFile :	V3399		

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS	ESTIMATED CONCENTRATION ug/L
Petroleum Hydrocarbons	260

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container	- No
Inappropriate Temperature	- No
Inappropriate Headspace	- No
Broken / Leaking Container	- No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.
Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.
* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.
** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 19-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"
Please check the mailing information and inform the lab if changes are required.

ALBERTA
RESEARCH
COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides & O

T09- 3399

NOV 0 4 2009
By: SS

R&MD NO:

Form Date: Jan 2007

Contact: Alec Blyth
Phone: 403 210 5345
Fax:
Email:

Quotation:

Results To: ARC
Calgary

Invoice To:

Mailing Address

Sample Information

Sample Location: K Battery

Sample Date: OCT 29 2009
Month Day Year
15 00

Sampled By: AB
Initials

User Sample #:

Sample Type:
- ☑ Ground Water
- ☐ Surface Water
- ☐ Treated Water
- ☐ Sediment
- ☐ Soil
- ☐ Effluent
- ☐ Air
- ☐ Other: Energy well

Analysis Requested

General Scans
- ☑ VPP
- ☑ EPP
- ☐ PESTE
- ☐

(Expanded List)
- ☐ PAH
- ☐ PPCP
- ☐ RFA
- ☐ GLYPHOSATE
- ☐ THM
- ☐ DRUGA
- ☐ DRUGN
- ☐ NPE
- ☐ Other

Hydrocarbon Scans
- ☐ HCV - volatile
- ☐ HCE - extractable
- ☐ BTEX

Air Analysis Scans
- ☐ VOC
- ☐ RSC
- ☐ C1C4
- ☐ PAH
- ☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

Prior contact with the laboratory is recommended to arrange for sample submissions and requirements. Appropriate sampling procedures for the various analyses are available upon request from the laboratory. An Analysis Request Form should be completed for each sampling event.

Shipping Address:

Alberta Research Council
Hwy 16A & 75 Street
Vegreville, Alberta
T9C 1T4

ALBERTA RESEARCH COUNCIL   ORGANICS ANALYSIS DATA SHEET   ARC SAMPLE NUMBER: T09-3402

Contact: Blyth, Alec
SmpNo :   ProjNo :   GrpSmpNo :
StaNo :   StaType:
Comment: Site2 - Well 1
Matrix :
SmpDate: 29-Oct-09 @ 0900   Samplers..ID1 :
EndDate: @   ..ID2 :

EXTRACTABLE PRIORITY POLLUTANTS

METHOD: IE340	TimeLines (days)	
SCAN: EPP	from sample date	
	Max	Actual
Date Received : 4-Nov-09 by: SS	-	6 --
Date Extracted: 10-Nov-09 by: drc	7	12 *
Date Analyzed : 11-Nov-09 by: drc	21	13 ok
Raw DataFile : E3402		

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100730	1,2,4-Trichlorobenzene	0.0		.1	.1
103632	2,3,4,6-Tetrachlorophenol	0.0		.1	.2
100700	2,4-Dichlorophenol	0.0		.1	.2
100703	2,4-Dinitrophenol	0.0		.1	.2
100733	2,6-Dinitrotoluene	0.0		.1	.1
100699	2-Chlorophenol	0.0		.2	.2
100704	2-Nitrophenol	0.0		.1	.2
100698	4-Chloro-3-methylphenol	0.0		.1	.2
100705	4-Nitrophenol	0.0		.1	.2
100710	Acenaphthylene	0.0		.1	.1
100731	Benzidine	0.0		.2	.2
100716	Benzo(a)pyrene	0.0		.1	.2
100715	Benzo(ghi)perylene	0.0		.2	.1
100739	Bis(2-chloroethoxy)methane	0.0		.1	.1
100741	Bis(2-chloroisopropyl)ether	0.0		.1	.1
100743	Butylbenzylphthalate	.2	H	.1	.1
100744	Di-n-butylphthalate	.5	H	.1	.1
100718	Dibenzo(ah)anthracene	0.0		.5	.1
100746	Dimethyl phthalate	0.0		.1	.1
100720	Fluorene	0.0		.1	.1
100727	Hexachlorobutadiene	0.0		.5	.1
100729	Hexachloroethane	0.0		.5	.1
100749	Isophorone	0.0		.1	.1
100736	N-Nitrosodiphenylamine	0.0		.1	.1
100735	Nitrobenzene	0.0		.1	.1
100723	Phenanthrene	0.0		.1	.1
100724	Pyrene	0.0		.1	.1
100734	1,2-Diphenylhydrazine	0.0		.1	.1
100708	2,4,6-Trichlorophenol	0.0		.1	.2
100701	2,4-Dimethylphenol	0.0		.2	.2
100732	2,4-Dinitrotoluene	0.0		.1	.1
100725	2-Chloronaphthalene	0.0		.1	.1
100702	2-Methyl-4,6-dinitrophenol	0.0		.1	.2
100738	4-Bromophenyl phenyl ether	0.0		.1	.1
100742	4-Chlorophenyl phenyl ether	0.0		.1	.1
100709	Acenaphthene	0.0		.1	.1
100711	Anthracene	0.0		.1	.1
100712	Benzo(a)anthracene	0.0		.1	.1
100713	Benzo(b)fluoranthene	0.0		.1	.1
100714	Benzo(k)fluoranthene	0.0		.1	.1
100740	Bis(2-chloroethyl)ether	0.0		.1	.1
100748	Bis(2-ethylhexyl)phthalate	.8	H	.1	.1
100717	Chrysene	0.0		.1	.1
100747	Di-n-octyl phthalate	0.0		.1	.1
100745	Diethyl phthalate	.1	H	.1	.1
100719	Fluoranthene	0.0		.1	.1
100726	Hexachlorobenzene	0.0		.1	.1
100728	Hexachlorocyclopentadiene	0.0		.1	.1
100721	Indeno(1,2,3-cd)pyrene	0.0		.1	.1
100737	N-Nitroso-di-n-propylamine	0.0		.2	.1
100722	Naphthalene	0.0		.1	.1
100706	Pentachlorophenol	0.0		.1	.2
100707	Phenol	0.0		.1	.2

