REPORT

Water Report Level 1/2

Aberfoyle South Pit Expansion

Submitted to:

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Distribution List

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APPENDICES

1.0 INTRODUCTION

WSP Canada Inc. (WSP), formerly Golder Associates Ltd. (Golder), is pleased to provide CBM Aggregates, a division of St. Marys Cement Inc. (Canada) [CBM], with this Level 1/2 Water Report in support of a Class A Pit Below Water licence application under the *Aggregate Resources Act (ARA)* at the proposed Aberfoyle South Pit Expansion. The property is approximately 85 hectares (ha) in size and is located at 6947 Concession Road 2, in the Township of Puslinch, County of Wellington, Ontario (Figure 1).

This assessment is completed in accordance with the Natural Resources and Forestry (MNRF) requirements for a "Water Report Level 1/2" as described in *Aggregate Resources of Ontario Standards: A compilation of the four standards adopted by Ontario Regulation 244/97 under the Aggregate Resources Act* (August 2020), as well as the requirements of the County of Wellington Official Plan. A Terms of Reference (ToR) was initially submitted on October 12, 2021 to the County of Wellington, Township of Puslinch Grand River Conservation Authority and later issued in final form on September 7, 2023 incorporating Township, County and agency review comments (Appendix A). For the purpose of this report, the following definitions are used:

Property (Figure 1) – The total land area owned by CBM. The total property area is 85 ha in size.

Site (Figure 1) – The total land area within the property owned by CBM that is proposed for licensing under the ARA. The proposed site / licence area is approximately 44 ha in size.

Extraction Limit (Figure 1) – The extraction limit demarks the area within the site in which aggregate extraction is proposed. The area within the extraction limit is approximately 27 ha in size.

1.1 Objectives

The overall objectives of the assessment are to: 1) characterize the baseline hydrogeological and hydrological conditions in the vicinity of the site under the "Existing Conditions Scenario" (current, pre-extraction conditions); and 2) assess the potential effects of the proposed "Operations Scenario" and "Rehabilitated Scenario" on groundwater and surface water resources and the potential need for mitigation (if necessary). The following tasks were completed during the period of 2018 through 2022 to achieve the Study objectives:

- A review of publicly available hydrogeologic and hydrologic data and reports for the Site and surrounding area.
- A field investigation program that included: borehole drilling and monitoring well installations; stream standpipe piezometers and surface water monitoring installations; monthly groundwater monitoring (water levels and temperatures); quarterly stream monitoring (water levels and flow); groundwater quality sampling; and hydraulic conductivity testing.
- A review of local groundwater users based on the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) and Permit To Take Water (PTTW) databases.
- Development of a Site water budget for Existing, Operations and Rehabilitated Scenarios to estimate pre- and post-development surplus, runoff and infiltration rates.
- The construction and calibration of a numerical groundwater flow model and subsequent predictive simulations to estimate potential water quantity impacts of the proposed below-water extraction on surrounding groundwater and surface water receptors.

- The development of a groundwater / surface water mixing model to assess potential thermal impacts of the proposed aggregate extraction on water temperatures in local streams and creeks.
- An assessment of groundwater vulnerability and the potential for water quality impacts.
- An analysis of potential cumulative effects of the proposed aggregate extraction in light of the other neighbouring aggregate operations.

2.0 SITE LAND USE AND PROPOSED DEVELOPMENT

2.1 Existing Conditions Scenario

The Property is roughly rectangular in shape and is comprised of approximately 50% agricultural fields, which are flanked by three wooded areas in the northwest, north-central and southeast portions of the property (Figure 1). An unoccupied residence, including a bungalow, a barn, and two garage/shed buildings, is located in the western portion of the property.

Mill Creek flows from north to south along the eastern and southeastern portion of the property (Figure 2), exits the property along the southern boundary, and then flows westward approximately 150 m to the south of the property boundary. There are five small tributaries to Mill Creek proximal to the property (Figure 2), referred to as Tributary 1, 2, 3, 4 and 5. Tributaries 1, 3 and 5 originate off-property but then flow onto the property and join Mill Creek, while Tributaries 2 and 4 are located entirely off-property. All the woodland areas on the property are part of the Mill Creek-Puslinch Provincially Significant Wetland (PSW).

Land use directly adjacent to the property is largely composed of rural residential properties consisting of single family dwellings surrounded by wooded areas.

2.2 Operations Scenario

The proposed extraction area on the property is approximately 27 ha in size, within a total proposed licenced area of approximately 44 ha (Figure 1). The proposed extraction area limit was established by applying a minimum 30 m setback from watercourses, wetlands and / or property limits as per ARA requirements, and an approximate 60 m offset from Mill Creek.

Reserve estimates indicate that there are approximately 5.5 million tonnes of aggregate present within the proposed extraction area, with over 95% of the resource situated below water, as delineated by the measured high water table elevation (discussed in Section 5). Based on borehole drilling results, the maximum depth of extraction is expected to be up to 20 m below the current ground surface to a maximum lower extraction elevation of 285 m above sea level (masl).

Aggregate extraction will initially begin above the water table in the west-central portion of the extraction area and proceed westward towards the western edge. Aggregate extraction by dragline will then begin below the water table in the westernmost part of the extraction area and proceed in an easterly direction. Above water table and below water table extraction will then proceed generally concurrently in an eastward direction until aggregate extraction has been completed, creating ponding conditions effectively throughout the operational period.

The raw aggregate will be temporarily stockpiled on-site to allow the pore water within the aggregate to drain back to the emerging pit pond prior to transport of the raw aggregate feedstock off-site for processing at the nearby CBM Aberfoyle South Pit operation.

For the purposes of this assessment, it is assumed that aggregate extraction will take place on the Aberfoyle South Expansion over a period of approximately 6 to 10 years, depending on market conditions, with a maximum annual aggregate extraction rate of 1 million tonnes per year. Site operations will not involve any pumping or active dewatering and there will be no direct off-site discharge of water to any watercourse or wetland. Within the extraction area, all drainage will be directed internally to the emerging pit pond.

2.3 Rehabilitated Scenario

Site rehabilitation will result in a permanent pond with a variety of naturalized shoreline features. The pond water elevation is expected to reside at an elevation of +/- 302.0 masl. As part of the final rehabilitation design, the extraction faces will be completed at a 3:1 slope above-water and a 2:1 slope below-water.

3.0 BACKGROUND INFORMATION

The following reports were reviewed within the context of this assessment. All of these reports pertain to studies within, or including, the Mill Creek subwatershed.

Aggregates

- Golder, 2006. *Draft Report on Mill Creek Cumulative Impact Assessment.* 04-1112-064. Submitted to Ontario Ministry of Natural Resources, Guelph. November 2006.
- University of Waterloo, 2018. *Cumulative Effects in the Mill Creek Subwatershed.* Department of Biology. Prepared for Friends of Mill Creek. November 4, 2018.
- 8Trees Inc., 2019. *Monitoring Report CBM – St. Mary's Cement McMillan Pit (Licence #5737).* Submitted to MNRF. February 19, 2019.
- LRG Environmental, 2019. *Mill Creek Coordinated Monitoring Report, January 1 to December 31, 2018*. Submitted to Dufferin Aggregates, a division of CRH Canada Group Inc. 10-001. March 26, 2019.
- WSP, 2021. Mill Creek Aggregates Pit - 2020 Coordinated Monitoring Report – Prepared for Dufferin Aggregates, A CRH Company. Project No.: 111-52958-10. March 25, 2021.
- WSP, 2023. Mill Creek Aggregates Pit - 2022 Coordinated Monitoring Report – Prepared for Dufferin Aggregates, A division of CRH Canada Inc. Project No.: 111-52958-14-100. March 29, 2023.
- Harden Environmental Services Ltd., 2023a. Puslinch Water Level Monitoring Data and Map. July 28, 2023.
- Harden Environmental Services Ltd., 2023b. Mill Creek Aggregates Pit – Review of 2022 Monitoring Data. August 9, 2023.

Source Water Protection

- Matrix, 2017. *City of Guelph Tier Three Water Budget and Local Area Risk Assessment.* Submitted to the Lake Erie Source Protection Region. March 2017.

- Grand River Source Protection Authority, 2019. *Grand River Source Protection Area, Approved Assessment Report.* August 2019.

General Environmental

- Ontario Ministry of Natural Resources, 1984. *Wetland Data Record and Evaluation: Galt Creek Wetland*. Cambridge District OMNR. September 1984.
- Grand River Conservation Authority (GRCA), 1996. *Mill Creek Subwatershed Study*. Prepared by CH2M Gore and Storrie Ltd., et al. June 1996.
- C. Portt and Associates and Blackport and Associates, 2002. *Mill and MacCrimmon Creek Review of Flow Requirements for Fish Habitat (Draft).* Prepared for Department of Fisheries and Oceans. February 17, 2002.
- Township of Puslinch, 2019. *Fuel Spill Update – May 17, 2019 Update from the Ministry of the Environment, Conservation and Parks.* Public Notices – Puslinch Township. May 17, 2019

4.0 REGIONAL SETTING

4.1 Climate

The site is located approximately 16 km southeast of the Environment Canada (EC) Kitchener / Waterloo climate station. The Kitchener / Waterloo period of record spans 49 years (1971-2020) and is a reasonably proximal dataset to characterize average climatological conditions in the vicinity of the Site.

Based on the composite Kitchener / Waterloo climate station data, average annual precipitation is 871 millimetres (mm) per year (mm/yr) and the average annual temperature is 7°C.

Additional information on climate is provided in Section 6.0 - Site Water Balance.

4.2 Topography

There are topographic highs located northwest, east and south of the property, and topography in the area generally slopes towards Mill Creek and its tributaries (Figure 2). Topography within the proposed extraction area is generally flat, varying from about 303 to 304 masl, with the exception of a small hill in the western portion of the extraction area, which reaches a peak height of 309.2 masl. The topography on the property northwest of the proposed extraction area varies from approximately 304 masl in the wooded wetland areas, to peaks of 308.8 and 308.3 masl, on two small hills. These three hills on the western side of the property likely represent the surface expression of the southern terminus of a regional topographic rise associated with the Wentworth Till deposit.

4.3 Drainage

The predominant surface water features on the property are Mill Creek and the Mill Creek-Puslinch PSW, which receive the majority of drainage from the site (Figure 2). Mill Creek enters at the northeast corner of the property and flows southerly and then westerly within the property before it exits through the southern property limit. Mill Creek is a major tributary of the Grand River, draining a catchment area of approximately 104 square kilometres (km^2), with about 66 km^2 of this area located upstream of the property. The Mill Creek-Puslinch PSW surrounds the main branch of Mill Creek along its flow path and resides in the forested regions of the property, located along the edges of the property boundary and continuing beyond the property. Drainage from the site to Mill Creek passes through the Puslinch Mill-Creek PSW, before continuing towards Mill Creek.

Several unnamed tributaries of Mill Creek, originating in and surrounded by the Mill Creek-Puslinch PSW, exist within or proximal to the site, including: Tributary 1, Tributary 2, Tributary 3, Tributary 4 and Tributary 5 (Figure 2). Tributaries 1 and 2 enter the property along the eastern perimeter and discharge to Mill Creek within the property. Tributaries 3 and 5 drain the northwestern portion of the property, converging into a single watercourse (Tributary 3), and eventually discharge to Mill Creek over 800 m downstream (west) of the property. Tributary 4, located just west of the property, discharges to Tributary 3.

4.4 Geology

There are three main surficial soil units mapped by the Ontario Geologic survey (OGS) on and in the vicinity of the property (Figure 3):

- Gravelly Deposits (7b) of the Aberfoyle Outwash Channel occur centrally within the site. These materials form the subject resource of the ARA licence application.
- Stone Poor, Carbonate-Derived Silty to Sandy Till (5b) is present on the western side of the property and in the northwest corner of the proposed licence area (Site). It is associated with the regionally prevalent Wentworth Till northwest of the property.
- Organic Deposits (20) are present in areas roughly coincident with the wetlands and wooded areas on the property and may be immediately underlain by Units 7b or 5b in some places.

Based on previous interpretations (Matrix 2017), the above surficial units are underlain by either a continuation of Wentworth Till or Port Stanley Till down to bedrock. Bedrock underlying the site and surrounding area is mapped as Paleozoic Guelph Formation Dolostone (Armstrong and Dodge 2007).

4.5 Hydrostratigraphy

For this water resource assessment, we have adopted the prevailing hydrostratigraphic interpretation for the area as described in the Tier 3 Study Report (Matrix 2017). From ground surface downwards, the main hydrostratigraphic units are organized as follows:

1. Overburden A (Shallow)
    a. Sand and Gravel (Aquifer)
    b. Wentworth Till – Weathered (Weak Aquifer)
2. Overburden B (Deep)
    a. Wentworth Till (Aquitard) [underlying Sand and Gravel]
    b. Port Stanley Till (Aquitard) [underlying Wentworth Till – Weathered]
3. Bedrock
    a. Contact Aquifer – Weathered bedrock layer.
    b. Competent Bedrock - Bedrock layer containing the Guelph Formation and the Reformatory Quarry Member.

On the site and surrounding property, the Overburden A hydrostratigraphic unit is mainly comprised of Sand and Gravel (Aquifer), an unconfined, relatively high transmissivity unit, which is inferred to correspond to OGS mapped

Unit 7b. As discussed in Section 5, the Sand and Gravel Aquifer forms the below-water portion of the aggregate resource on-site and is thus a principal subject of the impact assessment described herein.

The underlying Overburden B is comprised of relatively low transmissivity till units and will remain intact during extraction activities. Although the hydraulic interaction between the Bedrock and Overburden A (where extraction will occur) is somewhat limited because of the intervening low transmissivity tills in Overburden B, the upper portion of the Bedrock is conceptualized as receiving some recharge from above. This is discussed further in Section 7 - Groundwater Modelling.

4.6 Groundwater Flow

Estimated recharge rates to the Sand and Gravel range from 300 mm/yr to 400 mm/yr whereas recharge rates to the Wentworth Till are lower at 200 mm/yr – 300 mm/yr (Matrix 2017). Upon recharging the system, shallow groundwater flow is inferred to occur in a south to southwesterly direction based on average measured groundwater levels on the property and static water levels of overburden wells in the MECP WWIS database. The primary discharge zone for shallow groundwater is Mill Creek, although its tributaries intercept a relatively small portion of groundwater flow prior to joining with Mill Creek.

4.7 Nearby Aggregate Sites

Nearby aggregate sites include: 1) the Dufferin Aggregates Mill Creek Aggregates Pit operation, with the closest notable water feature being the Phase 3 Pond located approximately 200 m northeast of the Site; and 2) the former CBM McMillan Pit, with the pit pond located approximately 500 m east of the Site (Figure 1).

The Phase 3 Pond at the Mill Creek Pit underwent active extraction from 2007 through 2013, and extraction is no longer taking place in that area (LRG 2019). The CBM McMillan Pit ceased aggregate extraction in 2004 and currently operates as an aquaculture facility pond (8Trees 2019). The remaining licensed reserve on the CBM McMillan Pit is on the east side, further away from the Site and Mill Creek. Both of these aggregate sites are located on the opposite (east) side of Mill Creek relative to the Site.

4.8 Water Users

4.8.1 MECP Water Well Record Review

According to the MECP Water Well Information System (WWIS) database, there are 17 neighbouring wells within 500 m of the property in addition to eight wells on the property itself, as shown on Figure 5.

The water well records for the on-property and neighbouring wells are provided in Appendix B and summarised in Table B-1. It should be noted that the information presented in Table B-1 has been checked against the original well record scans and where needed, corrections have been made to the information entered into in the WWIS where it contradicts the original well records. With reference to Table B-1, the following is noted:

- Ten of the 17 neighbouring wells are completed in the bedrock, and the remaining seven neighbouring wells are completed in the overburden.
- Eight of the 10 neighbouring bedrock wells are categorized as water supply wells, while the remaining two are test wells drilled for the Region of Waterloo (inactive). The depth to bedrock in the wells varied from 15.2 m to 29.6 m.
- Five of the seven neighbouring overburden wells are categorized as water supply wells, while the other two are test wells, including well 16-79 (ID 6707090), which is part of the Puslinch groundwater monitoring

program undertaken on behalf of the Township of Puslinch. The depth of the wells varied from 8.2 m to 29.0 m and for the most part appear to be screened in the Overburden Aquifer.

The eight wells on the property include six monitoring wells installed by WSP on behalf of CBM, a water supply well drilled on the western part of the property near the residence and barn in 1978 (currently inactive), and a test well drilled on the property for the Region of Waterloo in 1980 (currently inactive). These are discussed further in Section 5. The potential for impacts to groundwater users proximal to the Site as a result of the proposed on-site activities is discussed in Section 8.

We anticipate that CBM will be required to complete a door-to-door survey of private wells for properties within 500 m of the Site upon licence approval and prior to the initiation of aggregate extraction, noting that participation by neighbouring property owners would be voluntary.

4.8.2 Permit To Take Water Review

According to the MECP Permit To Take Water (PTTW) database (last accessed in January 2022) there is one permit to take water (# 5557-B93NZ5) proximal to the study area, which is held by Dufferin Aggregates, a division of CRH Group Canada Inc. and is associated with the Mill Creek Aggregates Pit, located northeast of the Site (Figure 5). Under this permit, water is pumped from “Pond 1” (1,200 m northeast of the site) and used for aggregate washing and pumped from “Pond 4” (800 m east of the site) into Pond 1 to maintain the water level in Pond 1. Details of the Permit are provided in Table 1.

Water takings recorded for the 2020 period under this Permit were reported in WSP (2021). Water was pumped from Pond 1 for washing on 180 days from March to November 2020, at an average rate of 7,111,861 L/day. Water was also pumped from Pond 4 to Pond 1 on 15 days from May to July 2020, at an average rate of 1,093,933 L/day. Both of these daily rates and annual water takings were lower than the maximum permitted amounts. It should also be noted that most of the water used for aggregate washing is recirculated in the system, so the consumptive water taking is small.

Table 1: Permit To Take Water Details (Permit 5557-B93NZ5)

Source Name	Source Type	Taking Purpose	Taking Category	Max Taken per Minute (litres)	Max. Num. of Hrs Taken per Day	Max. Taken per Day (litres)	Max. Num. of Days Taken per Year
Pond 1	Pond Dugout	Aggregate Washing	Industrial	11,366	12	8,183,000	275 (Mar – Dec)
Pond 4	Pond Dugout	Other – Industrial	Industrial	11,806	24	17,000,000	364

The potential for impacts to water users proximal to the Site, as a result of the proposed on-Site activities, is discussed in Section 8, noting again that the Mill Creek Pit is on the opposite (east) side of Mill Creek relative to the Site.

4.9 Source Water Protection Considerations

The GRCAs Policy Mapping Tool (https://maps.grandriver.ca/swp-policymapping/), accessed in October 2021, confirmed that the site lies external to any source water protection land use policies. In addition, the GRCAs online GIS tool (https://maps.grandriver.ca/web-gis/public/) was consulted to determine if the Site location has any other interactions with source water protection mapping (GRCA 2021a). The following is noted:

- The Site lies at least 2 km external to any Wellhead Protection Area (WHPA) and is located outside the Wellhead Water Quantity Zone;
- The Site is identified as an area of downward hydraulic gradients, and the Site extraction area is shown to have an average annual recharge rate in the range of 300 to 400 mm/yr (GRCA 2021a).
- The Site extraction area is classed as a Significant Groundwater Recharge Area (SGRA) with a vulnerability score of 4 (GRCA 2021a). The extraction area's classification as an SGRA is related to a) the presence of the relatively high permeability sand and gravel deposit; and b) the Tier Three modelling indicating recharge rates beyond the SGRA threshold of 225 mm/yr (Matrix 2017, and GRCA 2019).
- The bedrock aquifer underlying the Site has a calculated Intrinsic Vulnerability of "Medium" (GRCA 2021a), which is consistent with the ISI (Intrinsic Susceptibility Index) calculated by WSP using site-specific borehole data.

4.10 Hydrocarbon Spill Event Upstream of the Site

On January 13, 2019, a tanker truck accident occurred on Highway 401 that resulted in a quantity of jet fuel directly entering Mill Creek approximately 2.5 km upstream of the site. According to the LRG Environmental (LRG) investigation that took place:

> *"An unknown, but potentially significant, quantity of jet fuel entered Mill Creek directly in the Hanlon reach in the vicinity of Drive Point 17 (DP17). An earthen berm was later installed across the drainage swale that was allowing fuel to enter Mill Creek, but fuel was seen visibly penetrating the berm by members of LRG Environmental several weeks after the berm was constructed. Fuel was trapped under the ice and absorbed onto the stream banks throughout the winter months." (LRG 2019)*

According to eyewitness accounts, and despite initial attempts at containment, fuel continued to enter Mill Creek via a drainage swale several weeks after the initial spill (LRG 2019).

In addition to the potential for surface water contamination to reach the downstream CBM property, CBM was concerned that the spill may have entered the subsurface, travelled downgradient from the spill area, and eventually reached the unconfined sand and gravel aquifer on the CBM property.

In order to assess the potential for this spill to have impacted water quality at the CBM site, WSP included surface water and groundwater sampling for petroleum hydrocarbons (PHC F1 to F4) and benzene, toluene, ethylbenzene, and xylene (BTEX) on the site as part of the baseline water quality assessment in this study. The scope of the sampling program and the water quality results are discussed further in Section 5.

5.0 SITE FIELD PROGRAM

A Site field program was initiated in January 2018 with the objectives of confirming the presence of economic aggregate resource deposits, and characterizing baseline hydrogeologic and hydrologic conditions under the Existing Conditions Scenario at the property. The following sections describe the methodology and results of the field program.

5.1 Borehole Drilling and Monitoring Well Installation

5.1.1 Methodology

An initial borehole drilling program was carried out between January 9 and 17, 2018. During this period a total of 16 boreholes were drilled (BH18-01 to BH18-11 and MW18-01 to MW18-05) at the locations shown on Figure 1. Locations MW18-02 to MW18-05 were completed as monitoring wells in the overburden aquifer. The borehole originally intended to be completed as MW18-01 was drilled, but a monitoring well was not installed. A second borehole was drilled on June 21, 2018 adjacent to the original location planned for MW18-01 and well MW18-01B was installed at that location.

A sixth overburden monitoring well, MW18-06, located in the north-central portion of the property (Figure 1), was installed on November 23, 2018 to complement the existing overburden monitors around the periphery of the proposed extraction area.

The January 2018 drilling and monitoring well installation was carried out by Choice Sonic Drilling Ltd. (CSD) of Mount Albert, Ontario, under WSP supervision. A track-mounted Sonic SDC 550 rotasonic drill rig was employed. Each borehole was continuously cored to a depth of 14.94 m, producing a 114 mm (4 ½”) diameter soil continuous core which was logged and photographed by WSP field personnel. The boreholes were terminated at a depth of 14.94 m (50‘), as this was considered to be sufficiently deep to confirm the presence of aggregates at the property, and sufficiently deep to install monitoring wells within the unconfined sand and gravel aquifer.

The June 2018 drilling and installation of MW18-01B install was carried out by Aardvark Drilling Ltd. (Aardvark) of Guelph, Ontario, under WSP supervision. A track-mounted Yamma A45 hollow stem auger drill rig was employed. The borehole was advanced to a depth of 6.55 m, producing a 203.2 mm (8”) diameter hole. Soil cuttings were logged by WSP during the drilling.

The November 2018 drilling and installation of MW18-06 was carried out by CSD under WSP supervision with the Sonic SDC 550 rig. The borehole was continuously cored to a depth of 9.14 m, producing a 114 mm (4 ½”) diameter soil continuous core which was again logged and photographed by WSP field personnel.

All monitoring wells were installed using 2 m to 3 m long No. 10 slot, 52 mm diameter (2”) Schedule 40 PVC well screens and PVC riser pipes. The screens were positioned within the overburden water table aquifer. In general, 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.

Records of the borehole drilling and monitoring wells installations are provided in Appendix C. The monitoring wells were surveyed by Van Harten Surveying Inc. of Guelph, Ontario on November 30, 2018 using the UTM Zone 17 CSRS 2010 datum, with elevations relative to the CGVD 1928, 1978 Adjustment datum.

A summary of borehole drilling and well completion is provided below in Table 2.

Table 2: Borehole and Monitoring Well Summary

Well / Borehole ID	Easting (m)	Northing (m)	Ground Elevation (masl)	Riser Pipe Stick-Up (m)	Drilled Depth (mbgs)	Screen Top (mbgs)	Screen Bottom (mbgs)
MW18-01A/B	565094	4808766	302.66	0.79	14.94	2.59	6.25
MW18-02	565724	4809059	303.35	1.01	14.94	7.32	10.37
MW18-03	566010	4809432	303.66	0.87	14.94	7.32	10.37
MW18-04	566032	4809696	303.81	0.94	14.94	8.84	11.89
MW18-05	565243	4809513	307.17	0.85	14.94	8.84	11.89
MW18-06	565549	4809337	303.07	0.78	9.14	6.09	9.14
TW11-16	565090	4808761	302.39	0.58	41.46	22.26	41.46
BH18-01	565981	4809639	303	-	14.94	-	-
BH18-02	565764	4809428	303	-	14.94	-	-
BH18-03	565417	4809208	304	-	14.94	-	-
BH18-04	565178	4808939	303	-	14.94	-	-
BH18-05	565081	4809023	307	-	14.94	-	-
BH18-06	565175	4809088	303	-	14.94	-	-
BH18-07	565568	4809076	304	-	14.94	-	-
BH18-08	565608	4809212	305	-	14.94	-	-
BH18-09	565698	4809315	302	-	14.94	-	-
BH18-10	565598	4809499	305	-	14.94	-	-
BH18-11	565915	4809532	303	-	14.94	-	-

5.1.2 Results

With reference to the borehole logs provided in Appendix C, a southwest to northeast geological cross-section is presented on Figure 4. A generalized description of subsurface conditions encountered during drilling is as follows, from ground surface downwards:

- **Surficial Soils -** A brown silty to sandy layer was encountered in some locations up to 3 m in thickness, which was typically overlain by a thin veneer of topsoil. This layer may correspond to Unit 5b in the OGS mapping, but may simply be fine grained layers within the sand and gravel of Unit 7b.

- **Sand and Gravel** - A brown to grey sand and gravel layer was encountered beneath the surficial soils which varied in thickness from 6 to >15 m, with an average observed thickness of approximately 12 m. The relative proportions of sand and gravel vary from borehole to borehole; however, sand is typically the higher proportion material. This is presumed to correspond to Unit 7b in the OGS mapping. Some boreholes encounter the occasional silt lens (<1 m thick) within the sand and gravel strata.

- **Wentworth or Port Stanley Till** - While five of the boreholes terminated in the sand and gravel, 12 of the boreholes were drilled deep enough to encounter the underlying silt till unit, which was found to vary from 2 to 7 m thick (typically about 5 m thick). The material was described as brown or grey sand and silt, silt, or clayey silt, and is inferred to correspond to the Wentworth or Port Stanley Till.
- **Bedrock -** Well MW18-05 (14.6 m / 292.4 masl), borehole BH18-11 (13.1 m / 289.9 masl) and previously drilled test well TW11-16 (22.0 m / 280.4 masl) all encountered the underlying medium brown dolostone of the Guelph Formation.

With reference to the cross-section A-A' presented on Figure 4, the confirmed base of the aggregate resource varies from a high elevation of 294 masl to a low elevation of ~287 masl. It is noted that BH18-01, BH18-09, BH18-10, MW18-03 and MW18-04 were terminated at elevations ranging from 290.7 to 287.1 masl while still in sand and gravel and before fine grained material or bedrock was encountered, indicating that sand and gravel is present below the confirmed elevation of 287.1 masl at some locations within the property.

Therefore, the maximum lower elevation of aggregate extraction for this ARA licence application is proposed to be 285 masl, where the sand and gravel is present to that depth.

Dragline extraction will "follow" the base of the sand and gravel unit, leaving the underlying silt till in place. As such, the lowest elevation of extraction in licenced area will be higher than 285 masl in places where the sand and gravel is not present to that depth.

5.2 Groundwater Levels

5.2.1 Methodology

The property groundwater monitoring network consists of six overburden monitoring wells (MW18-01B to MW18-06), one previously existing bedrock well (TW11-16), and six standpipe piezometers (SP18-01 to SP18-04, SP22-01, and SP22-02) at the surface water stations (Figure 1), with most locations equipped with pressure transducers ("dataloggers"). Water level monitoring began in April 2018 and has continued to December 2022 with monthly monitoring events for the wells and quarterly events for the standpipes. Groundwater level monitoring is being continued in 2023 with monitoring events at a quarterly frequency.

Monitoring events included manual readings using a water level probe and collecting data from in well dataloggers. The transducers record pressure at 15-minute intervals which is then corrected for barometric pressure changes and converted to water elevations. Groundwater level data presented and analysed in this report comprise the data collected from April 2018 to December 2022.

5.2.2 Results

Manual groundwater levels are presented in Table 3 and groundwater hydrographs are presented on Figure 13. To address more specific aspects of groundwater flow on the site, a plot of groundwater head observed in the overburden and bedrock is presented on Figure 14, an inferred high water table map for the property is presented on Figure 15, and groundwater head under typical conditions are presented on Figure 16. With reference to this table and these figures, the following are noted.

- The groundwater levels in the overburden aquifer vary by +/- 1 m or less annually (Figure 13). The hydrographs indicate that the highest groundwater levels occur during late spring / early summer and the lowest groundwater levels occur during late summer. This pattern is consistent with an unconfined aquifer that receives the bulk of its recharge after the spring freshet. Very short term increases or "spikes" in groundwater levels correlate to major precipitation events and melts (Figure 13), suggesting that the overburden aquifer can respond rapidly to recharge inputs.

- Groundwater levels in the bedrock aquifer observed at TW11-16 parallel nearby groundwater levels in the overburden aquifer (MW18-01B) but are often on the order of 0.1 to 0.2 m lower in elevation (Figure 14). This indicates that in general, there is a downward hydraulic gradient, and the overburden aquifer is providing some recharge to the bedrock aquifer. The downward gradient is greater during seasonal low groundwater levels (i.e., drier conditions) and less during seasonal high groundwater levels (i.e., wet conditions).
- Figure 15 presents “high water table” conditions observed during the monitoring period. These groundwater levels were measured on January 12, 2020, and occurred during a winter freshet event, when warm temperatures caused a snow melt, and a significant rainfall event also took place.
- Figure 16 presents “typical water table” conditions observed during the monitoring period. These groundwater levels were measured on July 1, 2019 when groundwater levels were near their annual mean and precipitation levels immediately preceding the date were not particularly high or low. The interpretation of the water table and groundwater flow patterns are again informed by groundwater heads, surface water conditions, and topography.
- Under typical groundwater conditions (Figure 16), the highest groundwater elevations on the property were observed to be 303.5 masl in the northeast corner of the property near Mill Creek (MW18-04) and 303.8 masl between Tributaries 3 and 5 in the northwest part of the property along Concession 2 (MW18-05). The lowest groundwater elevations on the property were observed on the western side of the property near the confluence of Tributaries 3, 4 and 5 (301.4 masl observed at MP18-04). Shallow horizontal groundwater flow within the proposed extraction area is observed to generally be from the northeast to the southwest, with some flow southwards towards Mill Creek.
- Groundwater level monitoring data was made available to WSP for Puslinch Well 16-79 (MECP # 6707090), located just northeast of the Site along Mill Creek (see inset on Figure 17). This well is approximately 9 m deep and screened in the water table aquifer, so its groundwater levels (Figure 17) are indicative of the water table at that location. The maximum groundwater level at Well 16-79 for the period of record April 2018 to December 2022 was 303.76 masl, and the maximum water level at Well 16-79 since recording began in 1989 was 303.88 masl, which compares conservatively to the maximum groundwater level of 303.95 masl observed by WSP at the nearest on site well (MW18-04), suggesting the maximum predicted water table interpretation for the Aberfoyle South site is reasonable.

Table 3 - Groundwater Level Measurements
Aberfoyle South Pit Expansion

Date	MW18-01B	MW18-02	MW18-03	MW18-04	MW18-05	MW18-06	TW11-16	SP18-01	SP18-02	SP18-03	SP18-04	SP22-01	SP22-02
2018-04-24	-	302.76	303.28	303.66	304.11	-	301.97	-	-	-	-	-	-
2018-06-04	-	302.51	303.12	303.49	303.68	-	301.75	-	-	-	-	-	-
2018-06-21	-	302.37	302.98	303.34	303.41	-	-	-	-	-	-	-	-
2018-07-06	-	302.41	302.99	303.37	303.38	-	-	302.51	302.98	302.03	301.34	-	-
2018-08-03	301.54	302.33	302.93	303.28	303.15	-	301.41	-	-	-	-	-	-
2018-08-31	301.67	302.42	303.00	303.39	303.26	-	301.48	-	-	-	-	-	-
2018-09-17	-	-	-	-	-	-	-	302.49	302.95	302.00	301.33	-	-
2018-10-04	301.80	302.61	303.21	303.43	303.38	-	301.53	-	-	-	-	-	-
2018-10-29	301.75	302.54	303.15	303.48	303.41	-	301.49	-	-	-	-	-	-
2018-11-30	301.88	302.72	303.27	303.61	303.84	303.00	301.69	-	-	-	-	-	-
2019-01-03	301.89	302.71	303.22	303.57	303.91	302.97	301.76	-	-	302.00	-	-	-
2019-02-05	302.05	302.81	303.35	303.72	303.88	303.14	301.79	-	-	-	-	-	-
2019-03-07	301.80	302.57	303.11	-	303.72	302.76	301.66	-	-	-	-	-	-
2019-03-28	-	-	-	-	-	-	-	302.70	303.10	302.03	301.45	-	-
2019-04-09	301.96	302.82	303.33	303.66	303.98	303.12	301.90	-	-	-	-	-	-
2019-05-08	301.96	302.78	303.27	303.63	304.09	303.00	301.99	-	-	-	-	-	-
2019-06-06	301.97	302.73	303.32	303.66	303.99	303.01	301.94	-	-	-	-	-	-
2019-06-28	-	-	-	-	-	-	-	302.66	303.04	302.03	301.45	-	-
2019-07-03	301.85	302.58	303.15	303.53	303.73	302.75	301.79	-	-	-	-	-	-
2019-08-02	301.70	302.40	303.00	303.38	303.46	302.62	301.62	-	-	-	-	-	-
2019-09-02	301.70	302.38	303.02	303.34	303.27	302.55	301.53	-	-	-	-	-	-
2019-10-03	301.87	302.53	303.18	303.56	303.36	302.74	-	302.59	303.25	302.00	301.48	-	-
2019-11-06	301.88	302.72	303.23	303.60	303.68	303.03	301.71	-	-	-	-	-	-
2019-12-03	301.85	302.64	303.21	303.54	303.76	302.89	-	-	-	-	-	-	-
2019-12-19	-	-	-	-	-	-	-	-	-	302.03	-	-	-
2020-01-07	301.89	302.70	303.21	303.57	303.93	302.95	-	-	-	-	-	-	-
2020-02-04	301.93	302.68	303.22	303.62	304.04	302.93	301.94	-	-	-	-	-	-
2020-03-02	301.88	302.62	303.18	303.56	303.90	302.89	301.84	-	-	-	-	-	-
2020-03-06	-	-	-	-	-	-	-	302.86	303.29	302.03	301.61	-	-
2020-03-31	301.97	302.75	303.28	303.65	304.08	303.03	301.98	-	-	-	-	-	-
2020-04-24	301.86	302.59	303.15	303.52	303.84	302.80	301.83	-	-	-	-	-	-
2020-05-19	301.92	302.69	303.25	303.62	303.84	302.96	301.81	-	-	-	-	-	-
2020-06-17	301.75	302.46	303.05	303.42	303.55	302.70	301.62	302.57	302.96	301.94	301.38	-	-
2020-07-27	301.59	302.33	302.93	303.31	303.20	302.49	301.41	-	-	-	-	-	-
2020-09-04	301.50	302.28	302.90	303.25	302.82	302.43	301.20	-	-	-	-	-	-
2020-09-25	-	-	-	-	-	-	-	301.84	302.97	301.99	301.30	-	-
2020-10-06	301.67	302.43	303.05	303.38	303.03	302.63	301.41	-	-	-	-	-	-
2020-11-05	301.68	302.54	303.09	303.41	303.26	302.76	301.46	-	-	-	-	-	-
2020-12-03	301.86	302.73	303.22	303.59	303.47	302.99	301.56	-	-	-	-	-	-
2020-12-18	-	-	-	-	-	-	-	-	-	301.98	-	-	-
2021-01-05	301.89	302.74	303.23	303.60	303.79	303.00	301.66	-	-	-	-	-	-
2021-02-02	301.76	302.48	303.06	303.44	303.66	302.73	301.58	-	-	-	-	-	-
2021-03-03	301.84	302.63	303.18	303.53	303.70	302.92	301.61	-	-	-	-	-	-
2021-03-29	301.92	302.73	303.25	303.61	303.90	303.03	301.73	302.79	303.39	302.03	301.46	-	-
2021-04-23	301.83	302.58	303.13	303.49	303.84	302.82	301.69	-	-	-	-	-	-
2021-06-07	301.62	302.31	302.70	303.24	303.43	302.50	301.14	-	-	-	-	-	-
2021-06-28	301.63	302.31	-	-	303.35	302.50	-	302.52	303.07	-	301.37	-	-
8/12&16/2021	301.60	302.37	302.93	303.26	303.36	302.60	301.49	-	-	-	-	-	-
2021-08-31	301.55	302.32	302.93	303.27	303.21	302.55	301.34	-	-	-	-	-	-
2021-09-23	302.05	302.89	303.34	303.70	303.71	303.24	301.69	302.80	303.26	302.03	301.77	-	-
2021-10-27	301.94	302.74	303.28	-	303.94	303.03	301.74	-	-	-	-	-	-
2021-12-16	301.91	302.71	303.22	303.56	304.00	302.98	301.80	302.75	303.16	302.03	301.48	-	-
2022-03-14	301.88	-	303.22	303.61	303.95	303.01	301.85	-	-	301.98	-	-	-
2022-06-03	301.70	302.42	303.01	303.41	303.59	302.65	301.64	302.56	303.05	302.03	301.37	302.65	302.02
2022-10-12	301.47	302.27	302.90	303.25	302.91	302.48	301.23	302.01	302.98	302.01	301.29	-	-
2022-12-06	301.70	302.52	303.09	303.44	303.25	302.78	301.42	302.63	303.04	302.03	301.41	302.50	303.15

Notes:

Groundwater levels are in units of metres above sea level (masl)

5.3 Groundwater Temperature

5.3.1 Methodology

Baseline groundwater temperature conditions within the unconfined overburden aquifer were established by taking temperature measurements in the water column at the mid-point of the well screen within each overburden monitoring well during each monthly monitoring event. The temperature was measured using a water level meter with a built-in temperature probe. The field work was carried out by WSP personnel.

5.3.2 Results

The groundwater temperature data from April 2018 to December 2022 for the six overburden monitoring wells is tabulated in Table 4 and presented as temperature versus time graphs on Figure 18. With reference to Table 4 and Figure 18, the following are noted:

- The shallowest wells exhibit the greatest seasonal fluctuation in temperature, with MW18-01B (well screen mid-point at 4.7 mbgs) exhibiting a seasonal fluctuation of approximately +/- 3.5°C from a mean temperature of about 8.5°C.
- The deepest wells exhibit the least seasonal fluctuation, with MW18-04 and MW18-05 (well screen mid-point at 10.4 mbgs) exhibiting season fluctuations of approximately +/- 1°C from a mean temperature of about 9°C.
- The peak high and low groundwater temperatures in the shallow wells occurred in October and April, respectively, whereas the peak high and low temperature in the deeper wells occurred in December and July, respectively. These shifts in peak times versus depth are simply a result of the time it takes for temperature fluctuations in the air to propagate into the ground from the surface.

Table 4 - Groundwater Temperature Monitoring Results
Aberfoyle South Pit Expansion

Well ID	MW18-01B Southwest (4.7m bgs)	MW18-02 South Central (8.9 m bgs)	MW18-03 East (8.9 m bgs)	MW18-04 Northeast (10.4 m bgs)	MW18-05 Northwest (10.4 m bgs)	MW18-06 Central (7.6 m bgs)
Date	Temp ^{o}C	Temp ^{o}C	Temp ^{o}C	Temp ^{o}C	Temp ^{o}C	Temp ^{o}C
2018-04-24		8.3	7.1	9.3	9.2	
2018-06-04		8.0	6.9	9.0	8.9	
2018-07-06	7.5	7.9	7.3	8.8	8.7	
2018-08-02	8.5	8.0	7.7	8.7	8.7	
2018-08-31	9.8	8.1	8.4	8.6	8.8	
2018-10-04	12.0	8.5	9.3	8.7	9.2	
2018-10-29	11.4	8.9	10.0	8.9	9.6	
2018-11-30	9.1	9.3	10.3	9.3	10.2	10.4
2019-01-03	7.2	9.3	9.6	9.5	10.3	10.3
2019-02-05	6.4	8.6	8.7	9.5	10.1	9.6
2019-03-07	5.5	8.3	8.0		9.6	8.5
2019-04-09	5.1	7.8	7.2	9.2	9.0	7.8
2019-05-08	6.0	7.6	6.8	9.0	8.7	7.6
2019-06-06	6.5	7.6	6.8	8.5	8.4	7.5
2019-07-03	8.3	7.6	7.2	8.7	8.3	7.5
2019-08-02	10.1	7.7	7.7	8.5	8.4	7.7
2019-09-02	11.0	8.0	8.1	8.5	8.6	8.3
2019-10-03	11.5	8.6	9.2	8.9	9.4	9.2
2019-11-06	10.7	9.2	10.2	9.3	10.0	10.2
2019-12-03	9.1	9.5	10.4	9.7	10.4	10.5
2020-01-07	7.0	9.5	9.6	9.8	10.5	9.9
2020-02-04	6.1	9.0	9.0	9.9	10.2	9.5
2020-03-02	5.7	8.7	8.7	9.8	9.9	8.9
2020-03-31	5.2	8.1	7.9	9.6	9.5	8.4
2020-04-24	5.4	7.9	7.6	9.3	8.9	7.9
2020-05-19	6.0	7.9	7.4	9.2	8.9	7.9
2020-06-17	7.6	8.0	7.4	8.9	8.5	7.8
2020-07-27	9.0	8.0	7.7	8.7	8.8	8.1
2020-09-04	10.9	8.5	8.7	8.9	9.2	9.1
2020-10-06	11.7	8.4	8.9	8.8	9.3	9.5
2020-11-05	10.4	8.7	9.5	9.1	9.6	10.1
2020-12-03	8.5	8.9	9.5	9.2	9.9	10.1
2021-01-05	6.6	8.9	9.2	9.4	10.1	9.9
2021-02-02	5.6	8.7	8.9	9.4	10.0	9.6
2021-03-03	5.3	8.2	8.1		9.6	8.2
2021-03-29	5.3	8.3	7.9	9.4	9.3	8.1
2021-04-23	5.7	8.3	8.0	9.6	9.3	8.5
2021-06-07	7.1	8.3	8.2	9.3	9.2	8.3
2021-08-14	10.5	8.5	8.4	9.0	9.2	8.8
2021-08-31	11.6	8.5	8.7	9.0	9.4	9.1
2021-09-23	12.7	9.0	9.7	9.1	9.7	10.2
2021-10-27	12.0	9.5	10.7	9.6	10.0	10.0
2021-12-16	8.7	9.8	10.6	9.7	10.7	10.7
2022-03-14	5.6		8.8	9.8	10.0	9.0
2022-06-03	7.5	8.4	8.4	9.4	9.2	8.5
2022-10-12	11.3	9.0	9.3	9.2	9.8	10.1
2022-12-06	9.0	9.4	9.9	9.7	10.6	10.8

1. Groundwater temperature measured at the mid-point of the well screen
2. m bgs = metres below ground surface

5.4 Hydraulic Testing

5.4.1 Methodology

Single well response tests (SWRTs) were conducted in the six overburden monitoring wells installed on property to assess the hydraulic conductivity of the overburden water table aquifer. The field testing was carried out in August 2018 at MW18-01B to MW18-05 and in February 2019 at MW18-06. The field work and analysis was carried out by WSP personnel.

Two test methods were employed in the field to create displacement in the monitoring wells: physical slugs and pneumatic displacement. Where the hydraulic conductivity was high, based on little drawdown during monitoring well development, and the standpipe was airtight, a pneumatic displacement rising head test was employed. Where responses were slower or the standpipe was not airtight, a physical slug was used as the displacement method.

To perform an SWRT using a physical slug, a pressure transducer is first installed below the water level in the riser pipe to record changes in the height of the water column during the test. The displacement is initiated by lowering a slug of a known volume to rapidly raise the water level in the well. The subsequent falling water level is recorded over time with the pressure transducer (i.e., falling head test). Once the water level returned to static, a second slug test is initiated by removing the slug from the well causing a rapid drop in water levels and the subsequent rise in water level was recorded using the pressure transducer (i.e., rising head test).

A pneumatic displacement rising head test is conducted by sealing off the top of the riser pipe with the test apparatus, and then using air pressure to displace groundwater in the riser pipe out through the well screen. The pressure in the system is monitored using pressure transducers at two locations in the riser pipe: in the water column at a known depth, and in the air space above the water column. Air pressure is then suddenly released, and the transient response is observed as a rising head test. This test method provided more instantaneous displacement of water in the wellbore and a better fit with theoretical displacement than traditional tests using a physical slug to displace the water. Implementing a pneumatic method is consistent with Butler’s (1998) recommendation for testing high k aquifers.

5.4.2 Results

The single well response test data was analyzed using the commercial aquifer analysis software AQTESOLV. The Bouwer-Rice (1976) analysis method was used when responses were overdamped (approached static water level), and the Springer-Gelhar (1991) method was when responses were underdamped (oscillating around static water level). Results of the SWRTs are presented in Appendix D and summarized in Table 5.

Table 5: Single Well Hydraulic Test Results for the Overburden Aquifer

Monitoring Well ID	Test Date	Test Method	Test Interval (mbgs)	Aquifer Matrix	Hydraulic Cond. (m/s)
MW18-01B	2018-08-03	Pneumatic displacement, rising head test	2.7 to 5.8	Sand to Sand and Gravel, some silt	4 x 10-6
MW18-02	2018-08-02	Physical slug, rising head test	7.5 to 10.5	Sand and Gravel	1 x 10-3
MW18-03	2018-08-02	Physical slug, rising head test	7.3 to 10.3	Sand and Gravel	8 x 10-4

Monitoring Well ID	Test Date	Test Method	Test Interval (mbgs)	Aquifer Matrix	Hydraulic Cond. (m/s)
MW18-04	2018-08-02	Pneumatic displacement, rising head test	8.8 to 10.8	Sand, some gravel	4 x 10-4
MW18-05	2018-08-02	Physical slug, rising head test	8.9 to 11.9	Silt and Sand	1 x 10-6
MW18-06	2019-02-05	Physical slug, rising head test	6.1 to 9.1	Sand to Sand and Gravel	6 x 10-4

The hydraulic conductivity results for the overburden aquifer ranged from $1x10^{-6}$ m/s to $1x10^{-3}$ m/s. The sand and gravel hydraulic conductivity results ranged from 4×10^{-4} m/s to 1×10^{-3} m/s (MW18-02, 03, 04, and 06). The results in the 10^{-6} m/s range are inferred to be associated with a higher fines content in the sand and gravel (MW18-01B and MW18-05).

5.5 Water Quality

5.5.1 Methodology

Baseline surface water and groundwater quality at the property was assessed by conducting three water sampling events on January 18, 2019, April 9, 2019 and finally on August 12 and 16, 2021. The objective of these sampling events was to assess general surface water and groundwater quality, and in addition, to assess the potential impacts of a PHC spill that occurred approximately 2.5 km upstream along Mill Creek on January 13, 2019 as described in Section 4.10.

On January 18, 2019 water quality samples were collected by WSP personnel from monitoring wells MW18-01B, MW18-02, MW18-03, MW18-04 and at surface water station SW-2 (Figure 1). The groundwater samples were collected using a peristaltic pump and low flow sampling methods once observed groundwater field indicator parameters (pH, electrical conductivity, temperature, and Eh) had stabilized. The water samples were collected in pre-supplied laboratory bottles, placed in ice-packed coolers, and delivered to the Bureau Veritas Laboratories' (BV Labs) sample depot in Waterloo, Ontario following Chain of Custody protocols. The samples were analysed at the laboratory for PHC F1 to F4 and BTEX.

On April 9, 2019 water quality samples were again collected by WSP personnel, this time from all six overburden monitoring wells MW18-01B to MW18-06. The samples were collected using dedicated Waterra Model D-25 inertial pumps and 16-millimetre (5/8 inch) inner diameter polyethylene tubing. Prior to sampling, the wells were purged of a minimum of three well volumes of groundwater. Field parameters (including pH, electrical conductivity, and temperature) were recorded after each purged volume, to ensure water chemistry had stabilized prior to sampling. The water samples were collected in pre-supplied laboratory bottles, placed in ice-packed coolers, and again delivered to the BV Labs following Chain of Custody protocols. The samples were analysed at the laboratory for the RCAP groundwater suite (which includes general chemistry, inorganics and metals), as well as PHC F1 to F4 and BTEX.

Table 6 - Baseline Water Quality Results for Surface Water and Groundwater
Aberfoyle South Pit Expansion

	Unit	ODWS			PWQO	MECP Table 2	SW18-01 (at Stn SW2)	MW18-01B	MW18-02	MW18-03	MW18-04	MW18-01B	MW18-02	MW18-03	MW18-04	MW18-05	MW18-06	MW 18-02	MW 18-03	MW 18-04	MW18-01B	SW18-01 (at Stn SW2)
		MAC	AO	OG			18-Jan-19	18-Jan-19	18-Jan-19	18-Jan-19	18-Jan-19	09-Apr-19	09-Apr-19	09-Apr-19	09-Apr-19	09-Apr-19	09-Apr-19	16-Aug-21	16-Aug-21	16-Aug-21	12-Aug-21	12-Aug-21
Inorganics																						
Anion Sum	me/L											6.45	6.65	7.02	7.54	7.23	6.15					
Bicarb. Alkalinity (calc. as CaCO3)	mg/L											250	180	180	180	320	210					
Calculated TDS	mg/L		500									370	370	390	420	360	350					
Carb. Alkalinity (calc. as CaCO3)	mg/L											2.7	3.1	2.8	2.5	3.9	3					
Cation Sum	me/L											7.85	7.21	7.67	8.13	7.09	7.57					
Hardness (CaCO3)	mg/L			80-100								390	310	310	330	340	350					
Ion Balance (% Difference)	%											9.73	4.03	4.41	3.75	0.92	10.3					
Langelier Index (@ 20C)	N/A											1	0.981	0.925	0.88	1.07	1.03					
Langelier Index (@ 4C)	N/A											0.753	0.732	0.676	0.632	0.818	0.776					
Saturation pH (@ 20C)	N/A											7.07	7.27	7.28	7.29	7.05	7.14					
Saturation pH (@ 4C)	N/A											7.31	7.52	7.53	7.54	7.3	7.39					
Total Ammonia-N	mg/L											<0.050	<0.050	<0.050	0.057	0.064	0.051					
Conductivity	umho/cm											700	700	750	800	630	680					
Dissolved Organic Carbon	mg/L											0.74	0.65	0.51	0.81	0.59	0.72					
Orthophosphate (P)	mg/L											<0.010	<0.010	<0.010	<0.010	<0.010	<0.010					
pH	pH			6.5-8.5								8.07	8.25	8.21	8.17	8.11	8.17					
Dissolved Sulphate (SO4)	mg/L		500									18	55	56	76	32	43					
Alkalinity (Total as CaCO3)	mg/L			30-500								250	180	180	190	320	220					
Dissolved Chloride (Cl-)	mg/L		250			790000						12	64	77	79	3.4	32					
Nitrite (N)	mg/L	1.0										<0.010	<0.010	<0.010	<0.010	<0.010	<0.010					
Nitrate (N)	mg/L	10.0										10.1	<0.10	<0.10	<0.10	<0.10	<0.10					
Nitrate + Nitrite (N)	mg/L											10.1	<0.10	<0.10	<0.10	<0.10	<0.10					
Field Parameters																						
pH	pH			6.5-8.5			8.35	7.66	7.67	7.71	7.7	7.82	7.76	7.74	7.74	7.62	7.69					
Conductivity	uS						843.4	-	723.7	773.3	808.8	716.2	699.1	753.4	799.3	633.9	681.5					
Temperature	°C						0.9	6	5.8	6.6	6.9	5.8	8	7.3	9.1	9.2	8.6					
Metals																						
Dissolved Aluminum (Al)	µg/L			100								<5.0	<5.0	<5.0	<5.0	<5.0	<5.0					
Dissolved Antimony (Sb)	µg/L	6				6						<0.50	<0.50	<0.50	<0.50	<0.50	<0.50					
Dissolved Arsenic (As)	µg/L	10				25						<1.0	<1.0	1.2	2.1	1.1	1.6					
Dissolved Barium (Ba)	µg/L	1000				1000						29	130	120	88	74	130					
Dissolved Beryllium (Be)	µg/L					4						<0.50	<0.50	<0.50	<0.50	<0.50	<0.50					
Dissolved Boron (B)	µg/L	5000				5000						<10	<10	<10	15	11	<10					
Dissolved Cadmium (Cd)	µg/L	5				2.7						<0.10	<0.10	<0.10	<0.10	<0.10	<0.10					
Dissolved Calcium (Ca)	µg/L											94000	79000	78000	78000	75000	90000					
Dissolved Chromium (Cr)	µg/L	50				50						<5.0	<5.0	<5.0	<5.0	<5.0	<5.0					
Dissolved Cobalt (Co)	µg/L					3.8						<0.50	<0.50	<0.50	<0.50	<0.50	<0.50					
Dissolved Copper (Cu)	µg/L		1000			87						<1.0	<1.0	<1.0	<1.0	<1.0	<1.0					
Dissolved Iron (Fe)	µg/L		300									<100	1000	490	380	160	850					
Dissolved Lead (Pb)	µg/L	10				10						<0.50	<0.50	<0.50	<0.50	<0.50	<0.50					
Dissolved Magnesium (Mg)	µg/L											37000	28000	29000	33000	37000	30000					
Dissolved Manganese (Mn)	µg/L		50									<2.0	54	34	92	16	34					
Dissolved Molybdenum (Mo)	µg/L					70						0.81	1.9	0.93	1.1	3.9	2.8					
Dissolved Nickel (Ni)	µg/L					100						<1.0	<1.0	<1.0	<1.0	<1.0	<1.0					
Dissolved Phosphorus (P)	µg/L											<100	<100	<100	<100	<100	<100					
Dissolved Potassium (K)	µg/L											1200	1100	1500	2000	890	1200					
Dissolved Selenium (Se)	µg/L	50				10						<2.0	<2.0	<2.0	<2.0	<2.0	<2.0					
Dissolved Silicon (Si)	µg/L											4500	4400	3800	2900	5700	5900					
Dissolved Silver (Ag)	µg/L					1.5						<0.10	<0.10	<0.10	<0.10	<0.10	<0.10					
Dissolved Sodium (Na)	µg/L		200000			490000						2200	21000	31000	34000	5000	12000					
Dissolved Strontium (Sr)	µg/L											110	290	230	210	90	180					
Dissolved Thallium (Tl)	µg/L					2						<0.050	<0.050	<0.050	<0.050	<0.050	<0.050					
Dissolved Titanium (Ti)	µg/L											<5.0	<5.0	<5.0	<5.0	<5.0	<5.0					
Dissolved Uranium (U)	µg/L	20				20						0.44	0.27	0.78	1.1	2	0.18					
Dissolved Vanadium (V)	µg/L					6.2						<0.50	<0.50	<0.50	<0.50	<0.50	<0.50					
Dissolved Zinc (Zn)	µg/L		5000			1100						13	<5.0	<5.0	<5.0	<5.0	55					
Mercury (Hg)	ug/L	1				0.29						<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					
PHCs F1 - F4 (-BTEX)																						
F1 (C6 to C10)	µg/L				NV		<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
F1 (C6 to C10) minus BTEX	µg/L				NV	750	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
F2 (C10 to C16)	µg/L				NV	150	**190**	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
F3 (C16 to C34)	µg/L				NV	500	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	**270**	<200	<200	<200	<200	<200
F4 (C34 to C50)	µg/L				NV	500	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
BTEX																						
Benzene	µg/L	1			100	5	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Toluene	µg/L	60	24		0.8	24	<0.20	<0.20	<0.20	<0.20	<0.20	**0.38**	**0.27**	<0.20	<0.20	**0.25**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethylbenzene	µg/L	140	1.6		8	2.4	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
o-Xylene	µg/L				2		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
p+m-Xylene	µg/L				70		<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Total Xylenes	µg/L	90	20		NV	300	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40

NOTES

ODWS - Ontario Drinking Water Standards, Objectives and Guidelines
MAC - maximum acceptable concentration
AO - aesthetic objective
OG - operational guideline
PWQO - Provincial Water Quality Objectives

🟦 Exceedance of MECP Table 2 for Potable Groundwater - Coarse Grained Sediments - Residential / Parkland / Institutional Use
▨ Exceedance of ODWS
🟨 Exceedance of PWQO

Prepared by: PGM
Checked By: GWS

On August 12 and 16, 2021 water quality samples were again collected by WSP personnel, this time at monitoring wells MW18-01B, MW18-02, MW18-03 and MW18-04, in addition to surface water at station SW-2. These samples were collected in a manner similar to the January 18, 2019 sampling event and sent to BV Labs following the same transfer protocols, for PHC and BTEX analysis.

5.5.2 Results

Water quality analytical results for the three water sampling events including sample chain of custody and certificates of analyses, are provided in Appendix E.

Baseline water quality results are presented in Table 6. Groundwater analytical results are compared to “Table 2: Full Depth Generic Site Condition Standards [SCS] in a Potable Groundwater Condition - Coarse Grained Sediments - Residential / Parkland / Institutional Use” from the Ministry of Environment, Conservation and Parks (MECP) *Soil, ground water and sediment standards for use under Part XV.1 of the Environmental Protection Act*, dated July 1, 2011, and to “Ontario Drinking Water Quality Standards (ODWS)” from the MECP *Safe Drinking Water Act*, dated January 1, 2020. Surface water analytical results are compared to Provincial Water Quality Objectives (PWQO) dated 1994 and ODWS. Key results are summarized below.

5.5.2.1 Surface Water

With reference to Table 6, ODWS and PWQO, there were no exceedances in surface water at SW-2 in any of the sampling events. It is noted that there was a single detection of PHC F2 in January 2019 at a concentration of 190 ug/L immediately following the fuel spill upstream. While there is no PWQO criterion for this parameter, this detection suggests that traces of fuel were likely carried downstream along Mill Creek and reached the property. There were no further PHC detections at SW-2 when this location was resampled in August 2021.

5.5.2.2 Groundwater

With reference to Table 6 and relative to ODWS, there were several elevated ODWS parameters (i.e., appears to be above background, but not an exceedance) and exceedances for hardness, iron, manganese and nitrate in the baseline samples collected in April 2019, as noted below.

Well	**Hardness**	**Nitrate**	**Iron**	**Manganese**	**Chloride / Sodium**	**Hydrocarbons / BTEX**
MW18-01B	X	X				
MW18-02	X		X	X	EL	Toluene 0.38 ug/L
MW18-03	X		X	EL	EL	Toluene 0.27 ug/L
MW18-04	X		X	X	EL	
MW18-05	X					Toluene 0.25 ug/L
MW18-06	X		X	EL	EL	PHC F3 270 ug/L

X – exceeds ODWS EL – elevated ODWS parameter

Hardness, iron and manganese are often elevated in groundwater in the area relative to ODWS and is considered to be naturally occurring. The elevated nitrate relative to ODWS is likely due to agricultural activities, and the elevated sodium and chloride in some instances relative to the other groundwater samples is likely due to road salting.

The groundwater analytical results for general chemistry, inorganics and metals met all MECP Table 2 criteria, noting that there were trace detections for toluene at three wells and a slight detection of PHC F3 at one well in April 2019 above the method detection limit (MDL). Wells resampled in August 2021 did not show any PHC or BTEX detections above the MDL.

5.5.2.3 Summary

Groundwater quality at all wells met MECP Table 2 Criteria, and there were some minor exceedances of ODWS notably for hardness, iron, manganese and in one location, nitrate. There are also elevated concentrations of sodium and chloride at some wells.

There was one low level detection of PHC F2 in Mill Creek at SW-2 immediately after the spill event in January 2019, and in the spring of 2019, there was one low level PHC F3 detection at MW18-06 located 600 m downgradient of Mill Creek. However, the most recent water quality sampling in August 2021 did not detect PHCs or BTEX, suggesting that the hydrocarbon spill that occurred in 2019 upstream of the site along Mill Creek, near Highway 401, has largely dissipated in proximity to the property.

5.6 Surface Water

5.6.1 Hydrologic Setting

The Site (Figure 1) is located in the Mill Creek subwatershed, which is part of the Middle Grand River watershed. There are several surface water features proximal to the Site, most notably Mill Creek, which is in many places a sensitive cold water stream (LESPRTT 2008), and flows around the east and south sides of the Site from northeast to southwest, through the CBM owned property. While the Site (44 ha) and proposed extraction area (27 ha) within the Site is comprised of agricultural fields and a residential area, the Mill Creek-Puslinch PSW surrounds the Site on all sides, occupying approximately 35 ha of the total CBM owned property (85 ha). The Mill Creek-Puslinch PSW does not extend onto the Site, and there is a 30 m buffer zone between the proposed extraction area and the Mill Creek-Puslinch PSW (Figure 1). Northeast of the property, and upstream and east of Mill Creek, are the rehabilitated aggregate extraction ponds and wetland areas within the Mill Creek Aggregates Pit property (owned by Dufferin Aggregates).

Throughout the summer, Mill Creek reportedly sustains considerable flow from groundwater contributions delivered by the surrounding glaciofluvial outwash deposits, which helps to maintain cool water temperatures (GRCA 1996).

There are five unnamed tributaries to Mill Creek (Tributaries #1-5, Figure 1) situated proximal to the Site. The following four unnamed tributaries (excluding Tributary #3) lie outside of the Site, as seen on Figure 1:

- Tributary #1 originates in the Mill Creek-Puslinch PSW approximately 780 m southeast of the property and flows through the southeast corner of the property and into Mill Creek;
- Tributary #2 originates in the Mill Creek-Puslinch PSW approximately 130 m east of the property and flows into Mill Creek;
- Tributary #4 originates in the Mill Creek-Puslinch PSW approximately 180 m west of the property and flows into Tributary #3 just west of the property; and
- Tributary #5 originates in the Mill Creek-Puslinch PSW just northwest property and flows southwest into Tributary #3.

Tributary #3 originates in the Mill Creek-Puslinch PSW approximately 330 m north of the property, flowing first through the Mill Creek-Puslinch PSW and then through the northwest portion of the Site before re-entering the Mill Creek-Puslinch PSW and joining Mill Creek approximately 530 m west of the property. On-site hydraulic and geomorphic investigations for Tributary #3 concluded that the tributary is a perennial water feature that is characterized by a narrow channel and high riparian cover. The estimated wetted width ranges between 2-5 m with an average wetted depth of approximately 0.3 m. Substrates are composed of cobble, sand and silt. The presence of watercress indicates that the tributary is likely groundwater-fed (O'Neil and Hildebrand 1986). Tributary #3 was considered a water feature of interest for the impact assessment study.

5.6.2 GRCA Regulated Area and Floodplain Mapping

As shown on Figure 6, the property and Site lies within the "Regulation Limit" (GRCA 2021b) and "Regulatory Floodplain" (GRCA 2021c), which is assumes the greater of a "100-year flood" or "Regional Storm" (based on Hurricane Hazel rainfall). Additionally, Mill Creek and its associated tributaries are classed as "Regulated Watercourses".

If, in future, regional flooding were to occur, the flood elevations along Mill Creek in the vicinity of the Site would likely range from 302.5 masl to 303.5 masl, which would flood onto portions of the property and the proposed pit. Impacts of a regional flood event and proposed mitigations are discussed in Section 8.0.

5.6.3 Hydrology

To identify the surface water features on and proximal to the Site (i.e., watercourses, waterbodies, and/or drainage features), MNRF mapping was reviewed, and Site-specific information was collected by WSP during hydrological investigations conducted between June 2018 to December 2022.

5.6.3.1 Monitoring Stations

Surface water (SW-1 to SW-6) and shallow groundwater (SP18-01 to SP22-02) monitoring stations were installed at four locations on Mill Creek and Tributary #3. The monitoring stations, their locations and their installation dates are summarized below in Table 7, and shown on Figure 1.

Table 7: Surface Water Monitoring Locations

Station Name	UTM Zone	Northing	Easting	Installation Date	Measurements
SW-1 & SP18-01 (Tributary #3 of Mill Creek, at Concession Road 2)	17	565414	4809548	June 2018	Shallow Groundwater Level, Shallow Groundwater Temperature, Water Level, Water Temperature and Discharge
SW-2 & SP18-02 (Mill Creek at Sideroad 20 South)	17	566054	4809706	June 2018	Shallow Groundwater Level, Shallow Groundwater Temperature, Water Level, Water Temperature and Discharge
SW-3 & SP18-03 (Mill Creek, at the downstream property line)	17	565832	4808946	June 2018	Shallow Groundwater Level, Shallow Groundwater Temperature, Water Level, Water Temperature and Discharge
SW-4 & SP18-04 (Tributary #3 of Mill Creek, at the	17	564993	4809111	June 2018	Shallow Groundwater Level, Shallow Groundwater Temperature, Water Level,

Station Name	UTM Zone	Northing	Easting	Installation Date	Measurements
downstream property line)					Water Temperature and Discharge
SW-5 & SP22-01 (Mill Creek-Puslinch PSW, directly west of Tributary #3)	17	4809552	565510	March 2022	Shallow Groundwater Level, Shallow Groundwater Temperature and Water Level
SW-6 & SP22-02 (Mill Creek-Puslinch PSW, directly west of Mill Creek)	17	4809407	566046	March 2022	Shallow Groundwater Level, Shallow Groundwater Temperature and Water Level

5.6.3.2 Surface Water and Shallow Groundwater Levels

Water level transducer dataloggers were installed to monitor water levels in the surface water features and shallow (groundwater) standpipes at key locations on and around the Site. Temperature (TIDBIT) loggers were also installed at each surface water station (apart from SW-5 and SW-6), along with a manual staff gauge. Both the dataloggers and TIDBIT loggers were programmed to record water levels and temperature, respectively, at 15-minute intervals. The elevations of the staff gauges were surveyed by Van Harten on November 30, 2018 and referenced to the Canadian Geodetic Vertical Datum of 1928 (1978 adjustment) datum. Water levels were manually recorded at the staff gauge locations concurrently during each quarterly site visit.

The surface water and shallow groundwater stations at Mill Creek (SW-2, SW-3 and SP18-02, SP18-03, respectively), the Tributary #3 of Mill Creek (SW-1, SW-4 and SP18-01, SP18-04, respectively), and the adjacent Mill Creek-Puslinch PSW (SW-5, SW-6 and SP22-01, SP22-02, respectively) were monitored quarterly following their installation in late spring of 2018 and early spring of 2022. Hydrographs of the measured surface water and shallow groundwater levels for the six monitoring stations are provided on Figures 7 to 12.

The ranges in surface water levels for SW-1 through SW-6 are presented in Table 8 for the available period of record based on daily averages. The ranges in groundwater levels for SP18-01 through SP22-02 are presented in Table 8 for the available period of record based on daily averages.

Table 8: Maximum and Minimum Water Levels at SW-1 through SW-6 (2018 – 2022)

Period of Record		Surface Water Station Water Levels					
		Tributary #3		Mill Creek		Mill Creek-Puslinch PSW	
		SW-1(1)	SW-4(1)	SW-2(1)	SW-3(1)	SW-5(1)	SW-6(1)
Catchment Area (ha)		54	72	6,767	7,123	n/a	n/a
2018	min	302.43	301.22	302.93	301.16	-(2)	-(2)
	max	302.93	301.67	303.24	301.57	-(2)	-(2)
	avg	302.56	301.33	302.98	301.26	-(2)	-(2)
2019	min	302.41	301.22	302.92	301.19	-(2)	-(2)
	max	302.99	301.73	303.37	301.73	-(2)	-(2)
	avg	302.63	301.36	303.08	301.36	-(2)	-(2)
2020	min	302.41	301.19	302.89	301.18	-(2)	-(2)

Period of Record		Surface Water Station Water Levels					
		Tributary #3		Mill Creek		Mill Creek-Puslinch PSW	
		SW-1(1)	SW-4(1)	SW-2(1)	SW-3(1)	SW-5(1)	SW-6(1)
Catchment Area (ha)		54	72	6,767	7,123	n/a	n/a
	max	303.03	301.83	303.64	302.17	-(2)	-(2)
	avg	302.57	301.31	303.01	301.34	-(2)	-(2)
2021	min	302.41	301.19	302.81	301.17	-(2)	-(2)
	max	302.92	301.64	303.31	301.75	-(2)	-(2)
	avg	302.58	301.30	302.92	301.31	-(2)	-(2)
2022	min	302.42	301.19	302.84	301.14	302.36	303.48
	max	302.87	301.61	303.30	301.73	302.66	303.78
	avg	302.55	301.31	302.94	301.27	302.42	303.55

Note: (1) Survey datum is based on Realtime Can-Net Network Observations (UTM Zone 17 CSRS 2010, Elevations are CGVD 1928, 1978 Adjustment).

(2) SW-5 and SW-6 were not installed until March 2022.

Table 9: Maximum and Minimum Water Levels at SP18-01 through SP22-02 (2018 – 2022)

Period of Record		Groundwater Station Water Levels					
		Tributary #3		Mill Creek		Mill Creek-Puslinch PSW	
		SP18-01(1)	SP18-04(1)	SP18-02(1)	SP18-03(1)	SP22-01(1)	SP22-02(1)
Catchment Area (ha)		54	72	6,767	7,123	n/a	n/a
2018	min	302.00	301.24	302.89	301.99	-(2)	-(2)
	max	302.79	301.74	303.21	302.05	-(2)	-(2)
	avg	302.52	301.39	302.98	302.01	-(2)	-(2)
2019	min	302.43	301.32	302.91	301.88	-(2)	-(2)
	max	302.90	301.75	303.45	302.18	-(2)	-(2)
	avg	302.66	301.46	303.10	302.03	-(2)	-(2)
2020	min	301.82	301.27	302.95	301.93	-(2)	-(2)
	max	302.91	301.90	303.66	302.21	-(2)	-(2)
	avg	302.56	301.44	303.12	301.98	-(2)	-(2)
2021	min	302.24	301.27	303.00	301.88	-(2)	-(2)
	max	302.84	301.79	303.57	302.28	-(2)	-(2)
	avg	302.65	301.43	303.21	302.01	-(2)	-(2)
2022	min	301.69	301.22	302.95	301.93	301.97	302.88
	max	302.86	301.72	303.35	302.20	302.78	303.34
	avg	302.47	301.38	303.06	302.01	302.31	303.07

Note: (1) Survey datum is based on Realtime Can-Net Network Observations (UTM Zone 17 CSRS 2010, Elevations are CGVD 1928, 1978 Adjustment).

(2) SW-5 and SW-6 were not installed until March 2022.

As detailed in Table 8 above, the difference between water levels at each SW station situated within a watercourse is due to SW-1 and SW-2 being hundreds of metres upstream of their downstream counterpart (i.e., SW-4 and SW-3, respectively). Similarly, as detailed in Table 9 above, the difference between water levels at each SP station is also due to the distance between upstream (i.e., SP18-01 and SP18-02) and downstream counterparts, (i.e., SP18-04 and SP18-03, respectively. Water levels within the Mill Creek-Puslinch PSW demonstrated similar differences in water levels as SW-6 and SP22-02 were situated at a higher elevation than SW-5 and SP22-01.

Figures 7 to 12 display the continuous water level data for each monitoring station. Generally, water level records at the surface water stations are marked by low water levels during the summer and early fall. Winter water levels generally remained low, marked with high water events likely caused by short melt events. Water levels through the spring were moderate to high following the freshet. Water levels in the fall were marked with responses to large precipitation events.

An increase in water level, not in response to a precipitation event recorded at any Environment Canada (EC) or GRCA meteorological stations, was noted in late August to late September in 2020, on Figures 7 to 10. The GRCA has two flow gauges on Mill Creek including the Mill Creek (Side Road 10) flow gauge (8797042), approximately 3 km downstream of the Site and the Aberfoyle flow gauge (9668042), approximately 2.6 km upstream from the Site. Data provided by the GRCA at the Mill Creek (Side Road 10) flow gauge did not record a similar peak level event over this period. The increase in the water level records in both Tributary #3 and Mill Creek are likely reflective of a significant local discharge event upstream of the Site as the sporadic rainfall events over the month-long period do not support the steady increase and sharp decline of the water level seen at each station.

5.6.3.3 Stream Flow

Instantaneous flow measurements were also collected at the surface water monitoring stations SW-1 to SW-4. The measurements were collected from June 2018 to December 2022. Measurements were collected through standard velocity-area methods, using a wading rod and stream velocity meter. Velocity was measured at 60% of water depth, except when water depth exceeded 0.5 m, in which case velocity was measured at both 20% and 80% of water depth. Instantaneous flow measurements for all stations are summarized in Table 10.

Table 10: Instantaneous Flow Measurements

Date	Flow (L/s)			
	Tributary #3		Mill Creek	
	SW-1	SW-4	SW-2	SW-3
June 14, 2018	0.6	1.0	208	- (1)
July 6, 2018	0.8	1.6	290	330
September 17, 2018	0	0.1	242	306
January 3, 2019	22.0	21.5	643	682
March 28, 2019	26.3	38.4	745	794

Date	Flow (L/s)			
	Tributary #3		Mill Creek	
	SW-1	SW-4	SW-2	SW-3
June 28, 2019	11.8	13.1	525	641
October 3, 2019	17.3	25.9	794	801
December 19, 2019	7.4	10.7	504	524
March 6, 2020	49.7	84.7	1050	1190
June 17, 2020	1.1	1.8	324	395
September 25, 2020	0	0	264	259
December 18, 2020	2.3	4.9	351	363
March 29, 2021	36.5	52.1	875	1010
June 28, 2021	0	0.3	235	282
September 23, 2021 (3)	203	288	2720	2890
December 16, 2021	16.8	30.6	630	605
March 14, 2022	12.9	26.64	736	616
June 3, 2022	1.0	2.13	324	333
October 12, 2022	0	0	164	197
December 6, 2022	1.5	3.9	284	287

Note: L/s = Liters per second

(1) Flow not used in rating curve model as there was a suspected equipment error when measuring the velocity. The downstream station showed double the flow rate as the upstream station.

