REPORT

Maximum Predicted Water Table Report

CBM Dance Pit Expansion

Submitted to:

CBM Aggregates, a Division of St. Marys Cement Inc. (Canada)
55 Industrial Street
Toronto, Ontario
M4G 3W9

Attention: Mr. David Hanratty,
Director of Land & Resources

Submitted by:

Golder Associates Ltd.
210 Sheldon Drive, Cambridge, Ontario, N1T 1A8, Canada
+1 519 620 1222

1653019

April 2021

Distribution List

1 copy - CBM Aggregates, a Division of St. Marys Cement Inc. (Canada)

1 copy - Esher Planning Inc.

1 copy - Golder Associates Ltd.

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada) to prepare a Maximum Predicted Water Table Report as part of an evaluation of the potential for aggregate extraction on Part of the North Half of Lots 14 and 15, Concession 10, Township of North Dumfries, Regional Municipality of Waterloo, Ontario. The subject property (Site), also known as the Dance Pit Expansion (Figure 1), is approximately 28.4 ha in total size, of which 21.2 ha is proposed for aggregate extraction. A Class A, Category 3 Licence for Extraction Above the Water Table will be required.

The Site is located in North Dumfries on the south side of Cedar Creek Road in a semi-rural setting west of the City of Cambridge. The Site is actively farmed, and the surrounding land use includes a residential subdivision to the east (within the City of Cambridge), a rural residence to the north and existing licensed pits to the north, south and west. Some of the licensed pit property to the south is currently being farmed.

The Dance Pit was licensed for aggregate extraction in 1992 (Class A Category 3 Licence (pit above water table) No. 17348) and extraction began in 1995. The existing pit encompasses an area of 45 ha with 41.3 ha approved for aggregate extraction.

The development of a sand and gravel pit is proposed at the Site and extraction will be limited to 1.5 m above the water table. As per the Aggregates Resources Act (ARA), a Maximum Predicted Water Table Report is required to document the groundwater characteristics found on the property and to help ensure the depth to the water table across the Site is well defined. This report has also been prepared to meet the requirements of a Stage 1 Hydrogeological Study for the Regional Municipality of Waterloo (Regional Municipality of Waterloo, 2008). This Maximum Predicted Water Table Report is to accompany a rezoning application and the ARA licence application for the Site.

2.0 METHODOLOGY

The water resource evaluation consisted of a background review of existing available information, as well as field investigations.

The background review consisted of reviewing the following available information:

- Aggregate Resource Inventory prepared for the Dance property by Planning and Engineering Initiatives Ltd. (PEIL) in 1990;
- Borehole logs for BH1, BH2, BH3, BH4 and BH5;
- Aerial photography and topographic survey data acquired on October 16, 2014 by Automated Engineering Technologies (AET) Ltd. of Guelph, Ontario;
- Water level data for monitoring wells BH1, BH2 and BH5 provided by CBM;
- Grand River Information Network data and mapping;
- Published topographic, physiographic, Quaternary and bedrock maps;
- Published Quaternary geology reports;
- Ministry of the Environment, Conservation and Parks (MECP) water well records and permits to take water;

- Grand River Source Protection Assessment Report and Grand River Source Protection Plan; and
- Aggregate Resources Inventory Paper for Regional Municipality of Waterloo.

The field investigation carried out by Golder consisted of the following:

- A site visit, including a survey of surrounding properties;
- Completion of test pits and drilling of monitoring wells;
- Single well hydraulic testing of the three on-site wells;
- Five years of water level monitoring at monitoring wells on the Dance Pit property and the Dance Pit Expansion; and
- Water quality sampling and analysis at the three on-site wells.

3.0 PHYSICAL SETTING

Topographic mapping for the Site indicates that the ground surface ranges in elevation from approximately 311 masl (metres above sea level) in the southeast portion of the Site to 326 masl along parts of the western boundary of the Site (Figure 2). The overall topographic relief across the Site is approximately 15 m. The surrounding topographic conditions range from flat to hummocky.

The environmental features of the surrounding area are shown on Figure 1. With the exception of a small woodlot in the southeast corner of the property, that doesn't register on the mapping, there are no woodlots on the Site. To the north and northeast of the Site there is a wetland complex referred to as the Gilholm Salisbury Wetland and to the west there is a wetland complex referred to as the Milroy Lake Wetland. The Gilholm Salisbury Wetland is approximately 70 m from the Site, while the Milroy Lake Wetland is approximately 960 m from the Site.

The Site lies within the Grand River watershed, with a small pond and tributary (Devil's Creek) of the Grand River located approximately 80 m northeast of the Site. There is also a tributary of Cedar Creek located approximately 880 m west of the Site.

The northern part of the Site is within the physiographic region described as the Guelph Drumlin Field, while the southern part of the Site is within the Horseshoe Moraines (Chapman and Putnam, 1984). The general landform pattern of the Guelph Drumlin Field consists of drumlins or groups of drumlins fringed by gravel terraces and separated by swampy valleys with tributaries flowing to the Grand River (Chapman and Putnam, 1984). The drumlins are generally located north of Cambridge. The Horseshoe Moraines are comprised of two distinct landform components: 1) irregular, stony knobs and ridges, which are composed mostly of till, with some sand and gravel deposits (kames); and 2) sand and gravel terraces with swampy valley floors (Chapman and Putnam, 1984).

Karrow (1987) identifies the northern part of the Site as lying within outwash gravel and the southern part of the Site as a thin veneer of Wentworth Till, which is known to be a stony, sandy silt till. The surrounding area is also characterized by these two surficial deposits along with lacustrine sand and outwash sand along the tributary of Cedar Creek and other ice-contact gravel (kames and eskers). Surficial geology mapping by the Ontario Geological Survey (OGS) (2003) is shown on Figure 3. The surficial coarse grain deposits are underlain by till, which may be the Maryhill or the Port Stanley Till, which extends to the surface of the bedrock. In general, the overburden includes the outwash gravels and till sequences. Wells situated on the property to the south of the Site indicate that the total overburden thickness is between 39 and 50 m with greater thickness in topographic high areas and less thickness in topographic low areas and excavated areas. The well logs indicate approximately 17 m to 32 m of low permeability glacial till separating the near surface granular soils from the bedrock. Other wells completed to bedrock within 1 km of the site indicate the overburden thickness ranges from approximately 47 m to 61 m. Bedrock beneath the glacial deposits is comprised of Middle Silurian dolostone of the Guelph Formation, which dips regionally toward the southwest.

The Aggregate Resource Inventory Paper (ARIP) for the Regional Municipality of Waterloo, ARIP 161 (OGS and PEIL, 1998), identifies the Site as a sand and gravel resource area of primary significance, specifically identified as Selected Area No. 32. The ice-contact stratified drift has an estimated depth greater than 6 m and gravel content greater than 35%.

An overburden aquifer and a bedrock aquifer are present in the area. Further details on groundwater levels, flow direction and water use are provided in Section 6.

4.0 TEST PITTING, BOREHOLE DRILLING AND MONITORING WELL INSTALLATION

In the spring of 1990, Planning and Engineering Initiatives Ltd. (PEIL) advanced 18 test pits across the Dance Pit property and the Site to an approximate depth of 6 mbgs (below ground surface) to assess the potential aggregate resources on the property (PEIL, 1990). The locations of these test pits are shown on Figure 4, where they are identified as TP1 through TP18.

Boreholes BH1 to BH5 were drilled by Gartner Lee Limited in 1998 and 2005 for various proponents, to assess potential aggregate resources and to help establish the depth to the water table. The boreholes are located on the existing Dance Pit property and on a property to the west of the Dance Pit as shown on Figure 4. Borehole logs are provided in Appendix A (we note that the ground elevations on the logs may have been surveyed to an incorrect datum and have been corrected for this study). BH1, BH2 and BH5 were completed as monitoring wells.

As part of the study, Golder advanced twenty test pits (TP16-1 to TP16-20) across both properties in January 2016 at the locations shown on Figure 4. The test pits were advanced to a depth of approximately 5.5 mbgs.

Three boreholes (BH16-1, BH16-2 and BH16-3) were drilled in January 2016, by Choice Sonic Drilling Ltd. as part of the resource investigation (locations shown on Figure 4). The boreholes were each continuously cored to a nominal depth of 21.3 mbgs, using a track-mounted, rotasonic drill rig, which obtained a 114 mm diameter (4 ½”) soil core. Each borehole was completed as a monitoring well. Monitoring wells were installed using 1.52 m long, No. 10 slot, PVC well screens and PVC riser pipes. At each monitoring well location, the open borehole was filled with bentonite hole-plug to the desired bottom of monitoring well depth. The annulus of the borehole adjacent to the monitoring well screen was backfilled with silica sand to approximately 0.6 m above the top of the screen. The remainder of the borehole annulus was backfilled with bentonite hole-plug up to approximately 0.3 mbgs. The monitoring wells were completed with monument-style above ground casings set in concrete at ground surface and the top of the monitoring well riser pipes were equipped with removable J-plugs. The well locations were selected to help establish the water table elevation and groundwater flow direction. Record of Borehole logs are provided in Appendix A.

The borehole results from 2016 are summarized in Table 1.

Table 1: Borehole Results for BH16-1 to BH16-3

Borehole	Easting (m)	Northing (m)	Ground Elevation (masl)	Stickup (m)	Base of Resource (masl)	Screen Interval (m)
BH16-1	552882	4799690	320.16	0.94	309.95	15.2 – 16.7
BH16-2	553091	4798926	321.81	0.72	309.92	15.2 – 16.7
BH16-3	553293	4799371	319.25	0.91	308.89	19.8 – 21.3

5.0 RESOURCE CHARACTERIZATION

The 1990 PEIL resource investigation generally found sand and gravel aggregate resources to be present across the Dance Pit property and the Site at depths greater than 6 m.

The test pits dug in 1990 and 2016 on the Site encountered an overburden (topsoil) layer ranging in thickness from 0.15 to 1.0 m. Beneath the overburden was a sand and gravel layer (i.e. the aggregate resource), which often contained cobbles and occasionally boulders, and was typically encountered to the bottom of the test pits (5.5 mbgs). Crushable material (i.e. grain size greater than 50 mm) was identified in all but one test pit (TP16-13).

A cross-section through the Site is shown on Figure 5 with the location shown on Figure 4. The borehole and monitoring well results for the Site indicate the base of the coarse-grained aggregate resource to be at an elevation ranging from 308.9 to 310.0 masl.

The estimated volume of coarse-grained aggregate resource on the Site is 2.3 million m^3 or approximately 4.2 million tonnes assuming an aggregate resource density of 1.80 t/m^3. This resource estimate assumes vertical extraction to the property limit and assumes setbacks and does not account for losses due to leaving side slopes in place, and processing losses. When these factors are taken into account and a portion of the extraction area in the southeast part of the property is removed, the total tonnage will be somewhat less.

6.0 GROUNDWATER

6.1 Hydraulic Conductivity

Single well response tests were conducted at BH16-1, BH16-2 and BH16-3 on November 8, 2016. Three tests were conducted at each well consisting of a rising head test following removal of the Waterra tubing, a falling head test following the insertion of a solid slug and a rising head test following bailing water from the well. The tests were analyzed using the Hvorslev analysis. Results of each of the three tests were consistent. The range of hydraulic conductivity calculated from the tests is as follows:

- BH16-1 – 5.4 x 10^{-5} to 6.1 x 10^{-5} m/s (completed in sand to silty sand);
- BH16-2 – 6.6 x 10^{-6} to 8.6 x 10^{-6} m/s (completed in sand to silty sand); and
- BH16-3 – 5.4 x 10^{-6} to 5.5 x 10^{-6} m/s (completed in sand to silty sand).

6.2 Groundwater Elevations

A shallow unconfined aquifer is present at ground surface overlying fine-grained material. A network of overburden monitoring wells has been constructed at the Site to define the water table elevation in the overburden. Groundwater levels have been measured in the Dance Pit wells since 1998 in BH1 and BH2 and since 2005 in BH5. A hydrograph of the water levels in the existing wells, from 1998 through 2018 (Appendix B), was provided by CBM to review long-term water level trends. The water levels tend to fluctuate seasonally and generally follow (with a lag) the precipitation trends (outlined in Section 7.2). The highest water levels were observed in 2008 and 2009, which correspond with the high precipitation recorded in 2008 and the first half of 2009. Similar high-water levels were also observed in the spring of 2017, which corresponds with the above normal precipitation recorded in early 2017, and in the spring of 2019, which corresponds with the above normal precipitation recorded in 2019. Overall, the water levels in the wells to the west of the Site have fluctuated by approximately 1.5 m to 2.0 m since 1998 with no long-term increasing or decreasing trend.

Transducer dataloggers were installed in the three existing wells (BH1, BH2 and BH5) and the three on-Site wells (BH16-1, BH16-2 and BH16-3) in April 2016. When the transducer dataloggers are downloaded, a manual water level is also recorded at that time for confirmation. The manual measurements are summarized in Table B1 in Appendix B. A hydrograph of the water levels (five years) in the wells since the installation of the transducer dataloggers is included on Figure B2 in Appendix B.

The depth to the water table, as measured in the monitoring wells on the Site over the past five years (not including off-Site wells), has ranged from 11.17 mbgs at BH16-1 to 13.86 mbgs at BH16-2. The measured water levels appear to fluctuate seasonally and have shown little variation within the wells, with less than 1.2 m of fluctuation in BH16-1 and BH16-3 and less than 1.6 m of fluctuation in BH16-2 since continuous monitoring began in April 2016. Water levels were highest in May 2017 and lowest in December 2016. The water table elevations in the on-Site wells have ranged from a low of 306.9 masl at BH16-3 to a high of 309.4 masl at BH16-2.

6.3 Groundwater Flow

Regional groundwater flow in the overburden aquifer is anticipated to flow to the southeast toward the Grand River.

Based on the water levels measured on May 16, 2017 (maximum water table), the inferred water table across the Site is provided on Figure 6 and is shown to slope in general from west to east with an east-northeast direction in the northern part of the property. The water levels on the Site in May 2017 range from a high of 309.3 masl (BH16-2) along the west boundary to a low of 307.2 masl (BH16-3) along the east boundary. There appears to be some mounding at BH5 (Dance Pit), where water levels are slightly higher than surrounding water levels, which may be caused by enhanced infiltration within the pit. The direction of horizontal groundwater flow in the overburden aquifer at the Site is inferred to be in an easterly direction. The gradient of the water table across the Site is approximately 0.007, based on the May 2017 results.

6.4 Water Well Records

The MECP water well database contains 41 well records within a 1 km buffer of the Site (Figure 7). Most of the wells are test wells, monitoring wells or observation wells (26) at the surrounding aggregate pits or other sites within the City of Cambridge. The remaining wells are listed as domestic water supply wells (9), livestock water supply wells (2) and abandoned wells (4). The records for the water supply wells indicate that 5 of them are completed in the overburden and 6 of them are completed in the bedrock.

6.5 Groundwater Use

The MECP issues Permits to Take Water (PTTW) for water users taking more than 50,000 L/day (i.e. large water users). With the Site being located in a prime area for aggregate extraction, one of the main water uses is aggregate washing, which happens in a closed loop system, allowing for recirculation of the water. There are six PTTWs within 2.5 km of the Site including one for the Dance Pit. The water takings for aggregate washing are located north, west and south of the Site.

The City of Cambridge, including the residential area to the east, is supplied by municipal water from various production wells. There are seven Region of Waterloo production wells located within 3 km of the Site to the northeast, east and southeast, with the closest approximately 1.9 km away from the Site. Outside of the City, rural residences rely on water supplies from private wells. Based on a review of aerial photography, it is estimated that there are 11 residential properties and 1 commercial property within 1 km of the property boundary that utilize groundwater, including 2 properties north of the Site on Cedar Creek Road, 5 properties west of the Site on Cedar Creek Road and 5 properties south of the Site on Spragues Road (not including the residential development to the east that relies on a municipal water supply).

6.6 Groundwater Quality

Groundwater samples were collected from BH16-1, BH16-2 and BH16-3 in August 2016 following purging of the wells. The samples were submitted to Maxxam Laboratories for analysis of general inorganics and metals, and BTEX (benzene, toluene, ethylbenzene and xylene). The water quality results are provided in Appendix C along with the laboratory certificates of analysis. The results have been compared to the Ontario Drinking Water Standards (ODWS), Guidelines and Objectives, as discussed below.

Hardness concentrations exceeded the operational guideline in all the wells, which is typical in wells completed in the overburden in southern Ontario. Total dissolved solids (910 mg/L), chloride (270 mg/L) and sodium (250 mg/L) exceeded the aesthetic objectives at BH16-1. Nitrate (18.4 mg/L) exceeded the maximum acceptable concentration of 10 mg/L at BH16-3. Further analysis of the exceedances is provided in the following sections. No additional ODWS parameters were exceeded at the wells sampled during the August 2016 monitoring event. No petroleum hydrocarbons (BTEX, F1-F4) were detected in the monitoring wells.

It is important to examine groundwater quality results such as these in the context of the three general development stages of the proposed pit: 1) pre-development, 2) during operation and 3) post-development. Groundwater quality is discussed in relation to each of these stages below.

6.6.1 Pre-Development Water Quality

Two main contaminants of concern related to the existing agricultural land use (nitrates and pathogens) are commonly observed in groundwater located within agricultural settings, such as those that comprise the Site. These contaminants are typically introduced as a result of the application of fertilizer and manure required to aid in the growing and maintenance of crops. Pesticides and herbicides, which are also used in the maintenance of crops by the agricultural community, are readily biodegradable and are not widely detected in rural groundwater (Conboy and Goss, 1999). In the case of pathogens, these can also be introduced through rural septic systems, from wildlife and manure, and biosolids spreading. Nitrate was detected at all three wells during the August 2016 sampling event (BH16-1 – 4.91 mg/L; BH16-2 – 3.36 mg/L; BH16-3 – 18.4 mg/L). The highest concentration was detected at BH16-3 on the downgradient side of the property indicating that there is some impact from current or historical agricultural practices.

Impacts from winter road salt application (i.e., chloride, sodium) are often identified in shallow aquifers located near existing roadways. Chloride and sodium were identified at low concentrations at BH16-2 and BH16-3, and at elevated concentrations at BH16-1, located close to Cedar Creek Road.

6.6.2 Water Quality during Operation

During operation of the pit, there is a potential for petroleum hydrocarbon impacts to occur as a result of equipment refuelling on-Site, if a spill occurs. However, fuel storage and handling would be managed in accordance with regulations set forth by the Technical Standards and Safety Authority (TSSA) and CBM's own fuel handling procedures. As such, petroleum hydrocarbon contamination is not considered to be a significant concern with respect to this operation. No petroleum hydrocarbons were detected in the monitoring wells during the August 2016 monitoring event. No other potential sources of contamination are considered to be significant during the operational phase of the property.

If farming continues to take place on parts of the land while the pit is operational, there continues to be the potential for the introduction of nitrates and pathogens into groundwater, in a manner similar to the current circumstances.

6.6.3 Post-Development Water Quality

Upon rehabilitation, the proposed pit would be returned to agricultural land use. One of the key differences between pre- and post-extraction is the reduction in unsaturated zone thickness above the water table through the removal of the overlying sand and gravel resource. While there is a perception that reduced unsaturated zone thickness can adversely affect the “filtering capacity” of the subsurface, it is in fact travel through the saturated zone where “filtering” predominantly takes place (Golder, 2010). As such, the “filtering capacity” of the subsurface will remain substantially the same upon rehabilitation. An agricultural land use is consistent with that of the surrounding land outside of the City and where aggregate extraction is not occurring. An agricultural land use would therefore not pose an incrementally higher risk to water quality than is already present in the area.

Groundwater quality samples should be taken on an annual basis during operations and continue for a period of two years after final rehabilitation of the Site has taken place.

7.0 SURFACE WATER

This section discusses the surface water balance of the proposed Dance Pit Expansion.

7.1 Water Balance Methodology

The Meteorological Service Data Analysis and Archive division of Environment Canada (EC) provides monthly water budget summaries for meteorological stations with greater than 20 years of meteorological data. These water budgets include monthly values for all parts of the water budget (rainfall, snowmelt, potential evaporation, etc.) for each of the years in the historic record, as well as average monthly values over the entire record.

The water balance assessment was based on meteorological data from the EC Thornthwaite water budgets (Roseville MOE, Ontario between 1973 and 2005), watershed boundaries, land use data, and the existing soil types.

This method describes water flux in a unit area of soil on a monthly basis based on a balance of precipitation (rainfall and snowmelt), evapotranspiration (ET), soil storage, and surplus. The water budget can be summarized as follows:

$$P = S + ET + R + I$$

Where: P = precipitation;

S = change in soil water storage;

ET = evapotranspiration;

R = surface runoff; and,

I = infiltration (groundwater recharge).

The various water budget components associated with catchment areas are typically presented in millimetres (mm) over their respective sub-catchments and represent the amount of water per unit of watershed area.

The water budget model combines accumulated rainfall and snowmelt to estimate total precipitation. Rainfall represents precipitation when monthly mean temperatures are greater than 0^{o}C. Snowmelt is initiated when snow is on the ground and monthly mean temperatures are greater than 0^{o}C. Hence, snowmelt is based on the depletion of snow storage (accumulated precipitation during periods of sub-zero temperatures). Precipitation data collected at EC Roseville MOE monitoring station (1973 to 2005) indicated a mean annual precipitation (P) of 908 mm/year.

The potential or maximum ET is estimated, in this case, by the empirical Thornthwaite equation (using average monthly temperature and hours of daylight) and represents the amount of water that would be evaporated or transpired under wet soil-water scenarios. The actual ET is the total evapotranspiration for the period of study based on evapotranspiration demand, available soil-water storage, and the rate at which soil water is drawn from the ground (as defined by an established drying curve specific to the soil type). The mean annual potential ET for the study Site is approximately 610 mm/year based on data provided by EC.

Annual water surplus is the difference between P and the actual ET. The water surplus represents the total amount of water available for either surface runoff (R) or groundwater infiltration (I) on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snow-melt, and maximum soil or snow pack storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use. The WHC is related to specific soil properties, including field capacity and wilting point.

7.2 Precipitation

Table 2 (following the text) includes total monthly precipitation from 2008 through 2020, as well as the 30-year normal (1981 to 2010) for the Roseville Station.

The 30-year normal in Roseville is 918.7 mm with total annual precipitation ranging from 713.6 mm (2012) to 1,137.2 mm (2008) over the period from 2008 to 2020. The annual precipitation was more than 10% below the normal in 2010, 2012, 2015 and 2020 and more than 10% above the normal in 2008, 2013 and 2019. For comparison, a review of the precipitation data back to 2001 also indicates that the precipitation recorded in 2008 and 2012 were the extreme high and low recorded since that time. The average annual precipitation over the past thirteen years (2008 – 2020) is 894 mm, which is approximately 2.7% below the 30-year normal (918.7 mm) or close to normal conditions. Based on the review of precipitation records, it appears that in the past thirteen years, the area has experienced both extreme high and low precipitation conditions, but overall, the average is close to normal conditions.