Zero (0) values indicate that the analyte is not DETECTED.   MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected   Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.
** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar

Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4   (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta   T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3402

EXTRACTABLE PRIORITY POLLUTANTS

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment: Site2 - Well 1
Matrix :
SmpDate: 29-Oct-09 @ 0900 Samplers..ID1 :
EndDate: @ ..ID2 :

METHOD: IE340
SCAN: EPP

	TimeLines (days) from sample date Max	Actual	
Date Received : 4-Nov-09 by: SS	-	6	--
Date Extracted: 10-Nov-09 by: drc	7	12	*
Date Analyzed : 11-Nov-09 by: drc	21	13	ok

Raw DataFile : E3402

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS — ESTIMATED CONCENTRATION

No additional compounds reported

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container - No
Inappropriate Temperature - No
Inappropriate Headspace - No
Broken / Leaking Container - No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA
RESEARCH
COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides & O

T09- 3402

NOV [illegible]

R&MD NO:

BY: SS

Form Date: Jan 2007

Contact: Alec Blyth
Phone: 403 210 5345
Fax:
Email:

Quotation:

Results To: ARC Calgary

Invoice To:

Mailing Address

Sample Information

Sample Location: K-House

Sample Date: Oct 29 2009 (Month Day Year) 900

Sampled By: AB (Initials)

User Sample #:

Sample Type:
- ☑ Ground Water
- ☐ Surface Water
- ☐ Treated Water
- ☐ Sediment
- ☐ Soil
- ☐ Effluent
- ☐ Air
- ☐ Other:

Analysis Requested

General Scans
- ☑ VPP
- ☑ EPP
- ☐ PESTE
- ☐

(Expanded List)
- ☐ PAH
- ☐ PPCP
- ☐ RFA
- ☐ GLYPHOSATE
- ☐ THM
- ☐ DRUGA
- ☐ DRUGN
- ☐ NPE
- ☐ Other

Hydrocarbon Scans
- ☐ HCV - volatile
- ☐ HCE - extractable
- ☐ BTEX

Air Analysis Scans
- ☐ VOC
- ☐ RSC
- ☐ C1C4
- ☐ PAH
- ☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

Prior contact with the laboratory is recommended to arrange for sample submissions and requirements. Appropriate sampling procedures for the various analyses are available upon request from the laboratory. An Analysis Request Form should be completed for each sampling event.