2) Manual stream flow measurements are typically collected with an estimate error between 5-10% and under some conditions, upstream flows may appear to be greater than those downstream, however the difference is within the estimated error of the measurements.

3) A 79.1 mm rainfall event was recorded at Kitchener / Waterloo meteorological station over a two-day period from September 21st to 22nd, 2021.

The instantaneous flow measurements along the main channel of Mill Creek (SW-2 and SW-3) can be seen on Figures 8 and 9, respectively. The instantaneous flow measurements along Tributary #3 (SW-1 and SW-4), downstream of SW-2 and SW-3, can be seen on Figures 7 and 10, respectively.

Stage discharge relationships were used to developed continuous flow records for these monitoring stations. Similar to the continuous water level record, the continuous flow record at all stations is marked by low flows during the summer and early fall. Winter flows generally remained low, marked with high flow events likely caused by short melt events. Flows through the spring were moderate to high following the freshet. Flows in the fall were marked with responses to large precipitation events. As described above and as seen on Figures 7 to 10, an increase in flow was observed in Tributary #3 and Mill Creek in early to late September 2020, which was apparently not in response to a recorded local precipitation event, but consistent with increased flows observed at the Mill Creek (Side Road 10) flow gauge.

The baseflow at each station was estimated using BFLOW (Jung et al. 2016) and the results are plotted on Figures 7 to 10. It is important to note that the BFLOW results are not physically based and are computed by applying a series of low pass filters to the flow data as a function of time. For the purpose of this assessment, the proportion of runoff to interflow and baseflow as a percentage of the total flow was assumed to be based on the number of low pass filter steps completed. Noting that interflow and baseflow (i.e., the movement of water above and below the groundwater table, respectively), in the context of these calculations, represent the second and third passes of the BFLOW analysis, respectively. The number of filter steps completed are represented by the suffix number displayed at the end of BFLOW (i.e., BFLOW1 represents a total of one filter step completed for the BFLOW process which will be used as a basis to represent runoff). The proportion of runoff / interflow / baseflow as a percentage of the total flow at each station is summarized in Table 11.

Table 11: Assumed Proportions of Runoff / Interflow / Baseflow at the Surface Water Monitoring Stations

BFLOW Low Pass Filter Steps		Runoff / Interflow / Baseflow Proportions & Average Yearly Flow			
		Tributary #3		Mill Creek	
		SW-1	SW-4	SW-2	SW-3
BFLOW1 (Runoff)	Avg. Flow (L/s)	9	9	180	182
	Proportion (%)	47	44	32	28
BFLOW2 (Interflow)	Avg. Flow (L/s)	4	5	114	118
	Proportion (%)	23	24	20	18
BFLOW3 (Baseflow)	Avg. Flow (L/s)	5	7	271	359
	Proportion (%)	30	33	48	54

The results of the BFLOW analysis indicate that this reach of Mill Creek is supported by approximately 50% baseflow through most of the year, with runoff (~30%) and interflow (~20%) playing a smaller role in seasonal fluctuations, while Tributary #3 has a slightly higher portion of seasonal runoff. Surface runoff was responsible for the short-lived precipitation responses in Mill Creek and Tributary #3 through the years, as seen on Figures 7 to 10. As a note, the period of the BFLOW analysis was relatively short (2018 to 2022), therefore, there is some uncertainty in the proportion of runoff, interflow and baseflow predicted by the analysis.

5.6.4 Water Temperature

Water temperature TIDBIT loggers were installed at each of the surface water and shallow groundwater monitoring stations (with the exception of SW-5 and SW-6) along this reach of Mill Creek and Tributary #3. The continuous water temperature data is displayed on Figure 19 for each surface water and associated shallow groundwater monitoring station. Water temperatures at SW-1 to SW-4 and SP18-01 to SP22-02 followed a typical seasonal trend, where temperatures warm through the spring as air temperatures consistently remain above 0 °C. This warming continues until mid-summer when daily air temperatures begin to drop. The temperatures drop rapidly through the fall and remain around 0 °C through the winter until the spring freshet.

The instantaneous maximum and daily average maximum recorded at each surface water and shallow groundwater monitoring station and are summarized in Table 12.

Table 12: Instantaneous and Daily Average Maximum Water Temperature Measurements

Surface Water & Shallow Groundwater Stations		Instantaneous Max. (C)	Daily Avg. Max. (C)
Tributary #3	SW-1	29.15	22.61
	SP18-01	15.81	15.79
	SW-4	23.00	24.91
	SP18-04	14.68	14.64
Mill Creek	SW-2	23.81	21.26
	SP18-02	12.44	12.42
	SW-3	23.00	20.94
	SP18-03	11.45	11.42
Mill Creek-Puslinch PSW	SP22-01	13.27	13.27
	SP22-02	10.92	10.92

These instantaneous maximum water temperature measurements within Tributary #3 and this reach of Mill Creek occurred during early July of 2018 (SW-4) and 2020 (SW-1, SW-2, and SW-3). As seen on Figure 19, at Tributary #3 (SW-1 and SW-4), the upstream section (SW-1) displays the greatest fluctuation in temperature throughout the year, particularly from 2020 – 2021, while the downstream end (SW-4) displays the narrowest range of temperatures. Given that SW-4 has a greater baseflow component than SW-1, it's expected that SW-4's baseflow component would lead to less temperature fluctuations given groundwater's moderating effects on stream water temperature during summer and winter. At Mill Creek (SW-2 and SW-3), both SW stations maintain similar fluctuations in temperature throughout the year.

Similarly, the instantaneous maximum shallow groundwater temperature measurements were observed during the summer months and remained significantly lower than their surface water counterparts. As seen on Figures F7–F12 in Appendix F, at Tributary #3 (SP-18-01 and SP18-04), both the upstream and downstream sections (SP-18-01 and SP18-04, respectively) display the greatest fluctuations in temperature throughout the year, particularly from 2018 – 2019. Similarly, at Mill Creek (SP18-02 and SP18-03), both shallow groundwater monitoring standpipes maintained similar fluctuations in temperature throughout the year. The range of water temperatures exhibited at the SW-2 and SW-3 along Mill Creek showed average water temperatures below the stream thermal capacity nomogram detailed in a study by Stoneman and Jones (1996) for coolwater streams (i.e., below 20 ^{o}C). Within the Mill Creek-Puslinch PSW (SP22-01 and SP22-02), the PSW directly west of Tributary #3 showed greater fluctuations in temperature through the year compared to the PSW directly west of Mill Creek.

5.7 Groundwater - Surface Water Interaction

The data collected during the field investigations at the Aberfoyle South Pit Expansion property provide insights into the nature of groundwater - surface water (GW-SW) interaction at Mill Creek, Tributary #3, and in the Provincially Significant Wetlands on the property. The GW-SW interaction data for the surface water stations (SW-1 to SW-6) and their associated shallow groundwater monitoring standpipe (SP18-01 to SP22-02) are presented in Appendix F, along with deeper overburden wells, where they are proximal to the particular station.

Figures F1 to F6 present the groundwater head and surface water elevation data for each location, and Figures F7 to F12 present the groundwater and surface water temperature data for each location, as collected during the monitoring program for the July 2018 to December 2022 period.

5.7.1 GW-SW Heads

With reference to the surface water and shallow groundwater head data at SW-1 to SW-6 presented on Figures F1 to F6 (Appendix F), the following observations are made:

- SW-1 (upstream on Tributary #3) –Surface water levels (SW-1) and shallow groundwater levels (SP18-01) parallel one another very closely and a slight upward hydraulic gradient (~0 to 0.1 m/m) is observed most times of the year (Appendix Figure F1). Water levels at SW-1 are observed to decline and often dry up in the mid-summer period (July-August) each season, during which time shallow groundwater heads at SP18-01 are 0.3 to 0.5 m below the streambed.
- SW-4 (downstream on Tributary #3) –Surface water levels (SW-4) and shallow groundwater levels (SP18-04) again parallel one another very closely and a slight upward hydraulic gradient (~0 to 0.2 m/m) is observed most times of the year (Appendix Figure F4). Water levels at SW-4 are observed to decline and occasionally dry up in the mid-summer period (July-August) each season, during which time shallow groundwater heads at SP18-04 remained at or higher than the level of the streambed.
- SW-2 (upstream on Mill Creek) –Surface water levels (SW-2) and shallow groundwater levels (SP18-02) again generally parallel one another very closely until late July 2020 (Appendix Figure F2). Mill Creek flows throughout the year and the water level in the creek fluctuates by about 0.5 m in response to precipitation and snow melt. There is generally a slight upward gradient between shallow groundwater (SP18-02) and SW-2 (~0 to 0.15 m/m) throughout the year. Deeper overburden groundwater levels at MW18-04 (screened ~12 mbgs) show an upward vertical gradient of ~0.05 m/m relative to SW-2.
- SW-3 (downstream on Mill Creek) –The head in SP18-03 was above the top of the standpipe (at ~302 masl) causing the standpipe to flow continuously (Appendix Figure F3). Although no water level data was obtained for SP18-03, the continuous flow at the standpipe indicates there is a consistent upward vertical gradient at this location of ~0.5 to 0.7 m/m. Mill Creek flows throughout the year and the water level in the creek fluctuates by about 0.5 m in response to precipitation and snow melt.
- SW-5 (in a Provincially Significant Wetland east of Tributary 3) – Surface water levels (SW-5) and shallow groundwater levels (SP22-01) parallel one another closely (Appendix Figure F5). An upward hydraulic gradient (~0 to 0.2 m/m) is noted when surface water is present in the spring and late fall. During the summer and early fall surface water was not present, except in response to major precipitation events, and groundwater levels dropped below the ground surface.

- SW-6 (in a Provincially Significant Wetland on the east side of the property) – The head observed at SP22-02 remained 0.1 to 0.7 m below ground surface during the monitoring period (March to December 2022), including when surface water was present (March to May) (Appendix Figure F6). Shallow groundwater at this location followed groundwater levels in the nearby piezometer closely (MW18-03) (screened ~10 mbgs).
- SW-1, SW-2, SW-3 and SW-4 –As previously noted in Sections 5.6.3.2 and 5.6.3.3, there appears to have been a significant local surface water discharge event just upstream of the Site in September 2020 that lasted for a period of several weeks and then abruptly ended. This unexplained local discharge event affected water levels in both Mill Creek and Tributary #3 at all 4 stations. The source of this discharge is not known, but it could have been caused for example, by the breach of a beaver pond resulting in the discharge of water to the ditch along Concession Road #2, leading to water discharging both to Tributary #3 and Mill Creek. This surface water discharge event seems to have had a lingering effect on the shallow groundwater head at SP18-02, which diverged upward from the trends at SW-2 and MW18-04 for a period of about a year, until ~October 2021, after which its water level gradually dropped and its trend appears to again converge with that of SW-2 and MW18-04. No lingering effects to shallow groundwater were observed at SW-1, SW-3 or SW-4.

5.7.2 GW-SW Temperatures

Groundwater and surface water interactions include thermal interactions in addition to hydraulic interactions. With reference to the surface water and shallow groundwater temperature data at SW-1 to SW-6 presented on Figures F7 to F12 (Appendix F), the following observations are made:

- SW-1 (upstream on Tributary #3) – Surface water temperature fluctuates from ~0 to 22°C while shallow groundwater temperatures fluctuate from ~3 to 15°C (Appendix F, Figure F7). The peak shallow groundwater temperature lags the peak surface water temperature consistently by about 1 to 1.5 months. The shallow groundwater temperature peak is ~5°C cooler in the summer and ~ 3°C warmer in the winter.
- SW-4 (downstream on Tributary #3) – Very similar temperature trend to SW-1 (Appendix F, Figure F10). Surface water temperature fluctuates from ~0 to 18°C while shallow groundwater temperatures fluctuate from ~3 to 14°C. The peak shallow groundwater temperature lags the peak surface water temperature consistently by about 1 to 1.5 months. The shallow groundwater temperature peak is ~4°C cooler in the summer and ~ 2°C warmer in the winter.
- SW-2 (upstream on Mill Creek) – Mill Creek has a similar surface water temperature trend to Tributary #3, but a different shallow groundwater temperature trend (Appendix F, Figure F8). Surface water temperature fluctuates from ~0 to 20°C while shallow groundwater temperatures only fluctuate from ~7 to 11°C. The peak shallow groundwater temperature lags the peak surface water temperature consistently by about 1 to 1.5 months. The shallow groundwater temperature peak is ~8°C cooler in the summer and ~ 6°C warmer in the winter. Deep overburden groundwater at MW18-04 (screened ~10 mbgs) shows even less seasonal temperature fluctuation (about +/- 1°C) and the temperature peaks at depth lag the surface water peaks by about 6 months.
- SW-3 (downstream on Mill Creek) – SW-3 has a very similar trend to SW-2 on Mill Creek (Appendix F, Figure F9). Surface water temperature fluctuates from ~0 to 19°C while shallow groundwater temperatures only fluctuate from ~7 to 11°C. The peak shallow groundwater temperature lags the peak surface water temperature consistently by about 1 to 1.5 months. The shallow groundwater temperature peak is ~8°C cooler in the summer and ~ 6°C warmer in the winter.

5.7.3 Summary

Mill Creek

The data collected for surface water and shallow groundwater at monitoring stations SW-2 and SW-3 indicate that there are relatively continuous upward hydraulic gradients along this reach of Mill Creek. The temperature of the shallow groundwater discharging to Mill Creek provides a cooling effect in the peak summer months, and a warming effect in the peak winter months.

Tributary #3

The data collected for surface water and shallow groundwater at monitoring stations SW-1 and SW-4 indicate that there are relatively continuous upward hydraulic gradients along this reach of Tributary #3, but there is insufficient baseflow to consistently sustain water in Tributary #3 through the entire summer period. When there is baseflow and water in the tributary, the shallow groundwater discharging to Tributary #3 does provide a cooling effect in the peak summer months, and a warming effect in the peak winter months, but the magnitude of the temperature difference is less than that observed at the Mill Creek monitoring stations SW-2 and SW-3.

Provincially Significant Wetlands

The data collected for surface water and shallow groundwater at monitoring stations SW-5 and SW-6, in the initial 10 months of months of monitoring show variable conditions in the Provincially Significant Wetlands. At SW-5, when surface water is present, there is an upward gradient providing a cooling effect in the peak summer months, and a warming effect in the peak winter months, until surface water dries out in the summer months. At SW-6, groundwater levels were consistently below ground surface and when surface water was present it was not closely connected to groundwater levels.

6.0 WATER BALANCE

This section presents the water balance assessment for the proposed pit operation under existing conditions, operational conditions and final rehabilitation conditions.

6.1 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 presented herein is based on composite meteorological data from the EC Thornthwaite water budgets (Environment Canada Kitchener/Waterloo station [ID 6144239] between 1971 and 2020), watershed boundaries, land use data, and the existing soil types. The meteorological data set used in this assessment was derived by combining daily observations of Waterloo Wellington A (6149387, 1971-2002), Region of Waterloo Int'l A (6149388, 2002-2010) and Kitchener/Waterloo (6144239, 2010-2020). Any remaining data gaps were filled by using meteorological observations at nearby surface weather stations (Roseville and Guelph Turfgrass).

The Thornthwaite 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 (infiltration below the root zone and available for groundwater recharge).

The various water budget components associated with catchment areas are typically presented in millimetres (mm) per time step 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 °C. Snowmelt is initiated when snow is on the ground and monthly mean temperatures are greater than 0 °C. Hence, snowmelt is based on the depletion of snow storage (accumulated precipitation during periods of sub-zero temperatures). Composite precipitation data collected at the Kitchener/Waterloo monitoring station (1971 to 2020) indicated a mean annual precipitation (P) of 871 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 saturated 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 Site is approximately 602 mm/year based on data provided by EC.

Annual water surplus is the difference between P and the actual ET assuming year to year changes in soil moisture storage are negligible. The water surplus represents the total amount of water available for either surface runoff I 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 snowmelt, and maximum soil or snowpack storage is exceeded. Maximum soil storage is quantified using a Water Holding Capacity (WHC) specific to the soil type and land use. WHC is defined as the difference is soil moisture content between the field capacity and wilting point and is assigned across the site based on soil type and vegetation cover.

6.2 Catchment Delineation

The water balance evaluation was performed for the CBM owned property as a whole, including the area of proposed extraction, the proposed licensed area, and the surrounding lands. Land uses under existing and operational conditions were taken from desktop delineations using SOLRIS V3 and are summarized in Table 13. External surface water flowing onto the property (and Site) was assumed to pass through via Mill Creek and its tributaries and was not included for the purposes of this water balance.

6.3 Water Balance Scenarios

Under existing conditions, the property is primarily composed of agricultural and rural residential land surrounded by forested wetland areas (Figure 1).

Under operational conditions, the proposed extraction area will be excavated to form the proposed pit leaving a narrow border of open pasture defined by the setback boundary (Figure 1). The proposed extraction area was separated into the above and below water extraction area based on an assumed permanent pond water elevation of 302.0 masl and a 2:1 side slope to the crest of the pit (303.5 masl).

Aggregate extraction will initially begin above the water table in the west-central portion of the extraction area and proceed westward towards the western edge. Aggregate extraction by dragline will then begin below the water table in the westernmost part of the extraction area and proceed in an easterly direction. Above water table and below water table extraction will then proceed generally concurrently in an eastward direction until aggregate extraction has been completed, creating ponding conditions effectively throughout the operational period.

Rehabilitated conditions were also considered in this study to assess residual changes in water surplus after aggregate extraction operations have ceased and the Site is rehabilitated. Under rehabilitated conditions, the entire proposed extraction area will form a permanent pond without surface water outflow. Runoff that flows into the pond is assumed to exit the pond as either infiltration / shallow groundwater flow or as evaporation.

6.4 Water Balance Parameters

Soil information was taken from the Ontario Quaternary Soils Mapping (Ontario Geological Survey 1997) and Ontario Soil Survey Complex (OMAFRA 2009). Soils at the property are primarily composed of gravelly loam for agricultural areas and gravelly loam / organics for the wetland / forested areas. Gravelly sand was assumed to be the dominant soil type for the proposed pit area under operational conditions based on borehole results presented in Section 5.1.

The maximum soil storage is quantified using a 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 practical 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 exposed bedrock (representing shallow storage in surface depressions and cracks) 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 determine 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 13.

Table 13: Summary of Catchment Areas, WHCs, Soil Types, and Infiltration Factors

Existing Conditions					
Soil Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m^2)**
Forested Swamp	300 mm	Mature Forest	Gravelly Loam / Organics	0.7	368,991
Marsh	150 mm	Wetland	Gravelly Loam	0	14,948
Impervious Built-up Areas	90% Precip.[1]	Roadway	Paved	0	5,302
Moderately Rooted Agricultural / Pasture	150 mm	Tilled / Pastures & Shrubs	Gravelly Loam	0.75	463,269
Total					**852,509**

Operational Conditions (Proposed Excavation Pit)					
Soil Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m^2)**
Forested Swamp	300 mm	Mature Forest	Gravelly Loam / Organics	0.7	368,991
Marsh	150 mm	Wetland	Gravelly Loam	0	14,948
Impervious Built-up Areas	90% Precip.[1]	Roadway	Paved	0	5,302
Moderately Rooted Agricultural / Pasture	150 mm	Tilled / Pastures & Shrubs	Gravelly Loam	0.75	188,497
Above Water Extraction Area (Bare)	75 mm	Sand (unsaturated)	Gravelly Sand	1	8,427
Below Water Extraction Area	Precip. – Lake Evap.	Flooded Pit	n/a	1	266,345
Total					**852,509**

Rehabilitated Conditions					
Soil Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m^2)**
Forested Swamp	300 mm	Mature Forest	Gravelly Loam / Organics	0.7	368,991

Marsh	150 mm	Wetland	Gravelly Loam	0	14,948
Impervious Built-up Areas	90% Precip.[1]	Roadway	Paved	0	5,302
Pasture	150 mm	Pastures & Shrubs	Gravelly Loam	0.75	188,497
Above Water Extraction Area	150 mm	Pastures & Shrubs	Gravelly Sand	1	8,427
Below Water Extraction Area	Precip. – Lake Evap.	Pond	n/a	1	266,345
Total					**852,509**

Notes:

[1] Surplus assumed as 90% of precipitation and null (i.e., 0%) infiltration factor (Conservation Authorities Geoscience Group 2013).

[2] Marsh – A type of wetland ecosystem in which water can cover the ground for long periods of time.

For marsh areas, a WHC of 150 mm with a null (i.e., 0%) infiltration factor was applied to reflect the predominantly upward hydraulic gradients expected in the marsh areas.

For forested swamp areas, a WHC of 300 mm and an infiltration factor of 0.7 were used, representing rolling land with an average slope 2.8 m/km to 3.8 m/km, a soil type in between combinations of clay and loam and open sandy loam soil, and wooded land use. The forested swamp areas were observed to be dry for large parts of the year during quarterly field visits and from available water level data.

For moderately rooted agricultural / pasture areas under existing, operational conditions, and rehabilitated conditions, a WHC of 150 mm and an infiltration factor of 0.75 were used, representing land between rolling land (with an average slope 2.8 m/km to 3.8 m/km) and flat land (with an average slope < 0.6 m/km), open sandy loam soil, and cultivated land use (tilled / pasture and shrubs).

For the above water extraction area under operational conditions, a WHC of 75 mm and an infiltration factor of 1.0 were used as the excavation of the pit will result in a closed depression without a surface water overflow under normal conditions. As such, any runoff that flows into the pit will contribute to the pit pond and eventually exit the pit as either infiltration / shallow groundwater flow or as evaporation. Under rehabilitation conditions, a WHC of 150 mm as assigned to the setback area to reflect the pasture and shrubs that will revegetate this area, with the assumption that it will be rehabilitated with 100% of the net precipitation infiltrating within the Site.

For the impervious built-up areas, only 10% of the precipitation will infiltrate the pervious surfaces (i.e., gravel roadways) and the remaining 90% of surplus will contribute to runoff.

For the open water areas (flooded pit), it was assumed surplus equals the difference of the precipitation and lake evaporation, which was estimated using the NOAA-GLERL Great Lakes Evaporation Model by the National Oceanic and Atmospheric Administration (NOAA) for Lake Ontario (663 mm) over the same period as the water budget (1971 – 2020) (NOAA 2021). With the unavailability of recent pan evaporation data from local meteorological stations, lake evaporation estimates from Lake Ontario were deemed to be representative of evaporation conditions within the region.

6.5 Water Balance Results

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

6.5.1 Existing Conditions

The water balance results for existing conditions on the property are provided in Table 14.

Table 14: 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)
Forested Swamp	368,991	276	101,840	193.2	71,290	82.8	30,550
Marsh	14,948	303	4,530	0	0	303	4,530
Impervious Built-up Areas	5,302	784	4,160	0	0	784	4,160
Moderately Rooted Agricultural / Pasture	463,269	303	140,370	227	105,280	76	35,090
TOTAL	**852,509**	**294**	**250,900**	**207**	**176,570**	**87**	**74,330**

The total average annual surplus for property under existing conditions was estimated to be 294 mm or 250,900 m^3 per year and the estimated infiltration is approximately 207 mm or 176,570 m^3 per year. Runoff was calculated as the difference between surplus and infiltration and was estimated to be 87 mm or 74,330 m^3 per year. Based on the assessment, approximately 70% of the annual surplus infiltrates while the remaining 30% is surface runoff under existing conditions. Surface runoff primarily drains into both Mill Creek, which runs along the east and south sections of the property, adjacent to the Site, and Tributary #3 to Mill Creek that transects the northwest section of the property and crosses through the Site.

6.5.2 Operational Conditions (Full Extraction)

The water balance results for operational conditions are provided in Table 15.

Table 15: 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)
Forested Swamp	368,991	276	101,840	193	71,290	83	30,550
Marsh	14,948	303	4,530	0	0	303	4,530
Impervious Built-up Areas	5,302	784	4,155	0	0	784	4,155
Moderately Rooted Agricultural / Pasture	188,497	303	57,115	227	42,835	76	14,280

Land use	Area	Surplus		Infiltration		Runoff	
	(m^2)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Above Water Extraction Area (Bare)	8,427	346	3,315	346	3,315	0	0
Below Water Extraction Area	266,345	208	55,160	208	55,160	0	0
TOTAL	**852,509**	**265**	**226,115**	**202**	**172,600**	**63**	**53,515**

The total average annual surplus for the property was estimated to be 265 mm or 226,115 m^3 per year and the estimated infiltration is approximately 202 mm or 172,600 m^3 per year. Runoff was estimated to be 63 mm or 53,515 m^3 per year. Based on the assessment, 76% of the annual surplus infiltrates while the remaining 24% is surface runoff under operational conditions.

6.5.3 Rehabilitated Conditions

The water balance results for the rehabilitated conditions are provided in Table 16.

Table 16: 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)
Forested Swamp	368,991	276	101,840	193	71,290	83	30,550
Marsh	14,948	303	4,530	0	0	303	4,530
Impervious Built-up Areas	5,302	784	4,155	0	0	784	4,155
Pasture	188,497	303	57,115	227	42,835	76	14,280
Above Water Extraction Area	9,588	303	2,905	303	2,905	0	0
Below Water Extraction Area	265,184	208	55,160	208	55,160	0	0
TOTAL	**852,509**	**265**	**225,705**	**202**	**172,190**	**63**	**53,515**

The total average annual surplus for the property was estimated to be 265 mm or 225,705 m^3 per year and the estimated infiltration is approximately 202 mm or 172,190 m^3 per year. Runoff was estimated to be 63 mm or 53,515 m^3 per year. Based on the assessment, 76% of the annual surplus infiltrates while the remaining 24% is surface runoff under rehabilitated conditions.

6.6 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 17.

Table 17: Water Balance Summary

Scenario Considered	Surplus (m^3/yr)	Infiltration (m^3/yr)	Runoff (m^3/yr)
Existing Conditions	250,900	176,570	74,330
Operational Conditions	226,115	172,600	53,515
Rehabilitated Conditions	225,705	172,190	53,515

Under operational conditions, the water surplus on the property is anticipated to decrease by 9.9% or 24,785 m^3/yr – representing a minor decrease in evapotranspiration associated with the removal of moderately rooted agricultural / pasture area to a flooded pit. Infiltration is expected to remain similar to existing conditions, with a slight decrease of 3,970 m^3/yr as available surplus within the extraction area will infiltrate in the pit area. This will effectively change the total runoff from the property to 63 mm/yr (53,515 m^3/yr). This equates to an overall decrease in runoff on the property of 20,815 m^3 per year.

Under rehabilitated conditions, the components of the water balance will continue to function very similarly to operational conditions, as the below water extraction area will remain ponded. The setback area will consist of vegetated lands, runoff will continue to drain to the rehabilitated pond, and thus surplus is projected to only decrease by 10% or 25,195 m^3/yr. The rehabilitated pond will be a closed depression without a surface water overflow under normal conditions. As such, Site runoff that flows into the pond will eventually exit the pond as either infiltration / shallow groundwater flow or as evaporation. Infiltration is expected to decrease by 4,380 m^3/yr and the runoff will decrease by 20,815 m^3/yr, compared to existing conditions.

7.0 GROUNDWATER MODELLING

A three-dimensional numerical groundwater flow model was constructed in FEFLOW (Diersch 2020). Once the model was calibrated to current conditions using Site and regional hydrogeologic data, the model was used to simulate the transient effects of aggregate extraction and the long-term changes to the groundwater flow system from the rehabilitated pit pond.

A full description of the groundwater modelling work carried out as part of this water resources assessment is provided in Appendix G. The overall groundwater modelling results are summarized as follows.

- During site operations, aggregate extraction will result in the gradual formation of a pit pond, which is predicted cause a temporary localized reduction in the groundwater table elevation due to the removal of aggregate material, the volume of which will be replaced by groundwater seeping into the pond. The effects on groundwater will be largely confined to the licence area (Site) and surrounding CBM owned property.
- There will be a small area immediately northeast of the proposed licence area (see Appendix G, Figure 12b) west of Mill Creek, where the temporary groundwater table reduction is predicted to be up to approximately 2.5 m (see Appendix G, Figure 12b - Year 6 of extraction operations).

- Temporary reductions to baseflow contributions in the area immediately surrounding the pit pond during operations are predicted to reach a maximum of 29% at SW4 (Tributary 3) and 1.7% at SW3 (Mill Creek).
- Upon rehabilitation, creation of a permanent pond will result in localized water table "flattening", which is predicted to decrease the local groundwater elevation approximately 1.0 m at the northern end of the pond and increase the local groundwater elevation approximately 0.9 m at the southern end of the pond (see Appendix G, Figure 14b).
- Post-rehabilitation, baseflow contributions along Tributary #3 are expected to change by -7.5% at SW1 and +0.8% at SW4, while Mill Creek is expected to experience a baseflow reduction of roughly 2% along this reach, as a result of the long-term changes in the water table around the final pit pond.
- The PSW areas located upgradient of the rehabilitated pond (Areas 1, 5 and 6 – Appendix G, Figure 16) may show decreases in groundwater discharge of up to 173 mm/yr, while PSWs downgradient of the pond (Areas 2, 3, 4 and 7 – Appendix G, Figure 16) may show gains in groundwater discharge of up to 489 mm/yr, mainly as a result of localized water table flattening.

Additionally, a groundwater temperature mixing-model employed to assess potential changes to temperature at nearby receptors using very conservative (worst case) assumptions. The temperature modelling exercise suggests that the thermal influence of the rehabilitated pond on nearby surface water features is expected to be very slight, with a predicted temperature increase of < 1°C at both Mill Creek and Tributary #3.

It should be noted that this prediction was made using highly conservative "worst-case" assumptions, and that actual observed temperature changes in surface water courses as a result of the thermal influence of a future pit pond are likely to be lower than predicted using this worst-case approach.

8.0 IMPACT ASSESSMENT

Based on the groundwater and surface water field investigations, groundwater modelling and water balance calculations, the impact assessment evaluates potential changes to the hydrogeologic / hydrologic system on the Site and surrounding area as a result of Operational and Post-Rehabilitation Scenarios, and the effect these changes may have on water users and ecological receptors. The primary groundwater receptors in the vicinity of the Site are private wells located within the predicted radius of influence. The main surface water receptors in the vicinity of the Site are Mill Creek and its tributaries, and the Mill Creek-Puslinch PSW.

8.1 Groundwater Resources

8.1.1 Potential Impacts to Groundwater Users

Short Term Operational Impacts

The field investigations and groundwater flow modelling predict that there will be a temporary reduction in localized groundwater table elevations during active aggregate extraction, which will be mostly confined to the proposed licence area (Site) and the immediate surrounding CBM owned property. As discussed in Section 7, numerical modelling predicts that one groundwater user (residential well #6708455 constructed in the overburden) may experience a reduction in water level during the operational period of approximately 1 m, as this overburden well is within the predicted zone of influence (Appendix G, Figure 12b).

Well #6708455 is an overburden well drilled to a depth of 8.2 m, with a static water level reported to be 1.8 m deep. If this well experiences a short-term decline in the water level of approximately 1 m, the pump (reportedly installed at 4.57 m below surface) could be lowered in the well to restore the current available drawdown. As such, short term impacts to groundwater levels at this well, if they occur, can be mitigated. No other overburden groundwater (well) users are predicted to experience any significant change in groundwater levels during aggregate extraction operations. Bedrock groundwater (well) users are not predicted to be impacted by the proposed aggregate extraction, as groundwater levels in the underlying bedrock aquifer are not expected to change during operation.

Post-Rehabilitation Impacts

Post-rehabilitation, the predicted long-term reduction in the groundwater table elevation at the same groundwater user (residential well #6708455 constructed in the overburden), will be less, in the range of only 0.3 to 0.6 m (Appendix G, Figure 14b), which is not expected to impact the well. No other overburden groundwater (well) users are predicted to experience any significant change in groundwater levels post-rehabilitation. Bedrock groundwater (well) users are not predicted to be impacted by the proposed aggregate extraction, as groundwater levels in the underlying bedrock aquifer are not expected to change post-rehabilitation.

Potential Impacts to Groundwater Quality

The operation of the pit will require the use of heavy equipment, similar to the current farm equipment utilized at the site for agricultural purposes. As with the farm equipment, there is a small potential for petroleum hydrocarbons to be spilled and enter the ground or groundwater system. However, all fuel handling will be subject to applicable Provincial Standards (i.e., TSSA) and CBM's Best Management Practices. Mitigation measures will be in place to prevent, and if needed respond to, a spill event.

The area upgradient of the Site is comprised of wooded areas, wetlands, and private "estate" homes; there is little if any direct connection to agricultural lands that have the potential to impact groundwater quality at the Site. As such, the groundwater reporting to the future pit pond is not expected to introduce nitrates and/or pathogens in rehabilitated conditions.

The post-rehabilitation scenario represents an opportunity to generally improve water quality as the resulting change in land use will reduce the potential for agricultural impacts directly on the Site, as the lands are currently farmed, and the use of pesticides and fertilizer/manure are a common practice for farming.

8.1.2 Potential Groundwater Impacts to Baseflow

Short Term Operational Impacts

The field investigations and groundwater flow modelling predict that there will be localized temporary reductions in baseflow during active aggregate extraction, which will be mostly confined to the proposed licence area (Site) and the immediate surrounding CBM owned property. The baseflow reduction along Tributary #3 is expected to reach 29% at SW-4 along Tributary #3 on the Site, but a decrease of only 1.7% is predicted at SW-3 along Mill Creek. As these are the nearest groundwater receptors to the Site, no other surface water receptors are predicted to experience a change in groundwater levels during aggregate extraction operations.

Post-Rehabilitation Impacts

Post-rehabilitation, groundwater flow modelling predicts there will be changes in baseflow along Tributary #3, varying from an increase of up to 1% to in some areas to a decrease of 7.5% in other areas, primarily due to localized water table flattening. There will also be a slight reduction in water surplus due to the evaporation of water from the rehabilitated pond, which is predicted to result in an overall reduction water reporting as baseflow along this reach of Mill Creek of approximately 2%. The PSW areas located upgradient of the rehabilitated pond (Areas 1, 5 and 6 – Appendix G, Figure 16) are predicted to show a decrease in groundwater discharge of up to 173 mm/yr, while Mill Creek-Puslinch PSWs downgradient of the pond (Areas 2, 3, 4 and 7 – Appendix G, Figure 16) are predicted to show a gain in groundwater discharge of up to 489 mm/yr, mainly as a result of localized water table flattening. No other surface water receptors are predicted to experience a change in groundwater levels post-rehabilitation.

Groundwater levels around the rehabilitated pond are also predicted to exhibit less seasonal variability, resulting in smaller seasonal fluctuations in baseflow in comparison to current existing conditions. This reduced variability is likely to lead to higher baseflow to Mill Creek and its tributaries during dry periods, and lower baseflow during wet periods of the season.

8.1.3 Potential Groundwater Temperature Impacts

As described in Appendix G and summarized in Section 7, a groundwater temperature mixing-model was used to assess potential changes to temperature at nearby surface water features using conservative (worst case) assumptions. Temperature modelling suggests that the thermal influence of the rehabilitated pond on nearby surface water features is expected to be very slight, with a predicted temperature increase of < 1°C at both Mill Creek and Tributary #3. This slight temperature increase is not expected to have a material impact on surface water receptors.

8.1.4 Monitoring and Mitigation

As discussed in Section 8.6, a monitoring program will be implemented on the property in the setback areas around the pit, in order to confirm the zone of influence and monitor for potential interference with neighbouring private wells. In the event that complaints are received regarding interference to water wells in the vicinity of the Site, the complaints response plan discussed in Section 8.5 would be implemented.

8.2 Surface Water Resources

8.2.1 Potential Impacts to Surface Water

There is a portion of Tributary #3 approximately 200 m long that crosses through the northwest corner of the Site immediately northwest and outside of the proposed extraction area, which is the only surface water course on the Site. Mill Creek and three of its tributaries (Tributaries #1, #3, and #5) lie outside of the proposed licence area within the CBM owned property, and Tributary #4 lies off-property to the west. These water courses have the potential to be impacted by the proposed aggregate extraction on the Site and are considered in the impact assessment.

The total catchment area of Tributary #3 and Mill Creek near their confluence is 1.48 km^2 and 72.37 km^2, respectively (estimated using Ontario Flow Assessment Tool, OFAT), as represented on Figure 2. Aggregate extraction will convert approximately 0.11 km^2 and 0.17 km^2 of the surface water catchments of Tributary #3 (approximately 7.43%) and Mill Creek (approximately 0.24%), respectively, into a pond that is internally drained to shallow groundwater. This loss of catchment for Tributary #3 and Mill Creek is predicted to result in an approximate reduction in runoff reporting to these watercourses of 6,650 m^3/yr and 12,795 m^3/yr, respectively, relative to existing conditions. While the creation of a pond will reduce the direct runoff to Tributary #3 and Mill Creek, the water surplus collected in the rehabilitated pond will infiltrate and report to Mill Creek as baseflow.

The proposed extraction area within the Site is situated adjacent to wetlands areas on all sides, which are currently supported by groundwater and surface water inputs from the surrounding area to maintain its hydroperiod. While aggregate extraction will result in decreased runoff to these wetland areas, the potential impact to the Mill Creek-Puslinch PSW due to reduced runoff are expected to be mitigated by the infiltration surplus from the rehabilitated pit.

The water balance assessment in Section 6.0 suggests that overall, there will be decrease in water surplus of 9.9% from 250,900 to 226,115 m^3 per year for the Site and CBM owned property under operational conditions. Post-rehabilitation, the water balance assessment predicts a similar decrease in water surplus of 10.0% from 250,900 to 225,705 m^3 per year relative to current conditions. As observed above, runoff volumes to Mill Creek and Tributary #3 are expected to decline, however baseflow to Mill Creek is expected to slightly increase as a result of the increase in infiltration from the rehabilitated pond. This change from runoff to infiltration is expected to decrease peak runoff flows from the Site, while at the same time moderating the magnitude of baseflow fluctuations at nearby receptors.

Overall, the extraction of aggregates and creation of a pond at the Site upon rehabilitation is not predicted to have adverse impacts on the local surface water hydrology of Mill Creek or the Mill Creek-Puslinch PSW, via land use changes, surface water drainage alterations and / or pit operation. The reduction in runoff from the Site is predicted to have minor localized impacts to Tributary #3, but the runoff lost from downsizing of the catchments will largely be offset by water directed to the rehabilitated pond, most of which will report to Mill Creek and the Mill Creek-Puslinch PSW as baseflow.

8.3 Source Water Protection

The extraction of aggregates below the water table within the Site are not expected to impact the Source Water Protection status of the Site. The Site is not proximal to any Wellhead Protection Area (WHPA) and is located outside the Wellhead Water Quantity Zone. The Site is currently classed as a Significant Groundwater Recharge Area (SGRA), and the Site Operation and Rehabilitation scenarios the were evaluated predict an annual recharge rate that will maintain the current SGRA classification.

The Site currently has a Vulnerability score of 4 (GRCA 2021a) and the removal of sand and gravel may result in a slight increase in vulnerability scoring in some localized areas of the Site, for example, in areas where the fine-grained silt till that underlies the sand and gravel is relatively thin and the upper bedrock surface is relatively shallow. However, aggregate extraction below the water table will also result in the separation and accumulation of fines in the bottom of the pond by the drag-line operation, and these fines will help mitigate any change in Vulnerability. It is also important to note that below-water aggregate extraction is not a prescribed drinking water threat under the *Clean Water Act.*

In summary, predicted changes in recharge and vulnerability at the Site during Operations and Post-rehabilitation are such that groundwater in the overburden and bedrock aquifers is not expected to be adversely impacted from a Source Water Protection perspective relative to current conditions.

8.4 Potential Impacts of a Regional Flood Event

As noted in Section 5.6.2, the Site is located within the Mill Creek floodplain. Should a regional flood event occur, the removal of aggregate from the Site would provide additional temporary storage capacity for water to Mill Creek in comparison to current conditions, which would help reduce the effects of flooding downstream from the Site. A regional flood event would result in a temporary stoppage in operations, but this is expected to be a short lived event, and the potential for significant damage to site infrastructure would be minimal.

8.5 Water Well Complaints Response

Based on the results of the impact assessment, one private well within the radius of influence of the proposed pit is predicted to experience a slight decline in their groundwater level, noting that the predicted magnitude of the water level decline should not impact the well's performance. Any water well interference complaint received by CBM will be responded to in light of the collected monitoring data and under the Complaints Response Protocol described herein.

If a water well complaint regarding a private well is received by CBM within 500 m of the Site, the following actions shall be taken, as detailed in Figure 20:

- CBM will conduct an initiate meeting with the resident and assess if the problem can be easily rectified or if additional steps are necessary;
- If the water supply is compromised and it is possible that the impact is attributable to extraction, then the well owner will be immediately offered a temporary water supply at the licensee's expense;
- The licensee will contact a licensed well contractor to complete a well/system inspection (where accessible) to determine the groundwater level, pump depth setting and condition of the well system ;
- The designated contractor will respond to the well owner and propose a plan to rectify the problem as expediently as possible. The well owner must then provide authorization of the work;
- If the issue raised by the well owner is related to loss of water supply the licensee will have a licensed professional geoscientist/engineer review available groundwater level data from existing on-site monitoring wells and determine the likely cause of the impact at the expense of CBM and the results will be provided to the well owner;
- Based on a review of groundwater level information by the professional geoscientist/engineer and well construction and performance information from the licensed well contractor, if it is concluded that the well interference complaint is most likely attributable to aggregate extraction activities at the Site and the water supply is at risk, then the licensee shall continue to supply water to the well owner at the licensee's expense until the problem is rectified and the water supply is restored. The following mitigation measures shall be considered, and the appropriate measure(s) implemented at the expense of the licensee, in consultation with the affected property owner in order to ensure a mutually agreeable solution is implemented:
  - Adjust pump pressure;
  - Lowering of the pump to take advantage of existing water storage within the well;
  - Deepening of the well to increase the available water column;
  - Widening of the well to increase the available storage of water;
  - Relocation of the well to another unaffected area on the property; or
  - Drilling of multiple low yield wells.

- If the issue with the well is pump failure, should the well owner choose to have the pump repaired or replaced at their expense, the well contractor would correct the situation for the well owner; and
- If it has been determined that extraction activities did not cause the water supply interference, then the licensee shall provide 24 hours notice and thereafter discontinue the temporary water supply.

8.6 Proposed Monitoring Program

Site-specific groundwater and surface water monitoring recommendations have been developed to measure and evaluate the actual effects on potential receptors associated with the development of the proposed pit, and to allow for comparison of the actual effects measured during the monitoring program and those predicted as part of the impact assessment. Monitoring is proposed to begin carried out upon licence approval and prior to the initiation of aggregate extraction, and continue through the Operational Period and one year beyond the completion of Site Rehabilitation.

8.6.1 Groundwater Monitoring

The proposed groundwater level monitoring program will include overburden wells MW18-01 to MW18-06 and the bedrock well TW11-16 within the setback area of the Site, as shown on Figure 2. Groundwater level monitoring will consist of recording groundwater level data at 15 minute intervals using data loggers, along with quarterly logger downloads and manual water level measurements. Groundwater temperature and groundwater quality monitoring is not proposed, as neither thermal impacts nor water quality impacts are predicted.

8.6.2 Surface Water Monitoring

The proposed surface level monitoring program will include the monitoring stations SW-1 to SW-6 and their associated shallow standpipes SP18-01 to SP18-04, SP22-01, and SP22-02 within the setback area of the Site, as shown on Figure 2. Surface water level monitoring will consist of recording water level data at 15 minute intervals using data loggers, along with quarterly logger downloads and manual water level measurements. Surface water temperature and water quality monitoring is not proposed, as neither thermal impacts nor water quality impacts are predicted.

8.6.3 Data Review and Reporting

Groundwater and surface water levels shall be reviewed by CBM quarterly, and reported to the MNRF annually as part of the licence requirements. Water level trends during Operations and Post-Rehabilitation shall be compared to Pre-Operational conditions. If the results of the monitoring program indicate the potential for adverse impact to groundwater users (private wells) or surface water features (Mill Creek and its tributaries), then appropriate enhanced monitoring and/or mitigative actions would be developed and implemented.

9.0 CUMULATIVE EFFECTS ASSESSMENT

A cumulative effects assessment was completed for the proposed pit operation on the Aberfoyle South Pit Expansion project in accordance with the *Cumulative Effects Assessment (Water Quality and Quantity) Best Practices Paper for Below-Water Sand and Gravel Extraction Operations in Priority Subwatersheds in the Grand River Watershed* (GRCA 2010). The stated purpose of the GRCA document is to *“outline a reasonable, consistent, and scientifically defensible approach to assessing potential cumulative effects of below-water sand and gravel extraction…as part of MNR’s review/approval process under the ARA.”*

Section 2 *Assessment of Cumulative Effects Related to Sand and Gravel Operations Below the Water Table in the Grand River Watershed* and Section 3 *Other Assessment Considerations* provide a framework by which a technical study may meet the best-practices of a cumulative effects assessment, which has been followed herein.

9.1 Initial Assessment

As per the guidance provided in GRCA (2010) the following initial assessment has been completed the South Aberfoyle Pit Expansion Project, as presented in Table 18.

Table 18: Initial Assessment to Evaluate Potential for Cumulative Effects

Initial Assessment	Aberfoyle South Pit Expansion Project
Proximity to licenced above- and below-water sand and gravel aggregate extraction operations and the potential for overlapping cumulative effects including changes to surface water drainage patterns and water balance	The sand and gravel deposits in the Aberfoyle area are a very important source of aggregates for the Greater Golden Horseshoe (GGH) and Waterloo-Wellington market. As such, there are a number of licenced pits within a 5 km distance from the Site within the Mill Creek Subwatershed. These pits are predominantly located on the east side of Mill Creek (i.e., on the other side of a groundwater divide within the subwatershed) and are upstream and upgradient of the Site, as shown on Figure 21).
Proximity to licence applications for proposed above- and below- water sand and gravel extraction operations	The nearest active licence application is for the CBM Lanci Pit Expansion application for below-water extraction, which is located approximately 2 km east of the Site and east of Mill Creek.
Degree of environmental degradation existing within the subwatershed, if available (e.g., ground water/surface water quantity and quality, impacts on natural features and functions, ecosystem health)	The Mill Creek subwatershed has been extensively studied (e.g., GRCA 1996; Golder 2006; Matrix Solutions 2014 and 2017; University of Waterloo 2018) and is actively monitored for potential cumulative effects. These studies all indicate that the Mill Creek Subwatershed is in good health. A further description of studies that considered cumulative effects on Mill Creek is provided in Section 9.4. The studies also typically recommend that hydrogeologic, hydrologic and aquatic conditions continue to be monitored by the various stakeholders engaged in activities within the subwatershed.
Potential impacts on the level of stress that the proposed below-water sand and gravel extraction operation may have, using the most current stress assessment provided by the GRCA	The assessment conducted herein indicates that the incremental stress of the proposed Project could potentially place on water resources is very low.

Initial Assessment	Aberfoyle South Pit Expansion Project
Proximity to municipal water wells and intakes, if the information is available	The Site is not proximal to any Municipal wells or intakes and is located within a designated “SGRA”. The proposed future land use is consistent with that designation.
Vulnerability of the groundwater resources in the subwatershed and the potential impact that the proposed below-water sand and gravel extraction operation may have on vulnerability (if any).	The Site currently has a “moderate” vulnerability rating. While the removal of aggregate material is likely to increase the ISI vulnerability slightly, the overall vulnerability rating of the Site is not expected to change, as the silty till layer below the sand and gravel and above the bedrock provides inherent protection to the bedrock aquifer.
Other activities or features in the study area that could significantly affect or rely on groundwater resources.	Other groundwater users within the Mill Creek Subwatershed include Municipal water supply and bottled water supply. Both occur a significant distance upstream and upgradient from the Site. This project is not expected to have a cumulative impact on these other activities.

9.2 Local Scale Cumulative Effects

As per the guidance provided in GRCA (2010) the following potential for local scale cumulative effects have been considered and assessed for the South Aberfoyle Pit Expansion project, as presented in Table 19.

Table 19: Local Scale Cumulative Effects

Local Scale Cumulative Effects	Aberfoyle South Pit Expansion Project
Characterize the existing conditions at the site and in the vicinity of the site, and during the extractive and rehabilitation stages.	The Water Report meets the required characterization scope.
Assess the potential impacts to groundwater and surface water resources from the proposed below water sand and gravel extraction operation relative to the impacts of existing above - and below water sand and gravel extraction operations for all development stages.	The Water Report meets the required impact assessment scope (Section 8)
Establish monitoring requirements to identify and distinguish between individual and cumulative effects.	The Water Report includes a proposed monitoring program (Section 8.6) and recommends a Private Well Survey be conducted prior to the start of aggregate extraction operations (Section 10).

Local Scale Cumulative Effects	Aberfoyle South Pit Expansion Project
Establish a mitigation and implementation plan, as appropriate.	As noted in Section 9.1 (Table 18) the Mill Creek subwatershed has been extensively studied and these studies all indicate that the Mill Creek Subwatershed is in good health. The impact assessment (Section 8) does not predict significant impacts to water resources, however, should the proposed monitoring identify a potential for impacts and enhanced monitoring and mitigation plan will be developed and implemented (Section 8.6).
The cumulative impact assessment should consider impacts from both a spatial and a temporal perspective.	This Water Report considered temporal and spatial impacts on the Local Scale and did not predict significant impacts to Water Resources (Section 8).
Temporal impacts may occur where potential operations overlap in time and duration. The applicant should assess cumulative effects resulting from existing conditions and potential impacts that could reasonably be expected to occur in the future due to other aggregate operations.	This is discussed in Section 9.3.

9.3 Watershed/Subwatershed Cumulative Effects

As per the guidance provided in GRCA (2010) the following potential for Watershed/Subwatershed cumulative effects have been considered and assessed for the South Aberfoyle Pit Expansion project, as presented in Table 20.

Table 20: Watershed/Subwatershed Scale Cumulative Effects

Watershed/Subwatershed Scale Cumulative Effects	Aberfoyle South Pit Expansion Project
The appropriate scale for this assessment is typically the quaternary-level watersheds (e.g., Mill Creek watershed). A broader scale approach may be encouraged if the proposed aggregate operation drains directly to a higher-level watershed or if reasonably-anticipated potential cumulative effects are likely to occur at a broader scale.	The groundwater modelling (Appendix G) carried out as part of the Water Report used an appropriate scale to assess potential effects at the Mill Creek Subwatershed scale, and the Impact Assessment (Section 8) did not predict there to be impacts at the that scale during any phase of proposed operation.

Watershed/Subwatershed Scale Cumulative Effects	Aberfoyle South Pit Expansion Project
Through a hydrogeological assessment, each successive applicant for a below-water sand and gravel extraction licence or licence amendment, will be encouraged to provide information and analyses that will place the impacts of their proposal into the subwatershed context.	The Impact Assessment (Section 8) and Cumulative Effects Assessment (Section 9) satisfies this requirement.
Each successive applicant will be encouraged to prepare an inventory of other below-water aggregate extraction operations in the same subwatershed (either licenced or with an active licence application) and prepare an estimate of the cumulative effects. This estimate should be based on each site at its full operational size (i.e., maximum open water exposure, usually at the end of operations). This analysis will ideally be based on the assessment prepared and submitted for each site as part of the application for licence.	The purpose of the South Aberfoyle Pit Expansion project is not to increase CBM's overall rate of aggregate extraction within the Aberfoyle area, but rather to ensure their ability to continue to provide valuable aggregate resources to the GGH and Waterloo-Wellington market in the long term at the current rate of extraction. This sustainable development approach is consistent with the objective of minimizing potential cumulative effects of aggregate extraction on the Mill Creek Subwatershed.

9.4 Studies at Other Sites

As noted in Section 9.1 (Table 18) the Mill Creek subwatershed has been extensively studied and these studies indicate that the Mill Creek Subwatershed is in good health. These studies were reviewed by WSP and review summaries are provided below, which support the conclusion that this proposed project will not have a significant cumulative effect on the Mill Creek Subwatershed.

9.4.1 Dufferin Mill Creek Pit

Recent Coordinated Monitoring Reports for the Dufferin Aggregates Mill Creek Pit (2019, 2020 and 2022), as well as peer review comments from Harden Environmental regarding the 2022 Coordinated Monitoring Report were reviewed. Key findings in the 2022 monitoring report are summarized as follows:

- Hydrology – Stream flow in Mill Creek responded to climatic conditions, including precipitation events, periods of snow melt and periods of low precipitation. Flow rates were observed to be within historical range observed since 2000. There is no indication that aggregate extraction has affected stream flow in Mill Creek. Given the extensive surface water monitoring data that demonstrate a lack of flow impacts on Mill Creek, reduction of the surface water monitoring program should be considered.
- Groundwater – Groundwater levels, groundwater gradients, and baseflow to Mill Creek were found to be within historical ranges. There was one hydraulic gradient action threshold triggered in 2022, but it was triggered by a precipitation event and was not attributable to aggregate operations. Groundwater temperatures were influenced by the pit ponds; however, these effects were localized and there were no

thermal impacts to Mill Creek. Groundwater quality remained consistent with previous years and there were no impacts attributable to aggregate operations.

- Fisheries – No impacts to the trout fishery in Mill Creek were identified.
- Conclusions and Recommendations – The available monitoring data do not indicate that the Mill Creek aggregate operation negatively impacted the local environment in 2022.

The Harden peer review Discussion section stated that “aggregate extractive activities at this Site have had an impact on groundwater levels and temperature”. However, they noted that these effects were very localized, they did not indicate that these changes in groundwater levels were impacting Mill Creek, and they stated that “Mill Creek is located near enough to the ponds to have a small temperature change occur”, although none was observed at Mill Creek in the 2022 monitoring program.

The extensive data set acquired by the monitoring program at the Dufferin Aggregates Mill Creek Pit, which spans more than two decades, indicates that this aggregate pit operation has not adversely impacted the local environment, including the Mill Creek hydrology, hydrogeology or fishery, suggesting that this pit does not contribute a cumulative impact to Mill Creek.

Based on the current Impact Assessment, the proposed Aberfoyle South Pit expansion is not expected to impact the Dufferin Aggregate Mill Creek Pit operations, or trigger hydrogeologic thresholds set forth in heir monitoring program.

9.4.2 Mill Creek Cumulative Impact Study

Similar conclusions were reached in the Mill Creek Cumulative Impact Assessment (Golder 2006), which commenced to determine if below water table aggregate extraction was having a long-term negative effect on Mill Creek and its associated fish populations. The study found that the flows in Mill Creek appeared to correlate more closely to the long-term precipitation record than to aggregate extraction. This study also found that elevated summer stream temperatures in Mill Creek are primarily due to upstream on-line (non-aggregate) ponds that act as heat sinks.

9.4.3 CBM McMillan Pit

Long-term monitoring studies from 1994-2004 at the CBM McMillian Pit located 500 m east of Mill Creek (Limnoterra 2005) reached the conclusion that there was no measurable impact to Mill Creek as a result of below water extraction as groundwater drawdown in the vicinity of below water extraction operations is relatively minor compared with the natural seasonal variability of the water table. Also, the streamflow in Mill Creek did not decrease because of increased evaporation causing a deficit in potential baseflow. Additionally, other aggregate operations upgradient of the McMillian Pit began below water extraction around the same time (CBM McNally Pit, Dufferin MCAP, Phase I and Phase II, and PQA Mast Pit).

9.5 Summary

The cumulative effects assessment completed for the proposed pit operation on the Aberfoyle South Pit Expansion project consisted of an initial assessment, and assessment of local scale cumulative effects, and an assessment of Subwatershed/Watershed scale cumulative effects, as per the guidance provided in GRCA (2010). Based on this assessment, there are no cumulative effects predicted for water resources locally or within in the Mill Creek subwatershed as a result of below water sand and gravel extraction at the proposed Aberfoyle South

Pit Expansion Project Site. This assessment is consistent with previous cumulative effects assessments carried out in the Mill Creek Subwatershed by others.

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

A Level 1 and 2 Water Report has been prepared in support of a Class A Pit Below Water licence application under the Aggregate Resources Act (ARA) at the proposed Aberfoyle South Pit Expansion. The property is approximately 85 hectares (ha) in size and is located at 6947 Concession Road 2, in the Township of Puslinch, County of Wellington, Ontario (Figure 1).

The overall objectives of the Water Report was to characterize the baseline hydrogeological and hydrological conditions in the vicinity of the Site under the “Existing Conditions Scenario” (current, pre-extraction conditions); assess the potential effects of the proposed “Operations Scenario” and “Rehabilitated Scenario” on groundwater and surface water resources; and evaluate the potential need for mitigation.

Scope of Study

The following tasks were completed as part of the Water Resource technical study:

- A review of publicly available hydrogeologic and hydrologic data and reports for the Site and surrounding area.
- A field investigation program that included: borehole drilling and monitoring well installations; stream standpipe piezometers and surface water monitoring installations; monthly groundwater monitoring (water levels and temperatures); quarterly stream monitoring (water levels and flow); groundwater quality sampling; and hydraulic conductivity testing.
- A review of local groundwater users based on the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) and Permit To Take Water (PTTW) databases.
- Development of a Site water budget for Existing, Operations and Rehabilitated Scenarios to estimate pre- and post-development surplus, runoff and infiltration rates.
- The construction and calibration of a numerical groundwater flow model and subsequent predictive simulations to estimate potential water quantity impacts of the proposed below-water extraction on surrounding groundwater and surface water receptors. The development of a groundwater / surface water mixing model to assess potential thermal impacts of the proposed aggregate extraction on water temperatures in local streams and creeks.
- An assessment of groundwater vulnerability and the potential for water quality impacts.
- An analysis of potential cumulative effects of the proposed aggregate extraction in light of the other neighbouring aggregate operations.

Impact Assessment

The impact assessment evaluated potential changes to the hydrogeologic / hydrologic system on the Site and surrounding area as a result of Operational and Post-Rehabilitation Scenarios, and the effect these changes may have on water users and ecological receptors. The primary groundwater receptors in the vicinity of the Site are private wells located within the predicted zone of influence of the Site. The main surface water receptors in the vicinity of the Site are Mill Creek and its tributaries, and the Mill Creek-Puslinch PSW.

Potential Impacts to Groundwater Users

The field investigations and groundwater flow modelling predicts that there will be a temporary reduction in localized groundwater table elevations during active aggregate extraction, which will be mostly confined to the proposed licence area (Site) and the immediate surrounding CBM owned property.

There is one overburden groundwater user (residential well #6708455) immediately northeast of the proposed licence area within the predicted zone of influence of the Site. The reduction in the groundwater table elevation at this private well during operations is predicted to be approximately 1 m, and if required, the pump in the well can be lowered by this amount to restore its original drawdown capacity, thereby mitigating the potential impact. Post-rehabilitation, the predicted long-term reduction in the groundwater table elevation at the same well will be less, in the range of only 0.3 to 0.6 m, which is not expected to impact this groundwater user.

No other overburden groundwater (well) users are predicted to experience any change in groundwater levels during aggregate extraction operations or post-rehabilitation. The groundwater levels in the underlying bedrock aquifer at the Site and surround area are not expected to be impacted during operation or post-rehabilitation.

Potential Impacts to Groundwater Quality

The operation of the pit will require the use of heavy equipment and there is a potential for petroleum hydrocarbons to be spilled and enter the pit pond or groundwater system. However, all fuel handling will be subject to applicable Provincial Standards (i.e., TSSA) and CBM's Best Management Practices. Mitigation measures will be in place to prevent, and if needed respond to, a spill event.

The area upgradient of the Site is comprised of wooded areas, wetlands, and private "estate" homes; there is little if any direct connection to agricultural lands that have the potential to impact groundwater quality at the Site. As such, the groundwater reporting to the future pit pond is not expected to introduce nitrates and/or pathogens in rehabilitated conditions. The post-rehabilitation scenario represents an opportunity to generally improve water quality as the resulting change in land use will reduce the potential for agricultural impacts directly on the Site, as the lands are currently farmed.

Potential Groundwater Impacts to Baseflow

The field investigations and groundwater flow modelling predicts that there will be localized temporary reductions in baseflow during active aggregate extraction, which will be mostly confined to the proposed licence area (Site) and the immediate surrounding CBM owned property. The baseflow reduction along Tributary #3 is expected to reach 29% at SW-4 along Tributary #3 on the Site, but a decrease of only 1.7% is predicted at SW-3 along Mill Creek.

Upon post-rehabilitation, groundwater flow modelling predicts there will be changes in baseflow along Tributary #3, varying from an increase of up to 0.8% to in some areas to a decrease of 7.5% in other areas, primarily due to localized water table flattening. There will also be a slight reduction in water surplus due to the evaporation of water from the rehabilitated pond, which is predicted to result in an overall reduction water reporting as baseflow along this reach of Mill Creek of approximately 2%.

The Mill Creek-Puslinch PSW areas located upgradient of the rehabilitated pond are predicted to have a decrease in groundwater discharge of up to 173 mm/yr, while Mill Creek-Puslinch PSWs downgradient of the pond are predicted to have a gain in groundwater discharge of up to 489 mm/yr, mainly as a result of localized water table flattening. As these are the nearest groundwater receptors to the Site, no other natural receptors are predicted to experience a change in groundwater levels during aggregate extraction operations or post-rehabilitation.

Groundwater levels around the rehabilitated pond are predicted to exhibit less seasonal variability, resulting in smaller seasonal fluctuations in baseflow in comparison to current existing conditions. This reduced variability is expected to lead to higher baseflow during dry periods, and lower baseflow during wet periods of the season, which is likely to benefit the aquatic ecology of the streams and wetlands.

Potential Groundwater Temperature Impacts

Temperature modelling suggests that the thermal influence of the rehabilitated pond on nearby surface water features is expected to be very slight, with a predicted maximum temperature increase of < 1°C at both Mill Creek and Tributary #3. This slight temperature increase is not expected to have a material impact on surface water receptors.

Potential Impacts to Surface Water

The extraction of aggregates and creation of a pond at the Site upon rehabilitation is not predicted to have adverse impacts on the local surface water hydrology of Mill Creek or the Mill Creek-Puslinch PSW, via land use changes, surface water drainage alterations and / or pit operation. The reduction in runoff from the Site is predicted to have minor localized impacts to Tributary #3, but the runoff lost from downsizing of the catchments will largely be offset by water directed to the rehabilitated pond, most of which will report to Mill Creek and the Mill Creek-Puslinch PSW as baseflow.

Source Water Protection

The extraction of aggregates below the water table within the Site not expected to impact the Source Water Protection status of the Site. Groundwater in the overburden and bedrock aquifers is not expected to be adversely impacted from a Source Water Protection perspective relative to current conditions.

Cumulative Effects

The cumulative effects assessment completed for the proposed pit operation on the Aberfoyle South Pit Expansion project consisted of an initial assessment, and assessment of local scale cumulative effects, and an assessment of Subwatershed/Watershed scale cumulative effects, as per the guidance provided in GRCA (2010). Based on this assessment, there are no cumulative effects predicted for water resources locally or within in the Mill Creek subwatershed as a result of below water sand and gravel extraction at the proposed Aberfoyle South Pit Expansion project Site. This assessment is consistent with previous cumulative effects assessments carried out in the Mill Creek Subwatershed by others.

10.2 Recommendations

Private Well Survey

A door-to-door survey of private wells for properties within 500 m of the Site shall be carried out upon licence approval and prior to the initiation of aggregate extraction, to supplement and help verify the MECP WWIS information and confirm neighbouring water users, noting that participation by neighbouring property owners would be entirely voluntary.

Monitoring Program

A monitoring program shall be implemented on the property in the setback areas around the pit, in order to confirm the zone of influence with respect to the surrounding PSW, tributary features and Mill Creek, and monitor for potential interference with neighbouring private wells. In the event that complaints are received regarding interference to water wells in the vicinity of the Site, the Complaints Response Protocol would be implemented.

Well Complaint Protocol

There is one private well within the radius of influence of the proposed pit predicted to experience a slight decline in their groundwater level, noting that the predicted magnitude of the water level decline should not impact the well's performance. Any water well interference complaint received by CBM will be responded to in light of the collected monitoring data and under the Complaints Response Protocol .

Fuel Handling

All fuel handling on site shall be done in accordance with applicable TSSA Standards and CBM's Best Management Practices.

11.0 LIMITATIONS

11.1 Use of This 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 WSP 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 physical constraints applicable to this report.

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. WSP 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, WSP should be requested to re-evaluate the conclusions of this report, and to provide amendments, as required.

11.2 Groundwater Modelling General Limitations

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time and the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that field data provides a fraction of information for the site or model domain; as such a truly complete, comprehensive characterization of the groundwater system is not possible. Therefore, every groundwater model is, by necessity, a simplification of a reality.

The professional groundwater modelling services described in this report are conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions. The results of previous or simultaneous work provided by sources other than WSP and quoted and/or used herein are considered as having been obtained according to recognized and accepted professional rules and practices, and therefore deemed valid.