7.3 Catchment Delineation

Site catchments were delineated using topographic mapping and Site boundary information as illustrated on Figure 8 and summarized in Table 3 . As land use (existing pit operations) within the existing licence boundary is not expected to change, the water balance evaluated the catchment area of the Site.

7.4 Water Balance Scenarios

Under existing conditions, the catchment is composed of sparsely wooded and agricultural lands with no built-up areas. Under operational conditions, most of the Site will be excavated to form the proposed pit leaving a narrow border of agricultural land (open pasture) defined by the setback boundary.

Rehabilitated conditions were also considered in this study to determine the water surplus after excavation operations have ceased and the pit is fully reclaimed. The rehabilitated condition considers the pit to remain as a depression in the ground with sandy soil to support a fully vegetated cover. The bottom elevation of the pit will remain 2.0 m above the seasonally high water table and thus the rehabilitated pit is not anticipated to become ponded. No drainage will be directed off-Site under rehabilitated conditions for the property and the relatively gentle slope will encourage infiltration of any direct precipitation on the pit footprint. Due to the coarse nature of the sediments, it is estimated that precipitation will infiltrate with minimal ponding throughout the Site.

7.5 Water Balance Parameters

Soil information was taken from the 2012 Ontario Quaternary Soils Mapping. Soils at the Site are primarily Sandy Loam for the agricultural areas and Silt Loam for the wooded areas. Gravelly sand was assumed to be the operational conditions soil type for the Site based on existing borehole results as discussed prior in Sections 4.0 and 5.0.

The maximum soil storage is quantified using a Water Holding Capacity (WHC) that is based on guidelines provided in Table 3.1 of the Ministry of the Environment (MOE) Stormwater Management Planning and Design Manual (MOE, 2003). The WHC represents the total amount of water that can be stored in the soil capillaries and is defined as the water content between the field capacity and wilting point (the functional maximum and minimum soil water content, respectively).

WHCs are specific to the soil type and land use, whereby values typically range from approximately 10 mm for bedrock to 400 mm for mature forest over silt loam. For temperate region watersheds, soil storage is typically relatively stable year-round, remaining at or near field capacity with the exception of the typical mid- to late-summer dry period. As such, the change in soil storage is a minor component in the water budget, particularly at an annual scale. Surplus water remains in the system after actual ET has been removed (ET demand is met) and the maximum WHC is exceeded (soil-water storage demand is met).

There are three main factors that influence the percent infiltration of the total surplus: topography, soil type and ground cover. The sum of the fractions representing the three characteristics establishes the approximate annual percentage of surplus, which can be infiltrated in an area with a sufficient downward groundwater gradient.

Existing and proposed catchment areas are summarized by land use, WHC, soil type, and infiltration factor in Table 3.

Table 3: Summary of Catchment Areas, WHCs, Soil Types, and Infiltration Factors

Existing Conditions					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor**	**Catchment Areas (m²)**
Wooded	250 mm	Wooded	Sandy Loam	0.9	7,582
Agricultural	200 mm	Shallow Root Crops	Silt Loam	0.9	282,075
Built Up Area (Pervious)	100 mm	Excavation Pit	Gravelly sand	1.0	0
				Total	**289,657**
Operational Conditions (Proposed Excavation Pit)					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor**	**Catchment Areas (m²)**
Wooded	250 mm	Wooded	Sandy Loam	0.9	0
Agricultural	200 mm	Pasture & Shrub	Silt Loam	0.9	72,232
Built Up Area (Pervious)	100 mm	Excavation Pit	Gravelly Sand	1.0	217,425
				Total	**289,657**
Rehabilitated Conditions					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m²)**
Rehabilitated Pit	200 mm	Pasture & Shrub	Gravelly Sand	1.0	217,425
Agricultural	200 mm	Pasture & Shrub	Sand	0.9	72,232
				Total	**289,657**

For sparsely wooded areas, a WHC of 250 mm and an infiltration factor of 0.9 were used, representing flat land with an average slope of <0.6 m/km, sandy loam soil, and wooded land use.

For agricultural areas, a WHC of 200 mm and an infiltration factor of 0.9 were used, representing flat land with an average slope of <0.6 m/km, sandy loam soil, and cultivated land use (moderately rooted crops).

For the built-up pervious areas (pit areas), a WHC of 100 mm and an infiltration factor of 1.0 were used, representing flat land with an average slope of <0.6 m/km and open gravelly sand as the soil type. The high permeability of the proposed sand and gravel pit warrants a correspondingly high infiltration factor. Under rehabilitated conditions, a WHC of 200 mm was assigned to the pastures and shrubs that will re-vegetate the pit over a sand soil layer. During both operational and rehabilitated conditions, the pit areas are expected to have an infiltration factor of 1.0, representing a closed depression area. As a result, all available surplus from the pit will eventually infiltrate in the closed system.

7.6 Water Balance Results

Surplus values were estimated as the annual precipitation minus annual actual evapotranspiration. Runoff was calculated as the difference between surplus and infiltration.

7.6.1 Existing Conditions

The water balance results for the existing conditions are provided in Table 4.

Table 4: Existing Conditions Water Balance Results

Land Use	Area	Surplus		Infiltration		Runoff	
	(m^2)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Sparsely Wooded	7,582	306	2,320	275	2,088	31	232
Agricultural	282,075	313	88,289	282	79,460	31	8,829
Built Up Area (Pervious)	0	-	-	-	-	-	-
TOTAL	**289,657**	**313**	**90,609**	**282**	**81,548**	**31**	**9,061**

The total average annual surplus for the catchment area under existing conditions was estimated to be 313 mm or 90,609 m^3 per year and the estimated infiltration is approximately 282 mm or 81,548 m^3 per year. Runoff was estimated as the difference between surplus and infiltration and was estimated to be 31 mm or 9,061 m^3 per year. Based on the assessment, 90.0% of the annual surplus infiltrates while the remaining 10.0% is surface runoff under the existing condition.

7.6.2 Operational Conditions

The water balance results for operational conditions are provided in Table 5.

Table 5: Operational Conditions Water Balance Results

Land use	Area	Surplus		Infiltration		Runoff	
	(m^2)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Sparsely Wooded	0	-	-	-	-	-	-
Agricultural	72,232	313	22,609	282	20,348	31	2,261
Built Up Area (Pervious)	217,425	355	77,186	355	77,186	0	0
TOTAL	**289,657**	**345**	**99,794**	**337**	**97,534**	**8**	**2,261**

The total average annual surplus for the catchment area was estimated to be 345 mm or 99,794 m^3 per year and the estimated infiltration is approximately 337 mm or 97,534 m^3 per year. Runoff was estimated to be 8 mm or 2,261 m^3 per year. Based on the assessment, 97.7% of the annual surplus infiltrates while the remaining 2.3% is surface runoff.

7.6.3 Rehabilitated Conditions

The water balance results for the rehabilitated conditions are provided in Table 6.

Table 6: Rehabilitated Conditions Water Balance Results

Land use	Area	Surplus		Infiltration		Runoff	
	(m^2)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Wooded	0	-	-	-	-	-	-
Agricultural	72,232	313	22,609	282	20,348	31	2,261
Rehabilitated Pit	217,425	313	68,054	313	68,054	0	0
TOTAL	**289,657**	**313**	**90,662**	**305**	**88,402**	**8**	**2,261**

The total average annual surplus for the catchment area was estimated to be 313 mm or 90,662 m^3 per year and the estimated infiltration is approximately 305 mm or 88,402 m^3 per year. Runoff was estimated to be 8 mm or 2,261 m^3 per year. Based on the assessment, 97.5% of the annual surplus infiltrates while the remaining 2.5% is surface runoff.

7.6.4 Water Balance Summary

A summary of the annual water balance considering surplus, infiltration, and runoff for the existing, operational, and rehabilitated conditions is provided in Table 7.

Table 7: Water Balance Summary

	Existing Condition		Operational Condition			Rehabilitated Condition		
Parameter	**(mm)**	**(m^3/yr)**	**(mm)**	**(m^3/yr)**	**(%)**	**(mm)**	**(m^3/yr)**	**(%)**
Surplus	313	90,609	345	99,794	9.2%	313	90,662	0.1%
Infiltration	282	81,548	337	97,534	16.4%	305	88,402	7.8%
Runoff	31	9,061	8	2,261	-300.8%	8	2,261	-300.8%

Notes:
n/a = not applicable

Under operational conditions, surplus is anticipated to increase by 9.2% from 90,609 to 99,794 m^3 per year – representing the reduced evapotranspiration due to the removal of agricultural land use. Infiltration is expected to increase by 16.4% from 81,548 to 97,534 m^3 per year as the operational surplus is greater than existing conditions and the runoff from the pit area eventually infiltrates. This will effectively change the total runoff from the site to 8 mm/yr (2,261 m^3/yr). This equates to an overall decrease in runoff of 300.8% or 6,800 m^3 per year.

Under rehabilitated conditions, the objective was to restore the Site close to existing conditions. Rehabilitated conditions will be pasture and shrubs similar to that of existing, and thus surplus is projected to only increase by 0.1% to 90,662 m^3 per year. All available runoff from within the rehabilitated pit footprint will be contained within the pit and eventually infiltrated. The infiltration is expected to increase by 7.8% to 305 mm/yr (88,402 m^3/yr) and in the runoff will decrease 300.8% to 8 mm/yr (a decrease of 6,800 m^3/yr).

8.0 SOURCE WATER PROTECTION

The Clean Water Act was established to protect municipal sources of drinking water from contamination and over-use. Under the Clean Water Act, communities across Ontario are required to prepare an assessment report that will be the background to develop and implement source protection plans. The source protection plans, which have been approved and are in effect, contain policies that protect our municipal water supplies.

The following is summarized from the Grand River Source Protection Area Approved Assessment Report (Lake Erie Region Source Protection Committee, 2015). A wellhead protection area (WHPA) is the area around a wellhead where land use activities have the potential to affect the quality and quantity of water that flows into the municipal well. The WHPA is divided into zones based on travel time to the well (i.e. 2-year, 5-year and 25-year). The Site falls within the 25-year time of travel capture zone (referred to as WHPA-D) and the southeastern part of the Site falls within the 5-year time of travel capture zone (referred to as WHPA-C). On a regional scale, the intrinsic vulnerability is defined as high, medium or low and relates to how vulnerable the underlying aquifer is to potential surface contamination. The Site is mapped in an area of low intrinsic vulnerability. The WHPA mapping is combined with the intrinsic vulnerability mapping to produce a vulnerability score ranging from 2 (lowest) to 10 (highest). The portion of the Site that falls within WHPA-D has a vulnerability score of 2 and a score of 4 within the portion of the site that falls within WHPA-C. Potential threats (chemical, DNAPL and pathogen) are then assessed within the WHPA based on a number of factors. Due to the low vulnerability and distance from the municipal wells, chemical, DNAPL or pathogen threats are not considered significant threats at the Site.

The WHPA that encompasses part of the Site is for the Middleton Street Well Field. The Middleton Street Well Field has elevated concentrations of trichloroethylene (TCE) and chloride. As a result, the entire WHPA has been delineated as an “issue contributing area”. As such, specific policies have been developed relating to the chloride and TCE issues. The policies for chloride relate to sewage system, road salt and storage of snow threats while the policies for TCE relate to waste disposal, sewage system and DNAPL threats. The following table provides a summary of policies that apply to the Site (the Source Protection Plan should be read for more details).

Table 8: Grand River Source Protection Plan Policies

Identified Issue	Threat	Policy Number	Description
Chloride	Septic System or Holding Tank	RW-MC-10	Environmental Compliance Approval for a new large septic system will contain terms and conditions to ensure the activity never becomes a significant threat
Chloride	Discharge of Stormwater from a Stormwater Management Facility	RW-MC-16	Environmental Compliance Approval for discharge of stormwater form a stormwater management facility will contain terms and conditions to ensure the activity does not become a significant threat
Chloride	Discharge of Stormwater from a Stormwater Management Facility	RW-MC-18	Official plans will be amended to require development proposals for stormwater management facilities to be subject to a study to assess impact and mitigation measures
Chloride	Discharge of Stormwater from a Stormwater Management Facility	RW-CW-20	A risk management plan shall be required
Chloride	Application, Storage and Handling of Salt	RW-MC-36	Official plans will be amended requiring new roads as part of subdivision and condominium applications where salt could be applied be permitted subject to study
Chloride	Application, Storage and Handling of Salt	RW-CW-37	To provide guidance about the importance of source water protection and to promote best management practices the Regional Municipality of Waterloo shall develop and implement an education and outreach program for persons involved in the application, handling and storage of salt
Chloride	Storage of Snow	RW-CW-43	The Regional Municipality of Waterloo shall implement an education and outreach program for persons involved in the storage of snow

Identified Issue	Threat	Policy Number	Description
TCE	Waste Disposal Site	RW-MC-2	The establishment of waste disposal sites shall be prohibited within the Environmental Compliance Approvals process
TCE	Waste Disposal Site	RW-CW-3	The establishment of waste disposal sites shall be prohibited within Environmental Protection Act and exempt from Environmental Compliance Approvals
TCE	Storage of Sewage	RW-MC-11.1	Environmental Compliance Approval for storage of sewage (treatment or storage tank) will contain terms and conditions to ensure the activity never becomes a significant threat
TCE	Sanitary Sewers and Related Pipes	PW-MC-13	Combined sewers shall be prohibited
TCE	Handling and Storage of DNAPL	RW-CW-53	The Regional Municipality of Waterloo shall implement an education and outreach program for persons involved in the handling and storage of DNAPLs

None of the above-mentioned threats are proposed for the Site. Should chloride based products be used for dust-suppression or de-icing, then CBM should use best management practices outlined by the Regional Municipality of Waterloo through education outreach programs.

9.0 RESULTS

The following provides the results of the investigations in relation to the proposed licence application for the Site.

9.1 Extraction Elevation Limit

According to the Aggregate Resources of Ontario Provincial Standards or AROPS (Ontario, 1997), the maximum depth of extraction is to be a minimum of 1.5 m above the established seasonally high water table for a Class A Category 3 Licence. The monitoring well locations and measured water levels provide a good estimate of the water table elevation in support of the licence application for the proposed extraction. A review of the historical water levels in the adjacent Dance Pit indicate that the water levels in the spring of 2017 are similar to the high water levels in 2008 and early 2009 and are some of the highest to date. The highest groundwater elevations were measured in May 2017 at the on-Site wells and should be used to determine the pit floor elevation. These elevations will be the basis for determining the typical maximum water table elevation and hence, the maximum depth of excavation, which is set at 1.5 m above these elevations.

The proposed pit floor elevations are provided on Figure 9 and were provided to Harrington McAvan Ltd. (HML), planner for the file, in order to be incorporated on the Site Plans. The water table information outlined above was used to determine the proposed pit floor elevations. As noted on Figure 9, the final extracted pit floor will be relatively flat with a gentle slope to the east-northeast. Based on the highest water level measurements obtained at the Site, the pit floor elevation (maximum depth of extraction) will range from a high of approximately 311.2 masl in the southwestern corner of the Site to a low of approximately 309.3 masl in the northeastern corner of the Site (Figure 9). These elevations correspond to the addition of the required 1.5 m setback above the highest established water table elevation based on the 2017 high groundwater conditions.

The on-going water level monitoring will be used to confirm the proposed pit floor elevation. If sustained higher groundwater levels are observed in the future, the pit floor should be adjusted accordingly.

9.2 Potential Adverse Impacts to Groundwater Resources

Aggregate extraction will be limited to above the water table and, in addition, there are no plans for the washing of aggregate on the Site. As such, drawdown in groundwater levels, in the overburden aquifer, will not occur as a result of the proposed extraction operations on the Site. Therefore, there will be no interference with the surrounding well supplies and groundwater use.

It is expected that there is negligible potential for there to be impacts to water quality for neighbouring groundwater users as a result of this proposed operation as best management practices will be in place to control potential sources of contamination.

Also, since there will be no extraction below the water table and no alteration to drainage channels or surface water features on the Site, interference with the function of potential groundwater-dependent natural environment features will not occur.

9.3 Potential Adverse Impacts to Surface Water Resources

There are no surface watercourses or waterbodies within the Site. According to the City of Cambridge interactive GIS mapping service, Devil's Creek (tributary of the Grand River) is located approximately 80 m northeast of the Site. Additionally, tributaries and surface water bodies of Cedar Creek are located approximately 880 m west of the Site. Given that the proposed pit would drain internally, the change from the existing condition to the proposed condition may have a small and local effect on runoff and infiltration sourced flows in Devil's Creek.

The Ministry of Natural Resources and Forestry Ontario Flow Assessment Tool (OFAT) in conjunction with GIS mapping services was used to determine an approximate sub-catchment area of Devil's Creek (at the Cedar Creek Road crossing). This analysis revealed that the 28.97 ha Site represents approximately 21.2% of the sub-catchment area (a total of 136.5 ha). Under existing conditions, it is suspected that runoff from the Site rarely reports to Devils Creek directly. This runoff likely infiltrates and reports to the receiver through subsurface pathways. Although, some changes in Site surplus is proposed, it is all expected to drain internally and generally report to the same major receiving system. Overall, adverse effects on surface water resources and Devil's Creek are not expected.

10.0 CONCLUSIONS

The following conclusions are provided in support of a Class A Category 3 Above Water Table licence application for the Dance Pit Expansion.

1) The resource found on the Site is considered to be of primary significance according to ARIP mapping for the area and confirmed by on-Site testing.

2) No neighbouring groundwater users will be affected by the extraction of the resource on-Site to 1.5 m above the seasonally high water table.

3) Compared to existing conditions, average annual surplus over the Site footprint area increases under operational and rehabilitated conditions by approximately 9.2% and 0.1%, respectively.

4) Compared to existing conditions, average annual infiltration increases over the Site footprint area under operational and rehabilitated conditions to 97,534 m^3/yr and 88,402 m^3/yr, respectively.

5) Compared to existing conditions (9,061 m^3/yr), average annual off-Site runoff decreases under both operational and rehabilitated conditions to 2,261 m^3/yr.

6) There are no permanent surface water features on the Site. There will be no alteration as a result of aggregate extraction that would be expected to result in a significant impact to any surface water features adjacent to the Site.

7) The baseline water quality established as part of this assessment provides a basis for comparison of any subsequent testing, both during operations and post-rehabilitation.

8) There are currently no plans for water taking or aggregate washing to occur on the Site.

Considering the above conclusions, no adverse hydrogeological impacts associated with this licence application are anticipated. A maximum predicted water table and pit floor elevation have been determined for the Site.

11.0 RECOMMENDATIONS

The following recommendations are provided in order to support the licence application for the Dance Pit Expansion.

1) Quarterly groundwater level monitoring should be carried out on monitoring wells BH16-1, BH16-2 and BH16-3 to monitor groundwater fluctuations and confirm the high groundwater table in order to ensure maximum depth of extraction is at least 1.5 m above the water table on the property. The pressure transducers/data loggers should remain in the monitoring wells to record water levels between quarterly manual monitoring for a period up to the point of licence surrender.

2) Annual water quality monitoring should take place in monitoring wells BH16-1, BH16-2 and BH16-3 during operations and up to the point of licence surrender. The water quality analysis should include general inorganics, metals and benzene, toluene, ethylbenzene and xylene (BTEX).

3) The results of the monitoring program should be reported by a qualified professional on an annual basis to the licensee by April 30 of the year following, in the event the MNRF would like to see the results.

4) Fuel handling on the Site will be in accordance with existing regulations including proper procedures as defined by TSSA for fuel handling and the applicants’ fuel handling and spill response procedure.

12.0 SITE PLAN NOTES

The following notes should be placed on the site plan:

1) Quarterly groundwater level monitoring shall be carried out on monitoring wells BH16-1, BH16-2 and BH16-3 to monitor groundwater fluctuations and confirm the high groundwater table in order to ensure maximum depth of extraction is at least 1.5 m above the water table on the property in accordance with the Water Resource Assessment Report (Golder, 2020).

2) Annual water quality monitoring shall take place in monitoring wells BH16-1, BH16-2 and BH16-3 during operations, and up to the point of licence surrender, for the following parameters: general inorganics, metals and benzene, toluene, ethylbenzene and xylene (BTEX).

3) Water level and quality monitoring shall be documented in an annual report by a qualified professional and be available for review upon request.

13.0 LIMITATIONS OF REPORT

This report was prepared for the exclusive use of CBM. The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder and is based solely on the conditions of the property at the time of the work, supplemented by previous information and data obtained by others.

The assessment of environmental conditions at this Site has been made using the results of physical measurements from a number of locations and a desktop study. The Site conditions between sampling locations have been inferred based on conditions observed at drillhole locations. Subsurface conditions may vary from these sampled locations.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and geoscience professions currently practising under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in the future, including excavations, borings or other studies, Golder should be requested to re-evaluate the conclusions of this report, and to provide amendments, as required.

14.0 CLOSURE

Based on the foregoing considerations, it is the opinion of the undersigned that the extraction of this high quality sand and gravel resource on the proposed Dance Pit Expansion can be carried out with no appreciable hydrogeological or hydrological effects on the environs in the surrounding area.

Signature Page

Curriculum Vitae for the undersigned are included in Appendix E.

Golder Associates Ltd.

Greg Padusenko, MSc, PEng, PGeo
Senior Hydrogeologist

George Schneider, MSc, PGeo
Principal, Senior Geoscientist

Craig De Vito, PEng
Water Resources Engineer

NP/CDV/KM/GRP/GWS/ll

https://golderassociates.sharepoint.com/sites/107388/project files/6 deliverables/hydrogeology/report/final updated 2021/1653019 cbm dance fnl rpt 12apr2021.docx

REFERENCES

Chapman, L.J., and D.F. Putnam, 1984. The Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map P.2715 (coloured), scale 1:600 000.

Conboy, M.J., and M.J. Goss, 1999. Contamination of Rural Drinking Water Wells by Fecal Origin Bacteria. Water Quality Research Journal of Canada 34, 281-303.

Golder Associates Ltd., 2010. The Effect of Aggregate Extraction on Groundwater Quality. Submitted to the Ontario Stone, Sand and Gravel Association.

Karrow, P.F., 1987. Quaternary Geology of the Cambridge Area, Southern Ontario; Ontario Geological Survey, Map 2508, scale 1:50,000.

Lake Erie Region Source Protection Committee, 2015. Grand River Source Protection Area Approved Assessment Report. Prepared Under the Clean Water Act, 2006.