Shipping Address:

Alberta Research Council
Hwy 16A & 75 Street
Vegreville, Alberta
T9C 1T4

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3400

EXTRACTABLE PRIORITY POLLUTANTS
METHOD: IE340
SCAN: EPP

Contact: Blyth, Alec
SmpNo : ProjNo : GrpSmpNo :
StaNo : StaType:
Comment Site2 - Battery
Matrix :
SmpDate: 29-Oct-09 @ 1500 Samplers..ID1 :
EndDate: @ ..ID2 :

		TimeLines (days) from sample date Max	Actual
Date Received :	4-Nov-09 by: SS	-	6 --
Date Extracted:	10-Nov-09 by: drc	7	12 *
Date Analyzed :	11-Nov-09 by: drc	21	13 ok
Raw DataFile :	E3400		

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100730	1,2,4-Trichlorobenzene	0.0		.1	.1
103632	2,3,4,6-Tetrachlorophenol	0.0		.1	.2
100700	2,4-Dichlorophenol	0.0		.1	.2
100703	2,4-Dinitrophenol	0.0		.1	.2
100733	2,6-Dinitrotoluene	0.0		.1	.1
100699	2-Chlorophenol	0.0		.2	.2
100704	2-Nitrophenol	0.0		.1	.2
100698	4-Chloro-3-methylphenol	0.0		.1	.2
100705	4-Nitrophenol	0.0		.1	.2
100710	Acenaphthylene	0.0		.1	.1
100731	Benzidine	0.0		.2	.2
100716	Benzo(a)pyrene	24.3	H	.1	7.5
100715	Benzo(ghi)perylene	0.0		.2	.1
100739	Bis(2-chloroethoxy)methane	0.0		.1	.1
100741	Bis(2-chloroisopropyl)ether	0.0		.1	.1
100743	Butylbenzylphthalate	0.0		.1	.1
100744	Di-n-butylphthalate	0.0		.1	.1
100718	Dibenzo(ah)anthracene	0.0		.5	.1
100746	Dimethyl phthalate	0.0		.1	.1
100720	Fluorene	10.9	H	.1	2.0
100727	Hexachlorobutadiene	0.0		.5	.1
100729	Hexachloroethane	0.0		.5	.1
100749	Isophorone	0.0		.1	.1
100736	N-Nitrosodiphenylamine	0.0		.1	.1
100735	Nitrobenzene	0.0		.1	.1
100723	Phenanthrene	29.4	H	.1	1.5
100724	Pyrene	0.0		.1	.1

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100734	1,2-Diphenylhydrazine	0.0		.1	.1
100708	2,4,6-Trichlorophenol	0.0		.1	.2
100701	2,4-Dimethylphenol	0.0		.2	.2
100732	2,4-Dinitrotoluene	0.0		.1	.1
100725	2-Chloronaphthalene	0.0		.1	.1
100702	2-Methyl-4,6-dinitrophenol	0.0		.1	.2
100738	4-Bromophenyl phenyl ether	0.0		.1	.1
100742	4-Chlorophenyl phenyl ether	0.0		.1	.1
100709	Acenaphthene	20.7	H	.1	2.0
100711	Anthracene	0.0		.1	.1
100712	Benzo(a)anthracene	6.3	H	.1	.4
100713	Benzo(b)fluoranthene	0.0		.1	.1
100714	Benzo(k)fluoranthene	0.0		.1	.1
100740	Bis(2-chloroethyl)ether	0.0		.1	.1
100748	Bis(2-ethylhexyl)phthalate	0.0		.1	.1
100717	Chrysene	0.0		.1	.1
100747	Di-n-octyl phthalate	0.0		.1	.1
100745	Diethyl phthalate	0.0		.1	.1
100719	Fluoranthene	25.0	H	.1	2.0
100726	Hexachlorobenzene	0.0		.1	.1
100728	Hexachlorocyclopentadiene	0.0		.1	.1
100721	Indeno(1,2,3-cd)pyrene	0.0		.1	.1
100737	N-Nitroso-di-n-propylamine	0.0		.2	.1
100722	Naphthalene	0.0		.1	.1
100706	Pentachlorophenol	0.0		.1	.2
100707	Phenol	0.0		.1	.2

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

ALBERTA RESEARCH COUNCIL   ORGANICS ANALYSIS DATA SHEET   ARC SAMPLE NUMBER: T09-3400

Contact: Blyth, Alec
SmpNo :   ProjNo :   GrpSmpNo :
StaNo :   StaType:
Comment: Site2 - Battery
Matrix :
SmpDate: 29-Oct-09 @ 1500   Samplers..ID1 :
EndDate: @   ..ID2 :

EXTRACTABLE PRIORITY POLLUTANTS
METHOD: IE340
SCAN: EPP

		TimeLines (days) from sample date Max	Actual	
Date Received :	4-Nov-09 by: SS	-	6	--
Date Extracted:	10-Nov-09 by: drc	7	12	*
Date Analyzed :	11-Nov-09 by: drc	21	13	ok