The model presented herein provides a predictive scientific tool to evaluate the impacts of specified hydrological stressors on a real groundwater system and to compare various scenarios in support of a decision-making process. The model's accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

Signature Page

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https://golderassociates.sharepoint.com/sites/21291g/deliverables/hydrogeology level 1 and 2/09 water report final nov 2023/1791470-4000-rev2 aberfoyle s water report nov2023.docx

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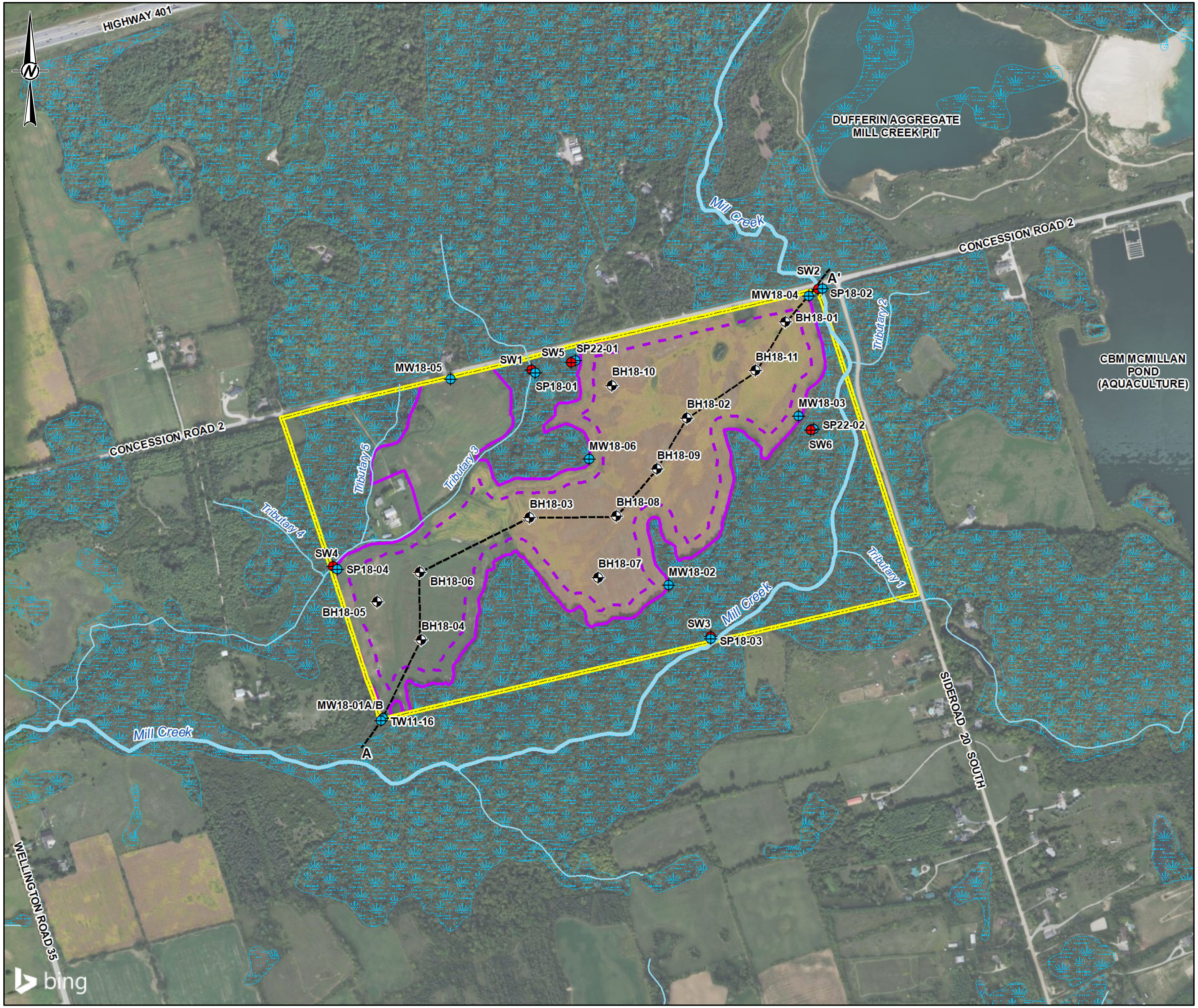
Figures



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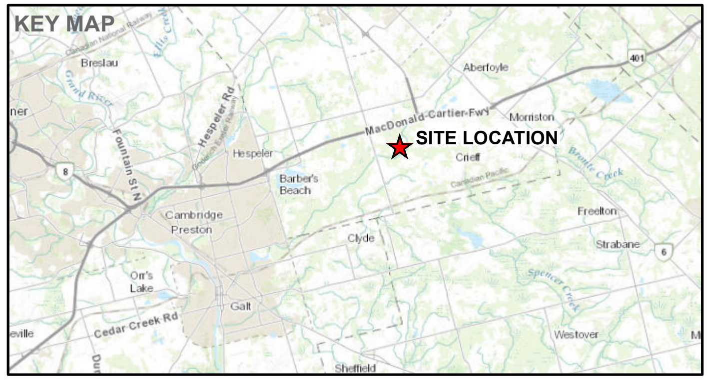

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LEGEND

- ⊕ Resource Evaluation Borehole
- ⊕ Groundwater Monitor
- ⊕ Surface Water Monitor
- — Watercourse
- - - Site Cross-Section Line
- ▨ Provincially Significant Wetland (Evaluated)
- ☐ Property Boundary
- ☐ Proposed Extraction Area

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REFERENCE(S)

1. MECP WATER WELL RECORD DATA OBTAINED SEPTEMBER 2020.
2. BASEDATA: MNRF LIO, OBTAINED 2019
3. IMAGERY SOURCE: © 2023 MICROSOFT CORPORATION © 2022 MAXAR ©CNES (2022) DISTRIBUTION AIRBUS DS
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4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC.(CANADA)

PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
STUDY AREA

CONSULTANT
wsp

YYYY-MM-DD	2023-02-08
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
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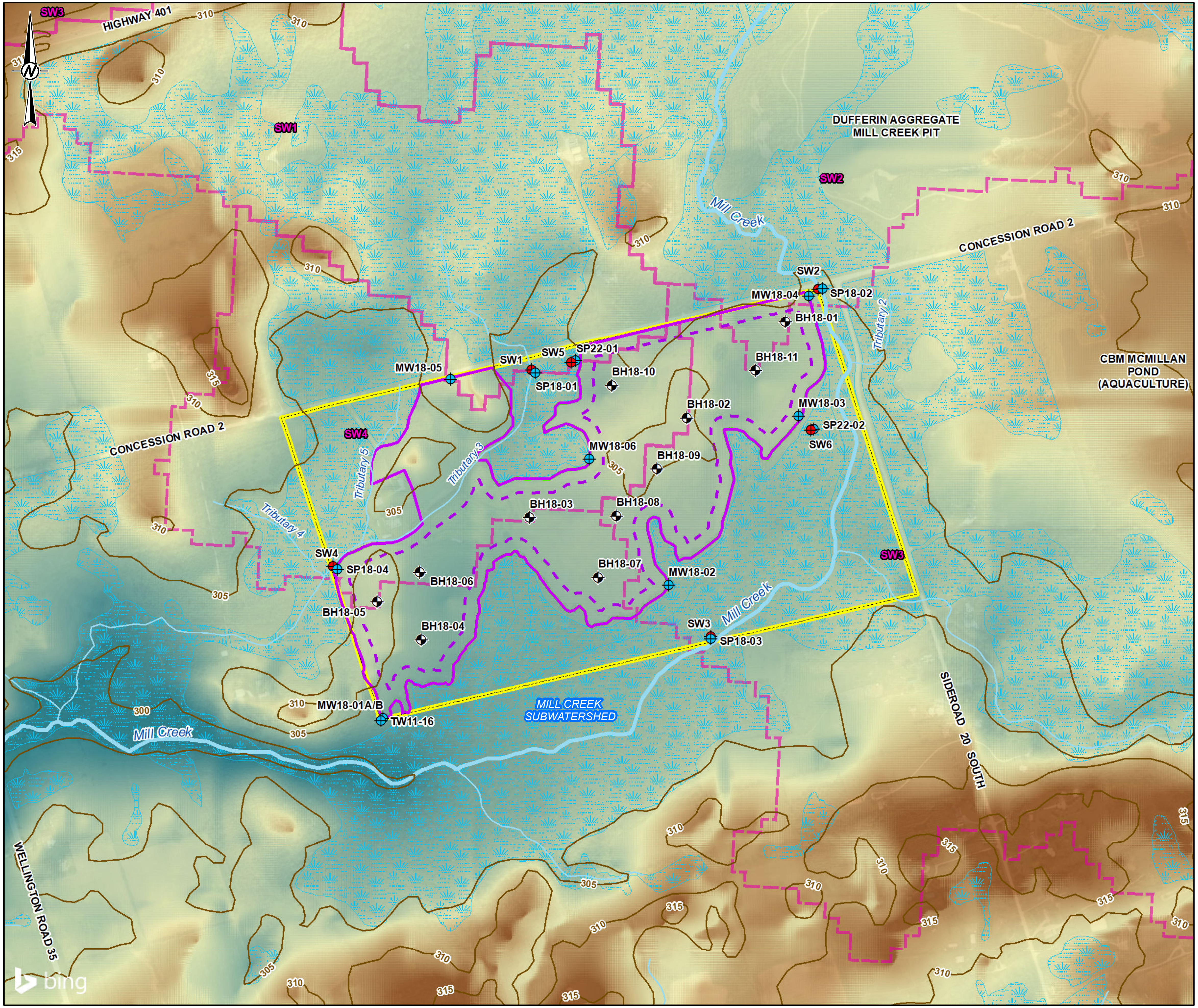

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PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
TOPOGRAPHY AND DRAINAGE

CONSULTANT

wsp

YYYY-MM-DD	2023-02-08
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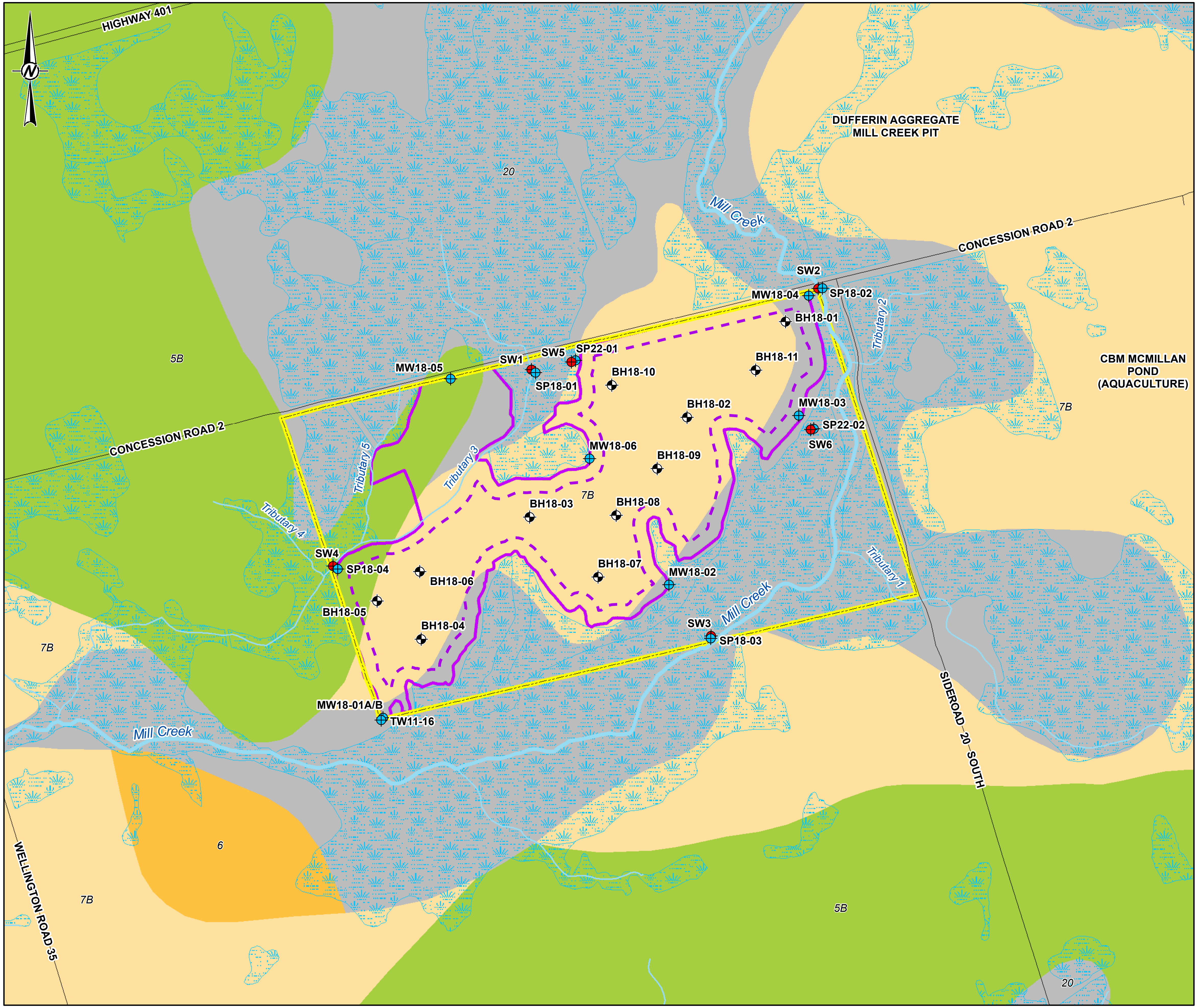

LEGEND

- Resource Evaluation Borehole
- Groundwater Monitor
- Surface Water Monitor
- Watercourse
- Field Verified Wetland Edge
- Provincially Significant Wetland (Evaluated)
- Property Boundary
- Licence Boundary / Site Boundary
- Proposed Extraction Area

Surficial Geology

- 🟩 5b: Stone-poor, carbonate-derived silty to sandy till
- 🟧 6: Ice-contact stratified deposits
- 🟨 7b: Gravelly deposits
- ⬜ 20: Organic deposits

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1. SURFICIAL GEOLOGY DATA OBTAINED VIA GEOLOGY ONTARIO MNDMF MISCELLANEOUS RELEASE - DATA MRD128-REV MISCELLANEOUS RELEASE - DATA SURFICIAL GEOLOGY OF SOUTHERN ONTARIO 2010-01-01T01:01:01Z SURFICIAL GEOLOGY OF SOUTHERN ONTARIO ONTARIO GEOLOGICAL SURVEY -95 -74 57 41
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PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
SURFICIAL GEOLOGY

CONSULTANT
wsp

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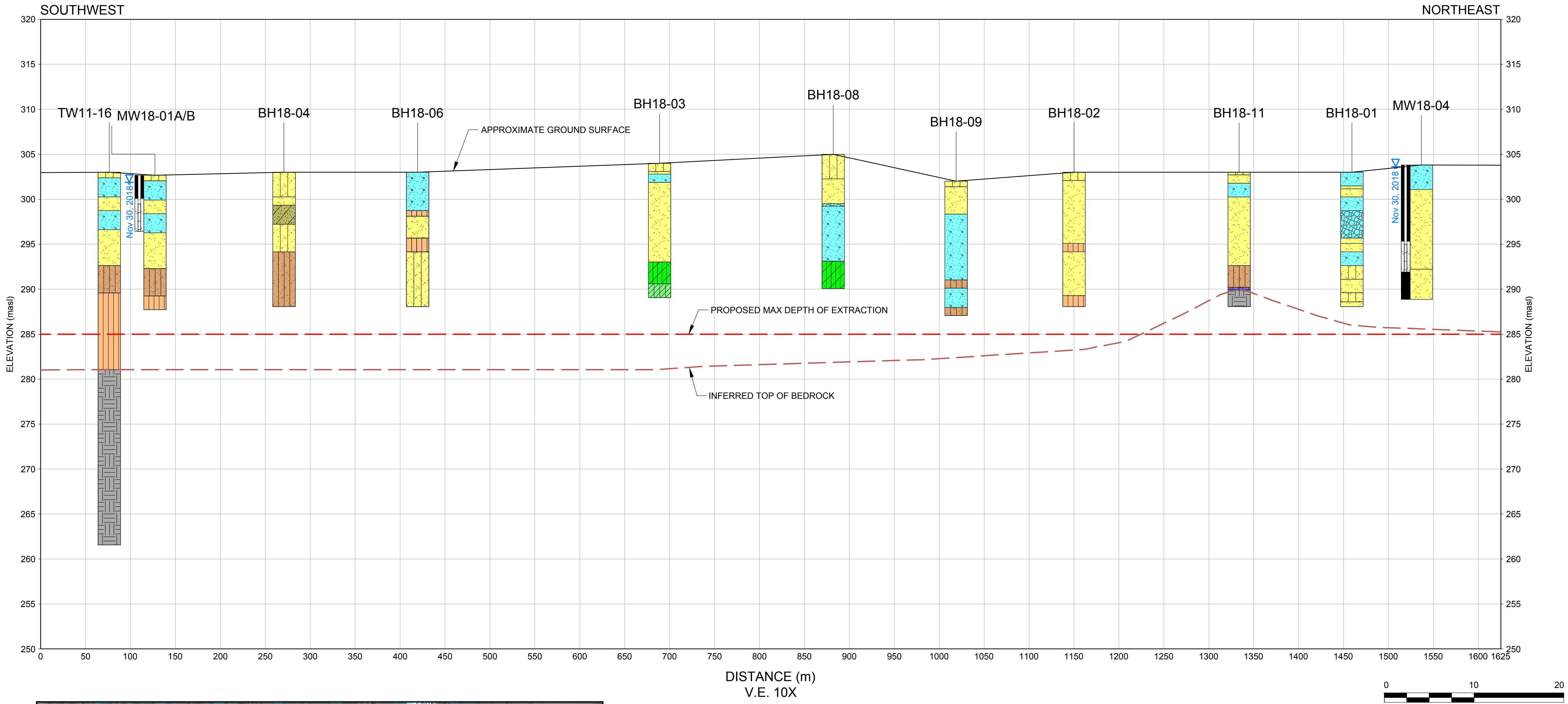

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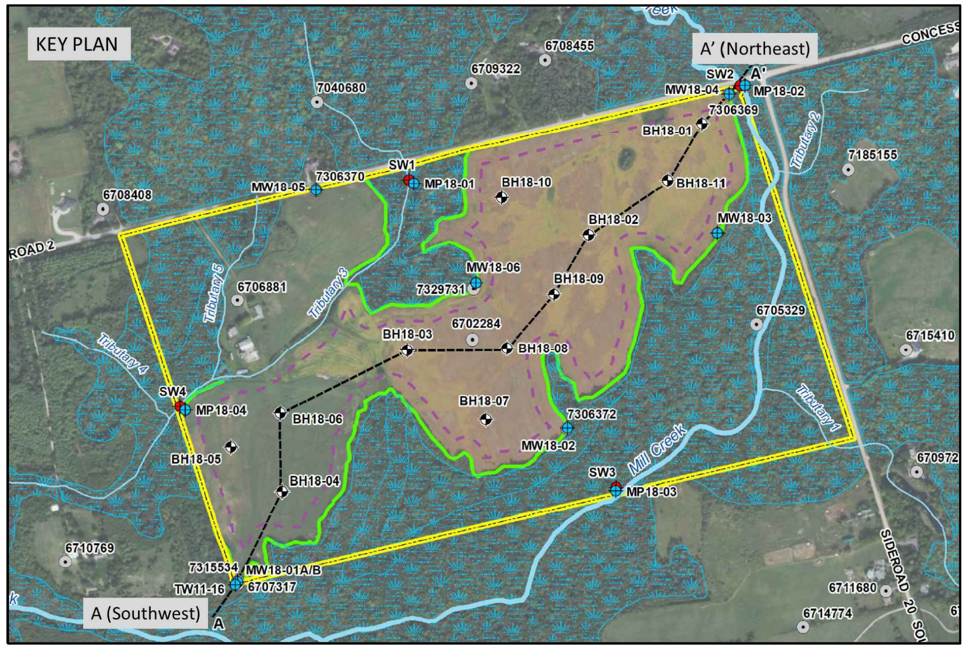

LEGEND

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▨	SAND AND GRAVEL	▨	SILTY CLAY
▨	SAND	▨	CLAYEY SAND
▨	SILTY SAND	▨	COBBLES
▨	SILT	▨	BEDROCK
▨	SANDY SILT		

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC.(CANADA)

PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
GEOLOGICAL CROSS-SECTION A-A'

CONSULTANT

YYYY-MM-DD	2023-02-08
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APPROVED	GS

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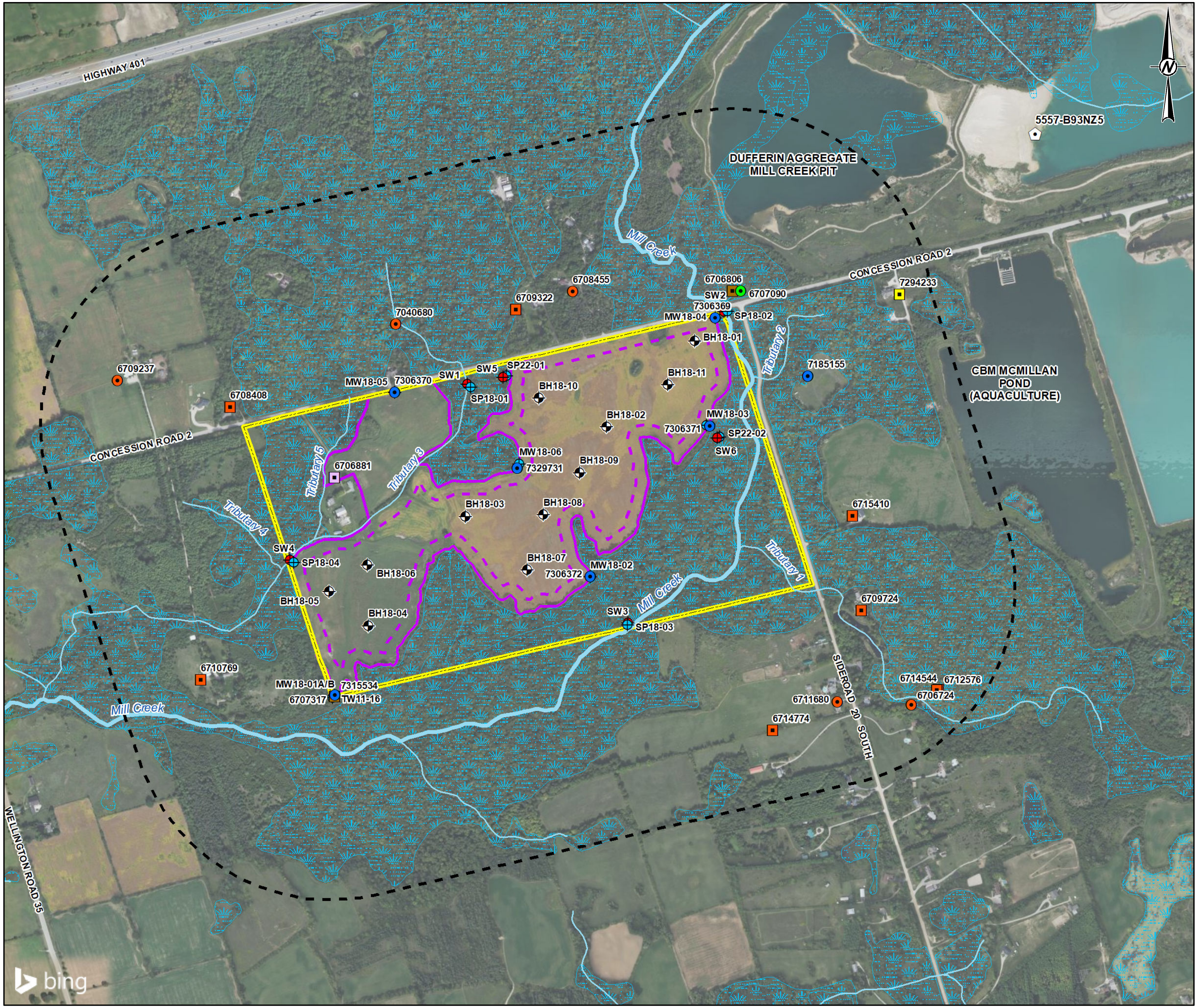

LEGEND

- ⌖ Resource Evaluation Borehole
- ⌖ Groundwater Monitor
- ⌖ Surface Water Monitor
- ⬠ Permit to Take Water Location

Water Well Records

- ■ Bedrock, Domestic
- ■ Bedrock, Domestic (inactive)
- ■ Bedrock, Municipal (inactive)
- ■ Bedrock, Public
- ● Overburden, Domestic
- ● Overburden, Monitoring Well
- ● Overburden, Municipal (inactive)
- — Watercourse
- ▨ Provincially Significant Wetland (Evaluated)
- ▭ Property Boundary
- ▭ Licence Boundary / Site Boundary
- ⬚ Site Boundary 500 m Buffer
- ⬚ Proposed Extraction Area

0 100 200 300 400

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REFERENCE(S)

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CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC.(CANADA)

PROJECT

ABERFOYLE SOUTH PIT EXPANSION

TITLE

MECP WATER WELL RECORDS AND PERMIT TO TAKE WATER

CONSULTANT

wsp

YYYY-MM-DD	2023-02-08
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PREPARED	SO
REVIEWED	GWS
APPROVED	GWS

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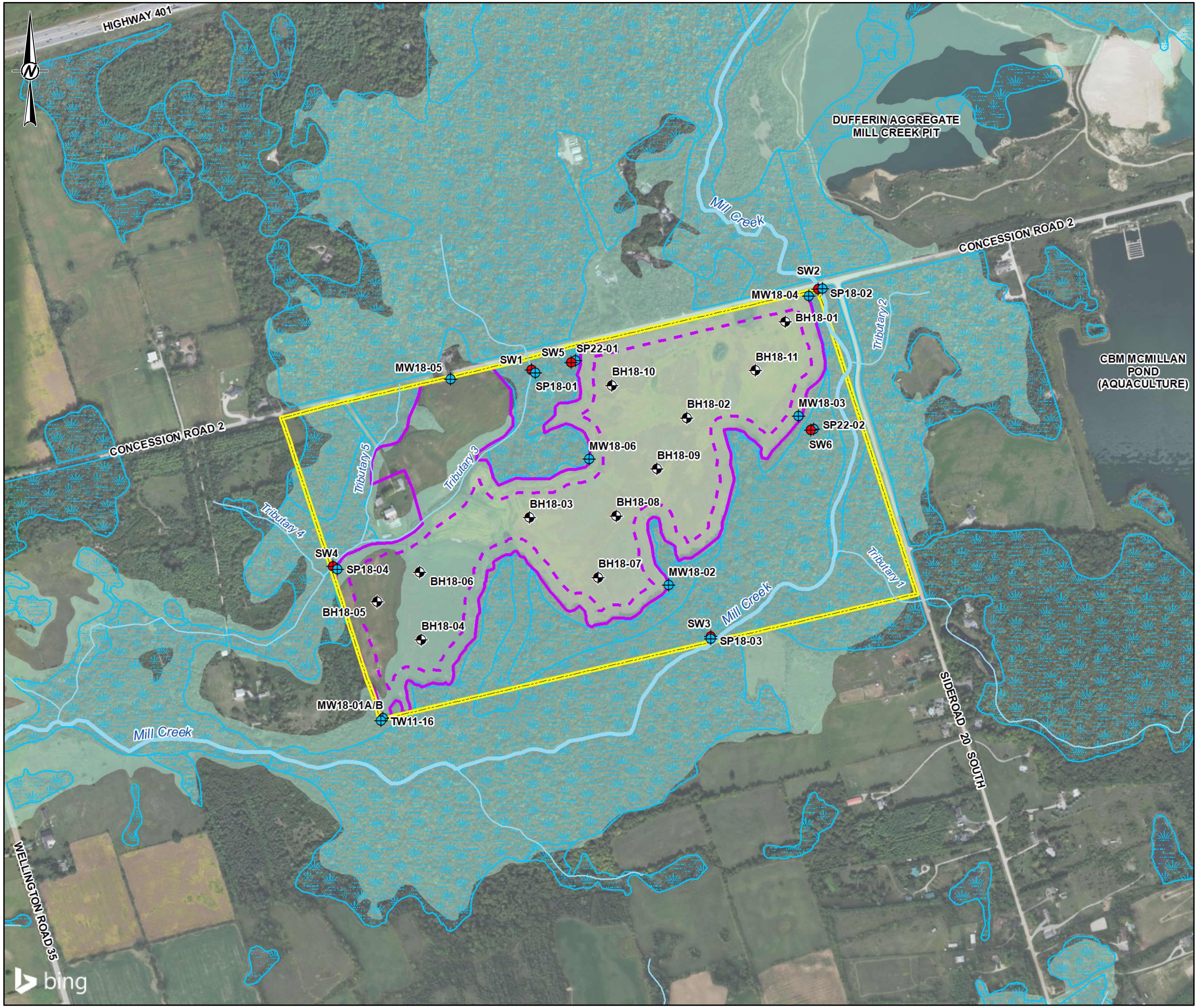

LEGEND

⊕	Resource Evaluation Borehole
⊕	Groundwater Monitor
⊕	Surface Water Monitor
—	Watercourse
▨	Provincially Significant Wetland (Evaluated)
▭	Property Boundary
▭	Licence Boundary / Site Boundary
⬚	Proposed Extraction Area
▢	Floodplain (GRCA)

0 100 200 300 400

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REFERENCE(S)

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CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC.(CANADA)

PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
FLOODPLAIN MAPPING

CONSULTANT
wsp

YYYY-MM-DD	2023-02-08
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1791470	0008	0	6

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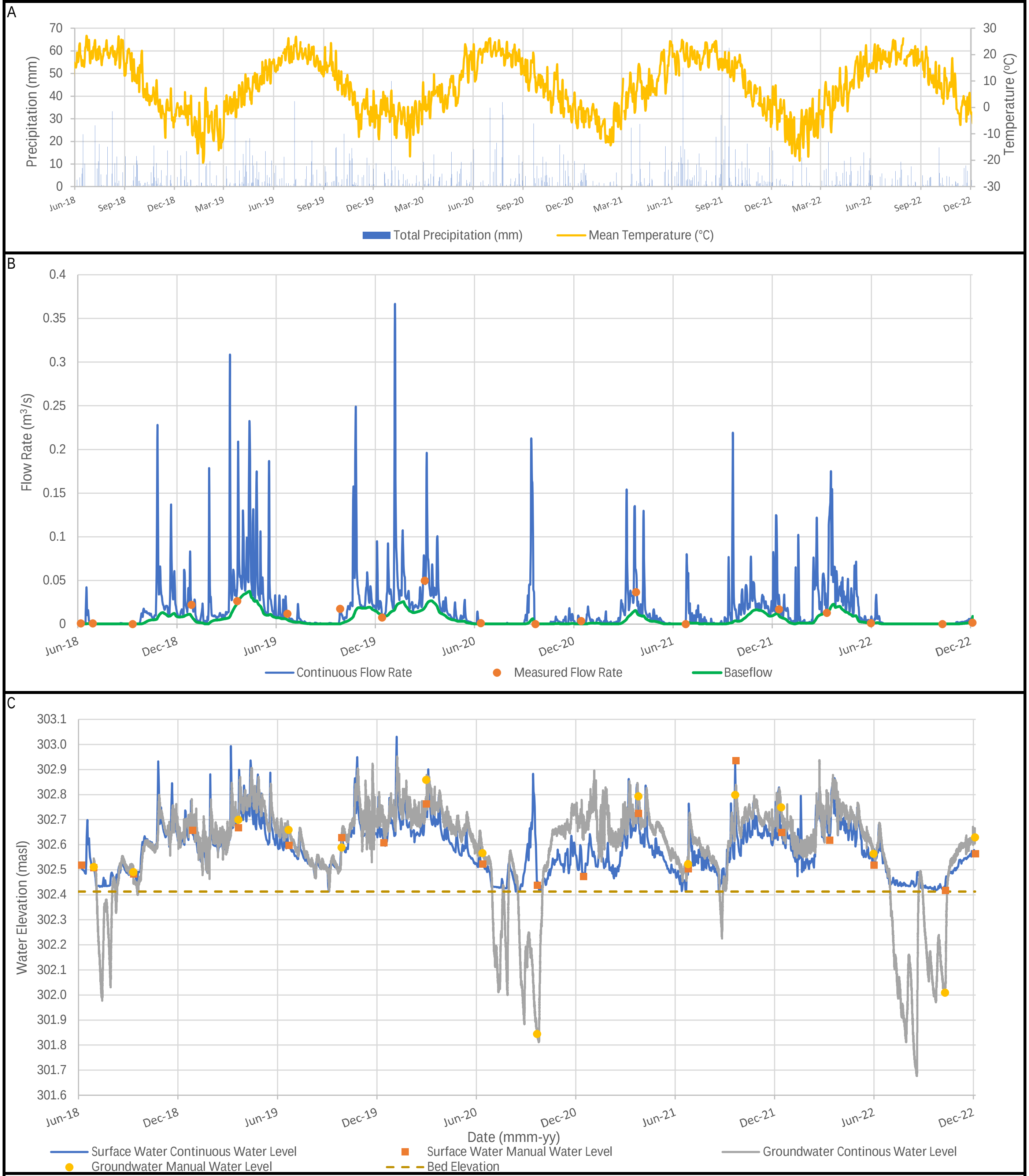
25mm
0

Path: S:\Clients\CBM_Aggregates\Aberfolye_Pit\99_PROJ\1791470_CBM\40_PROD\0008_South_Pit_Extension\1791470-0008-CH-0006.mxd

Water Levels at Tributary #3 (SW-1 and SP18-01) Adjacent to Aberfoyle South Pit Expansion (2018 - 2022)

FIGURE 7



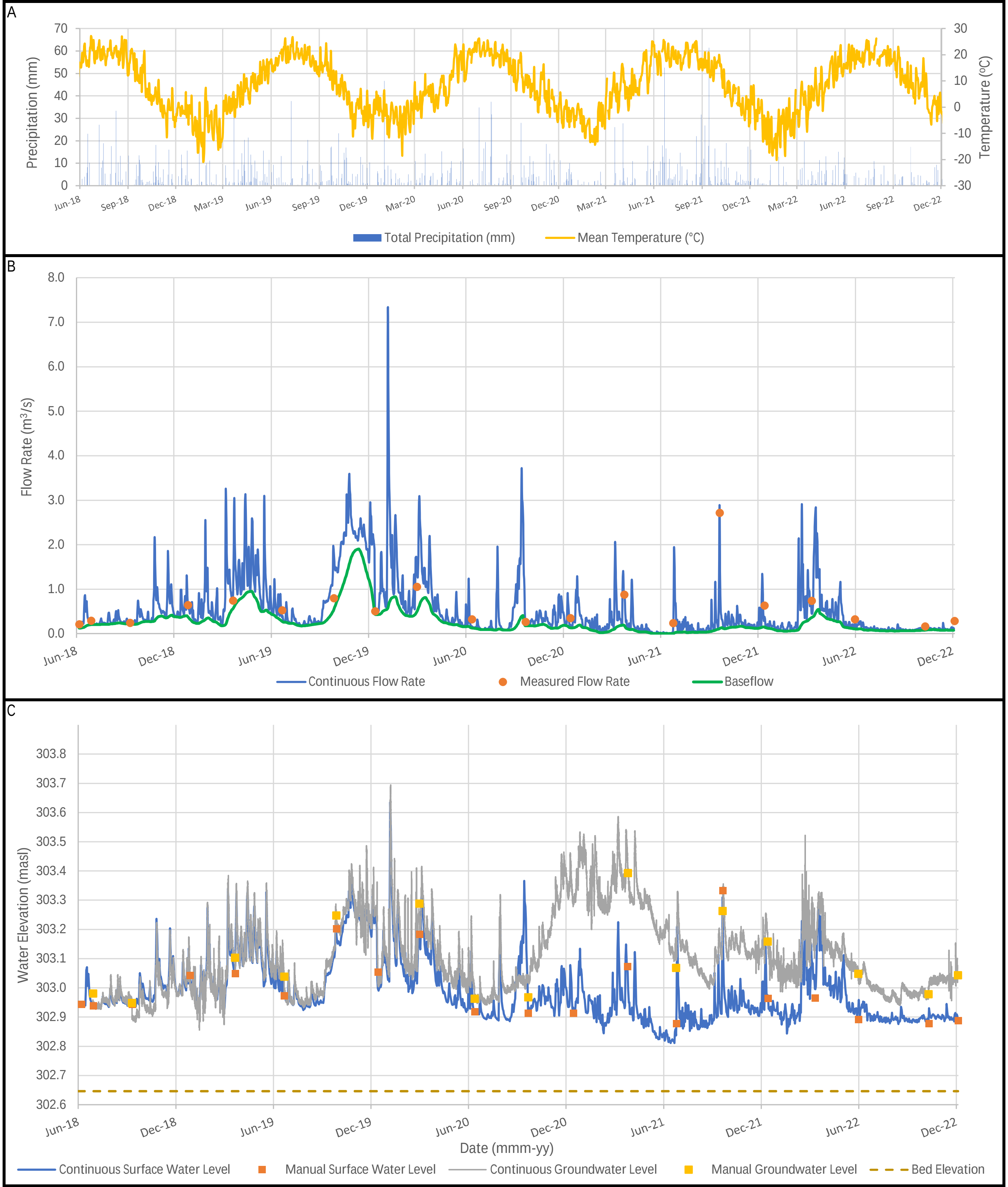
A. Total Daily Precipitation and Mean Daily Temperature (Kitchener/Waterloo, ON, EC Climate ID#6144239) B. Flow rate C. Water Level

PROJECT: 1791470
DATE: October 2023

DRAWN: MR/PGM
CHECK: CDV

Water Levels at Mill Creek (SW-2 and SP18-02) Adjacent to Aberfoyle South Pit Expansion (2018 - 2022)

FIGURE 8



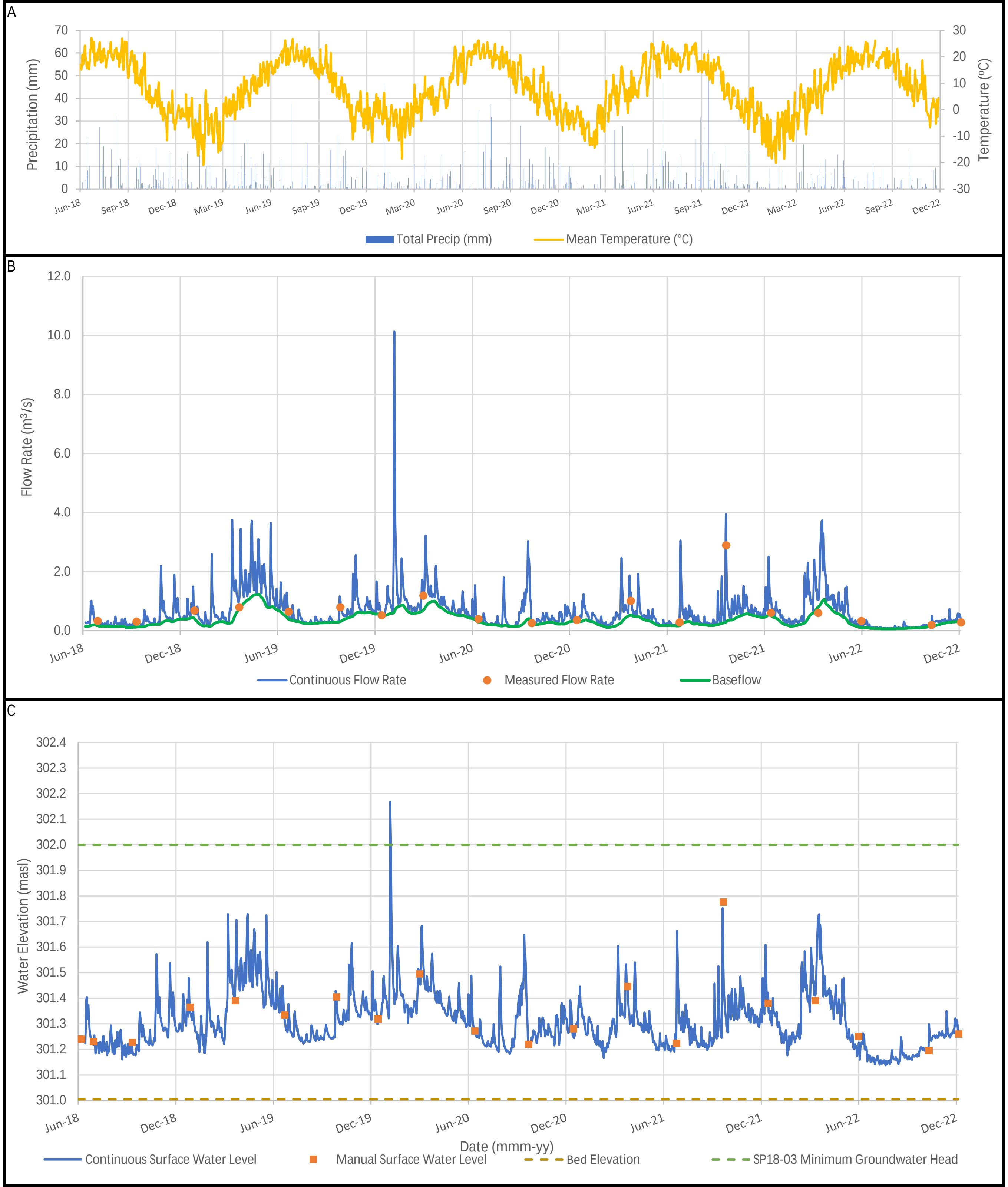
A. Total Daily Precipitation and Mean Daily Temperature (Kitchener/Waterloo, ON, EC Climate ID#6144239) B. Stream Flow C. Water Level

PROJECT: 1791470
DATE: October 2023

DRAWN: MR/PGM
CHECK: CDV

Water Levels at Mill Creek (SW-3 and SP18-03) Adjacent to Aberfoyle South Pit Expansion (2018 - 2022)

FIGURE 9



A. Total Daily Precipitation and Mean Daily Temperature (Kitchener/Waterloo, ON, EC Climate ID#6144239) B. Stream Flow C. Water Level

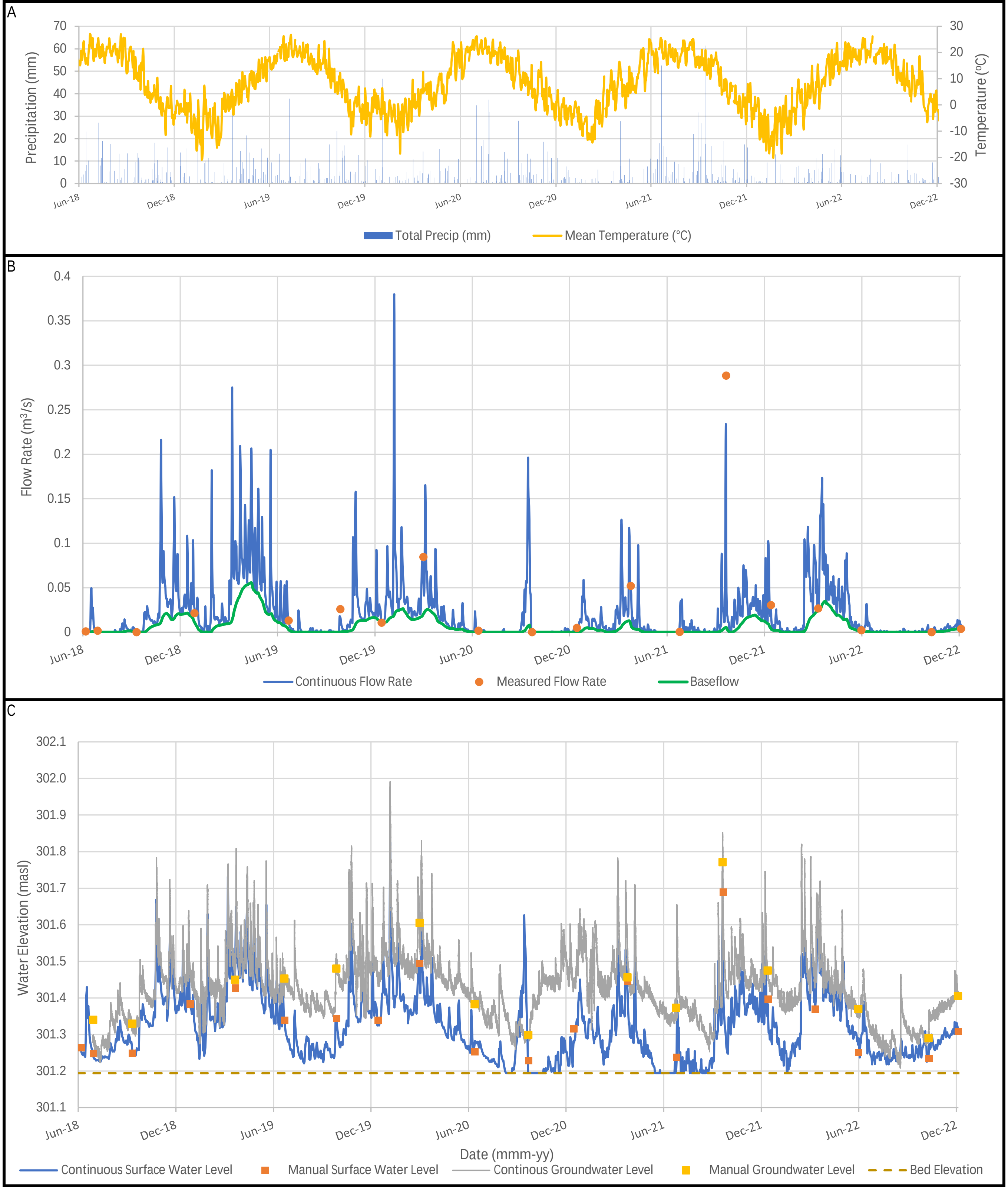
PROJECT: 1791470
DATE: October 2023

wsp

DRAWN: MR/PGM
CHECK: CDV

Water Levels at Tributary #3 (SW-4 and SP19-04) Adjacent to Aberfoyle South Pit Expansion (2018 - 2022)

FIGURE 10



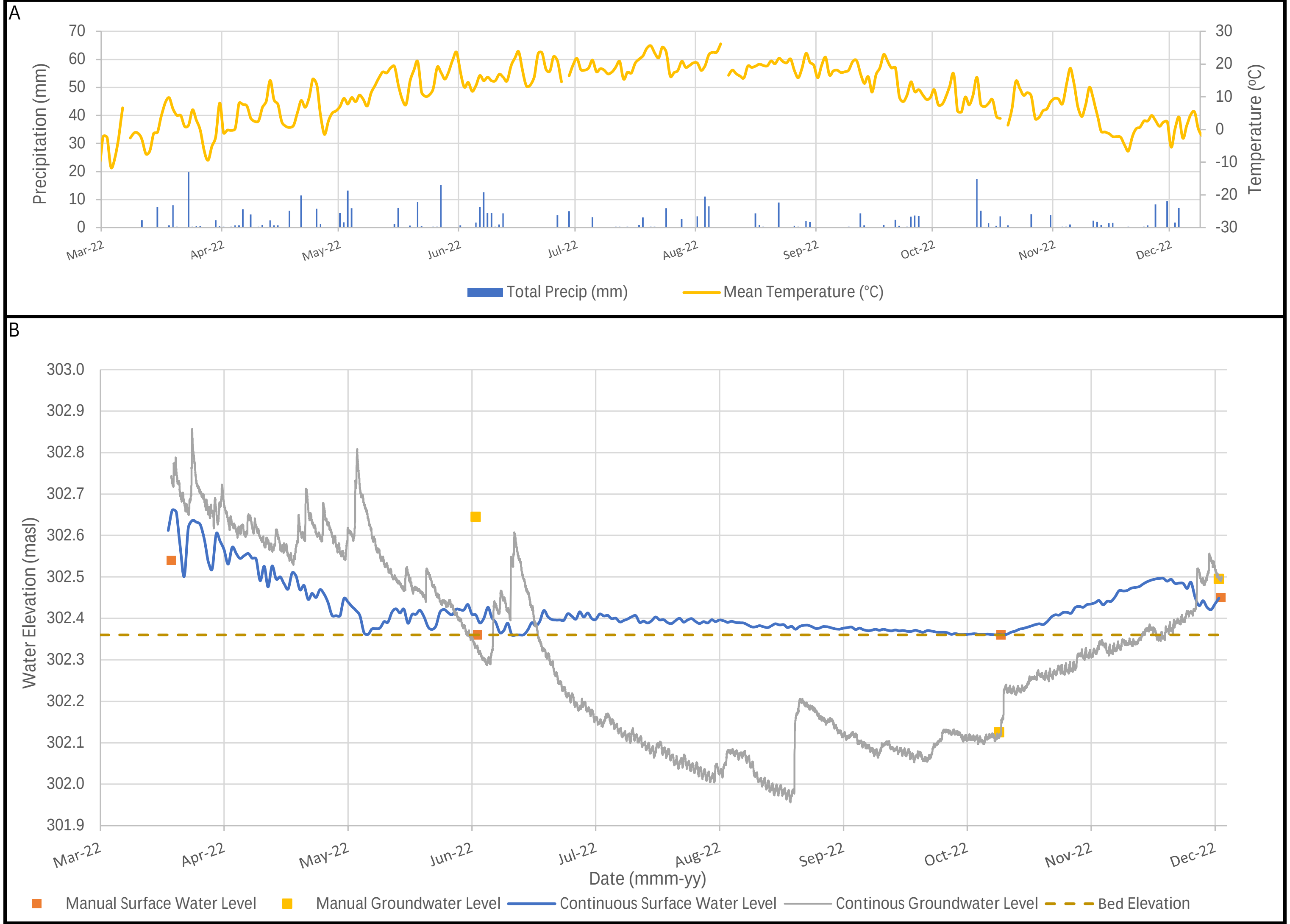
A. Total Daily Precipitation and Mean Daily Temperature (Kitchener/Waterloo, ON, EC Climate ID#6144239) B. Stream Flow C. Water Level

PROJECT: 1791470
DATE: October 2023

DRAWN: MR/PGM
CHECK: CDV

Water Levels within the Mill Creek-Puslinch PSW (SW-5 and SP22-01) Adjacent to Aberfoyle South Pit Expansion (2022)

FIGURE 11



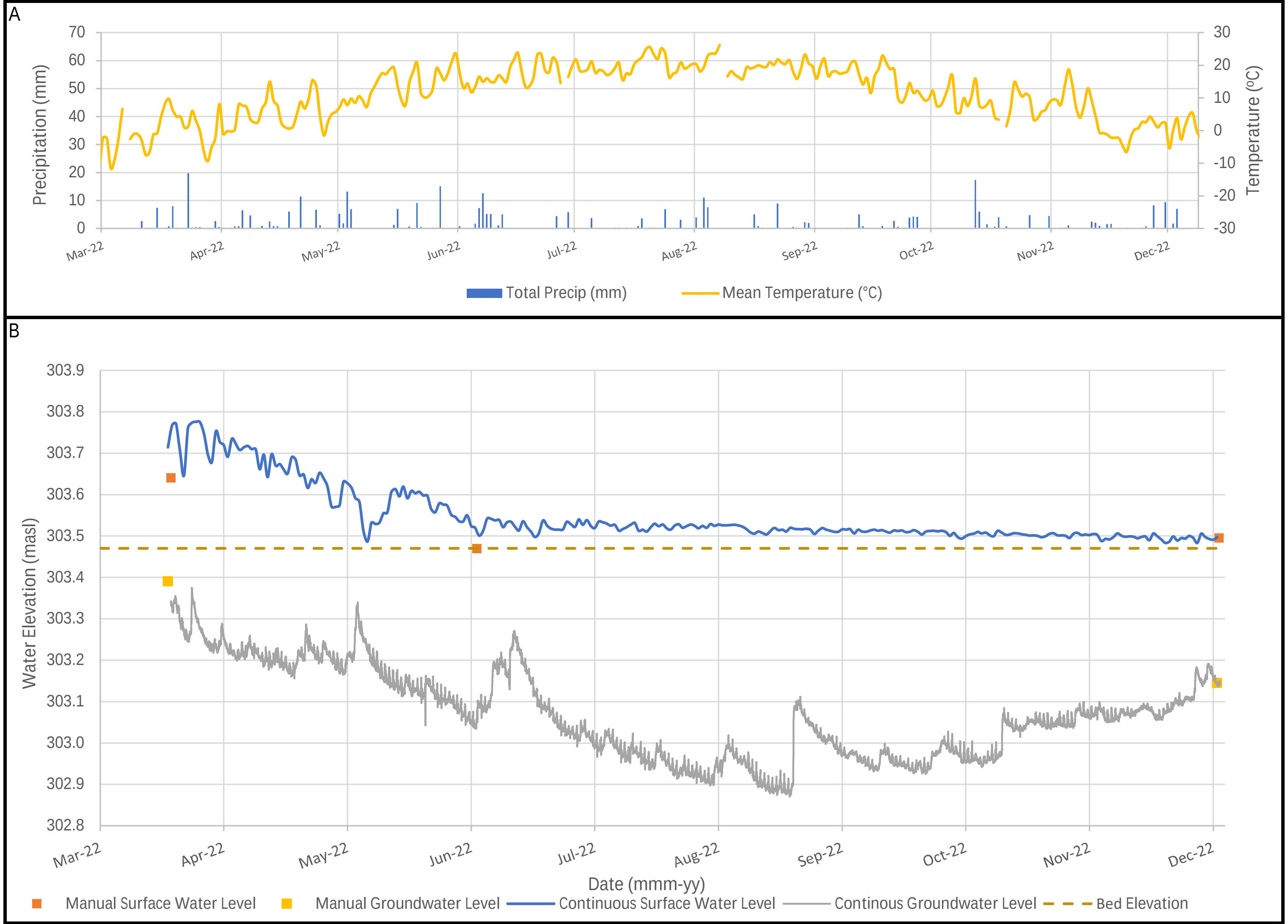
A. Total Daily Precipitation and Mean Daily Temperature (Kitchener/Waterloo, ON, EC Climate ID#6144239) B. Water Level

PROJECT: 1791470
DATE: October 2023

DRAWN: MR/PGM
CHECK: CDV

Water Levels Within the Mill Creek-Puslinch PSW (SW-6 and SP22-02) Adjacent to Aberfoyle South Pit Expansion (2022)

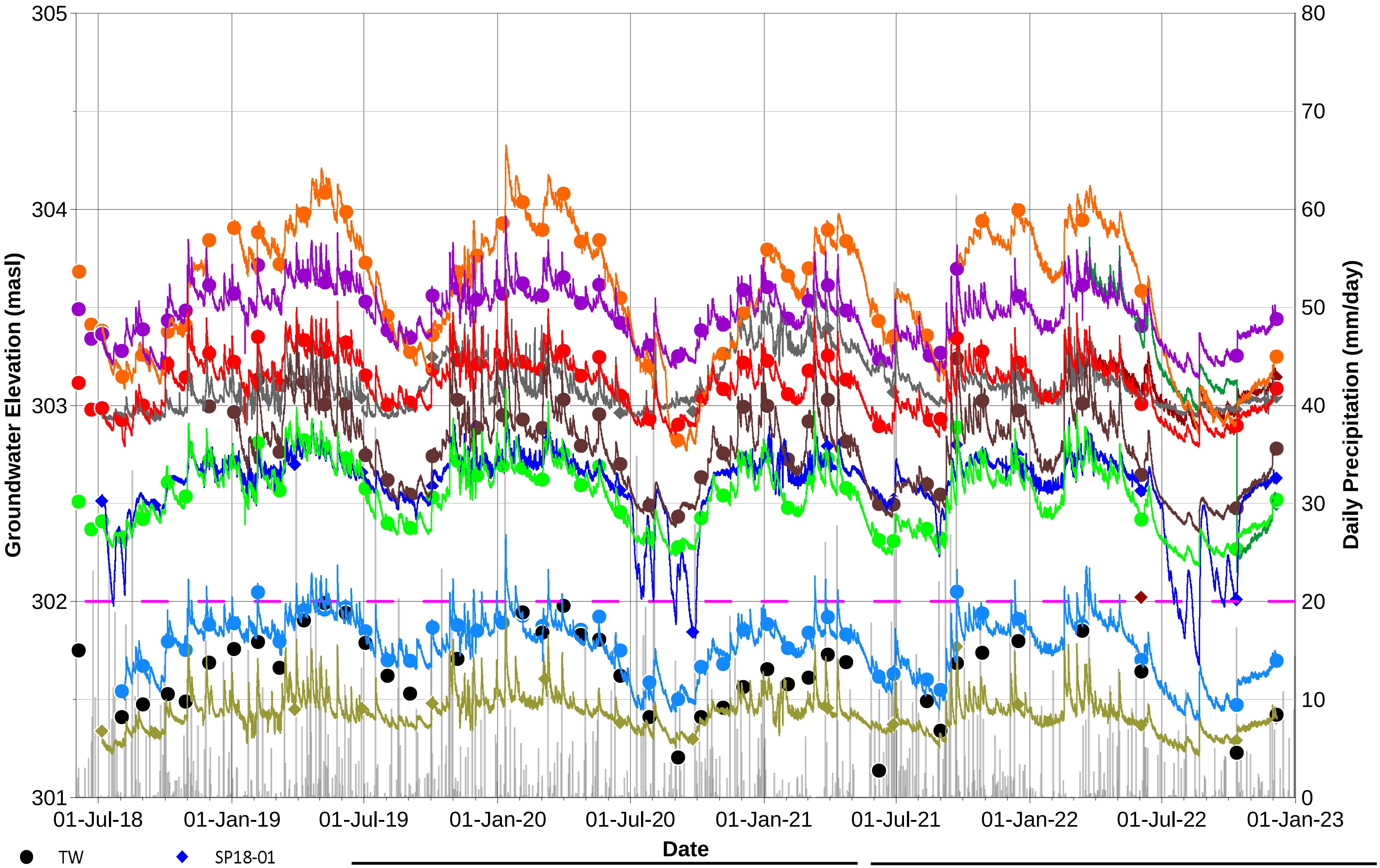
FIGURE 12



A. Total Daily Precipitation and Mean Daily Temperature (Kitchener/Waterloo, ON, EC Climate ID#6144239) B. Water Level

PROJECT: 1791470
DATE: October 2023

DRAWN: MR/PGM
CHECK: CDV



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. SP18-03 is a minimum head.

DATE	2023-Jan-26
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

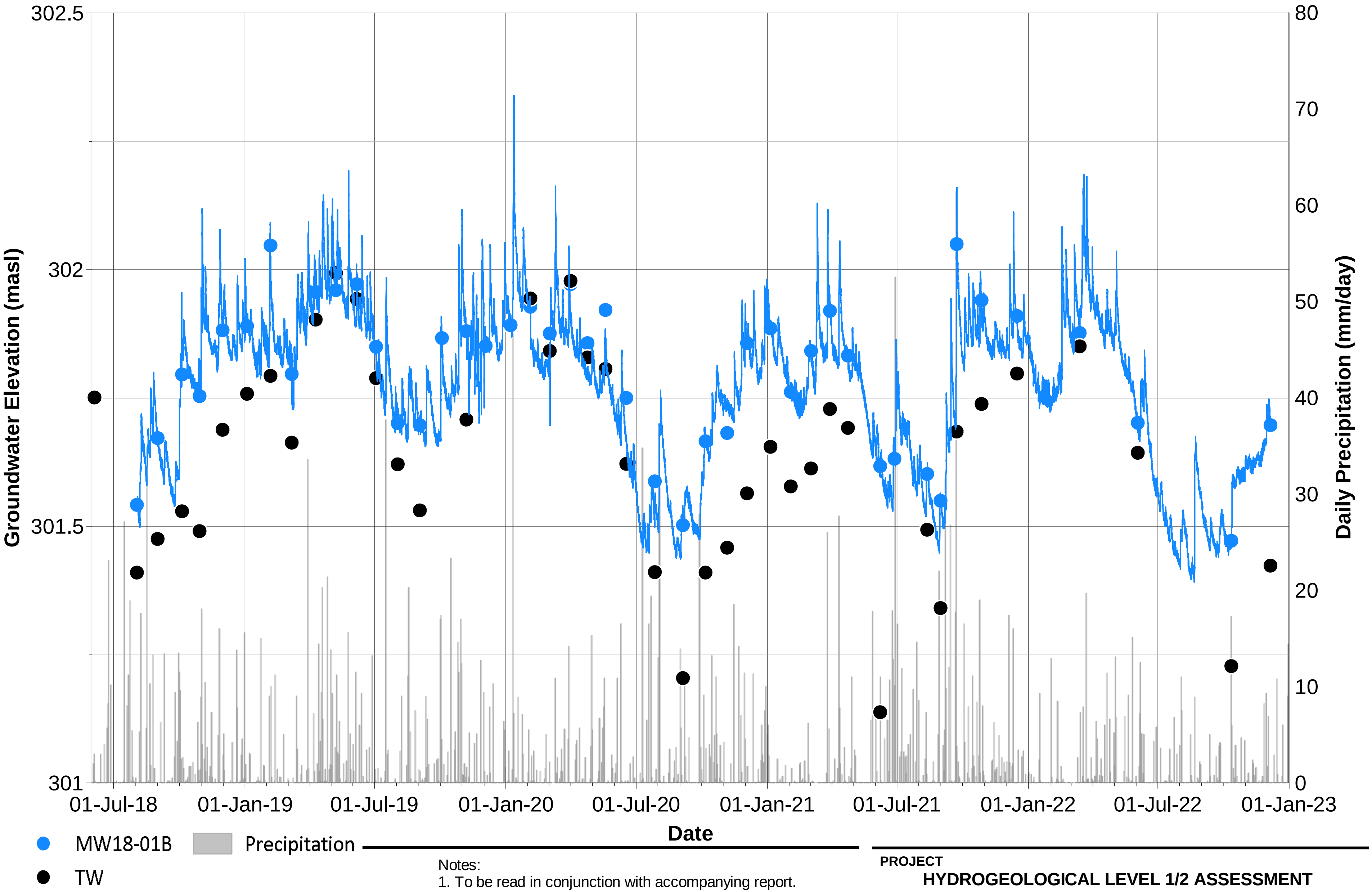
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

GROUNDWATER ELEVATION HYDROGRAPHS

PROJECT NO.	**REV**	**FIGURE**
1791470		13



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).

DATE 2023-Jan-26
DESIGN PGM
REVIEW GWS
APPROVED GWS

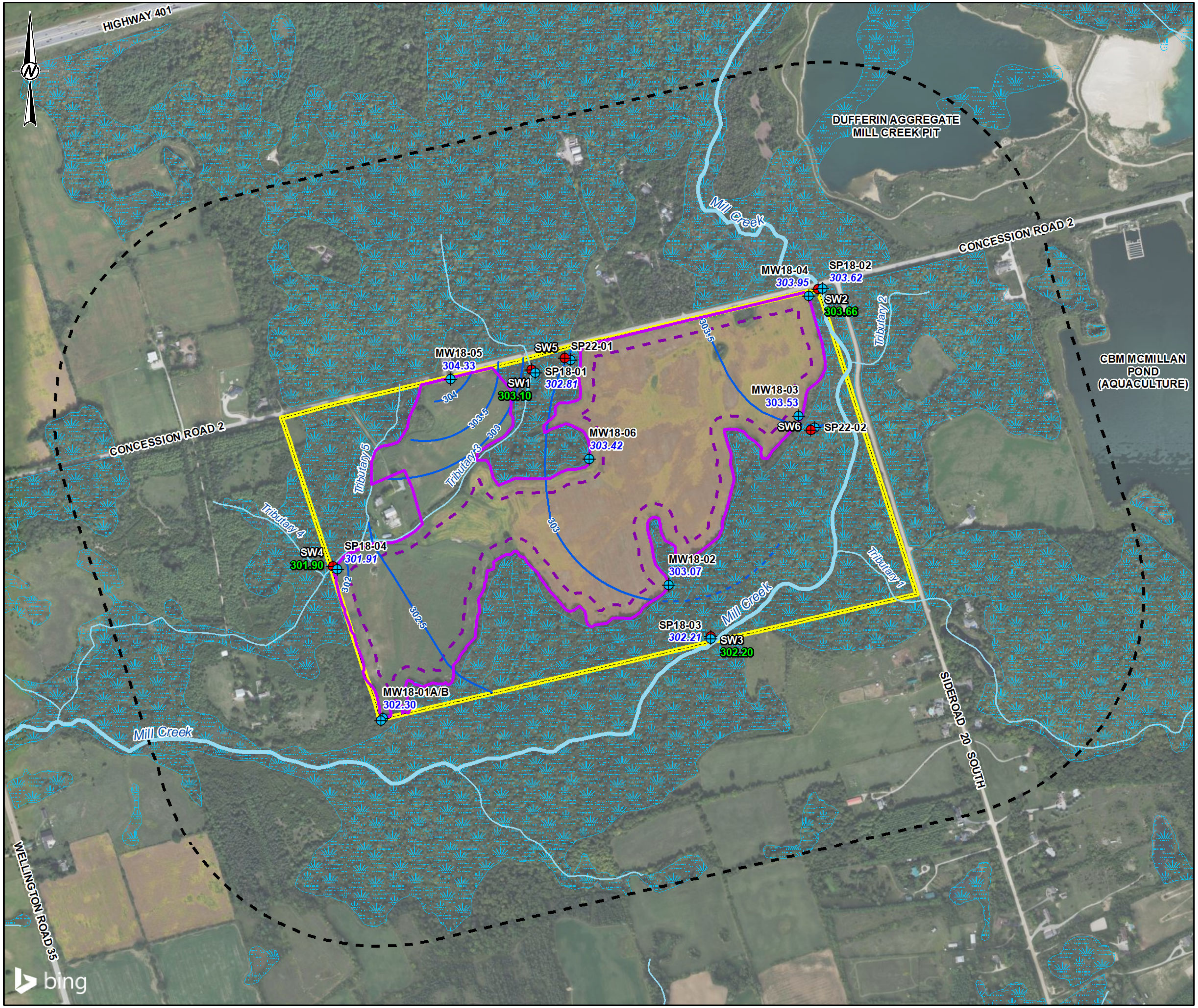
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

OVERBURDEN - BEDROCK GROUNDWATER ELEVATION HYDROGRAPHS

PROJECT NO. 1791470
REV
FIGURE 14



LEGEND

- ⊕ Groundwater Monitor
- ● Surface Water Monitor
- Watercourse
- Inferred Water Table Elevation Contours
- Water Table Elevation Contours
- Provincially Significant Wetland (Evaluated)
- Property Boundary
- Property Boundary 500 m Buffer
- Proposed Extraction Area
- Licence Boundary / Site Boundary
- *303.65* Groundwater elevations observed at January 12, 2020.
- *303.65* Groundwater head above ground surface
- **303.66** Surface water elevations observed at January 12, 2020.

0 100 200 300 400

1:8,500 METRES

REFERENCE(S)

1. GROUNDWATER LEVATIONS SELECTED MARCH 12, 2020.
2. BASEDATA: MNRF LIO, OBTAINED 2019
3. IMAGERY SOURCE: © 2023 MICROSOFT CORPORATION © 2022 MAXAR ©CNES (2022) 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), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY IMAGE SEPTEMBER 2016
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
INFERRED HIGH WATER TABLE ELEVATION

CONSULTANT
wsp

YYYY-MM-DD	2022-02-12
DESIGNED	SO/PGM
PREPARED	SO
REVIEWED	GWS
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1791470	0008	0	**15**

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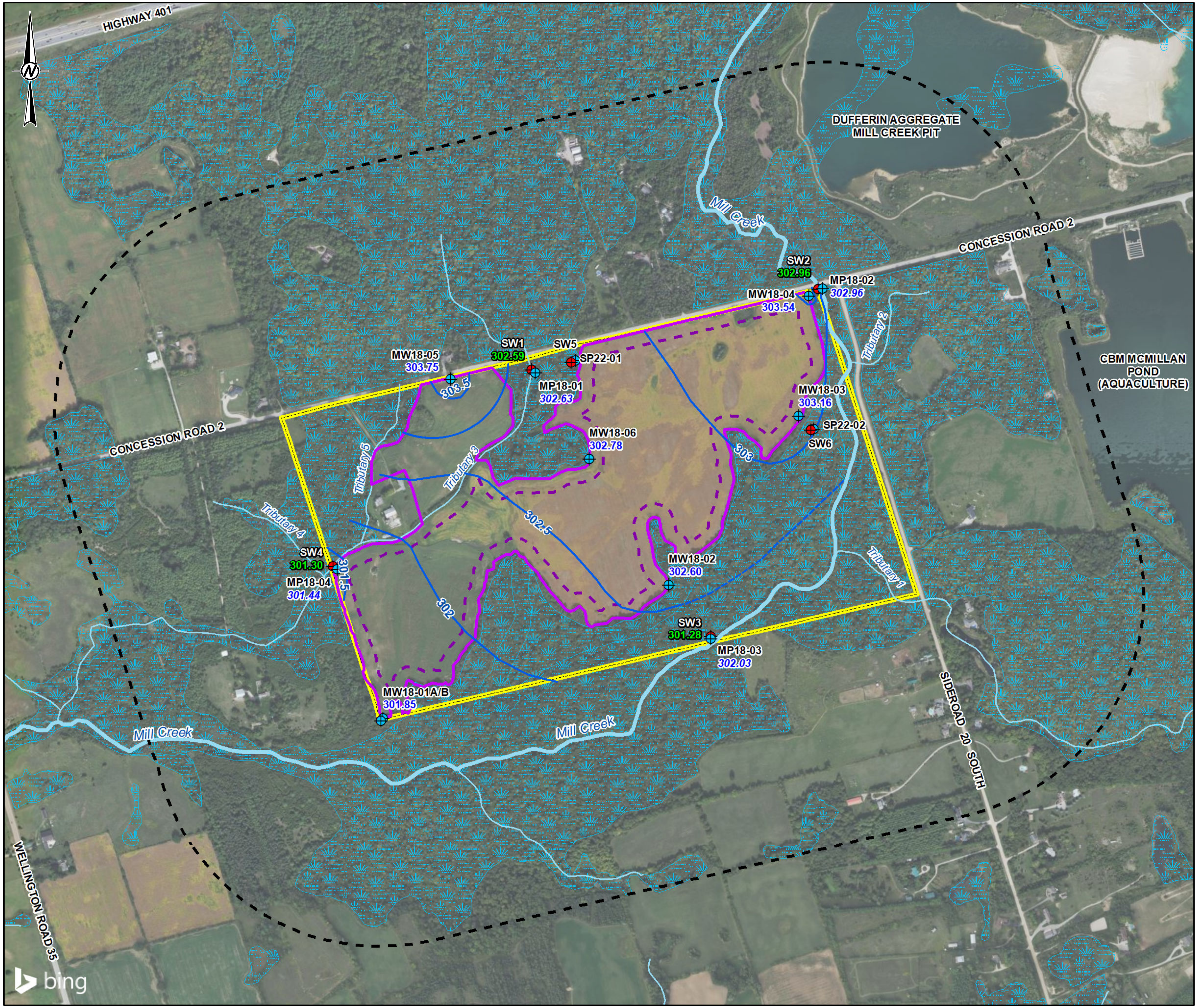

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LEGEND

- ⊕ Groundwater Monitor
- ⊕ Surface Water Monitor
- — Watercourse
- - - Inferred Water Table Elevation Contours
- — Water Table Elevation Contours
- ▨ Provincially Significant Wetland (Evaluated)
- ▭ Property Boundary
- ▭ Licence Boundary / Site Boundary
- ▭ Property Boundary 500 m Buffer
- ▭ Proposed Extraction Area
- 303.65 Groundwater elevations observed at July 1, 2019.
- *303.65* Groundwater head above ground surface
- **303.66** Surface water elevations observed at July 1, 2019.

0 100 200 300 400

1:8,500 METRES

REFERENCE(S)

1. GROUNDWATER LEVATIONS SELECTED MARCH 12, 2020.
2. BASEDATA: MNRF LIO, OBTAINED 2019
3. IMAGERY SOURCE: 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), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
© 2023 MICROSOFT CORPORATION © 2023 MAXAR ©CNES (2023) DISTRIBUTION AIRBUS DS IMAGE SEPTEMBER 2016
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
ABERFOYLE SOUTH PIT EXPANSION

TITLE
INFERRED TYPICAL WATER TABLE ELEVATION

CONSULTANT
wsp

YYYY-MM-DD	2023-11-23
DESIGNED	SO/PGM
PREPARED	SO
REVIEWED	GWS
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1791470	0008	0	16

25mm

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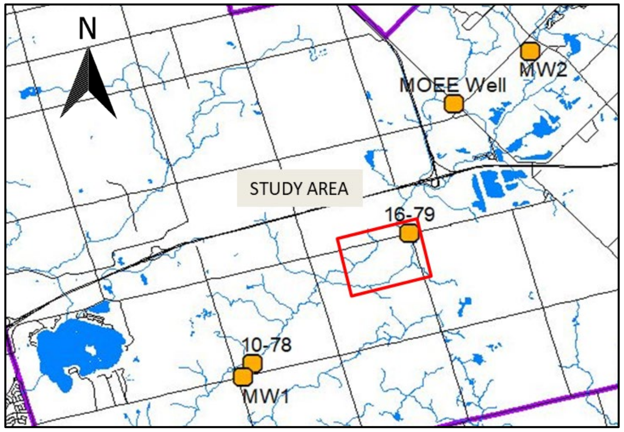
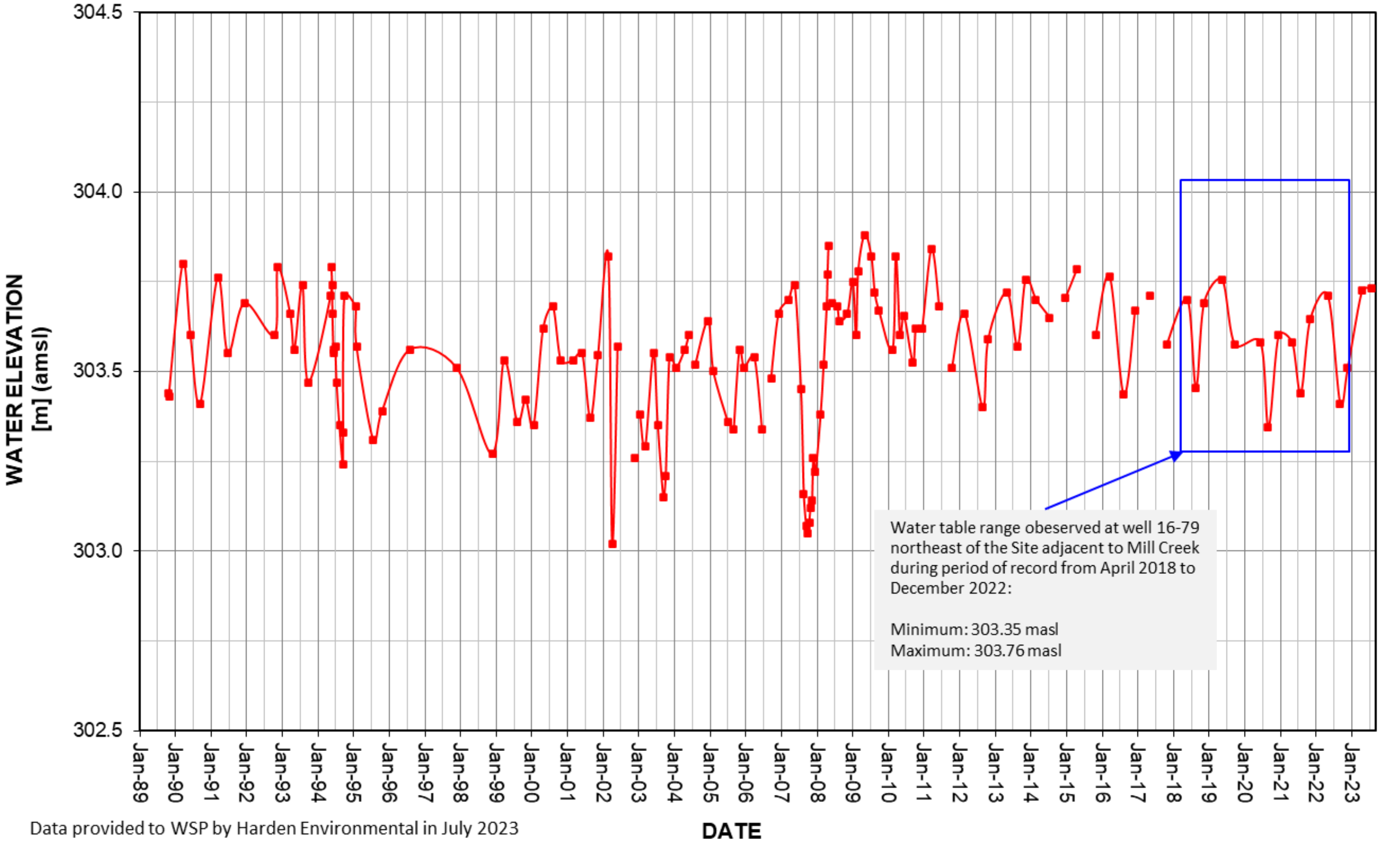


Puslinch Monitoring Well 16-79



Water table range obeserved at well 16-79 northeast of the Site adjacent to Mill Creek during period of record from April 2018 to December 2022:

Minimum: 303.35 masl
Maximum: 303.76 masl

Data provided to WSP by Harden Environmental in July 2023

CLIENT
CBM Aggregates, a division of St. Marys Cement Inc. (Canada)

PROJECT
Aberfoyle South Pit Expansion - Water Report

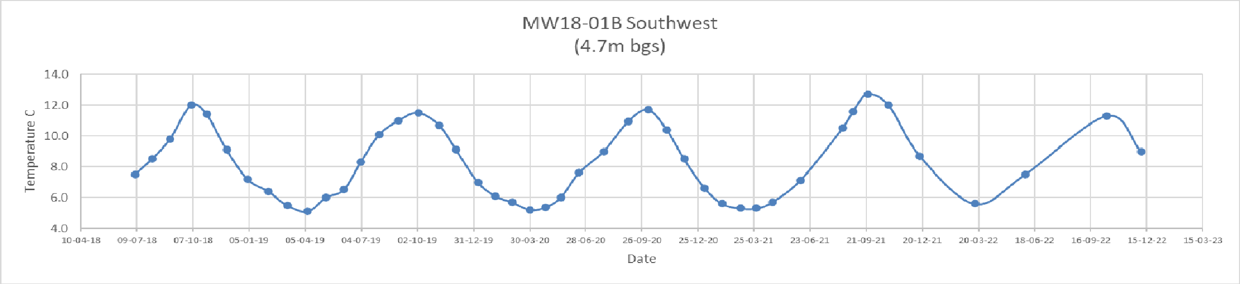
CONSULTANT
wsp

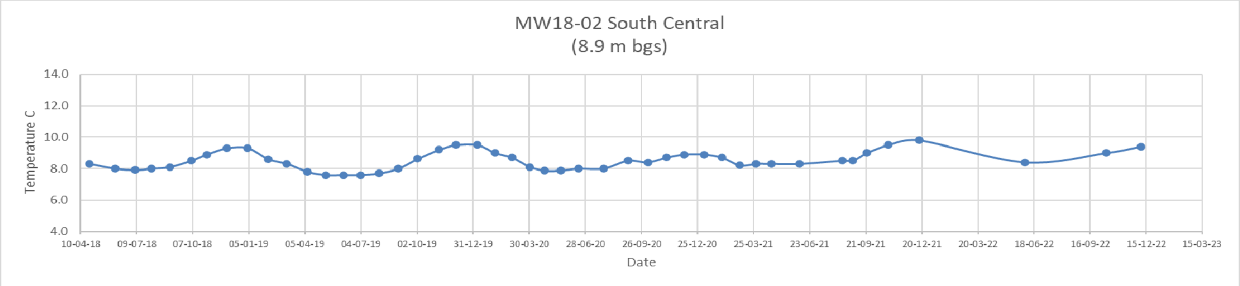
YYYY-MM-DD	2023-10-16
PREPARED	N/A
DESIGN	N/A
REVIEW	GWS
APPROVED	GWS

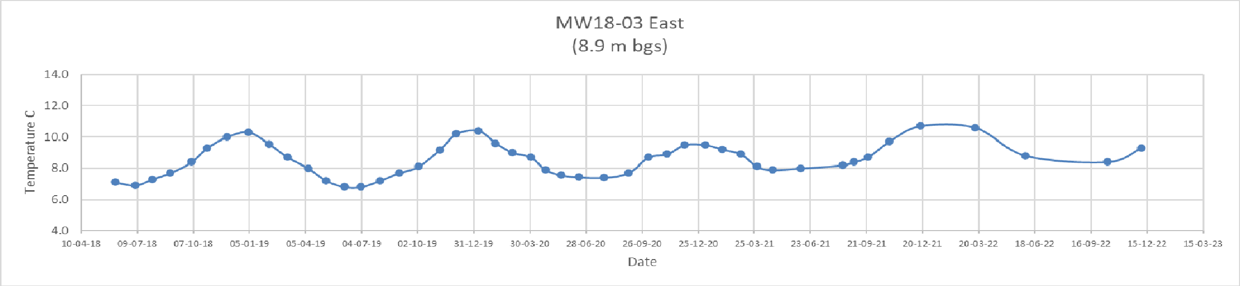
TITLE
Historic Groundwater Levels in the Overburden Aquifer at Monitoring Well 16-79
Located Northeast of the Aberfoyle South Pit Expansion Site

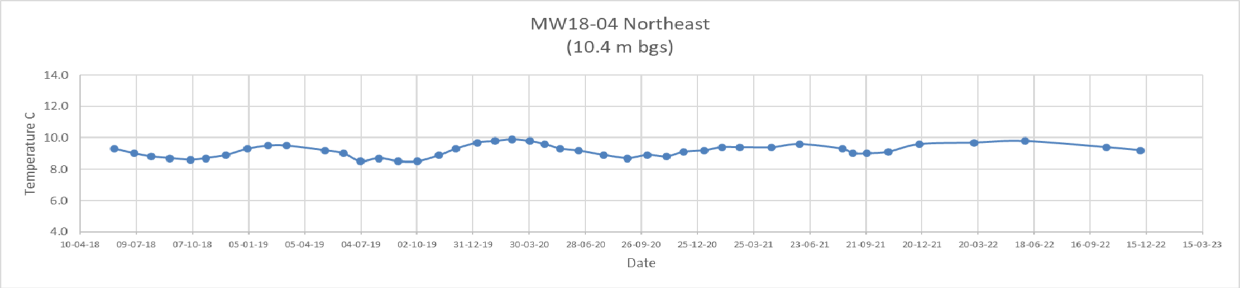
PROJECT No. **1791470 (4000)**
Rev. **A**
17 FIG.