Ontario, 1997. Aggregate Resources of Ontario Provincial Standards (Version 1.0).

Ontario Geological Survey and Planning Engineering Initiatives Limited, 1998. Aggregate Resources Inventory of the Regional Municipality of Waterloo, Townships of North Dumfries, Wellesley, Wilmot, and Woolwich and the Cities of Cambridge, Kitchener and Waterloo; Ontario Geological Survey, Aggregate Resources Inventory Paper 161, 64p.

Ontario Geological Survey, 2003. 1:250,000 scale, Surficial Geology of Southern Ontario [electronic resource] Miscellaneous Release – Data 128.

Planning and Engineering Initiatives Ltd., 1990. Aggregate Resource Inventory Dance Property Lots 14, 15, 16, Concession 10, Township of North Dumfries, Regional Municipality of Waterloo.

Regional Municipality of Waterloo, 2008. Guidelines for Hydrogeological Assessments for Proposed Mineral Aggregate Resource Extraction Projects (Draft).

TABLES

Table 2
Monthly Precipitation Data for the Roseville Station
Dance Pit Expansion

MONTH	2008 (mm)	2009 (mm)	2010 (mm)	2011 (mm)	2012 (mm)	2013 (mm)	2014 (mm)	2015 (mm)	2016 (mm)	2017 (mm)	2018 (mm)	2019 (mm)	2020 (mm)	30-Year Normal[1] (mm)
January	20	74	29.4	61.2	55.4	102.5	89.3	30.1	63.4	98.2	64	38.2	127.9	68.1
February	93.2	79.4	31	70.6	24.6	43.4	60.3	60	48.1	93.4	83.2	73.1	63	54.6
March	74.2	71.8	40.6	105.4	32	39.6	40.3	13.2	125.2	71.1	36.7	52.7	71.7	55
April	43.6	128.1	72.7	94.1	28.9	121.8	92.4	99.2	57.4	110.6	97.9	109.5	47.8	77.2
May	66	65.8	53.8	63.7	32.4	64.4	66.6	86	59	54.5	60.1	110.1	53.7	87.9
June	140.3	52.8	127	55.4	91.6	92.4	59.6	134.4	55.6	80.8	90.1	99.7	59.2	76.3
July	180.6	85.3	121.4	28.2	41.5	121.7	163.8	91.7	72.8	68.1	52.1	106	31.3	98.2
August	81.7	95.3	42.4	77.9	56.8	40.3	34.4	39.7	190.8	122.2	126.7	101.7	68.3	83.9
September	126.7	34.9	99.7	85.6	102.1	135.5	91.7	41.5	55.2	23.2	64.2	84.1	81.2	85.4
October	59.8	81.1	83.4	117.9	151.9	162.8	72.1	87.7	42.7	64.4	85.3	164.6	80.7	75.3
November	103.1	35	25.3	88.6	17.4	38.8	55.2	59.1	54.2	61.3	80.7	34.4	63.6	88.4
December	148	61.7	26.5	99.2	79	80.3	21.8	57.6	74.2	27	63.9	44.1	68.7	68.5
TOTAL	**1137.2**[2]	**865.2**[3]	**753.2**[4]	**947.8**[5]	**713.6**[6]	**1043.5**[7]	**847.5**[8]	**800.2**[9]	**898.6**[10]	**874.8**[11]	**904.9**[12]	**1018.2**[13]	**817.1**[14]	**918.7**

1 - *1981 to 2010*

2 - *excludes data gaps totalling 50 days in January, February, March, May, August, September and November*

3 - *excludes data gaps totalling 34 days in February, June, July, August, September, October, November and December*

4 - *excludes data gaps totalling 45 days in March, April, May, June, August, November and December*

5 - *excludes data gaps totalling 31 days in April, May and November*

6 - *excludes data gaps totalling 31 days in February, March, May, June, July, September, November and December*

7 - *excludes data gaps totalling 32 days in January, February, March, May, June, October and December*

8 - *excludes data gaps totalling 22 days in March, April, August, September, November and December*

9 - *excludes data gaps totalling 15 days in February, March, August and November*

10 - *excludes data gaps totalling 32 days in February, March, April, May, June, September, November and December*

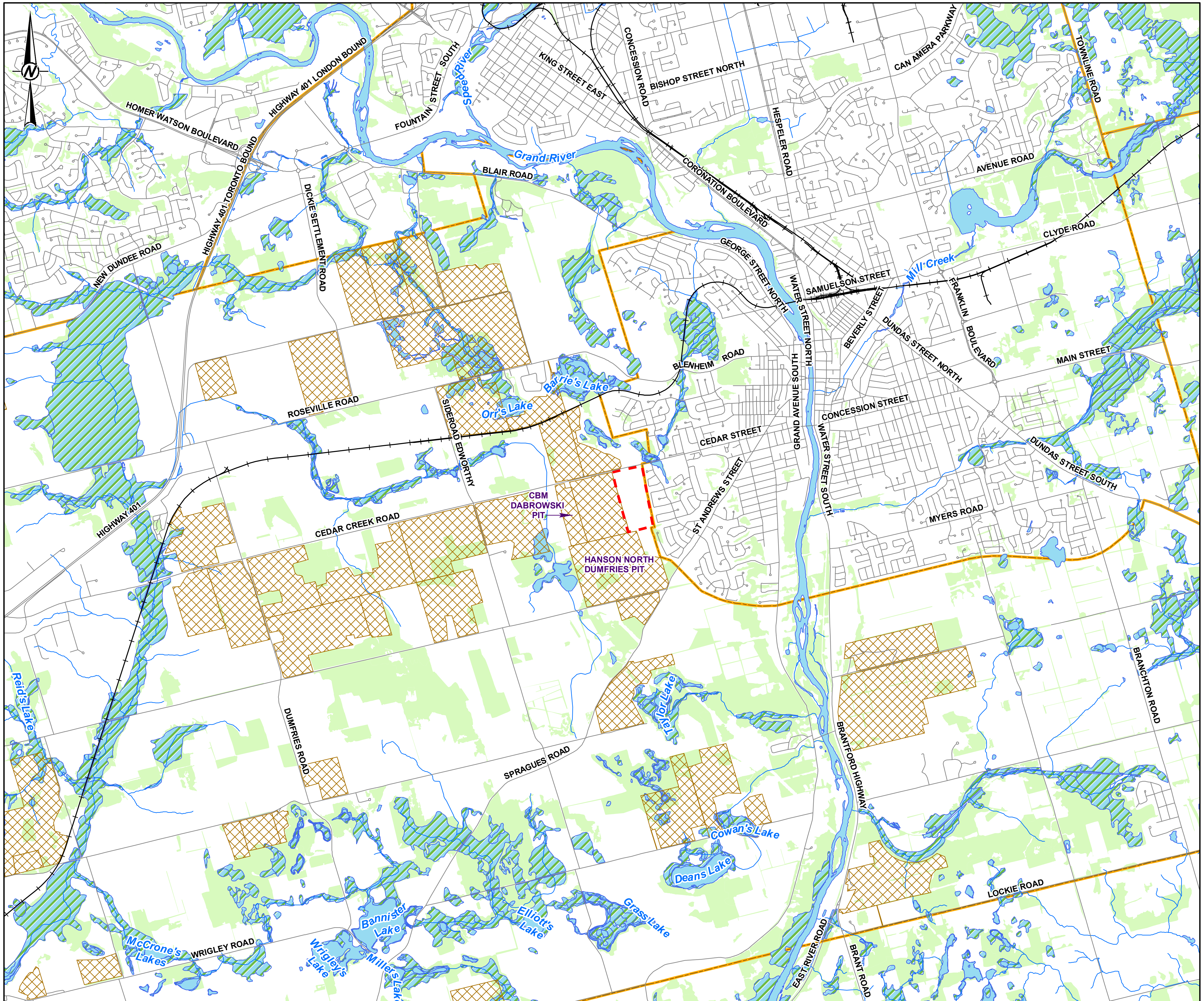
11 - *excludes data gaps totalling 42 days in March, April, May, June, July, September, October, November and December*

12_ *excludes data gaps totalling 27 days in January, February, May, July, August, October, November, December*

13_ *excludes data gaps totalling 64 days in January, March, September, November, December. Gaps exceed 60 days so alternate data was provided by weather station KW.*

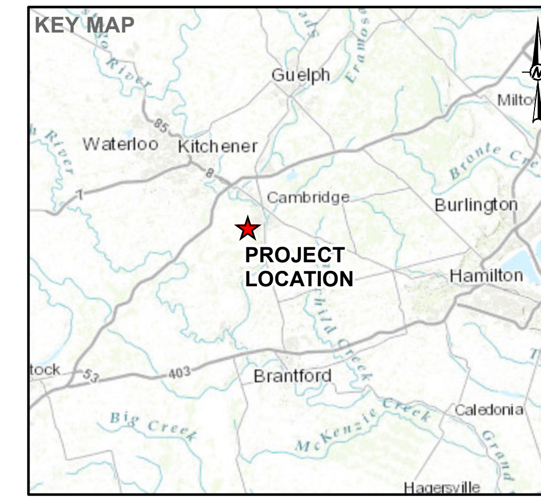
14_ *excludes data gaps totalling 8 days in January, November and December*

FIGURES



LEGEND

- RAILWAY
- ROAD
- WATERCOURSE
- WATERBODY
- PROVINCIALLY SIGNIFICANT WETLAND
- EXISTING ACTIVE AGGREGATE SITE
- MUNICIPAL BOUNDARY
- EXPANSION LICENCE BOUNDARY



0 1 2 3

1:50,000 KILOMETERS

REFERENCE(S)
1. BASEDATA MNRF 2016
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT
ST MARYS
ST. MARYS CEMENT INC. (CANADA)

PROJECT
DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE
SITE LOCATION PLAN

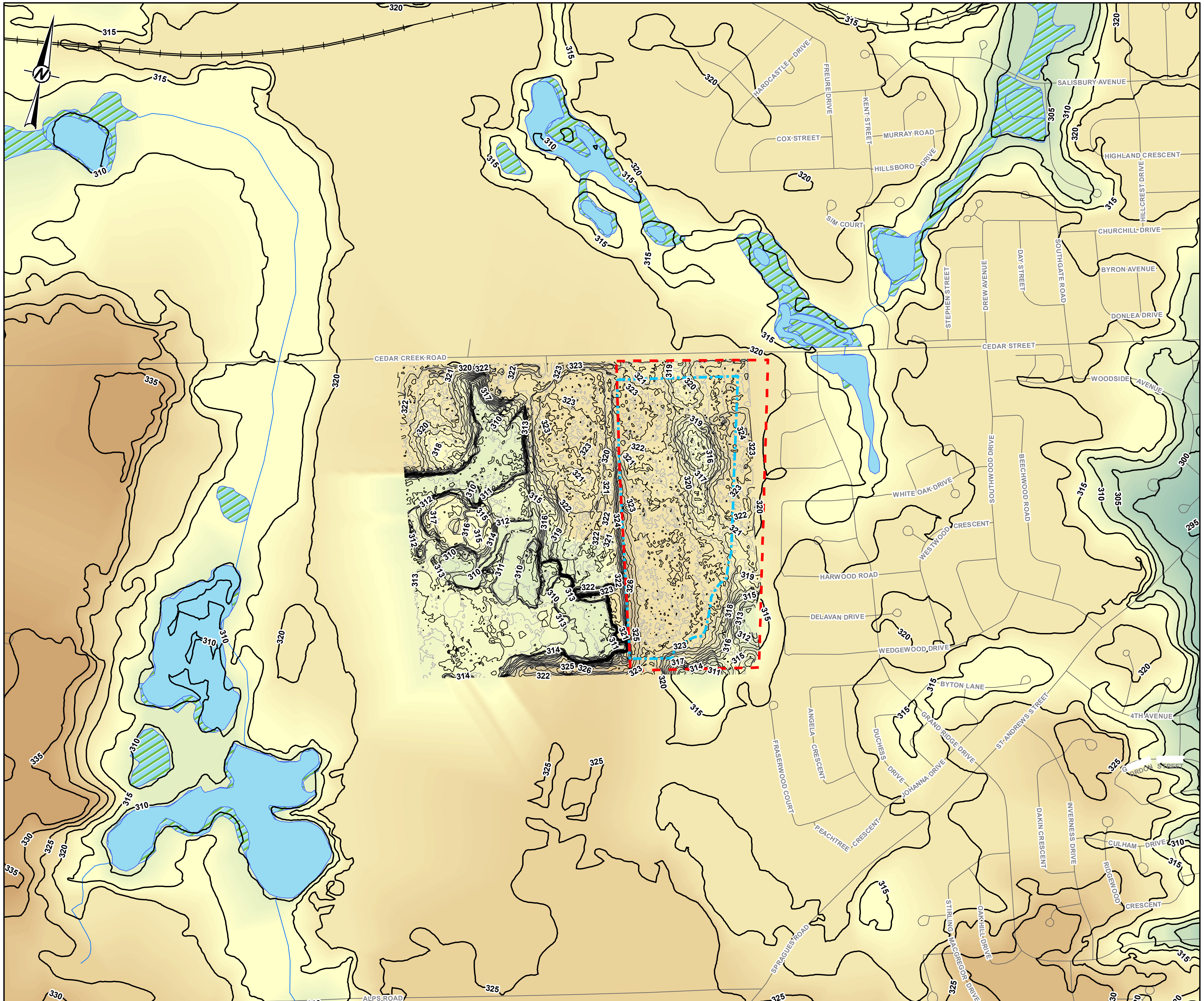
CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

S:\Clients\CBM_Aggregates\North_Dumfries_ON\99_PROJ\1653019_CBM_DancePit_Expansion\40_PROD\0003_Hydrogeology_Report\1653019_0003_CS_0001.mxd



LEGEND

PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION

EXPANSION LICENCE BOUNDARY

CONTOUR - 10 m INTERVAL

CONTOUR - 0.5 m INTERVAL

WATERCOURSE

WATERBODY

WETLAND SIGNIFICANCE

TOPOGRAPHY (m)

HIGH: 350

LOW: 280

0 250 500 750

1:10,000 METRES

REFERENCE(S)

1. BASEDATA MNRF 2016
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. TOPOGRAPHY COMPILED USINGS DETAILED SITE TOPOGRAPHY FROM CBM (PROVIDED 2016) AND MNRF 10M CONTOUR DATA (DOWNLOADED 2016)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT

ST MARYS

ST. MARYS CEMENT INC. (CANADA)

PROJECT

DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE

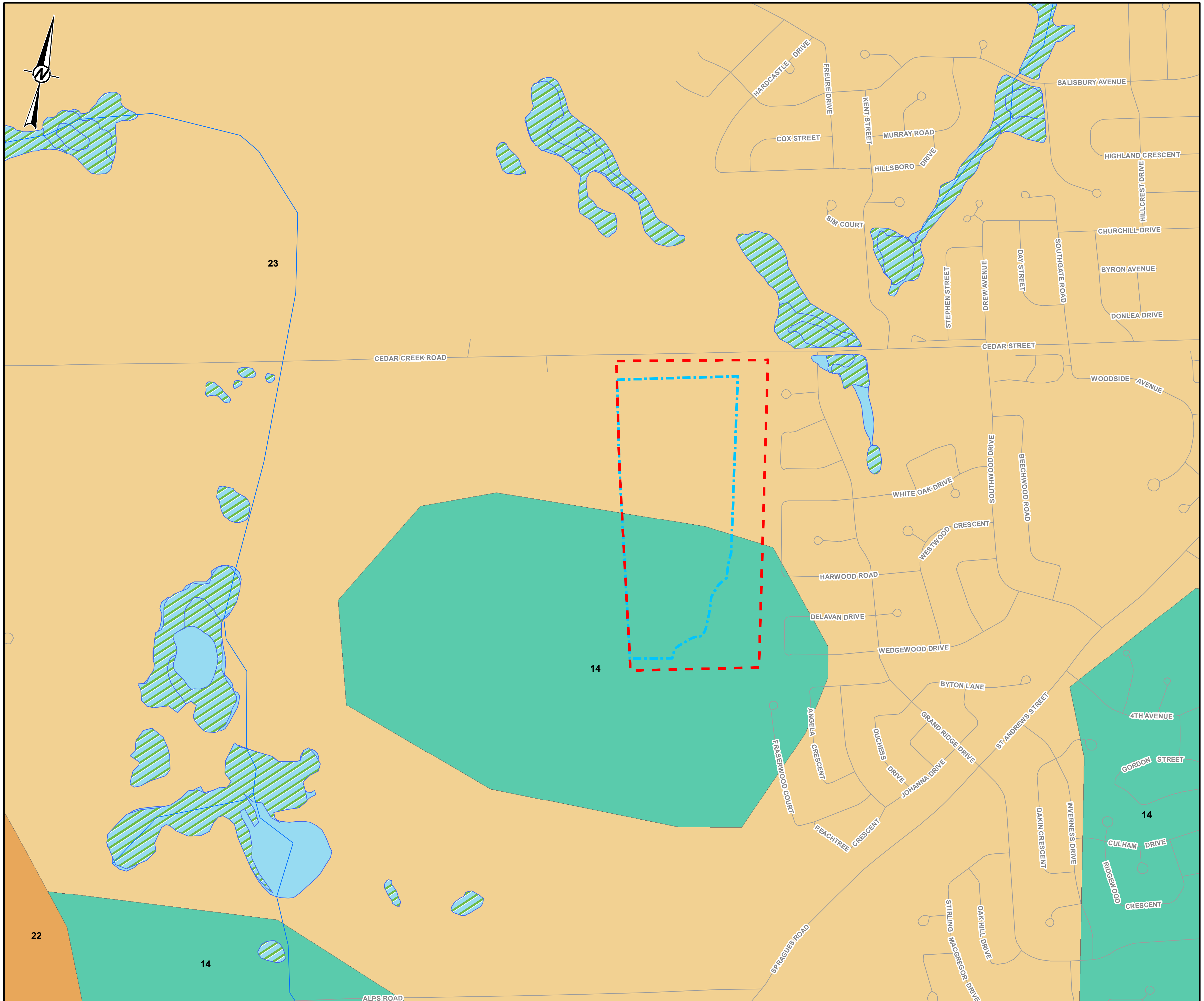
TOPOGRAPHY AND DRAINAGE

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	2



LEGEND
PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION
EXPANSION LICENCE BOUNDARY
WATERCOURSE
WATERBODY
WETLAND_SIGNIFICANCE
SURFICIAL GEOLOGY
14: WENTWORTH TILL
22: GLACIOFLUVIAL ICE
23: GLACIOFLUVIAL OUTWASH DEPOSITS

0 250 500 750
1:10,000 METRES

REFERENCE(S)
1. BASEDATA MNRF 2016
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. OSG SURFICIAL GEOLOGY OBTAINED FROM MNDM (1: 1M SCALE, 2003).
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE
SURFICIAL GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

S:\Clients\CBM_Aggregates\North_Dumfries_ON\99_PROJ\1653019_CBM_DancePit_Expansion\40_PROD\0003_Hydrogeology_Report\1653019_0003_CS_0003.mxd

LEGEND

- PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION
- EXPANSION LICENCE BOUNDARY
- 1990 TEST PIT
- 2016 TEST PIT
- 2016 MONITORING WELL
- EXISTING MONITORING WELL
- BOREHOLE LOCATION
- CROSS-SECTION

0 100 200 300
1:5,000 METRES

REFERENCE(S)
1. IMAGERY: © 2020 MICROSOFT CORPORATION © 2019 DIGITALGLOBE ©CNES (2019) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

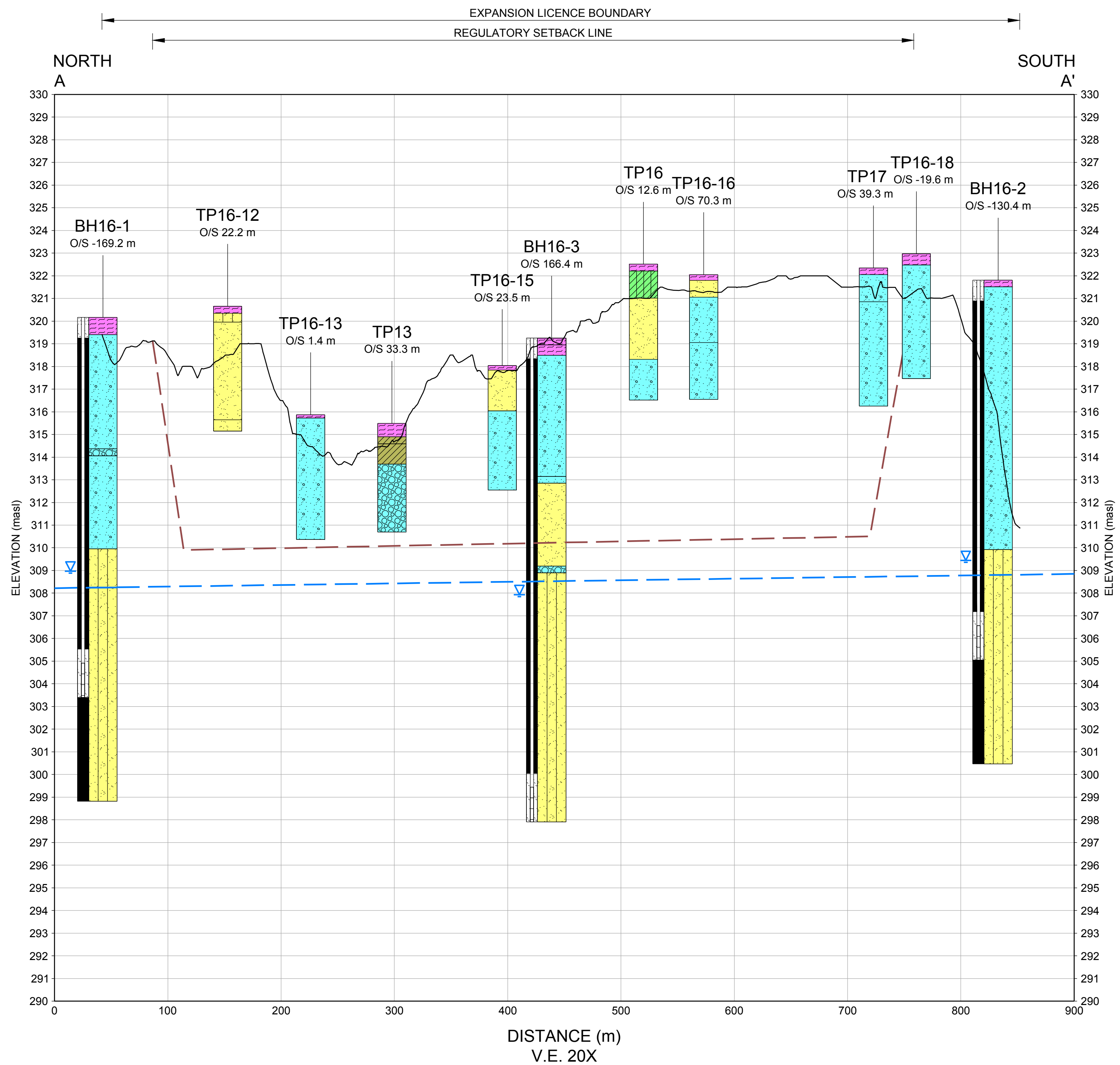
TITLE
LOCATION OF TEST PITS AND BOREHOLES/MONITORING WELLS

CONSULTANT

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



STRATIGRAPHY LEGEND

- TOPSOIL
- GRAVEL
- GRAVELLY SAND
- SAND
- SAND TO SILTY SAND
- CLAY
- SILTY CALY

LEGEND

- WATER LEVEL (MEASURED MAY, 2017)
- GROUND SURFACE (EXISTING)
- INTERPRETED HIGH WATER TABLE (APPROXIMATE)
- PROPOSED PIT FLOOR ELEVATION (APPROXIMATE)