Raw DataFile : E3400

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS   ESTIMATED CONCENTRATION

No additional compounds reported

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container - No
Inappropriate Temperature - No
Inappropriate Headspace - No
Broken / Leaking Container - No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
Date: 13-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4   (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta   T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA
RESEARCH
COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides &

T09- 3400

NOV 0 4 2009

By: SS

R&MD NO:

Form Date: Jan 2007

Contact: Alec Blyth
Phone: 403 210 5345
Fax:
Email:

Quotation:

Results To: ARC
Calgary

Invoice To:

Mailing Address

Sample Information

Sample Location: K Battery

Sample Date: OCT 29 2009
Month Day Year
15 00

Sampled By: AB
Initials

User Sample #:

Sample Type:
- ☑ Ground Water
- ☐ Surface Water
- ☐ Treated Water
- ☐ Sediment
- ☐ Soil
- ☐ Effluent
- ☐ Air
- ☐ Other: Energy well

Analysis Requested

General Scans
- ☑ VPP
- ☑ EPP
- ☐ PESTE
- ☐

(Expanded List)
- ☐ PAH
- ☐ PPCP
- ☐ RFA
- ☐ GLYPHOSATE
- ☐ THM
- ☐ DRUGA
- ☐ DRUGN
- ☐ NPE
- ☐ Other

Hydrocarbon Scans
- ☐ HCV - volatile
- ☐ HCE - extractable
- ☐ BTEX

Air Analysis Scans
- ☐ VOC
- ☐ RSC
- ☐ C1C4
- ☐ PAH
- ☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

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Shipping Address:

Alberta Research Council
Hwy 16A & 75 Street
Vegreville, Alberta
T9C 1T4

ALBERTA RESEARCH COUNCIL ORGANICS ANALYSIS DATA SHEET ARC SAMPLE NUMBER: T09-3401

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

Contact: Blyth, Alec
SmpNo :
ProjNo :
GrpSmpNo :
StaNo :
StaType:
Comment: Site2 - Well 1
Matrix :
SmpDate: 29-Oct-09 @ 0900
Samplers..ID1 :
EndDate: @
..ID2 :

		TimeLines (days) from sample date Max	Actual
Date Received :	4-Nov-09 by: SS	-	6 --
Date Extracted:	13-Nov-09 by: SS	7	15 *
Date Analyzed :	14-Nov-09 by: SS	7	16 *
Raw DataFile :	V3401		

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100651	1,1,1,2-Tetrachloroethane	0.0		.1	.1	95227	1,1,1-Trichloroethane	0.0		.1	.1
95224	1,1,2,2-Tetrachloroethane	0.0		.1	.1	95228	1,1,2-Trichloroethane	0.0		.1	.1
95214	1,1-Dichloroethane	0.0		.1	.1	95216	1,1-Dichloroethylene	0.0		.1	.1
100645	1,1-Dichloropropylene	0.0		.1	.1	100652	1,2,3-Trichlorobenzene	0.0		.1	.1
100655	1,2,3-Trichloropropane	0.0		.1	.1	100653	1,2,4-Trichlorobenzene	0.0		.1	.1
100656	1,2,4-Trimethylbenzene	0.0		.1	.1	100640	1,2-Dibromo-3-chloropropane	0.0		.3	.1
100641	1,2-Dibromoethane	0.0		.1	.1	95211	1,2-Dichlorobenzene	0.0		.1	.1
95215	1,2-Dichloroethane	0.0		.1	.1	95218	1,2-Dichloropropane	0.0		.1	.1
100657	1,3,5-Trimethylbenzene	0.0		.1	.1	95212	1,3-Dichlorobenzene	0.0		.1	.1
100644	1,3-Dichloropropane	0.0		.1	.1	95213	1,4-Dichlorobenzene	0.0		.1	.1
100643	2,2-Dichloropropane	0.0		.1	.1	95207	2-Chloroethoxyethylene	0.0		.4	.1
100638	2-Chlorotoluene	0.0		.1	.1	100639	4-Chlorotoluene	0.0		.1	.1
95200	Benzene	0.0		.1	.1	100634	Bromobenzene	0.0		.1	.1
95201	Bromodichloromethane	0.0		.1	.1	95202	Bromoform	0.0		.5	.1
95203	Bromomethane	0.0		.1	.1	95204	Carbon tetrachloride	0.0		.1	.1
95205	Chlorobenzene	0.0		.1	.1	95206	Chloroethane	0.0		.1	.1
95208	Chloroform	.1	H	.1	.1	106204	Chloromethane	0.0		.5	.1
95209	Dibromochloromethane	0.0		.1	.1	95210	Dibromomethane	0.0		.1	.1
95221	Ethyl benzene	0.0		.1	.1	100646	Hexachlorobutadiene	0.0		.3	.1
100647	Isopropylbenzene	0.0		.1	.1	102608	MTBE	0.0		.1	.1
95222	Methylene chloride	0.0		2.0	.1	100649	Naphthalene	0.0		.1	.1
95223	Styrene	0.0		.1	.1	100397	TRIHALOMETHANES	.1	H	.1	.1
95225	Tetrachloroethylene	0.0		.3	.1	95226	Toluene	0.0		.1	.1
100654	Trichloroethylene	0.0		.1	.1	95229	Trichlorofluoromethane	0.0		.1	.1
95232	Vinyl chloride	0.0		.5	.1	100407	XYLENES	0.0		.1	.1
100642	cis-1,2-Dichloroethylene	0.0		.1	.1	95219	cis-1,3-Dichloropropylene	0.0		.3	.1
95234	m,p-Xylene	0.0		.1	.1	100637	n-Butylbenzene	0.0		.1	.1
100650	n-Propylbenzene	0.0		.1	.1	95233	o-Xylene	0.0		.1	.1
100648	p-Isopropyltoluene	0.0		.1	.1	100635	sec-Butylbenzene	0.0		.1	.1
100636	tert-Butylbenzene	0.0		.1	.1	95217	trans-1,2-Dichloroethylene	0.0		.1	.1
95220	trans-1,3-Dichloropropylene	0.0		.3	.1						