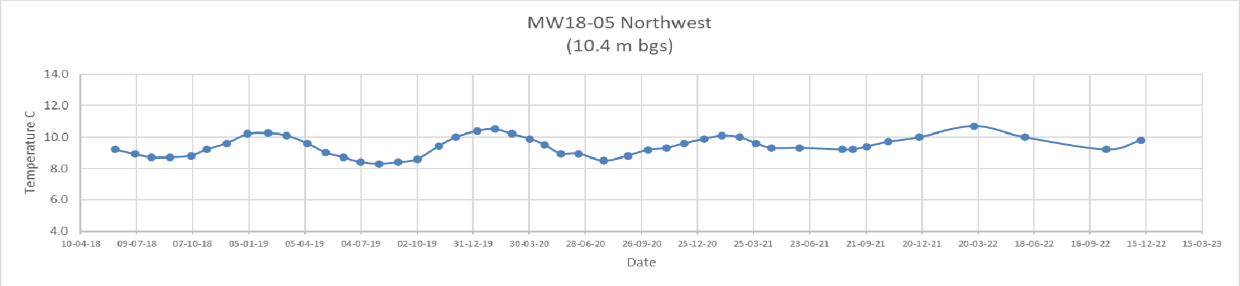
Figure 18 - Groundwater Temperature Monitoring Results
Aberfoyle South Pit Expansion

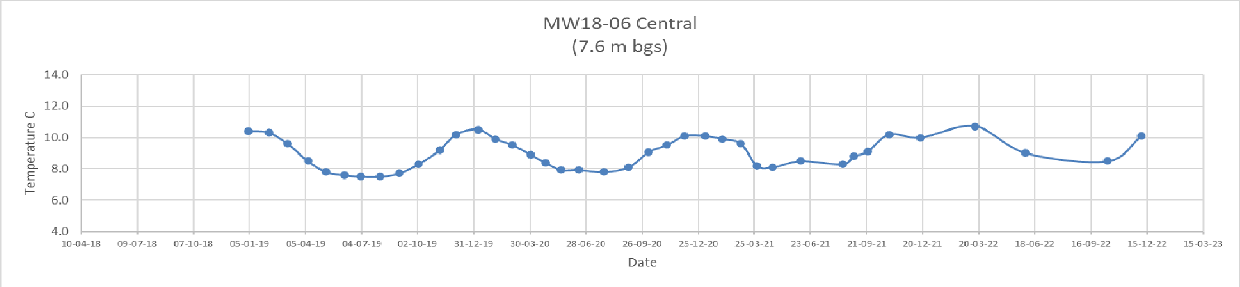








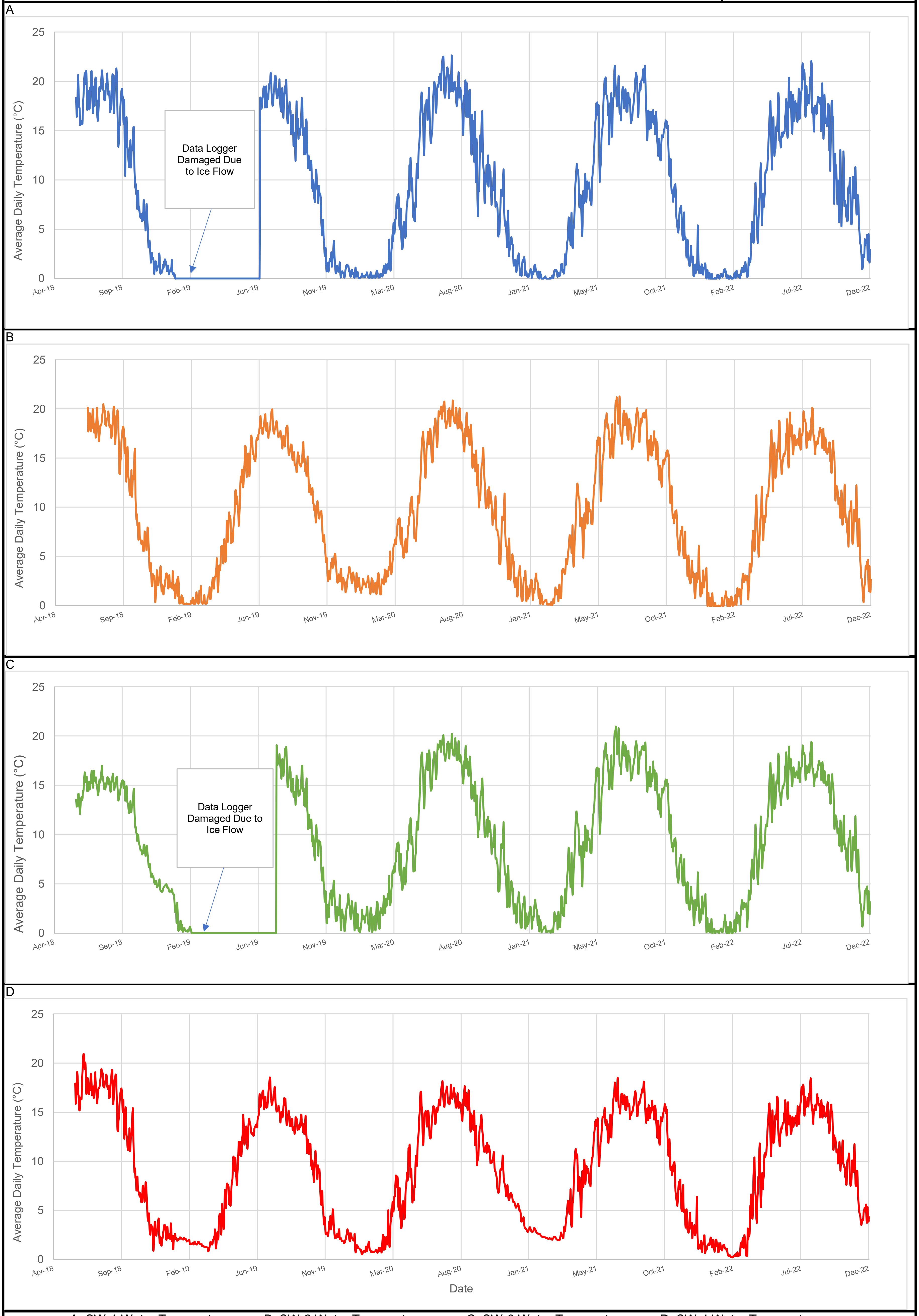




Prepared by: PGM
Checked by: GWS

Water Temperatures at Tributary #3 (SW-1 & SW4) and Mill Creek (SW-2 & SW-3) Adjacent to Aberfoyle South Pit Expansion (2018 - 2022)

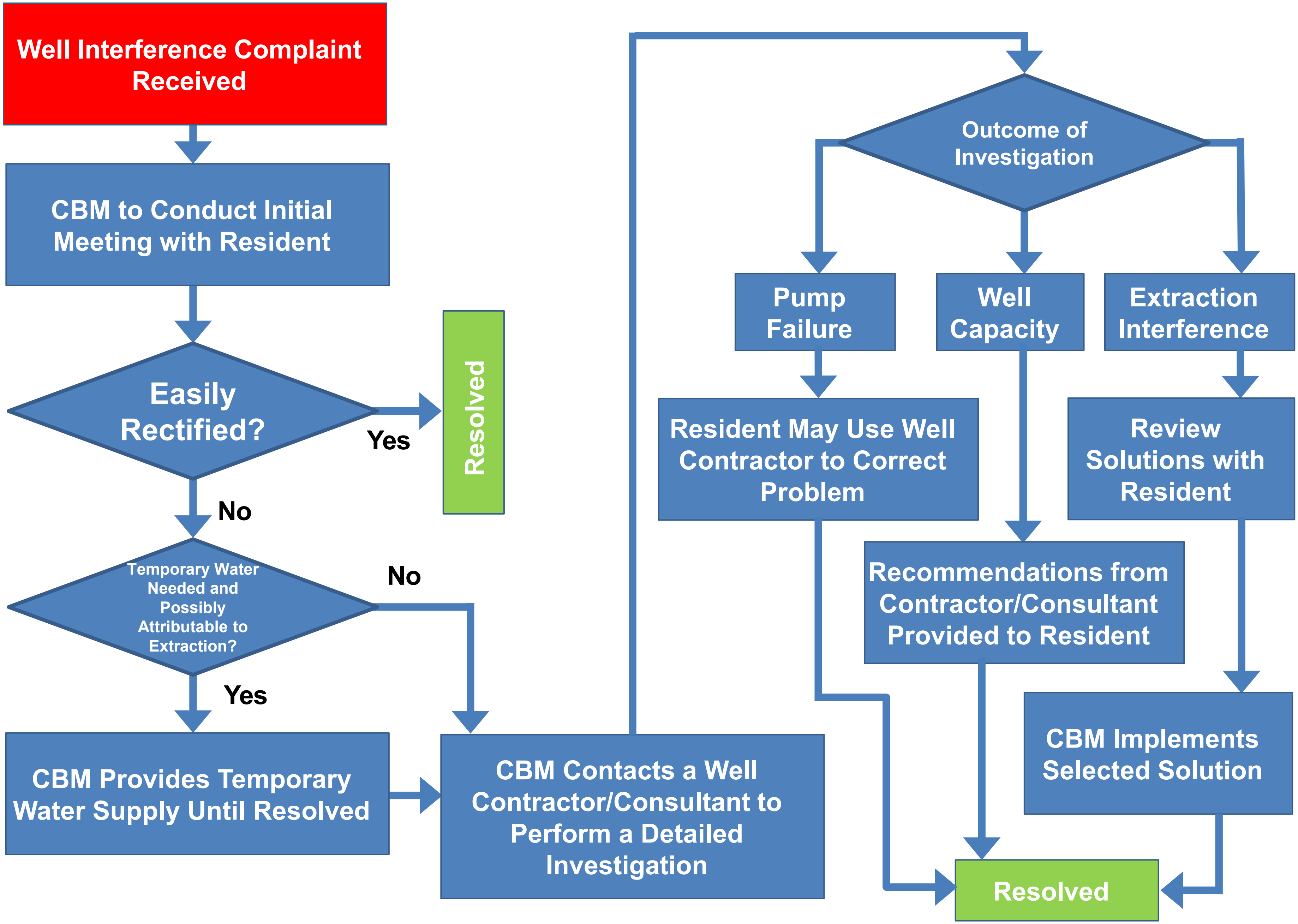
FIGURE 19



A. SW-1 Water Temperature B. SW-2 Water Temperature C. SW-3 Water Temperature D. SW-4 Water Temperature

PROJECT: 1791470
DATE: November 2023

DRAWN: MR
CHECK: CDV



CLIENT

CBM AGGREGATES (CBM), A DIVISION OF ST. MARYS CEMENT INC. (CANADA)

CONSULTANT

YYYY-MM-DD 2023-05-24
PREPARED PGM
DESIGN PGM
REVIEW GWS
APPROVED GWS

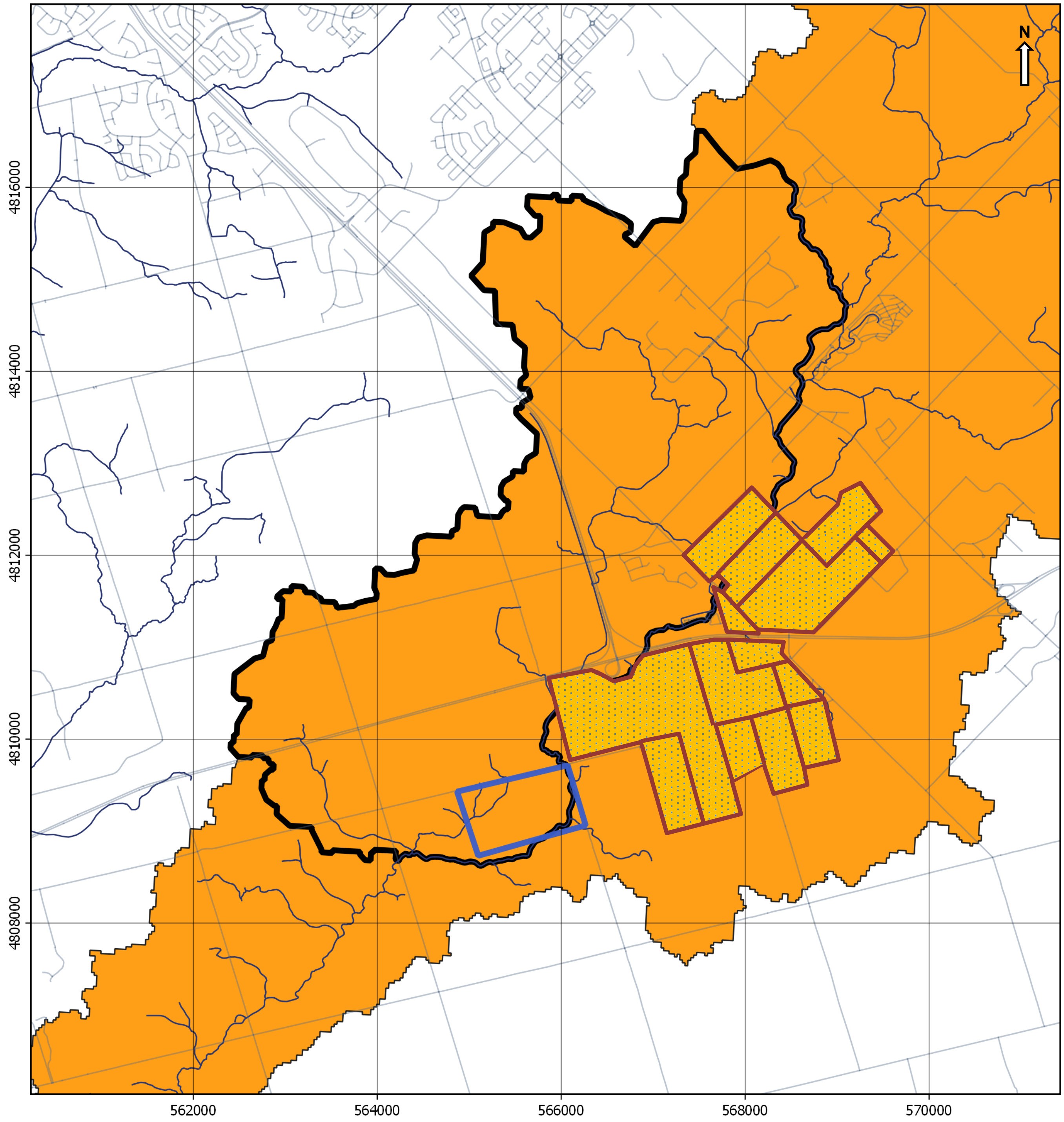
PROJECT

Aberfoyle South Pit Expansion

TITLE

Well Interference Complaint Response Flow Chart

PROJECT No.	PHASE	Rev.	FIGURE
1791470	**4000**	**A**	**20**



LEGEND

- Rivers / Streams
- Roads
- ▭ Model Boundary
- ▭ Study Area
- ■ Mill Creek Catchment
- ▨ Existing Aggregate Operation

NOTE

CLIENT
CBM Aggregates

PROJECT
Aberfoyle South Pit Expansion
Water Report Level 1/2

CONSULTANT
wsp

YYYY-MM-DD	2023-02-10
PREPARED	SK
DESIGN	SK
REVIEW	JR
APPROVED	GS

TITLE
Existing Aggregate Operations
Proximal to the Study Area

PROJECT No.	Rev.	FIG.
1791470	**B**	**21**

APPENDIX A

Terms of Reference

TECHNICAL MEMORANDUM

DATE September 7, 2023 **Project No.** 1791470

TO CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada)

FROM Heather Melcher **EMAIL heather.melcher@wsp.com**

TERMS OF REFERENCE FOR NATURAL ENVIRONMENT AND WATER RESOURCES TECHNICAL STUDIES FOR THE CBM ABERFOYLE SOUTH PIT EXPANSION, TOWNSHIP OF PUSLINCH, ONTARIO

WSP Canada Inc. (WSP; formerly Golder Associates Ltd. [Golder]) has been retained by CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada) to carry out technical studies in support of Planning Act applications to the Township of Puslinch and the County of Wellington and an application to the Ministry of Natural Resources and Forestry (MNRF) for a Class “A” licence (Pit Below Water) under the *Aggregate Resources Act* (ARA) for the property located at 6947 Concession Road 2, Township of Puslinch, Wellington County, Ontario (the site; Figure 1). The site will be an expansion to CBM’s existing Aberfoyle South Pit.

The technical studies for the ARA licence application and Planning Act applications will include a number of disciplines, including hydrogeology, surface water and natural environment.

The technical requirements of these supporting studies are outlined in the County of Wellington Official Plan (2021) and the Aggregate Resources of Ontario Provincial Standards: A Compilation of the Four Standards Adopted by Ontario Regulation 244/97 Under the Aggregate Resources Act (2020). Golder’s proposed approach to the project has been developed to meet these requirements.

The above studies will be integrated to ensure that any key linkages between the hydrogeological and hydrological components, and the receiving natural environment features, are holistically evaluated to support the completion of the potential impact assessments for the proposed expansion of the pit and the development of appropriate mitigation measures, if required.

Integrated Water Resource Assessment

The following provides the proposed scope of the water resources program consisting of hydrogeology (groundwater) and hydrology (surface water) components.

Hydrogeology

The program for hydrogeology consists of the following:

- A review of publicly available data and reports relevant to the Site and subwatershed.
- A review of the Grand River Source Protection Plan (GRCA 2021) and any other applicable policies.

- A field investigation program that includes:
    - Borehole drilling, grain size analysis and monitoring well installation (see Figure 1)
    - Baseline groundwater quality monitoring (general water quality parameters including major ions, metals, and petroleum hydrocarbons)
    - Hydraulic conductivity testing (single well response tests) of the monitoring wells installed as part of the field program
    - Groundwater level and temperature monitoring (dataloggers to record water level and temperature hourly and downloaded quarterly)
- A review of local groundwater users based on the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) and Permit To Take Water (PTTW) databases.
- A private well survey of properties surrounding the site was originally planned for 2020 or 2021. The purpose of such a survey was to supplement the MECP WWIS information and “ground truth” the current condition of neighbouring resident’s water supply wells. Activities would have included door-to-door visits and subsequent interactions between field staff and residents. Participation would be entirely voluntary. However, as a result of ongoing COVID-19 concerns this task has been postponed for the time being. It is proposed that this activity be completed at later date prior to any aggregate extraction taking place on the site.
- In conjunction with surface water studies, the development of a Site water budget for Existing, Operations and Rehabilitated Scenarios to determine pre-and post-development surplus, runoff, and infiltration rates.
- The construction and calibration of a 3D numerical groundwater flow model based on the “Tier 3 Model” with high resolution refinement of the model mesh within the immediate area of the site, and subsequent predictive simulations to estimate potential water flow impacts of the proposed below-water extraction on surrounding groundwater and surface water receptors.
- The development of a groundwater analytical model to predict the potential for thermal impacts to local watercourses, including Mill Creek, taking into account the Grand River Conservation Authority (GRCA) Cumulative Effects Assessment Best Practices Paper (GRCA 2010).
- Analysis and qualitative hydrogeologic impact assessment.
- An assessment of groundwater vulnerability and potential changes to water chemistry.
- An analysis of potential cumulative effects in light of the presence of other nearby aggregate operations, taking into account the GRCA Cumulative Effects Assessment Best Practices Paper (GRCA 2010).
- Development of a monitoring plan for groundwater.
- The results of the hydrogeological assessment will be summarized in a Maximum Predicted Water Table Report and a Level 1 and 2 Water Report that fulfills the current County of Wellington Official Plan policies and ARA requirements.

Surface Water Resources

An assessment of surface water resources in the area of the site, as well as adjoining areas that may be affected by proposed expansion, will be completed to allow for quantification of potential effects. The surface water resources assessment consists of the following:

- Background review of the available information pertaining to within approximately 500 metres of the site. the information reviewed will consist of:

i) Aerial photographs and topographic, physiographic, and geologic mapping

ii) Published water resources reports

iii) Any existing permits or monitoring reports from the site, and nearby lands (e.g., Mill Creek Pit)

- Review of GRCA floodplain data for the site, and assessment of potential impacts of extraction on flood elevations on-site and both upstream and downstream.
- Site reconnaissance to identify and confirm drainage features and catchment boundaries adjacent to the pit. The site reconnaissance is also used to corroborate the findings of the information review and identify local features that were not apparent from the background review.
- A water budget and pit water balance using a Thornthwaite water budget tool, developed for the existing pit footprint area (footprint) and the proposed expansion lands. The Thornthwaite water budget information will be used to develop an annual pit water balance for the existing operation. A future pit water balance will be estimated by including future footprint and land-use information.
- The floodplain assessment will provide appropriate flooding intervals through mapping and elevations for the site and the study area.
- The in-stream water level, temperature and flow monitoring in Mill Creek and associated tributaries in the vicinity of the site will allow Golder to characterise the creek reaches and therefore better understand potential effect of the proposed extraction on site. The in-stream water level monitors will be paired with stream piezometer monitoring stations and visited quarterly.
- An effects assessment on features within the catchment of the site that documents the magnitude and significance of expected changes in the water budget of the site.
- Development of a monitoring plan for surface water.
- A report that describes the surface water assessments, including a description of existing and proposed conditions and expected effects, and will ultimately be included as an appendix to the Level 1 and 2 Water Report.

Natural Environment Assessment

Golder is undertaking a work program for a natural environment assessment to evaluate the natural features in the vicinity of the site (see Figure 1). Golder will assess the potential impacts of the proposed below water extraction on those features and their ecological functions and, if necessary, recommend measures to prevent or mitigate negative impacts on any significant features. The proposed program consists of the following:

- Background data compilation and review of existing documents and information sources which will be focused on designated features in the vicinity of the site. This will include a review of relevant County of Wellington and Provincial policies.
- Review of the water balance completed as part of the surface water assessment, as described above, and assessment of the potential impacts of that water balance on natural features on, and in the vicinity of, the site.
- Species at Risk (SAR) screening focussing on those species listed under the Ontario *Endangered Species Act* (ESA) and federal *Species at Risk Act* (SARA). First completed at a desktop exercise using up to date air photos, and then updated based on the results of the field surveys.
- Communication with the MECP and MNRF for additional information regarding SAR, fisheries data and the Mill Creek Puslinch Provincially Significant Wetland.
- Field surveys including:

i) Plant community assessment using the Ecological Land Classification (ELC) system for southern Ontario (Lee et al*.* 1998).

ii) Delineate/confirm the boundaries of natural heritage features including wetlands and woodlands using a handheld GPS. Note that wetlands were delineated using Ontario Wetland Evaluation System (OWES). The wetland boundary will be verified in the field with the Grand River Conservation Authority (GRCA). The woodland boundary will be verified in the field with the County and/or Township. CBM will have the boundaries surveyed by a registered surveyor.

iii) Three season botanical inventory, including surveys for butternut and black ash.

iv) Three rounds of anuran call count surveys following protocols from the Marsh Monitoring Program method for vocalizing frog surveys (BSC 2008)

v) Two rounds of amphibian habitat assessment and egg mass surveys following protocols from the Sampling Protocol for Determining the Presence of Jefferson Salamanders (*Ambystoma jeffersonianum*) in Ontario (JSRT 2013)

vi) Assessment of the site and vicinity as habitat for Blanding's turtle.

vii) Three rounds of breeding bird surveys following protocols from the Canadian Breeding Bird Survey (Downes and Collins 2003), and the Ontario Breeding Bird Atlas (Cadman et al. 2007)

viii) Bat habitat and acoustic surveys based on guidance from the MNRF document Survey Protocol for Species at Risk Bats within Treed Habitats (MNRF 2017) and Bat and Bat Habitat: Guidelines for Wind Power Projects (MNR 2011).

ix) Wildlife habitat assessment and general wildlife surveys (Visual Encounter Surveys) following provincially accepted methods (Bookhout 1994; McDiarmid 2012; MNRF 2016; MNRF 2017; Pyle 1994).

x) A qualitative fish habitat assessment in Mill Creek and tributaries on the site and in the vicinity, using MTO Fisheries Assessment Protocols and Golder's Technical Procedures (unpublished file information). These protocols include a description of aquatic habitat (e.g., permanence, stage, confinement), habitat mapping of key habitat features (e.g., riffles, pools, woody debris) and characteristics (e.g., wetted and bankfull width/depth, substrate types, cover, seepage areas), a description of riparian and/or aquatic vegetation, identifying locations of any critical fish habitat areas or barriers to fish movement and observations of any fish and aquatic species.

- Assessment of Significant Wildlife Habitat, per the Significant Wildlife Habitat Criteria Schedules for Ecoregion 7E (2015).
- Assessment of linkages and connectivity for wildlife.
- Analysis of the data collected in conjunction with the background data compilation and integration with the hydrogeological and surface water studies to complete a potential impact assessment.
- Development of the final rehabilitation, including appropriate setbacks, upland and wetland plantings, creation of wetlands and wildlife habitat, and a monitoring plan, where appropriate.
- One single natural environment report that includes a description of existing conditions through the desktop review and results of the field surveys, an assessment of impacts on all natural features, as outlined in the Provincial Policy Statement (MMAH 2020), the rehabilitation plan, a description of any mitigation and monitoring, and will meet the requirements of:
  - Natural Environment Report (NER), based on ARA standards (Ontario 2020).
  - Environmental Impact Assessment (EIA) for the County of Wellington (Wellington 2021).
  - Environmental Impact Study guidelines and submission standards for Wetlands of the GRCA (2005).

Closing

We trust this Terms of Reference meets with your approval. If you have any questions or comments, please do not hesitate to contact the undersigned.

WSP Canada Inc.

Heather J. Melcher

Heather Melcher, MSc
Director, Ecology and Water Resources

George Schneider

George Schneider, MSc, PGeo
Principal, Senior Hydrogeologist

HM/GS/ld

Attachments: Figure 1: Study Area, Groundwater and Surface Water Monitoring Locations

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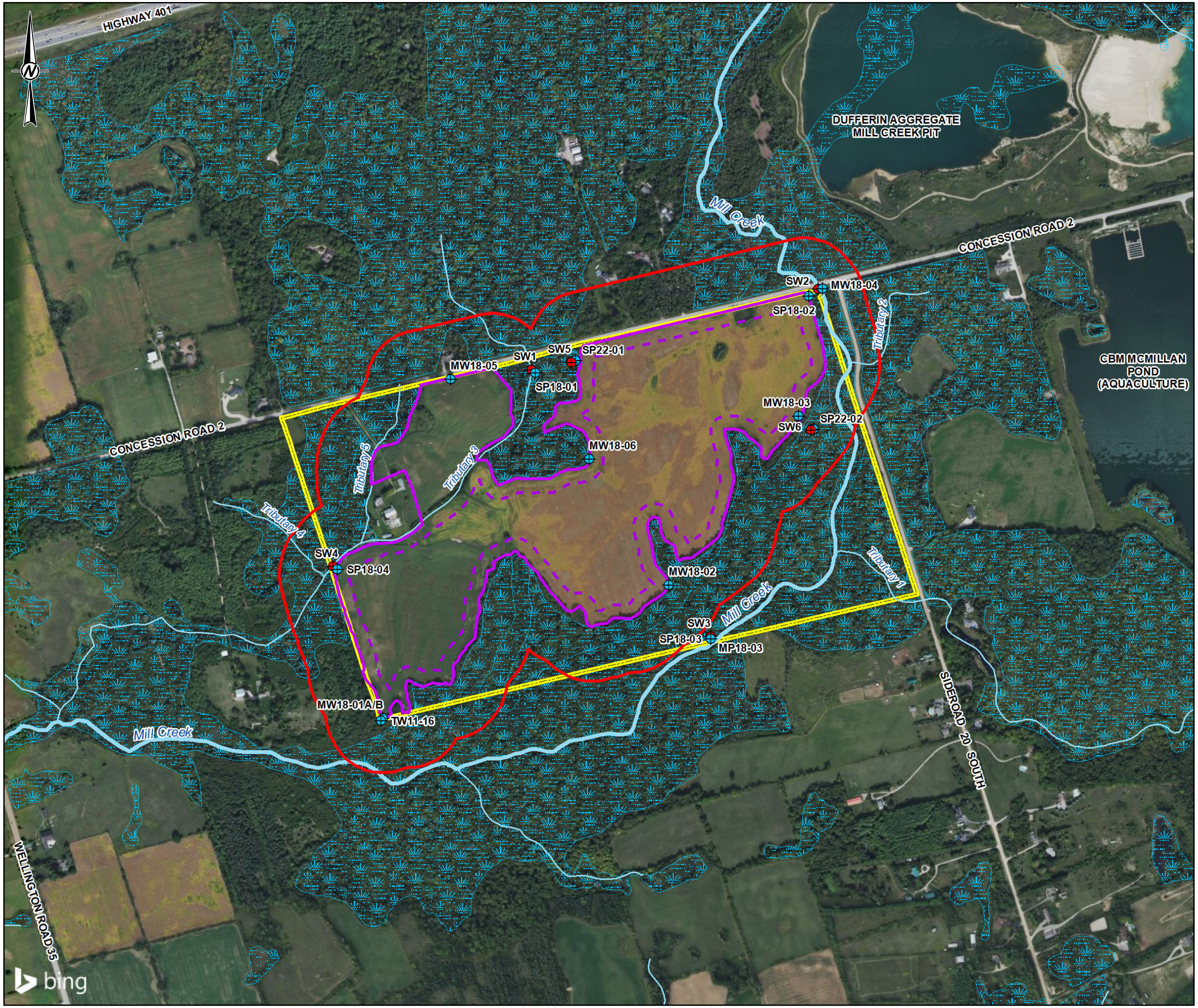
FIGURE 1

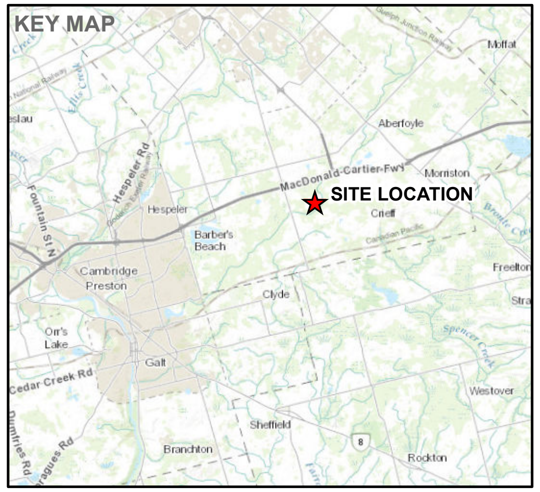
Study Area

Groundwater and Surface Water Monitoring Locations



LEGEND

- ⊕ GROUNDWATER MONITOR
- ⊕ SURFACE WATER MONITOR
- — WATERCOURSE
- ▨ PROVINCIALLY SIGNIFICANT WETLAND (EVALUATED)
- ▭ PROPERTY BOUNDARY
- ▭ PROPOSED EXTRACTION AREA
- ▭ LICENCE BOUNDARY / SITE BOUNDARY
- ▭ STUDY AREA



0 100 200 300 400

1:8,500 METRES

REFERENCE(S)

1. GROUNDWATER LEVATIONS SELECTED MARCH 12, 2020.
2. BASEDATA: MNRF LIO, OBTAINED 2019
3. IMAGERY SOURCE: 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), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
© 2023 MICROSOFT CORPORATION © 2023 MAXAR ©CNES (2023) DISTRIBUTION AIRBUS DS IMAGE SEPTEMBER 2016
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM

CLIENT

ST. MARYS CEMENT INC. (CANADA)

PROJECT

ABERFOYLE SOUTH PIT EXPANSION

TITLE

STUDY AREA, GROUNDWATER AND SURFACE WATER MONITORING LOCATIONS

CONSULTANT

wsp

YYYY-MM-DD	2020-12-04
DESIGNED	SO/PGM
PREPARED	ST
REVIEWED	DH
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1791470	0001	0	1

Path: S:\Clients\CBM_Aggregates\Aberfolye_Pit\99_PROJ\1791470_CBM\40_PROD\0006_Natural_Environment_Level_1_2\1791470-0006-CH-0005.mxd

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

25mm

0

APPENDIX B

MECP Water Well Records

Table B-1
Summary of Wells in MECP WWIS Database
Aberfoyle South Pit Expansion

WELL ID	Well Depth (m)	Depth to Rock (m)	SWL (m)	Aquifer	Distance from Pit (m)	Well Purpose / Well Name	Use	Easting (m)	Northing (m)	Driller	Date Drilled	Tag #	County	Township	Con	Lot
6706806	32.3	20.7	23.2	Bedrock	120	Test Hole TW16-78	Municipal (inactive)	566074	4809763	2336	1978-09-15	-	WELLINGTON	PUSLINCH TOWNSHIP	02	021
6708408	30.5	18.3	3.4	Bedrock	430	Water Supply	Domestic	564837	4809477	2336	1986-02-04	-	WELLINGTON	PUSLINCH TOWNSHIP	02	017
6709322	30.8	24.7	3.7	Bedrock	160	Water Supply	Domestic	565540	4809717	4005	1988-07-18	-	WELLINGTON	PUSLINCH TOWNSHIP	02	020
6709724	19.5	17.4	3.0	Bedrock	600	Water Supply	Domestic	566391	4808976	4005	1989-05-14	-	WELLINGTON	PUSLINCH TOWNSHIP	01	021
6710769	29.6	26.2	5.8	Bedrock	340	Water Supply	Domestic	564765	4808805	2336	1991-10-30	-	WELLINGTON	PUSLINCH TOWNSHIP	01	017
6712576	29.0	25.9	4.3	Bedrock	900	Water Supply	Domestic	566580	4808781	4005	1998-06-24	-	WELLINGTON	PUSLINCH TOWNSHIP	01	021
6714544	29.9	29.0	11.3	Bedrock	900	Water Supply	Domestic	566578	4808779	2336	2003-07-22	-	WELLINGTON	PUSLINCH TOWNSHIP	01	021
6714774	32.0	29.6	4.9	Bedrock	650	Water Supply	Domestic	566174	4808680	2663	2003-11-04	-	WELLINGTON	PUSLINCH TOWNSHIP	01	020
7294233	25.3	19.5	3.0	Bedrock	500	Water Supply	Public	566485	4809754	7556	2017-08-29	A213730	WELLINGTON	PUSLINCH TOWNSHIP	01	021
6715410	16.8	15.2	6.0	Bedrock	450	Water Supply	Domestic	566370	4809209	2663	2005-06-27	A017774	WELLINGTON	PUSLINCH TOWNSHIP	01	021
6706724	27.7	-	1.2	Overburden	850	Water Supply	Domestic	566514	4808743	2336	1978-06-08	-	WELLINGTON	PUSLINCH TOWNSHIP	02	021
6707090	14.6	-	0.3	Overburden	130	Test Hole TW16-79	Municipal (mon well)	566094	4809763	2336	1979-09-14	-	WELLINGTON	PUSLINCH TOWNSHIP	02	021
6708455	8.2	-	1.8	Overburden	170	Water Supply	Domestic	565681	4809761	3518	1985-09-03	-	WELLINGTON	PUSLINCH TOWNSHIP	02	020
6709237	22.6	-	5.8	Overburden	650	Water Supply	Domestic	564560	4809542	4207	1988-03-31	-	WELLINGTON	PUSLINCH TOWNSHIP	02	017
6711680	29.0	-	4.6	Overburden	700	Water Supply	Domestic	566332	4808750	2336	1994-12-02	-	WELLINGTON	PUSLINCH TOWNSHIP	01	020
7040680	16.8	-	1.2	Overburden	350	Water Supply	Domestic	565245	4809681	2336	2007-01-18	A044189	WELLINGTON	PUSLINCH TOWNSHIP	02	018
7185155	10.7	-	-	Overburden	230	Observation Well	Mon Well	566260	4809553	6032	2012-07-12	A093901	WELLINGTON	PUSLINCH TOWNSHIP	01	021
6706881	22.9	19.2	4.6	Bedrock	on site	Water Supply	Inactive	565094	4809303	4208	1978-09-13	-	WELLINGTON	PUSLINCH TOWNSHIP	01	018
6707317	41.5	22.0	1.2	Bedrock	on site	Test Hole TW11-16	Municipal (inactive)	565094	4808763	2336	1980-08-13	-	WELLINGTON	PUSLINCH TOWNSHIP	01	018
7306369	14.9	-	0.2	Overburden	on site	MW18-04	Mon Well	566032	4809696	7531	2018-01-09	A224751	WELLINGTON	PUSLINCH TOWNSHIP	01	019
7306370	14.9	14.6	3.3	Overburden	on site	MW18-05	Mon Well	565243	4809513	7531	2018-01-16	A202890	WELLINGTON	PUSLINCH TOWNSHIP	01	019
-	14.9	-	0.4	Overburden	on site	MW18-03	Mon Well	566018	4809429	7531	2018-01-10	-	WELLINGTON	PUSLINCH TOWNSHIP	01	019
7306372	14.9	-	0.6	Overburden	on site	MW18-02	Mon Well	565724	4809059	7531	2018-01-16	A203869	WELLINGTON	PUSLINCH TOWNSHIP	01	019
7315534	6.1	-	0.8	Overburden	on site	MW18-01A/B	Mon Well	565095	4808767	7238	2018-06-21	A237247	WELLINGTON	PUSLINCH TOWNSHIP	01	019
7329731	9.1	-	0.1	Overburden	on site	MW18-06	Mon Well	565545	4809326	7531	2018-11-24	A248765	WELLINGTON	PUSLINCH TOWNSHIP	01	019

Notes:

1. Well information presented in this table has been corrected based on a review of copies of the original Water Well Records

Ministry of the Environment
Ontario

15/78

The Ontario Water Resources Act 40P/89

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

(11) 6706724 MUNICIP 67012 CON. CØN 01

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC	LOT
Wellington	Puslinch	Con ~~5~~ 1	0~~24~~ 21

[redacted] 2 Puslinch

DATE COMPLETED DAY 08 MO. ~~Jun~~ 06 YR. 78

[redacted] 308520 RC 4 ELEVATION 1008 RC 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Dug Well				0	12
Brown	Clay Sand	Stones		12	25
"	" "	Gravel		25	91
		5" shoe	Total Depth 91 ft.		

(31) 0012 23 | 002560528 12 | 0091605281 1

32

(41) WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0090	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

(51) CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
05"	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	0086
05"	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE			0091
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER, ETC.)

(71) PUMPING TEST

PUMPING TEST METHOD: 1 ☐ PUMP 2 ☒ BAILER

PUMPING RATE: 0015 GPM

DURATION OF PUMPING: 01 HOURS 00 MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ RECOVERY: 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
004 FEET	014 FEET	004 FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE: GPM

PUMP INTAKE SET AT: FEET

WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☒ SHALLOW ☐ DEEP

RECOMMENDED PUMP SETTING: 025 FEET

RECOMMENDED PUMPING RATE: 0010 GPM

FINAL STATUS OF WELL 1

- 1 ☒ WATER SUPPLY
- 2 ☐ OBSERVATION WELL
- 3 ☐ TEST HOLE
- 4 ☐ RECHARGE WELL
- 5 ☐ ABANDONED, INSUFFICIENT SUPPLY
- 6 ☐ ABANDONED, POOR QUALITY
- 7 ☐ UNFINISHED

WATER USE 01

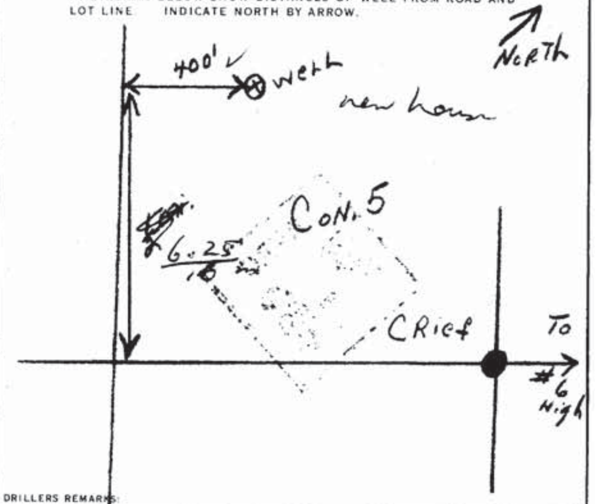
- 1 ☒ DOMESTIC
- 2 ☐ STOCK
- 3 ☐ IRRIGATION
- 4 ☐ INDUSTRIAL
- ☐ OTHER
- 5 ☐ COMMERCIAL
- 6 ☐ MUNICIPAL
- 7 ☐ PUBLIC SUPPLY
- 8 ☐ COOLING OR AIR CONDITIONING
- 9 ☐ NOT USED

METHOD OF DRILLING 1

- 1 ☒ CABLE TOOL
- 2 ☐ ROTARY (CONVENTIONAL)
- 3 ☐ ROTARY (REVERSE)
- 4 ☐ ROTARY (AIR)
- 5 ☐ AIR PERCUSSION
- 6 ☐ BORING
- 7 ☐ DIAMOND
- 8 ☐ JETTING
- 9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

CONTRACTOR

NAME OF WELL CONTRACTOR: Graham Well Drilling Ltd. LICENCE NUMBER: 2336

ADDRESS: Guelph, Ont.

NAME OF DRILLER OR BORER: J. Hawkins 22w LICENCE NUMBER:

SIGNATURE OF CONTRACTOR: Robert H. Graham

SUBMISSION DATE DAY 9 MO. Jun. YR. 78

DSWO

OFFICE USE ONLY

DATA SOURCE: 1 CONTRACTOR: 2336 DATE RECEIVED: 070778

DATE OF INSPECTION: July 20/78 INSPECTOR: EG

REMARKS: CSS.S8

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506—4—77

Ministry of the Environment

Ontario

4/6/78

The Ontario Water Resources Act

40P/8g

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 6706806 MUNICIP 67012 CON. CON 02

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
Wellington	Puslinch Twsp.	2	021

OWNER (SURNAME FIRST) 28-47	ADDRESS	DATE COMPLETED 48-53
R. of Waterloo	Marsland Centre Kitchener Ont.	DAY 05 MO. 09 ~~Sept.~~ YR. 78

21 ZONE 17 EASTING 66060 NORTHING 4809540 RC 4 ELEVATION 1000 RC 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
	Top Soil			0	1
Brown	Clay Sand	Stones		1	30
"	" "	Large Gravel		30	40
"	" "	Gravel		40	55
Gray	" "	Stones		55	60
"	" "	Gravel		60	68
M.Brown	Rock			68	78
D.Brown	Rock			78	106ft.
	TW. 16	6½ shoe	Total Depth 106 ft.		

31 0001 02 0030605281 2 0055605281 1 0060205281 2 0068205281 1 0106612 78

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
10-13 0076	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL 14
15-18	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL 19
20-23	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL 24
25-28	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL 29
30-33	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL 34 80

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
10-11 ~~6¼~~ 06	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 12	.188	0	13-16 0071
17-18 ~~6¼~~ 06	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE 19		71	20-23 0106
24-25	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 26			27-30

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33	DIAMETER 34-38 INCHES	LENGTH 39-40 FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN 41-44 FEET	80

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER, ETC.)
10-13	14-17	
18-21	22-25	
26-29	30-33	80

71 PUMPING TEST

PUMPING TEST METHOD 10: 1 ☒ PUMP 2 ☐ BAILER

PUMPING RATE 11-14: 0004 ~~0270~~ GPM

DURATION OF PUMPING: 01 15-16 HOURS 00 17-18 MINS

STATIC LEVEL 19-21: ~~-66~~ ~~Flowing~~ FEET

WATER LEVEL END OF PUMPING 22-24: 026 ~~25'11"~~ FEET

25 WATER LEVELS DURING: 1 ☐ PUMPING 2 ☒ RECOVERY

15 MINUTES 26-28	30 MINUTES 29-31	45 MINUTES 32-34	60 MINUTES 35-37
FEET	~~Flowing~~ FEET	FEET	FEET

IF FLOWING, GIVE RATE 38-41: 0004 GPM

PUMP INTAKE SET AT: FEET

WATER AT END OF TEST 42: 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP

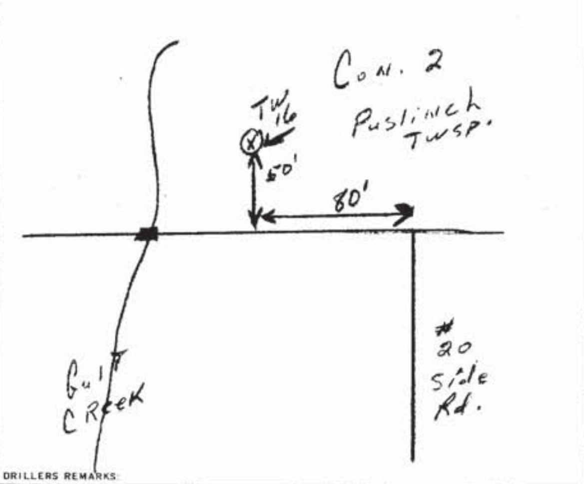
RECOMMENDED PUMP SETTING 43-45: 060 FEET

RECOMMENDED PUMPING RATE 46-49: 0004 ~~0270~~ GPM

50-53

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

FINAL STATUS OF WELL 54: 3

1 ☐ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☒ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED POOR QUALITY
7 ☐ UNFINISHED

WATER USE 55-56: 06

1 ☐ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☒ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 57: 4

1 ☐ CABLE TOOL
2 ☒ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☒ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: Graham Well Drilling Ltd. LICENCE NUMBER: 2336

ADDRESS: Guelph, Ont.

NAME OF DRILLER OR BORER: Jim Hawkins 22W LICENCE NUMBER:

SIGNATURE OF CONTRACTOR: R Graham

SUBMISSION DATE: DAY 6 MO. Sept. YR. 78

OFFICE USE ONLY

DATA SOURCE 58: 1 CONTRACTOR 59-62: 2336 DATE RECEIVED 63-68: 161078 80

DATE OF INSPECTION: Aug. 29/80 INSPECTOR:

REMARKS: KP

CSS.S8

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506-4-77

Ministry of the Environment
Ontario

The Ontario Water Resources Act

40P18y

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 — 6706881 — MUNICIP 67012 — CON. CON — 01

COUNTY OR DISTRICT: Wellington
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: Puslinch
CON., BLOCK, TRACT, SURVEY, ETC: 1 (Rear)
LOT: 018

[redacted] RR. Cambridge (G)

DATE COMPLETED: DAY 13 MO 09 Sept YR 78

309080 RC 4 ELEVATION 1000 RC 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
	Dug Well			0	20
Grey	Clay	some Gravel		20	63
Grey	Limestone			63	75

31: 0020 23 | 0063 20511 | 0075 215

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0068	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL
0073	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
06 ~~6 1/4~~	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	188	0	0063 ~~63~~
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.):
DIAMETER: INCHES
LENGTH: FEET
MATERIAL AND TYPE:
DEPTH TO TOP OF SCREEN: FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☒ PUMP 2 ☐ BAILER
PUMPING RATE: 0025 GPM
DURATION OF PUMPING: 01 HOURS 00 MINS
STATIC LEVEL: 015 FEET
WATER LEVEL END OF PUMPING: 070 FEET
WATER LEVELS DURING: 1 ☐ PUMPING 2 ☒ RECOVERY

15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
015 FEET	015 FEET	015 FEET	015 FEET

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☒ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING: 035 FEET
RECOMMENDED PUMPING RATE: 0010 GPM

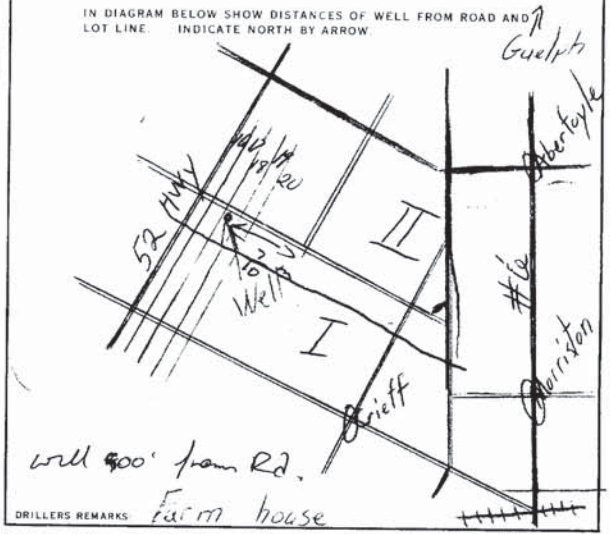
FINAL STATUS OF WELL 1
1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 02
1 ☐ DOMESTIC
2 ☒ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 2
1 ☐ CABLE TOOL
2 ☒ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



well 900' from Rd.

DRILLERS REMARKS: Farm house

CONTRACTOR

NAME OF WELL CONTRACTOR: Wesley Packham — LICENCE NUMBER: 4208
ADDRESS: R.R.2 Ancaster
NAME OF DRILLER OR BORER: Wesley Packham — LICENCE NUMBER: 4208
SIGNATURE OF CONTRACTOR: Wesley Packham
SUBMISSION DATE: DAY 13 MO Sept YR 78

OFFICE USE ONLY

DATA SOURCE: 1 — CONTRACTOR: 4208 — DATE RECEIVED: 090179
DATE OF INSPECTION: July 1979 — INSPECTOR: PJ
REMARKS:

CSS.S8

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506-4-77

Ministry
of the
Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

HOP/89

44/79

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 6707090 MUNICIP 67012 CON. CON 02

COUNTY OR DISTRICT Wellington	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE Puslinch	CON., BLOCK, TRACT, SURVEY, ETC. 2	LOT 25-27 021
OWNER (SURNAME FIRST) 28-47 Region of Waterloo	ADDRESS Marsland Centre , Waterloo ,Ont.		DATE COMPLETED 48-53 DAY 14 MO 09 Sept YR. 79

21 ZONE 17 EASTING 566080 NORTHING 4809540 RC 4 ELEVATION 1000 RC 4 BASIN CODE 23 II III IV

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Brown	clay, sand	stones		0	15
"	"	gravel		15	25
Brown	sand	gravel	water bearing	25	30
"	clay sand		fine	30	48
	TW# 16/79		Total depth	48'	

31 0015064528 12 0025640511 0030642911 81 0048560583

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
10-13 0023-28	14 1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
15-18	19 1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
20-23	24 1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
25-28	29 1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
30-33	34 80 1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
10-11 06¼	12 1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	13-16 0023
17-18	19 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE	screen	23	20-23 0028
24-25	26 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			27-30

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33 050	DIAMETER 34-38 6006 INCHES	LENGTH 39-40 05 FEET
MATERIAL AND TYPE stainless steel	DEPTH TO TOP OF SCREEN 41-44 0020 FEET	50

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
10-13 30	14-17 48	coarse gravel
18-21	22-25	
26-29	30-33 80	

71 PUMPING TEST

PUMPING TEST METHOD 10 1 ☒ PUMP 2 ☐ BAILER	PUMPING RATE 11-14 250 0250 GPM	DURATION OF PUMPING 15-16 24 HOURS 17-18 00 MINS

STATIC LEVEL 19-21	WATER LEVEL END OF PUMPING 22-24	25 WATER LEVELS DURING 1 ☐ PUMPING 2 RECOVERY 15 MINUTES 26-28	30 MINUTES 29-31	45 MINUTES 32-34	60 MINUTES 35-37
000 ground level FEET	013 FEET	FEET	ground FEET	FEET	FEET

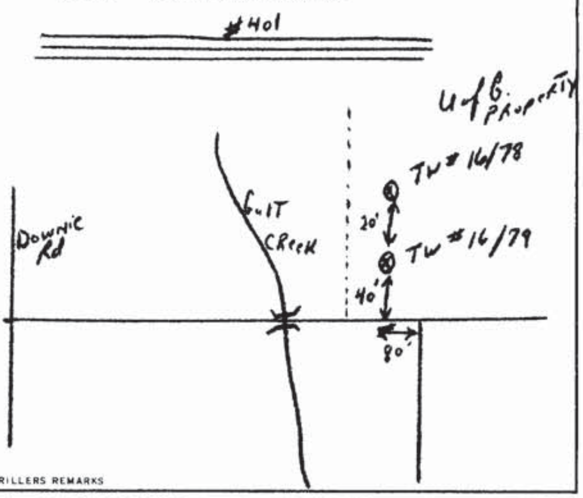
IF FLOWING, GIVE RATE 38-41 GPM	PUMP INTAKE SET AT 15 FEET	WATER AT END OF TEST 42 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE ☒ SHALLOW ☐ DEEP	RECOMMENDED PUMP SETTING 43-45 020 20ft. FEET	RECOMMENDED PUMPING RATE 46-49 0250 250 GPM

50-53

FINAL STATUS OF WELL 3	54 1 ☐ WATER SUPPLY 2 ☐ OBSERVATION WELL 3 ☒ TEST HOLE 4 ☐ RECHARGE WELL 5 ☐ ABANDONED, INSUFFICIENT SUPPLY 6 ☐ ABANDONED POOR QUALITY 7 ☐ UNFINISHED
WATER USE 6	55-56 1 ☐ DOMESTIC 2 ☐ STOCK 3 ☐ IRRIGATION 4 ☐ INDUSTRIAL ☐ OTHER 5 ☐ COMMERCIAL 6 ☒ MUNICIPAL 7 ☐ PUBLIC SUPPLY 8 ☐ COOLING OR AIR CONDITIONING 9 ☐ NOT USED
METHOD OF DRILLING 1	57 1 ☒ CABLE TOOL 2 ☐ ROTARY (CONVENTIONAL) 3 ☐ ROTARY (REVERSE) 4 ☐ ROTARY (AIR) 5 ☐ AIR PERCUSSION 6 ☐ BORING 7 ☐ DIAMOND 8 ☐ JETTING 9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE INDICATE NORTH BY ARROW.



DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR Graham Well Drilling Ltd.	LICENCE NUMBER 2336
ADDRESS Guelph, Ont.	
NAME OF DRILLER OR BORER J. Hawkins 22W	LICENCE NUMBER
SIGNATURE OF CONTRACTOR R Graham	SUBMISSION DATE DAY 30 MO sept YR 79

OFFICE USE ONLY

DATA SOURCE 58 1	CONTRACTOR 59-62 2336	DATE RECEIVED 63-68 121079
DATE OF INSPECTION Aug. 29/80	INSPECTOR	
REMARKS CSS.S8		

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506-4-77

Ministry of the Environment
Ontario

The Ontario Water Resources Act 40P/8g

WATER WELL RECORD

31/80
1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 6707317 MUNICIP. 67012 CON. CON 01

COUNTY OR DISTRICT: Wellington
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: Puslinch
CON., BLOCK, TRACT, SURVEY, ETC: Rear 1st Con.
LOT 25-27: 018
OWNER (SURNAME FIRST) 28-47: ~~R. of Waterloo, %~~ Morrison Beatty Ltd.
ADDRESS: Waterloo, Ontario
DATE COMPLETED 48-53: DAY 13 MO 08 ~~Aug~~ YR. 80

21 ZONE 17 EASTING 565080 NORTHING 4808540 RC. 4 ELEVATION 1000 RC. 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
	Top soil			0	1
Brown	Clay	Stones Gravel		1	20
Brown	Sand	Gravel		20	23
Brown	Clay Sand	Gravel		23	72
Brown	Rock		Med. Brown	72	76
Brown	Dark "		Hard	76	104
Grey	Rock		Dark	104	125
Blue Grey	Rock		Hard	125	136
		Total Depth			136

31 0001 02 0020605121 1 00234281 1 #18, 11 00726052811 1 00766 1278 01046126573 1
32 01252 1265 01369 1273

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0074 ~~74-78~~	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
06 ~~64~~	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	0073
06 ~~64~~	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		73	0136
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN
SIZE(S) OF OPENING (SLOT NO.):
DIAMETER: INCHES
LENGTH: FEET
MATERIAL AND TYPE:
DEPTH TO TOP OF SCREEN: FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☒ PUMP 2 ☐ BAILER
PUMPING RATE: 0350 GPM
DURATION OF PUMPING: 02 HOURS 00 MINS
STATIC LEVEL: 004 FEET
WATER LEVEL END OF PUMPING: 045 FEET
WATER LEVELS DURING: 1 ☐ PUMPING 2 ☒ RECOVERY

15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
004 FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP
RECOMMENDED PUMP SETTING: 100 FEET
RECOMMENDED PUMPING RATE: 0300 GPM

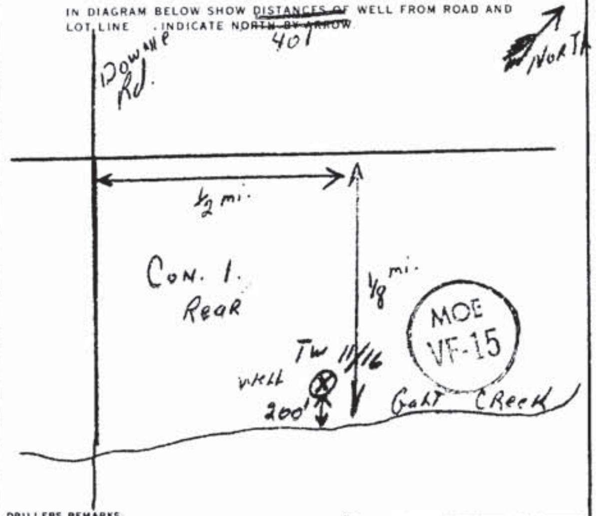
FINAL STATUS OF WELL 3
1 ☐ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☒ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 06
1 ☐ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☒ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 4
1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☒ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE ~~NORTH BY ARROW~~



DRILLERS REMARKS:

CONTRACTOR
NAME OF WELL CONTRACTOR: Graham Well Drilling Ltd.
LICENCE NUMBER: 2336
ADDRESS: Guelph, Ontario
NAME OF DRILLER OR BORER: J. Hawkins 22W
LICENCE NUMBER:
SIGNATURE OF CONTRACTOR: R W Graham
SUBMISSION DATE: DAY 30 MO. Aug YR. 80

OFFICE USE ONLY
DATA SOURCE: 1
CONTRACTOR: 2336
DATE RECEIVED: 080980
DATE OF INSPECTION:
INSPECTOR:
REMARKS:

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506—4—77 FORM 7

Ministry of the Environment
Ontario 3/86

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 6708408 PT.

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC	LOT
WELLINGTON	PusLinch	— 2	17

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
Joe Burgess Const.	Site #7, RR #1, KINCARDINE, ONT.	DAY 04 MO 02 YR. 86

21 ZONE EASTING NORTHING RC ELEVATION RC BASIN CODE

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
	TOP	Soil		0	1
BROWN	CLAY	SAND + STONES		1	15
"	"	" GRAVEL		15	55
"	SAND	GRAVEL		55	60
Med."	Rock			60	70
D. "	Rock			70	100
			TOTAL Depth	100 ft.	

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
98-100	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
5"	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	61
5"	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		61'	100'
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
—	INCHES	FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN
	FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER, ETC.)
—		

71 PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
1 ☒ PUMP 2 ☐ BAILER	15 GPM	1 HOURS — MINS

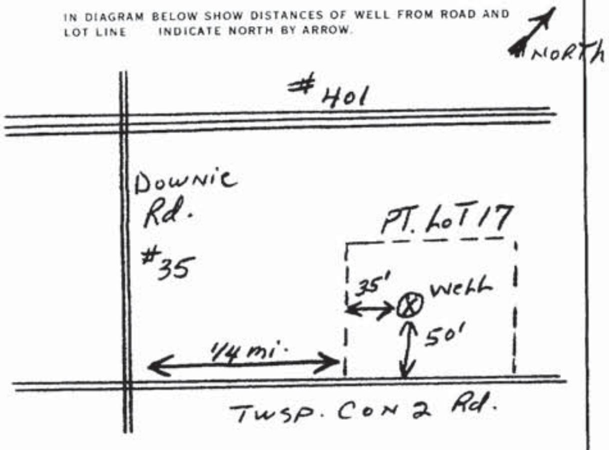
STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
11 FEET	25 FEET	11 FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	FEET	1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☒ DEEP	40 FEET	10 GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE INDICATE NORTH BY ARROW.



FINAL STATUS OF WELL
- 1 ☒ WATER SUPPLY
- 2 ☐ OBSERVATION WELL
- 3 ☐ TEST HOLE
- 4 ☐ RECHARGE WELL
- 5 ☐ ABANDONED, INSUFFICIENT SUPPLY
- 6 ☐ ABANDONED, POOR QUALITY
- 7 ☐ UNFINISHED

WATER USE
- 1 ☒ DOMESTIC
- 2 ☐ STOCK
- 3 ☐ IRRIGATION
- 4 ☐ INDUSTRIAL
- ☐ OTHER
- 5 ☐ COMMERCIAL
- 6 ☐ MUNICIPAL
- 7 ☐ PUBLIC SUPPLY
- 8 ☐ COOLING OR AIR CONDITIONING
- 9 ☐ NOT USED

METHOD OF DRILLING
- 1 ☒ CABLE TOOL
- 2 ☐ ROTARY (CONVENTIONAL)
- 3 ☐ ROTARY (REVERSE)
- 4 ☐ ROTARY (AIR)
- 5 ☐ AIR PERCUSSION
- 6 ☐ BORING
- 7 ☐ DIAMOND
- 8 ☐ JETTING
- 9 ☐ DRIVING

DRILLERS REMARKS:

CONTRACTOR

NAME OF WELL CONTRACTOR: GRAHAM Well DRILLING LTD.
LICENCE NUMBER: 2336
ADDRESS: Guelph, ONT.
NAME OF DRILLER OR BORER: J. HAWKINS
LICENCE NUMBER:
SIGNATURE OF CONTRACTOR: R H Graham
SUBMISSION DATE: DAY 028 MO. 02 YR. 86

OFFICE USE ONLY

DATA SOURCE:
CONTRACTOR:
DATE RECEIVED: 230486
DATE OF INSPECTION:
INSPECTOR:
REMARKS:

CSS.ES

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Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

6708455

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

MUNICIP
CON.

COUNTY OR DISTRICT: [redacted]
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: PUSLINCH
CON, BLOCK, TRACT, SURVEY ETC: CON 2
LOT: 20

RR-22 CAMBRIDGE ONT N3C2V4
DATE COMPLETED: DAY 3 MO 9 YR. 85

ELEVATION
BASIN CODE

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BLACK	TOP SOIL			0	2
BROWN	SAND	STONES,	LOOSE.	2	25
BROWN	GRAVEL		LOOSE, COARSE	25	27

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
27	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6½	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	27
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)
DIAMETER INCHES
LENGTH FEET
MATERIAL AND TYPE
DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☒ PUMP 2 ☐ BAILER AIR
PUMPING RATE: 12 GPM
DURATION OF PUMPING: 1 HOURS ___ MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING: 1 ☐ PUMPING 2 ☒ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
6 FEET	9 FEET	6 FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP
RECOMMENDED PUMP SETTING: 15 FEET
RECOMMENDED PUMPING RATE: 10 GPM

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED POOR QUALITY
7 ☐ UNFINISHED

WATER USE

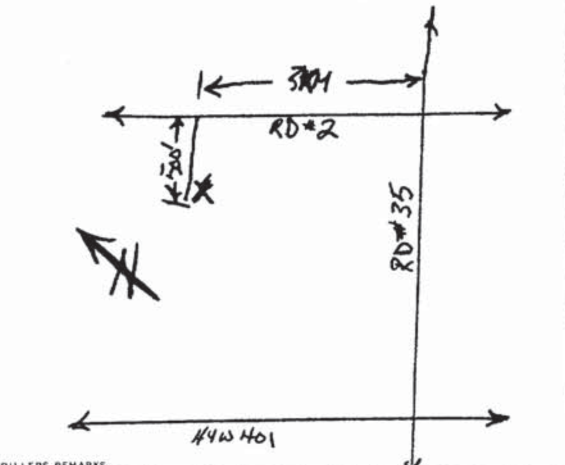
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING

1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☒ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

3222 LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE INDICATE NORTH BY ARROW



DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR: MCLAUGHLIN WATER WELLS
LICENCE NUMBER: 3518
ADDRESS: 38 DOLMAN ST, BRESLAU, ONT.
NAME OF DRILLER OR BORER: R&B MCLAUGHLIN
LICENCE NUMBER:
SIGNATURE OF CONTRACTOR: R. McLaughlin
SUBMISSION DATE: DAY 12 MO. 10 YR. 85

OFFICE USE ONLY

DATA SOURCE
CONTRACTOR
DATE RECEIVED 010606
DATE OF INSPECTION
INSPECTOR
REMARKS

CSS.ES

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FORM NO. 0506—4—77 FORM 7

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

6709237

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT
Wellington	Puslinch	II	17

[redacted] R #22 Cambridge Ont.

DATE COMPLETED DAY 31 MO Mar YR 88

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
Brown	clay	stone		0	20
Grey	gravel	sand clay		20	50
Grey	clay	sand		50	70
Grey	gravel	sand		70	74

31
32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
74	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
6 1/4	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	.188	0	74
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)
DIAMETER INCHES
LENGTH FEET
MATERIAL AND TYPE
DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☒ ~~PUMP~~ Air 2 ☐ BAILER
PUMPING RATE: 30 GPM
DURATION OF PUMPING: 1 HOURS 0 MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
19' FEET	73 FEET	21 FEET	20 FEET	20 FEET	20 FEET

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP
RECOMMENDED PUMP SETTING: 65 FEET
RECOMMENDED PUMPING RATE: 20 GPM

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED
9 ☐ DEWATERING

WATER USE

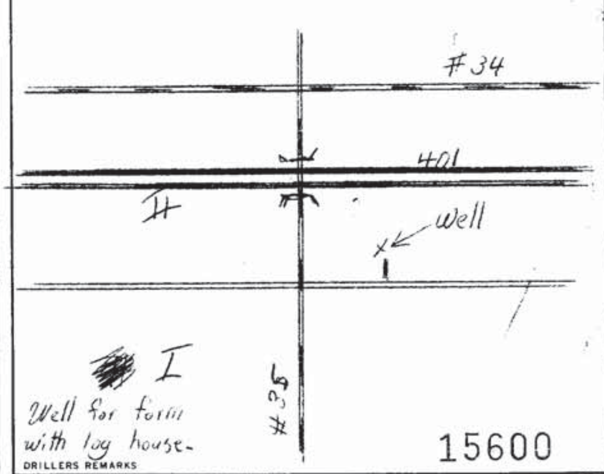
1 ☒ DOMESTIC
2 ☒ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF CONSTRUCTION

1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☒ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING
☐ DIGGING ☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



Well for form with log house.

DRILLERS REMARKS

15600

CONTRACTOR

NAME OF WELL CONTRACTOR: Packham Well Drilling Inc.
WELL CONTRACTOR'S LICENCE NUMBER: 4207
ADDRESS: 1235 Trinity Rd Ancaster Ont.
NAME OF WELL TECHNICIAN: Mervyn Packham
WELL TECHNICIAN'S LICENCE NUMBER: 10058
SIGNATURE OF TECHNICIAN/CONTRACTOR: Mervyn Packham
SUBMISSION DATE DAY 31 MO Mar. YR 88

OFFICE USE ONLY

DATA SOURCE
CONTRACTOR: 4207
DATE RECEIVED: MAY 18 1988
DATE OF INSPECTION
INSPECTOR
REMARKS

CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506 (11/86) FORM 9

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 6709322 MUNICIP 67012 CON.

COUNTY OR DISTRICT WELLINGTON S.	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE PUSLINCH	CON., BLOCK, TRACT, SURVEY, ETC. CON.2	LOT 20
OWNER (SURNAME FIRST) XANADA CUSTOM HOMES	ADDRESS P.O.BOX 155,FREELTON,ONT.LOR 1KO		DATE COMPLETED DAY 18 MO 7 YR 88

21 ZONE EASTING NORTHING RC ELEVATION RC BASIN CODE

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
BROWN	GRAVEL &	SAND	LOOSE	0	15
BROWN	SAND		LOOSE	15	35
GREY	SAND &	FINE GRAVEL	LOOSE	35	78
GREY	GRAVEL &	SAND	PACKED	78	81
GREY	LIMESTONE		HARD	81	101

31
32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
84	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
98	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
6¼	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	.188	+1	81
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE 5 ☐ PLASTIC		81	101
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			

SCREEN
SIZE(S) OF OPENING (SLOT NO.) DIAMETER INCHES LENGTH FEET
MATERIAL AND TYPE DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☐ PUMP 2 ☒ BAILER
PUMPING RATE: 16 GPM
DURATION OF PUMPING: 1 HOURS MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING 1 ☒ PUMPING 2 ☐ RECOVERY: 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
12 FEET	90 FEET	90 FEET	90 FEET	90 FEET	90 FEET

IF FLOWING GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☐ CLEAR 2 ☒ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP
RECOMMENDED PUMP SETTING: 96 FEET
RECOMMENDED PUMPING RATE: 10 GPM

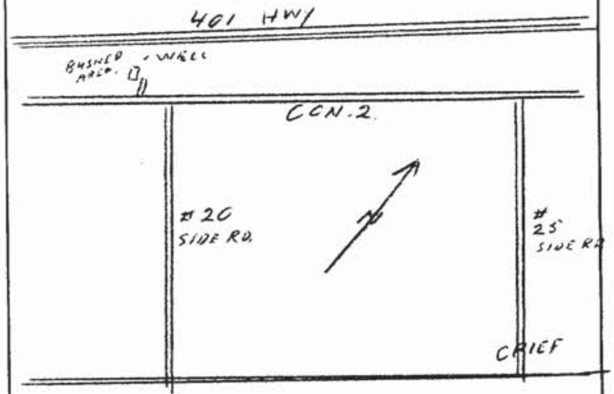
FINAL STATUS OF WELL
1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED
9 ☐ DEWATERING

WATER USE
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF CONSTRUCTION
1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING
☐ DIGGING ☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



31040

DRILLERS REMARKS

CONTRACTOR
NAME OF WELL CONTRACTOR: OCONNOR WELL DRILLING LTD.
WELL CONTRACTOR'S LICENCE NUMBER: 4005
ADDRESS: RR # 1 MILLGROVE,ONT,LOR 1VO
NAME OF WELL TECHNICIAN: W.HOWE
WELL TECHNICIAN'S LICENCE NUMBER: T-0518
SIGNATURE OF TECHNICIAN/CONTRACTOR: JB OConnor
SUBMISSION DATE: DAY MO YR.

OFFICE USE ONLY
DATA SOURCE
CONTRACTOR: 4005
DATE RECEIVED: AUG 16 1988
DATE OF INSPECTION
INSPECTOR
REMARKS

CSS.ES

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FORM NO. 0506 (11/86) FORM 9

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 6709724 MUNICIP. 67012 CON. CON 01

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON, BLOCK, TRACT, SURVEY, ETC	LOT 25-27
[redacted]	PUSLINCH	CON.1	21

21 CAMBRIDGE,ONT.N3C 2V3

DATE COMPLETED 48-53 DAY 14 MO 5 YR 89

RC. ELEVATION RC. BASIN CODE II III IV

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
BROWN	SAND		LOOSE	0	35
BROWN	SAND &	GRAVEL	LOOSE	35	43
BROWN	GRAVEL		PACKED	43	55
GREY	GRAVEL		PACKED	55	57
GREY	LIMESTONE		HARD	57	64

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
10-13 62	1 ☐ FRESH 3 ☐ SULPHUR 4 ☐ MINERALS 2 ☐ SALTY 6 ☐ GAS 14
15-18	1 ☐ FRESH 3 ☐ SULPHUR 4 ☐ MINERALS 2 ☐ SALTY 6 ☐ GAS 19
20-23	1 ☐ FRESH 3 ☐ SULPHUR 4 ☐ MINERALS 2 ☐ SALTY 6 ☐ GAS 24
25-28	1 ☐ FRESH 3 ☐ SULPHUR 4 ☐ MINERALS 2 ☐ SALTY 6 ☐ GAS 29
30-33	1 ☐ FRESH 3 ☐ SULPHUR 4 ☐ MINERALS 2 ☐ SALTY 6 ☐ GAS 34 80

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
10-11 6¼	12 1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	.188	+3	13-16 57
17-18	19 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE 5 ☐ PLASTIC		57	20-23 64
24-25	26 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			27-30

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33	DIAMETER 34-38 INCHES	LENGTH 39-40 FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN 41-44 FEET	10

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
10-13	14-17	
18-21	22-25	
26-29	30-33	80

71 PUMPING TEST

PUMPING TEST METHOD 10	PUMPING RATE 11-14	DURATION OF PUMPING
1 ☐ PUMP 2 ☒ BAILER	20 GPM	15-16 1 HOURS 17-18 MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	25 WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ RECOVERY			
		15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
19-21 10 FEET	22-24 35 FEET	26-28 10 FEET	29-31 10 FEET	32-34 10 FEET	35-37 10 FEET

IF FLOWING, GIVE RATE 38-41	PUMP INTAKE SET AT	WATER AT END OF TEST 42
GPM	FEET	1 ☐ CLEAR 2 ☒ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING 43-45	RECOMMENDED PUMPING RATE 46-49
☐ SHALLOW ☒ DEEP	60 FEET	10 GPM

50-53

FINAL STATUS OF WELL

54
1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED
☐ DEWATERING

WATER USE

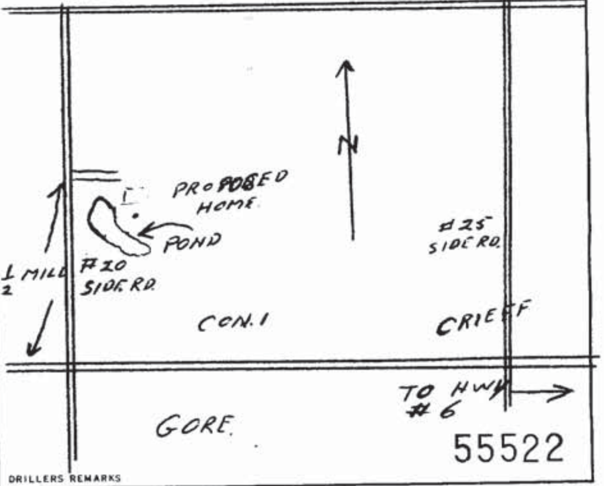
55-56
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF CONSTRUCTION

57
1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING
☐ DIGGING
☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



55522

DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR: OCONNOR WELL DRILLING LTD.
WELL CONTRACTOR'S LICENCE NUMBER: 4005
ADDRESS: RR # 1 MILLGROVE,ONT.LOR 1VO
NAME OF WELL TECHNICIAN: B.W.OCONNOR
WELL TECHNICIAN'S LICENCE NUMBER: T-0290
SIGNATURE OF TECHNICIAN/CONTRACTOR: B.OConnor
SUBMISSION DATE DAY ____ MO ____ YR. ____

OFFICE USE ONLY

DATA SOURCE 58
CONTRACTOR 59-62: 4005
DATE RECEIVED 63-68: MAY 29 1989
80
DATE OF INSPECTION
INSPECTOR
REMARKS
CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506 (11/86) FORM 9

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

48-91

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

6710769

MUNICIP 67012 CON. CON 01

COUNTY OR DISTRICT [redacted]

TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: SLINCH

CON., BLOCK, TRACT, SURVEY, ETC: CON 1

LOT 17

R#22 CAMBRIDGE, ONT.