NOTE(S)

1. PROPOSED PIT FLOOR ELEVATION RANGES FROM 309.3 masl (NORTHEAST CORNER) TO 311.2 masl (SOUTHWEST CORNER).

0 5 10
1:250 VERTICAL METRES

0 100 200
1:5,000 HORIZONTAL METRES

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE
CROSS SECTION A - A'

CONSULTANT GOLDER

YYYY-MM-DD	2020-04-08
DESIGNED	
PREPARED	DD
REVIEWED	GP
APPROVED	GP

PROJECT NO.	CONTROL	REV.	FIGURE
1653019		A	5

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Path: \\golder.gds\gal\mississauga\gis\Clients\CBM_Aggregates\North_Dumfries_ON\99_PROJ\1653019_CBM_DancePit_Expansion\40_PROD\0003_Hydrogeology_Report\ | File Name: 1653019_0003_CS_0005.dwg

LEGEND

- PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION
- EXPANSION LICENCE BOUNDARY
- WELL LOCATION
- 308.64 GROUNDWATER LEVEL (MAY 2017)
- FLOW DIRECTION
- GROUNDWATER CONTOUR
- INFERRED GROUNDWATER CONTOUR

0 100 200 300

1:5,000 METRES

REFERENCE(S)

1. IMAGERY: © 2020 MICROSOFT CORPORATION © 2019 DIGITALGLOBE ©CNES (2019) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT

ST. MARYS CEMENT INC. (CANADA)

PROJECT

DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE

INFERRED GROUNDWATER CONTOURS AND FLOW DIRECTION

CONSULTANT

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

- PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION
- EXPANSION LICENCE BOUNDARY
- EXTENSION PROPERTY 1 km BUFFER
- MECP WATER WELL RECORD (ABANDONED)
- MECP WATER WELL RECORD (DOMESTIC WATER SUPPLY)
- MECP WATER WELL RECORD (MONITORING WELL OR TEST HOLE)
- MECP WATER WELL RECORD (LIVESTOCK WATER SUPPLY)

0 100 200 300 400 500

1:12,000 METRES

REFERENCE(S)

1. IMAGERY: © 2020 MICROSOFT CORPORATION © 2019 DIGITALGLOBE ©CNES (2019) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. MOECC WATER WELLS RECORDS OBTAINED JULY 2016
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT

ST MARYS

ST. MARYS CEMENT INC. (CANADA)

PROJECT

DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE

WATER WELL RECORDS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm

LEGEND

PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION

EXPANSION LICENCE BOUNDARY

LANDCOVER

PASTURE/SHRUBS

LIGHTLY WOODED

0 50 100 150 200

1:3,500 METRES

REFERENCE(S)
1. IMAGERY: © 2020 MICROSOFT CORPORATION © 2019 DIGITALGLOBE ©CNES (2019) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. WATERSHED BOUNDARY GENERATED USING MNRF ONTARIO FLOW ASSESSMENT TOOL III (OFAT)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT

ST MARYS

ST. MARYS CEMENT INC. (CANADA)

PROJECT

DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE

WATER BALANCE SITE CATCHMENTS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

- PROPOSED LIMIT OF EXTRACTION FOR DANCE PIT EXPANSION
- EXPANSION LICENCE BOUNDARY
- WELL LOCATION
- PIT FLOOR ELEVATION CONTOUR (masl)

0 100 200 300

1:5,000 METRES

NOTE(S)

1. MAX WATER LEVEL BETWEEN APRIL 20TH AND MAY 16TH PLUS 1.5M

REFERENCE(S)

1. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. SITE PLAN PROVIDED BY CBM APRIL 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17N

CLIENT

ST MARYS

ST. MARYS CEMENT INC. (CANADA)

PROJECT

DANCE PIT EXPANSION LICENCE
CAMBRIDGE, ONTARIO

TITLE

PROPOSED PIT FLOOR ELEVATION

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
1653019	0003	0	9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

APPENDIX A

Borehole Logs

BOREHOLE LOG

PROJECT: 97-399

BOREHOLE: 1

HYDROGEOLOGICAL ASSESSMENT
Dabrowski Property, North Dumfries, Ontario
FOR: Blue Circle Aggregates

DATE: 30 January 1998
GEOLOGIST PW
ELEVATION 322.61 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0–10.4		**GRAVEL, COBBLES AND SAND** Brown gravel, cobbles and sand, high percentage of fractured stone pieces, sand fraction was mostly medium sand with some fine and some coarse sand, dry.		1		GS					
10.4–17.7		**SILT** Brown silt with some clay, trace fine sand, moist.		2		GS					Water level at 11.58 m below ground surface on January 31, 1998.
		Borehole terminated at 17.68 m in silt.									

Printed: 16 NOV 98

Gartner Lee Limited

BOREHOLE LOG	**PROJECT:** 97-399	**BOREHOLE:** 2	1 of 1

HYDROGEOLOGICAL ASSESSMENT
Dabrowski Property, North Dumfries, Ontario
FOR: Blue Circle Aggregates

DATE: 30 January 1998
GEOLOGIST PW
ELEVATION 322.38 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0 – 9.8	**GRAVEL, COBBLES AND SAND** Brown gravel, cobbles and sand, high percentage of fractured stone pieces, sand fraction was mostly medium sand with some fine sand and some coarse sand, dry.	1	GS					
9.8 – 10.4	**CLAYEY SILT** Brown clayey silt, APL to WTPL.	2	GS					
10.4 – 12.8	**SAND WITH SOME GRAVEL** Brown medium to coarse sand with some fine to medium gravel, dry.	3	GS					Water level at 11.48 m below ground surface on January 31, 1998.
12.8 – 15.2	**FINE SAND** Brown fine sand, wet.	4	GS					
15.2 – 18.3	**CLAYEY SILT** Grey to brown-grey clayey silt, APL.	5	GS					
18.3	Borehole terminated at 18.29 m in clayey silt.							

BOREHOLE LOG

PROJECT: 97-399

BOREHOLE: 3

HYDROGEOLOGICAL ASSESSMENT
TCG Cedar Street Pit, North Dumfries, Ontario
FOR: TCG Materials Limited

DATE: 31 January 1998
GEOLOGIST PW
ELEVATION ~ 319 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	COMMENTS
0 – 4.6	**SAND** Brown medium sand with some fine sand and some coarse sand, dry.	1	GS	
4.6 – 11.3	**SAND AND GRAVEL** Brown sand and gravel, mostly medium sand with some fine sand and some coarse sand, high percentage of fractured gravel, dry.	2	GS	
		3	GS	
11.3 – 12.8	**SAND** Brown coarse sand, dry.			
12.8 – 13.7	**SILT TILL** Brown silt with subrounded medium gravel, moist.	4	GS	Soil wet at about 12.8 m below ground surface.
	Borehole terminated at 13.72 m in silt till.			

Printed: 3 FEB 98

Gartner Lee Limited

BOREHOLE LOG	**PROJECT:** 97-399	**BOREHOLE:** 4	1 of 1

HYDROGEOLOGICAL ASSESSMENT
TCG Cedar Street Pit, North Dumfries, Ontario
FOR: TCG Materials Limited

DATE: 31 January 1998
GEOLOGIST PW
ELEVATION ~ 321 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0.9		**SAND** Brown medium sand with some fine sand and some coarse sand, dry.									
8.5		**SAND AND GRAVEL** Brown sand and gravel, mostly medium sand with some fine sand and some coarse sand, dry.		1		GS					
9.8		**SAND** Brown medium sand, dry.									
10.4		**SAND AND GRAVEL** Brown sand and gravel, mostly medium sand with some fine sand and some coarse gravel, dry.		2		GS					
18.0		**SAND** Brown medium sand with some coarse sand, dry. Becoming wet below about 14.9 m Gradational change to a fine sand below about 15 m.		3		GS					Soil wet at about 14.9 m below ground surface.
		Borehole terminated at 17.98 m in fine sand.									

Printed: 3 FEB 98

Gartner Lee Limited

BOREHOLE LOG

PROJECT: BH5

Cedar Street (Dance) Pit
North Dumfries Township, Region of Waterloo
FOR: CBM/St Marys Cement Inc.

DATE: 20 June 2005
LOGGED BY FJG
GROUND ELEV 317.40 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION
0 – 9.8	**GRAVEL, COBBLES AND SAND** Brown gravel, cobbles and medium sand, some fine sand, some coarse sand, trace silt, high percentage of fractured stone pieces, moist.
9.8 – 15.3	**SAND** Brown medium sand, trace silt, moist. -becomes wet by about 10.7m -becomes saturated by about 12.2m
15.3	Borehole terminated at 15.25 m in sand.

SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD
1	SS	50/ 0.08m		100	
2	SS	64/ 0.15m		93	
3	SS	54/ 0.08m		100	
4	SS	50/ 0.13m		39	
5	GS				
6	GS				
7	SS	48		54	
8	GS				
9	SS	41		61	
10	SS	58		100	
11	SS	50/ 0.13m		100	

N VALUE: 15 30 45 60

WATER CONTENT (%): 10 20 30 40

RECORD OF BOREHOLE: BH16-1

PROJECT: 1648132 (2000)

LOCATION: Dance Pit Expansion, Cambridge, ON

BORING DATE: January 25, 2016

SHEET 1 OF 1

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Sonic Drill 550	OVERBURDEN - (ML) SILT, some sand, fine; brown (TOPSOIL); cohesive, w>PL.		0.00							Concrete; Sand Pack (#2)
		(SP) GRAVELLY SAND, medium to coarse; brown, with cobbles; non-cohesive, moist.		0.76	A	SDC					
4					B	SDC					
6		(GP) GRAVEL, some sand; grey, with cobble/boulder fragments; non-cohesive, moist.		5.79							
		(SP) GRAVELLY SAND, medium to coarse; brown, with cobbles; non-cohesive, moist.		6.10	C	SDC					Bentonite
					D	SDC					
10		(SP-SM) SAND to SILTY SAND, medium to fine, trace gravel; brown; non-cohesive, wet.		10.21							
12					E	SDC					▽ Jan. 26, 2016
					F	SDC					Sand Pack (#2); Screen (0.25 mm slot size)
					G	SDC					Bentonite
		END OF BOREHOLE		21.34							
		1.SDC = Sonic Drill Core									
		2. See Appendix B for Sample Gradations									

DEPTH SCALE

1 : 125

Golder Associates

LOGGED: RA

CHECKED:

RECORD OF BOREHOLE: BH16-2

PROJECT: 1648132 (2000)

LOCATION: Dance Pit Expansion, Cambridge, ON

BORING DATE: January 25, 2016

SHEET 1 OF 1

DATUM: Geodetic

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○; 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl; 10 20 30 40

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE							
0	Sonic Drill 550	OVERBURDEN - (ML) SILT, some sand, fine; brown (TOPSOIL); cohesive, w~PL.		0.00					Concrete
		(SP) GRAVELLY SAND, medium to coarse; brown, with cobbles; non-cohesive, moist.		0.30	A	SDC			Sand Pack (#2)
4					B	SDC			
6–8					C	SDC			Bentonite
10					D	SDC			
12		(SP-SM) SAND to SILTY SAND, fine, trace gravel (below 18 m depth), trace clay (below 18 m depth); brown; non-cohesive, moist to wet (wet below 13.4 m depth).		11.89	E	SDC			
14									▽ Jan. 26, 2016
16					F	SDC			Sand Pack (#2); Screen (0.25 mm slot size)
18–20					G	SDC			Bentonite
22		END OF BOREHOLE		21.34					
		1.SDC = Sonic Drill Core							
		2. See Appendix B for Sample Gradations							
24									

DEPTH SCALE

1 : 125

Golder Associates

LOGGED: RA

CHECKED:

MIS-BHS 001 1648132.GPJ GAL-MIS.GDT 2/6/16

RECORD OF BOREHOLE: BH16-3

PROJECT: 1648132 (2000)

LOCATION: Dance Pit Expansion, Cambridge, ON

BORING DATE: January 26, 2016

SHEET 1 OF 1

DATUM: Geodetic

BORING METHOD: Sonic Drill 550

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	
OVERBURDEN - (ML) SILT, some sand, fine; brown (TOPSOIL); cohesive, w<PL.	0.00
OVERBURDEN - (SM) SILTY SAND, trace gravel; brown; non-cohesive, moist.	0.30
(SP) GRAVELLY SAND, medium to coarse; brown, with cobbles; non-cohesive, moist.	0.76
(GP) SANDY GRAVEL; grey; non-cohesive, moist.	6.10
(SP) SAND, fine, some to trace gravel; brown; non-cohesive, moist to wet (wet below 8.2 m depth).	6.40
(GP) GRAVEL, some sand; brown/grey; non-cohesive, wet.	10.06
(SP-SM) SAND to SILTY SAND, fine, trace clay (below 19.8 m depth), with clay lens from 16.8 to 17.1 m depth; brown; non-cohesive, wet.	10.36
END OF BOREHOLE	21.34

SAMPLE NUMBER	TYPE
A	SDC
B	SDC
C	SDC
D	SDC
E	SDC
F	SDC
G	SDC

1.SDC = Sonic Drill Core

2. See Appendix B for Sample Gradations

PIEZOMETER OR STANDPIPE INSTALLATION: Concrete; Sand Pack (#2); Bentonite; Jan. 26, 2016 (water level); Sand Pack (#2); Screen (0.25 mm slot size)

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp W Wl 10 20 30 40

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES: 0 2 4 6 8 10 12 14 16 18 20 22 24

DEPTH SCALE 1 : 125

Golder Associates

LOGGED: RA

CHECKED:

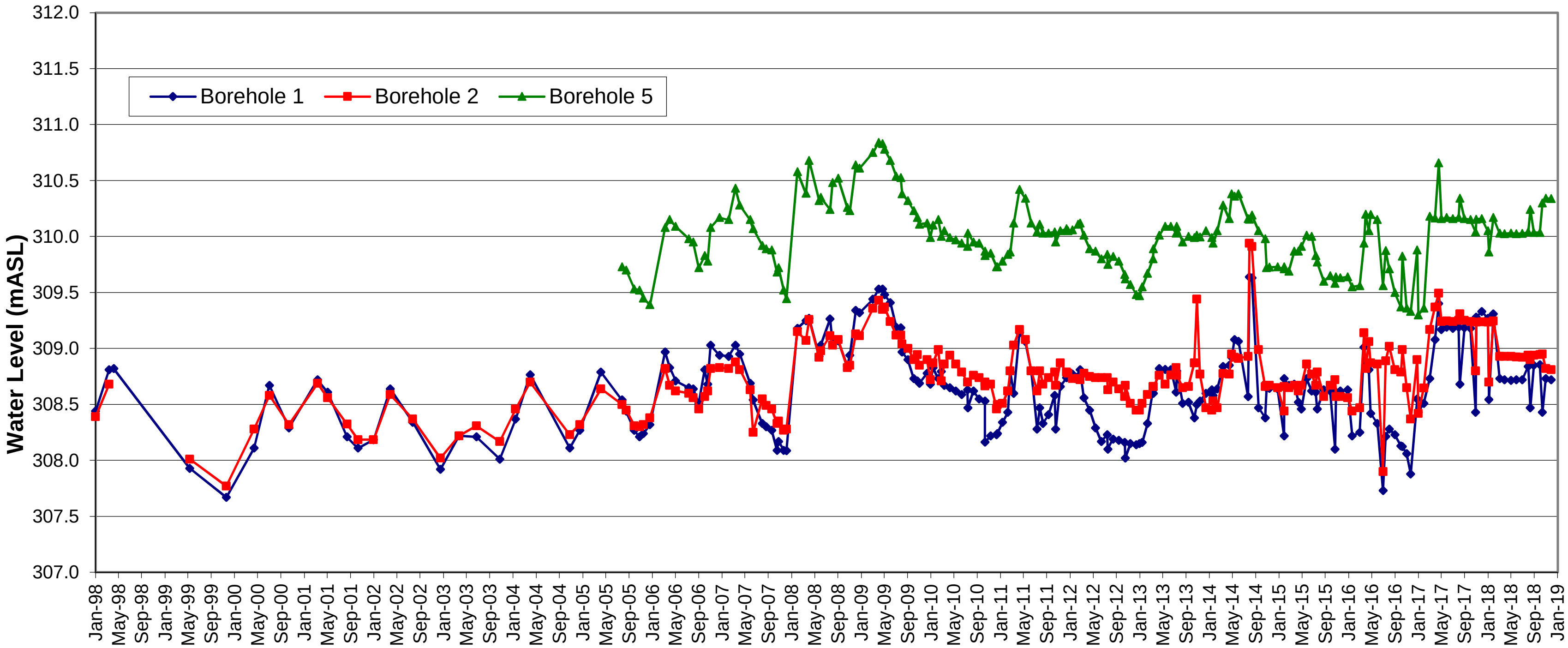
APPENDIX B

Hydrographs

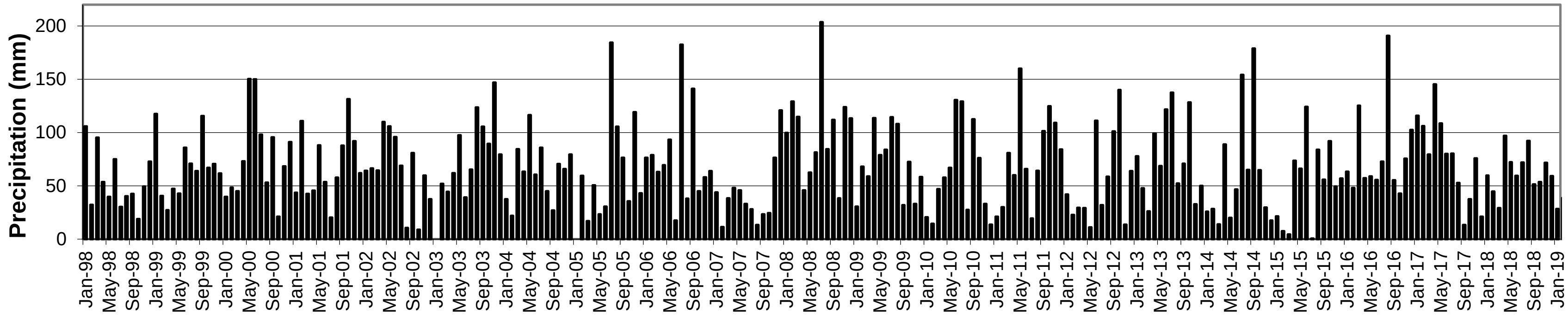
TABLE B1
GROUNDWATER LEVEL MEASUREMENTS
DANCE PIT EXPANSION

DATE	Groundwater Elevation					
	BH1 (masl)	BH2 (masl)	BH5 (masl)	BH16-1 (masl)	BH16-2 (masl)	BH16-3 (masl)
20-Apr-16	309.01	309.15	309.94	308.65	308.64	307.52
16-May-16	308.82	309.06	310.05	308.57	308.72	307.57
12-Aug-16	308.22	308.89	309.88	308.04	308.22	307.19
08-Nov-16	308.13	308.99	309.83	307.96	308.11	307.07
22-Jun-17	309.01	309.31	310.72	308.80	308.90	307.89
10-Apr-19	308.97	309.09	310.23	308.74	308.79	307.71
21-Jun-19	309.05	309.37	310.79	308.82	308.89	307.90
06-Sep-19	308.58	309.07	310.50	308.41	308.52	307.58
11-Dec-19	308.67	308.86	310.36	308.48	308.42	307.50
01-Apr-20	309.21	309.22	310.58	308.95	309.04	307.97
24-Jun-20	308.72	308.97	310.38	308.54	308.66	307.70
23-Sep-20	308.27	308.94*	310.08	308.14	308.29	307.32
11-Dec-20	308.19	308.72	309.87	308.07	308.01	307.18
17-Mar-21	308.27	308.81	310.06	308.07	307.93	307.05