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 16-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
Alberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

ALBERTA RESEARCH COUNCIL   ORGANICS ANALYSIS DATA SHEET   ARC SAMPLE NUMBER: T09-3401

Contact: Blyth, Alec
SmpNo :   ProjNo :   GrpSmpNo :
StaNo :   StaType:
Comment: Site2 - Well 1
Matrix :
SmpDate: 29-Oct-09 @ 0900   Samplers..ID1 :
EndDate: @   ..ID2 :

VOLATILE PRIORITY POLLUTANTS
METHOD: IE505
SCAN: VPP

	TimeLines (days) from sample date Max	Actual	
Date Received : 4-Nov-09 by: SS	-	6	--
Date Extracted: 13-Nov-09 by: SS	7	15	*
Date Analyzed : 14-Nov-09 by: SS	7	16	*

Raw DataFile : V3401

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS	ESTIMATED CONCENTRATION
No additional compounds reported	

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container - No
Inappropriate Temperature - No
Inappropriate Headspace - No
Broken / Leaking Container - No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.

Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
SS
Date: 16-Nov-09
Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Blyth, Alec
Sustainable Ecosystems
ALberta Research Council
3608-33 St NW
Calgary, Alberta T2L 2A6

"results relate only to the item tested"

Please check the mailing information and inform the lab if changes are required.

ALBERTA RESEARCH COUNCIL

Analytical Chemistry
Alberta Research Council
Bag 4000, Vegreville, Alberta
T9C 1T4

Analysis Request Form
Pesticides & Or

T09- 3401

NOV 0 4 2009

R&MD NO:

By: SS

Form Date: Jan 2007

Contact: Alec Blyth
Phone: 403 210 5345
Fax:
Email:

Quotation:

Results To: ARC
Calgary

Invoice To:

Mailing Address

Sample Information

Sample Location: K-House

Sample Date: Oct 29 2009 (Month Day Year) 900

Sampled By: AB (Initials)

User Sample #:

Sample Type:
- ☑ Ground Water
- ☐ Surface Water
- ☐ Treated Water
- ☐ Sediment
- ☐ Soil
- ☐ Effluent
- ☐ Air
- ☐ Other:

Analysis Requested

General Scans
- ☑ VPP
- ☑ EPP
- ☐ PESTE
- ☐

(Expanded List)
- ☐ PAH
- ☐ PPCP
- ☐ RFA
- ☐ GLYPHOSATE
- ☐ THM
- ☐ DRUGA
- ☐ DRUGN
- ☐ NPE
- ☐ Other

Hydrocarbon Scans
- ☐ HCV - volatile
- ☐ HCE - extractable
- ☐ BTEX

Air Analysis Scans
- ☐ VOC
- ☐ RSC
- ☐ C1C4
- ☐ PAH
- ☐ PESTE

Comments:

SUBMISSION INFORMATION AND REQUIREMENTS:
(780) 632-8455 (780) 632-8620 (fax)

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Vegreville, Alberta
T9C 1T4