DATE COMPLETED: DAY 30 MO 10 YR 91

RC. ELEVATION RC BASIN CODE II III IV

21

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN	CLAY	STONES		0	10
BROWN	SAND	GRAVEL		10	35
BROWN	SAND			35	75
GRAY	CLAY	GRAVEL		75	86
D. BROWN	ROCK			86	97
			TOTAL DEPTH	97	
		6" DRIVE SHOE			

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
95	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6"	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	.188	0	86
6"	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE 5 ☐ PLASTIC		86	97
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.) —
DIAMETER INCHES
LENGTH FEET
MATERIAL AND TYPE —
DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
—	—	

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☒ PUMP 2 ☐ BAILER
PUMPING RATE: 25 GPM
DURATION OF PUMPING: 1 HOURS MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ RECOVERY: 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
19 FEET	45 FEET	19 FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE — GPM
PUMP INTAKE SET AT FEET
WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP
RECOMMENDED PUMP SETTING: 60 FEET
RECOMMENDED PUMPING RATE: 20 GPM

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED
☐ DEWATERING

WATER USE

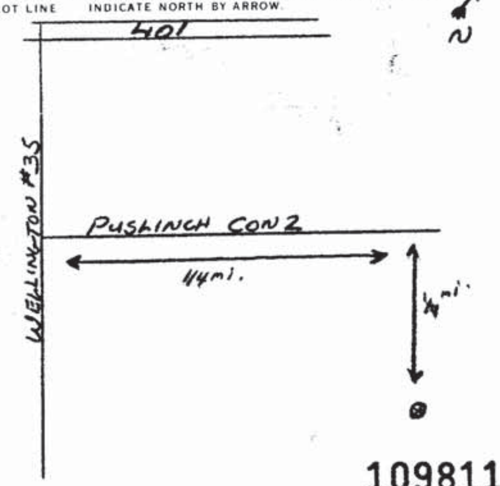
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF CONSTRUCTION

1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☒ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING
☐ DIGGING ☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



109811

DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR: GRAHAM WELL DRILLING LTD
WELL CONTRACTOR'S LICENCE NUMBER: 2336
ADDRESS: RR#5 ROCKWOOD N0B-2K0
NAME OF WELL TECHNICIAN: JIM WILSON
WELL TECHNICIAN'S LICENCE NUMBER: T-1924
SIGNATURE OF TECHNICIAN/CONTRACTOR
SUBMISSION DATE: DAY 030 MO 010 YR 91

OFFICE USE ONLY

DATA SOURCE
CONTRACTOR 2336
DATE RECEIVED NOV 06 1991
DATE OF INSPECTION
INSPECTOR
REMARKS

CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506 (11/86) FORM 9

Ontario Ministry of Environment and Energy

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

71-94

11

6711680

Municipality: 67012 Con.: CON 01

County or District: [redacted]

Township/Borough/City/Town/Village: PUSLINCH TWP

Con block tract survey, etc.: CON 1

Lot: 20

Address: RR#6 GUELPH, ONT.

Date completed: 02 day 12 month 94 year

21 Northing RC Elevation RC Basin Code

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	Depth – feet To
BROWN	CLAY	GRAVEL		0	75
BROWN	SAND			75	90
GREY	CLAY	GRAVEL		90	95
BROWN	GRAVEL		COARSE	95'	
			TOTAL DEPTH	95'	
		6" DRIVE SHOE			

31

32

41 WATER RECORD

Water found at – feet	Kind of water
95	☒ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	Depth – feet To
6"	☒ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.188	+1	95
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter inches	Length feet

Material and type
Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☐ Annular space ☐ Abandonment

Depth set at – feet From	To	Material and type (Cement grout, bentonite, etc.)

71 PUMPING TEST

Pumping test method: ☒ Pump ☐ Bailer

Pumping rate: 15 GPM

Duration of pumping: 1 Hours 0 Mins

Static level	Water level end of pumping	15 minutes	30 minutes	45 minutes	60 minutes
15 feet	60 feet	20 feet	15 feet	15 feet	15 feet

Water levels during: ☐ Pumping ☒ Recovery

If flowing give rate: — GPM

Pump intake set at: feet

Water at end of test: ☒ Clear ☐ Cloudy

Recommended pump type: ☐ Shallow ☒ Deep

Recommended pump setting: 60 feet

Recommended pump rate: 10 GPM

FINAL STATUS OF WELL

- ☒ Water supply
- ☐ Observation well
- ☐ Test hole
- ☐ Recharge well
- ☐ Abandoned, insufficient supply
- ☐ Abandoned, poor quality
- ☐ Abandoned (Other)
- ☐ Dewatering
- ☐ Unfinished
- ☐ Replacement well

WATER USE

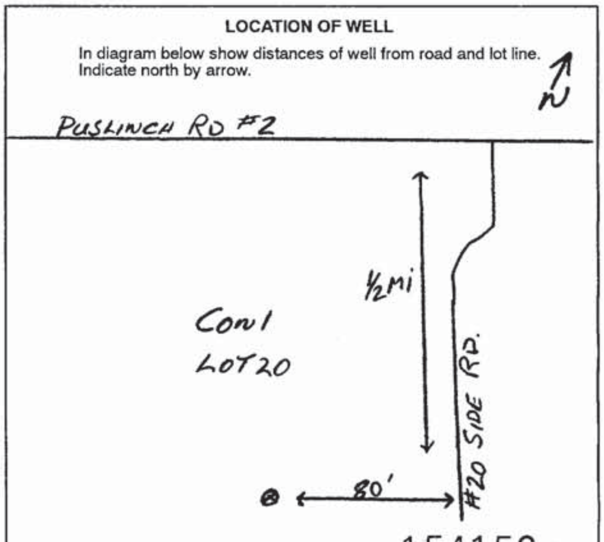
- ☒ Domestic
- ☐ Stock
- ☐ Irrigation
- ☐ Industrial
- ☐ Commercial
- ☐ Municipal
- ☐ Public supply
- ☐ Cooling & air conditioning
- ☐ Not used
- ☐ Other ....

METHOD OF CONSTRUCTION

- ☐ Cable tool
- ☐ Rotary (conventional)
- ☐ Rotary (reverse)
- ☒ Rotary (air)
- ☐ Air percussion
- ☐ Boring
- ☐ Diamond
- ☐ Jetting
- ☐ Driving
- ☐ Digging
- ☐ Other ....

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



154156

Name of Well Contractor: GRAHAM WELL DRILLING LTD

Well Contractor's Licence No.: 2336

Address: RR#5 ROCKWOOD, ONT. N0B-2K0

Name of Well Technician: JIM WILSON

Well Technician's Licence No.: T-1924

Signature of Technician/Contractor: Robert W. Graham

Submission date: day 30 mo 012 yr 94

MINISTRY USE ONLY

Data source:
Contractor: 2336
Date received: MAR 13 1995
Date of inspection:
Inspector:
Remarks:

CSS.ES

0506 (07/94) Front Form 9

2 - MINISTRY OF ENVIRONMENT & ENERGY COPY

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11

6712576

Municipality 67012 Con. CON 01

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
Wellington	Puslinch	Conc.1	21

[redacted]

Address: RR#2 Puslinch,Ont.N0B-2J0

Date completed 24 day 6 month 98 year

21 | Northing | RC | Elevation | RC | Basin Code

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	Depth – feet To
Brown	Sand	Gravel		0	18
Brown	Sand	Gravel,Clay		18	35
Brown	Sand	Gravel		35	85
Grey	Limestone			85	95

31

32

41 WATER RECORD

Water found at – feet	Kind of water
87	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	Depth – feet To
6.25	☒ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	0.188	+1	85
	☐ Steel ☐ Galvanized ☐ Concrete ☒ Open hole ☐ Plastic		85	95
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter inches	Length feet

Material and type | Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☐ Annular space ☐ Abandonment

Depth set at – feet From	To	Material and type (Cement grout, bentonite, etc.)

71 PUMPING TEST

Pumping test method ☐ Pump ~~☐ Bailer~~ Air

Pumping rate 50 GPM

Duration of pumping 0 Hours 30 Mins

Static level 14 feet

Water level end of pumping feet

Water levels during ☐ Pumping ☐ Recovery

15 minutes	30 minutes	45 minutes	60 minutes
feet	feet	feet	feet

If flowing give rate GPM

Pump intake set at feet

Water at end of test ☐ Clear ☒ Cloudy

Recommended pump type ☐ Shallow ☒ Deep

Recommended pump setting feet

Recommended pump rate 10 GPM

FINAL STATUS OF WELL

- ☒ Water supply
- ☐ Observation well
- ☐ Test hole
- ☐ Recharge well
- ☐ Abandoned, insufficient supply
- ☐ Abandoned, poor quality
- ☐ Abandoned (Other)
- ☐ Dewatering
- ☐ Unfinished
- ☐ Replacement well

WATER USE

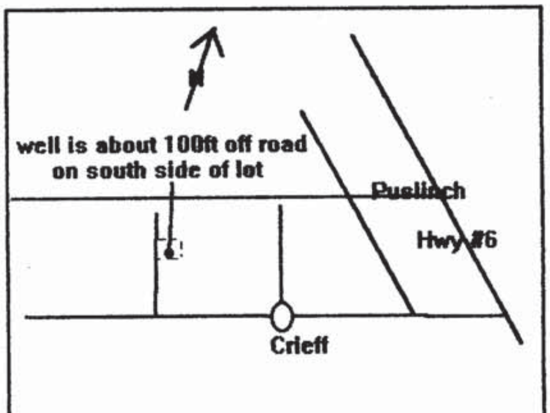
- ☒ Domestic
- ☐ Stock
- ☐ Irrigation
- ☐ Industrial
- ☐ Commercial
- ☐ Municipal
- ☐ Public supply
- ☐ Cooling & air conditioning
- ☐ Not used
- ☐ Other ....

METHOD OF CONSTRUCTION

- ☐ Cable tool
- ☐ Rotary (conventional)
- ☐ Rotary (reverse)
- ☐ Rotary (air)
- ☒ Air percussion
- ☐ Boring
- ☐ Diamond
- ☐ Jetting
- ☐ Driving
- ☐ Digging
- ☐ Other ....

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



190953

Name of Well Contractor: O'Connor Well Drilling Ltd

Well Contractor's Licence No.: 4005

Address: RR#1,Millgrove,Ont,L0R-1V0

Name of Well Technician: W. Howe

Well Technician's Licence No.: T-0518

Signature of Technician/Contractor

Submission date day mo yr

MINISTRY USE ONLY

Data source | Contracctor 4005 | Date received JUL 23 1998

Date of inspection | Inspector

Remarks

CSS. S9

0506 (07/94) Front Form 9

2 - MINISTER OF ENVIRONMENT & ENERGY COPY

Ontario Ministry of Environment and Energy

The Ontario Water Resources Act

WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11 | 6714544 | Municipality 67012 | Con. CON 01

4403

County or District: [redacted]

Township/Borough/City/Town/Village: PUSLINCH TWP

Con block tract survey, etc.: CON1

Lot: 21

Address of Well Location: 4159 SIDE RD 20S RR#2 PUSLINCH. N0B-2J0

Date completed: 22 day 07 month 03 year

21 | UTM Zone | Easting | Northing | RC | Elevation | RC | Basin Code | ii | iii | iv

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	Depth - feet To
BROWN	CLAY	STONES		0	55
BROWN	CLAY	SAND - GRAVEL		55	70
BROWN	SAND	GRAVEL		70	85
GREY	CLAY	GRAVEL		85	98
BROWN	ROCK		FRACTURED	98	
			TOTAL DEPTH	98'	

31

32

41 WATER RECORD

Water found at - feet	Kind of water
98	1 ☒ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet From	Depth - feet To
6"	1 ☒ Steel 2 ☐ Galvanized 3 ☐ Concrete 4 ☐ Open hole 5 ☐ Plastic	.188	+2	98
	1 ☐ Steel 2 ☐ Galvanized 3 ☐ Concrete 4 ☐ Open hole 5 ☐ Plastic			
	1 ☐ Steel 2 ☐ Galvanized 3 ☐ Concrete 4 ☐ Open hole 5 ☐ Plastic			

SCREEN

Sizes of opening (Slot No.) | Diameter inches | Length feet

Material and type | Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☒ Annular space ☐ Abandonment

Depth set at - feet From	Depth set at - feet To	Material and type (Cement grout, bentonite, etc.)
0	25	BENTONITE.

71 PUMPING TEST

Pumping test method: 1 ☒ Pump 2 ☐ Bailer

Pumping rate: 16 GPM

Duration of pumping: 1 Hours 0 Mins

Water levels during: 1 ☒ Pumping 2 ☐ Recovery

Static level	Water level end of pumping	15 minutes	30 minutes	45 minutes	60 minutes
37 feet	39 feet	39 feet	39 feet	39 feet	39 feet

If flowing give rate: — GPM

Pump intake set at: feet

Water at end of test: ☒ Clear ☐ Cloudy

Recommended pump type: ☐ Shallow ☒ Deep

Recommended pump setting: 50 feet

Recommended pump rate: 10-15 GPM

FINAL STATUS OF WELL

- 1 ☒ Water supply
- 2 ☐ Observation well
- 3 ☐ Test hole
- 4 ☐ Recharge well
- 5 ☐ Abandoned, insufficient supply
- 6 ☐ Abandoned, poor quality
- 7 ☐ Abandoned (Other)
- 8 ☐ Dewatering
- 9 ☐ Unfinished
- 10 ☐ Replacement well

WATER USE

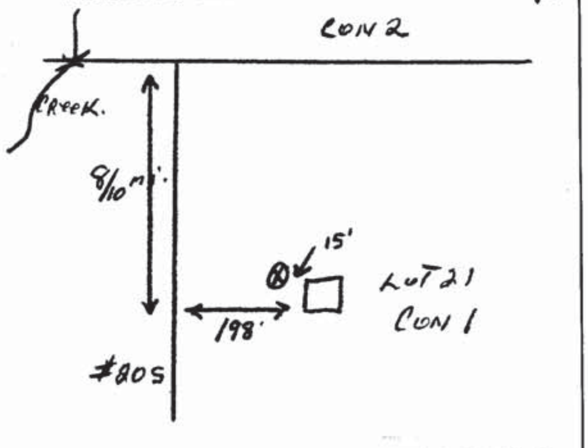
- 1 ☒ Domestic
- 2 ☐ Stock
- 3 ☐ Irrigation
- 4 ☐ Industrial
- 5 ☐ Commercial
- 6 ☐ Municipal
- 7 ☐ Public supply
- 8 ☐ Cooling & air conditioning
- 9 ☐ Not use
- 10 ☐ Other

METHOD OF CONSTRUCTION

- 1 ☐ Cable tool
- 2 ☐ Rotary (conventional)
- 3 ☐ Rotary (reverse)
- 4 ☒ Rotary (air)
- 5 ☐ Air percussion
- 6 ☐ Boring
- 7 ☐ Diamond
- 8 ☐ Jetting
- 9 ☐ Driving
- 10 ☐ Digging
- 11 ☐ Other

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



260733

Name of Well Contractor: GRAHAM WELL DRILLING LTD

Well Contractor's Licence No.: 2336

Address: RR#5 ROCKWOOD, ONT. N0B-2K0

Name of Well Technician: TIM WILSON

Well Technician's Licence No.: T-1924.

Signature of Technician/Contractor: Robert H. Graham

Submission date: day 31 mo 07 yr 03

MINISTRY USE ONLY

Data source | Contractor 2336 | Date received AUG 11 2003

Date of inspection | Inspector

Remarks

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Ontario Ministry of the Environment

Well Tag Number (Place sticker and print number below)

Well Record
Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

[redacted]

Address of Well Location (County/District/Municipality): 4220 20th Side Rd
Township: Puslinch
Lot: 20
Concession: 1
RR#/Street Number/Name: RR#2
City/Town/Village: Puslinch.
Site/Compartment/Block/Tract etc.
GPS Reading: NAD 8 3 Zone Easting Northing 43 25.733
Unit Make/Model
Mode of Operation: ☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth From	Metres To
Black	Top Soil			0	.30
Brown	Clay	Stones		.30	1.5
Brown	Sand		Coarse	1.5	26
Brown	Clay	Sand		26	29.5
Brown	Limestone		Broken	29.5	30.2
Brown	Limestone		Medium	30.2	32
			Total =	32 M	

Hole Diameter

Depth From	Metres To	Diameter Centimetres
0	6.09	25.4
6.09	32	15.87

Water Record

Water found at ___ Metres / Kind of Water
___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:

After test of well yield, water was
☑ Clear and sediment free
☐ Other, specify

Chlorinated ☑ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth From	Metres To
Casing				
15.87	☑ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			29.7
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen				
Outside diam	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	Slot No.		
No Casing or Screen				
	☑ Open hole		29.7	32

Test of Well Yield

Pumping test method: Subm. Pump
Pump intake set at - (metres)
Pumping rate - (litres/min) 113.5
Duration of pumping 1 hrs + ___ min
Final water level end of pumping 4.9 metres
Recommended pump type. ☐ Shallow ☑ Deep
Recommended pump depth. ___ metres
Recommended pump rate. 113.5 (litres/min)
If flowing give rate - (litres/min)
If pumping discontinued, give reason. N/A

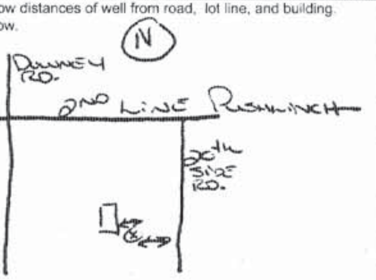
Draw Down Time min	Water Level Metres	Recovery Time min	Water Level Metres
Static Level	4.9		
1	4.9	1	
2	4.9	2	
3	4.9	3	
4	4.9	4	
5	4.9	5	
10	4.9	10	
15	4.9	15	
20	4.9	20	
25	4.9	25	
30	4.9	30	
40	4.9	40	
50	4.9	50	
60	4.9	60	

Plugging and Sealing Record ☑ Annular space ☐ Abandonment

Depth set at - Metres From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
0	6.09	Quick Grout	

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



H.1

Method of Construction

☐ Cable Tool ☑ Rotary (air) ☐ Diamond ☐ Digging
☐ Rotary (conventional) ☐ Air percussion ☐ Jetting ☐ Other
☐ Rotary (reverse) ☐ Boring ☐ Driving

Water Use

☑ Domestic ☐ Industrial ☐ Public Supply ☐ Other
☐ Stock ☐ Commercial ☐ Not used
☐ Irrigation ☐ Municipal ☐ Cooling & air conditioning

Final Status of Well

☑ Water Supply ☐ Recharge well ☐ Unfinished ☐ Abandoned, (Other)
☐ Observation well ☐ Abandoned, insufficient supply ☐ Dewatering
☐ Test Hole ☐ Abandoned, poor quality ☐ Replacement well

Audit No. Z 01953
Date Well Completed YYYY 2003 MM 11 DD 09
Was the well owner's information package delivered? ☐ Yes ☐ No
Date Delivered YYYY MM DD: Don't Have

Well Contractor/Technician Information

Name of Well Contractor: Hammond Well Drilling LTD
Well Contractor's Licence No.: 2663
Business Address (street name, number, city etc.): RR#5 #5896 County Rd #7 Guelph N1H 6J2
Name of Well Technician (last name, first name): Whitney John
Well Technician's Licence No.: T-2790
Signature of Technician/Contractor: X
Date Submitted YYYY 2003 MM 12 DD 01

Ministry Use Only

Data Source
Contractor: 2663
Date Received: DEC 24 2003
Date of Inspection YYYY MM DD
Remarks
Well Record Number: 6714774

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐ *Cette formule est disponible en français*

Ontario Ministry of the Environment

Well Tag Number (Place sticker and print number below)
A 017774
A017774

Well Record

Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

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- Please print clearly in blue or black ink only.

Ministry Use Only
MUN ___ CON ___ LOT ___

Well Owner's Information and Location of Well Information

[redacted]

RR#/Street Number/Name: RR#2
City/Town/Village: PUSLINCH
Site/Compartment/Block/Tract etc.:

GPS Reading NAD 83 Zone 17 Easting 566370 Northing 4809209
Unit Make/Model: MAGELLAN
Mode of Operation: ☐ Undifferentiated ☑ Averaged ☐ Differentiated, specify ______

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	DEPTH FROM	FT TO	Depth From	Metres To
BLACK	TOP SOIL			0	2	0	0.61
	SAND	GRAVEL / CLAY		2	50	0.61	15.24
BROWN	LIMESTONE			50	55	15.24	16.76
			TOTAL =		55 FT		16.76 M
		6 1/4 / 40.32 CASING DRIVE SHOE					

Hole Diameter

Depth From	Metres To	Diameter Centimetres
0	6.09	25.4
6.09	16.76	15.87

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth From	Metres To
Casing				
15.87 / 6 1/4	☑ Steel ☐ Fibreglass ☒ Plastic ☐ Concrete ☐ Galvanized	0.48 / .188	0.61 / +2	16.76 / 55
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen				
Outside diam	☐ Steel ☐ Fibreglass ☒ Plastic ☐ Concrete ☐ Galvanized	Slot No.		
No Casing or Screen				
	☐ Open hole	GRAVE SAN	15.24 / 50	16.76 / 55

Water Record

Water found at 16.76 Metres — Kind of Water: ☑ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: UNTESTED
___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:

After test of well yield, water was ☑ Clear and sediment free ☐ Other, specify ______

Chlorinated ☑ Yes ☐ No

Test of Well Yield

Pumping test method: SUBMERSIBLE PUMP
Pump intake set at - (metres): 40FT
Pumping rate - (litres/min): 30 GAL
Duration of pumping: 1 hrs + ____ min
Final water level end of pumping: 20FT metres
Recommended pump type. ☐ Shallow ☑ Deep
Recommended pump depth. 40FT metres
Recommended pump rate. (litres/min): 30GAL
If flowing give rate - (litres/min):
If pumping discontinued, give reason.

Draw Down Time min	Water Level Metres	Recovery Time min	Water Level Metres
Static Level	16		20
1	15	1	12
2	17	2	10
3	20	3	8
4	20	4	6
5	20	5	
10	20	10	
15	20	15	
20	20	20	
25	20	25	
30	20	30	
40	20	40	
50	20	50	
60	20	60	

Plugging and Sealing Record ☑ Annular space ☐ Abandonment

Depth set at - Metres From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
0	6.09	QUICK GROUT	40 GAL

Method of Construction

☐ Cable Tool ☑ Rotary (air) ☐ Diamond ☐ Digging
☐ Rotary (conventional) ☐ Air percussion ☐ Jetting ☐ Other
☐ Rotary (reverse) ☐ Boring ☐ Driving

Water Use

☑ Domestic ☐ Industrial ☐ Public Supply ☐ Other
☐ Stock ☐ Commercial ☐ Not used
☐ Irrigation ☐ Municipal ☐ Cooling & air conditioning

Final Status of Well

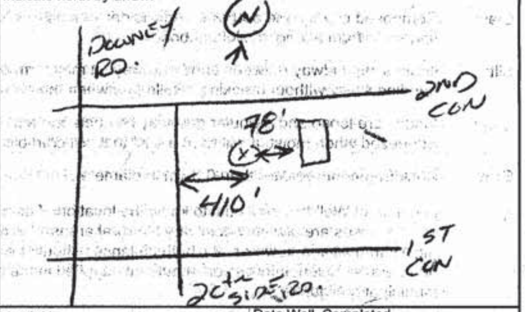
☑ Water Supply ☐ Recharge well ☐ Unfinished ☐ Abandoned, (Other)
☐ Observation well ☐ Abandoned, insufficient supply ☐ Dewatering
☐ Test Hole ☐ Abandoned, poor quality ☐ Replacement well

Well Contractor/Technician Information

Name of Well Contractor: HANNON WELL DRILLING LTD
Well Contractor's Licence No.: 2663
Business Address (street name, number, city etc.): RR#5 GUELPH ONT. N1H 6J2
Name of Well Technician (last name, first name): WHITNEY, JOHN
Well Technician's Licence No.: T-2790
Signature of Technician/Contractor: X
Date Submitted YYYY MM DD: 2005 07 01

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Audit No. Z 28969
Date Well Completed YYYY MM DD: 2005 06 27
Was the well owner's information package delivered? ☑ Yes ☐ No
Date Delivered YYYY MM DD: 2005 06 06

Ministry Use Only

Data Source
Contractor: 2663
Date Received: JUL 29 2005
Date of Inspection YYYY MM DD
Remarks
Well Record Number

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐ *Cette formule est disponible en français*

Ontario Ministry of the Environment

Well Ta A 044189 nber below)

A044189

Well Record

Regulation 903 Ontario Water Resources Act

page ___ of ___

04-07

Instructions for Completing Form

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- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

MUN | CON | LOT

[redacted]

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
WELLINGTON	PUSLINCH	18	2

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
6966 CON 2 RD.	PUSLINCH	

GPS Reading	NAD	Zone	Easting	Northing	Unit Make/Model	Mode of Operation:
	83	17	565245	4809681	GARMIN	☐ Undifferentiated ☒ Averaged ☐ Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth ~~Metres~~ FT From	To
BROWN	CLAY	SAND-STONES		0	14
GREY	CLAY	SAND-GRAVEL		14	45
BROWN	GRAVEL	SAND-BOULDERS	COARSE	45	55
			TOTAL DEPTH	55FT	

Hole Diameter

Depth ~~Metres~~ FT From	To	Diameter ~~Centimetres~~ INCHES
0	20	8 3/4
20	55	6

Water Record

Water found at ~~Metres~~ FT	Kind of Water	
55 FT	☒ Fresh	☐ Sulphur
☐ Gas	☐ Salty	☐ Minerals
☐ Other:		
m	☐ Fresh	☐ Sulphur
☐ Gas	☐ Salty	☐ Minerals
☐ Other:		
m	☐ Fresh	☐ Sulphur
☐ Gas	☐ Salty	☐ Minerals
☐ Other:		

After test of well yield, water was

☒ Clear and sediment free

☐ Other, specify

Chlorinated ☒ Yes ☐ No

Construction Record

Inside diam ~~centimetres~~ INCHES	Material	Wall thickness ~~centimetres~~ INCHES	Depth ~~Metres~~ FT From	To
Casing				
6"	☒ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	.188	+2	55
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen				
Outside diam	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	Slot No.		
No Casing or Screen				
	☐ Open hole			

Test of Well Yield

Pumping test method	Draw Down Time min	Water Level ~~Metres~~ FT	Recovery Time min	Water Level ~~Metres~~ FT
SUB				
Pump intake set at - (~~metres~~) 35FT	Static Level	4		
Pumping rate - (~~litres/min~~) 12GPM	1	4'6"	1	4'6"
Duration of pumping 1 hrs + 0 min	2	5'	2	~~5~~ 4
Final water level end of pumping 5' FT ~~metres~~	3	5	3	4
Recommended pump type. ☒ Shallow ☐ Deep	4	5	4	4
Recommended pump depth. 35 FT ~~metres~~	5	5	5	4
Recommended pump rate. 12GPM (~~litres/min~~)	10	5	10	4
	15	5	15	4
If flowing give rate - (litres/min)	20	5	20	4
	25	5	25	4
If pumping discontinued, give reason.	30	5	30	4
	40	5	40	4
	50	5	50	4
	60	5	60	4

Plugging and Sealing Record ☒ Annular space ☐ Abandonment

Depth set at - ~~Metres~~ FT From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
0	20	BENTONITE SLURRY	

Method of Construction

☐ Cable Tool ☒ Rotary (air) ☐ Diamond ☐ Digging

☐ Rotary (conventional) ☐ Air percussion ☐ Jetting ☐ Other

☐ Rotary (reverse) ☐ Boring ☐ Driving

Water Use

☒ Domestic ☐ Industrial ☐ Public Supply ☐ Other

☐ Stock ☐ Commercial ☐ Not used

☐ Irrigation ☐ Municipal ☐ Cooling & air conditioning

Final Status of Well

☒ Water Supply ☐ Recharge well ☐ Unfinished ☐ Abandoned, (Other)

☐ Observation well ☐ Abandoned, insufficient supply ☐ Dewatering

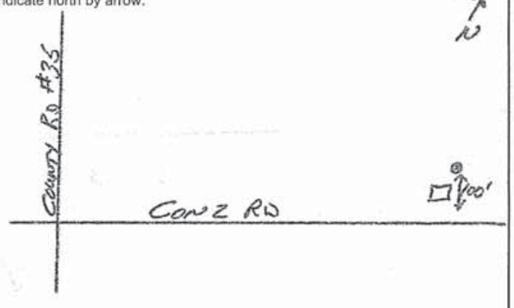
☐ Test Hole ☐ Abandoned, poor quality ☐ Replacement well

Well Contractor/Technician Information

Name of Well Contractor	Well Contractor's Licence No.
GRAHAM WELL DRILLING LTD	2336
Business Address (street name, number, city etc.)	
RR#5 ROCKWOOD, ON. N0B. 2K0	
Name of Well Technician (last name, first name)	Well Technician's Licence No.
WILSON Jim	T-1924
Signature of Technician/Contractor	Date Submitted YYYY MM DD
X Jim Wilson	07 01 31

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Audit No.	Date Well Completed YYYY MM DD
Z 49339	07 01 18
Was the well owner's information package delivered? ☒ Yes ☐ No	Date Delivered YYYY MM DD 07 01 18

Ministry Use Only

Data Source	Contractor 2336
Date Received YYYY MM DD FEB 09 2007	Date of Inspection YYYY MM DD
Remarks	Well Record Number

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☒ Well Owner's Copy ☐ *Cette formule est disponible en français*

Ontario Ministry of the Environment

Well Record

Regulation 903 Ontario Water Resources Act

Well Tag No. (*Plc* A093901 **A 093901**

Measurements recorded in: ☐ Metric ☒ Imperial

Page 1 of 1

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
CBM	AGGREGATES. LTD.		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (*inc. area code*)
55 INDUSTRIAL ST	TORONTO	ON	M4G3W9	9054778400

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
4218 SIDE Road S.	Puslinch		

County/District/Municipality	City/Town/Village	Province	Postal Code
Wellington	Aberfoyle	**Ontario**	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	566260	4809553		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (*m/ft*) From	Depth (*m/ft*) To
Brown.	gravel	Sand Cobbles.	hard	0	27
Brown	Sand	gravel	hard	27	35
	② 569043	488899			
	③ 568980	4809445			

Annular Space

Depth Set at (*m/ft*) From	Depth Set at (*m/ft*) To	Type of Sealant Used (*Material and Type*)	Volume Placed (*m³/ft³*)
6	1	Bentonite Chips	

Method of Construction

☐ Cable Tool
☐ Rotary (Conventional)
☐ Rotary (Reverse)
☒ Boring
☐ Air percussion
☐ Other, *specify*
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging

Well Use

☐ Public
☐ Domestic
☐ Livestock
☐ Irrigation
☐ Industrial
☐ Other, *specify*
☐ Commercial
☐ Municipal
☒ Test Hole
☐ Cooling & Air Conditioning
☐ Not used
☐ Dewatering
☐ Monitoring

Construction Record - Casing

Inside Diameter (*cm/in*)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (*cm/in*)	Depth (*m/ft*) From	Depth (*m/ft*) To
2	PVC	SC40	20	0

Construction Record - Screen

Outside Diameter (*cm/in*)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (*m/ft*) From	Depth (*m/ft*) To
2	PVC	10	35	20

Status of Well

☐ Water Supply
☐ Replacement Well
☒ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth Kind of Water: ☐ Fresh ☐ Untested
(*m/ft*) ☐ Gas ☐ Other, *specify*

Water found at Depth Kind of Water: ☐ Fresh ☐ Untested
(*m/ft*) ☐ Gas ☐ Other, *specify*

Water found at Depth Kind of Water: ☐ Fresh ☐ Untested
(*m/ft*) ☐ Gas ☐ Other, *specify*

Hole Diameter

Depth (*m/ft*) From	Depth (*m/ft*) To	Diameter (*cm/in*)
0	35	8

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (*m/ft*)

Pumping rate (*l/min / GPM*)

Duration of pumping
hrs + min

Final water level end of pumping (*m/ft*)

If flowing give rate (*l/min / GPM*)

Recommended pump depth (*m/ft*)

Recommended pump rate (*l/min / GPM*)

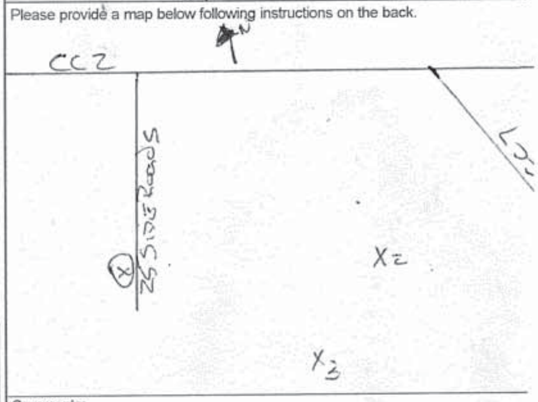
Well production (*l/min / GPM*)

Disinfected?
☐ Yes ☐ No

Draw Down Time (*min*)	Draw Down Water Level (*m/ft*)	Recovery Time (*min*)	Recovery Water Level (*m/ft*)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:
Aecon 9/2 A111

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
ATCOST Drilling	6032

Business Address (Street Number/Name)	Municipality
2160 Hwy #7 CONCORD.	YORK.

Province	Postal Code	Business E-mail Address
ont	L4K1W6	

Bus.Telephone No. (*inc. area code*)	Name of Well Technician (Last Name, First Name)
9056691253	Mynette Chris

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T1685		20120712

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☒ No	YYYYMMDD	20120712

Ministry Use Only

Audit No. Z131683

Received AUG 09 2012

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Ministry's Copy

24/7/12

Go Back to Map

Well ID

Well ID Number: 7294233
Well Audit Number: *Z266388*
Well Tag Number: *A213730*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	7053 CONCESSION 2
Township	PUSLINCH TOWNSHIP
Lot	021
Concession	CON 01
County/District/Municipality	WELLINGTON
City/Town/Village	OUSLINCH
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 566485.00 Northing: 4809754.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
GREY	SAND	GRVL		0 ft	52 ft
BRWN	GRVL	CLAY		52 ft	60 ft

	LMSN	60 ft	83 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 ft	20 ft	BENTONITE SLURRY 1 BAG HOLEPLUG	

Method of Construction & Well Use

Method of Construction	Well Use
Other Method	
DUAL ROTARY	Public

Status of Well

Water Supply

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
6.125 inch	STEEL	-2 ft	64 ft
	OPEN HOLE	64 ft	83 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7556

Results of Well Yield Testing

After test of well yield, water was	CLEAR
If pumping discontinued, give reason	
Pump intake set at	74 ft
Pumping Rate	18 GPM
Duration of Pumping	1 h:0 m

Final water level	
If flowing give rate	
Recommended pump depth	74 ft
Recommended pump rate	18 GPM
Well Production	
Disinfected?	Y

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL	10 ft		
1	9.4 ft	1	9.4 ft
2	9.4 ft	2	9.4 ft
3	9.4 ft	3	9.4 ft
4	9.4 ft	4	9.4 ft
5	9.4 ft	5	9.4 ft
10	9.4 ft	10	9.4 ft
15	9.4 ft	15	9.4 ft
20	9.4 ft	20	9.4 ft
25	9.4 ft	25	9.4 ft
30	9.4 ft	30	9.4 ft
40	9.4 ft	40	9.4 ft
45		45	
50	9.4 ft	50	9.4 ft
60	9.4 ft	60	9.4 ft

Water Details

Water Found at Depth	Kind
83 ft	Untested

Hole Diameter

Depth From	Depth To	Diameter
0 ft	20 ft	10 inch
20 ft	64 ft	6.625 inch
64 ft	83 ft	6 inch

Audit Number: Z266388

Date Well Completed: August 29, 2017

Date Well Record Received by MOE: September 06, 2017

Updated: March 7, 2019
Share facebook twitter Print
Tags

- Environment and energy,
- Drinking water

Ministry of the Environment, Conservation and Parks

The Ministry of the Environment, Conservation and Parks works to protect and sustain the quality of Ontario’s air, land, and water. We also coordinate Ontario’s actions on climate change in the name of healthier communities, ecological protection and economic prosperity.

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Topics

- Business and economy

APPENDIX C

Records of Borehole and Monitoring Well Drilling and Installation

PROJECT: 1791470

LOCATION: N 4809638.92; E 565980.54

RECORD OF BOREHOLE: BH18-01

BORING DATE: January 9, 2018

SHEET 1 OF 2

DATUM: UTM 17T

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

BORING METHOD: Sonic Drilling

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER
GROUND SURFACE	303.00	
(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	0.00	1
(SW) SAND; brown, no odour, no staining; non-cohesive, wet	301.48 1.52	
(SW) SAND; brown, no odour, no staining; non-cohesive, wet	301.17 1.83	2
(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	300.26 2.74	3
(GW) GRAVEL, some sand; brown/grey, no odour, no staining; non-cohesive, wet	298.73 4.27	4 5
(SW) SAND, some gravel; brown, no odour, no staining; non-cohesive, wet	295.68 7.32	
(SW) SAND; brown, no odour, no staining; non-cohesive, wet	295.08 7.92	6
(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	294.16 8.84	7

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DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809638.92; E 565980.54

RECORD OF BOREHOLE: BH18-01

BORING DATE: January 9, 2018

SHEET 2 OF 2

DATUM: UTM 17T

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
		--- *CONTINUED FROM PREVIOUS PAGE* ---									
10	Sonic Drilling	(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet		292.64	7						
11		(SM) SILTY SAND; brown, no odour, no staining; non-cohesive, wet		10.36 291.11	8						
12 13		(SW) SAND, trace silt; brown, no odour, no staining; non-cohesive, wet		11.89 289.60	9						
14		(SM) SILTY SAND; brown, no odour, no staining; non-cohesive, wet		288.58	10						
		(SW) SAND; brown, no odour, no staining; non-cohesive, wet		14.42 288.06							
15		END OF BOREHOLE		14.94							
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809428.49; E 565764.18

RECORD OF BOREHOLE: BH18-02

BORING DATE: January 10, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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	303.00							
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00	1						
1		(SW) SAND, some cobbles till 2.74 m, some gravel; brown, grey, no odour, no staining; non-cohesive, wet	302.09 0.91	2 3 4 5						
8		(ML) SILT; light brown, no odour, no staining; non-cohesive, wet	295.08 7.92	6						
9		(SW) SAND, some gravel; light grey, no odour, no staining; non-cohesive, wet	294.16 8.84	7						
10		*CONTINUED NEXT PAGE*								

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809428.49; E 565764.18

RECORD OF BOREHOLE: BH18-02

BORING DATE: January 10, 2018

SHEET 2 OF 2

DATUM: UTM 17T

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	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---						
10	Sonic Drilling	(SW) SAND, some gravel; light grey, no odour, no staining; non-cohesive, wet		7				
11				8				
12								
				9				
13			289.28 13.72					
14		(ML) SILT, light brown, no odour, no staining; non-cohesive, wet		10				
15		END OF BOREHOLE	288.06 14.94					
16								
17								
18								
19								
20								

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809208.38; E 565416.81

RECORD OF BOREHOLE: BH18-03

BORING DATE: January 10, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 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		304.00							
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist		0.00	1						
1		(SW) SAND, trace gravel; brown, grey, no odour, no staining; non-cohesive, wet		303.09 0.91							
		(SW/GW) SAND and GRAVEL; light brown/grey, no odour, no staining; non-cohesive, wet		302.78 1.22	2						
2		(SW) SAND, trace gravel from 7.32 m to 8.84 m, some gravel from 8.84 m to 10.97 m; brown, no odour, no staining; non-cohesive, wet		301.87 2.13							
3					3						
4											
5					4						
6					5						
7											
8		- Sandy silt lens at 8.08 m			6						
9					7						
10											

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809208.38; E 565416.81

RECORD OF BOREHOLE: BH18-03

BORING DATE: January 10, 2018

SHEET 2 OF 2

DATUM: UTM 17T

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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW) SAND, trace gravel from 7.32 m to 8.84 m, some gravel from 8.84 m to 10.97 m; brown, no odour, no staining; non-cohesive, wet		293.03	7 8						
11		(ML) CLAYEY SILT, trace gravel; brown, no odour, no staining; non-cohesive, wet		10.97 290.59	8 9						
13		(CL) SILTY CLAY, trace gravel; grey/brown, no odour, no staining; non-cohesive, wet		13.41 289.06	10						
15		END OF BOREHOLE		14.94							
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4808939.14; E 565178.26

RECORD OF BOREHOLE: BH18-04

BORING DATE: January 10, 2018

SHEET 1 OF 2

DATUM: UTM 17T

Column headings: 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

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER
		GROUND SURFACE	303.00	
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00	1
3		(SW) SAND, some gravel, trace cobbles; beige, no odour, no staining; non-cohesive, wet	300.26 2.74	2
4		(SC) CLAYEY SAND, trace cobbles; light brown, no odour, no staining; cohesive, wet	299.34 3.66	3
6		(SM) SILTY SAND, trace gravel from 5.78 m to 7.32 m, trace clay from 7.32 m to 8.84 m; light grey, no odour, no staining; non-cohesive, wet	297.22 5.78	4 5
9		(SW/ML) SAND and SILT; grey, no odour, no staining; non-cohesive, wet	294.16 8.84	6
10				

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4808939.14; E 565178.26

RECORD OF BOREHOLE: BH18-04

BORING DATE: January 10, 2018

SHEET 2 OF 2

DATUM: UTM 17T

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Sonic Drilling	(SW/ML) SAND and SILT; grey, no odour, no staining; non-cohesive, wet			6				
11					7				
12					8				
13									
14					9				
				288.06 14.94					
15		END OF BOREHOLE							
16									
17									
18									
19									
20									

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DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809022.87; E 565081.17

RECORD OF BOREHOLE: BH18-05

BORING DATE: January 10, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 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		307.00							
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist		0.00	1						
1											
2					2						
		(SW) SAND, some gravel, trace silt at 5.78 m; brown, no odour, no staining; non-cohesive, dry		304.26 2.74							
3					3						
4											
5					4						
		(SM) SILTY SAND; light brown, no odour, no staining; non-cohesive, wet		301.22 5.78							
6					5						
7											
		(SW/ML) SAND and SILT; brown, no odour, no staining; non-cohesive, wet		299.68 7.32							
8					6						
		(SM) SILTY SAND; light brown, no odour, no staining; non-cohesive, wet		298.16 8.84							
9					7						
10											

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809022.87; E 565081.17

RECORD OF BOREHOLE: BH18-05

BORING DATE: January 10, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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
		--- CONTINUED FROM PREVIOUS PAGE ---								
10	Sonic Drilling	(SM) SILTY SAND; light brown, no odour, no staining; non-cohesive, wet	296.64	7						
		(SW/ML) SAND and SILT; light brown, no odour, no staining; non-cohesive, wet	10.36							
11			295.11	8						
12		(ML) CLAYEY SILT; brown, no odour, no staining; non-cohesive, wet	11.89	9						
13			293.59							
		(SW/ML) SAND and SILT; light grey, no odour, no staining; non-cohesive, wet	13.41							
14			292.06	10						
15		END OF BOREHOLE	14.94							
16										
17										
18										
19										
20										

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470
LOCATION: N 4809088.00; E 565175.00

RECORD OF BOREHOLE: BH18-06

BORING DATE: January 11, 2018

SHEET 1 OF 2
DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 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		303.00							
0	Sonic Drilling	(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet		0.00	1						
1											
2					2						
3					3						
4				298.73 4.27							
		(ML) SILT; grey, no odour, no staining; non-cohesive, wet		298.12 4.88							
5		(SW) SAND, trace gravel from 4.88 m to 5.78 m; brown, no odour, no staining; non-cohesive, wet			4						
6					5						
7				295.68 7.32							
		(ML) SILT, some sand; grey, no odour, no staining; non-cohesive, wet									
8					6						
				294.16 8.84							
9		(ML/SW) SILT and SAND, some clay, cobbles from 13.41 m to 14.49 m; grey, no odour, no staining; non-cohesive, wet			7						
10											

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DEPTH SCALE
1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL
CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809088.00; E 565175.00

RECORD OF BOREHOLE: BH18-06

BORING DATE: January 11, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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
		--- CONTINUED FROM PREVIOUS PAGE ---								
10	Sonic Drilling	(ML/SW) SILT and SAND, some clay, cobbles from 13.41 m to 14.49 m; grey, no odour, no staining; non-cohesive, wet		7						
11				8						
12				9						
13										
14			288.06 14.94	10						
15		END OF BOREHOLE								
16										
17										
18										
19										
20										

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809075.81; E 565567.69

RECORD OF BOREHOLE: BH18-07

BORING DATE: January 11, 2018

SHEET 1 OF 2

DATUM: UTM 17T

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	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	304.00					
0	Sonic Drilling	(SW/GW) SAND and GRAVEL, trace silt from 1.22 m to 2.44 m; brown, no odour, no staining; non-cohesive, wet	0.00	1				
1–2				2				
		(SM) SILTY SAND; golden brown, no odour, no staining; non-cohesive, wet	301.56 2.44					
3–4		(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	301.26 2.74	3				
5		(SW) SAND; brown, no odour, no staining; non-cohesive, wet	299.12 4.88	4				
6–7				5				
8		(SW/GW) SAND and GRAVEL, come cobbles from 10.36 m to 11.28 m; grey, no odour, no staining; non-cohesive, wet	296.68 7.32	6				
9				7				
10								

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809075.81; E 565567.69

RECORD OF BOREHOLE: BH18-07

BORING DATE: January 11, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10 11	Sonic Drilling	(SW/GW) SAND and GRAVEL, come cobbles from 10.36 m to 11.28 m; grey, no odour, no staining; non-cohesive, wet			7 8						
		(ML) SILT, some sand; brown, no odour, no staining; non-cohesive, wet		292.72 11.28							
12		(GW) GRAVEL, some sand; brown, no odour, no staining; non-cohesive, wet		292.11 11.89	9						
13		(ML) SILT, some gravel; brown, no odour, no staining; non-cohesive, wet		291.20 12.80							
14		(CL) SILTY CLAY, some cobbles; brown, no odour, no staining; cohesive, w>PL		290.59 13.41	10						
15 16 17 18 19 20		END OF BOREHOLE		289.06 14.94							

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809211.84; E 565608.27

RECORD OF BOREHOLE: BH18-08

BORING DATE: January 11, 2018

SHEET 1 OF 2

DATUM: UTM 17T

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		305.00							
0	Sonic Drilling	(SW) SILTY SAND, some clay, some gravel; dark brown, no odour, no staining; non-cohesive, wet		0.00	1						
1											
2					2						
		(SW) SAND; brown, no odour, no staining; non-cohesive, wet		302.26 2.74							
3					3						
4											
5					4						
		(GW) GRAVEL, some sand; grey, no odour, no staining; non-cohesive, wet		299.51 5.49							
		(SW/GW) SAND and GRAVEL; grey, no odour, no staining; non-cohesive, wet		299.22 5.78							
6					5						
7											
8					6						
9					7						
10											

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DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

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PROJECT: 1791470

LOCATION: N 4809211.84; E 565608.27

RECORD OF BOREHOLE: BH18-08

BORING DATE: January 11, 2018

SHEET 2 OF 2

DATUM: UTM 17T

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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW/GW) SAND and GRAVEL; grey, no odour, no staining; non-cohesive, wet			7						
11					8						
				293.11 11.89							
12		(ML) CLAYEY SILT, some cobbles from 11.89 m to 13.41 m; brown, no odour, no staining; non-cohesive, wet			9						
13											
14					10						
				290.06 14.94							
15		END OF BOREHOLE									
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809315.00; E 565697.95

RECORD OF BOREHOLE: BH18-09

BORING DATE: January 12, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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	302.00							
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00							
		(SW) SAND, some gravel from 0.00 m to 1.83 m, some silt from 0.61 m to 3.66 m; brown, no odour, no staining; non-cohesive, wet	301.39 0.61	1						
1										
2				2						
3				3						
		(SW/GW) SAND and GRAVEL; brown/grey, no odour, no staining; non-cohesive, wet	298.34 3.66							
4										
5				4						
6										
7				5						
8				6						
9				7						
10										

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DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809315.00; E 565697.95

RECORD OF BOREHOLE: BH18-09

BORING DATE: January 12, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW/GW) SAND and GRAVEL; brown/grey, no odour, no staining; non-cohesive, wet			7						
11		(SW/ML) SAND and SILT, some cobbles; golden brown, no odour, no staining; non-cohesive, wet		291.03 10.97	8						
12		(SW/GW) SAND and GRAVEL; brown/grey, no odour, no staining; non-cohesive, wet		290.11 11.89	9						
13											
14		(SW/ML) SAND and SILT, some cobbles, some gravel; golden brown, no odour, no staining; non-cohesive, wet		287.98 14.02	10						
15		END OF BOREHOLE		287.06 14.94							
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809498.81; E 565598.17

RECORD OF BOREHOLE: BH18-10

BORING DATE: January 12, 2018

SHEET 1 OF 2

DATUM: UTM 17T

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		305.00							
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist		0.00							
		(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet		304.39 0.61	1						
1											
2					2						
3					3						
4											
5					4						
6											
7					5						
8					6						
9					7						
10											

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DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809498.81; E 565598.17

RECORD OF BOREHOLE: BH18-10

BORING DATE: January 12, 2018

SHEET 2 OF 2

DATUM: UTM 17T

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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet			7						
11					8						
12		(ML/SW) SILT and SAND, some cobbles; light brown, no odour, no staining; non-cohesive, wet		293.11 11.89	9						
14					10						
15		END OF BOREHOLE		290.06 14.94							
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809531.76; E 565915.05

RECORD OF BOREHOLE: BH18-11

BORING DATE: January 15, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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	303.00							
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00							
		(SW) SAND, some silt, some gravel; golden brown, no odour, no staining; non-cohesive, wet	302.70 0.30	1						
1		(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	301.78 1.22	2						
2		(SW) SAND; brown, no odour, no staining; non-cohesive, wet	300.26 2.74	3						
3				4						
4				5						
5				6						
6				7						
7										
8										
9										
10										

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CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL
CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809531.76; E 565915.05

RECORD OF BOREHOLE: BH18-11

BORING DATE: January 15, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			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
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW) SAND; brown, no odour, no staining; non-cohesive, wet		292.64 10.36	7						
11 12		(SW/ML) SAND and SILT; light brown, no odour, no staining; non-cohesive, wet		290.20 12.80	8 9						
13		(GW) GRAVEL/COBBLES; grey, no odour, no staining; non-cohesive, wet		289.89 13.11							
14		BEDROCK		288.06 14.94	10						
15		END OF BOREHOLE									
16											
17											
18											
19											
20											

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DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4808765.98; E 565094.29

RECORD OF BOREHOLE: MW18-01A/B

SHEET 1 OF 2

DATUM: UTM 17T

BORING DATE: January 11, 2018
OFFSET WELL INSTALLED: June 21, 2018

BORING METHOD: Sonic Drilling

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER
	GROUND SURFACE	302.66	
0	TOPSOIL - (SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00	1
	(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	302.05 0.61	
1			
2			2
	(SW) SAND; golden brown, no odour, no staining; non-cohesive, wet	299.92 2.74	
3			3
4	(SW/GW) SAND and GRAVEL, some silt, cobbles at 4.27 m; brown, no odour, no staining; non-cohesive, wet	298.39 4.27	
5			4
6	(SW) SAND, trace silt, trace gravel; golden brown, no odour, no staining; non-cohesive, wet	296.26 6.40	5
7			
8			6
9			7
10	*CONTINUED NEXT PAGE*		

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

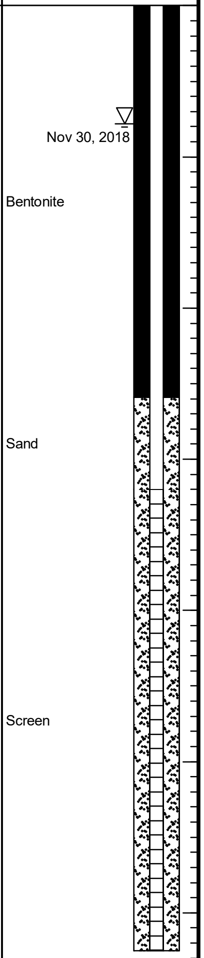
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

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



DEPTH SCALE
1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL
CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4808765.98; E 565094.29

RECORD OF BOREHOLE: MW18-01B

BORING DATE: January 11, 2018
OFFSET WELL INSTALLED: June 21, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			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 ⊢—O W—⊣ Wl: 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling			292.30 10.36	7						
11 12 13		(SW/ML) SILT and SAND, some clay at 11.89 m; brown, no odour, slight iron staining at 11.89 m; non-cohesive, wet		289.25 13.41	8 9						
14		(ML) SILT, some sand; grey; no odour, no staining; non-cohesive, wet		287.72 14.94	10						
15 16 17 18 19 20		END OF BOREHOLE									

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DEPTH SCALE
1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL
CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809051.11; E 565727.23

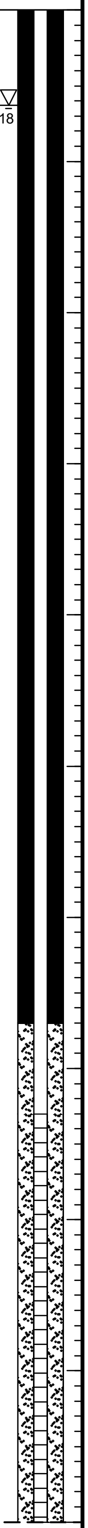
RECORD OF BOREHOLE: MW18-02

BORING DATE: January 16, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES 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	303.35							
0	Sonic Drilling	(SW) SAND, some gravel at 1.22 m; grey, no odour, no staining; non-cohesive, wet	0.00	1						Nov 30, 2018
1										
2				2						
3				3						Bentonite
4										
5				4						
6				5						
7										Sand
8				6						Screen
9		(SW/GW) SAND and GRAVEL; grey, no odour, no staining; non-cohesive, wet	294.51 8.84	7						
10										



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GTA-BHS 001 S:\CLIENTS\CBM_AGGREGATES\ABERFOLYE\ABERFOLYE_PIT\02_DATA\GINT\ABERFOLYE.GPJ GAL-MIS.GDT 1/27/22

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470
LOCATION: N 4809051.11; E 565727.23

RECORD OF BOREHOLE: MW18-02

BORING DATE: January 16, 2018

SHEET 2 OF 2
DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW/GW) SAND and GRAVEL; grey, no odour, no staining; non-cohesive, wet		292.99 10.36	7						Screen
11		(SM) SILTY SAND; brown, no odour, no staining; non-cohesive, wet			8						
12											Bentonite
13					9						
14				288.41 14.94							
15		END OF BOREHOLE									
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL
CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809429.20; E 566018.05

RECORD OF BOREHOLE: MW18-03

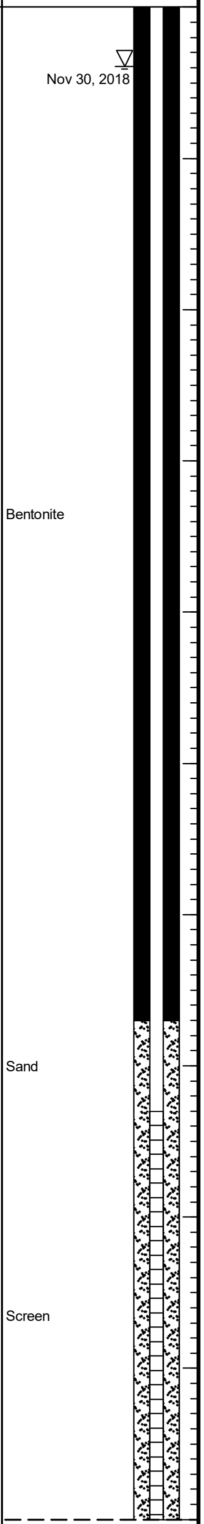
BORING DATE: January 10, 2018

SHEET 1 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE | SAMPLES | 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

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER
		GROUND SURFACE	303.66	
0	Sonic Drilling	(SW) SAND; brown, no odour, no staining; non-cohesive, wet	0.00	1
2		(SW) SAND, some cobbles at 5.18 m, some silt from 5.18 m to 5.78 m; brown, no odour, no staining; non-cohesive, wet	301.83 1.83	2 3 4 5 6
8		(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	295.43 8.23	7
10		*CONTINUED NEXT PAGE*		



DEPTH SCALE

1 : 50

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809429.20; E 566018.05

RECORD OF BOREHOLE: MW18-03

BORING DATE: January 10, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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
		--- CONTINUED FROM PREVIOUS PAGE ---								
10	Sonic Drilling	(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	293.30	7						Screen
		(ML) SILT, some clay, some cobbles; grey, no odour, no staining; non-cohesive, wet	10.36 291.77	8						
11										
12		(SW) SAND, some gravel, trace cobbles; grey, no odour, no staining; non-cohesive, wet	11.89 290.25	9						Bentonite
13		(SW) SAND, some silt, trace cobbles; brown, no odour, no staining; non-cohesive, wet	13.41 288.72	10						
14										
15		END OF BOREHOLE	14.94							
16										
17										
18										
19										
20										

DEPTH SCALE

1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809698.57; E 566029.37

RECORD OF BOREHOLE: MW18-04

BORING DATE: January 9, 2018

SHEET 1 OF 2

DATUM: UTM 17T

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	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	303.81					
0	Sonic Drilling	(SW/GW) SAND and GRAVEL; brown, no odour, no staining; non-cohesive, wet	0.00	1				Nov 30, 2018
1								
2				2				
3		(SW) SAND, some gravel at 4.27 m; brown, no odour, no staining; non-cohesive, wet	301.07 2.74	3				
4								Bentonite
5				4				
6				5				
7								
8				6				
9				7				Sand Screen
10		*CONTINUED NEXT PAGE*						

DEPTH SCALE

1 : 50

GOLDER MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470
LOCATION: N 4809698.57; E 566029.37

RECORD OF BOREHOLE: MW18-04

BORING DATE: January 9, 2018

SHEET 2 OF 2
DATUM: UTM 17T

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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(SW) SAND, some gravel at 4.27 m; brown, no odour, no staining; non-cohesive, wet			7						
11					8						Screen
		(SW) SAND, some gravel from 11.58 m to 11.89 m, some silt from 11.58 m to 14.94 m; brown, no odour, no staining; non-cohesive, wet		292.23 11.58							
12					9						
13											Bentonite
14					10						
				288.87							
15		END OF BOREHOLE		14.94							
16											
17											
18											
19											
20											

GTA-BHS 001 S:\CLIENTS\CBM_AGGREGATES\ABERFOLYE\ABERFOLYE_PIT\02_DATA\GINT\ABERFOLYE.GPJ GAL-MIS.GDT 1/27/22

DEPTH SCALE
1 : 50

GOLDER
MEMBER OF WSP

LOGGED: AL
CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809511.68; E 565241.19

RECORD OF BOREHOLE: MW18-05

BORING DATE: January 16, 2018

SHEET 1 OF 2

DATUM: UTM 17T

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}

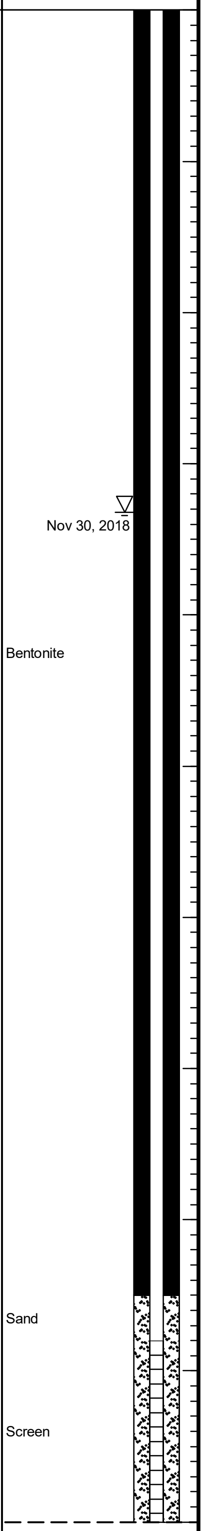
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl ; 10, 20, 30, 40

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	307.17			
0	Sonic Drilling	(SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00	1		
1		(SM) SILTY SAND, some cobbles; golden brown, no odour, no staining; non-cohesive, wet	305.95 1.22	2		
2						
3		(ML/SW) SILT and SAND, some gravel, some cobbles and boulders from 7.32 m to 8.84 m, some clay from 13.41 m to 14.94 m; golden brown, no odour, no staining; non-cohesive, wet	304.38 2.79	3		
4						
5				4		
6				5		
7						
8				6		
9				7		
10						

CONTINUED NEXT PAGE

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

GOLDER MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809511.68; E 565241.19

RECORD OF BOREHOLE: MW18-05

BORING DATE: January 16, 2018

SHEET 2 OF 2

DATUM: UTM 17T

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			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
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(ML/SW) SILT and SAND, some gravel, some cobbles and boulders from 7.32 m to 8.84 m, some clay from 13.41 m to 14.94 m; golden brown, no odour, no staining; non-cohesive, wet			7						
11					8						Screen
12					9						
13											Bentonite
14					10						
		BEDROCK		292.54 14.63							
15		END OF BOREHOLE		292.23 14.94							
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

LOGGED: AL

CHECKED: GWS

PROJECT: 1791470

LOCATION: N 4809336.59; E 565548.98

RECORD OF BOREHOLE: MW18-06

BORING DATE: November 23, 2018

SHEET 1 OF 1

DATUM: UTM 17T

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

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

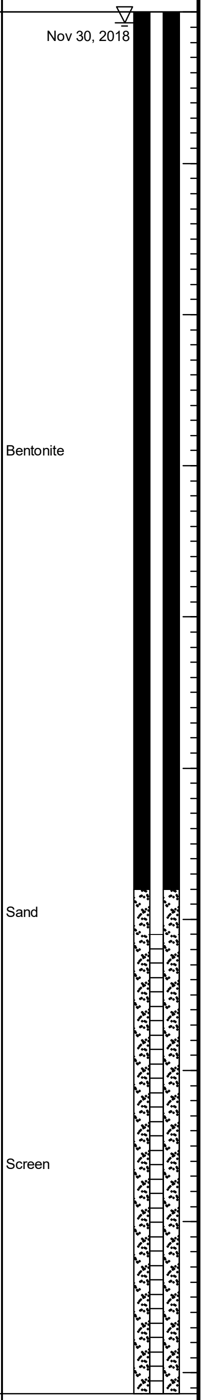
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

BORING METHOD: Sonic Drilling

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER
	GROUND SURFACE	303.07	
0	(SM) SILTY SAND, organics; brown, no odour, no staining; moist	0.00	1
1	(SW/GW) SAND and GRAVEL; grey, no odour, no staining; non-cohesive, wet	302.16 0.91	2 3
4	(SW) SAND; brown, no odour, no staining; non-cohesive, wet	299.41 3.66	4 5
7	(SW/GW) SAND and GRAVEL; grey, no odour, no staining; wet	296.36 6.71	6
9	END OF BOREHOLE	293.93 9.14	

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

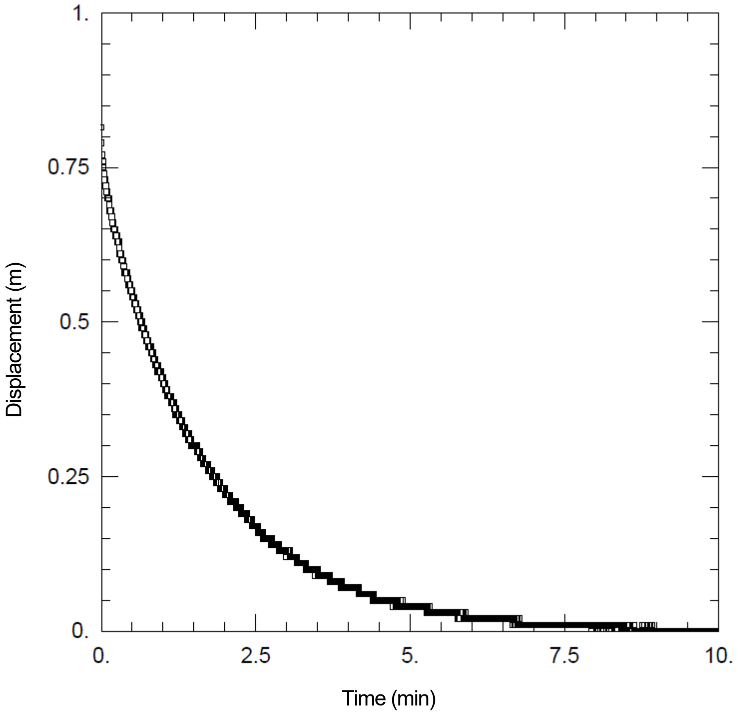
GOLDER MEMBER OF WSP

LOGGED: AL

CHECKED: GWS

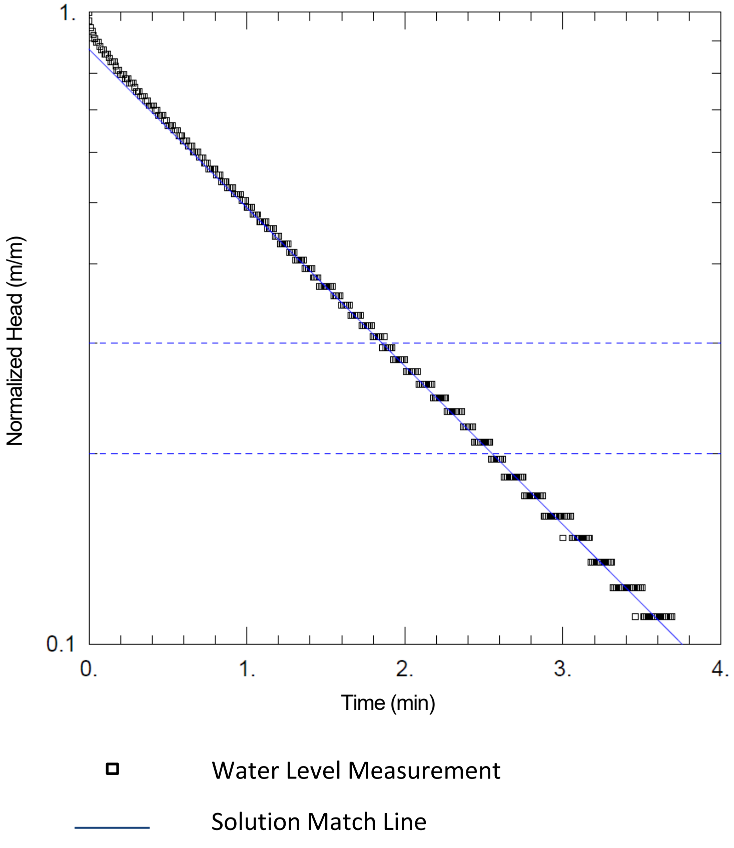
APPENDIX D

Single Well Hydraulic Response Test Results



TEST INFORMATION:

Test Well:	MW18-01B
Time of Test:	August 3, 2018
Test Type:	Rising Head Test
Test Method:	Pneumatic displacement, rising head test
Static Water Level:	1.895 mbmp
Initial Displacement:	0.815 m
Casing Radius:	0.026 m
Borehole Radius:	0.057 m
Open Well Screen Interval:	3.50 to 6.50 mbgs
Geology:	Silt and Sand



SOLUTION:

Solution Method:	Bouwer-Rice
Solution Type:	Zero Storage
Aquifer Model:	Unconfined

Hydraulic Conductivity (K) =

4×10^{-6} m/s

CLIENT

CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC.(CANADA)

PROJECT

ABERFOYLE SOUTH PIT EXPANSION

CONSULTANT

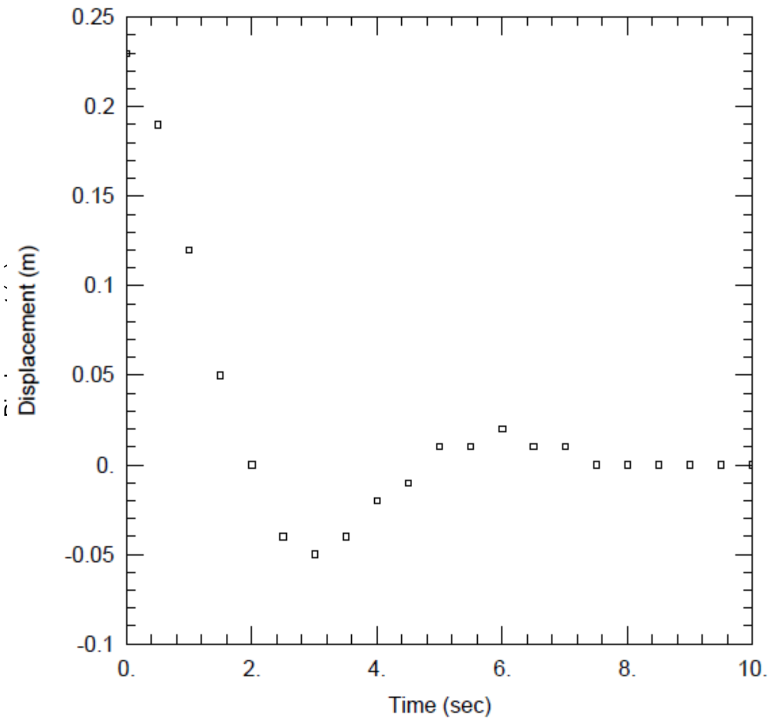
wsp

YYYY-MM-DD	2018-10-09
PREPARED	PGM
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

TITLE

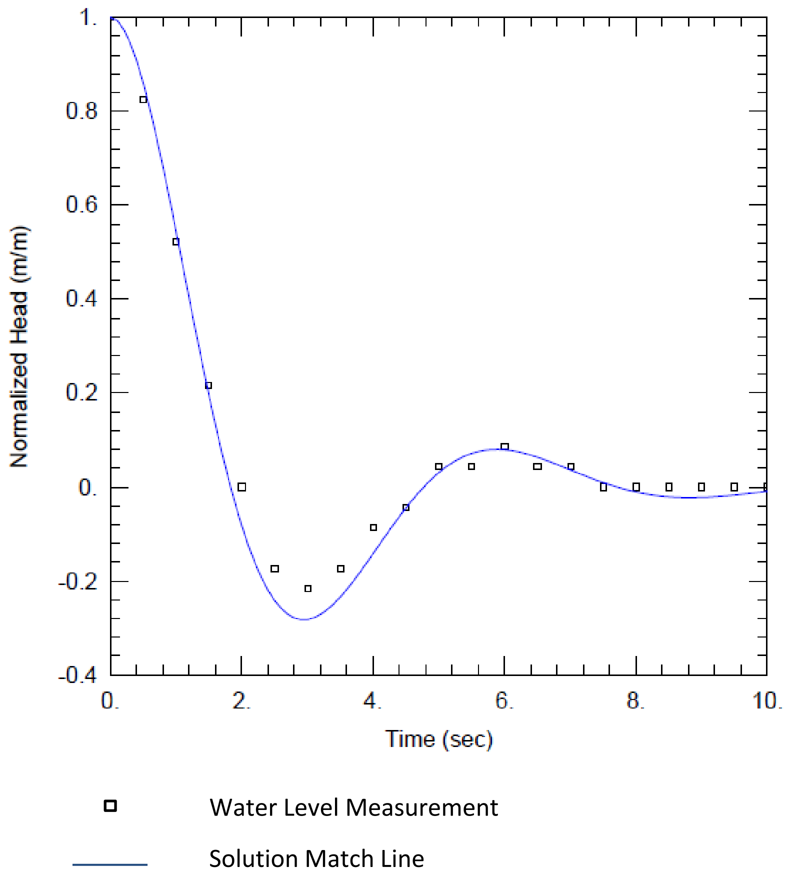
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL MW18-01B

PROJECT No.	PHASE	Rev.	FIGURE
1791470	**4000**	**A**	**1**



TEST INFORMATION:

Test Well:	MW18-02
Time of Test:	August 2, 2018
Test Type:	Rising Head Test
Test Method:	Physical slug, rising head test
Static Water Level:	2.032 mbmp
Initial Displacement:	0.536 m
Casing Radius:	0.026 m
Borehole Radius:	0.057 m
Open Well Screen Interval:	7.30 to 10.30 mbgs
Geology:	Sand and gravel



LUTION:

olution Method:	Springer-Gelhar
olution Type:	Inertial
ıquifer Model:	Unconfined

Hydraulic Conductivity (K) =

1 x 10^{-3} m/s

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS
CEMENT INC.(CANADA)

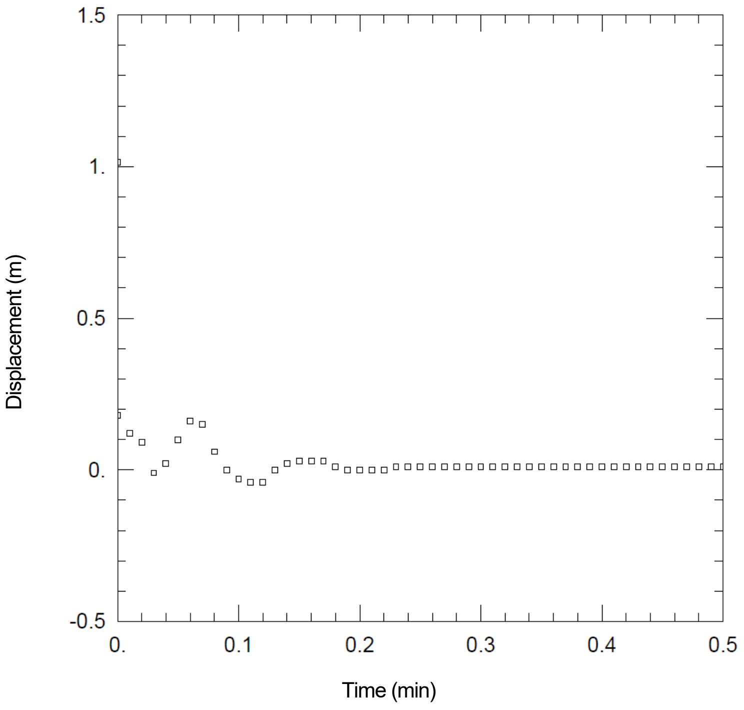
PROJECT
ABERFOYLE SOUTH PIT EXPANSION

CONSULTANT

YYYY-MM-DD	2022-01-28
PREPARED	PGM
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