* - measured October 8, 2020



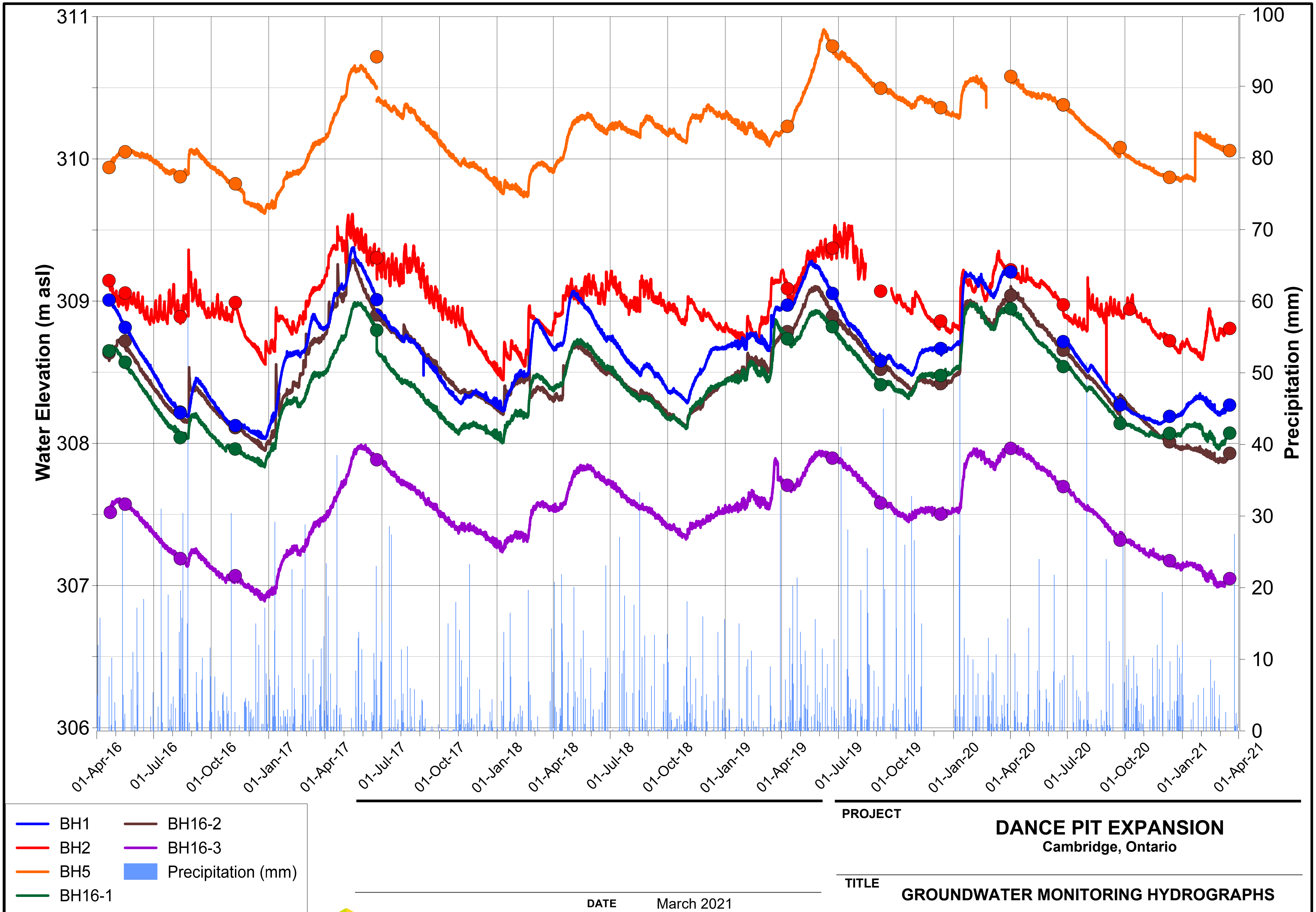
Monthly Precipitation



1998-2018 Groundwater Levels and Monthly Precipitation

CBM Cedar Street Pit, North Dumfries

FIGURE
B1



GOLDER

DATE	March 2021
DESIGN	PGM
REVIEW	GP
APPROVED	GP

PROJECT

DANCE PIT EXPANSION

Cambridge, Ontario

TITLE

GROUNDWATER MONITORING HYDROGRAPHS

PROJECT NO.	REV	FIGURE
1653019	A	B2

APPENDIX C

Water Quality

TABLE C1
WATER QUALITY SUMMARY
DANCE PIT EXPANSION

		Ontario Drinking Water Standards Criteria				BH16-1	BH16-2	BH16-3
	UNITS	MAC[1]	IMAC[2]	AO[3]	OG[4]	12-Aug-2016	12-Aug-2016	12-Aug-2016
Calculated Parameters								
Anion Sum	me/L					16.3	4.85	7.79
Bicarb. Alkalinity (calc. as CaCO3)	mg/L					380	210	270
Calculated TDS	mg/L			**500**		**910**	260	440
Carb. Alkalinity (calc. as CaCO3)	mg/L					3.9	2.4	2.5
Cation Sum	me/L					16.5	5.00	7.78
Hardness (CaCO3)	mg/L				80-100	290	240	360
Ion Balance (% Difference)	%					0.540	1.52	0.0500
Langelier Index (@ 20C)	N/A					0.939	0.780	0.921
Langelier Index (@ 4C)	N/A					0.693	0.531	0.672
Saturation pH (@ 20C)	N/A					7.10	7.30	7.08
Saturation pH (@ 4C)	N/A					7.35	7.55	7.32
Inorganics								
Total Ammonia-N	mg/L					<0.050	0.062	<0.050
Conductivity	umho/cm					1700	440	730
Dissolved Organic Carbon	mg/L			**5**		0.51	0.55	0.65
Orthophosphate (P)	mg/L					<0.010	<0.010	<0.010
pH	pH				6.5-8.5	8.04	8.08	8.00
Dissolved Sulphate (SO4)	mg/L			**500**		29	12	30
Alkalinity (Total as CaCO3)	mg/L				30-500	380	210	270
Dissolved Chloride (Cl)	mg/L			**250**		**270**	4.8	16
Nitrite (N)	mg/L	1				<0.010	0.015	0.017
Nitrate (N)	mg/L	10				4.91	3.36	18.4
Nitrate + Nitrite (N)	mg/L					4.91	3.37	18.4
Metals								
Dissolved Aluminum (Al)	ug/L				100	70	79	59
Dissolved Antimony (Sb)	ug/L		6			<0.50	<0.50	<0.50
Dissolved Arsenic (As)	ug/L		0.01			<1.0	<1.0	<1.0
Dissolved Barium (Ba)	ug/L	1000				280	92	180
Dissolved Beryllium (Be)	ug/L					<0.50	<0.50	<0.50
Dissolved Boron (B)	ug/L		5000			13	<10	11
Dissolved Cadmium (Cd)	ug/L	5				<0.10	<0.10	<0.10
Dissolved Calcium (Ca)	ug/L					71000	61000	89000
Dissolved Chromium (Cr)	ug/L	50				<5.0	<5.0	<5.0
Dissolved Cobalt (Co)	ug/L					<0.50	<0.50	<0.50
Dissolved Copper (Cu)	ug/L			**1000**		<1.0	<1.0	<1.0
Dissolved Iron (Fe)	ug/L			**300**		<100	<100	<100
Dissolved Lead (Pb)	ug/L	10				<0.50	<0.50	<0.50
Dissolved Magnesium (Mg)	ug/L					27000	21000	34000
Dissolved Manganese (Mn)	ug/L			**50**		37	16	7.7
Dissolved Molybdenum (Mo)	ug/L					4.1	2.5	2.7
Dissolved Nickel (Ni)	ug/L					<1.0	<1.0	<1.0
Dissolved Phosphorus (P)	ug/L					<100	<100	<100
Dissolved Potassium (K)	ug/L					1700	1300	970
Dissolved Selenium (Se)	ug/L	50				<2.0	<2.0	<2.0
Dissolved Silicon (Si)	ug/L					6000	4000	7000
Dissolved Silver (Ag)	ug/L					<0.10	<0.10	<0.10
Dissolved Sodium (Na)	ug/L			**200000**		**250000**	4500	12000
Dissolved Strontium (Sr)	ug/L					100	73	120
Dissolved Thallium (Tl)	ug/L					<0.050	<0.050	<0.050
Dissolved Titanium (Ti)	ug/L					<5.0	<5.0	<5.0
Dissolved Uranium (U)	ug/L	20				0.93	0.98	1.8
Dissolved Vanadium (V)	ug/L					0.79	0.67	0.79
Dissolved Zinc (Zn)	ug/L			**5000**		<5.0	<5.0	<5.0
BTEX & F1-F4 Hydrocarbons								
Benzene	ug/L	1				<0.20	<0.20	<0.20
Toluene	ug/L		60	**24**		<0.20	<0.20	<0.20
Ethylbenzene	ug/L		140	**1.6**		<0.20	<0.20	<0.20
o-Xylene	ug/L					<0.20	<0.20	<0.20
p+m-Xylene	ug/L					<0.40	<0.40	<0.40
Total Xylenes	ug/L		90	**20**		<0.40	<0.40	<0.40
F1 (C6-C10)	ug/L					<25	<25	<25
F1 (C6-C10) - BTEX	ug/L					<25	<25	<25
F2 (C10-C16 Hydrocarbons)	ug/L					<100	<100	<100
F3 (C16-C34 Hydrocarbons)	ug/L					<200	<200	<200
F4 (C34-C50 Hydrocarbons)	ug/L					<200	<200	<200

Notes:
[1] MAC = Maximum Acceptable Concentration
[2] IMAC = Interim Maximum Acceptable Concentration
[3] AO = Aesthetic Objective
[4] OG = Operational Guideline

Your Project #: 1653019
Your C.O.C. #: 573635-01-01

Attention:Greg Padusenko

Golder Associates Ltd
210 Sheldon Drive
Cambridge, ON
CANADA N1T 1A8

Report Date: 2016/08/18
Report #: R4120879
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6H1164
Received: 2016/08/12, 14:10

Sample Matrix: Water
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	3	N/A	2016/08/16	CAM SOP-00448	SM 22 2320 B m
Carbonate, Bicarbonate and Hydroxide	3	N/A	2016/08/17	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	3	N/A	2016/08/17	CAM SOP-00463	EPA 325.2 m
Conductivity	3	N/A	2016/08/16	CAM SOP-00414	SM 22 2510 m
Dissolved Organic Carbon (DOC) (1)	3	N/A	2016/08/16	CAM SOP-00446	SM 22 5310 B m
Petroleum Hydro. CCME F1 & BTEX in Water	3	N/A	2016/08/16	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (2)	3	2016/08/16	2016/08/17	CAM SOP-00316	CCME PHC-CWS m
Hardness (calculated as CaCO3)	3	N/A	2016/08/18	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Metals by ICPMS	3	N/A	2016/08/17	CAM SOP-00447	EPA 6020A m
Ion Balance (% Difference)	3	N/A	2016/08/18		
Anion and Cation Sum	3	N/A	2016/08/18		
Total Ammonia-N	3	N/A	2016/08/17	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (3)	3	N/A	2016/08/17	CAM SOP-00440	SM 22 4500-NO3I/NO2B
pH	3	N/A	2016/08/16	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	3	N/A	2016/08/17	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	3	N/A	2016/08/18		
Sat. pH and Langelier Index (@ 4C)	3	N/A	2016/08/18		
Sulphate by Automated Colourimetry	3	N/A	2016/08/17	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	3	N/A	2016/08/18		

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

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

Your Project #: 1653019
Your C.O.C. #: 573635-01-01

Attention:Greg Padusenko

Golder Associates Ltd
210 Sheldon Drive
Cambridge, ON
CANADA N1T 1A8

Report Date: 2016/08/18
Report #: R4120879
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6H1164

Received: 2016/08/12, 14:10

(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following “Alberta Environment’s Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods September 2003”. Documentation is available upon request. Modifications from Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil-Tier 1 Method: F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction.
(3) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==

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

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B6H1164
Report Date: 2016/08/18

Golder Associates Ltd
Client Project #: 1653019
Sampler Initials: GP

CCME PETROLEUM HYDROCARBONS (WATER)

Maxxam ID		CWN448	CWN448	CWN449	CWN450		
Sampling Date		2016/08/12 10:00	2016/08/12 10:00	2016/08/12 11:00	2016/08/12 12:00		
COC Number		573635-01-01	573635-01-01	573635-01-01	573635-01-01		
	UNITS	**BH16-1**	**BH16-1 Lab-Dup**	**BH16-2**	**BH16-3**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons							
Benzene	ug/L	<0.20	<0.20	<0.20	<0.20	0.20	4621484
Toluene	ug/L	<0.20	<0.20	<0.20	<0.20	0.20	4621484
Ethylbenzene	ug/L	<0.20	<0.20	<0.20	<0.20	0.20	4621484
o-Xylene	ug/L	<0.20	<0.20	<0.20	<0.20	0.20	4621484
p+m-Xylene	ug/L	<0.40	<0.40	<0.40	<0.40	0.40	4621484
Total Xylenes	ug/L	<0.40	<0.40	<0.40	<0.40	0.40	4621484
F1 (C6-C10)	ug/L	<25	<25	<25	<25	25	4621484
F1 (C6-C10) - BTEX	ug/L	<25	<25	<25	<25	25	4621484
F2-F4 Hydrocarbons							
F2 (C10-C16 Hydrocarbons)	ug/L	<100		<100	<100	100	4621869
F3 (C16-C34 Hydrocarbons)	ug/L	<200		<200	<200	200	4621869
F4 (C34-C50 Hydrocarbons)	ug/L	<200		<200	<200	200	4621869
Reached Baseline at C50	ug/L	Yes		Yes	Yes		4621869
Surrogate Recovery (%)							
1,4-Difluorobenzene	%	105	104	106	102		4621484
4-Bromofluorobenzene	%	97	95	99	96		4621484
D10-Ethylbenzene	%	99	92	102	88		4621484
D4-1,2-Dichloroethane	%	102	103	106	104		4621484
o-Terphenyl	%	108		104	106		4621869

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B6H1164
Report Date: 2016/08/18

Golder Associates Ltd
Client Project #: 1653019
Sampler Initials: GP

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		CWN448		CWN449		CWN450		
Sampling Date		2016/08/12 10:00		2016/08/12 11:00		2016/08/12 12:00		
COC Number		573635-01-01		573635-01-01		573635-01-01		
	UNITS	**BH16-1**	**RDL**	**BH16-2**	**RDL**	**BH16-3**	**RDL**	**QC Batch**
Calculated Parameters								
Anion Sum	me/L	16.3	N/A	4.85	N/A	7.79	N/A	4619861
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	380	1.0	210	1.0	270	1.0	4619475
Calculated TDS	mg/L	910	1.0	260	1.0	440	1.0	4619864
Carb. Alkalinity (calc. as CaCO3)	mg/L	3.9	1.0	2.4	1.0	2.5	1.0	4619475
Cation Sum	me/L	16.5	N/A	5.00	N/A	7.78	N/A	4619861
Hardness (CaCO3)	mg/L	290	1.0	240	1.0	360	1.0	4619765
Ion Balance (% Difference)	%	0.540	N/A	1.52	N/A	0.0500	N/A	4619860
Langelier Index (@ 20C)	N/A	0.939		0.780		0.921		4619862
Langelier Index (@ 4C)	N/A	0.693		0.531		0.672		4619863
Saturation pH (@ 20C)	N/A	7.10		7.30		7.08		4619862
Saturation pH (@ 4C)	N/A	7.35		7.55		7.32		4619863
Inorganics								
Total Ammonia-N	mg/L	<0.050	0.050	0.062	0.050	<0.050	0.050	4621400
Conductivity	umho/cm	1700	1.0	440	1.0	730	1.0	4621875
Dissolved Organic Carbon	mg/L	0.51	0.20	0.55	0.20	0.65	0.20	4621688
Orthophosphate (P)	mg/L	<0.010	0.010	<0.010	0.010	<0.010	0.010	4622285
pH	pH	8.04		8.08		8.00		4621884
Dissolved Sulphate (SO4)	mg/L	29	1.0	12	1.0	30	1.0	4622284
Alkalinity (Total as CaCO3)	mg/L	380	1.0	210	1.0	270	1.0	4621870
Dissolved Chloride (Cl)	mg/L	270	3.0	4.8	1.0	16	1.0	4622271
Nitrite (N)	mg/L	<0.010	0.010	0.015	0.010	0.017	0.010	4622205
Nitrate (N)	mg/L	4.91	0.10	3.36	0.10	18.4	0.50	4622205
Nitrate + Nitrite (N)	mg/L	4.91	0.10	3.37	0.10	18.4	0.50	4622205
Metals								
Dissolved Aluminum (Al)	ug/L	70	5.0	79	5.0	59	5.0	4621448
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	<0.50	0.50	<0.50	0.50	4621448
Dissolved Arsenic (As)	ug/L	<1.0	1.0	<1.0	1.0	<1.0	1.0	4621448
Dissolved Barium (Ba)	ug/L	280	2.0	92	2.0	180	2.0	4621448
Dissolved Beryllium (Be)	ug/L	<0.50	0.50	<0.50	0.50	<0.50	0.50	4621448
Dissolved Boron (B)	ug/L	13	10	<10	10	11	10	4621448
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	<0.10	0.10	<0.10	0.10	4621448
Dissolved Calcium (Ca)	ug/L	71000	200	61000	200	89000	200	4621448
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	<5.0	5.0	<5.0	5.0	4621448
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	<0.50	0.50	<0.50	0.50	4621448

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		CWN448		CWN449		CWN450		
Sampling Date		2016/08/12 10:00		2016/08/12 11:00		2016/08/12 12:00		
COC Number		573635-01-01		573635-01-01		573635-01-01		
	UNITS	**BH16-1**	**RDL**	**BH16-2**	**RDL**	**BH16-3**	**RDL**	**QC Batch**
Dissolved Copper (Cu)	ug/L	<1.0	1.0	<1.0	1.0	<1.0	1.0	4621448
Dissolved Iron (Fe)	ug/L	<100	100	<100	100	<100	100	4621448
Dissolved Lead (Pb)	ug/L	<0.50	0.50	<0.50	0.50	<0.50	0.50	4621448
Dissolved Magnesium (Mg)	ug/L	27000	50	21000	50	34000	50	4621448
Dissolved Manganese (Mn)	ug/L	37	2.0	16	2.0	7.7	2.0	4621448
Dissolved Molybdenum (Mo)	ug/L	4.1	0.50	2.5	0.50	2.7	0.50	4621448
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	<1.0	1.0	<1.0	1.0	4621448
Dissolved Phosphorus (P)	ug/L	<100	100	<100	100	<100	100	4621448
Dissolved Potassium (K)	ug/L	1700	200	1300	200	970	200	4621448
Dissolved Selenium (Se)	ug/L	<2.0	2.0	<2.0	2.0	<2.0	2.0	4621448
Dissolved Silicon (Si)	ug/L	6000	50	4000	50	7000	50	4621448
Dissolved Silver (Ag)	ug/L	<0.10	0.10	<0.10	0.10	<0.10	0.10	4621448
Dissolved Sodium (Na)	ug/L	250000	100	4500	100	12000	100	4621448
Dissolved Strontium (Sr)	ug/L	100	1.0	73	1.0	120	1.0	4621448
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	<0.050	0.050	<0.050	0.050	4621448
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	<5.0	5.0	<5.0	5.0	4621448
Dissolved Uranium (U)	ug/L	0.93	0.10	0.98	0.10	1.8	0.10	4621448
Dissolved Vanadium (V)	ug/L	0.79	0.50	0.67	0.50	0.79	0.50	4621448
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	<5.0	5.0	<5.0	5.0	4621448

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B6H1164
Report Date: 2016/08/18

Golder Associates Ltd
Client Project #: 1653019
Sampler Initials: GP

TEST SUMMARY

Maxxam ID: CWN448
Sample ID: BH16-1
Matrix: Water

Collected: 2016/08/12
Shipped:
Received: 2016/08/12

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4621870	N/A	2016/08/16	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4619475	N/A	2016/08/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	4622271	N/A	2016/08/17	Alina Dobreanu
Conductivity	AT	4621875	N/A	2016/08/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4621688	N/A	2016/08/16	Anastasia Hamanov
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	4621484	N/A	2016/08/16	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	4621869	2016/08/16	2016/08/17	Ksenia Trofimova
Hardness (calculated as CaCO3)		4619765	N/A	2016/08/18	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4621448	N/A	2016/08/17	Kevin Comerford
Ion Balance (% Difference)	CALC	4619860	N/A	2016/08/18	Automated Statchk
Anion and Cation Sum	CALC	4619861	N/A	2016/08/18	Automated Statchk
Total Ammonia-N	LACH/NH4	4621400	N/A	2016/08/17	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4622205	N/A	2016/08/17	Chandra Nandlal
pH	AT	4621884	N/A	2016/08/16	Surinder Rai
Orthophosphate	KONE	4622285	N/A	2016/08/17	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4619862	N/A	2016/08/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4619863	N/A	2016/08/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4622284	N/A	2016/08/17	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4619864	N/A	2016/08/18	Automated Statchk

Maxxam ID: CWN448 Dup
Sample ID: BH16-1
Matrix: Water

Collected: 2016/08/12
Shipped:
Received: 2016/08/12

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	4621484	N/A	2016/08/16	Anca Ganea

Maxxam ID: CWN449
Sample ID: BH16-2
Matrix: Water

Collected: 2016/08/12
Shipped:
Received: 2016/08/12

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4621870	N/A	2016/08/16	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4619475	N/A	2016/08/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	4622271	N/A	2016/08/17	Alina Dobreanu
Conductivity	AT	4621875	N/A	2016/08/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4621688	N/A	2016/08/16	Anastasia Hamanov
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	4621484	N/A	2016/08/16	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	4621869	2016/08/16	2016/08/17	Ksenia Trofimova
Hardness (calculated as CaCO3)		4619765	N/A	2016/08/18	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4621448	N/A	2016/08/17	Kevin Comerford
Ion Balance (% Difference)	CALC	4619860	N/A	2016/08/18	Automated Statchk
Anion and Cation Sum	CALC	4619861	N/A	2016/08/18	Automated Statchk
Total Ammonia-N	LACH/NH4	4621400	N/A	2016/08/17	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4622205	N/A	2016/08/17	Chandra Nandlal

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B6H1164
Report Date: 2016/08/18

Golder Associates Ltd
Client Project #: 1653019
Sampler Initials: GP

TEST SUMMARY

Maxxam ID: CWN449
Sample ID: BH16-2
Matrix: Water

Collected: 2016/08/12
Shipped:
Received: 2016/08/12

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH	AT	4621884	N/A	2016/08/16	Surinder Rai
Orthophosphate	KONE	4622285	N/A	2016/08/17	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4619862	N/A	2016/08/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4619863	N/A	2016/08/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4622284	N/A	2016/08/17	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4619864	N/A	2016/08/18	Automated Statchk

Maxxam ID: CWN450
Sample ID: BH16-3
Matrix: Water

Collected: 2016/08/12
Shipped:
Received: 2016/08/12

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4621870	N/A	2016/08/16	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4619475	N/A	2016/08/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	4622271	N/A	2016/08/17	Alina Dobreanu
Conductivity	AT	4621875	N/A	2016/08/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4621688	N/A	2016/08/16	Anastasia Hamanov
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	4621484	N/A	2016/08/16	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	4621869	2016/08/16	2016/08/17	Ksenia Trofimova
Hardness (calculated as CaCO3)		4619765	N/A	2016/08/18	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4621448	N/A	2016/08/17	Kevin Comerford
Ion Balance (% Difference)	CALC	4619860	N/A	2016/08/18	Automated Statchk
Anion and Cation Sum	CALC	4619861	N/A	2016/08/18	Automated Statchk
Total Ammonia-N	LACH/NH4	4621400	N/A	2016/08/17	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4622205	N/A	2016/08/17	Chandra Nandlal
pH	AT	4621884	N/A	2016/08/16	Surinder Rai
Orthophosphate	KONE	4622285	N/A	2016/08/17	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4619862	N/A	2016/08/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4619863	N/A	2016/08/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4622284	N/A	2016/08/17	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4619864	N/A	2016/08/18	Automated Statchk