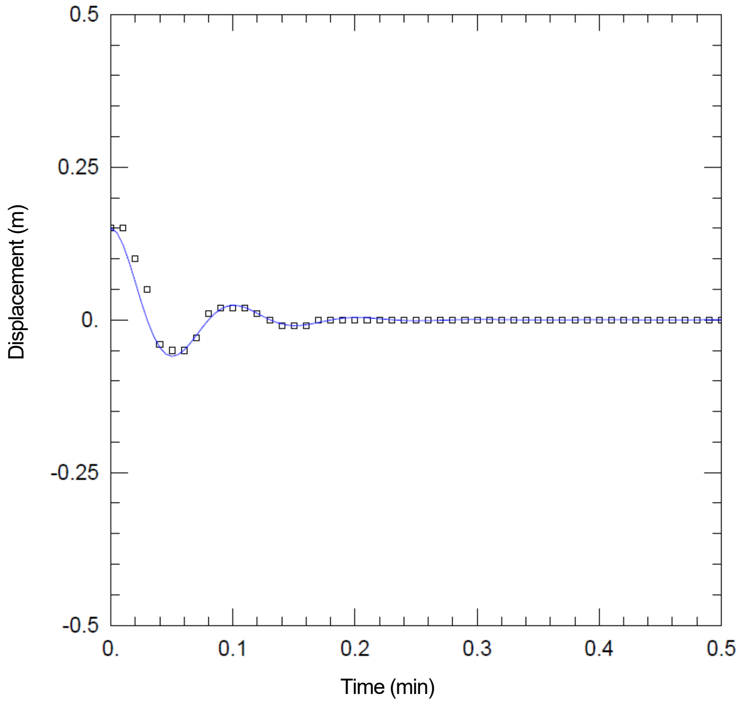
TITLE
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL MW18-02

PROJECT No.	PHASE	Rev.	FIGURE
1791470	**4000**	**A**	**2**



TEST INFORMATION:

Test Well:	MW18-03
Time of Test:	August 2, 2018
Test Type:	Rising Head Test
Test Method:	Physical slug, rising head test
Static Water Level:	1.600 mbmp
Initial Displacement:	1.015 m
Casing Radius:	0.026 m
Borehole Radius:	0.057 m
Open Well Screen Interval:	7.30 to 10.30 mbgs
Geology:	Sand and gravel



□ Water Level Measurement

— Solution Match Line

SOLUTION:

Solution Method:	Springer-Gelhar
Solution Type:	Inertial
Aquifer Model:	Unconfined

Hydraulic Conductivity (K) =

8×10^{-4} m/s

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS
CEMENT INC.(CANADA)

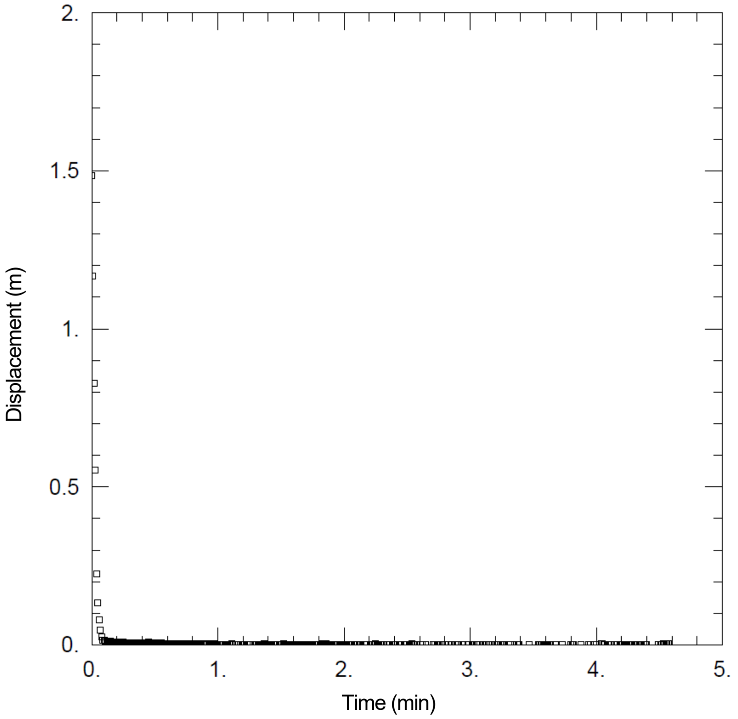
PROJECT
ABERFOYLE SOUTH PIT EXPANSION

CONSULTANT

YYYY-MM-DD	2019-03-12
PREPARED	PGM
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

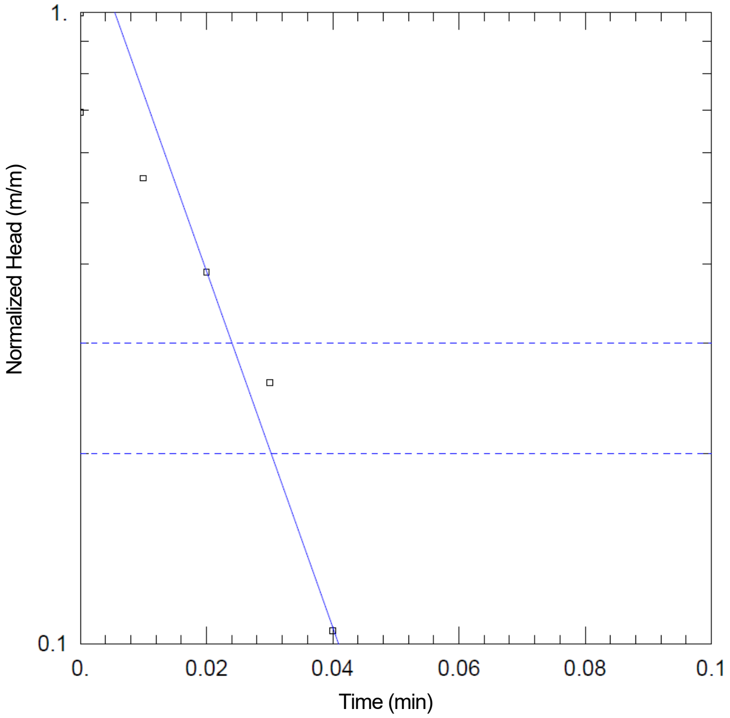
TITLE
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL MW18-03

PROJECT No.	PHASE	Rev.	FIGURE
1791470	**4000**	**A**	**3**



TEST INFORMATION:

Test Well:	MW18-04
Time of Test:	August 2, 2018
Test Type:	Rising Head Test
Test Method:	Pneumatic displacement, rising head test
Static Water Level:	1.477 mbmp
Initial Displacement:	2.133 m
Casing Radius:	0.026 m
Borehole Radius:	0.057 m
Open Well Screen Interval:	8.80 to 11.80 mbgs
Geology:	Sand



□ Water Level Measurement

—— Solution Match Line

SOLUTION:

Solution Method:	Bouwer-Rice
Solution Type:	Zero Storage
Aquifer Model:	Unconfined

Hydraulic Conductivity (K) =

5 x 10^{-4} m/s

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS
CEMENT INC.(CANADA)

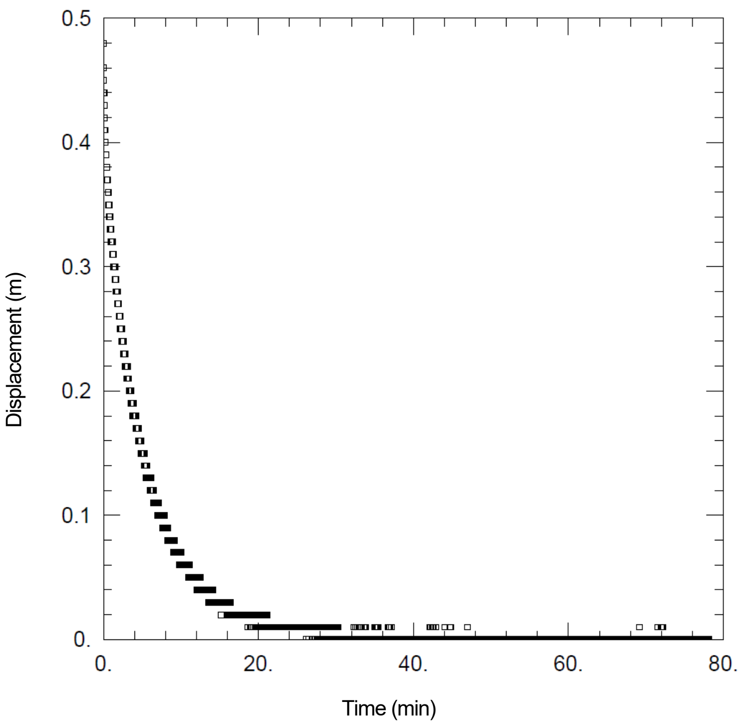
PROJECT
ABERFOYLE SOUTH PIT EXPANSION

CONSULTANT

YYYY-MM-DD	2018-10-09
PREPARED	PGM
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

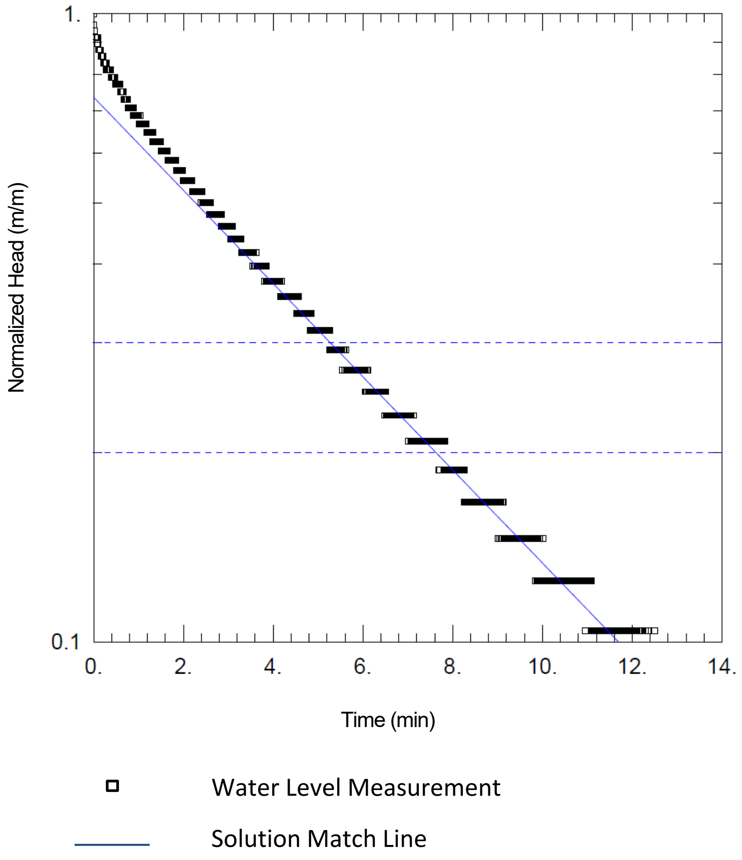
TITLE
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL MW18-04

PROJECT No.	PHASE	Rev.	FIGURE
1791470	**4000**	**A**	**4**



TEST INFORMATION:

Test Well:	MW18-05
Time of Test:	August 2, 2018
Test Type:	Rising Head Test
Test Method:	Physical slug, rising head test
Static Water Level:	1.895 mbmp
Initial Displacement:	0.479 m
Casing Radius:	0.026 m
Borehole Radius:	0.057 m
Open Well Screen Interval:	8.80 to 11.80 mbgs
Geology:	Silt and Sand



SOLUTION:

Solution Method:	Bouwer-Rice
Solution Type:	Zero Storage
Aquifer Model:	Unconfined

Hydraulic Conductivity (K) =

1×10^{-6} m/s

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS
CEMENT INC.(CANADA)

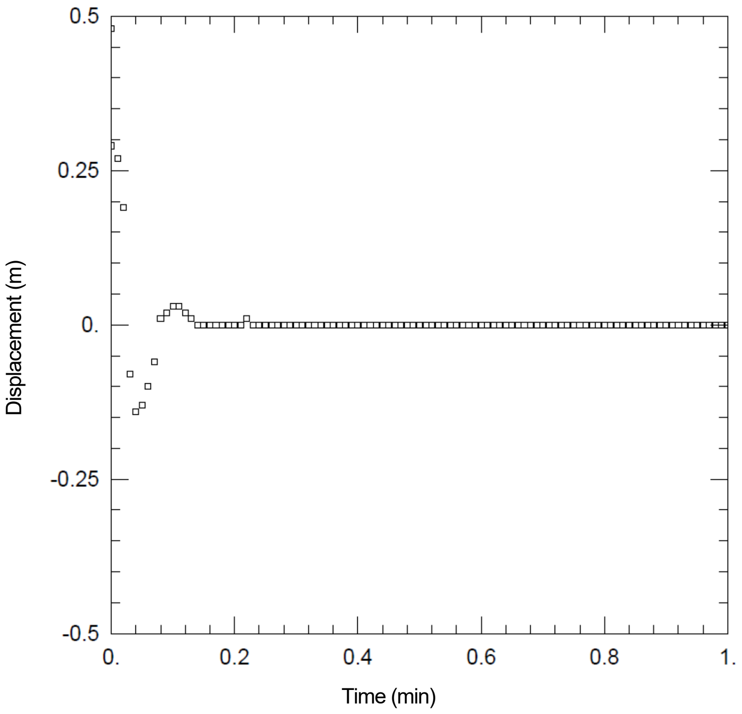
PROJECT
ABERFOYLE SOUTH PIT EXPANSION

CONSULTANT

YYYY-MM-DD	2018-10-09
PREPARED	PGM
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

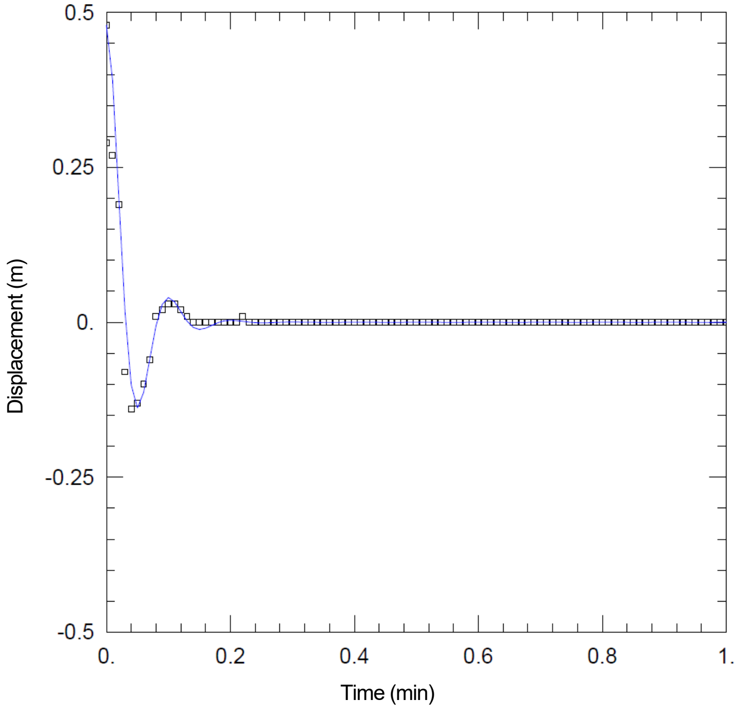
TITLE
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL MW18-05

PROJECT No.	PHASE	Rev.	FIGURE
1791470	4000	A	5



TEST INFORMATION:

Test Well:	MW18-06
Time of Test:	February 5, 2019
Test Type:	Rising Head Test
Test Method:	Physical slug, rising head test
Static Water Level:	0.71 mbmp
Initial Displacement:	0.48 m
Casing Radius:	0.026 m
Borehole Radius:	0.057 m
Open Well Screen Interval:	6.10 to 9.14 mbgs
Geology:	Sand and Gravel



☐ Water Level Measurement

— Solution Match Line

SOLUTION:

Solution Method:	Springer-Gelhar
Solution Type:	Inertial
Aquifer Model:	Unconfined

Hydraulic Conductivity (K) =

$$\boxed{6 \times 10^{-4}\ \text{m/s}}$$

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS
CEMENT INC.(CANADA)

PROJECT
ABERFOYLE SOUTH PIT EXPANSION

CONSULTANT

YYYY-MM-DD	2019-03-12
PREPARED	PGM
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

TITLE
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL MW18-06

PROJECT No.	PHASE	Rev.	FIGURE
1791470	**4000**	**A**	**6**

APPENDIX E

Water Quality - Certificates of Analysis

Your Project #: 1791470 (4000)
Your C.O.C. #: 117592

Attention: Paul Menkveld

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

Report Date: 2019/01/25
Report #: R5571078
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B917944
Received: 2019/01/22, 08:49

Sample Matrix: Water
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Petroleum Hydro. CCME F1 & BTEX in Water	5	N/A	2019/01/24	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (1)	3	2019/01/24	2019/01/24	CAM SOP-00316	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (1)	2	2019/01/24	2019/01/25	CAM SOP-00316	CCME PHC-CWS m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam’s profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
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.
(1) 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.

Your Project #: 1791470 (4000)
Your C.O.C. #: 117592

Attention: Paul Menkveld

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

Report Date: 2019/01/25
Report #: R5571078
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B917944
Received: 2019/01/22, 08:49

Encryption Key

Colby Coutu
Project Manager Assistant
25 Jan 2019 13:26:03

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.

O.REG 153 PHCS, BTEX/F1-F4 (WATER)

Maxxam ID		IUQ829	IUQ830	IUQ831	IUQ832	IUQ833		
Sampling Date		2019/01/18 14:30	2019/01/18 15:30	2019/01/18 17:45	2019/01/18 16:30	2019/01/18 17:00		
COC Number		117592	117592	117592	117592	117592		
	UNITS	**MW18-01B**	**MW18-02**	**MW18-03**	**MW18-04**	**SW18-01**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons								
Benzene	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	5942486
Toluene	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	5942486
Ethylbenzene	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	5942486
o-Xylene	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	5942486
p+m-Xylene	ug/L	<0.40	<0.40	<0.40	<0.40	<0.40	0.40	5942486
Total Xylenes	ug/L	<0.40	<0.40	<0.40	<0.40	<0.40	0.40	5942486
F1 (C6-C10)	ug/L	<25	<25	<25	<25	<25	25	5942486
F1 (C6-C10) - BTEX	ug/L	<25	<25	<25	<25	<25	25	5942486
F2-F4 Hydrocarbons								
F2 (C10-C16 Hydrocarbons)	ug/L	<100	<100	<100	<100	190	100	5943869
F3 (C16-C34 Hydrocarbons)	ug/L	<200	<200	<200	<200	<200	200	5943869
F4 (C34-C50 Hydrocarbons)	ug/L	<200	<200	<200	<200	<200	200	5943869
Reached Baseline at C50	ug/L	Yes	Yes	Yes	Yes	Yes		5943869
Surrogate Recovery (%)								
1,4-Difluorobenzene	%	102	103	104	102	102		5942486
4-Bromofluorobenzene	%	101	100	100	102	101		5942486
D10-Ethylbenzene	%	103	106	107	104	104		5942486
D4-1,2-Dichloroethane	%	95	95	95	97	98		5942486
o-Terphenyl	%	99	102	97	101	99		5943869

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Maxxam ID: IUQ829
Sample ID: MW18-01B
Matrix: Water

Collected: 2019/01/18
Shipped:
Received: 2019/01/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5942486	N/A	2019/01/24	Joe Paino
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5943869	2019/01/24	2019/01/24	Dorina Popa

Maxxam ID: IUQ830
Sample ID: MW18-02
Matrix: Water

Collected: 2019/01/18
Shipped:
Received: 2019/01/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5942486	N/A	2019/01/24	Joe Paino
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5943869	2019/01/24	2019/01/24	Dorina Popa

Maxxam ID: IUQ831
Sample ID: MW18-03
Matrix: Water

Collected: 2019/01/18
Shipped:
Received: 2019/01/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5942486	N/A	2019/01/24	Joe Paino
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5943869	2019/01/24	2019/01/24	Dorina Popa

Maxxam ID: IUQ832
Sample ID: MW18-04
Matrix: Water

Collected: 2019/01/18
Shipped:
Received: 2019/01/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5942486	N/A	2019/01/24	Joe Paino
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5943869	2019/01/24	2019/01/25	Dorina Popa

Maxxam ID: IUQ833
Sample ID: SW18-01
Matrix: Water

Collected: 2019/01/18
Shipped:
Received: 2019/01/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5942486	N/A	2019/01/24	Joe Paino
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5943869	2019/01/24	2019/01/25	Dorina Popa

GENERAL COMMENTS

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

Package 1	3.7°C

Project number updated as per client request.

Results relate only to the items tested.

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
5942486	1,4-Difluorobenzene	2019/01/23	105	70 - 130	102	70 - 130	99	%		
5942486	4-Bromofluorobenzene	2019/01/23	100	70 - 130	103	70 - 130	102	%		
5942486	D10-Ethylbenzene	2019/01/23	101	70 - 130	97	70 - 130	102	%		
5942486	D4-1,2-Dichloroethane	2019/01/23	94	70 - 130	100	70 - 130	99	%		
5943869	o-Terphenyl	2019/01/24	102	60 - 130	101	60 - 130	102	%		
5942486	Benzene	2019/01/23	100	70 - 130	102	70 - 130	<0.20	ug/L	9.0	30
5942486	Ethylbenzene	2019/01/23	107	70 - 130	102	70 - 130	<0.20	ug/L	NC	30
5942486	F1 (C6-C10) - BTEX	2019/01/23					<25	ug/L	4.9	30
5942486	F1 (C6-C10)	2019/01/23	95	70 - 130	102	70 - 130	<25	ug/L	4.9	30
5942486	o-Xylene	2019/01/23	102	70 - 130	100	70 - 130	<0.20	ug/L	NC	30
5942486	p+m-Xylene	2019/01/23	110	70 - 130	105	70 - 130	<0.40	ug/L	NC	30
5942486	Toluene	2019/01/23	106	70 - 130	103	70 - 130	<0.20	ug/L	NC	30
5942486	Total Xylenes	2019/01/23					<0.40	ug/L	NC	30
5943869	F2 (C10-C16 Hydrocarbons)	2019/01/24	105	50 - 130	104	60 - 130	<100	ug/L	7.9	30
5943869	F3 (C16-C34 Hydrocarbons)	2019/01/24	98	50 - 130	100	60 - 130	<200	ug/L	NC	30
5943869	F4 (C34-C50 Hydrocarbons)	2019/01/24	103	50 - 130	102	60 - 130	<200	ug/L	NC	30

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 (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 (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

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

Brad Newman, Scientific Service Specialist

Maxxam
A Bureau Veritas Group Company

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/3

REC'D IN WATERLOO

CHAIN OF CUSTODY RECORD 117592

Page 1 of 1

Invoice Information

Company Name: Golder
Contact Name: Paul Menkveld
Address: 210 Sheldon Dr.
Cambridge, ON
Phone: 226-750-8848 Fax: —
Email: paul_menkveld@golder.com

Report Information (if differs from invoice)

Company Name:
Contact Name:
Address:
Phone: Fax:
Email:

Project Information (where applicable)

Quotation #:
P.O. #/ AFE#:
Project #:
Site Location:
Site #:
Sampled By:

Turnaround Time (TAT) Required

☒ Regular TAT (5-7 days) Most analyses

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Rush TAT (Surcharges will be applied)
☐ 1 Day ☐ 2 Days ☐ 3-4 Days

Date Required:
Rush Confirmation #:

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

Regulation 153

☐ Table 1 ☐ Res/Park ☐ Med/ Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/ Other
☐ Table ____

FOR RSC (PLEASE CIRCLE) Y / [✓ N]

Other Regulations

☐ CCME ☐ Sanitary Sewer Bylaw
☐ MISA ☐ Storm Sewer Bylaw
☐ PWQO Region
☐ Other (Specify)
☐ REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / [✓ N]

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

Analysis Requested

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)									HOLD- DO NOT ANALYZE
1	MW18-01B	2019/01/18	14:30	GW	5		X	X													
2	MW18-02	↓	15:30	↓	↓		↓	↓													
3	MW18-03		17:45																		
4	MW18-04		16:30																		
5	SW18-01		17:00	SW																	
6																					
7																					
8																					
9																					
10																					

LABORATORY USE ONLY

CUSTODY SEAL [✓ Y] / N		COOLER TEMPERATURES
Present	Intact	
Y	Y	4/4/3

COOLING MEDIA PRESENT: Y / [✓ N]

COMMENTS

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
/ Paul Menkveld	2019/01/21	17:20	MAHMOUD AMIN	2019/01/22	08:49
			[illegible]	2019/01/22	15:26

22-Jan-19 08:49
Ema Gitej
B917944
MUA WAT-001

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Maxxam's standard Terms and Conditions. Signing of this Chain of Custody document is acknow available for viewing at www.maxxam.ca/terms. Sample container, preservation, hold time and packages information can be viewed at http://maxxam.ca/wp-content/uploads/Ontario-COC.pdf.

MAXXAM DRIVER

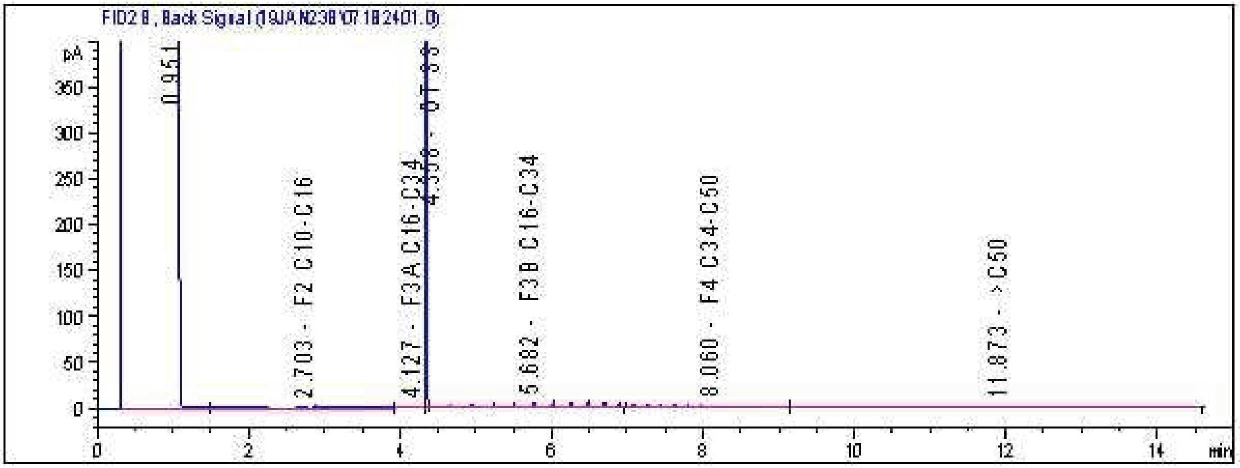
COC-1004 (03/17)

White: Maxxam ~ Yellow: Client

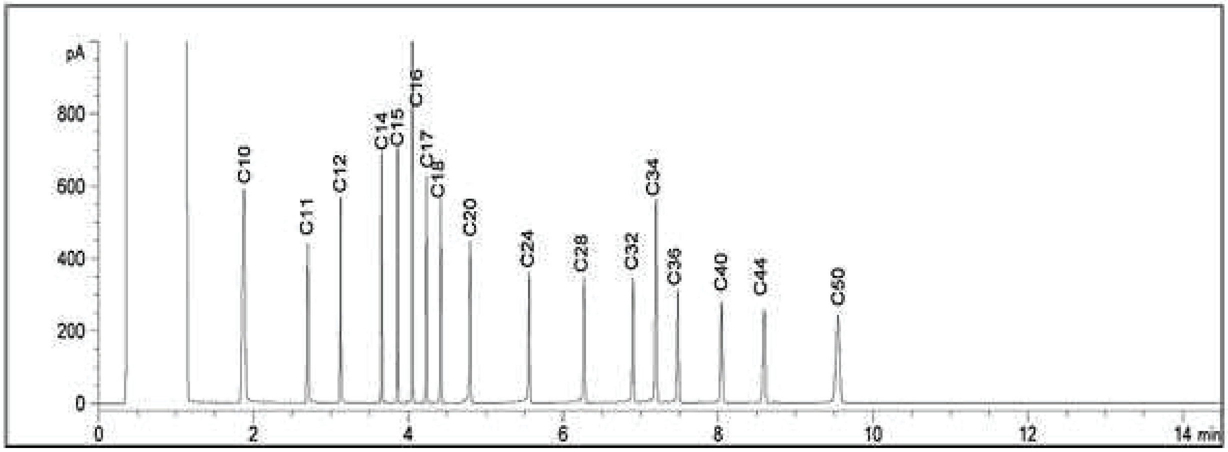
Maxxam Job #: B917944
Report Date: 2019/01/25
Maxxam Sample: IUQ829

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-01B

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

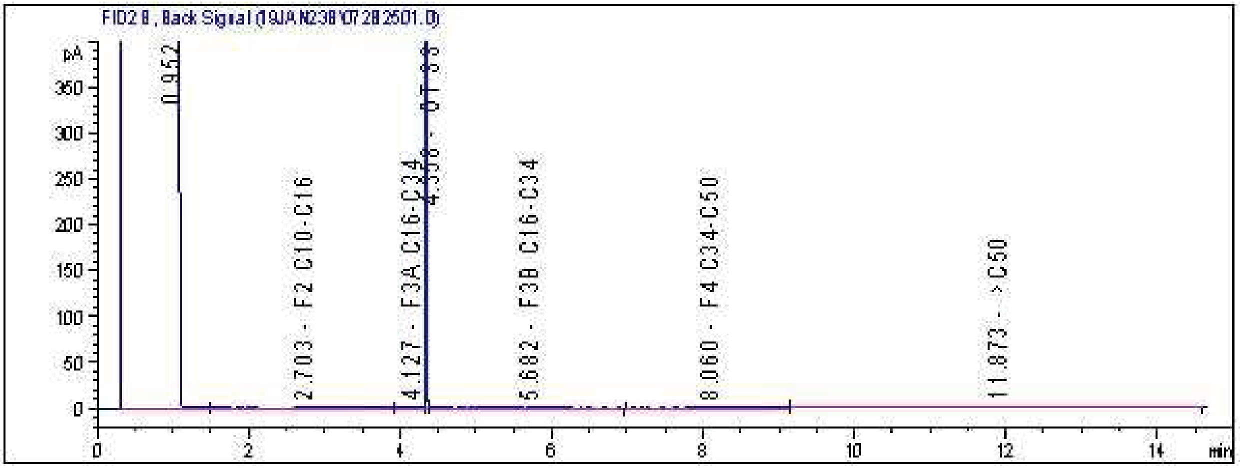
Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

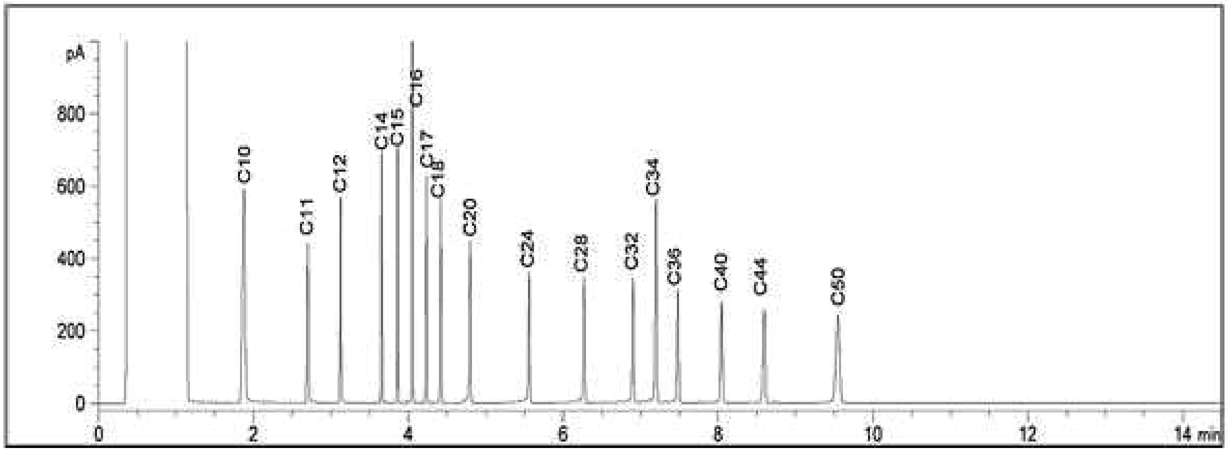
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

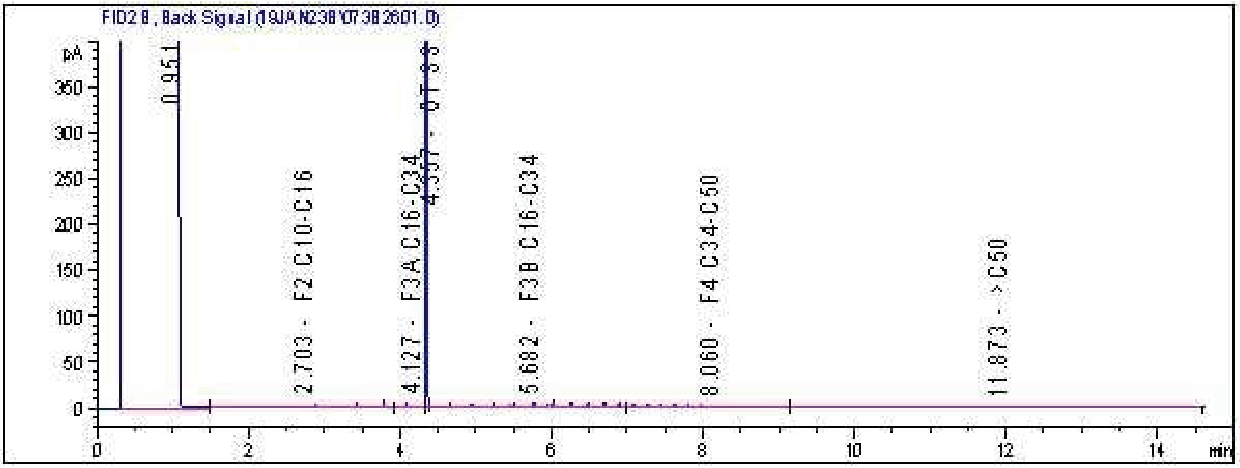
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

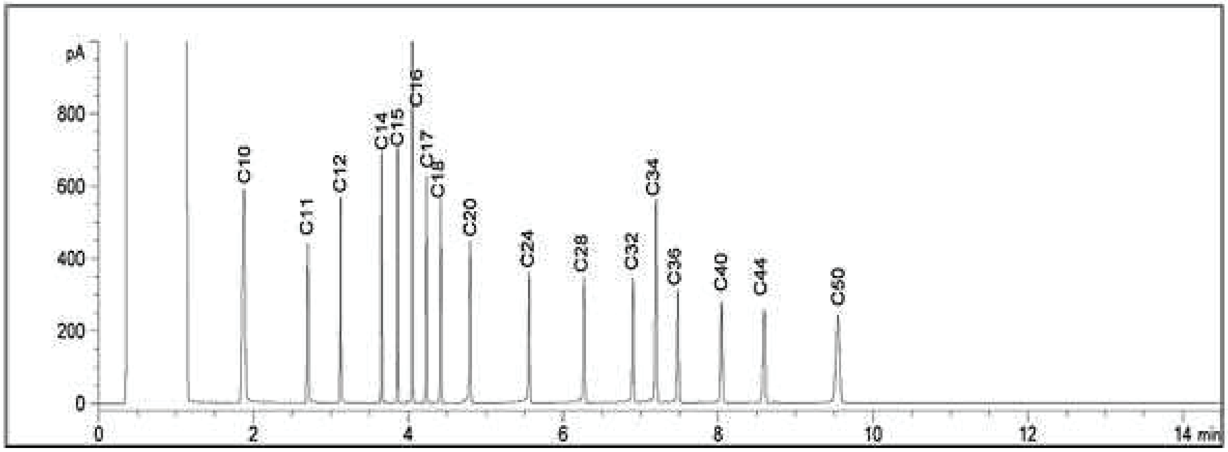
Maxxam Job #: B917944
Report Date: 2019/01/25
Maxxam Sample: IUQ831

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-03

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

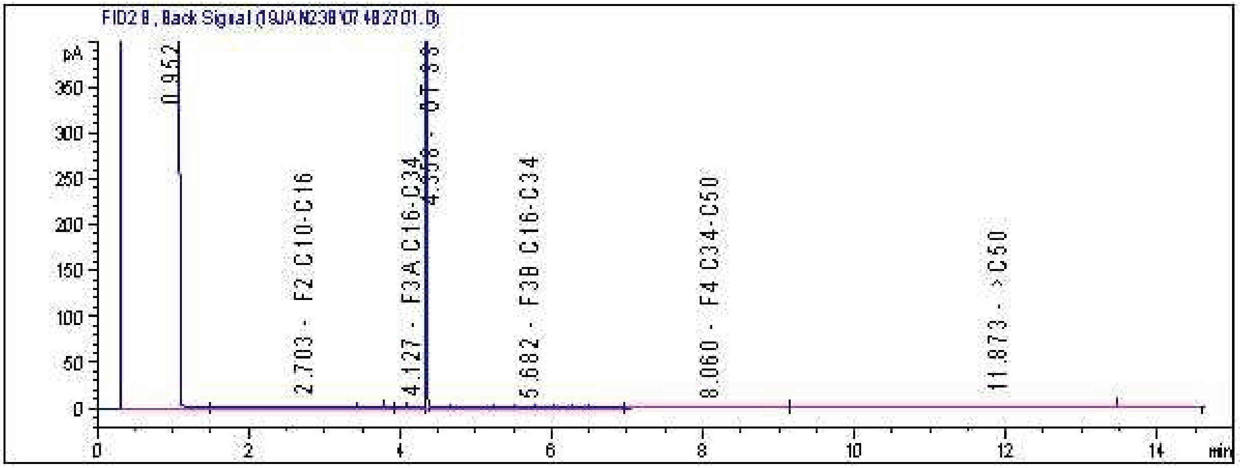
Gasoline: **C6 - C12**	Diesel: **C10 - C24**	Jet Fuels: **C6 - C16**
Varsol: **C8 - C12**	Fuel Oils: **C6 - C32**	Creosote: **C10 - C26**
Kerosene: **C8 - C16**	Motor Oils: **C16 - C50**	Asphalt: **C18 - C50+**

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

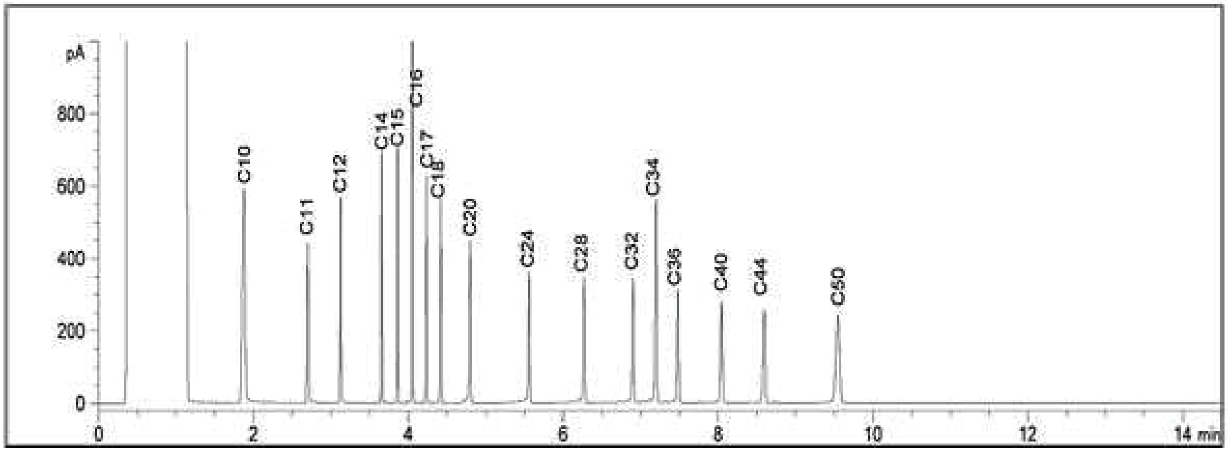
Maxxam Job #: B917944
Report Date: 2019/01/25
Maxxam Sample: IUQ832

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-04

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

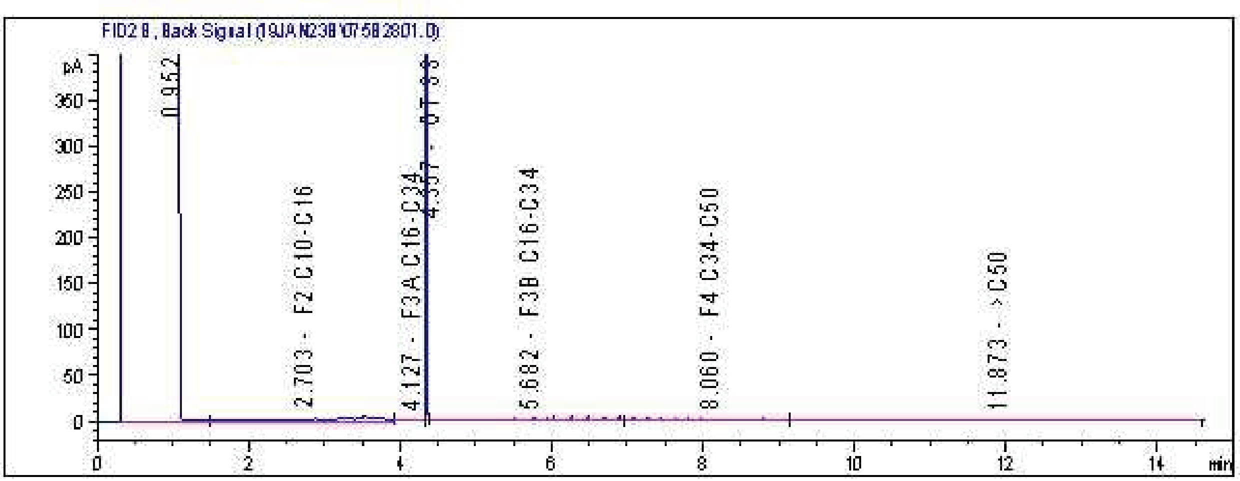
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

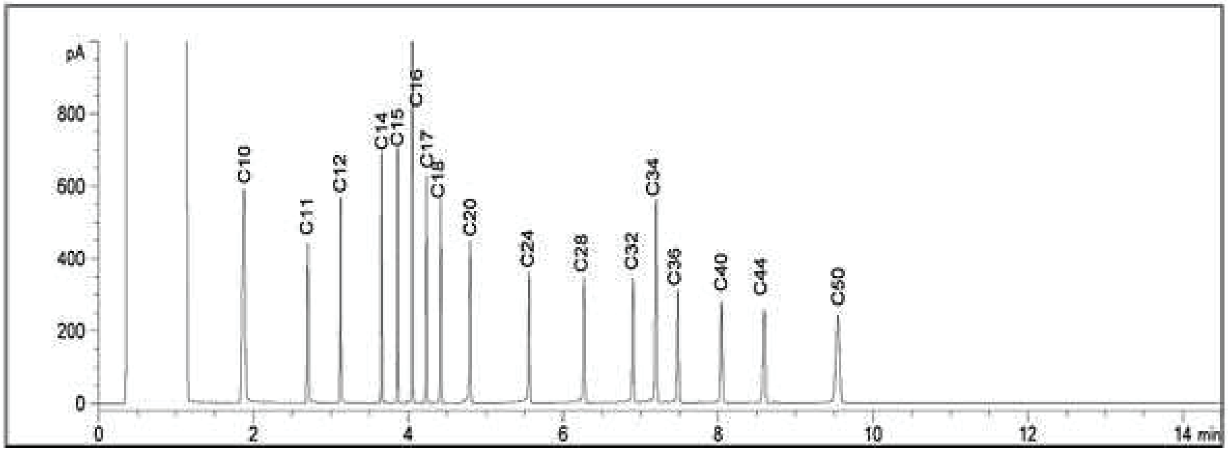
Maxxam Job #: B917944
Report Date: 2019/01/25
Maxxam Sample: IUQ833

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: SW18-01

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

Your Project #: 1791470 (4000)
Your C.O.C. #: 712029-01-01

Attention: Alexandra Smofsky

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/04/18
Report #: R5676147
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B995482
Received: 2019/04/11, 10:00

Sample Matrix: Ground Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	6	N/A	2019/04/17	CAM SOP-00448	SM 23 2320 B m
Carbonate, Bicarbonate and Hydroxide	6	N/A	2019/04/17	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	6	N/A	2019/04/15	CAM SOP-00463	SM 4500-Cl E m
Conductivity	1	N/A	2019/04/15	CAM SOP-00414	SM 23 2510 m
Conductivity	5	N/A	2019/04/16	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	6	N/A	2019/04/12	CAM SOP-00446	SM 23 5310 B m
Petroleum Hydro. CCME F1 & BTEX in Water	6	N/A	2019/04/16	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (2)	6	2019/04/15	2019/04/16	CAM SOP-00316	CCME PHC-CWS m
Hardness (calculated as CaCO3)	6	N/A	2019/04/15	CAM SOP 00102/00408/00447	SM 2340 B
Mercury	6	2019/04/15	2019/04/16	CAM SOP-00453	EPA 7470A m
Dissolved Metals by ICPMS	6	N/A	2019/04/12	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	6	N/A	2019/04/18		
Anion and Cation Sum	6	N/A	2019/04/17		
Total Ammonia-N	6	N/A	2019/04/15	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (3)	6	N/A	2019/04/16	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	6	2019/04/13	2019/04/17	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	6	N/A	2019/04/15	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	6	N/A	2019/04/18		
Sat. pH and Langelier Index (@ 4C)	6	N/A	2019/04/18		
Sulphate by Automated Colourimetry	6	N/A	2019/04/15	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	6	N/A	2019/04/18		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam
A Bureau Veritas Group Company

Your Project #: 1791470 (4000)
Your C.O.C. #: 712029-01-01

Attention: Alexandra Smofsky
Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/04/18
Report #: R5676147
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B995482
Received: 2019/04/11, 10:00

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
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.
(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 Ema Gitej

Ema Gitej
Senior Project Manager
18 Apr 2019 17:56:23

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.

Total Cover Pages : 2

RCAP - COMPREHENSIVE (GROUND WATER)

Maxxam ID		JKT724	JKT725			JKT725		
Sampling Date		2019/04/09 13:30	2019/04/09 11:30			2019/04/09 11:30		
COC Number		712029-01-01	712029-01-01			712029-01-01		
	UNITS	**MW18-01B**	**MW18-02**	**RDL**	**QC Batch**	**MW18-02 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters								
Anion Sum	me/L	6.45	6.65	N/A	6065974			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	250	180	1.0	6064746			
Calculated TDS	mg/L	370	370	1.0	6064751			
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.7	3.1	1.0	6064746			
Cation Sum	me/L	7.85	7.21	N/A	6065974			
Hardness (CaCO3)	mg/L	390	310	1.0	6066688			
Ion Balance (% Difference)	%	9.73	4.03	N/A	6065973			
Langelier Index (@ 20C)	N/A	1.00	0.981		6064749			
Langelier Index (@ 4C)	N/A	0.753	0.732		6064750			
Saturation pH (@ 20C)	N/A	7.07	7.27		6064749			
Saturation pH (@ 4C)	N/A	7.31	7.52		6064750			
Inorganics								
Total Ammonia-N	mg/L	<0.050	<0.050	0.050	6069886			
Conductivity	umho/cm	700	700	1.0	6069344			
Dissolved Organic Carbon	mg/L	0.74	0.65	0.50	6067512			
Orthophosphate (P)	mg/L	<0.010	<0.010	0.010	6069400			
pH	pH	8.07	8.25		6069345			
Dissolved Sulphate (SO4)	mg/L	18	55	1.0	6069399			
Alkalinity (Total as CaCO3)	mg/L	250	180	1.0	6069343			
Dissolved Chloride (Cl-)	mg/L	12	64	1.0	6069398			
Nitrite (N)	mg/L	<0.010	<0.010	0.010	6069364			
Nitrate (N)	mg/L	10.1	<0.10	0.10	6069364			
Nitrate + Nitrite (N)	mg/L	10.1	<0.10	0.10	6069364			
Metals								
Dissolved Aluminum (Al)	ug/L	<5.0	<5.0	5.0	6067880	<5.0	5.0	6067880
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	6067880	<0.50	0.50	6067880
Dissolved Arsenic (As)	ug/L	<1.0	<1.0	1.0	6067880	<1.0	1.0	6067880
Dissolved Barium (Ba)	ug/L	29	130	2.0	6067880	130	2.0	6067880
Dissolved Beryllium (Be)	ug/L	<0.50	<0.50	0.50	6067880	<0.50	0.50	6067880
Dissolved Boron (B)	ug/L	<10	<10	10	6067880	<10	10	6067880

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

RCAP - COMPREHENSIVE (GROUND WATER)

Maxxam ID		JKT724	JKT725			JKT725		
Sampling Date		2019/04/09 13:30	2019/04/09 11:30			2019/04/09 11:30		
COC Number		712029-01-01	712029-01-01			712029-01-01		
	UNITS	**MW18-01B**	**MW18-02**	**RDL**	**QC Batch**	**MW18-02 Lab-Dup**	**RDL**	**QC Batch**
Dissolved Cadmium (Cd)	ug/L	<0.10	<0.10	0.10	6067880	<0.10	0.10	6067880
Dissolved Calcium (Ca)	ug/L	94000	79000	200	6067880	78000	200	6067880
Dissolved Chromium (Cr)	ug/L	<5.0	<5.0	5.0	6067880	<5.0	5.0	6067880
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	6067880	<0.50	0.50	6067880
Dissolved Copper (Cu)	ug/L	<1.0	<1.0	1.0	6067880	<1.0	1.0	6067880
Dissolved Iron (Fe)	ug/L	<100	1000	100	6067880	1000	100	6067880
Dissolved Lead (Pb)	ug/L	<0.50	<0.50	0.50	6067880	<0.50	0.50	6067880
Dissolved Magnesium (Mg)	ug/L	37000	28000	50	6067880	28000	50	6067880
Dissolved Manganese (Mn)	ug/L	<2.0	54	2.0	6067880	53	2.0	6067880
Dissolved Molybdenum (Mo)	ug/L	0.81	1.9	0.50	6067880	1.9	0.50	6067880
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	1.0	6067880	<1.0	1.0	6067880
Dissolved Phosphorus (P)	ug/L	<100	<100	100	6067880	<100	100	6067880
Dissolved Potassium (K)	ug/L	1200	1100	200	6067880	1100	200	6067880
Dissolved Selenium (Se)	ug/L	<2.0	<2.0	2.0	6067880	<2.0	2.0	6067880
Dissolved Silicon (Si)	ug/L	4500	4400	50	6067880	4300	50	6067880
Dissolved Silver (Ag)	ug/L	<0.10	<0.10	0.10	6067880	<0.10	0.10	6067880
Dissolved Sodium (Na)	ug/L	2200	21000	100	6067880	21000	100	6067880
Dissolved Strontium (Sr)	ug/L	110	290	1.0	6067880	280	1.0	6067880
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	6067880	<0.050	0.050	6067880
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	5.0	6067880	<5.0	5.0	6067880
Dissolved Uranium (U)	ug/L	0.44	0.27	0.10	6067880	0.28	0.10	6067880
Dissolved Vanadium (V)	ug/L	<0.50	<0.50	0.50	6067880	<0.50	0.50	6067880
Dissolved Zinc (Zn)	ug/L	13	<5.0	5.0	6067880	<5.0	5.0	6067880

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

RCAP - COMPREHENSIVE (GROUND WATER)

Maxxam ID		JKT726	JKT727			JKT727		
Sampling Date		2019/04/09 15:30	2019/04/09 17:00			2019/04/09 17:00		
COC Number		712029-01-01	712029-01-01			712029-01-01		
	UNITS	**MW18-03**	**MW18-04**	**RDL**	**QC Batch**	**MW18-04 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters								
Anion Sum	me/L	7.02	7.54	N/A	6065974			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	180	180	1.0	6064746			
Calculated TDS	mg/L	390	420	1.0	6064751			
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.8	2.5	1.0	6064746			
Cation Sum	me/L	7.67	8.13	N/A	6065974			
Hardness (CaCO3)	mg/L	310	330	1.0	6066688			
Ion Balance (% Difference)	%	4.41	3.75	N/A	6065973			
Langelier Index (@ 20C)	N/A	0.925	0.880		6064749			
Langelier Index (@ 4C)	N/A	0.676	0.632		6064750			
Saturation pH (@ 20C)	N/A	7.28	7.29		6064749			
Saturation pH (@ 4C)	N/A	7.53	7.54		6064750			
Inorganics								
Total Ammonia-N	mg/L	<0.050	0.057	0.050	6069886	<0.050	0.050	6069886
Conductivity	umho/cm	750	800	1.0	6069344			
Dissolved Organic Carbon	mg/L	0.51	0.81	0.50	6067512			
Orthophosphate (P)	mg/L	<0.010	<0.010	0.010	6069400			
pH	pH	8.21	8.17		6069345			
Dissolved Sulphate (SO4)	mg/L	56	76	1.0	6069399			
Alkalinity (Total as CaCO3)	mg/L	180	190	1.0	6069343			
Dissolved Chloride (Cl-)	mg/L	77	79	1.0	6069398			
Nitrite (N)	mg/L	<0.010	<0.010	0.010	6069364			
Nitrate (N)	mg/L	<0.10	<0.10	0.10	6069364			
Nitrate + Nitrite (N)	mg/L	<0.10	<0.10	0.10	6069364			
Metals								
Dissolved Aluminum (Al)	ug/L	<5.0	<5.0	5.0	6067880			
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	6067880			
Dissolved Arsenic (As)	ug/L	1.2	2.1	1.0	6067880			
Dissolved Barium (Ba)	ug/L	120	88	2.0	6067880			
Dissolved Beryllium (Be)	ug/L	<0.50	<0.50	0.50	6067880			
Dissolved Boron (B)	ug/L	<10	15	10	6067880			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

RCAP - COMPREHENSIVE (GROUND WATER)

Maxxam ID		JKT726	JKT727			JKT727		
Sampling Date		2019/04/09 15:30	2019/04/09 17:00			2019/04/09 17:00		
COC Number		712029-01-01	712029-01-01			712029-01-01		
	UNITS	**MW18-03**	**MW18-04**	**RDL**	**QC Batch**	**MW18-04 Lab-Dup**	**RDL**	**QC Batch**
Dissolved Cadmium (Cd)	ug/L	<0.10	<0.10	0.10	6067880			
Dissolved Calcium (Ca)	ug/L	78000	78000	200	6067880			
Dissolved Chromium (Cr)	ug/L	<5.0	<5.0	5.0	6067880			
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	6067880			
Dissolved Copper (Cu)	ug/L	<1.0	<1.0	1.0	6067880			
Dissolved Iron (Fe)	ug/L	490	380	100	6067880			
Dissolved Lead (Pb)	ug/L	<0.50	<0.50	0.50	6067880			
Dissolved Magnesium (Mg)	ug/L	29000	33000	50	6067880			
Dissolved Manganese (Mn)	ug/L	34	92	2.0	6067880			
Dissolved Molybdenum (Mo)	ug/L	0.93	1.1	0.50	6067880			
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	1.0	6067880			
Dissolved Phosphorus (P)	ug/L	<100	<100	100	6067880			
Dissolved Potassium (K)	ug/L	1500	2000	200	6067880			
Dissolved Selenium (Se)	ug/L	<2.0	<2.0	2.0	6067880			
Dissolved Silicon (Si)	ug/L	3800	2900	50	6067880			
Dissolved Silver (Ag)	ug/L	<0.10	<0.10	0.10	6067880			
Dissolved Sodium (Na)	ug/L	31000	34000	100	6067880			
Dissolved Strontium (Sr)	ug/L	230	210	1.0	6067880			
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	6067880			
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	5.0	6067880			
Dissolved Uranium (U)	ug/L	0.78	1.1	0.10	6067880			
Dissolved Vanadium (V)	ug/L	<0.50	<0.50	0.50	6067880			
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	5.0	6067880			

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

RCAP - COMPREHENSIVE (GROUND WATER)

Maxxam ID		JKT728		JKT729		
Sampling Date		2019/04/09 14:30		2019/04/09 10:30		
COC Number		712029-01-01		712029-01-01		
	UNITS	**MW18-05**	**QC Batch**	**MW18-06**	**RDL**	**QC Batch**
Calculated Parameters						
Anion Sum	me/L	7.23	6065974	6.15	N/A	6065974
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	320	6064746	210	1.0	6064746
Calculated TDS	mg/L	360	6064751	350	1.0	6064751
Carb. Alkalinity (calc. as CaCO3)	mg/L	3.9	6064746	3.0	1.0	6064746
Cation Sum	me/L	7.09	6065974	7.57	N/A	6065974
Hardness (CaCO3)	mg/L	340	6066688	350	1.0	6066688
Ion Balance (% Difference)	%	0.920	6065973	10.3	N/A	6065973
Langelier Index (@ 20C)	N/A	1.07	6064749	1.03		6064749
Langelier Index (@ 4C)	N/A	0.818	6064750	0.776		6064750
Saturation pH (@ 20C)	N/A	7.05	6064749	7.14		6064749
Saturation pH (@ 4C)	N/A	7.30	6064750	7.39		6064750
Inorganics						
Total Ammonia-N	mg/L	0.064	6069886	0.051	0.050	6069886
Conductivity	umho/cm	630	6069344	680	1.0	6069344
Dissolved Organic Carbon	mg/L	0.59	6067512	0.72	0.50	6067512
Orthophosphate (P)	mg/L	<0.010	6069491	<0.010	0.010	6069400
pH	pH	8.11	6069345	8.17		6069345
Dissolved Sulphate (SO4)	mg/L	32	6069489	43	1.0	6069399
Alkalinity (Total as CaCO3)	mg/L	320	6069343	220	1.0	6069343
Dissolved Chloride (Cl-)	mg/L	3.4	6069488	32	1.0	6069398
Nitrite (N)	mg/L	<0.010	6069364	<0.010	0.010	6069364
Nitrate (N)	mg/L	<0.10	6069364	<0.10	0.10	6069364
Nitrate + Nitrite (N)	mg/L	<0.10	6069364	<0.10	0.10	6069364
Metals						
Dissolved Aluminum (Al)	ug/L	<5.0	6067880	<5.0	5.0	6067880
Dissolved Antimony (Sb)	ug/L	<0.50	6067880	<0.50	0.50	6067880
Dissolved Arsenic (As)	ug/L	1.1	6067880	1.6	1.0	6067880
Dissolved Barium (Ba)	ug/L	74	6067880	130	2.0	6067880
Dissolved Beryllium (Be)	ug/L	<0.50	6067880	<0.50	0.50	6067880
Dissolved Boron (B)	ug/L	11	6067880	<10	10	6067880
Dissolved Cadmium (Cd)	ug/L	<0.10	6067880	<0.10	0.10	6067880

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

RCAP - COMPREHENSIVE (GROUND WATER)

Maxxam ID		JKT728		JKT729		
Sampling Date		2019/04/09 14:30		2019/04/09 10:30		
COC Number		712029-01-01		712029-01-01		
	UNITS	**MW18-05**	**QC Batch**	**MW18-06**	**RDL**	**QC Batch**
Dissolved Calcium (Ca)	ug/L	75000	6067880	90000	200	6067880
Dissolved Chromium (Cr)	ug/L	<5.0	6067880	<5.0	5.0	6067880
Dissolved Cobalt (Co)	ug/L	<0.50	6067880	<0.50	0.50	6067880
Dissolved Copper (Cu)	ug/L	<1.0	6067880	<1.0	1.0	6067880
Dissolved Iron (Fe)	ug/L	160	6067880	850	100	6067880
Dissolved Lead (Pb)	ug/L	<0.50	6067880	<0.50	0.50	6067880
Dissolved Magnesium (Mg)	ug/L	37000	6067880	30000	50	6067880
Dissolved Manganese (Mn)	ug/L	16	6067880	34	2.0	6067880
Dissolved Molybdenum (Mo)	ug/L	3.9	6067880	2.8	0.50	6067880
Dissolved Nickel (Ni)	ug/L	<1.0	6067880	<1.0	1.0	6067880
Dissolved Phosphorus (P)	ug/L	<100	6067880	<100	100	6067880
Dissolved Potassium (K)	ug/L	890	6067880	1200	200	6067880
Dissolved Selenium (Se)	ug/L	<2.0	6067880	<2.0	2.0	6067880
Dissolved Silicon (Si)	ug/L	5700	6067880	5900	50	6067880
Dissolved Silver (Ag)	ug/L	<0.10	6067880	<0.10	0.10	6067880
Dissolved Sodium (Na)	ug/L	5000	6067880	12000	100	6067880
Dissolved Strontium (Sr)	ug/L	90	6067880	180	1.0	6067880
Dissolved Thallium (Tl)	ug/L	<0.050	6067880	<0.050	0.050	6067880
Dissolved Titanium (Ti)	ug/L	<5.0	6067880	<5.0	5.0	6067880
Dissolved Uranium (U)	ug/L	2.0	6067880	0.18	0.10	6067880
Dissolved Vanadium (V)	ug/L	<0.50	6067880	<0.50	0.50	6067880
Dissolved Zinc (Zn)	ug/L	<5.0	6067880	55	5.0	6067880

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (GROUND WATER)

Maxxam ID		JKT724	JKT725	JKT726	JKT727	JKT728	JKT729		
Sampling Date		2019/04/09 13:30	2019/04/09 11:30	2019/04/09 15:30	2019/04/09 17:00	2019/04/09 14:30	2019/04/09 10:30		
COC Number		712029-01-01	712029-01-01	712029-01-01	712029-01-01	712029-01-01	712029-01-01		
	UNITS	**MW18-01B**	**MW18-02**	**MW18-03**	**MW18-04**	**MW18-05**	**MW18-06**	**RDL**	**QC Batch**
Metals									
Mercury (Hg)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	6070691

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

O.REG 153 PHCS, BTEX/F1-F4 (GROUND WATER)

Maxxam ID		JKT724	JKT725	JKT726			JKT726		
Sampling Date		2019/04/09 13:30	2019/04/09 11:30	2019/04/09 15:30			2019/04/09 15:30		
COC Number		712029-01-01	712029-01-01	712029-01-01			712029-01-01		
	UNITS	**MW18-01B**	**MW18-02**	**MW18-03**	**RDL**	**QC Batch**	**MW18-03 Lab-Dup**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons									
Benzene	ug/L	<0.20	<0.20	<0.20	0.20	6072382			
Toluene	ug/L	0.38	0.27	<0.20	0.20	6072382			
Ethylbenzene	ug/L	<0.20	<0.20	<0.20	0.20	6072382			
o-Xylene	ug/L	<0.20	<0.20	<0.20	0.20	6072382			
p+m-Xylene	ug/L	<0.40	<0.40	<0.40	0.40	6072382			
Total Xylenes	ug/L	<0.40	<0.40	<0.40	0.40	6072382			
F1 (C6-C10)	ug/L	<25	<25	<25	25	6072382			
F1 (C6-C10) - BTEX	ug/L	<25	<25	<25	25	6072382			
F2-F4 Hydrocarbons									
F2 (C10-C16 Hydrocarbons)	ug/L	<100	<100	<100	100	6070399	<100	100	6070399
F3 (C16-C34 Hydrocarbons)	ug/L	<200	<200	<200	200	6070399	<200	200	6070399
F4 (C34-C50 Hydrocarbons)	ug/L	<200	<200	<200	200	6070399	<200	200	6070399
Reached Baseline at C50	ug/L	Yes	Yes	Yes		6070399	Yes		6070399
Surrogate Recovery (%)									
1,4-Difluorobenzene	%	98	100	100		6072382			
4-Bromofluorobenzene	%	102	101	101		6072382			
D10-Ethylbenzene	%	103	104	101		6072382			
D4-1,2-Dichloroethane	%	94	93	93		6072382			
o-Terphenyl	%	90	92	93		6070399	91		6070399

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

O.REG 153 PHCS, BTEX/F1-F4 (GROUND WATER)

Maxxam ID		JKT727	JKT728	JKT729		
Sampling Date		2019/04/09 17:00	2019/04/09 14:30	2019/04/09 10:30		
COC Number		712029-01-01	712029-01-01	712029-01-01		
	UNITS	**MW18-04**	**MW18-05**	**MW18-06**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons						
Benzene	ug/L	<0.20	<0.20	<0.20	0.20	6072382
Toluene	ug/L	<0.20	0.25	<0.20	0.20	6072382
Ethylbenzene	ug/L	<0.20	<0.20	<0.20	0.20	6072382
o-Xylene	ug/L	<0.20	<0.20	<0.20	0.20	6072382
p+m-Xylene	ug/L	<0.40	<0.40	<0.40	0.40	6072382
Total Xylenes	ug/L	<0.40	<0.40	<0.40	0.40	6072382
F1 (C6-C10)	ug/L	<25	<25	<25	25	6072382
F1 (C6-C10) - BTEX	ug/L	<25	<25	<25	25	6072382
F2-F4 Hydrocarbons						
F2 (C10-C16 Hydrocarbons)	ug/L	<100	<100	<100	100	6070399
F3 (C16-C34 Hydrocarbons)	ug/L	<200	<200	270	200	6070399
F4 (C34-C50 Hydrocarbons)	ug/L	<200	<200	<200	200	6070399
Reached Baseline at C50	ug/L	Yes	Yes	Yes		6070399
Surrogate Recovery (%)						
1,4-Difluorobenzene	%	100	100	97		6072382
4-Bromofluorobenzene	%	102	101	101		6072382
D10-Ethylbenzene	%	104	101	103		6072382
D4-1,2-Dichloroethane	%	94	95	95		6072382
o-Terphenyl	%	92	92	93		6070399

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Maxxam ID: JKT724
Sample ID: MW18-01B
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6069343	N/A	2019/04/17	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	6064746	N/A	2019/04/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	6069398	N/A	2019/04/15	Deonarine Ramnarine
Conductivity	AT	6069344	N/A	2019/04/15	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	6067512	N/A	2019/04/12	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	6072382	N/A	2019/04/16	Abdi Mohamud
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li
Hardness (calculated as CaCO3)		6066688	N/A	2019/04/15	Automated Statchk
Mercury	CV/AA	6070691	2019/04/15	2019/04/16	Meghaben Patel
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg
Ion Balance (% Difference)	CALC	6065973	N/A	2019/04/18	Automated Statchk
Anion and Cation Sum	CALC	6065974	N/A	2019/04/17	Automated Statchk
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6069364	N/A	2019/04/16	Chandra Nandlal
pH	AT	6069345	2019/04/13	2019/04/17	Surinder Rai
Orthophosphate	KONE	6069400	N/A	2019/04/15	Deonarine Ramnarine
Sat. pH and Langelier Index (@ 20C)	CALC	6064749	N/A	2019/04/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	6064750	N/A	2019/04/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	6069399	N/A	2019/04/15	Deonarine Ramnarine
Total Dissolved Solids (TDS calc)	CALC	6064751	N/A	2019/04/18	Automated Statchk

Maxxam ID: JKT725
Sample ID: MW18-02
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6069343	N/A	2019/04/17	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	6064746	N/A	2019/04/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	6069398	N/A	2019/04/15	Deonarine Ramnarine
Conductivity	AT	6069344	N/A	2019/04/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	6067512	N/A	2019/04/12	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	6072382	N/A	2019/04/16	Abdi Mohamud
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li
Hardness (calculated as CaCO3)		6066688	N/A	2019/04/15	Automated Statchk
Mercury	CV/AA	6070691	2019/04/15	2019/04/16	Meghaben Patel
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg
Ion Balance (% Difference)	CALC	6065973	N/A	2019/04/18	Automated Statchk
Anion and Cation Sum	CALC	6065974	N/A	2019/04/17	Automated Statchk
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6069364	N/A	2019/04/16	Chandra Nandlal
pH	AT	6069345	2019/04/13	2019/04/17	Surinder Rai
Orthophosphate	KONE	6069400	N/A	2019/04/15	Deonarine Ramnarine
Sat. pH and Langelier Index (@ 20C)	CALC	6064749	N/A	2019/04/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	6064750	N/A	2019/04/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	6069399	N/A	2019/04/15	Deonarine Ramnarine
Total Dissolved Solids (TDS calc)	CALC	6064751	N/A	2019/04/18	Automated Statchk

TEST SUMMARY

Maxxam ID: JKT725 Dup
Sample ID: MW18-02
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg

Maxxam ID: JKT726
Sample ID: MW18-03
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6069343	N/A	2019/04/17	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	6064746	N/A	2019/04/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	6069398	N/A	2019/04/15	Deonarine Ramnarine
Conductivity	AT	6069344	N/A	2019/04/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	6067512	N/A	2019/04/12	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	6072382	N/A	2019/04/16	Abdi Mohamud
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li
Hardness (calculated as CaCO3)		6066688	N/A	2019/04/15	Automated Statchk
Mercury	CV/AA	6070691	2019/04/15	2019/04/16	Meghaben Patel
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg
Ion Balance (% Difference)	CALC	6065973	N/A	2019/04/18	Automated Statchk
Anion and Cation Sum	CALC	6065974	N/A	2019/04/17	Automated Statchk
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6069364	N/A	2019/04/16	Chandra Nandlal
pH	AT	6069345	2019/04/13	2019/04/17	Surinder Rai
Orthophosphate	KONE	6069400	N/A	2019/04/15	Deonarine Ramnarine
Sat. pH and Langelier Index (@ 20C)	CALC	6064749	N/A	2019/04/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	6064750	N/A	2019/04/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	6069399	N/A	2019/04/15	Deonarine Ramnarine
Total Dissolved Solids (TDS calc)	CALC	6064751	N/A	2019/04/18	Automated Statchk

Maxxam ID: JKT726 Dup
Sample ID: MW18-03
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li

Maxxam ID: JKT727
Sample ID: MW18-04
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6069343	N/A	2019/04/17	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	6064746	N/A	2019/04/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	6069398	N/A	2019/04/15	Deonarine Ramnarine
Conductivity	AT	6069344	N/A	2019/04/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	6067512	N/A	2019/04/12	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	6072382	N/A	2019/04/16	Abdi Mohamud

TEST SUMMARY

Maxxam ID: JKT727
Sample ID: MW18-04
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li
Hardness (calculated as CaCO3)		6066688	N/A	2019/04/15	Automated Statchk
Mercury	CV/AA	6070691	2019/04/15	2019/04/16	Meghaben Patel
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg
Ion Balance (% Difference)	CALC	6065973	N/A	2019/04/18	Automated Statchk
Anion and Cation Sum	CALC	6065974	N/A	2019/04/17	Automated Statchk
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6069364	N/A	2019/04/16	Chandra Nandlal
pH	AT	6069345	2019/04/13	2019/04/17	Surinder Rai
Orthophosphate	KONE	6069400	N/A	2019/04/15	Deonarine Ramnarine
Sat. pH and Langelier Index (@ 20C)	CALC	6064749	N/A	2019/04/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	6064750	N/A	2019/04/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	6069399	N/A	2019/04/15	Deonarine Ramnarine
Total Dissolved Solids (TDS calc)	CALC	6064751	N/A	2019/04/18	Automated Statchk

Maxxam ID: JKT727 Dup
Sample ID: MW18-04
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal

Maxxam ID: JKT728
Sample ID: MW18-05
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6069343	N/A	2019/04/17	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	6064746	N/A	2019/04/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	6069488	N/A	2019/04/15	Deonarine Ramnarine
Conductivity	AT	6069344	N/A	2019/04/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	6067512	N/A	2019/04/12	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	6072382	N/A	2019/04/16	Abdi Mohamud
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li
Hardness (calculated as CaCO3)		6066688	N/A	2019/04/15	Automated Statchk
Mercury	CV/AA	6070691	2019/04/15	2019/04/16	Meghaben Patel
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg
Ion Balance (% Difference)	CALC	6065973	N/A	2019/04/18	Automated Statchk
Anion and Cation Sum	CALC	6065974	N/A	2019/04/17	Automated Statchk
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6069364	N/A	2019/04/16	Chandra Nandlal
pH	AT	6069345	2019/04/13	2019/04/17	Surinder Rai
Orthophosphate	KONE	6069491	N/A	2019/04/15	Deonarine Ramnarine
Sat. pH and Langelier Index (@ 20C)	CALC	6064749	N/A	2019/04/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	6064750	N/A	2019/04/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	6069489	N/A	2019/04/15	Deonarine Ramnarine

TEST SUMMARY

Maxxam ID: JKT728
Sample ID: MW18-05
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Dissolved Solids (TDS calc)	CALC	6064751	N/A	2019/04/18	Automated Statchk

Maxxam ID: JKT729
Sample ID: MW18-06
Matrix: Ground Water

Collected: 2019/04/09
Shipped:
Received: 2019/04/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6069343	N/A	2019/04/17	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	6064746	N/A	2019/04/17	Automated Statchk
Chloride by Automated Colourimetry	KONE	6069398	N/A	2019/04/15	Deonarine Ramnarine
Conductivity	AT	6069344	N/A	2019/04/16	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	6067512	N/A	2019/04/12	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	6072382	N/A	2019/04/16	Abdi Mohamud
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	6070399	2019/04/15	2019/04/16	(Kent) Maolin Li
Hardness (calculated as CaCO3)		6066688	N/A	2019/04/15	Automated Statchk
Mercury	CV/AA	6070691	2019/04/15	2019/04/16	Meghaben Patel
Dissolved Metals by ICPMS	ICP/MS	6067880	N/A	2019/04/12	Matthew Ritenburg
Ion Balance (% Difference)	CALC	6065973	N/A	2019/04/18	Automated Statchk
Anion and Cation Sum	CALC	6065974	N/A	2019/04/17	Automated Statchk
Total Ammonia-N	LACH/NH4	6069886	N/A	2019/04/15	Chandra Nandlal
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6069364	N/A	2019/04/16	Chandra Nandlal
pH	AT	6069345	2019/04/13	2019/04/17	Surinder Rai
Orthophosphate	KONE	6069400	N/A	2019/04/15	Deonarine Ramnarine
Sat. pH and Langelier Index (@ 20C)	CALC	6064749	N/A	2019/04/18	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	6064750	N/A	2019/04/18	Automated Statchk
Sulphate by Automated Colourimetry	KONE	6069399	N/A	2019/04/15	Deonarine Ramnarine
Total Dissolved Solids (TDS calc)	CALC	6064751	N/A	2019/04/18	Automated Statchk

GENERAL COMMENTS

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

Package 1	4.0°C

Results relate only to the items tested.