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	17.3°C

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4621484	1,4-Difluorobenzene	2016/08/16	104	70 - 130	101	70 - 130	102	%		
4621484	4-Bromofluorobenzene	2016/08/16	99	70 - 130	100	70 - 130	97	%		
4621484	D10-Ethylbenzene	2016/08/16	106	70 - 130	98	70 - 130	93	%		
4621484	D4-1,2-Dichloroethane	2016/08/16	101	70 - 130	104	70 - 130	104	%		
4621869	o-Terphenyl	2016/08/16	107	60 - 130	107	60 - 130	105	%		
4621400	Total Ammonia-N	2016/08/17	100	80 - 120	98	85 - 115	<0.050	mg/L	NC	20
4621448	Dissolved Aluminum (Al)	2016/08/17	104	80 - 120	104	80 - 120	<5.0	ug/L		
4621448	Dissolved Antimony (Sb)	2016/08/17	107	80 - 120	103	80 - 120	<0.50	ug/L	NC	20
4621448	Dissolved Arsenic (As)	2016/08/17	100	80 - 120	97	80 - 120	<1.0	ug/L	NC	20
4621448	Dissolved Barium (Ba)	2016/08/17	103	80 - 120	100	80 - 120	<2.0	ug/L	1.1	20
4621448	Dissolved Beryllium (Be)	2016/08/17	104	80 - 120	102	80 - 120	<0.50	ug/L	NC	20
4621448	Dissolved Boron (B)	2016/08/17	102	80 - 120	101	80 - 120	<10	ug/L	NC	20
4621448	Dissolved Cadmium (Cd)	2016/08/17	104	80 - 120	102	80 - 120	<0.10	ug/L	NC	20
4621448	Dissolved Calcium (Ca)	2016/08/17	NC	80 - 120	102	80 - 120	<200	ug/L		
4621448	Dissolved Chromium (Cr)	2016/08/17	99	80 - 120	99	80 - 120	<5.0	ug/L	NC	20
4621448	Dissolved Cobalt (Co)	2016/08/17	96	80 - 120	96	80 - 120	<0.50	ug/L	NC	20
4621448	Dissolved Copper (Cu)	2016/08/17	102	80 - 120	101	80 - 120	<1.0	ug/L	NC	20
4621448	Dissolved Iron (Fe)	2016/08/17	98	80 - 120	98	80 - 120	<100	ug/L		
4621448	Dissolved Lead (Pb)	2016/08/17	98	80 - 120	97	80 - 120	<0.50	ug/L	NC	20
4621448	Dissolved Magnesium (Mg)	2016/08/17	NC	80 - 120	98	80 - 120	<50	ug/L		
4621448	Dissolved Manganese (Mn)	2016/08/17	98	80 - 120	98	80 - 120	<2.0	ug/L		
4621448	Dissolved Molybdenum (Mo)	2016/08/17	107	80 - 120	102	80 - 120	<0.50	ug/L	NC	20
4621448	Dissolved Nickel (Ni)	2016/08/17	94	80 - 120	96	80 - 120	<1.0	ug/L	NC	20
4621448	Dissolved Phosphorus (P)	2016/08/17	NC	80 - 120	107	80 - 120	<100	ug/L		
4621448	Dissolved Potassium (K)	2016/08/17	101	80 - 120	99	80 - 120	<200	ug/L		
4621448	Dissolved Selenium (Se)	2016/08/17	103	80 - 120	101	80 - 120	<2.0	ug/L	NC	20
4621448	Dissolved Silicon (Si)	2016/08/17	100	80 - 120	100	80 - 120	<50	ug/L		
4621448	Dissolved Silver (Ag)	2016/08/17	100	80 - 120	99	80 - 120	<0.10	ug/L	NC	20
4621448	Dissolved Sodium (Na)	2016/08/17	NC	80 - 120	98	80 - 120	110, RDL=100	ug/L	1.5	20
4621448	Dissolved Strontium (Sr)	2016/08/17	101	80 - 120	98	80 - 120	<1.0	ug/L		
4621448	Dissolved Thallium (Tl)	2016/08/17	99	80 - 120	97	80 - 120	<0.050	ug/L	NC	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4621448	Dissolved Titanium (Ti)	2016/08/17	102	80 - 120	100	80 - 120	<5.0	ug/L		
4621448	Dissolved Uranium (U)	2016/08/17	101	80 - 120	99	80 - 120	<0.10	ug/L	NC	20
4621448	Dissolved Vanadium (V)	2016/08/17	100	80 - 120	98	80 - 120	<0.50	ug/L	NC	20
4621448	Dissolved Zinc (Zn)	2016/08/17	99	80 - 120	97	80 - 120	<5.0	ug/L	NC	20
4621484	Benzene	2016/08/16	116	70 - 130	105	70 - 130	<0.20	ug/L	NC	30
4621484	Ethylbenzene	2016/08/16	118	70 - 130	110	70 - 130	<0.20	ug/L	NC	30
4621484	F1 (C6-C10) - BTEX	2016/08/16					<25	ug/L	NC	30
4621484	F1 (C6-C10)	2016/08/16	86	70 - 130	105	70 - 130	<25	ug/L	NC	30
4621484	o-Xylene	2016/08/16	118	70 - 130	112	70 - 130	<0.20	ug/L	NC	30
4621484	p+m-Xylene	2016/08/16	107	70 - 130	99	70 - 130	<0.40	ug/L	NC	30
4621484	Toluene	2016/08/16	111	70 - 130	103	70 - 130	<0.20	ug/L	NC	30
4621484	Total Xylenes	2016/08/16					<0.40	ug/L	NC	30
4621688	Dissolved Organic Carbon	2016/08/16	NC	80 - 120	103	80 - 120	<0.20	mg/L	0.55	20
4621869	F2 (C10-C16 Hydrocarbons)	2016/08/17	96	50 - 130	94	60 - 130	<100	ug/L	NC	30
4621869	F3 (C16-C34 Hydrocarbons)	2016/08/17	98	50 - 130	99	60 - 130	<200	ug/L	NC	30
4621869	F4 (C34-C50 Hydrocarbons)	2016/08/17	104	50 - 130	103	60 - 130	<200	ug/L	NC	30
4621870	Alkalinity (Total as CaCO3)	2016/08/16			100	85 - 115	<1.0	mg/L	0.54	25
4621875	Conductivity	2016/08/16			102	85 - 115	<1.0	umho/cm	0.18	25
4621884	pH	2016/08/16			102	98 - 103			0.67	N/A
4622205	Nitrate (N)	2016/08/17	93	80 - 120	100	80 - 120	<0.10	mg/L	NC	25
4622205	Nitrite (N)	2016/08/17	106	80 - 120	100	80 - 120	<0.010	mg/L		
4622271	Dissolved Chloride (Cl)	2016/08/17	108	80 - 120	104	80 - 120	<1.0	mg/L	NC	20
4622284	Dissolved Sulphate (SO4)	2016/08/17	NC	75 - 125	101	80 - 120	<1.0	mg/L	1.4	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4622285	Orthophosphate (P)	2016/08/17	105	75 - 125	100	80 - 120	<0.010	mg/L	NC	25

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Services

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

Maxxam

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel (905) 817-5700 Toll-free 800-563-6266 Fax (905) 817-5777 www.maxxam.ca

12-Aug-16 14:10
Ema Gitej
B6H1164
ABH ENV-885

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name	#21375 Golder Associates Ltd	Company Name		Quotation #	B63104
Attention	Accounts Payable	Attention	Greg Padusenko	P.O. #	
Address	210 Sheldon Drive	Address		Project	1653019
	Cambridge ON N1T 1A8			Project Name	
Tel	(519) 620-8182 Fax	Tel	Fax	Site #	
Email	AccountsPayable_Maxxam@golder.com	Email	gpadusenko@golder.com	Sampled By	

Only:
Bottle Order #: 573635
C#573635-01-01
Project Manager: Ema Gitej

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ___ ☐ PWQO ☐ Other ___

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects
Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.
Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ☐
Rush Confirmation Number: ___ (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	CCME Petroleum Hydrocarbons	RCAp - Comprehensive	# of Bottles	Comments
1		BH16-1	2016/08/12	10–	Water	✓	✓	✓	7	
2		BH16-2	2016/08/12	11–	water	✓	✓	✓	7	
3		BH16-3	2016/08/12	12–	water	✓	✓	✓	7	
4										
5										
6										
7										
8										
9										
10										

REC'D IN WATERLOO

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Autumn Linklater	16/08/12	14:00	GILLIAN SHIZ	2016/08/12	14:10	
				2016/08/12	18:34	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
	16/18/18 °C	Present	Y	
		Intact	Y	

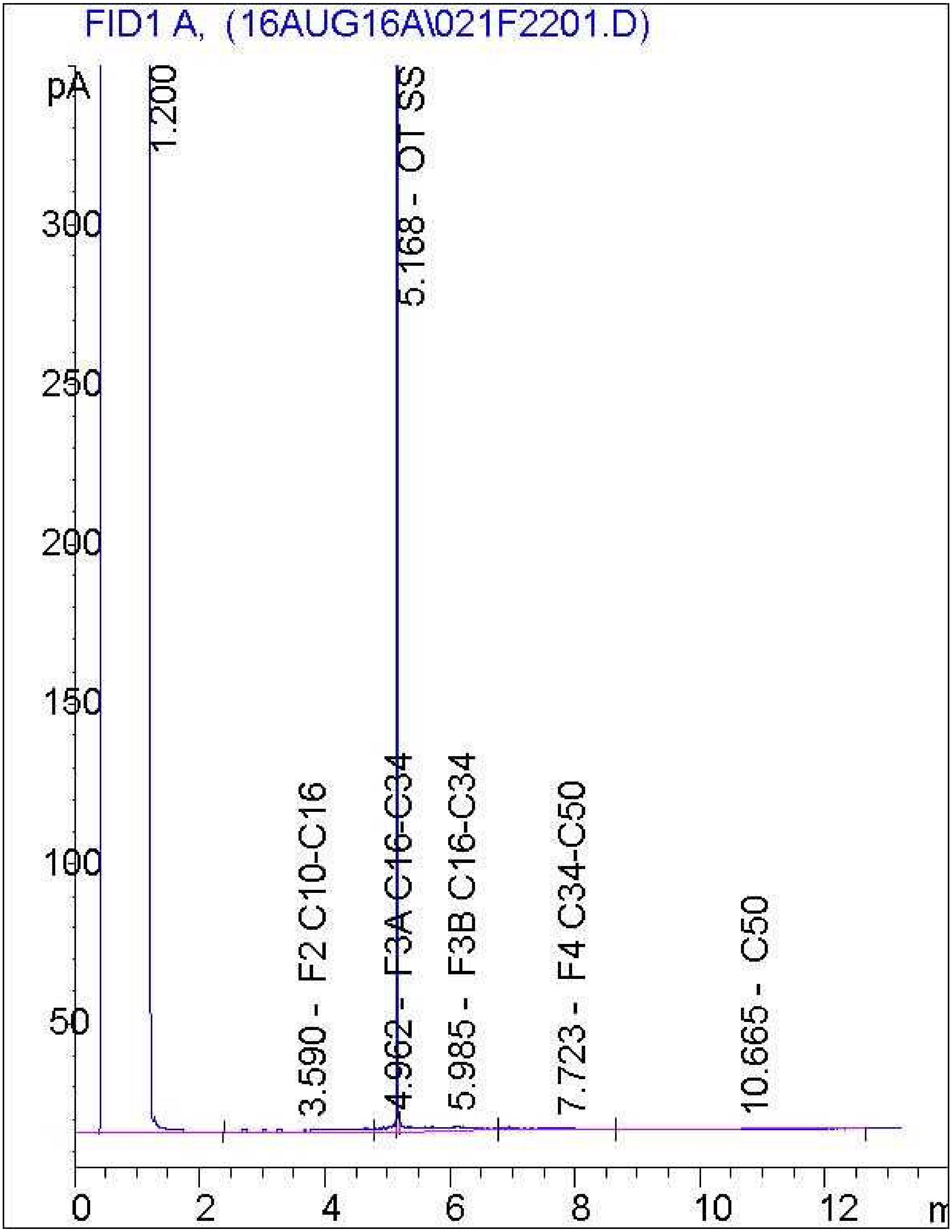
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics 4/1/5 MW# 349476

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

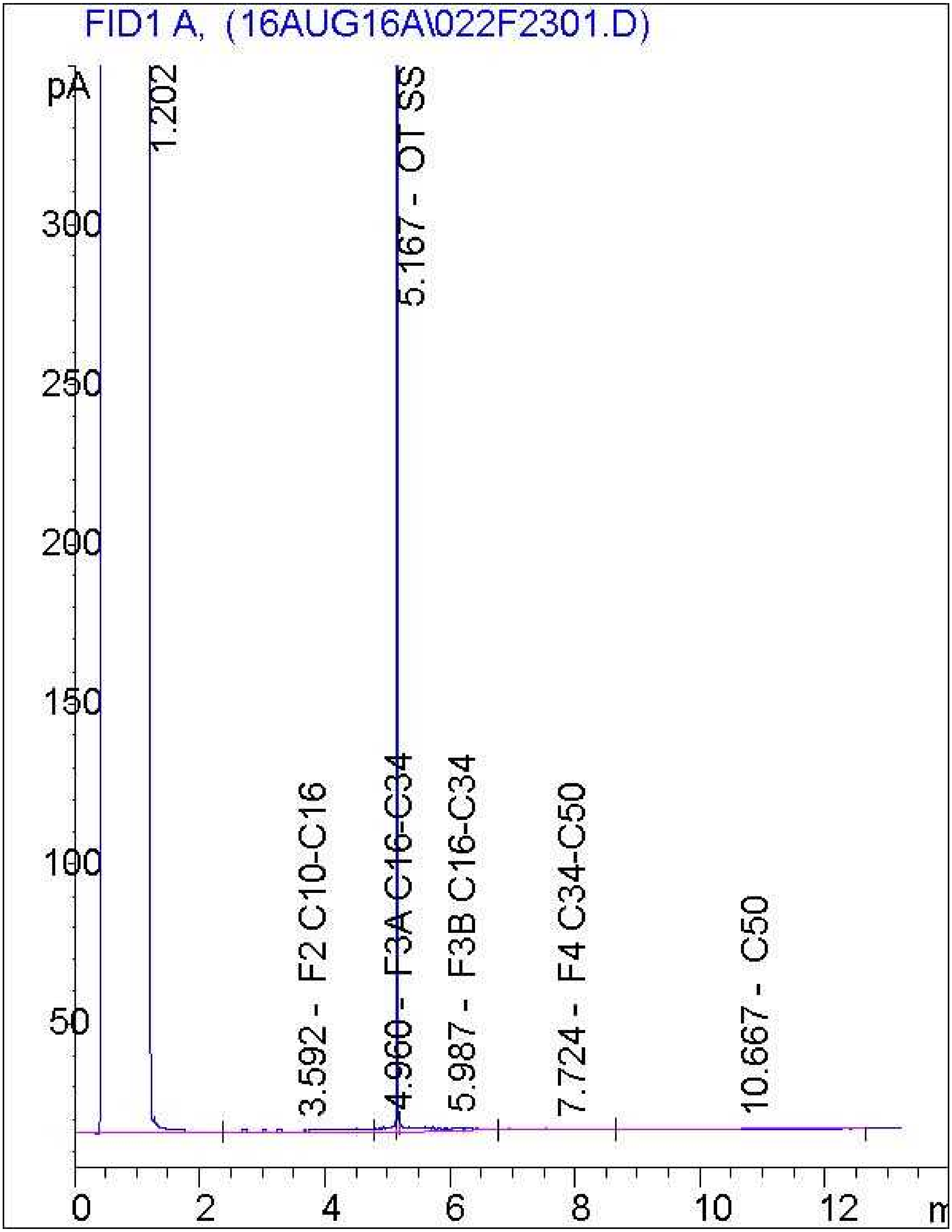


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

Maxxam Job #: B6H1164
Report Date: 2016/08/18
Maxxam Sample: CWN449

Golder Associates Ltd
Client Project #: 1653019
Client ID: BH16-2

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

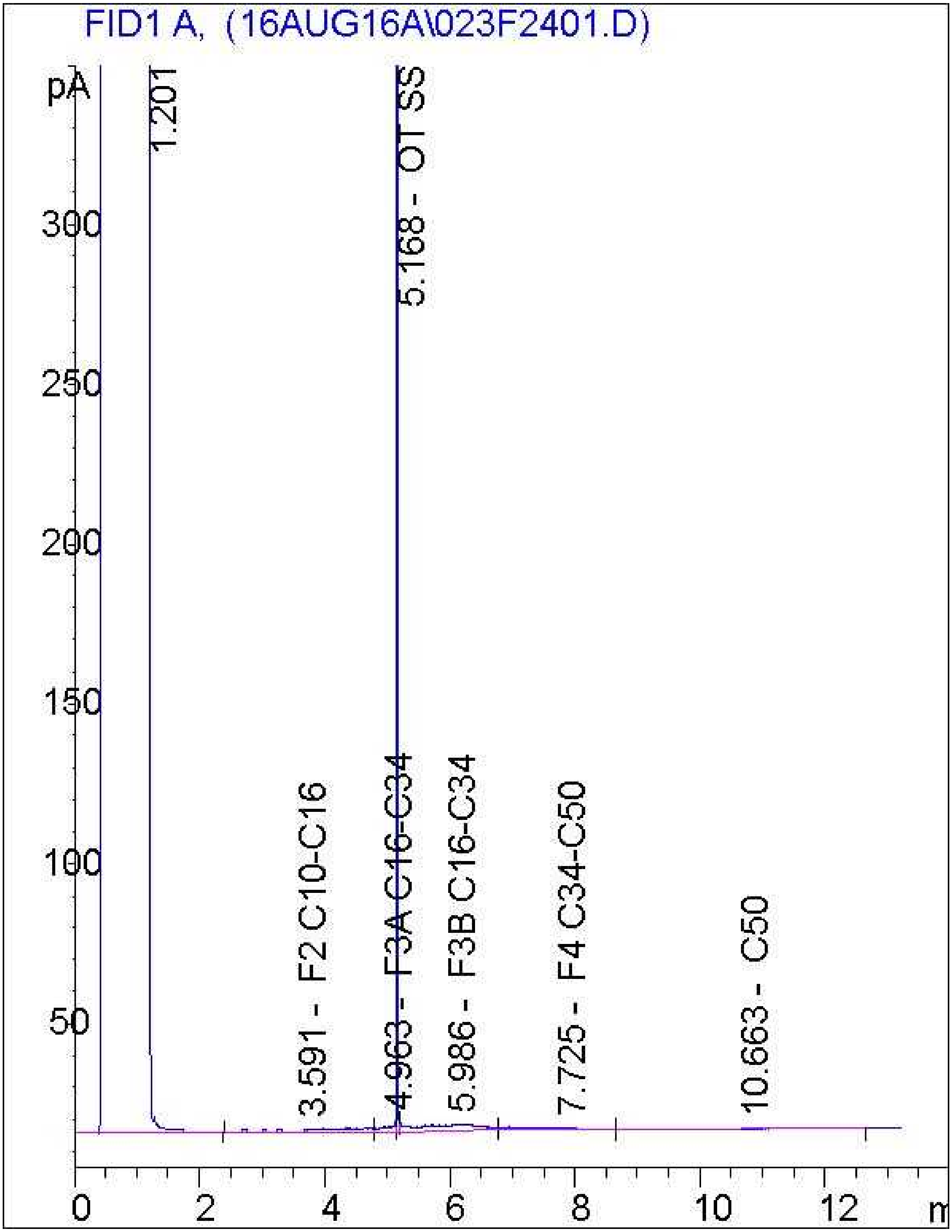


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

Maxxam Job #: B6H1164
Report Date: 2016/08/18
Maxxam Sample: CWN450

Golder Associates Ltd
Client Project #: 1653019
Client ID: BH16-3

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

APPENDIX D

Water Balance Results

Table D1: Water Balance Existing Condition Dance Pit Expansion

					Mature Forest			Agricultural									
					WHC	250 mm		WHC	200 mm								
					Total Area (m^2)	7,582		Total Area (m^2)	282,075								
					Infiltration Factor	0.9		Infiltration Factor	0.9								
Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspiration Mature Forest Areas	Surplus		Actual Evapotranspiration Agricultural Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.9	67.0	1	1	26	197	1	28	7,898	8,095	3.0	181	7,286	2.7	810	0.30
February	28	-5.9	54.0	1	1	45	341	1	47	13,258	13,599	5.6	337	12,239	5.1	1,360	0.56
March	31	-0.8	65.0	9	9	92	698	9	93	26,233	26,930	10.1	603	24,237	9.0	2,693	1.01
April	30	6.3	78.0	34	34	54	409	34	54	15,232	15,641	6.0	362	14,077	5.4	1,564	0.60
May	31	12.7	86.0	77	77	21	159	77	21	5,924	6,083	2.3	136	5,475	2.0	608	0.23
June	30	18.1	77.0	113	113	3	23	113	3	846	869	0.3	20	782	0.3	87	0.03
July	31	20.3	88.0	130	130	1	8	129	1	282	290	0.1	6	261	0.1	29	0.01
August	31	19.4	84.0	115	110	2	15	106	2	564	579	0.2	13	521	0.2	58	0.02
September	30	15.0	84.0	76	72	3	23	70	3	846	869	0.3	20	782	0.3	87	0.03
October	31	8.6	69.0	39	37	5	38	37	5	1,410	1,448	0.5	32	1,303	0.5	145	0.05
November	30	2.7	87.0	13	13	22	167	13	23	6,488	6,655	2.6	154	5,989	2.3	665	0.26
December	31	-3.7	69.0	2	2	32	243	2	33	9,308	9,551	3.6	214	8,596	3.2	955	0.36
Total			***908.0***	***610.0***	***599***	***306***	***2,320***	***592***	***313***	***88,289***	***90,609***	***35***	***2,080***	***81,548***	***31.2***	***9,061***	***3.47***
Average		***7.2***										***3***			***2.6***		***0.3***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table D2: Water Balance Operating Condition Dance Pit Expansion

Agricultural		Quarry	
WHC	200 mm	WHC	100 mm
Total Area (m^2)	72,232	Total Area (m^2)	217,425
Infiltration Factor	0.9	Infiltration Factor	1.0

Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspir	Surplus		Actual Evapotranspiration Quarry Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.9	67.0	1	1	28	2022.5	1	37	8,045	10,067	3.8	226	9,865	3.7	202	0.08
February	28	-5.9	54.0	1	1	47	3394.9	1	51	11,089	14,484	6.0	359	14,144	5.8	339	0.14
March	31	-0.8	65.0	9	9	93	6717.6	9	94	20,438	27,155	10.1	608	26,484	9.9	672	0.25
April	30	6.3	78.0	34	34	54	3900.5	34	54	11,741	15,641	6.0	362	15,251	5.9	390	0.15
May	31	12.7	86.0	77	77	21	1516.9	77	21	4,566	6,083	2.3	136	5,931	2.2	152	0.06
June	30	18.1	77.0	113	113	3	216.7	110	3	652	869	0.3	20	847	0.3	22	0.01
July	31	20.3	88.0	130	129	1	72.2	112	1	217	290	0.1	6	282	0.1	7	0.00
August	31	19.4	84.0	115	106	2	144.5	90	2	435	579	0.2	13	565	0.2	14	0.01
September	30	15.0	84.0	76	70	3	216.7	65	3	652	869	0.3	20	847	0.3	22	0.01
October	31	8.6	69.0	39	37	5	361.2	37	8	1,739	2,101	0.8	47	2,064	0.8	36	0.01
November	30	2.7	87.0	13	13	23	1661.3	13	38	8,262	9,923	3.8	230	9,757	3.8	166	0.06
December	31	-3.7	69.0	2	2	33	2383.7	2	43	9,349	11,733	4.4	263	11,495	4.3	238	0.09
Total			***908.0***	***610.0***	***592***	***313***	***22609***	***551***	***355***	***77,186***	***99,794***	***38***	***2,291***	***97,533***	***37.3***	***2,261***	***0.87***
Average		***7.2***										***3***			***3.1***		***0.1***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table D3: Water Balance Rehabilitated Condition Dance Pit Expansion

	Agricultural		Rehabilitated Quarry	
WHC	200 mm		WHC	200 mm
Total Area (m^2)	72,232		Total Area (m^2)	217,425
Infiltration Factor	0.9		Infiltration Factor	1.0

Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspir	Surplus		Actual Evapotranspiration Rehabilitated Quarry Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.9	67.0	1	1	28	2022.5	1	28	6,088	8,110	3.0	182	7,908	3.0	202	0.08
February	28	-5.9	54.0	1	1	47	3394.9	1	47	10,219	13,614	5.6	338	13,274	5.5	339	0.14
March	31	-0.8	65.0	9	9	93	6717.6	9	93	20,220	26,938	10.1	603	26,266	9.8	672	0.25
April	30	6.3	78.0	34	34	54	3900.5	34	54	11,741	15,641	6.0	362	15,251	5.9	390	0.15
May	31	12.7	86.0	77	77	21	1516.9	77	21	4,566	6,083	2.3	136	5,931	2.2	152	0.06
June	30	18.1	77.0	113	113	3	216.7	113	3	652	869	0.3	20	847	0.3	22	0.01
July	31	20.3	88.0	130	129	1	72.2	129	1	217	290	0.1	6	282	0.1	7	0.00
August	31	19.4	84.0	115	106	2	144.5	106	2	435	579	0.2	13	565	0.2	14	0.01
September	30	15.0	84.0	76	70	3	216.7	70	3	652	869	0.3	20	847	0.3	22	0.01
October	31	8.6	69.0	39	37	5	361.2	37	5	1,087	1,448	0.5	32	1,412	0.5	36	0.01
November	30	2.7	87.0	13	13	23	1661.3	13	23	5,001	6,662	2.6	154	6,496	2.5	166	0.06
December	31	-3.7	69.0	2	2	33	2383.7	2	33	7,175	9,559	3.6	214	9,320	3.5	238	0.09
Total			***908.0***	***610.0***	***592***	***313***	***22609***	***592***	***313***	***68,054***	***90,662***	***35***	***2,082***	***88,402***	***33.8***	***2,261***	***0.87***
Average		***7.2***										***3***			***2.8***		***0.1***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

APPENDIX E

Curriculum Vitae

Education

MSc. Earth Sciences, University of Waterloo, 1995

BSc. Honours Earth Sciences, Physics Minor, University of Waterloo, 1987

George Schneider, MSc.

Project Director

PROFESSIONAL SUMMARY

George Schneider is a Senior Geoscientist and Principal with Golder's Greater Toronto Area (GTA) Operations and has over 25 years of professional experience. George received his B.Sc. (1987) and M.Sc. (1995) in Earth Sciences from the University of Waterloo. From 1987 to 1995, he was a researcher in the Geophysics Laboratory at the Centre for Groundwater Research at the University of Waterloo and has co-authored more than 25 technical publications. George joined Golder in 1995; he became an Associate in 2002 and a Principal in 2006. George is a Professional Geoscientist registered in the Province of Ontario.

EMPLOYMENT HISTORY

Principal / Canadian Nuclear Services Leader, Golder Associates Ltd., (2013 to Present)

Cambridge, Ontario

Project Manager / Director responsible for multi-disciplinary projects including: nuclear waste management, explosives site remediation, mine site rehabilitation, aggregate resource studies, and groundwater supply and source water protection studies. George has been with Golder for 23 years, he is currently a leader of the Canadian Nuclear Services Group, responsible for project management, business development and client relations. **George is currently serving as a member of the Lake Erie Source Protection Committee (LESWPC) and as a member of the Water Committee and Waterloo-Wellington-Brant Regional Committee of the Ontario Stone Sand and Gravel Association (OSSGA).**

Principal / Division Manager, Golder Associates Ltd. (2006 to 2013)

Mississauga, Cambridge and Whitby, Ontario

RELEVANT EXPERIENCE

Project Experience – Aggregate Resources

CBM Aggregates (2016-present)

North Dumfries, Ontario

Senior reviewer for an aggregate resource evaluation and Level 1&2 Hydrogeological Assessment for a sand and gravel pit in North Dumfries, Ontario.

Ministry of Transportation Ontario (2013-2014)

Ontario

Provided specialized forensic engineering / geological advice and services related to aggregate resources on a property in northern Ontario. Work included resource modelling and resource valuation for a variety of potential land development scenarios.

Resource Evaluation Arriscraft International (2011)

Ontario

Conducted a geological testing program and completed a resource evaluation of the Hill Top Pit Property in Kitchener, Ontario. Resource evaluation results were used in the appraisal of the property for the purposes of acquisition.

Aggregate Properties Valuation – Confidential (2011)

Ontario, Alberta

Conducted valuation studies of more than a dozen aggregate properties in Ontario and Alberta to estimate the net present value of these properties for the purposes of financing.

Aggregate Source Investigations – MTO (2010-2011)

Northeastern Ontario

Project Director and senior technical reviewer for the geological and hydrogeological components of the 2010 Northeastern Region Aggregate Source Investigation (MTO Assignment NO. 5010-E-0003) which included assessment and permitting studies for 23 sites across Ontario.

Resource Evaluation, Weeks Pit and Quarry – Altus Group (2010-2011)

Parry Sound, Ontario

Senior technical review for an investigation to estimate the total aggregate resources available at the Weeks Pit and quarry property, in order to assist in the valuation of the property to settle an expropriation dispute with the owner and the MTO.

Feasibility Assessment – Lafarge (2010)

Harvey Township, Ontario

Senior technical review for an investigation to assess the feasibility for the development of a limestone quarry on the Buckhorn Property in support of the renewal of a mining lease for the property.

Soil Borrow Search - IBI Group (2009-2010)

Niagara, Ontario

Senior technical reviewer for a soil borrow search in the Niagara Region for the MTO, in support of new construction activities on Highway 406.

Geophysical Investigation – Confidential (2007)

Ontario

Project manager and senior technical advisor for a geophysical and test pitting investigation at a confidential quarry site in Ontario to assess the potential presence of buried waste, as part of a legal claim.

Preliminary Resource Evaluation – SCAW (2004)

Caledon, Ontario

Directed junior staff in a preliminary assessment of the potential for aggregate resources to be present on a property in Caledon, Ontario on behalf of the property owner.

Borehole Geophysical Logging – Confidential (2004)

Brechin, Ontario

Acquired gamma and conductivity borehole geophysical logs at a property near Brechin, Ontario for a confidential client.

Acton Quarry Escarpment Seep Investigation - Dufferin Aggregates (2003)

Acton, Ontario

Led a multidisciplinary project team in an investigation to assess hydrogeologic conditions at Phase 2 of the Acton Quarry and develop conceptual designs for short term and long term hydrogeologic mitigation systems to maintain seep flow in the Guelph-Amabel Formation along the Niagara Escarpment, immediately adjacent to advancing quarry workings.

Resource Evaluation – Dufferin Aggregates (2003)

Ontario

Led a project team to carry out a resource evaluation of the Mosport West Pit property for Dufferin Aggregates. The project involved the integration of high quality coring methods, gradation testing of core samples and ERI (electrical resistivity imaging) geophysical surveying to develop realistic 3D subsurface geologic models for these properties, from which available resources were then estimated and areas of preferred extraction were identified. Duties included: planning, ERI field QA/QC, ERI interpretation, correlation of geophysical and gradation data to establish empirical relationships between ERI response and resource quality and reporting.

ERI Investigation – Nelson Aggregates (2003)

Burlington, Ontario

Directed junior staff in an ERI geophysical investigation to map overburden thickness and assess the underlying rock for karst potential as part of a Level 2 Hydrogeological Assessment under the Aggregate Resources Act, for the planned expansion of the Nelson Quarry in Burlington, Ontario.

Aggregate Resource Evaluation – Confidential (2003)

Sudbury, Ontario

Carried out an evaluation of the potential aggregate resources present on properties in Dill Township near Sudbury, Ontario in support of the appraisal of the properties, which were to be expropriated from the owner by the MTO for the construction of an interchange and highway realignment.

Overburden Investigation – Dufferin Aggregates (2002)

Milton, Ontario

Conducted an ERI (electrical resistivity imaging) and test pitting investigation to develop a 3D model of overburden thickness and the top of bedrock to assist in planning overburden stripping requirements for Dufferin Aggregates in the Western Extension of the Milton North Quarry. Responsible for all aspects of planning, acquisition, processing, interpretation and reporting, as well as client liaison.

Gravel Pit Evaluation - Township of Perth East (2002)

Shakespeare, Ontario

Conducted an investigation to complete a resource evaluation, assess the net present value and make recommendations for optimization to the Perth East Gravel Pit near Shakespeare, Ontario. The Project Team consisted of Golder Associates Ltd., Beck and Associates GeoConsultants Inc. and MHBC Planning Ltd.

Aggregate Properties Valuation – Confidential (2002)

Ontario

Led a multidisciplinary project team which conducted valuations studies of four large aggregate properties in Ontario to estimate the net present value of these properties for the purposes of obtaining bank financing. The Project Team consisted of Golder Associates Ltd., Beck and Associates GeoConsultants Inc. and MHBC Planning Ltd.

Acton Quarry Resource Evaluation – Dufferin Aggregates (2002)

Acton, Ontario

Conducted a resource evaluation and estimated overburden stripping requirements for Phase 3 of the Acton Quarry, which involved ERI geophysical surveying, test pitting and drilling. Responsible for all aspects of planning, acquisition, processing, interpretation and reporting, as well as client liaison.

Overburden Investigation – Dufferin Aggregates (2001)

Milton, Ontario

Conducted a GPR and test pitting investigation to develop a 3D model of overburden thickness and the top of bedrock to assist in planning overburden stripping requirements for Dufferin Aggregates in the Milton North Quarry. Responsible for all aspects of planning, acquisition, processing, interpretation and reporting, as well as client liaison.

Quarry Resource Assessment – Dufferin Aggregates (2001)

Ontario

Acquired, processed, interpreted and reported gamma and conductivity geophysical log surveys in test boreholes at the Ogden Point Limestone Quarry to identify the stratigraphy within a Regional context and infer the suitability of strata within the quarry for use in the manufacture of cement products, based on experience elsewhere in Ontario.

Resource Evaluations – Dufferin Aggregates (1998-1999)

Ontario

Helped conduct sand and gravel resource evaluations as part of a multidisciplinary project team for Dufferin Aggregates at sand and gravel properties in Ontario including Mosport Pit 1 and 2, Bethany, TRT, Mill Creek, Paris and Naylor properties. The projects involved the integration of high quality coring methods, gradation testing of core samples and ERI (electrical resistivity imaging) geophysical surveying to develop realistic 3D subsurface geologic models for these properties, from which available resources were then estimated and areas of preferred extraction were identified. Duties included: ERI modelling and interpretation, 3D geological modelling, correlation of geophysical and gradation data to establish empirical relationships between ERI response and resource quality, volume and tonnage estimates and reporting.

Project Experience – Water Resources and Protection

Municipal Well Construction and Testing (2015-present)
Waterloo Region, Ontario

Project manager, contract administrator and senior technical reviewer for the construction and testing of new municipal supply wells in 2015 at K21, K4A and W6A/B and in 2016 at NH3. The work will construct and permit new supply wells at each of these sites in order to replace older wells with performance problems, provide system redundancy and help ensure the well fields can deliver their full permitted capacity.

Hydrogeological Assessment of Production Wells K23 and K24 (2014-present)
Waterloo Region, Ontario

Senior technical reviewer for the hydrogeological assessment of wells K23 and K24, initiated in 2014 to better understand increasing nitrate concentrations in the wells due to nearby anthropogenic sources, primarily septic systems and agricultural fertilizers. The investigation is developing an improved understanding of the hydrogeology, aquifer vulnerability and water quality in areas around the supply wells and the interrelationships between the wells and potential contaminant sources.

Hydrogeologic Data Analysis Software System Update (2014-present)
Waterloo Region, Ontario

Project manager and senior technical reviewer for the selection and implementation of a new hydrogeologic data analysis (HDA) system for the Region. The project involved a detailed assessment of the Region's current and future data needs, the procurement and evaluation of potential commercial software solutions, and the implementation of the new software database and tools.

Hydrogeologic and Source Water Protection Services (2013-present)
Centre Wellington, Ontario

Senior technical reviewer for hydrogeologic and source water protection services provided on an as-needed basis to the Township of Centre Wellington. The work includes on-going investigations and monitoring related to source water "Issues", as well as the evaluation of the hydrogeological aspects of infrastructure and development projects on behalf of the Township.

Hydrogeologic Services - Cambridge Aggregates (2008-present)
North Dumfries and Brant, Ontario

Senior technical reviewer for various projects for Cambridge Aggregates related to the development of large volume groundwater supply wells and Permits to Take Water for aggregate washing, and hydrogeological assessments in support of new licence applications and licence expansions under the Aggregate Resources Act.

Water Supply Class EA – Region of Waterloo (2010-2012)
West Montrose, Ontario, Canada

Senior technical reviewer for the hydrogeological component of a Water Supply Class Environmental Assessment for West Montrose. The hydrogeological component involved the exploration for an additional water supply within West Montrose. Through a field program involving drilling, hydraulic testing and water quality sampling a potential groundwater supply source was identified and carried forward as part of the assessment.

TICS Project – Region of Waterloo (2009-2012)
Waterloo Region, Ontario

Project manager for the Threats Inventory and Circumstances Survey (TICS) project for the Region of Waterloo. The project involved conducting Canada's largest drinking water census across the Waterloo Region and the evaluation of potential threats to drinking water sources in the Waterloo Region for each well field and surface water intake source.

Waterloo North Water Supply Class EA – Region of Waterloo (2008-2012)
Waterloo Region, Ontario

Senior technical advisor to the class EA project carried out for the Region of Waterloo with AECOM to develop additional groundwater supply wells in North Waterloo and Erbsville. The project involved the drilling of a new test supply well and a long term pumping test of three new supply wells, along with an extensive groundwater monitoring program.

New Wells Project – Region of Waterloo (2008-2009)
Waterloo Region, Ontario

Senior technical advisor to the project to install over 40 new monitoring wells nests throughout the Waterloo Region. Focus was on senior technical review and the interpretation of overburden and bedrock stratigraphy based on core logs, core photographs and samples, grain size analysis and geophysical logs, using nomenclature recently developed by the Ontario Geologic Survey (OGS).

Land Use Designations for Source Water Protection – Brookfield Homes (2007)
Paris, Ontario

Manager and senior technical review on a project to evaluate potential changes in land use designation within WHPAs and the associated change in risk to groundwater to well fields, that have high aquifer vulnerability ratings for a proposed development in Paris, Ontario.

Geophysical Investigation, Middleton Wellfield – Stantec (2005)
Cambridge, Ontario

Manager and senior technical reviewer on a project to use geophysical methods to map the top of bedrock and identify buried infrastructure around the Middleton Wellfield, in order to identify potential contaminant pathways to the shallow bedrock aquifer system.

IUS Project – Region of Waterloo (2005-present)
Waterloo Region, Ontario

The hydrogeological assessment and permitting of existing and potential new Municipal supply Wells for the Region of Waterloo's Integrated Urban Supply System. Assistant project manager, responsible for technical tasks, invoicing, budgeting, tendering and contract administration, presentations, interim and final reporting. Performed a technical role in the water supply development and expansion tasks carried out at the Chicopee, Breslau, Fountain Street, Lancaster, Seagrams and Waterloo North study areas.

Permit to Take Water – Lafarge (2002)
Guelph, Ontario

Completed a hydrogeologic study to support a permit to take water (PTTW) application for Lafarge Canada at the Guelph Asphalt and Ready Mix Concrete Plant in Guelph, Ontario.

Permit to Take Water – Lafarge (2002)
New Lowell, Ontario

Completed a hydrogeologic study to support a permit to take water (PTTW) application for Lafarge Canada at the Home Pit in New Lowell, Ontario.

Permit to Take Water – Heritage Golf Club (2002)
Barrie, Ontario

Completed a hydrogeologic study to support a permit to take water (PTTW) application for Heritage Golf Club near Barrie, Ontario. The work included the supervision and analysis of a 24 hour pumping test.

Geophysical Logging Investigation – Golder (1994)
Cambridge, Ontario

Acquired, processed, interpreted and reported on gamma and neutron geophysical logs in a test supply well in Cambridge East, Ontario as part of a water supply development programme for Golder Associates.

Groundwater Study - Victoria County (2000)
Oak Ridges Moraine, Ontario

Acquired gamma and conductivity geophysical logs in deep boreholes in the Oak Ridges Moraine as part of the Groundwater Study for Victoria County.

Oxford County Groundwater Study – Oxford County (2000)
Stratford, Ontario

Acquired gamma, conductivity, heat pulse flowmeter and optical televiewer geophysical logs in Municipal Supply wells in the Town of Stratford, Ontario, as part of the Oxford County Groundwater Study.

Permit to Take Water – Lafarge (2001)
New Dundee, Ontario

Completed a hydrogeologic study to support a permit to take water (PTTW) application for Lafarge Canada at Warren Bitulithic's Seibert Pit in New Dundee, Ontario.

Rotasonic Drilling Programme – Waterloo Region University of Waterloo (1990-1991)
Waterloo, Ontario

Under the direction of Dr. P.F. Karrow, carried out all aspects of two drilling programmes in 1990 and 1991 including: siting, permitting, utility clearances, drill supervision, well development, geophysical logging, vertical seismic profiling and reporting.

Borehole Geophysical Logging and Well Log Catalogue for the Waterloo Region University of Waterloo (1987-1993)
Waterloo, Ontario

Under the direction of Dr. J.P. Greenhouse, acquired the first digital geophysical logs in the Waterloo Region including: gamma, density, neutron, resistivity, conductivity and caliper log data. Collected and digitized historic logs, as well as digital logs from local consultants. Compiled these logs into a Catalogue in Viewlog format. This log catalogue formed the basis of the current understanding of the quaternary geology and overburden aquifer system in the Waterloo Region.

Seismic Reflection and VSP Studies – Waterloo Region - University of Waterloo (1987-1995)
Waterloo, Ontario

Under the direction of Dr. J.P. Greenhouse, carried out pioneering investigative work to optimise high resolution shallow seismic reflection and vertical seismic profiling geophysical methods for the characterisation of geology and aquifers in the Waterloo Region. This work culminated in the development of a controlled vibratory source for high resolution seismic surveys.

Professional Affiliations

Practising Member, Association of Professional Geoscientists of Ontario

Active Member, Society of Exploration Geophysicists

Publications

Monier-Williams, M.E., Davis, R.K., Paillet, F.L., Turpening, R.M., Sol, S.J.Y. and Schneider, G.W. 2009. Review of Borehole Based Geophysical Site Evaluation Tools and Techniques. NWMO Technical Report TR-2009-25, 174 p.

Emsley, S., Schneider, G.W., Sol, S.J.Y., Fleming, J. and Fairs, J. 2008. Review of Satellite, Airborne and Surface Based Geophysical Tools and Techniques for Screening Potential Nuclear Repository Candidate Sites. NWMO Technical Report TR-2008-15, 143 p.

Gill, J.B. and Schneider, G.W. 2005. Innovative Aggregate Resource Evaluations using Electrical Resistivity Imaging. In the proceedings of the 56th Highway Geology Symposium, Wilmington, North Carolina, May 2005, 15 p.

Schneider, G.W., Nobes, D.C., Lockhard, M.A. and Greenhouse, J.P. 1997. Urban Geophysics in the Kitchener-Waterloo Region, Ontario. In: Environmental Geology of Urban Areas, Geological Association of Canada, Edited by Nicholas Eyles, pp. 457-464.

Nobes, D.C. and Schneider, G.W., 1996. Results of Downhole Geophysical Measurements and Vertical Seismic Profile from the Canandaigua Borehole of New York State Finger Lakes. In: Subsurface Geologic Investigations of New York Finger Lakes: Implications for Late Quaternary Deglaciation and Environmental Change, Special Paper 311, The Geological Society of America, Edited by Henry T. Mullins and Nicholas Eyles, pp. 51-64.

Schneider, G.W. and Vanderkooy, J., 1996. A vibratory seismic system for high-resolution applications. Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems, Keystone, Colorado, April 28-May 1, 1996, pp. 181-188.

Sanderson M., Karrow P.F., Greenhouse J.P., Paloschi G.V.R., Schneider G., Mulamoottil G., Mason C., McBean E.A., Fitzpatrick P.N., Mitchell B., Shrubsole D., Child E., 1995. Canadian Water Resources Journal, Vol. 20, No. 3, pp. 145-160.

Schneider, G.W., Nobes, D.C., Lockhard, M.L., and Greenhouse, J.P., 1994. Urban Geology 4. Urban Geophysics in the Kitchener-Waterloo Region. Geoscience Canada, Volume 20, Number 4, pp. 149-156.

Sanderson, M., Karrow, P.F., Greenhouse, J.P., Paloschi, G.V.R., Schneider, G.W., Mulamoottil, G., Mason, C., Fitzpatrick, N., McBean, E., Mitchell, B., and Shrubsole, D., 1994. Susceptibility of groundwater to contamination in Kitchener-Waterloo: A case study with policy implications. Waterloo '94, Abstracts of GAC-MAC Annual meeting, May, 1994.

Greenhouse, J.P., and Schneider, G.W., 1994. Geophysics and Groundwater Supply in the Waterloo Region. A Poster. Waterloo '94, Abstracts of GAC-MAC Annual Meeting, May, 1994.

Schneider, G.W., and Greenhouse, J.P., 1994. The Geophysical Log Catalogue for the Waterloo Region. A Poster. Waterloo '94, Abstracts of GAC-MAC Annual Meeting, May, 1994.

Endres, A.L., Coe, R.D., Gilson, E.W., Zawadzki, A.A., Schneider, G.W. and Greenhouse, J.P., 1993. The use of neutron logging methods for the detection and monitoring of chlorinated solvents: A quantitative study. Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems, San Diego, California, April 18-22, 1993, pp. 39-50.

Karrow, P.F., Greenhouse, J.P., Paloschi, J.V.R., and Schneider, G.W., 1993. The 1990-91 Rotasonic drilling programme. Final Report to the Ontario MOEE as part of work under grant #E564G, 181 p.

Schneider, G.W. 1993b. Geophysical well logs for the Waterloo Region and surrounding areas: A catalogue (Third Edition). Quaternary Sciences

Institute Publication #9, Department of Earth Sciences, University of Waterloo, 699 p.

Schneider, G.W., DeRyck, S.M., and Ferre, P.A., 1993a. The application of automated high-resolution DC resistivity in monitoring hydrogeological field experiments. Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems, San Diego, California, April 18-22, 1993, pp. 145-162.

Annan, A.P., Brewster, M.L., Greenhouse, J.P., Redman, J.D., Schneider, G.W., Olhoeft, G.R., and Sander, K.A., 1992. Geophysical monitoring of DNAPL migration in a sandy aquifer. Expanded Abstracts SEG 62nd Annual Meeting, October, New Orleans, USA.

Brewster, M.L., Annan, A.P., Greenhouse, J.P., Schneider, G.W., and Redman, J.D., 1992. Geophysical detection of DNAPLs: Field experiments. IAH Conference "Modern Trends in Hydrogeology", May 10-13th, Hamilton, Ontario, Canada.

Schneider, G.W., and Greenhouse, J.P., 1992. Geophysical detection of perchloroethylene in a sandy aquifer using resistivity and nuclear logging techniques. Proceedings of the Symposium of the Application of Geophysics to Engineering and Environmental Problems, April 26-29th, 1992, Oakbrook, Illinois, USA, pp. 619-628.

Greenhouse, J.P., Brewster, M.L., Schneider, G.W., Redman, J.D., Annan, A.P., Olhoeft, G.R., Lucius, J., Sander, K.A., and Mazzella, A., 1991. Geophysics and solvents: The Borden experiments. The Leading Edge, Vol. 12, pp. 261-267.

Greenhouse, J.P., Nobes, D.C., Schneider, G.W. and Lockhard, M.L., 1991. Modification of the Shallow Seismic Reflection Method for Urban Geophysical Studies in Southern Ontario. Ontario Geological Survey Miscellaneous Paper #156, pp. 121-130.

Schneider, G.W., Nobes, D.C., Lockhard, M.L., and Greenhouse, J.P., 1991. Urban geophysics in the Kitchener-Waterloo region. Geological Association of Canada Program with Abstracts, Vol. 16, pp. A111. Presented at the 1991 Annual Meeting of the Geological Association of Canada, Toronto, Ontario, Canada.

Greenhouse, J.P., Nobes, D.C., and Schneider, G.W., 1990. Groundwater beneath the city: A geophysical study. Ground Water Management, Vol. 2, pp. 1179-1191. Proceedings of the Fourth Annual Outdoor Action Conference on Aquifer Restoration, Groundwater Monitoring and Geophysical Methods, Las Vegas, Nevada, USA.

Schneider, G.W., and Greenhouse, J.P., 1989. Geophysical well logs for the Waterloo Region and surrounding areas: A catalogue (Second Edition). Report of the Geophysics Lab, Department of Earth Sciences, University of Waterloo, 158 p.

Schneider, G.W., and Greenhouse, J.P., 1988b. The Columbia Test Site: Targets for EM/Magnetics/GPR Calibration. Report of the Geophysics Lab, University of Waterloo, 55 p.

Schneider, G.W., and Greenhouse, J.P., 1988a. Geophysical well logs for the Waterloo Region and surrounding areas: A catalogue. Report of the Geophysics Lab, Department of Earth Sciences, University of Waterloo, 110 p.

Nobes, D.C., Schneider, G.W., and Hodgson, S., 1987. Discussion on: "Effects of porosity and clay content on wave velocities in sandstones". Geophysics, Vol. 52 pp. 1439.

Education

B.A.Sc Geological Engineering (Water Resources Option) University of Waterloo, Waterloo, Ontario, 1997

M.Sc. Earth Sciences (Hydrogeology), University of Waterloo, Waterloo Ontario, 2001

Certifications

Registered Professional Geoscientist, Association of Professional Geoscientists Ontario (PGO)

Registered Professional Engineer, Association of Professional Engineers Ontario (PEO)

Golder Associates Ltd. – Cambridge

Project Manager / Hydrogeologist

Greg is a Project Manager/Hydrogeologist within Golder's Cambridge office with over 19 years of experience in groundwater resource consulting. He is a graduate of the M.Sc. program in hydrogeology at the University of Waterloo where he studied groundwater contamination from agricultural activities near a municipal well field in Southern Ontario. Greg has technical experience in assessment of aquifer and well yields, groundwater exploration, development and protection, groundwater/surface water interactions, source water protection, groundwater under the direct influence of surface water investigations, groundwater monitoring, borehole geophysics interpretation, groundwater modelling, well installations and well maintenance and decommissioning. He is typically responsible for hydrogeologic analysis, interpretation and assessment, field supervision, report preparation and project management. Greg has been a project hydrogeologist and project manager for several large and challenging groundwater resource development and protection projects in Ontario.

Employment History

Golder Associates Ltd. – Cambridge, Ontario

Hydrogeologist (2009 to Present)

Hydrogeologist and project manager responsible for the implementation and management of hydrogeological projects that encompass groundwater supply, development and protection. Greg has technical experience in assessment of aquifer and well yields, groundwater exploration, development and protection, groundwater/surface water interactions, source water protection, groundwater under the direct influence of surface water investigations, groundwater monitoring, borehole geophysics interpretation, well installations, and well maintenance and decommissioning.

Lotowater Technical Services Inc. – Paris, Ontario

Hydrogeologist (2000 to 2009)

Project hydrogeologist and project manager responsible for hydrogeologic assessments, water supply, development and protection projects, groundwater under the direct influence of surface water investigations and source water protection studies. Responsibilities included hydrogeologic analysis, interpretation and assessment, field supervision, report preparation, development and coordination of field investigation and/or monitoring programs and liaison with regulatory agencies. These projects typically included both a field investigation/testing component and a desk-top assessment/analysis. Projects included the exploration and development of groundwater supplies for various uses, assessing the associated impacts and developing water resources protection strategies. Several large and challenging groundwater resource and development projects have been undertaken in southern Ontario.

Research Experience – Woodstock, Ontario
M.Sc. Thesis (1997 to 2001)

Research on groundwater contamination from agricultural land use activities. The study investigated the increasing nitrate concentrations at a municipal well field located in an urban/rural area. The investigation included a hydrogeological investigation to assess the impacts of agricultural activities at the regional scale on nitrate quality in an urban/rural well field and to evaluate potential strategies to minimize the impacts within a reasonable time period. The research included the installation and monitoring of numerous monitoring wells, a large-scale aquifer test and numerical modelling of the aquifer system. The results were used to aide in protecting the municipal aquifer.

PROJECT EXPERIENCE – AGGREGATE RESOURCES

CBM Aggregates
Dorchester, Ontario, Canada

Lead Hydrogeologist for an integrated impact assessment supporting a major Site Plan amendment at the North Dorchester Pit. The proposed amendment is intended to permit the extraction of additional available aggregate resources from below the water table at the existing pit.

CBM Aggregates
Sunderland, Ontario, Canada

Lead Hydrogeologist for an integrated impact assessment to support a future licence application for the Sunderland Pit Expansion. The application is for aggregate extraction below the water table and the study includes a Level 1/2 Hydrogeological Assessment. The study also included a drilling and testing program to evaluate the resource.

CBM Aggregates
Peterborough County, Ontario, Canada

Lead Hydrogeologist for an integrated impact assessment to support a future licence application for the Blezard Line Pit. The application is for aggregate extraction above and below the water table and the study includes a Level 1/2 Hydrogeological Assessment. The study also included a drilling and testing program to evaluate the resource.

Lafarge Canada
Glen Morris, Ontario, Canada

Lead Hydrogeologist for an integrated impact assessment to support a future licence application for the Glen Morris Pit. The application is for aggregate extraction above and below the water table and the study includes a Level 1/2 Hydrogeological Assessment. The study also included a drilling and testing program to evaluate the resource.

CBM Aggregates
North Dumfries Township, Ontario, Canada

Lead Hydrogeologist for an integrated impact assessment to support a future licence application for the Dance Pit Extension to an existing licence. The application is for aggregate extraction above the water table and the study includes a Level 1/2 Hydrogeological Assessment.

Cambridge Aggregates
Ayr, Ontario, Canada

Lead Hydrogeologist for a Level 1/2 Hydrogeological Assessment in support of a licence application for the Ayr Pit. Work was conducted in a sensitive area and included the preparation of trigger levels and a contingency plan. Aggregate extraction is above the water table.

Cambridge Aggregates
North Dumfries Township, Ontario, Canada

Lead Hydrogeologist for a Level 1/2 Hydrogeological Assessment in support of a licence application to expand the North Dumfries Pit. Aggregate extraction is above the water table. Work also included testing a supply well to provide water for aggregate washing along with the associated permitting.

Preston Sand and Gravel
North Dumfries Township, Ontario, Canada

Lead Hydrogeologist for a Level 1/2 Hydrogeological Assessment in support of a licence application for the Henning Pit. Aggregate extraction is above the water table.

PROJECT EXPERIENCE – SOURCE WATER PROTECTION

Risk of Road Salt Application
Guelph, Ontario, Canada

Investigated an alternative approach to assessing the risk to municipal drinking water systems from road salt application threats. Reviewed impervious surface areas, chloride concentrations and salt loading factors to determine a salt quantity score which was combined with the vulnerability score to determine the salt risk score. The work was completed to provide additional information for assessing and managing the risk of salt impacts to the municipal wells.

Drinking Water Issue Review
Centre Wellington, Ontario, Canada

Field technician responsible for supervision of a proposed light rail transit in Ottawa. Duties included drilling supervision, rock core logging, soil logging. Additional duties included packer testing and monitoring well installation supervision.

Salt Risk Management Plan
Region of Waterloo, Ontario, Canada

Golder assisted the Region of Waterloo in the development of their Salt Risk Management Plan template which was developed for use under the Clean Water Act. The Risk Management Plan is to be developed for properties where a significant threat activity has been identified within the wellhead protection area. The study involved the review of the template and identification and evaluation of best management practices to develop an effective and easy to use template. The study is valuable in that it provides an understanding of potential threats to groundwater quality and how they can be managed.

Source Water Protection Technical Studies
Southern Ontario, Canada

Provide an important lead technical and task management role in the technical studies required for the assessment reports. Activities included the review of historical data, delineating wellhead protection areas, identifying the vulnerability within those areas, and conducting threat and issue evaluations within the areas. These studies were undertaken for various wellfields in the County of Brant, Townships of Centre Wellington and Southgate and the Town of Erin. Additional studies and updates to the initial work have been completed since that time.

SAAT Vulnerability Mapping Review
Grand River Watershed, Ontario, Canada

Review and refine the aquifer vulnerability mapping within twenty three wellhead protection areas in the Grand River Watershed for use in the Assessment Report. The review of the SAAT mapping considered bedrock outcrops, surficial geology, overburden thickness, individual SAAT point values, original ISI mapping and hydrogeologic interpretation. The revised vulnerability mapping reasonably characterized the intrinsic vulnerability in the WHPAs and provided improved mapping over previous versions.

PROJECT EXPERIENCE – GROUNDWATER EXPLORATION, DEVELOPMENT AND PROTECTION

Monitoring Well Installation
Region of Waterloo, Ontario, Canada

A new multi-level monitoring well was installed in Hespeler with monitors in both the bedrock and overburden. The monitoring well was constructed to monitor potential interference of external water takings on a municipal water supply. Downhole testing was completed to help determine the completion zones for the monitors.

Sentry Well Installation and Monitoring
Guelph, Ontario, Canada

Provide an important lead technical and task management role for the installation of sentry wells in the City of Guelph. Potential sources of contamination were identified in areas surrounding wells where the water quality has been slightly impacted. Well locations were selected to monitor water quality within the capture zones of these wells and provide an early warning of potential contamination. The wells were designed as hybrid multi-level monitoring wells to allow for multiple sampling and water level ports. Extensive in-hole testing was conducted in the boreholes.

Hydrogeological Assessment and Nitrate Investigation
Mannheim, Ontario, Canada

Elevated nitrate concentrations have been detected in some of the Mannheim production wells. This study was undertaken to assess the current nitrate concentrations in the groundwater and evaluate whether nitrate concentrations in the groundwater will eventually exceed Ontario Drinking Water Standards. The study included the installation of monitoring wells, water quality sampling, a wellfield shutdown test, mass balance modelling and an assessment of best management practices. The understanding gained through the investigation will help the Region of Waterloo in managing a reliable water supply system for this and future generations.

Construction and Testing of a New Municipal Supply Well
Region of Waterloo, Ontario, Canada

Project manager for the construction and testing of new municipal supply well in Maryhill. The work included the design of the production and aquifer testing to determine potential effects of the water taking on nearby water users and the environment. The well was constructed in an overburden aquifer. A report was prepared to support a permit to take water application.

Construction and Testing of a New Municipal Supply Well
Region of Waterloo, Ontario, Canada

Project manager for the construction and testing of new municipal supply well in New Hamburg. The work included the design of the production and aquifer testing to determine potential effects of the water taking on nearby water users and the environment. The well was constructed in a bedrock aquifer. A report was prepared to support a permit to take water application.

Wellfield Capacity Assessment
Township of Centre Wellington, Ontario, Canada

Project manager and hydrogeologist for a project to understand the sustainable limits of the water resource relative to future demand projections. The investigation characterized the underlying bedrock hydrostratigraphy through a large-scale field program including the installation of monitoring wells, geophysical logging and production well shutdown/pumping tests. Updated conceptual and numerical models were developed and used to assess the wellfield capacity.

Water Supply Class Environmental Assessment
West Montrose, Ontario, Canada

Project manager for the hydrogeologic component of West Montrose Water Supply Class EA. The project included identifying, evaluating and documenting a recommended solution for a new supply source in the Village of West Montrose, specifically identifying potential groundwater resources that could be used as a water supply for the Village. A staged approach was used for the investigation including a desktop study, field investigation of existing wells and an exploratory drilling program.

Groundwater Exploration Study
Paris, Ontario, Canada

Designed and implemented a groundwater exploration program as a project hydrogeologist and field project manager to provide a new groundwater supply source. Initial work included locating, designing and installing monitoring wells to better define the aquifer. Following the initial work a site was selected for a municipal test well and an aquifer test was carried out. Interpreted test data to determine the safe yield of the applicable aquifers.

Municipal Groundwater Study County of Brant, Ontario, Canada	Conducted a detailed evaluation of the regional hydrogeology of the bedrock and overburden aquifer systems across the County. This project included the installation and geophysical logging of monitoring wells to gain additional information on the hydrostratigraphy around the municipal well fields, as well as numerical modelling to aid in establishing wellhead protection areas.
Water Supply Upgrade Paris, Ontario, Canada	Hydrogeologist and field project manager for a detailed hydrogeological investigation to aid in the construction and testing of replacement wells for a municipal water supply. Testing was done to determine whether the groundwater supply was GUDI and to determine the effects of agricultural practices in the area. The project included a detailed field testing program, aquifer mapping, municipal well field capture zone analysis and groundwater protection measures.
Groundwater Protection Study Burford, Ontario, Canada	Hydrogeologist for a groundwater investigation to determine the groundwater capture zone and potential contaminated sources with the capture zone. The study also addressed groundwater quality concerns in the urban community, which is serviced by individual wells and on-site sewage disposal systems.
Sustainable Yield of Municipal Supply Wells St. George, Ontario, Canada	Conducted an assessment to provide an estimate of the sustainable yield of the municipal water supply. Incorporated aquifer test results into a groundwater model to estimate the sustainability of the water supply. In addition to the sustainability of the aquifer, impacts to surface water bodies were reviewed and long-term groundwater quality conditions were investigated.

TRAINING

Aquifer Mapping/Wellhead Delineation Workshop, 2001

Source Water Protection Best Management Practices and Other Measures for Protecting Drinking Water Supplies, 2003

Borehole Geophysics Short Course, 2007

Critical Thinking in Aquifer Test Interpretation, 2011

Interpreting Aquifer Tests in Fractured Rock, 2012

PUBLICATIONS

Padusenko, G. 1997. Undergrad Thesis (B.A.Sc.): The Influence of Scale on Hydraulic Conductivity Measurements.

Padusenko, G. 2001. Masters Thesis (M.Sc.): Regional Hydrogeologic Evaluation of a Complex Glacial Aquifer System in an Agricultural Landscape: Implications for Nitrate Distribution.

Padusenko, G. 2003. Presentation: A Comparison of Particle Count Data to On Line Turbidity From a Pumping Well. OWWA Conference.

Lotimer, T. and Padusenko, G. 2008. Presentation: Constructed Preferential Pathways: Where Did My Well Go? OWWA Conference.

Chapman et. al., 2015. Paper: Hybrid Multilevel System for Monitoring Groundwater Flow and Agricultural Impacts in Fractured Sedimentary Bedrock. National Groundwater Association – Groundwater Monitoring and Remediation.

Craig De Vito, P.Eng.

Water Resources Engineer

Education

Bachelor of Science Engineering (Co-op), University of Guelph, Guelph, Ontario, Canada, 2002-2007

Certifications

Professional Engineers of Ontario

PROFESSIONAL SUMMARY

Golder Associates Ltd. – Mississauga, Ontario

Water Resources Engineer (2007 to Present)

Responsible for conducting water quantity and water quality investigation programs that include hydraulic and hydrologic modelling, analysis of riverine and lacustrine environments, the design, execution and management of meteorological, hydrological and water quality field programs and development of water balance and water quality modelling analyses. Currently working on various surface mine and mine rehabilitation investigations of hydrology and water quality. Completes water resources projects from desktop reviews to design, construction monitoring and erosion & sediment control inspection.

Golder Associates Ltd. – Mississauga, Ontario

Water Resources (Co-Op) (May 2006 to December 2006)

Performed water flow and quality monitoring. Assisted with hydrological assessments.

RELEVANT EXPERIENCE

Canadian National Railway (2015-2016)
Algonquin Park, Ontario, Canada

Completed an Environmental Compliance Approval for Industrial Sewage Works for a temporary water treatment facility which was designed to treat contaminated water and sediments from a historic train derailment. The facility discharged to a near by lake within the Park.

Fish and Bird Emporium (2016)
Innisfil, Ontario, Canada

Lead a team that completed an Environmental Compliance Approval for Industrial Sewage Works for a tropic fish warehouse and distribution centre. The application included multiple water filtration facilities designed to reduce the effluent contaminant concentrations without impacting the health of the fish at the site.

CBM Aggregates (2007-2018)
Various Sites in Southern Ontario

Various aggregate properties have been monitored and evaluated for aggregate license applications. this monitoring included water level monitoring, stream flow monitoring, groundwater piezometer monitoring and meteorological monitoring. Detailed site water balances as well as site and water course characterization have been evaluate and reported as part of the multidisciplinary applications.

Client Confidential (2010-2018)
Bancroft, Ontario, Canada

Completed surface water investigations at a decommissioned mine site (uranium) near Bancroft, Ontario, including meteorology, flow and water quality monitoring. Developed a detailed water balance to evaluate the site drainage and adjacent stream networks. Characterized and reported the surface water networks and their impacts.

Client Confidential (2009-2018)
Near Kenora, Ontario, Canada

Completed surface water investigations at a former mine (nickel) near Kenora, Ontario, including meteorology, flow monitoring, water column profiling and water quality sampling. Flow regimes were characterized and modelled to evaluate impacts of adverse water quality on downstream environments. These investigations have lead to site rehabilitation design which have required applications for water taking and management permits.

Teck Resources (2013 2015)	Conducted water quality modelling to support mine site investigations for a mining project in British Columbia. Water quality parameters were modelled
Elk Valley, British Columbia, Canada	throughout the watersheds from natural sources, mining and metal processing activities as well as their reactions within the watershed. Modelling efforts were used to evaluate treatment options and water handling / management.
Metrolinx (2017-2018) *Toronto, Ontario, Canada*	Project manager for the program which included stormwater sampling of a Metrolinx rail yard. The sample results were compared to the municipal stormwater sewer quality limits and reported at the season.
Town of Oakville (2008-2012) *Oakville, Ontario, Canada*	Project manager for the program which included dry weather outfall sampling and wet weather storm sewer sampling. Results were analysed to develop water quality trends in order to estimate contaminate sources and evaluate the effectiveness of Best Management Practices and Stormwater Management Plans (Town of Oakville).
Trans Canada Pipelines Gas Line Construction (2017-2018) *Ontario, Canada*	Managed and supported continuous instream turbidity monitoring of many watercourse crossings as part of the Vaughan Mainline pipeline construction and Gravenhurst pipe replacement. This program included site reconnaissance, equipment installation, intensive 24 hour monitoring and troubleshooting, daily and final reporting.
County of Northhumberland (2009-2016) *Cobourg, Canada*	Ongoing support regarding a channel remediation design/assessment for the County of Northhumberland on a reach of Brookside Creek located downstream of the closed Eagleson Landfill to reroute unaffected surface water flows away from a zone of leachate influenced groundwater – conducted field studies, fluvial geomorphic and hydraulic analyses, preparation of conceptual/detailed design plans, liaison with contractor and reporting.
Region of Durham (2014-2016) *Whitby, Canada*	Completed a hydraulic analysis and fluvial geomorphic assessment at East Corbett Creek and tributary of East Corbett Creek. The analyses were conducted in support of a proposed extension of Consumers Drive that includes culvert crossings at the two watercourses – conducted field investigations, fluvial geomorphic analyses, hydraulic modelling, environmental permitting and reporting
Canadian National Railway (2016-2018) *Southern Ontario, Canada*	Many rail crossings were evaluated at locations of aging bridges, collapsed culverts and areas of flooding. Sites were visited and surveyed to confirm conditions and provide detailed data for desktop analysis. Hydraulic analyses were completed for each site to evaluate existing infrastructure. New crossing designs were evaluated based on MTO and CN guidelines and developed to conceptual and final designs.

golder.com