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
6070399	o-Terphenyl	2019/04/16	99	60 - 130	96	60 - 130	93	%		
6072382	1,4-Difluorobenzene	2019/04/16	99	70 - 130	97	70 - 130	96	%		
6072382	4-Bromofluorobenzene	2019/04/16	100	70 - 130	101	70 - 130	99	%		
6072382	D10-Ethylbenzene	2019/04/16	100	70 - 130	92	70 - 130	99	%		
6072382	D4-1,2-Dichloroethane	2019/04/16	96	70 - 130	92	70 - 130	91	%		
6067512	Dissolved Organic Carbon	2019/04/12	93	80 - 120	97	80 - 120	<0.50	mg/L	1.1	20
6067880	Dissolved Aluminum (Al)	2019/04/12	106	80 - 120	106	80 - 120	<5.0	ug/L	NC	20
6067880	Dissolved Antimony (Sb)	2019/04/12	105	80 - 120	101	80 - 120	<0.50	ug/L	NC	20
6067880	Dissolved Arsenic (As)	2019/04/12	101	80 - 120	99	80 - 120	<1.0	ug/L	NC	20
6067880	Dissolved Barium (Ba)	2019/04/12	99	80 - 120	100	80 - 120	<2.0	ug/L	0.55	20
6067880	Dissolved Beryllium (Be)	2019/04/12	99	80 - 120	97	80 - 120	<0.50	ug/L	NC	20
6067880	Dissolved Boron (B)	2019/04/12	92	80 - 120	95	80 - 120	<10	ug/L	NC	20
6067880	Dissolved Cadmium (Cd)	2019/04/12	102	80 - 120	100	80 - 120	<0.10	ug/L	NC	20
6067880	Dissolved Calcium (Ca)	2019/04/12	NC	80 - 120	104	80 - 120	<200	ug/L	1.7	20
6067880	Dissolved Chromium (Cr)	2019/04/12	96	80 - 120	94	80 - 120	<5.0	ug/L	NC	20
6067880	Dissolved Cobalt (Co)	2019/04/12	99	80 - 120	99	80 - 120	<0.50	ug/L	NC	20
6067880	Dissolved Copper (Cu)	2019/04/12	102	80 - 120	100	80 - 120	<1.0	ug/L	NC	20
6067880	Dissolved Iron (Fe)	2019/04/12	100	80 - 120	99	80 - 120	<100	ug/L	0.59	20
6067880	Dissolved Lead (Pb)	2019/04/12	97	80 - 120	98	80 - 120	<0.50	ug/L	NC	20
6067880	Dissolved Magnesium (Mg)	2019/04/12	NC	80 - 120	97	80 - 120	<50	ug/L	0.34	20
6067880	Dissolved Manganese (Mn)	2019/04/12	98	80 - 120	97	80 - 120	<2.0	ug/L	0.92	20
6067880	Dissolved Molybdenum (Mo)	2019/04/12	110	80 - 120	103	80 - 120	<0.50	ug/L	1.4	20
6067880	Dissolved Nickel (Ni)	2019/04/12	95	80 - 120	94	80 - 120	<1.0	ug/L	NC	20
6067880	Dissolved Phosphorus (P)	2019/04/12	107	80 - 120	106	80 - 120	<100	ug/L	NC	20
6067880	Dissolved Potassium (K)	2019/04/12	102	80 - 120	100	80 - 120	<200	ug/L	1.7	20
6067880	Dissolved Selenium (Se)	2019/04/12	104	80 - 120	101	80 - 120	<2.0	ug/L	NC	20
6067880	Dissolved Silicon (Si)	2019/04/12	103	80 - 120	101	80 - 120	<50	ug/L	0.24	20
6067880	Dissolved Silver (Ag)	2019/04/12	88	80 - 120	101	80 - 120	<0.10	ug/L	NC	20
6067880	Dissolved Sodium (Na)	2019/04/12	98	80 - 120	97	80 - 120	<100	ug/L	0.26	20
6067880	Dissolved Strontium (Sr)	2019/04/12	95	80 - 120	98	80 - 120	<1.0	ug/L	2.3	20
6067880	Dissolved Thallium (Tl)	2019/04/12	98	80 - 120	99	80 - 120	<0.050	ug/L	NC	20
6067880	Dissolved Titanium (Ti)	2019/04/12	101	80 - 120	98	80 - 120	<5.0	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**
6067880	Dissolved Uranium (U)	2019/04/12	96	80 - 120	99	80 - 120	<0.10	ug/L	3.3	20
6067880	Dissolved Vanadium (V)	2019/04/12	99	80 - 120	96	80 - 120	<0.50	ug/L	NC	20
6067880	Dissolved Zinc (Zn)	2019/04/12	98	80 - 120	95	80 - 120	<5.0	ug/L	NC	20
6069343	Alkalinity (Total as CaCO3)	2019/04/17			99	85 - 115	<1.0	mg/L	0.16	20
6069344	Conductivity	2019/04/15			101	85 - 115	<1.0	umho/cm	0.61	25
6069345	pH	2019/04/16			101	98 - 103			0.31	N/A
6069364	Nitrate (N)	2019/04/16	103	80 - 120	104	80 - 120	<0.10	mg/L	5.2	20
6069364	Nitrite (N)	2019/04/16	102	80 - 120	101	80 - 120	<0.010	mg/L	NC	20
6069398	Dissolved Chloride (Cl-)	2019/04/15	NC	80 - 120	103	80 - 120	<1.0	mg/L	0.038	20
6069399	Dissolved Sulphate (SO4)	2019/04/15	116	75 - 125	105	80 - 120	<1.0	mg/L	1.5	20
6069400	Orthophosphate (P)	2019/04/15	103	75 - 125	100	80 - 120	<0.010	mg/L	NC	25
6069488	Dissolved Chloride (Cl-)	2019/04/15	103	80 - 120	103	80 - 120	<1.0	mg/L	0.090	20
6069489	Dissolved Sulphate (SO4)	2019/04/15	108	75 - 125	104	80 - 120	<1.0	mg/L	3.1	20
6069491	Orthophosphate (P)	2019/04/15	99	75 - 125	101	80 - 120	<0.010	mg/L	NC	25
6069886	Total Ammonia-N	2019/04/15	104	75 - 125	104	80 - 120	<0.050	mg/L	13	20
6070399	F2 (C10-C16 Hydrocarbons)	2019/04/16	98	50 - 130	96	60 - 130	<100	ug/L	NC	30
6070399	F3 (C16-C34 Hydrocarbons)	2019/04/16	NC	50 - 130	97	60 - 130	<200	ug/L	NC	30
6070399	F4 (C34-C50 Hydrocarbons)	2019/04/16	94	50 - 130	93	60 - 130	<200	ug/L	NC	30
6070691	Mercury (Hg)	2019/04/16	105	75 - 125	103	80 - 120	<0.1	ug/L	NC	20
6072382	Benzene	2019/04/16	97	70 - 130	87	70 - 130	<0.20	ug/L	NC	30
6072382	Ethylbenzene	2019/04/16	103	70 - 130	91	70 - 130	<0.20	ug/L	NC	30
6072382	F1 (C6-C10) - BTEX	2019/04/16					<25	ug/L	NC	30
6072382	F1 (C6-C10)	2019/04/16	98	70 - 130	101	70 - 130	<25	ug/L	NC	30
6072382	o-Xylene	2019/04/16	100	70 - 130	87	70 - 130	<0.20	ug/L	NC	30
6072382	p+m-Xylene	2019/04/16	106	70 - 130	93	70 - 130	<0.40	ug/L	NC	30
6072382	Toluene	2019/04/16	104	70 - 130	92	70 - 130	<0.20	ug/L	NC	30

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**
6072382	Total Xylenes	2019/04/16					<0.40	ug/L	NC	30

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 spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 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 (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

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

Eva Pranjic

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

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.

11-Apr-19 10:00
Ema Gitej
B995482

JCC ENV-1279

Presence of Visible Particulate/Sediment

Maxxam Analytics
CAM FCD-01013/5
Page 1 of 1

When there is >1cm of visible particulate/sediment, the amount will be recorded in the field below

Bottle Types

			Inorganics					Organics											Hydrocarbons							Volatiles				Other
	Sample ID	All	CrVI	CN	General	Hg	Metals (Diss.)	Organic 1 of 2	Organic 2 of 2	PCB 1 of 2	PCB 2 of 2	Pest/ Herb 1 of 2	Pest/ Herb 2 of 2	SVOC/ ABN 1 of 2	SVOC/ ABN 2 of 2	PAH 1 of 2	PAH 2 of 2	Dioxin /Furan	F1 Vial 1	F1 Vial 2	F1 Vial 3	F1 Vial 4	F2-F4 1 of 2	F2-F4 2 of 2	F4G	VOC Vial 1	VOC Vial 2	VOC Vial 3	VOC Vial 4	
1	MW18 - 01B	TS																												
2	MW18 -02	TS																												
3	MW18-04	TS																												
4	MW18 - 05	TS																												
5	MW18-06	TS																												
6																														
7																														
8																														
9																														
10																														

Comments: Except Metals and Mercury bottles

Legend:

P	Suspended Particulate
TS	Trace Settled Sediment (just covers bottom of container or less)
S	Sediment greater than (>) Trace, but less than (<) 1 cm

Recorded By: (signature/print) COLENE CURITAO

Maxxam
A Bureau Veritas Group Company

IMMEDIATE

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

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:

Company Name: #1326 Golder Associates Ltd
Attention: Accounts Payable
Address: 6925 Century Ave Suite 100
Mississauga ON L5N 7K2
Tel: (905) 567-4444 Fax: (905) 567-6561
Email: AP_CustomerService@golder.com

REPORT TO:

Company Name:
Attention: Alexandra Smofsky
Address:
Tel: (905) 567-6100 Ext: 1298 Fax:
Email: Alexandra_Smofsky@golder.com

PROJECT INFORMATION:

Quotation #: B80683
P.O. #:
Project: 1791470 (4000)
Project Name:
Site #:
Sampled By: PGM

Laboratory Use Only:

Maxxam Job #:
Bottle Order #: 712029
COC #: C#712029-01-01
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)

REC'D IN WATERLOO

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	RCAp - Comprehensive	Mercury	O.Reg 153 PHCs, BTEX/F1-F4								# of Bottles	Comments
1		MW18-01B	9Apr19	13:30	GW	X	X	X	X								9	Note hold times
2		MW18-02	↓	11:30	↓	↓	↓	↓	↓								↓	
3		MW18-03	↓	15:30	↓	↓	↓	↓	↓								↓	
4		MW18-04	↓	17:00	↓	↓	↓	↓	↓								↓	
5		MW18-05	↓	14:30	↓	↓	↓	↓	↓								↓	
6		MW18-06	↓	10:30	↓	↓	↓	↓	↓								↓	
7																		
8																		
9																		
10																		

11-Apr-19 10:00
Ema Gitej
B995482
JCC ENV-1279

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Paul Meakveld	19/04/10	18:40	MAHMOUD AMIN	19/04/11	10:00	
			[illegible]	2019/04/11	14:15	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Recei	Custody Seal	Yes	No
	4/4/4 no ICE	Present	Y	
		Intact	Y	

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* 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.

0/2/3

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

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

White: Maxxa Yellow: Client

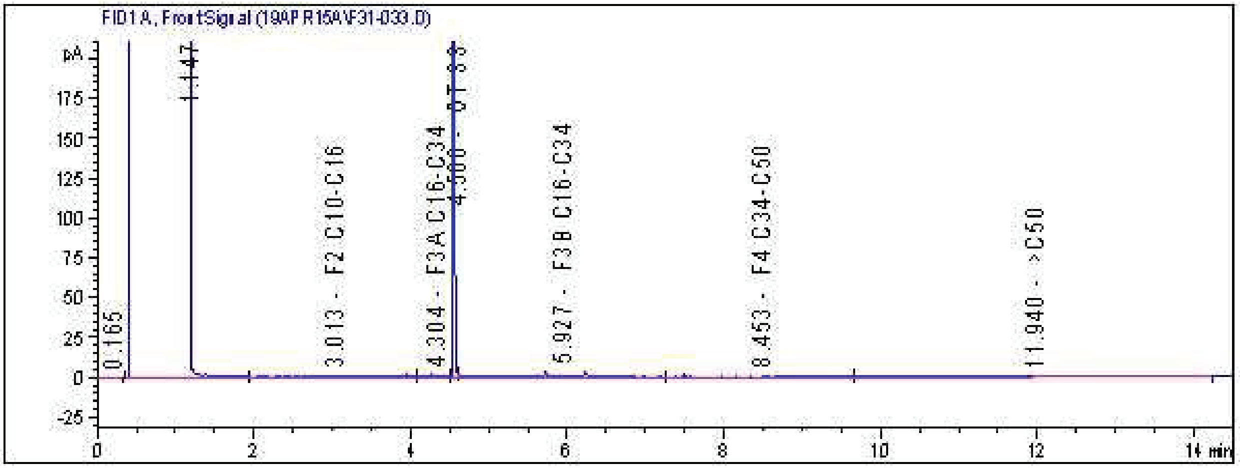
MW #111533

Maxxam Analytics International Corporation o/a Maxxam Analytics

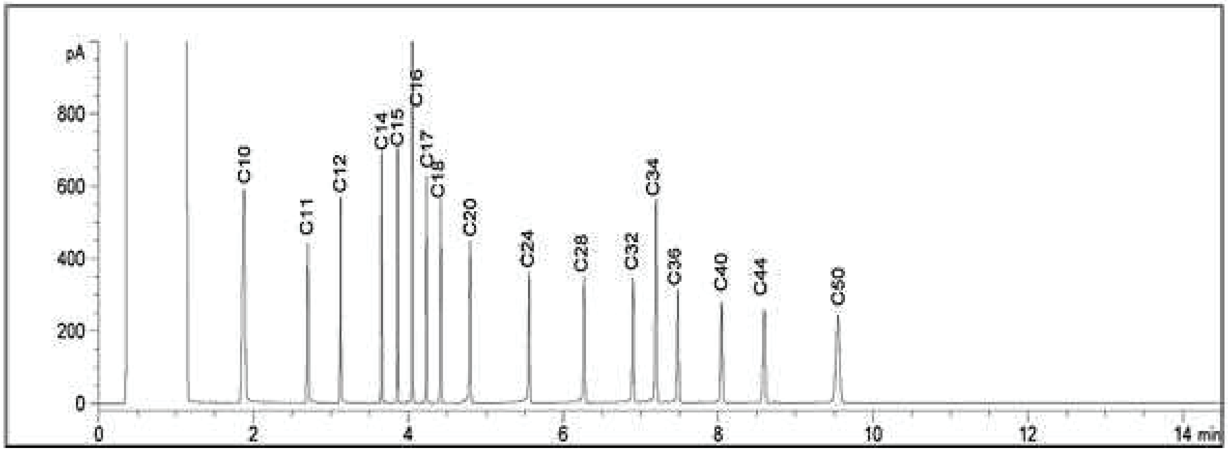
Maxxam Job #: B995482
Report Date: 2019/04/18
Maxxam Sample: JKT724

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-01B

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

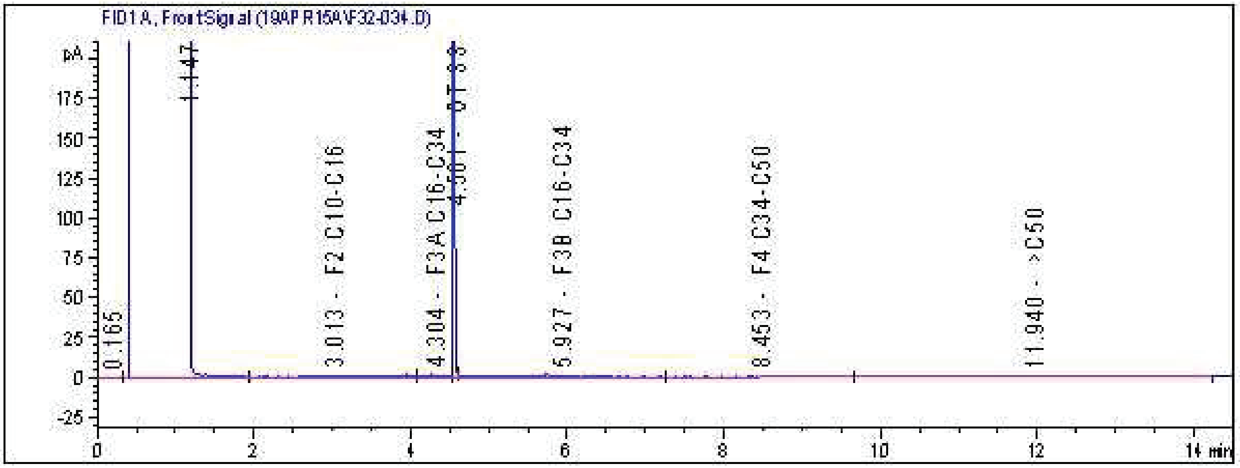
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

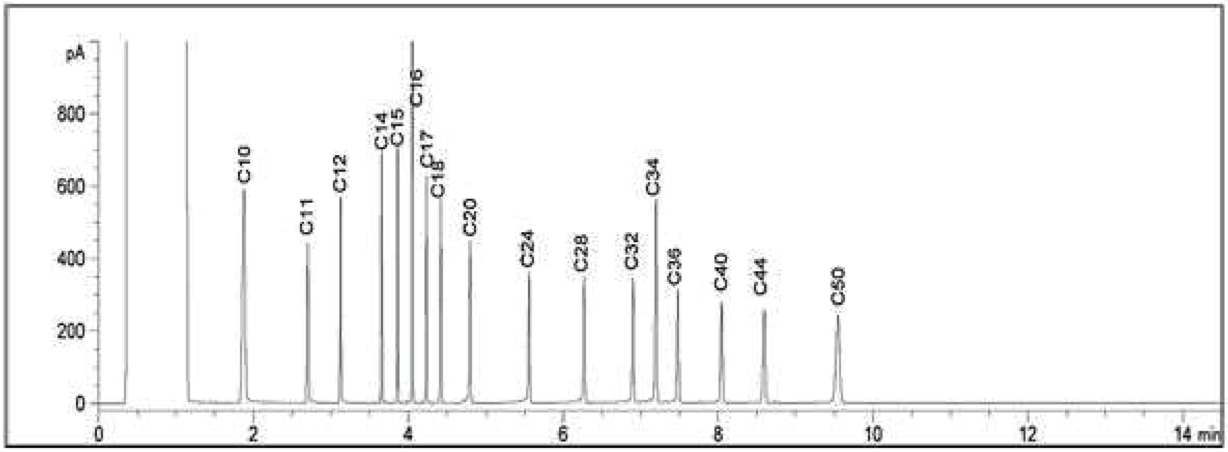
Maxxam Job #: B995482
Report Date: 2019/04/18
Maxxam Sample: JKT725

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-02

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

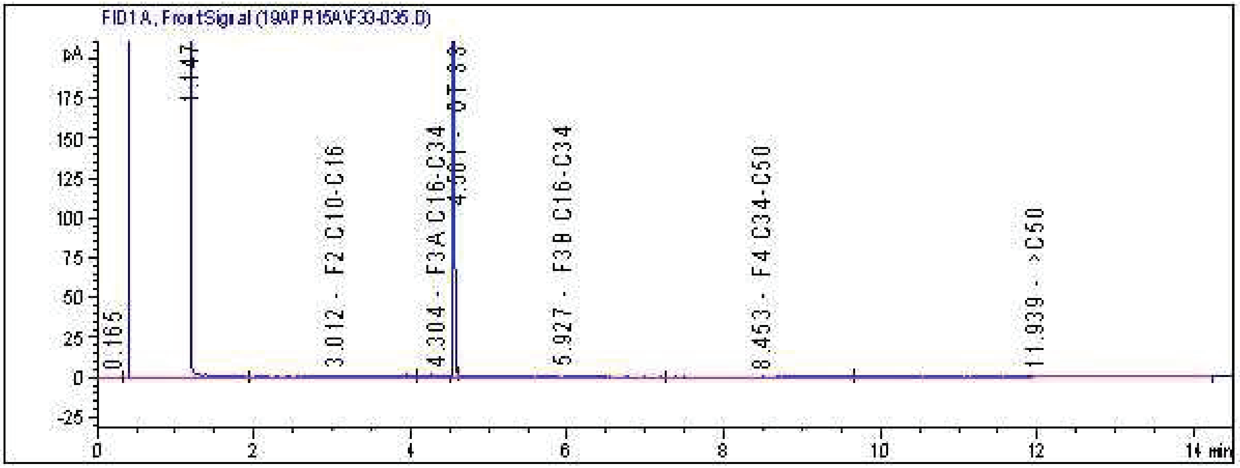
Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

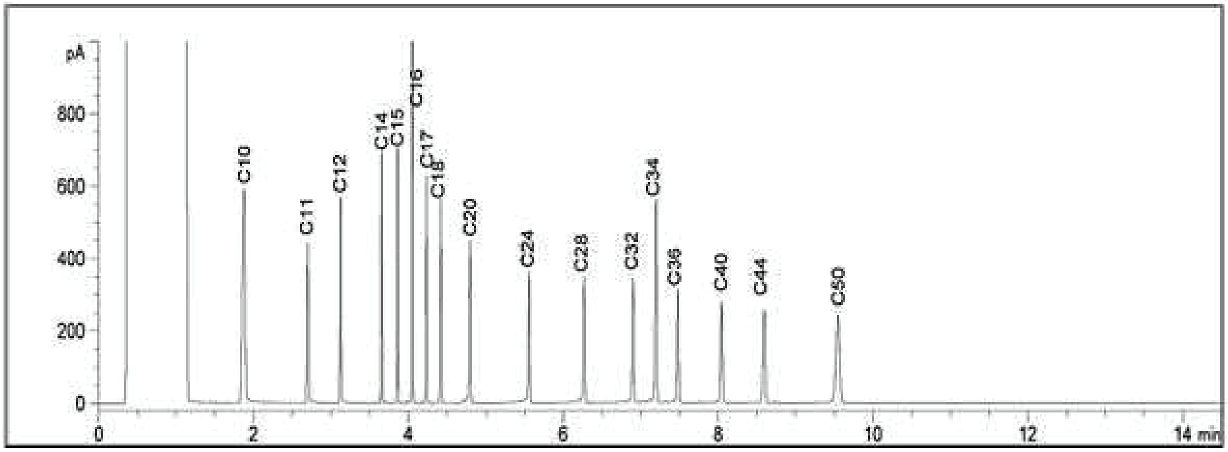
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

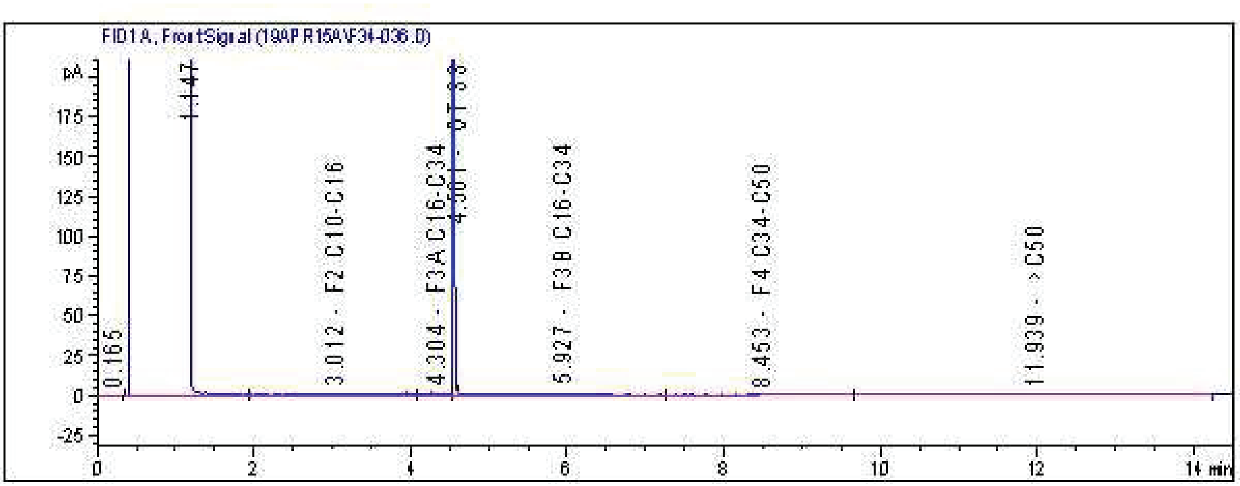
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

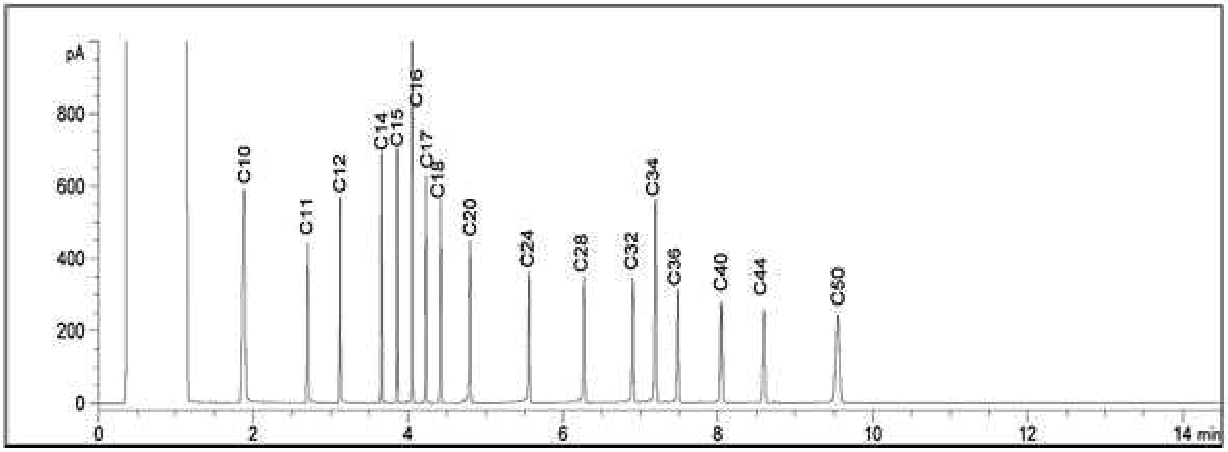
Maxxam Job #: B995482
Report Date: 2019/04/18
Maxxam Sample: JKT726 Lab-Dup

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-03

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

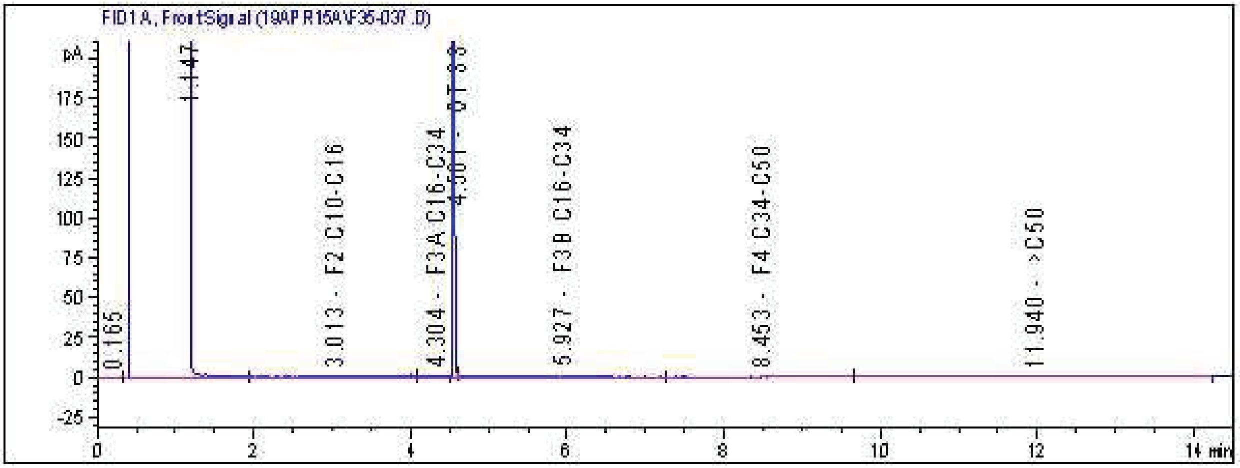
Gasoline:	**C6 - C12**	Diesel:	**C10 - C24**	Jet Fuels:	**C6 - C16**
Varsol:	**C8 - C12**	Fuel Oils:	**C6 - C32**	Creosote:	**C10 - C26**
Kerosene:	**C8 - C16**	Motor Oils:	**C16 - C50**	Asphalt:	**C18 - C50+**

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

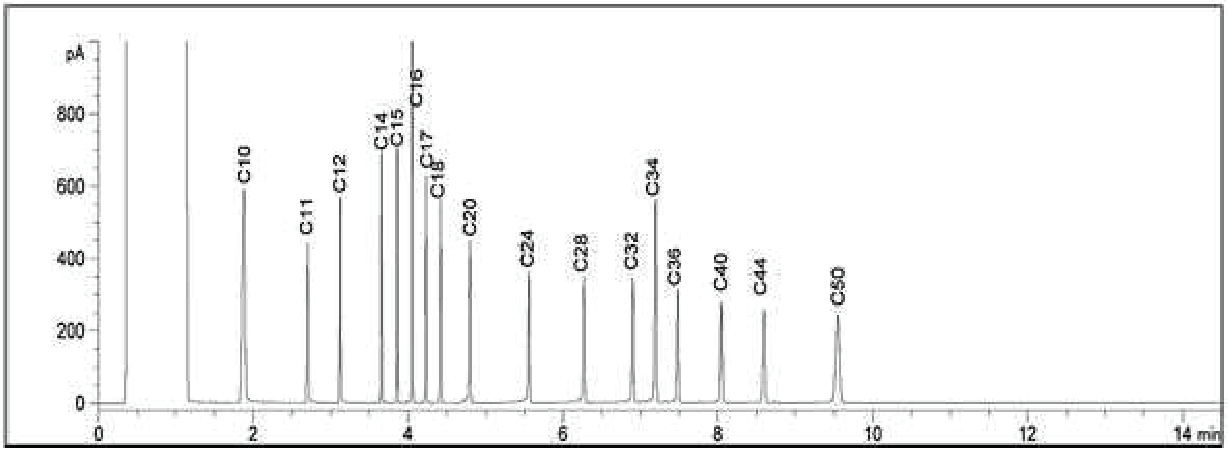
Maxxam Job #: B995482
Report Date: 2019/04/18
Maxxam Sample: JKT727

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-04

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

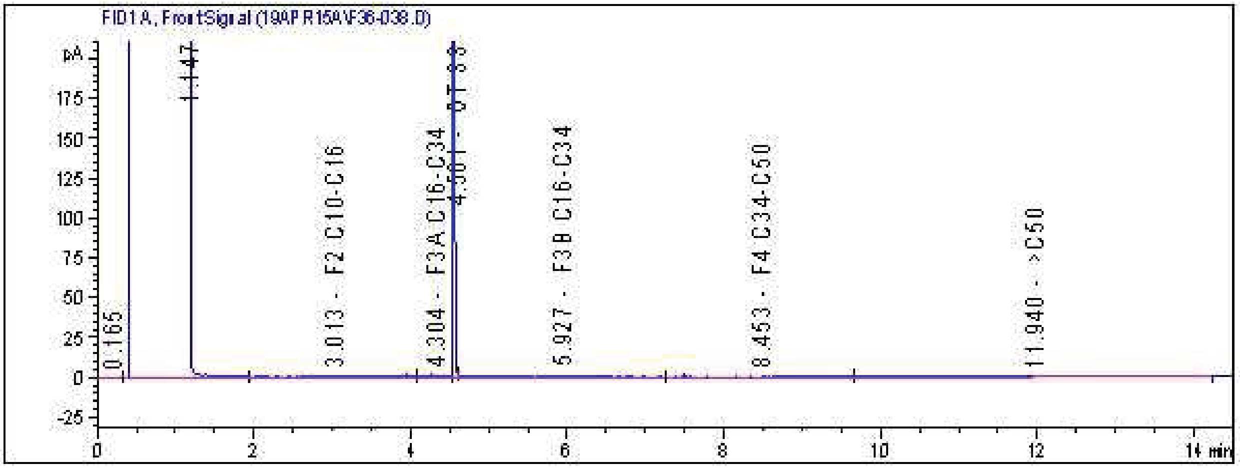
Gasoline:	**C6 - C12**	Diesel:	**C10 - C24**	Jet Fuels:	**C6 - C16**
Varsol:	**C8 - C12**	Fuel Oils:	**C6 - C32**	Creosote:	**C10 - C26**
Kerosene:	**C8 - C16**	Motor Oils:	**C16 - C50**	Asphalt:	**C18 - C50+**

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

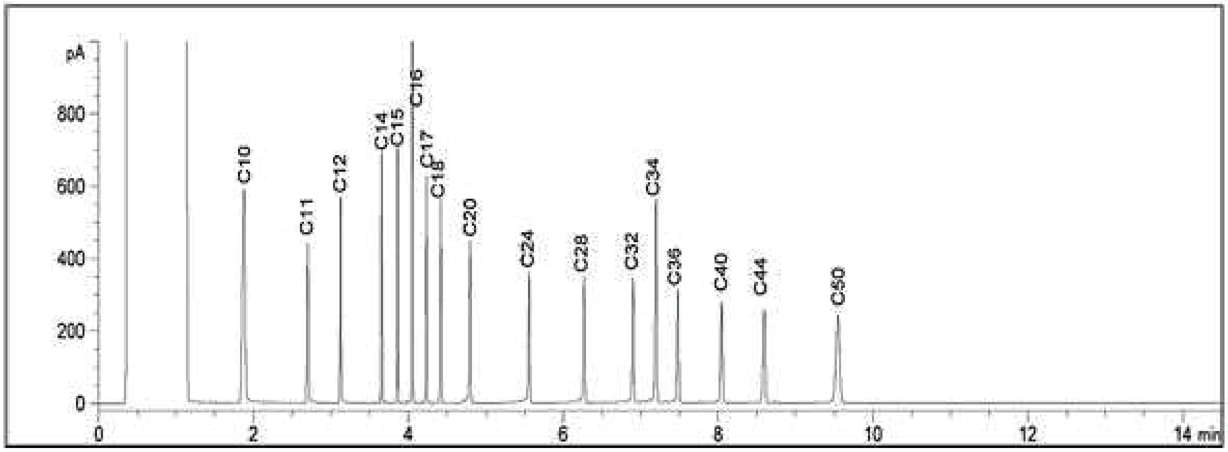
Maxxam Job #: B995482
Report Date: 2019/04/18
Maxxam Sample: JKT728

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-05

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

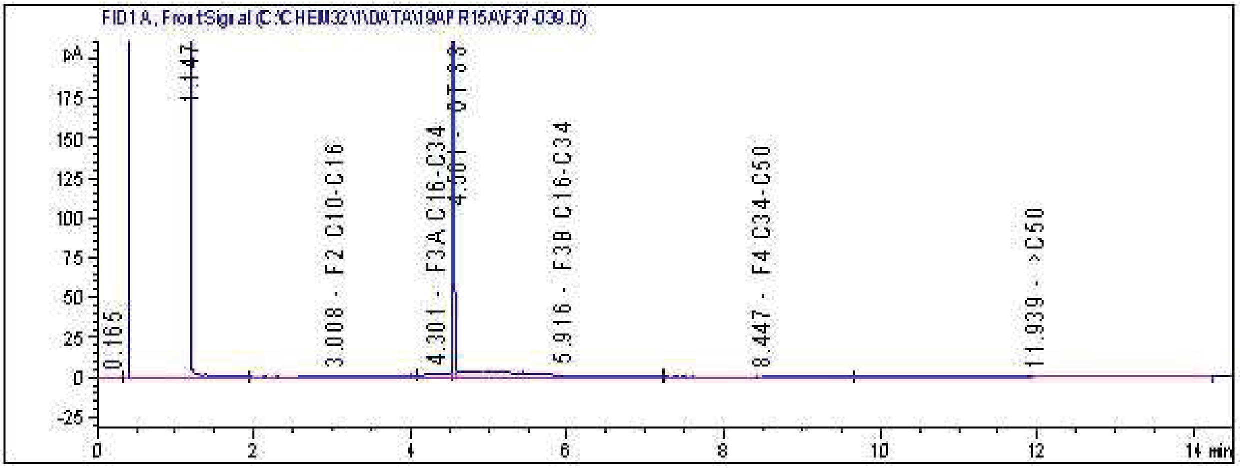
Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

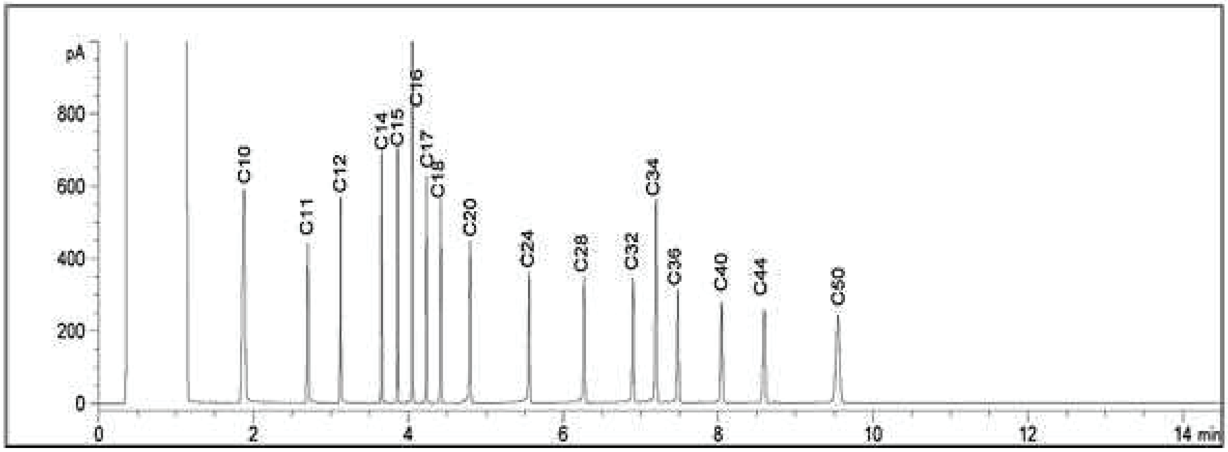
Maxxam Job #: B995482
Report Date: 2019/04/18
Maxxam Sample: JKT729

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW18-06

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Reference Spectrum



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline: **C6 - C12**
Varsol: **C8 - C12**
Kerosene: **C8 - C16**

Diesel: **C10 - C24**
Fuel Oils: **C6 - C32**
Motor Oils: **C16 - C50**

Jet Fuels: **C6 - C16**
Creosote: **C10 - C26**
Asphalt: **C18 - C50+**

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

Your Project #: 1791470 (4000)
Your C.O.C. #: 840234-01-01

Attention: Paul Menkveld

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

Report Date: 2021/08/20
Report #: R6773684
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1N2262
Received: 2021/08/16, 16:05

Sample Matrix: Ground Water
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Petroleum Hydro. CCME F1 & BTEX in Water	3	N/A	2021/08/19	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (1)	3	2021/08/18	2021/08/19	CAM SOP-00316	CCME PHC-CWS m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
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.
(1) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Bureau Veritas Laboratories 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.

Your Project #: 1791470 (4000)
Your C.O.C. #: 840234-01-01

Attention: Paul Menkveld

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

Report Date: 2021/08/20
Report #: R6773684
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1N2262
Received: 2021/08/16, 16:05

Encryption Key Ema Gitej

Ema Gitej
Senior Project Manager
20 Aug 2021 02:38:24

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: emese.gitej@bureauveritas.com
Phone# (905)817-5829
==
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total Cover Pages : 2

O.REG 153 PHCS, BTEX/F1-F4 (GROUND WATER)

BV Labs ID		QJW304	QJW305			QJW305			QJW306		
Sampling Date		2021/08/16 11:00	2021/08/16 11:45			2021/08/16 11:45			2021/08/16 13:00		
COC Number		840234-01-01	840234-01-01			840234-01-01			840234-01-01		
	UNITS	**MW 18-02**	**MW 18-03**	**RDL**	**QC Batch**	**MW 18-03 Lab-Dup**	**RDL**	**QC Batch**	**MW 18-04**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons											
Benzene	ug/L	<0.20	<0.20	0.20	7528496				<0.20	0.20	7528496
Toluene	ug/L	<0.20	<0.20	0.20	7528496				<0.20	0.20	7528496
Ethylbenzene	ug/L	<0.20	<0.20	0.20	7528496				<0.20	0.20	7528496
o-Xylene	ug/L	<0.20	<0.20	0.20	7528496				<0.20	0.20	7528496
p+m-Xylene	ug/L	<0.40	<0.40	0.40	7528496				<0.40	0.40	7528496
Total Xylenes	ug/L	<0.40	<0.40	0.40	7528496				<0.40	0.40	7528496
F1 (C6-C10)	ug/L	<25	<25	25	7528496				<25	25	7528496
F1 (C6-C10) - BTEX	ug/L	<25	<25	25	7528496				<25	25	7528496
F2-F4 Hydrocarbons											
F2 (C10-C16 Hydrocarbons)	ug/L	<100	<100	100	7527360	<100	100	7527360	<100	100	7527360
F3 (C16-C34 Hydrocarbons)	ug/L	<200	<200	200	7527360	<200	200	7527360	<200	200	7527360
F4 (C34-C50 Hydrocarbons)	ug/L	<200	<200	200	7527360	<200	200	7527360	<200	200	7527360
Reached Baseline at C50	ug/L	Yes	Yes		7527360	Yes		7527360	Yes		7527360
Surrogate Recovery (%)											
1,4-Difluorobenzene	%	103	100		7528496				102		7528496
4-Bromofluorobenzene	%	86	83		7528496				84		7528496
D10-o-Xylene	%	103	99		7528496				100		7528496
D4-1,2-Dichloroethane	%	104	106		7528496				108		7528496
o-Terphenyl	%	96	95		7527360	95		7527360	95		7527360

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

TEST SUMMARY

BV Labs ID: QJW304
Sample ID: MW 18-02
Matrix: Ground Water

Collected: 2021/08/16
Shipped:
Received: 2021/08/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	7528496	N/A	2021/08/19	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7527360	2021/08/18	2021/08/19	Dennis Ngondu

BV Labs ID: QJW305
Sample ID: MW 18-03
Matrix: Ground Water

Collected: 2021/08/16
Shipped:
Received: 2021/08/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	7528496	N/A	2021/08/19	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7527360	2021/08/18	2021/08/19	Dennis Ngondu

BV Labs ID: QJW305 Dup
Sample ID: MW 18-03
Matrix: Ground Water

Collected: 2021/08/16
Shipped:
Received: 2021/08/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7527360	2021/08/18	2021/08/19	Dennis Ngondu

BV Labs ID: QJW306
Sample ID: MW 18-04
Matrix: Ground Water

Collected: 2021/08/16
Shipped:
Received: 2021/08/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	7528496	N/A	2021/08/19	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7527360	2021/08/18	2021/08/19	Dennis Ngondu

GENERAL COMMENTS

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

Package 1	9.7°C

Results relate only to the items tested.

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
7527360	o-Terphenyl	2021/08/19	98	60 - 130	101	60 - 130	99	%		
7528496	1,4-Difluorobenzene	2021/08/19	98	70 - 130	98	70 - 130	101	%		
7528496	4-Bromofluorobenzene	2021/08/19	102	70 - 130	101	70 - 130	91	%		
7528496	D10-o-Xylene	2021/08/19	88	70 - 130	92	70 - 130	100	%		
7528496	D4-1,2-Dichloroethane	2021/08/19	102	70 - 130	99	70 - 130	104	%		
7527360	F2 (C10-C16 Hydrocarbons)	2021/08/19	99	60 - 130	100	60 - 130	<100	ug/L	NC	30
7527360	F3 (C16-C34 Hydrocarbons)	2021/08/19	103	60 - 130	104	60 - 130	<200	ug/L	NC	30
7527360	F4 (C34-C50 Hydrocarbons)	2021/08/19	107	60 - 130	106	60 - 130	<200	ug/L	NC	30
7528496	Benzene	2021/08/19	111	50 - 140	105	50 - 140	<0.20	ug/L	0.44	30
7528496	Ethylbenzene	2021/08/19	115	50 - 140	118	50 - 140	<0.20	ug/L	0.58	30
7528496	F1 (C6-C10) - BTEX	2021/08/19					<25	ug/L	1.9	30
7528496	F1 (C6-C10)	2021/08/19	95	60 - 140	97	60 - 140	<25	ug/L	0.93	30
7528496	o-Xylene	2021/08/19	111	50 - 140	113	50 - 140	<0.20	ug/L	3.1	30
7528496	p+m-Xylene	2021/08/19	114	50 - 140	110	50 - 140	<0.40	ug/L	3.8	30
7528496	Toluene	2021/08/19	99	50 - 140	100	50 - 140	<0.20	ug/L	0.50	30
7528496	Total Xylenes	2021/08/19					<0.40	ug/L	3.8	30

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 (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 (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Eva P

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Eva Pranjic
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

BUREAU VERITAS

Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free 800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:

Company Name: #21375 Golder Associates Ltd
Attention: Accounts Payable
Address: 210 Sheldon Drive
Cambridge ON N1T 1A8
Tel: (519) 620-8182 Fax:
Email: CanadaAccountsPayableInvoices@golder.com

REPORT TO:

Company Name:
Attention: Paul Menkveld
Address:
Tel: Fax:
Email: Paul_Menkveld@golder.com

PROJECT INFORMATION:

Quotation #: B80683
P.O. #:
Project: 1791470 (4000)
Project Name:
Site #:
Sampled By: DGM

Laboratory Use Only:

BV Labs Job #:	Bottle Order #:
	840234
COC #:	**Project Manager:**
C#840234-01-01	Ema Gitej

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS 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 ☐ Reg 406 Table ___
☐ 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	O.Reg 153 PHCs, BTEX/F1-F4										# of Bottles	Comments
1		~~MW18-01B~~																
2		MW18-02	18Aug21	11:00	GW		X										4	
3		MW18-03	↓	11:45	↓		X										↓	
4		MW18-04	↓	13:00	↓		X										↓	
5		~~SW18-01~~																
6																		
7																		
8																		
9																		
10																		

REC'D IN WATERLOO

16-Aug-21 16:05
Ema Gitej
C1N2262
ENV-1441

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
/ Paul Menkveld	21/08/16		Jaspreet Kaur	2021/08/16	15:05	
				2021/08/16	17:36	

On Ice

Laboratory Use Only

Time Sensitive	Temperature (°C) on Recei	Custody Seal	Yes	No
	7 / 12 / 10	Present		[✓ No]
		Intact		

White: BV Labs Yellow: Client

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* 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.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

6/6/5

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

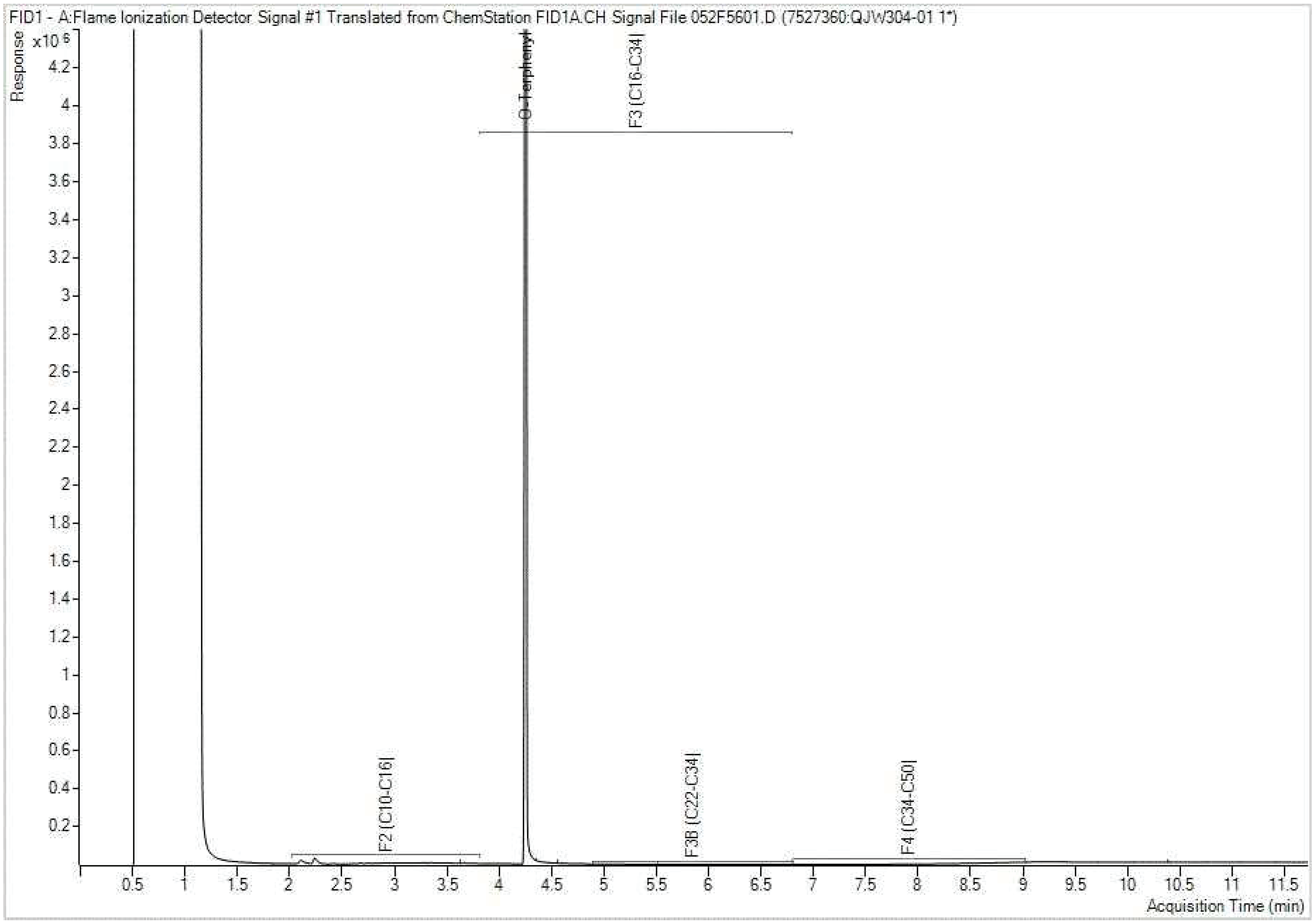
Bureau Veritas Canada (2019) Inc.

WA# 421142

BV Labs Job #: C1N2262
Report Date: 2021/08/20
BV Labs Sample: QJW304

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW 18-02

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

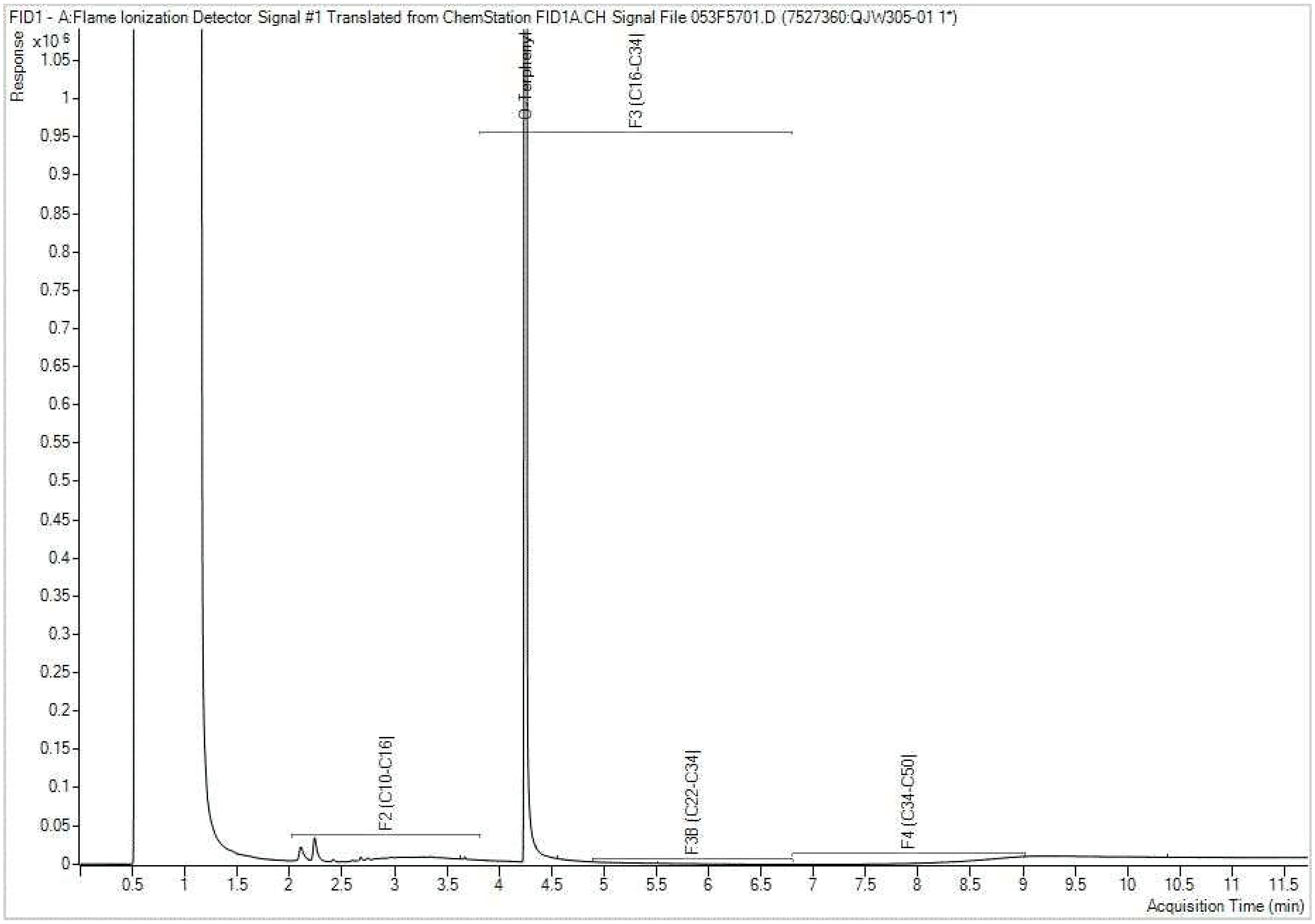


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BV Labs Job #: C1N2262
Report Date: 2021/08/20
BV Labs Sample: QJW305

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW 18-03

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

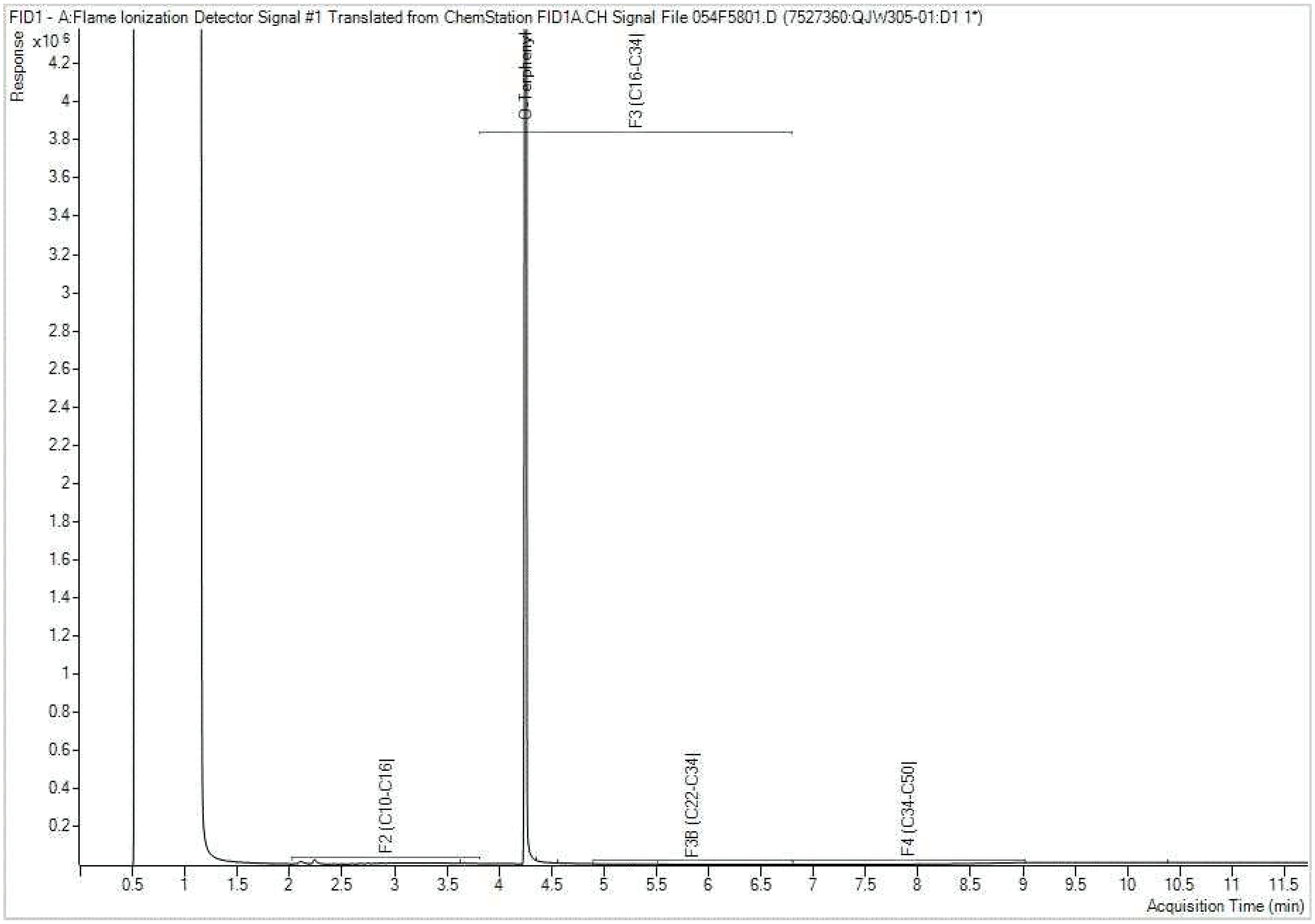


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BV Labs Job #: C1N2262
Report Date: 2021/08/20
BV Labs Sample: QJW305 Lab-Dup

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW 18-03

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

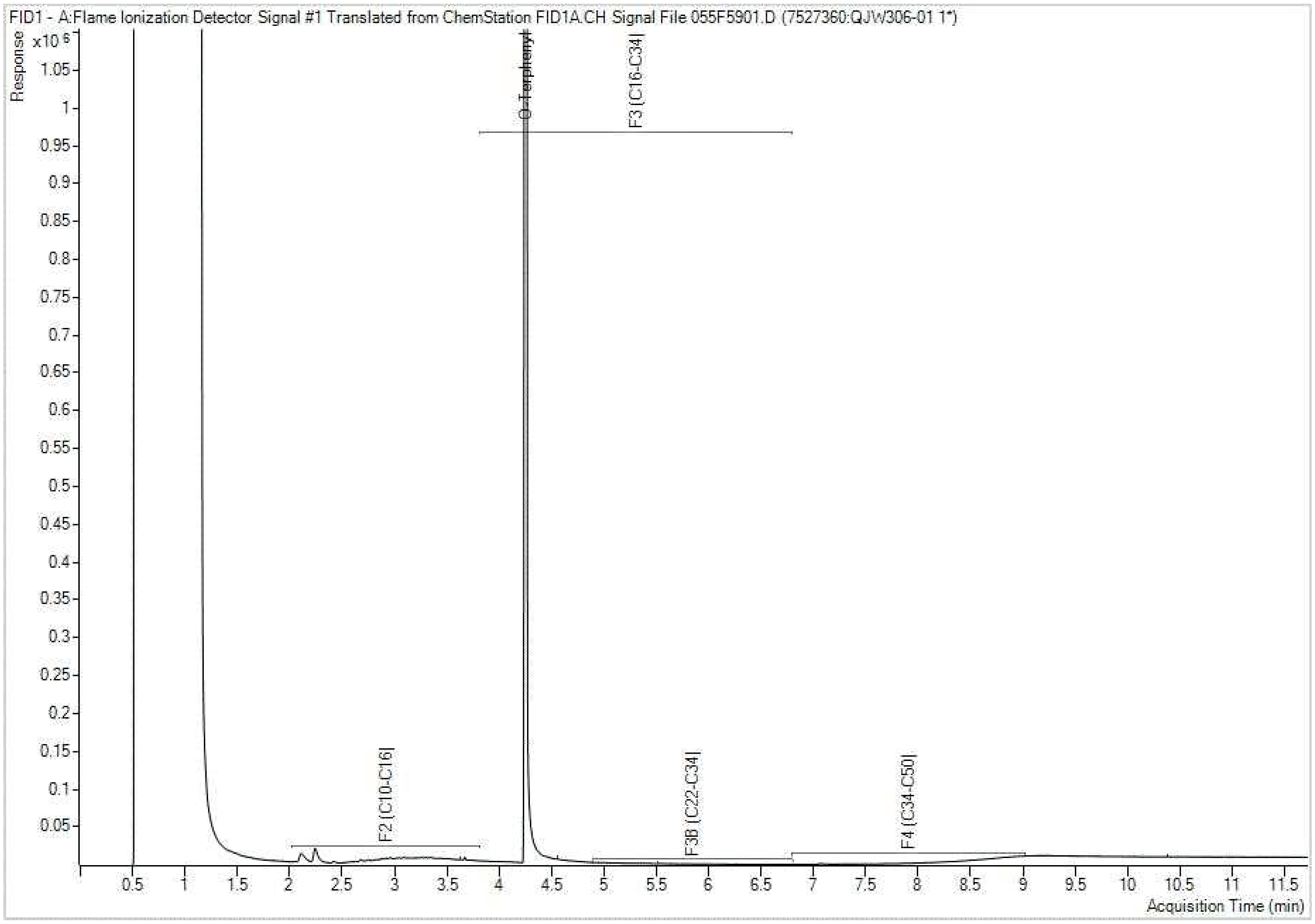


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BV Labs Job #: C1N2262
Report Date: 2021/08/20
BV Labs Sample: QJW306

Golder Associates Ltd
Client Project #: 1791470 (4000)
Client ID: MW 18-04

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.

Your Project #: 1791420 (4000)
Your C.O.C. #: 155622

Attention: Paul Menkveld
Golder Associates Ltd
210 Sheldon Drive
Cambridge, ON
CANADA N1T 1A8

Report Date: 2021/08/20
Report #: R6773688
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1N0480
Received: 2021/08/13, 08:06

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Petroleum Hydro. CCME F1 & BTEX in Water	2	N/A	2021/08/17	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (1)	2	2021/08/18	2021/08/18	CAM SOP-00316	CCME PHC-CWS m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
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.
(1) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Bureau Veritas Laboratories 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.

Your Project #: 1791420 (4000)
Your C.O.C. #: 155622

Attention: Paul Menkveld
Golder Associates Ltd
210 Sheldon Drive
Cambridge, ON
CANADA N1T 1A8

Report Date: 2021/08/20
Report #: R6773688
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1N0480
Received: 2021/08/13, 08:06

Encryption Key Ema Gitej

```
Ema Gitej
Senior Project Manager
20 Aug 2021 02:50:28
```

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: emese.gitej@bureauveritas.com
Phone# (905)817-5829
==
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

O.REG 153 PHCS, BTEX/F1-F4 (WATER)

BV Labs ID		QJM690	QJM691			QJM691		
Sampling Date		2021/08/12 12:00	2021/08/12 15:00			2021/08/12 15:00		
COC Number		155622	155622			155622		
	UNITS	**MW18-01B**	**SW18-01**	**RDL**	**QC Batch**	**SW18-01 Lab-Dup**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons								
Benzene	ug/L	<0.20	<0.20	0.20	7525875			
Toluene	ug/L	<0.20	<0.20	0.20	7525875			
Ethylbenzene	ug/L	<0.20	<0.20	0.20	7525875			
o-Xylene	ug/L	<0.20	<0.20	0.20	7525875			
p+m-Xylene	ug/L	<0.40	<0.40	0.40	7525875			
Total Xylenes	ug/L	<0.40	<0.40	0.40	7525875			
F1 (C6-C10)	ug/L	<25	<25	25	7525875			
F1 (C6-C10) - BTEX	ug/L	<25	<25	25	7525875			
F2-F4 Hydrocarbons								
F2 (C10-C16 Hydrocarbons)	ug/L	<100	<100	100	7526286	<100	100	7526286
F3 (C16-C34 Hydrocarbons)	ug/L	<200	<200	200	7526286	<200	200	7526286
F4 (C34-C50 Hydrocarbons)	ug/L	<200	<200	200	7526286	<200	200	7526286
Reached Baseline at C50	ug/L	Yes	Yes		7526286	Yes		7526286
Surrogate Recovery (%)								
1,4-Difluorobenzene	%	102	102		7525875			
4-Bromofluorobenzene	%	91	91		7525875			
D10-o-Xylene	%	116	118		7525875			
D4-1,2-Dichloroethane	%	112	111		7525875			
o-Terphenyl	%	95	91		7526286	80		7526286

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

TEST SUMMARY

BV Labs ID: QJM690
Sample ID: MW18-01B
Matrix: Water

Collected: 2021/08/12
Shipped:
Received: 2021/08/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	7525875	N/A	2021/08/17	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7526286	2021/08/18	2021/08/18	(Kent) Maolin Li

BV Labs ID: QJM691
Sample ID: SW18-01
Matrix: Water

Collected: 2021/08/12
Shipped:
Received: 2021/08/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	7525875	N/A	2021/08/17	Anca Ganea
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7526286	2021/08/18	2021/08/18	(Kent) Maolin Li

BV Labs ID: QJM691 Dup
Sample ID: SW18-01
Matrix: Water

Collected: 2021/08/12
Shipped:
Received: 2021/08/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	7526286	2021/08/18	2021/08/18	(Kent) Maolin Li

GENERAL COMMENTS

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

Package 1	5.0°C

Results relate only to the items tested.

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**
7525875	1,4-Difluorobenzene	2021/08/17	98	70 - 130	97	70 - 130	104	%		
7525875	4-Bromofluorobenzene	2021/08/17	106	70 - 130	108	70 - 130	80	%		
7525875	D10-o-Xylene	2021/08/17	96	70 - 130	95	70 - 130	113	%		
7525875	D4-1,2-Dichloroethane	2021/08/17	99	70 - 130	100	70 - 130	110	%		
7526286	o-Terphenyl	2021/08/18	97	60 - 130	100	60 - 130	99	%		
7525875	Benzene	2021/08/17	100	50 - 140	106	50 - 140	<0.20	ug/L	NC	30
7525875	Ethylbenzene	2021/08/17	113	50 - 140	119	50 - 140	<0.20	ug/L	NC	30
7525875	F1 (C6-C10) - BTEX	2021/08/17					<25	ug/L	NC	30
7525875	F1 (C6-C10)	2021/08/17	90	60 - 140	96	60 - 140	<25	ug/L	NC	30
7525875	o-Xylene	2021/08/17	111	50 - 140	115	50 - 140	<0.20	ug/L	NC	30
7525875	p+m-Xylene	2021/08/17	108	50 - 140	113	50 - 140	<0.40	ug/L	NC	30
7525875	Toluene	2021/08/17	88	50 - 140	101	50 - 140	<0.20	ug/L	NC	30
7525875	Total Xylenes	2021/08/17					<0.40	ug/L	NC	30
7526286	F2 (C10-C16 Hydrocarbons)	2021/08/18	101	60 - 130	105	60 - 130	<100	ug/L	NC	30
7526286	F3 (C16-C34 Hydrocarbons)	2021/08/18	105	60 - 130	107	60 - 130	<200	ug/L	NC	30
7526286	F4 (C34-C50 Hydrocarbons)	2021/08/18	109	60 - 130	110	60 - 130	<200	ug/L	NC	30

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 (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 (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Eva P

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Eva Pranjic
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

BUREAU VERITAS

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/6

CHAIN OF CUSTODY RECORD

155622 Page 1 of 1

Invoice Information

Company Name: Golder Associates Ltd
Contact Name: Accounts Payable
Address: 210 Sheldon Dr.
Cambridge, ON N1T 1A8
Phone: 226-750-8848
Email: Canada Accounts Payable Invoice@golder.com

Report Information (if differs from invoice)

Company Name:
Contact Name: Paul Marttell
Address:
Phone: Fax:
Email: Paul_marttell@golder.com

Project Information (where applicable)

Quotation #: B80683
P.O. #/ AFE#:
Project #: 1791420 (4000)
Site Location:
Site #:
Site Location Province:
Sampled By: PGM

Turnaround Time (TAT) Required

☒ Regular TAT (5-7 days) Most analyses

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Rush TAT (Surcharges will be applied)

☐ 1 Day ☐ 2 Days ☐ 3-4 Days

Date Required:
Rush Confirmation #:

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS LABORATORIES' DRINKING WATER CHAIN OF CUSTODY

Regulation 153

☐ Table 1 ☐ Res/Park ☐ Med/ Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/ Other
☐ Table ____
FOR RSC (PLEASE CIRCLE) Y / N

Include Criteria on Certificate of Analysis: Y / N

Other Regulations

☐ CCME ☐ Sanitary Sewer Bylaw
☐ MISA ☐ Storm Sewer Bylaw
☐ PWQO Region
☐ Other (Specify)
☐ REG 558 (MIN. 3 DAY TAT REQUIRED)
☐ REG 406 Table

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

Analysis Requested

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)									HOLD- DO NOT ANALYZE
1	MW18-01B	2021/08/12	12:00	GW	4		X	X													
2	SW18-01	"	15:00	SW	4		X	X													
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

LABORATORY USE ONLY

CUSTODY SEAL [✓ Y] / N

Present	Intact	COOLER TEMPERATURES
Y	Y	5/5/5C
	-	9/7/7

COOLING MEDIA PRESENT: [✓ Y] / N ice

COMMENTS picked after hours

REC'D IN WATERLOO

13-Aug-21 08:06
Ema Gitej
C1N0480
AVX ENV-1086

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
/ Paul Marttell	2021/08/12	22:00	TAMSIN DULEN	2021/08/13	08:06
			/ SHANNON KERR	2021/08/13	15:57

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BV# 426637

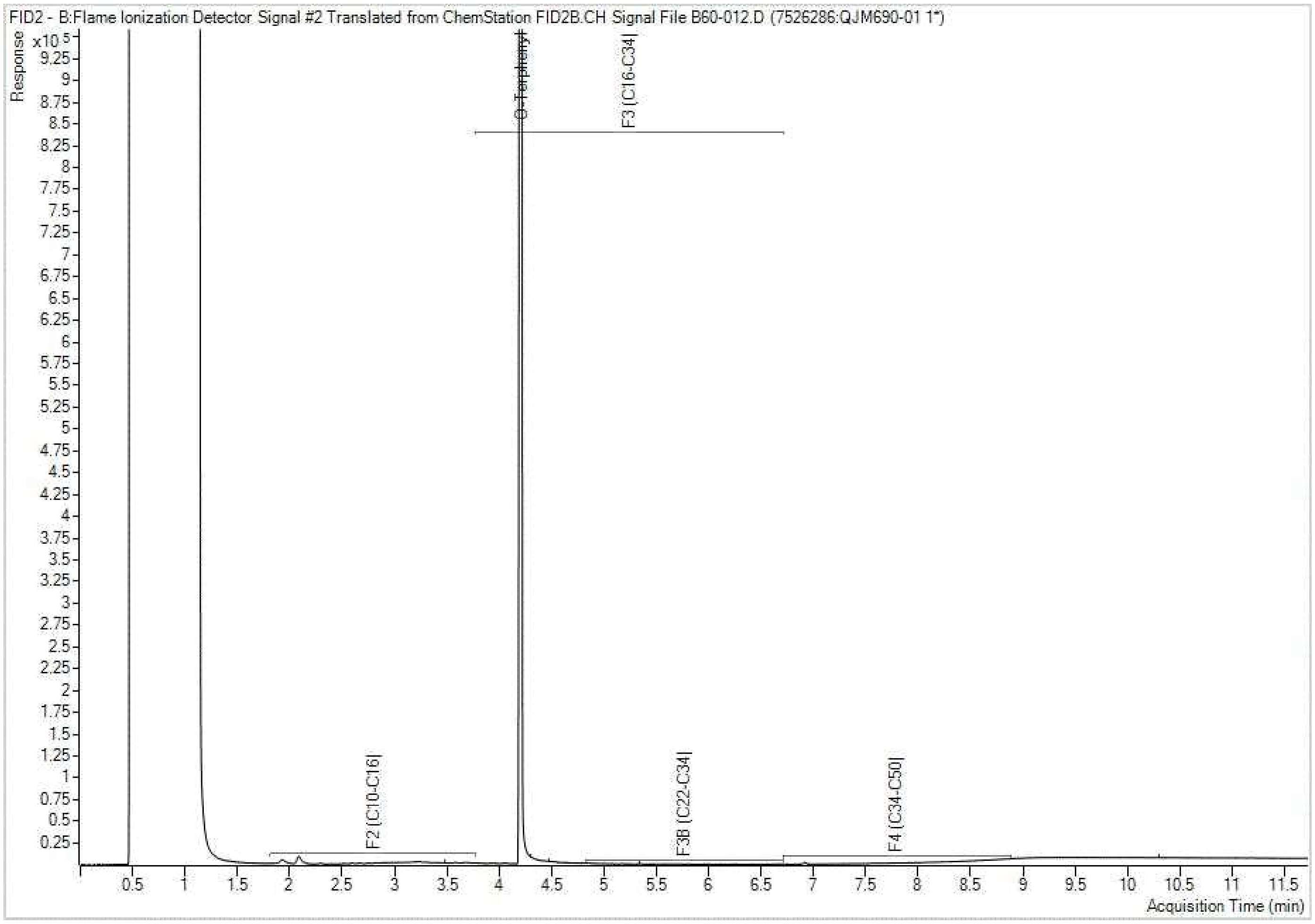
COC-1004 (06/19)

White: BV Labs - Yellow: Client

BV Labs Job #: C1N0480
Report Date: 2021/08/20
BV Labs Sample: QJM690

Golder Associates Ltd
Client Project #: 1791420 (4000)
Client ID: MW18-01B

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

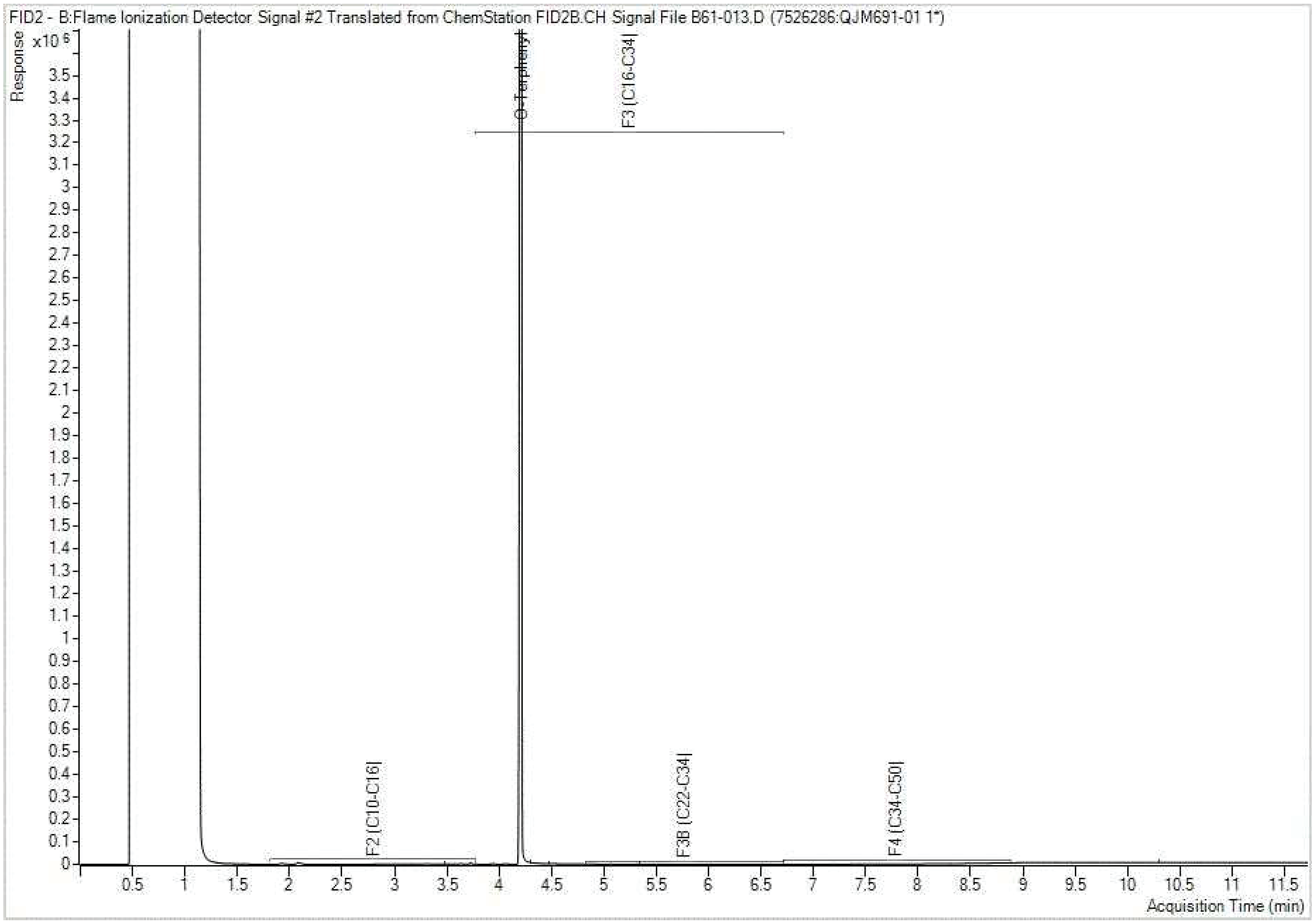


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BV Labs Job #: C1N0480
Report Date: 2021/08/20
BV Labs Sample: QJM691

Golder Associates Ltd
Client Project #: 1791420 (4000)
Client ID: SW18-01

Petroleum Hydrocarbons F2-F4 in Water Chromatogram

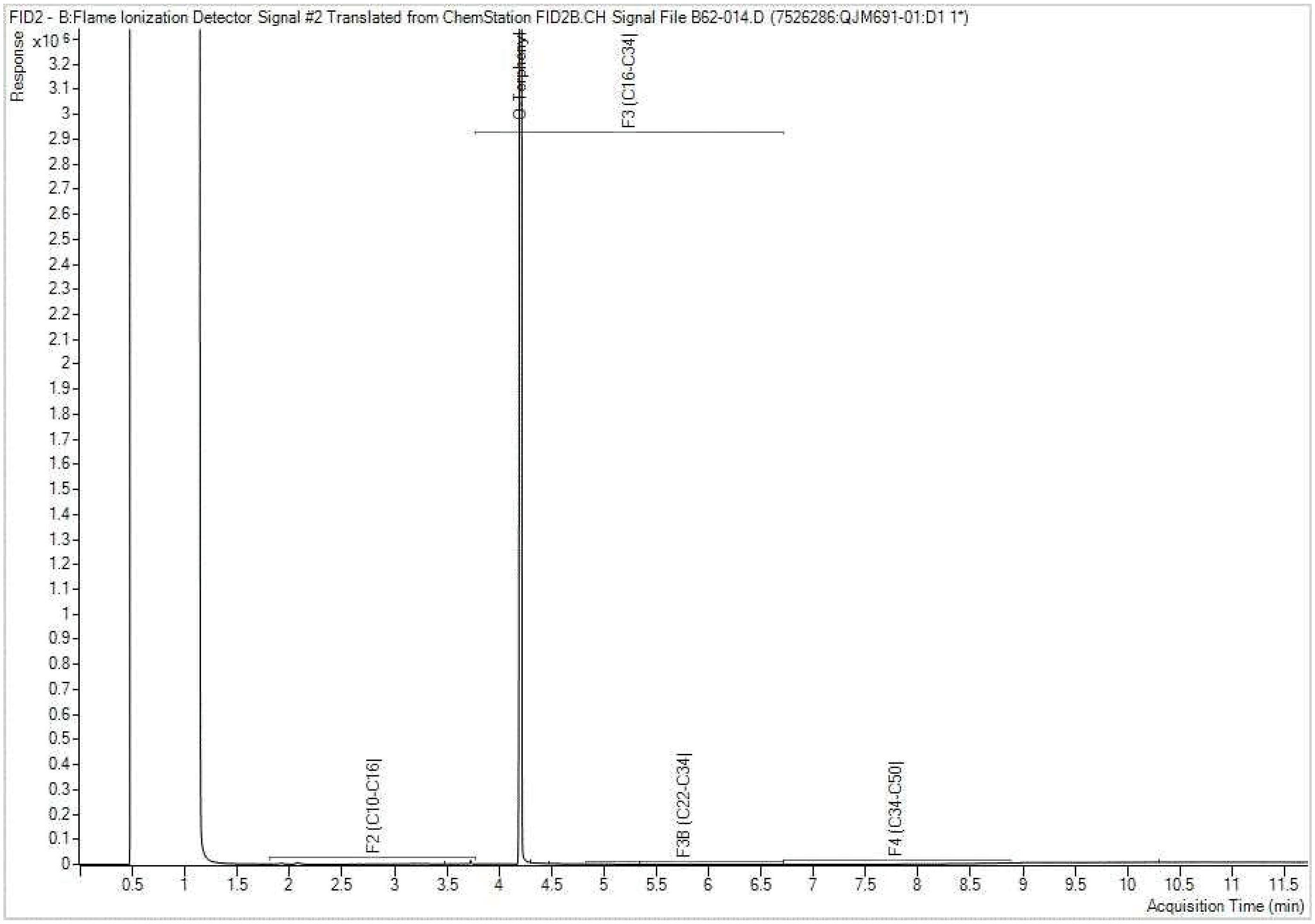


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BV Labs Job #: C1N0480
Report Date: 2021/08/20
BV Labs Sample: QJM691 Lab-Dup

Golder Associates Ltd
Client Project #: 1791420 (4000)
Client ID: SW18-01

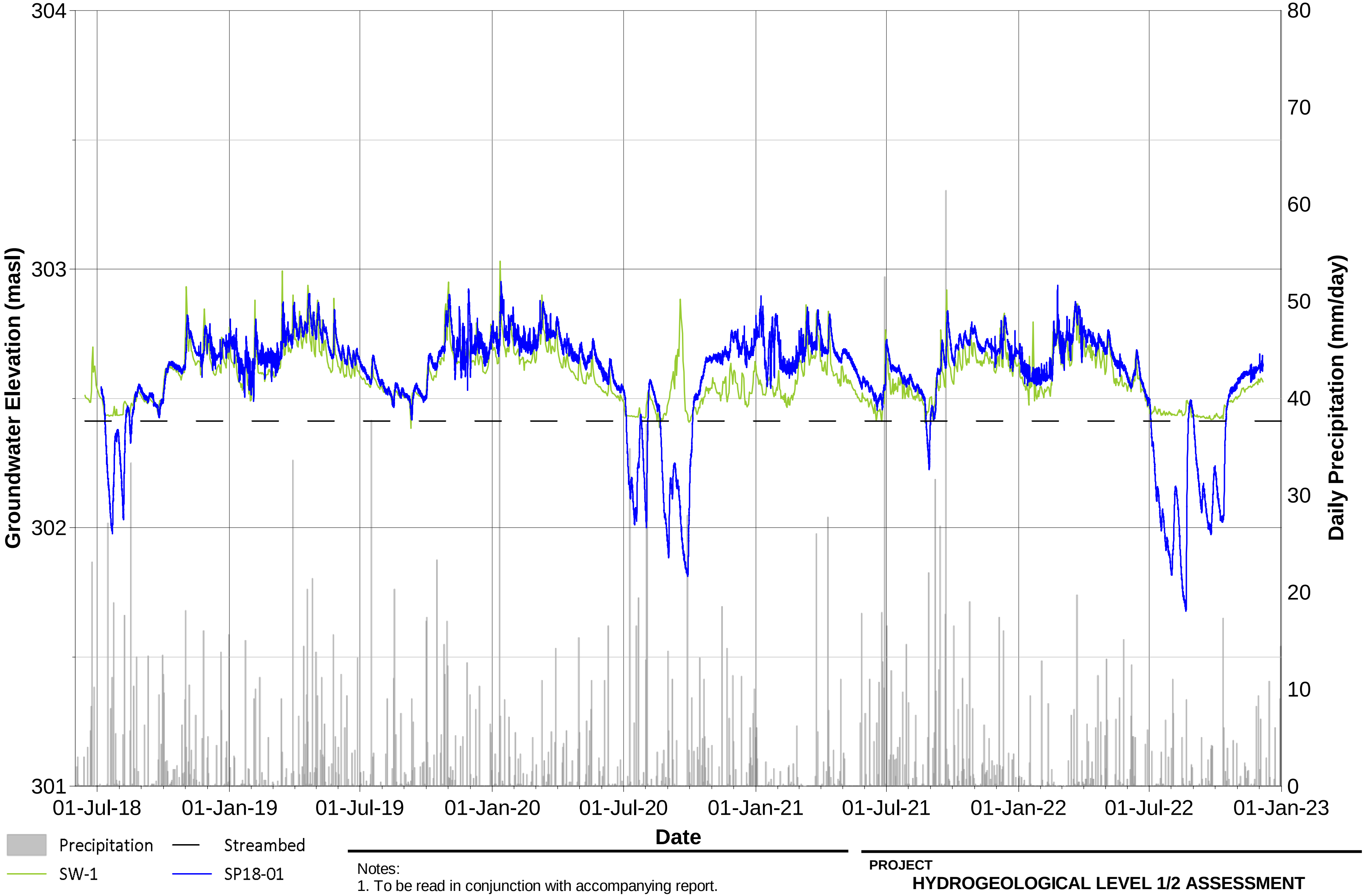
Petroleum Hydrocarbons F2-F4 in Water Chromatogram



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

APPENDIX F

Groundwater – Surface Water Interaction Hydrographs and Thermographs



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. Surface water head calculated as a daily average.

wsp

DATE 2023-Jan-26
DESIGN PGM
REVIEW GWS
APPROVED GWS

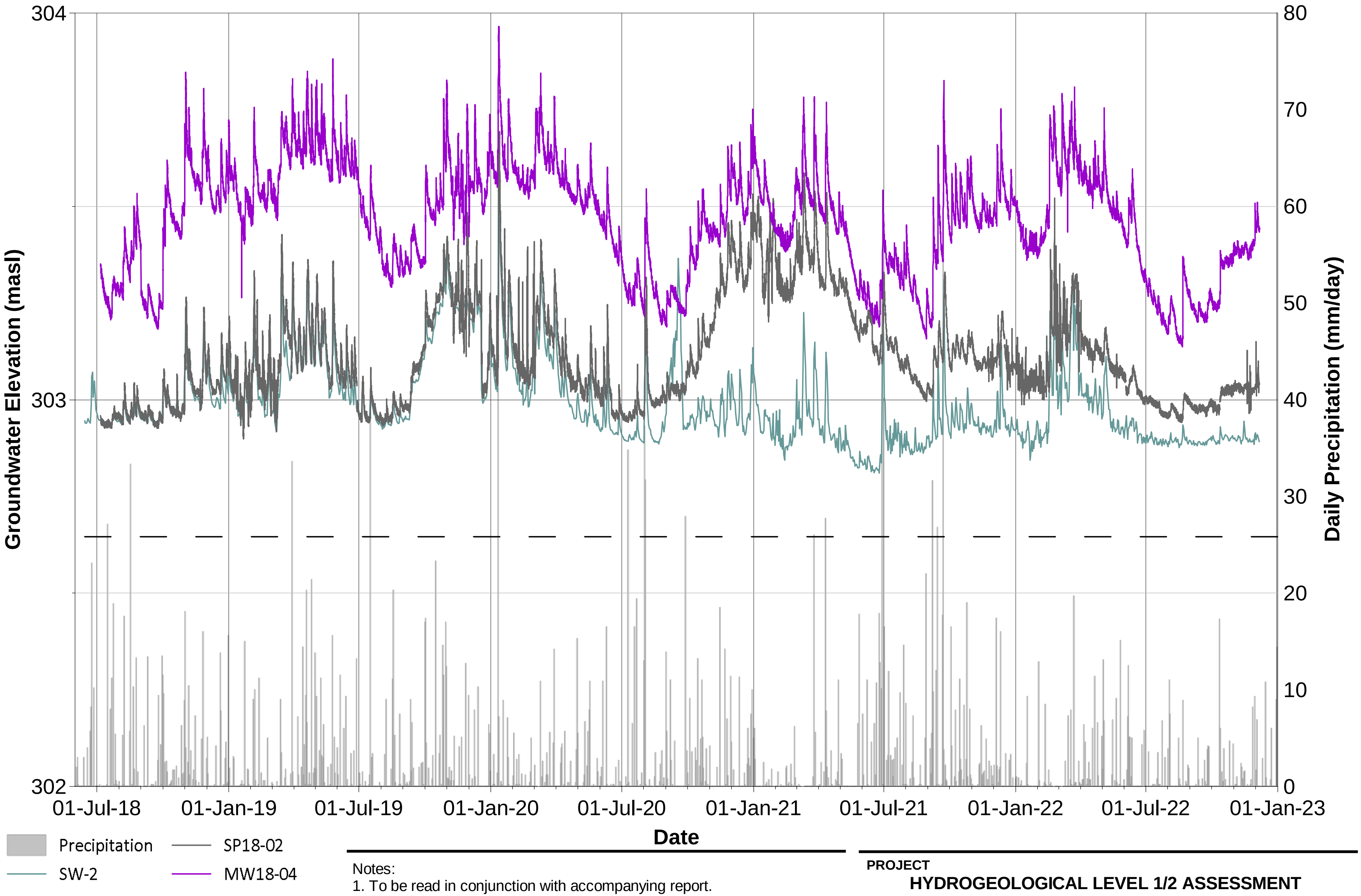
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-1 GROUNDWATER-SURFACE WATER ELEVATION HYDROGRAPHS

PROJECT NO. 1791470
REV
FIGURE F.1.



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. Surface water head calculated as a daily average.

DATE	2023-Jan-26
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

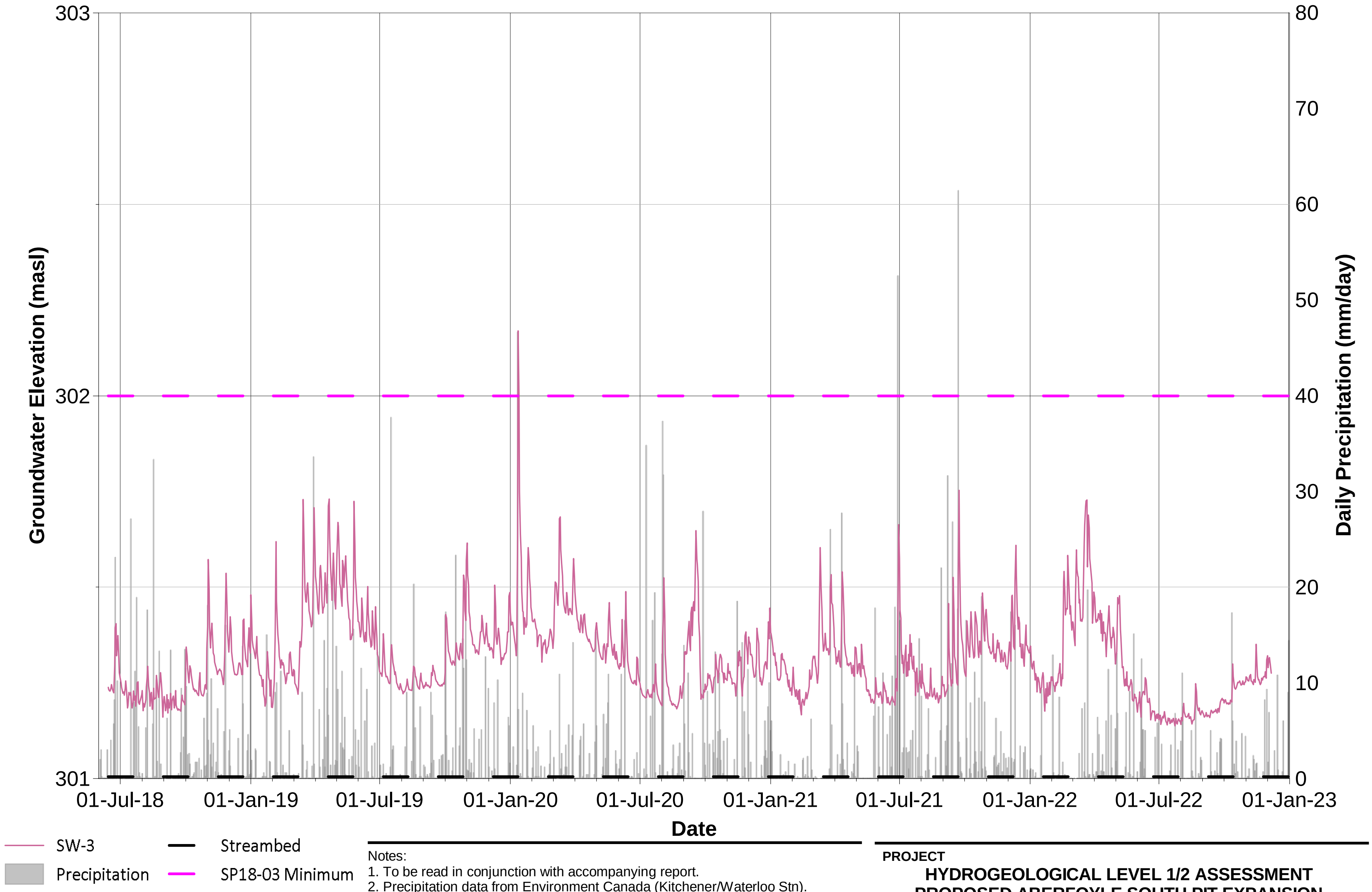
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-2 GROUNDWATER-SURFACE WATER
ELEVATION HYDROGRAPHS

PROJECT NO.	**REV**	**FIGURE**
1791470		F.2.



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. SP18-03 is a minimum head.
4. Surface water head is calculated as a daily average.

DATE	2023-Jan-26
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

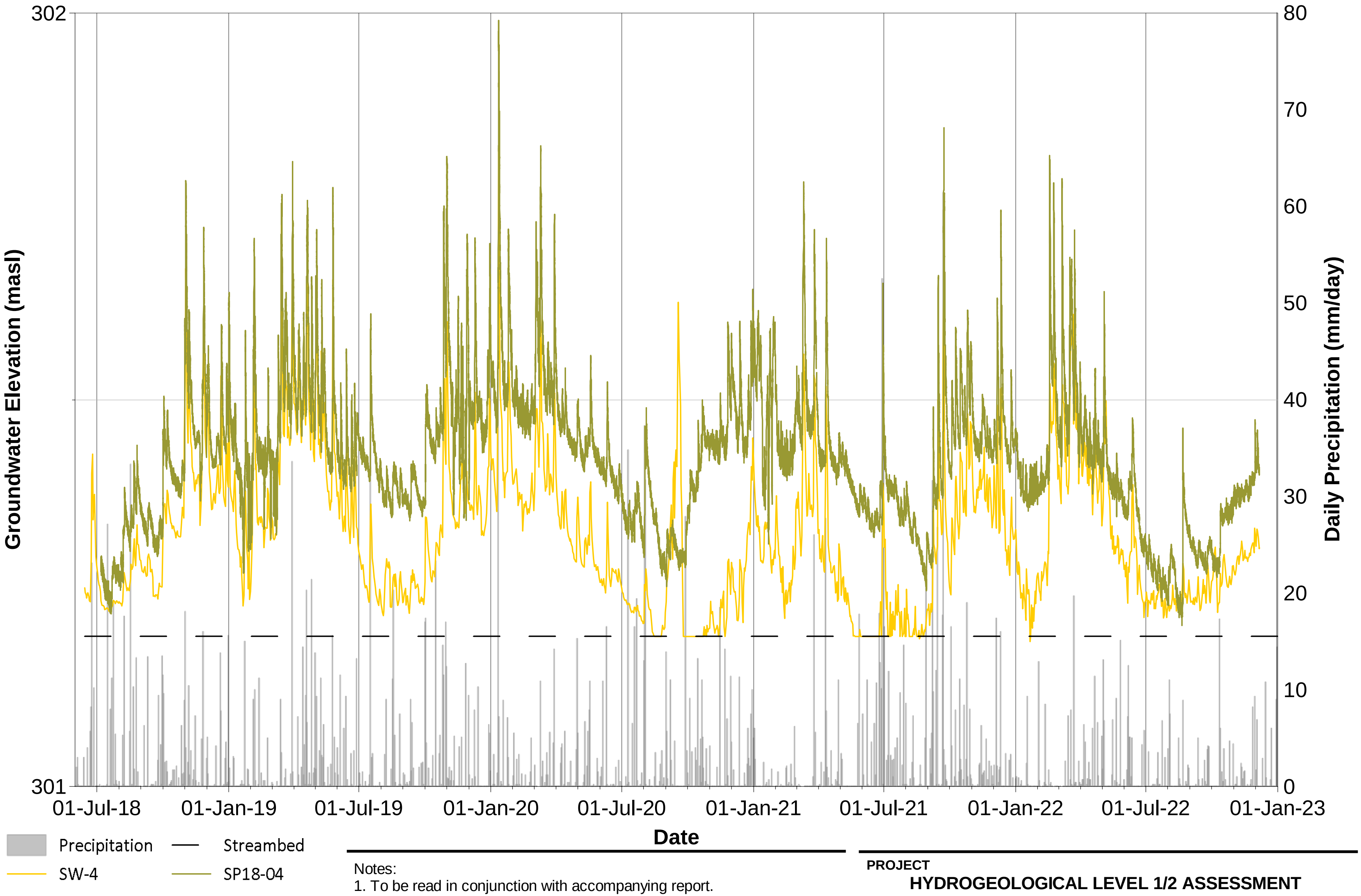
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-3 GROUNDWATER-SURFACE WATER ELEVATION HYDROGRAPHS

PROJECT NO. 1791470
REV
FIGURE F.3.



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. Surface water head is calculated as a daily average.

wsp

DATE	2023-Jan-26
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

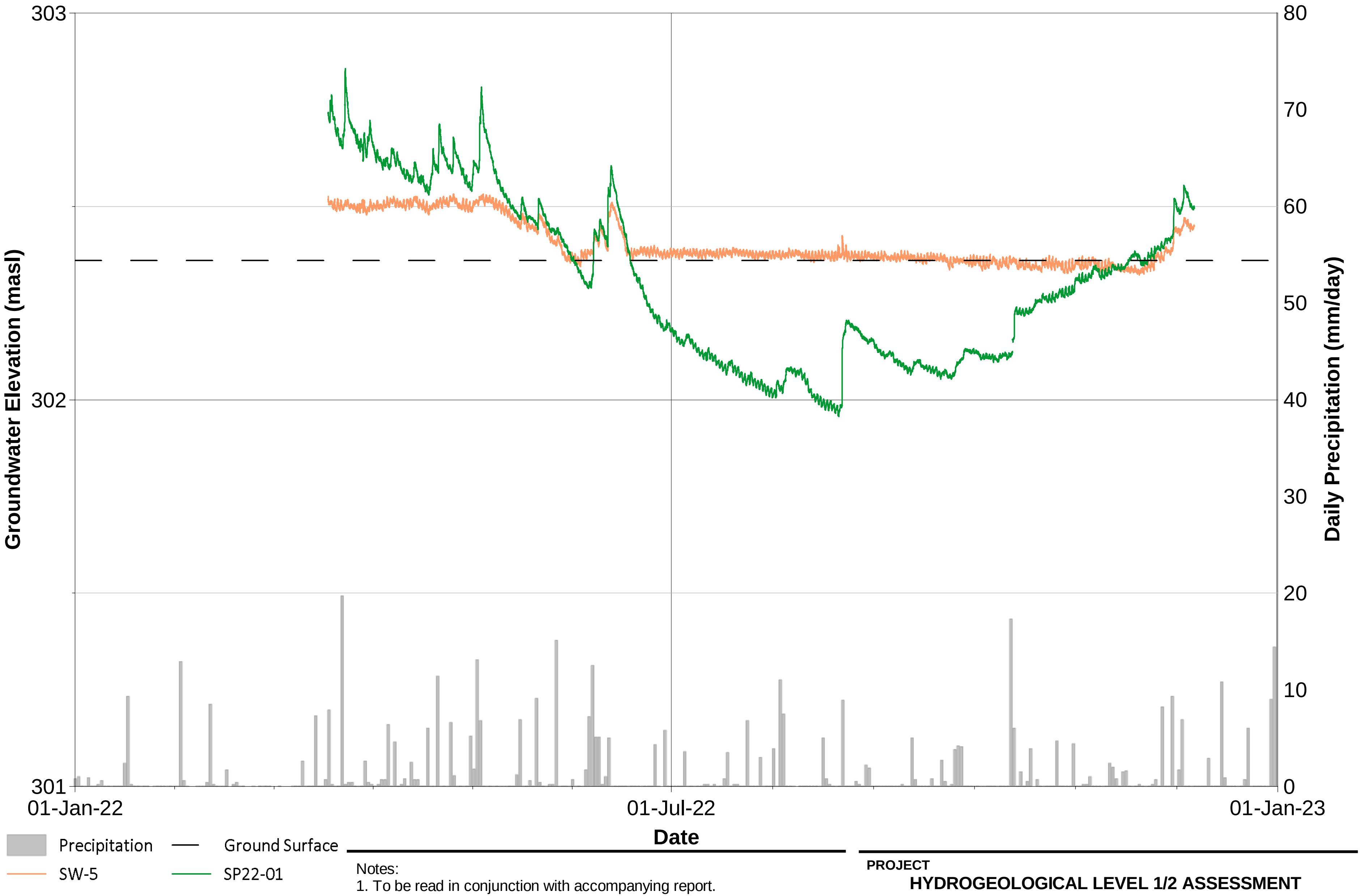
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-4 GROUNDWATER-SURFACE WATER
ELEVATION HYDROGRAPHS

PROJECT NO.	**REV**	**FIGURE**
1791470		F.4.



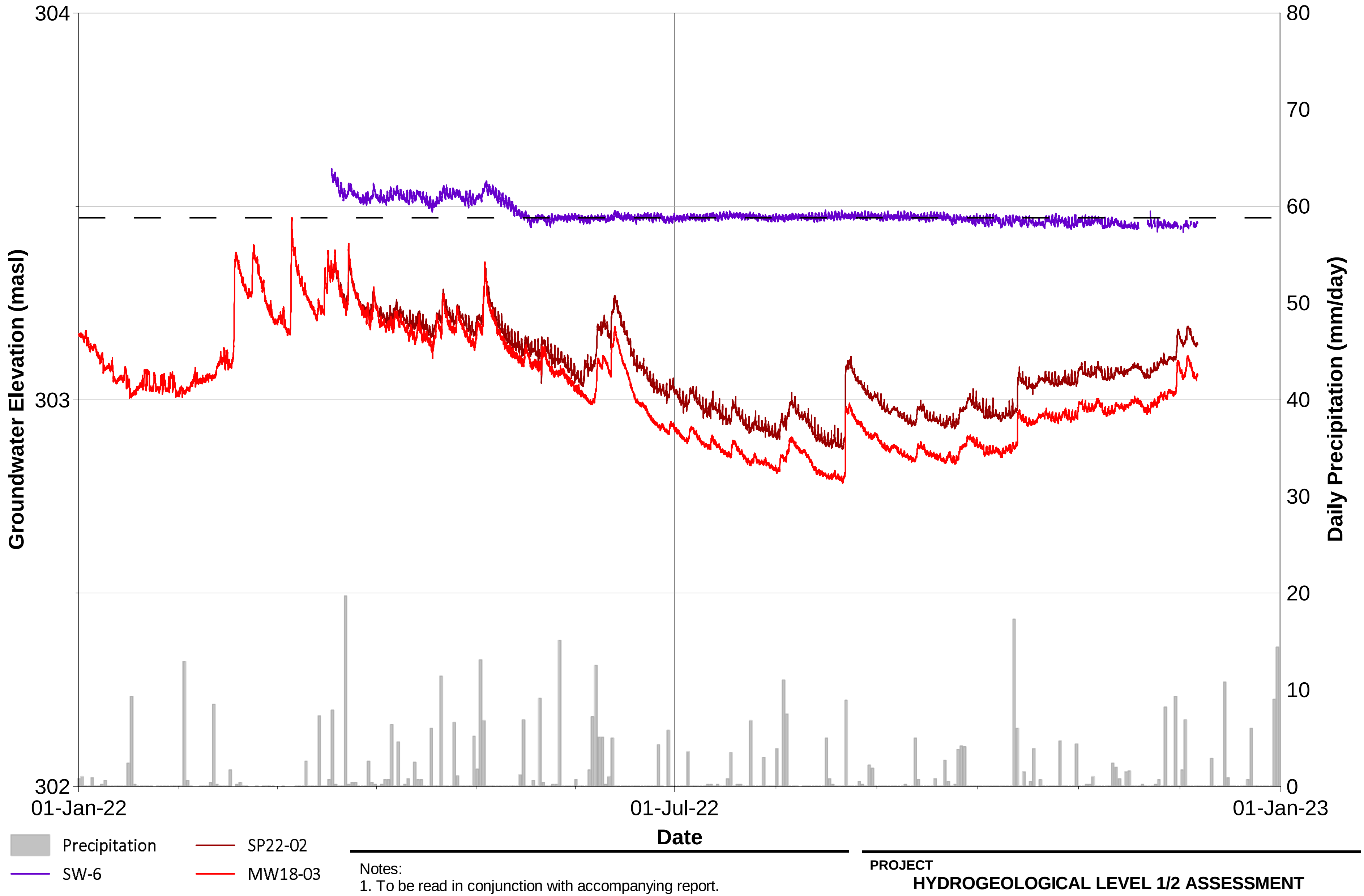
Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. Surface water head calculated as a daily average.

DATE	2023-Jan-27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
SW-5 GROUNDWATER-SURFACE WATER
ELEVATION HYDROGRAPHS

PROJECT NO.	REV	FIGURE
1791470		F.5.



Notes:
1. To be read in conjunction with accompanying report.
2. Precipitation data from Environment Canada (Kitchener/Waterloo Stn).
3. Surface water head calculated as a daily average.

DATE	2023-Jan-27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

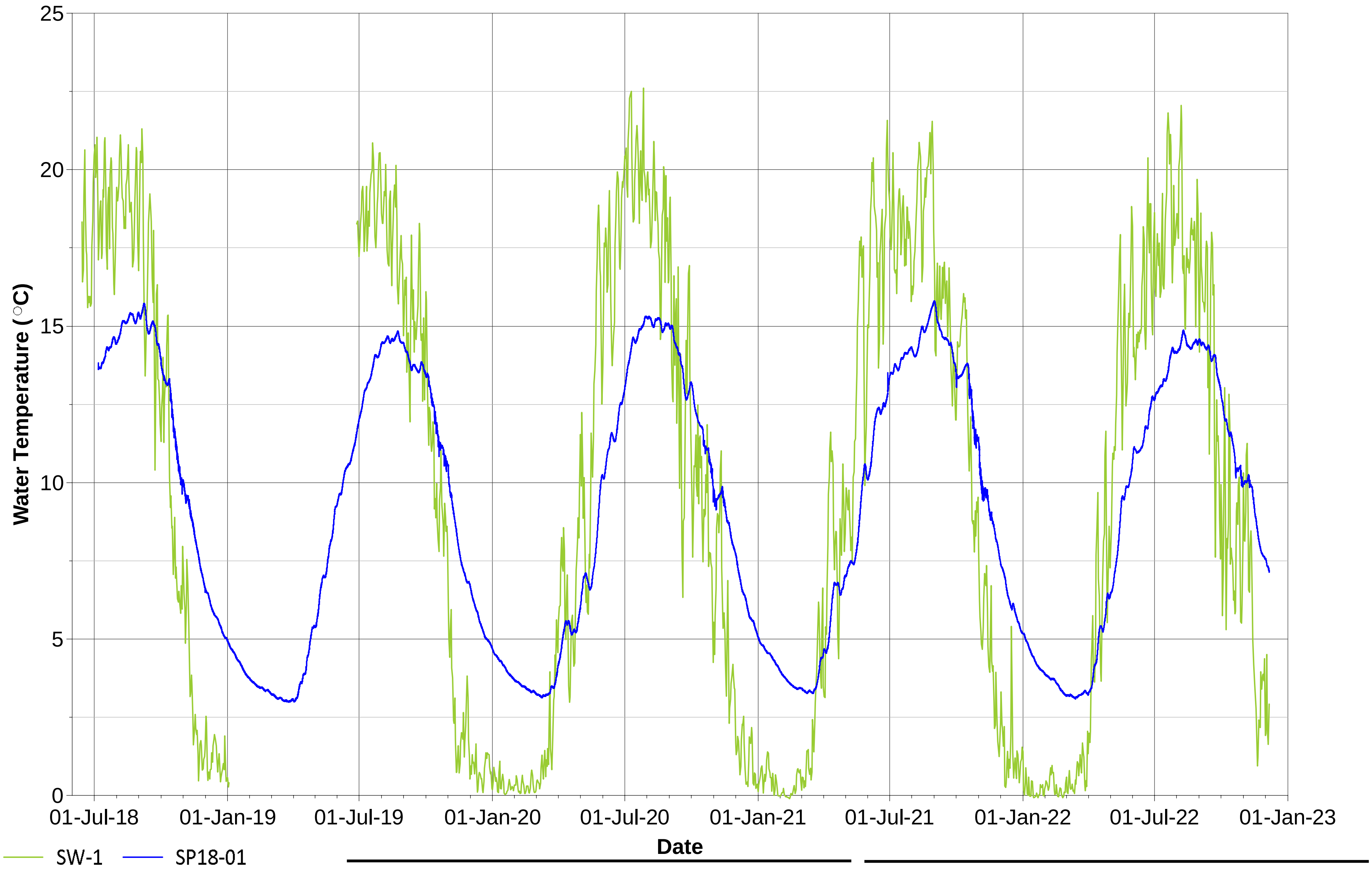
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-6 GROUNDWATER-SURFACE WATER
ELEVATION HYDROGRAPHS

PROJECT NO.	**REV**	**FIGURE**
1791470		F.6.



Notes:
1. To be read in conjunction with accompanying report.

DATE	2023-Jan-27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

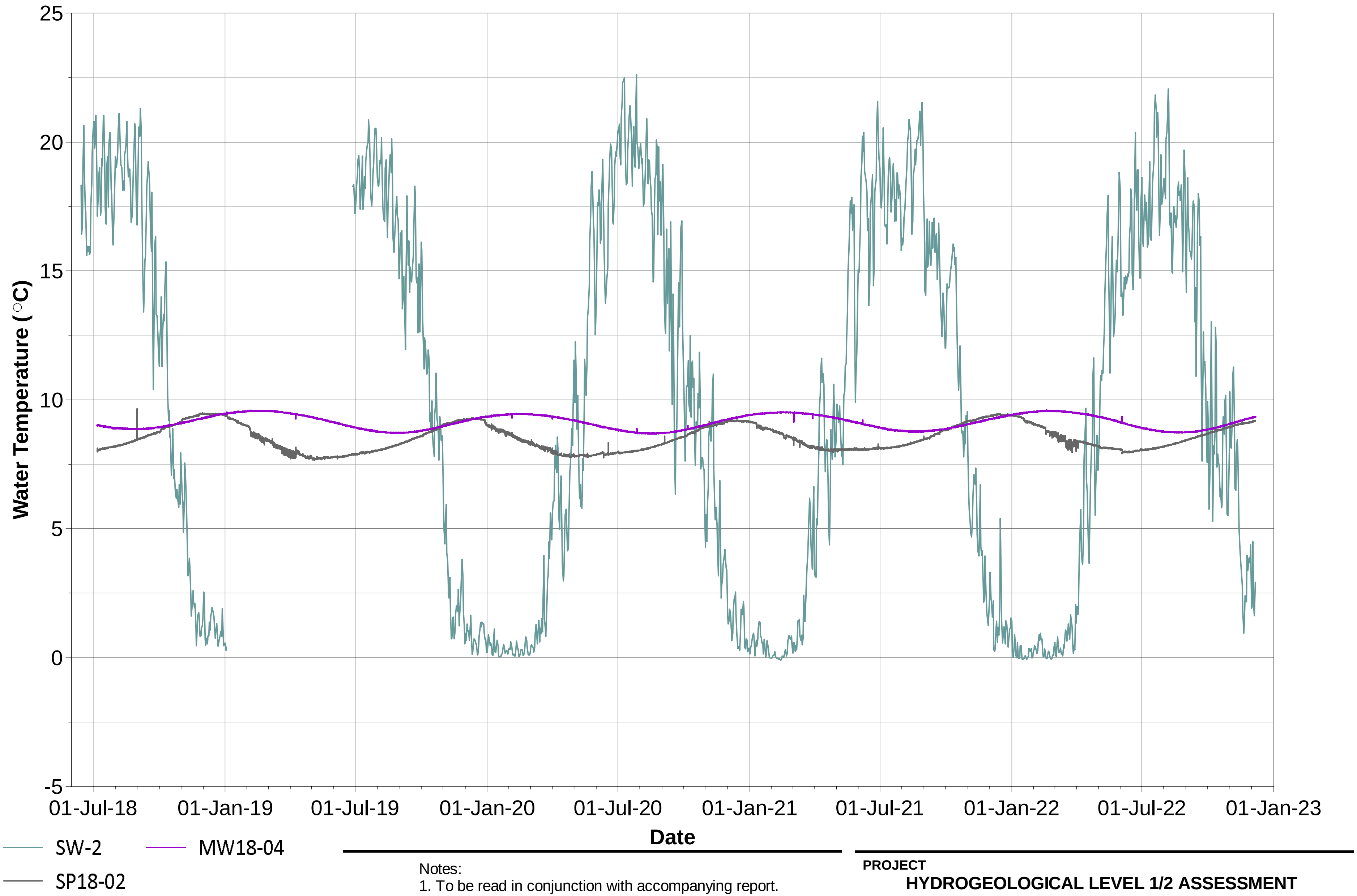
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-1 GROUNDWATER-SURFACE WATER TEMPERATURE

PROJECT NO.	**REV**	**FIGURE**
1791470		F.7.



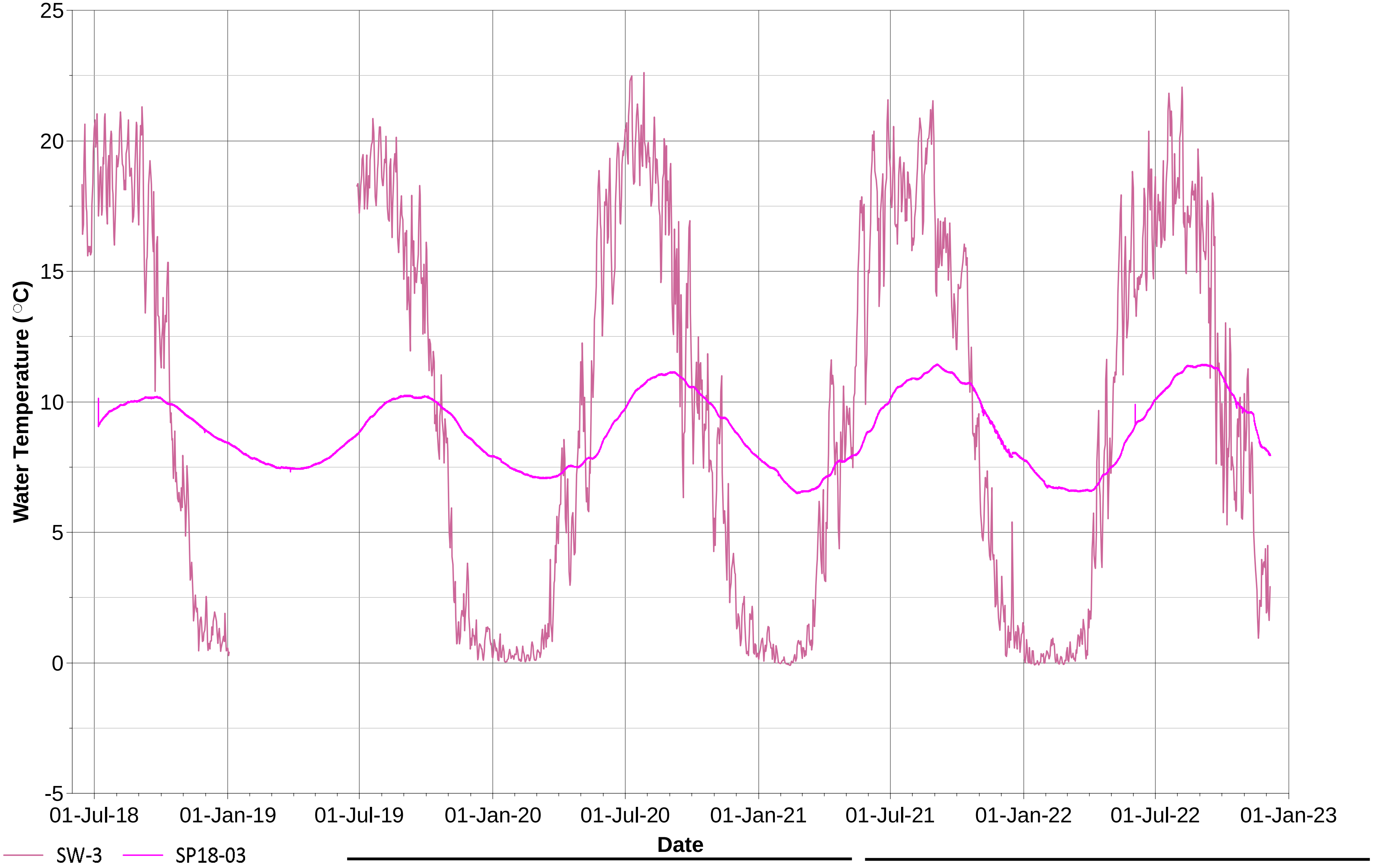
Notes:
1. To be read in conjunction with accompanying report.

DATE	2023-Jan27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
SW-2 GROUNDWATER-SURFACE WATER
ELEVATION HYDROGRAPHS

PROJECT NO.	**REV**	**FIGURE**
1791470		F.8.



Notes:
1. To be read in conjunction with accompanying report.

DATE 2023-Jan-27
DESIGN PGM
REVIEW GWS
APPROVED GWS

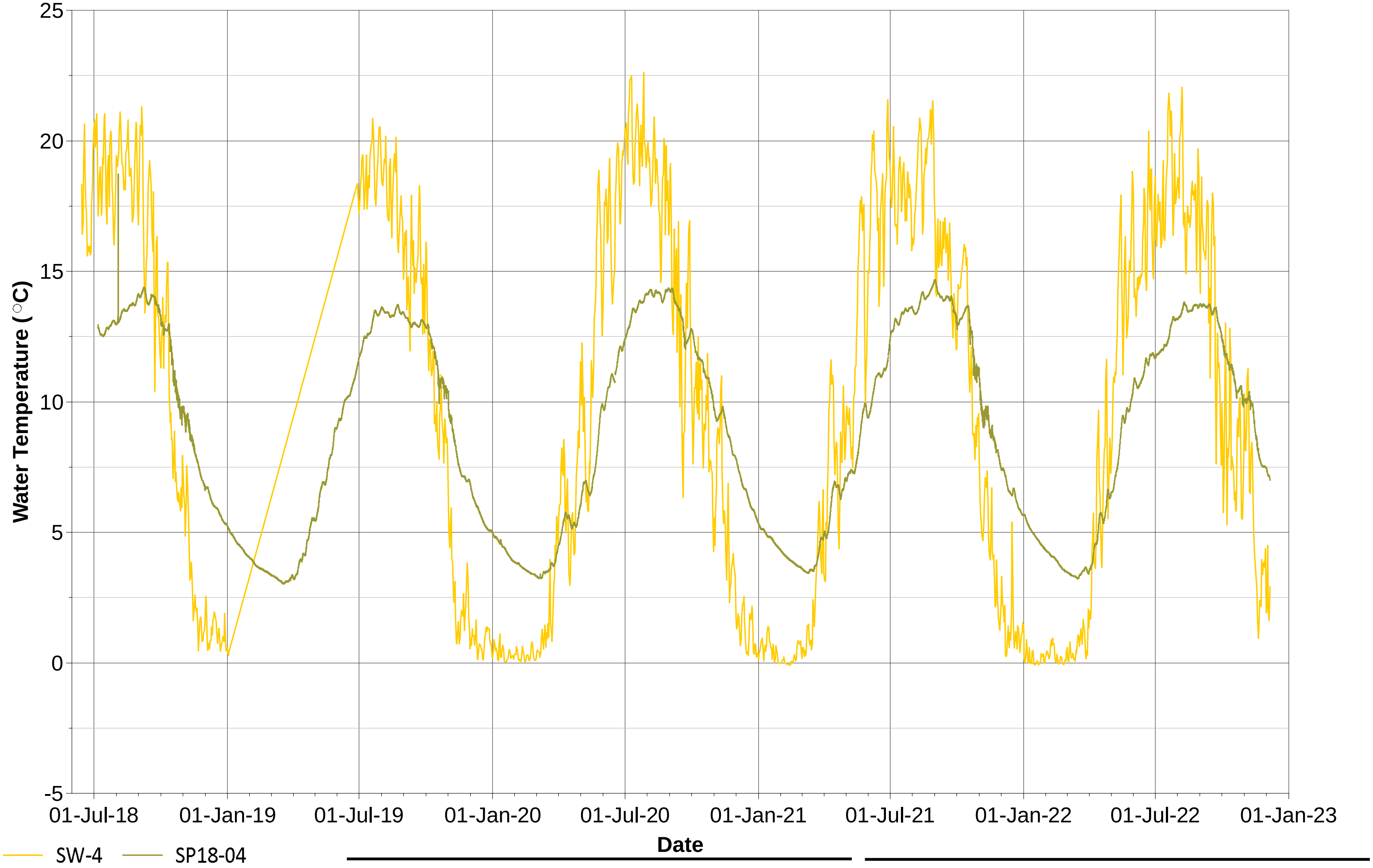
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-3 GROUNDWATER-SURFACE WATER TEMPERATURE

PROJECT NO. 1791470
REV
FIGURE F.9.



Notes:
1. To be read in conjunction with accompanying report.

wsp

DATE	2023-Jan-27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

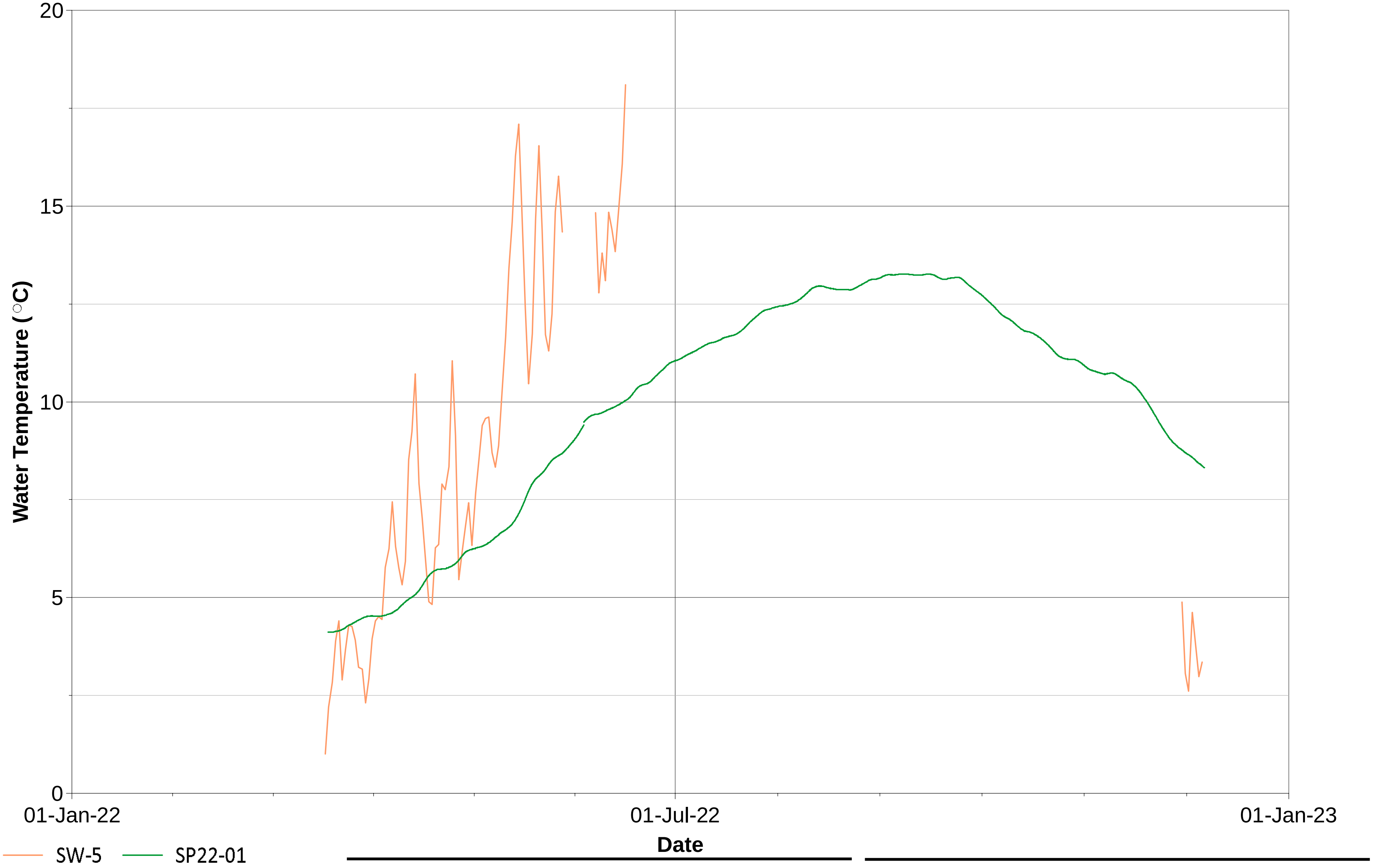
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-4 GROUNDWATER-SURFACE WATER TEMPERAURE

PROJECT NO.	**REV**	**FIGURE**
1791470		F.10.



Notes:
1. To be read in conjunction with accompanying report.
2. Surface water temperature reported as a daily average when surface water levels are greater than 3cm at the logger.

DATE	2023-Jan-27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

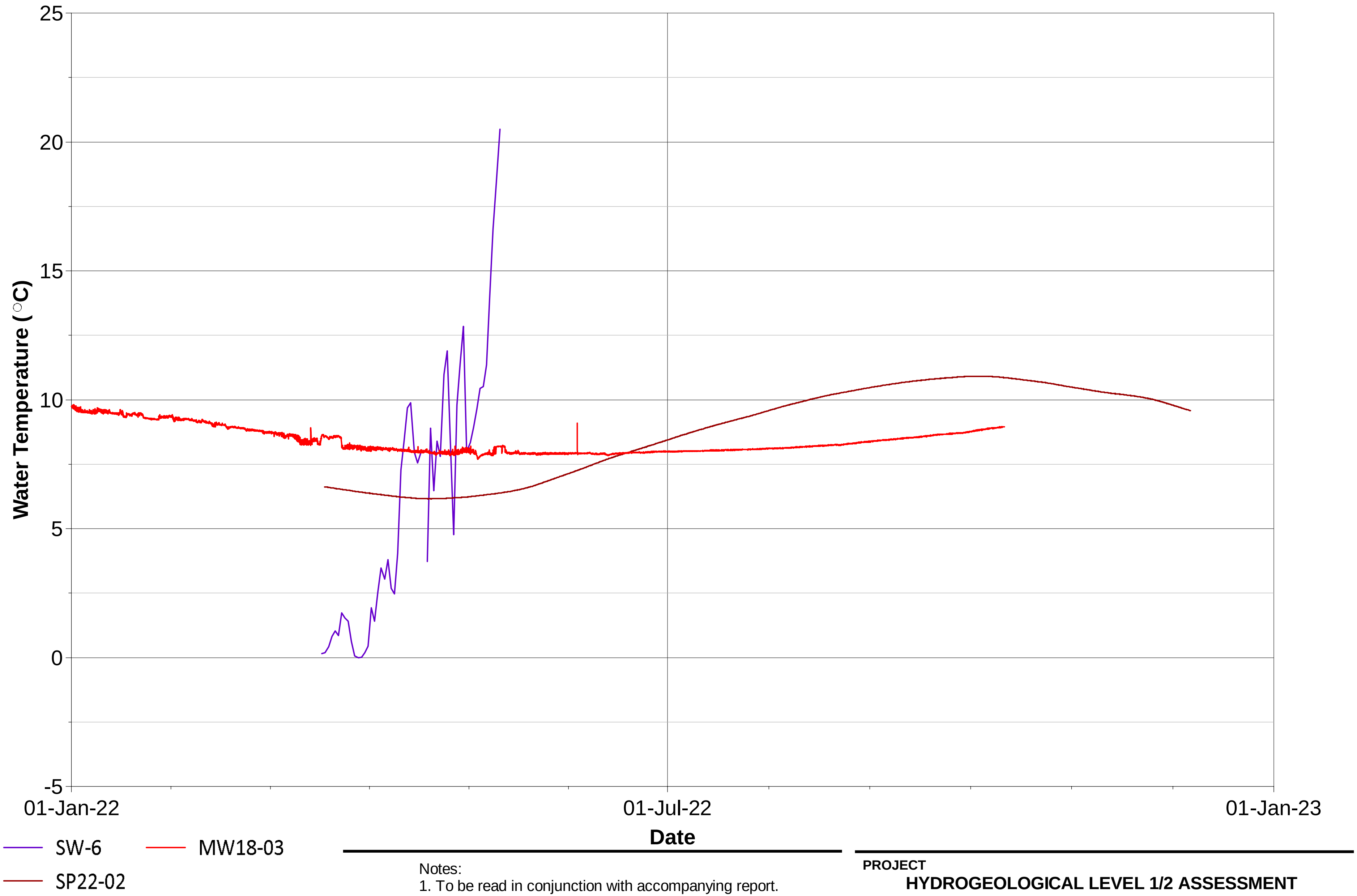
PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-5 GROUNDWATER-SURFACE WATER TEMPERAURE

PROJECT NO.	**REV**	**FIGURE**
1791470		F.11.



Notes:
1. To be read in conjunction with accompanying report.
2. Surface water temperature reported as a daily average when surface water levels are greater than 3cm at the logger.

DATE	2023-Jan-27
DESIGN	PGM
REVIEW	GWS
APPROVED	GWS

PROJECT

HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED ABERFOYLE SOUTH PIT EXPANSION
PUSLINCH, ONTARIO

TITLE

SW-6 GROUNDWATER-SURFACE WATER TEMPERAURE

PROJECT NO.	**REV**	**FIGURE**
1791470		F.12.

APPENDIX G

Groundwater Modelling

TECHNICAL MEMORANDUM

DATE February 16, 2023 **Project No.** 1791470

TO Mr. Stephen May
CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada)

CC

FROM Simon Krause / Jeff Randall / George Schneider **EMAIL simon.krause@wsp.com / jeff.randall@wsp.com / george.schneider@wsp.com**

APPENDIX G - GROUNDWATER MODELLING – ABERFOYLE SOUTH PIT EXPANSION

This memorandum presented the results of the groundwater modelling completed by Golder for CBM Aggregates (CBM) as part of the Level 1/2 Water Report for the Aberfoyle South Pit Expansion. We trust that this meets your current needs. If you require anything further, please contact the undersigned.

WSP Canada Inc.

Simon Krause
Environmental Scientist

George Schneider
Senior Geoscientist

SK/JR/GWS

https://golderassociates.sharepoint.com/sites/21291g/deliverables/hydrogeology level 1 and 2/09 final feb 2023/app g - gw_modelling/text/1791470-4000 appg gw modelling draft 14feb2023.docx

Table of Contents

TABLES

FIGURES (after text)

1.0 INTRODUCTION

As part of the Level 1/2 Water Resources assessment in support of a Below Water Licence Application at the proposed Aberfoyle South Pit Extension, a numerical groundwater modelling exercise was completed. The property is approximately 85 hectares (ha) in size and is located at 6947 Concession Road 2, in the Township of Puslinch, County of Wellington, Ontario (Figure 1).

1.1 Main Study Objectives and Project Tasks

The main objectives of numerical groundwater modelling were to assess the potential effects of the proposed below water extraction on groundwater resources, including existing water users and natural environment receptors. Of specific interest was the assessment of potential changes to baseflow and potential changes in groundwater temperature on the nearby Mill Creek and its tributaries located on and proximal to the Site.

The modelling assessment was composed of the following tasks:

- Creation of a calibrated numerical groundwater model of current conditions (Existing Conditions Scenario) to act as a baseline for comparison with predictive simulations.
- Creation of a transient operational model to simulate potential short-term changes resulting from below water table aggregate extraction, which will over time form a pit pond within the proposed licenced extraction area (Operational Scenario).
- Creation of a steady-state model to simulate long-term changes to the hydrogeologic system resulting from the ultimate rehabilitated site condition which includes a pit pond within the proposed extraction area (Final Rehabilitated Scenario).
- An assessment of potential thermal effects on groundwater was also made based on the numerical groundwater flow model and available groundwater temperature monitoring data, which evaluated potential changes to stream temperatures as a result of changes in groundwater discharging to surface water.

The groundwater model domain boundaries are presented on Figure 1. The CBM owned property limit and locations of property-specific data considered in developing the groundwater model, including test boreholes, groundwater monitoring wells, and surface water monitoring stations, are shown on Figure 2. For the purpose of this report, the following definitions are used:

Site / Licence area (Figure 2) - The land area within the property owned by CBM that is proposed for licensing under the ARA. The proposed site / licence area is approximately 44 ha in size.

Extraction Limit (Figure 2) - The extraction limit demarks the area within the Site in which aggregate extraction is proposed. The extraction limit area is approximately 27 ha in size.

2.0 PHYSICAL SETTING AND HYDROGEOLOGIC CONCEPTUALIZATION

The following provides a description of the physical setting and the hydrogeologic conceptualization incorporated into the numerical groundwater model construction.

2.1 Surface Topography and Drainage

The topography within and surrounding the model domain slopes from high ground in the north and west to the southeast. Topographic elevations within the model domain range from 359 metres above sea level (masl) in the north to 299 masl in the south (Figure 3). The licence area is located near the southern end of the model domain. The valley bottom that forms part of the eastern and southern model domain is defined by Mill Creek, the predominant surface water feature in the area. Secondary features include several tributaries of Mill Creek and widely distributed wetlands.

2.2 Geology

The geology local to the property can be broadly separated into two overburden units and underlying bedrock. The upper-most overburden unit (referred to in the Tier Three study as Overburden A (Matrix Solutions, 2017)) consists of sand and gravel deposits, organic deposits, and a silty to sandy till. It is underlain by a lower overburden unit (Overburden B) composed primarily of silty till. A weathered bedrock layer lies between the overburden and the deeper, competent sedimentary bedrock.

2.3 Groundwater Flow

The highest rates of groundwater recharge enter the shallow aquifer through the sand and gravel deposits, with reduced recharge rates to areas comprised of till and organic deposits. Groundwater flow generally follows topography from northwest to the east and south, ultimately discharging at Mill Creek.

3.0 NUMERICAL GROUNDWATER MODEL

3.1 General Flow Modelling Approach

Numerical groundwater flow modelling was completed as part of this Study to simulate Existing Conditions and to predict potential groundwater impacts during the Operations and Final Rehabilitation scenarios.

The modelling approach consists of three phases:

1) Construction of an “Existing Conditions” model based regional mapping, available regional-scale groundwater modelling (e.g., Tier 3 Assessment, Matrix Solutions (2017)), as well as property-specific geological and hydrogeologic data;
2) Calibration of the numerical model to observed groundwater levels and baseflows through refinements of the model input parameters; and
3) Adapting the Existing Conditions model to reflect the proposed Operations and Final Rehabilitation scenarios to predict potential changes to groundwater conditions resulting from the proposed below-water aggregate extraction.

To simulate potential impacts during the annual cycles of aggregate extraction and inactivity or “recovery”, the Operations scenario was run transiently to simulate the full evolution of the “pit pond” resulting from below-water aggregate extraction over time. The predictive simulation of the Final Rehabilitation scenario was run as a steady-state model to assess the long-term impacts of the final rehabilitation pond condition.

3.2 General Flow Modelling Assumptions

The following assumptions are considered as part of the modelling analyses:

- Steady-state flow models reflect average annual conditions with time-constant model parameters, boundary conditions, and model calibration targets.
- The steady-state Existing Conditions and Final Rehabilitation scenarios were simulated as variably saturated models.
- Within the transient Operational simulation, annual changes to the aquifer properties were implemented to simulate the growth of the pit pond footprint. All other boundary conditions reflect steady-state annual average values.
- The final pond configuration is assumed to extend the entire depth of the shallow sand and gravel aquifer.

3.3 Model Input Data

To inform and guide the numerical model construction and calibration, data from multiple sources were reviewed and incorporated. Sources of these data included the following:

- Ontario Ministry of Northern Development. Mines, Natural Resources and Forestry (NDMNRF) Quaternary Geology of Southern Ontario (NDMNRF, 2010).
- Ontario Ministry of Northern Development. Mines, Natural Resources and Forestry (NDMNRF) Digital Elevation Model (DEM) (NDMNRF, 2019).
- Stratigraphic information and water level data from the Ministry of Environment Conservation and Parks (MECP) Water Well Information System (WWIS) (MECP, 2019b).
- Water level and temperature data from nine wells and stream piezometers on the property.
- Baseflow estimated from measurements at four surface water stations on the property.
- Sub-catchment delineations from the Ontario Flow Assessment Tool (NDMNRF, 2017).
- Initial groundwater model parameter values from the Tier Three report (Matrix Solutions, 2017).
- Water takings from the MECP Permit to Take Water (PTTW) database (MECP, 2019a), and a report to the Township of Puslinch (CIMA Canada Inc., 2019).

3.4 Code Selection

The 3D groundwater flow model was constructed using FEFLOW (Version 7.2 Update 6, July 2020), a multi-purpose finite element groundwater flow code developed by WASY GmbH, Berlin, Germany (Diersch, 2020). FEFLOW is capable of simulating variably saturated groundwater flow in porous media under a variety of hydrogeological conditions. The Algebraic Multigrid Methods for Systems Solver (SAMG) is used to solve the groundwater flow equations. FEFLOW is recognized as an industry standard for general purpose groundwater flow modelling and has gained wide acceptance from academia, consultants, and regulatory agencies worldwide.

3.5 3D Groundwater Flow Model Construction and Calibration

This section presents the extents of the numerical groundwater flow model, the modelled discretization and characterization of the aquifer system within the model, as well as the calibration methodology and resulting calibrated model parameters.

3.5.1 Model Domain and Grid

The numerical model domain covers an area of 24.4 km^2 and is shown on Figure 1. The model is bound to the west and south by the Mill Creek watershed boundary and to the east by Mill Creek itself. The choice of Mill Creek as a boundary is supported by the findings of the Tier Three study (Matrix Solutions, 2017) that shows Mill Creek is the primary discharge feature in the area. No flow boundaries at the northern edge of the model domain run perpendicular to topographic elevation contours. The northern boundary is approximately seven kilometres from the local site footprint and has minimal to no effect on the modelling results in our area of interest.

The finite element grid varies in nodal spacing between 10 and 150 metres (m). It is refined in the area of the proposed pit and around surface water features (including streams and creeks) and coarsens towards the outer model boundary. Vertically, the model is discretized into six numerical layers (Figure 4).

3.5.2 Model Layers

The hydrogeologic units conceptualized for the numerical groundwater model are consistent with those developed in the Tier Three Study report (Matrix Solutions, 2017) and include an adjustment to one of the surficial deposits (described in greater detail below). Available surface topography LiDAR data and a review of bedrock contact elevations were used to update the model topography and bedrock surfaces, respectively. The modelled hydrostratigraphic units, from ground surface downwards, are:

- Overburden A - A shallow overburden layer containing surficial organic deposits (where they are present at surface), weathered Wentworth Till, and coarse sand and gravel deposits.
- Overburden B - Basal till layer overlying the bedrock containing Wentworth and Port Stanley tills.
- Contact Aquifer - Weathered bedrock layer.
- Competent Bedrock - Bedrock layer containing the Guelph Formation and the Reformatory Quarry Member.

The top model surface was assigned from a 0.5 m resolution LiDAR DEM (NDMNRF, 2019). The DEM was upscaled to a 10 m resolution and verified against field surveys at on-property boreholes (Figure 3).

Relative thicknesses of the two overburden layers were assigned based on the ratio of unit thicknesses applied in the Tier Three model (Matrix Solutions, 2017). Within the local property boundary, the overburden thicknesses were updated to incorporate data collected on-property. The thicknesses of the two overburden units are shown on Figure 5.

The uppermost hydrogeological layer is the shallow aquifer system composed of organic material surface deposits, coarse sand and gravel units, and the weathered Wentworth Till. This unit is subdivided into two numerical layers: A 0.5 m thick upper layer defined by topography including the surficial organic deposits (where they exist) and surface water boundary conditions. The spatial distribution of the surficial organic deposits hydrostratigraphic unit (HSU) was assigned based on Quaternary mapping (NDMNRF, 2010), confirmed against the Tier Three model (Matrix, 2017), and updated to align with on-property boreholes drilled as part of this assessment. Wetland areas are assumed to have accumulated detritus and are also designated as organic deposits. Where organic material is not present, the material properties from the underlying Overburden A layer were applied. A summary of the numerical model hydrostratigraphy is illustrated on Figures 6a and 6b.

The remainder of the Overburden A unit consists of weathered Wentworth Till and outwash sand and gravel deposits. Across the model, this layer ranges in thickness from 0.9 to ~35 m.

Underlying the Overburden A unit is the Overburden B unit; a basal till aquitard layer consisting of the Wentworth Till and Port Stanley Till HSUs. The thickness of the till unit varies between 0.3 m and ~25 m across the model.

Underlying the Overburden B unit is the bedrock unit (Figure 7). The bedrock surface was estimated based on provincial MECP Water Well Information System data in addition to borehole data from on-property drilling. The MECP dataset was reviewed, and data points with poor location accuracy and/or suspect contact elevations were removed. The uppermost bedrock layer represents the weathered bedrock “Contact Aquifer”, modelled as a 4 m thick layer overlying the competent bedrock unit below. The contact aquifer (and underlying competent bedrock) concepts are sourced directly from the Tier Three study (Matrix Solutions, 2017).

The competent bedrock unit is composed of the Guelph Formation to the west and north and the Reformatory Quarry to the east (Figure 6b). This unit is divided into two numeric model layers totalling a thickness of 35 m. The bottom of this layer (base of the model) was assigned a no-flow boundary to reflect the material properties of the deeper bedrock units.

3.5.3 Boundary Conditions

The perimeter of the model domain was assigned as a no-flow boundary condition, except where surface water features are present. Within the surface layer, tributaries, ditches, and wetlands are set as type 1 (Dirichlet) constrained flow boundary conditions (Figure 8).

Two variations of Mill Creek boundary conditions have been implemented for the predictive analyses. These variations consider the following:

- a case where Mill Creek boundary conditions can accept discharge from the groundwater system. This configuration results in a conservative estimate of drawdown, as water from Mill Creek is not able to infiltrate and offset reductions in groundwater elevations. The modelled groundwater drawdown results are taken from this model variation.
- a second case where Mill Creek boundary conditions local to the site can both accept discharge from and supply water to the groundwater system. This configuration is conservative with respect to baseflow in Mill Creek. The modelled baseflow results are taken from this model variation.

Model recharge is assigned based on the overburden material in model layer 1. Regions underlain by sand and gravel are expected to experience higher rates of recharge than those underlain by till and organic deposits. Where wetlands fall within the Quaternary Sand and Gravel zones, the Organic Deposit recharge rates are applied (Figure 9). Recharge is applied as a type 2 (specified flux) flow boundary condition with rates adjusted through the calibration process. Table 1 presents the calibrated recharge rates and, for comparison, the ranges in applied recharge from the Tier Three report.

Table 1: Modelled Recharge Rates

Unit	Tier Three Report (mm/a)[1]	Calibrated Recharge (mm/a)
Organic Deposits	<5 to 100	100
Weathered Wentworth Till	200-300	200
Sand and Gravel	300-400	350

[1] Matrix Solutions (2017).

The model domain includes three extraction wells (belonging to Capital Paving Inc.) extracting a total of 281 m^3/d from the Overburden A unit (model layers 1 and 2) and the bedrock units (model layers 4, 5, and 6) (CIMA Canada Inc., 2019, MECP, 2019a). No additional extraction wells were found in the Permit To Take Water database and individual residential groundwater extractions were not explicitly included in the model.

The predictive models simulate the pit pond and other flooded pits as areas of increased hydraulic conductivity (1 m/s) and high unsaturated flow porosity (0.99) to approximate the removal/absence of solids from these pits. The pits extend to the bottom of the Overburden A unit (i.e., this assumes that extraction is to the bottom of the sand and gravel layer). This approach allows the model to determine the ultimate pit pond elevation as part of the simulations, rather than prescribing them in the model.

3.5.4 Model Parameters

Initial estimates and ranges of hydraulic conductivity are presented in Table 2. Single well response tests performed on the property provide additional property-specific information of the horizontal hydraulic conductivity in the sand and gravel unit. As noted in Section 5.4, Table 5 of the main report, the conductivities calculated (using the Bouwer-Rice and Spring-Gelhar methods) ranged from 1x10^{-6} m/s to 8x10^{-4} m/s with a geometric mean of 7.8x10^{-5} m/s. During calibration, the initial estimates and anisotropy were adjusted to best fit observed groundwater elevations and measured baseflow. Anisotropy in the overburden units is supported by the presence of thin interbedded silt and clay, particularly within the sand and gravel units.

Table 2: Modelled Hydraulic Conductivities

Unit	Tier Three Report [1]		Calibrated Conductivity	
Hydrostratigraphic Unit	**K$_{XY}$ (m/s)**	**K$_{Z}$ (m/s)**	**K$_{XY}$ (m/s)**	**K$_{Z}$ (m/s)**
Organic Deposits	5.0x10^{-4}	5.0x10^{-4}	1.0x10^{-6}	5.0x10^{-7}
Weathered Wentworth Till	1.0x10^{-5} to 1.0x10^{-4}	5.0x10^{-5} to 5.0x10^{-6}	5.0x10^{-5}	1.0x10^{-5}
Sand and Gravel	2.5x10^{-4} to 2.5x10^{-3}	1.3x10^{-5} to 5.0x10^{-4}	2.0x10^{-4}	1.0x10^{-4}
Local Sand and Gravel	2.5x10^{-4} to 2.5x10^{-3}	1.3x10^{-5} to 5.0x10^{-4}	1.0x10^{-4}	5.0x10^{-5}
Wentworth Till	5.0x10^{-5}	2.5x10^{-5}	5.0x10^{-6}	2.5x10^{-6}
Port Stanley Till	1.0x10^{-8} to 1.0x10^{-6}	1.0x10^{-8} to 5.0x10^{-7}	1.0x10^{-6}	5.0x10^{-7}
Contact Aquifer	5.0x10^{-7} to 2.1x10^{-3}	1.0x10^{-8} to 2.5x10^{-4}	1.0x10^{-5}	1.0x10^{-5}
Guelph Formation [2]	4.0x10^{-7} to 6.0x10^{-4}	-	7.0x10^{-7}	7.0x10^{-8}
Reformatory Quarry Member [2]	2.0x10^{-7} to 2.0x10^{-4}	-	6.0x10^{-7}	1.2x10^{-8}

[1] Matrix Solutions (2017).

[2] Horizontal hydraulic conductivity ranges from reported "High Quality Bedrock Borehole Test Results".

3.5.5 Model Calibration

Numerical model calibration involves the systematic adjustment of material properties and/or boundary conditions to produce an acceptable match to observed groundwater conditions. The hydraulic conductivities and recharge rates were adjusted during calibration to match observed groundwater conditions across the regional model. The calibration dataset consists of 51 groundwater targets (Table 3 and Figure 10), including on-property overburden monitoring wells and stream piezometers (Figure 2), as well as data from wells in the WWIS database (MECP, 2019b). Groundwater elevation and baseflow data collected on-property reflects an annual average calculated over a period from the summer of 2018 to the summer of 2019.

Table 3: Groundwater Elevation Calibration Targets

Well ID	Observed (masl)	Simulated (masl)	Well ID	Observed (masl)	Simulated (masl)
6711403	305.63	306.55	6707984	329.35	329.31
6702645	317.41	315.65	6715549	329.49	327.94
7040680	302.43	303.09	6715494	312.37	317.14
6708736	303.43	302.33	6702641	326.86	333.60
6711420	306.29	306.72	6702353	313.82	317.14
6704673	313.92	313.26	6703856	311.95	316.77
6711419	307.32	307.19	6710657	319.26	318.66
6708127	309.54	310.27	6712248	320.35	318.59
6713645	318.43	318.84	6709388	311.02	311.48
6703852	308.06	307.23	6703848	327.97	327.97
6702511	317.50	315.33	6708331	313.14	314.56
6705851	303.05	301.73	6705870	307.42	309.36
6708455	302.73	303.27	6703783	329.41	333.23
6704041	306.54	307.21	6707995	330.29	326.51
6704295	322.25	320.48	6705005	328.50	327.97
6715099	323.99	323.04	6708738	324.00	326.18
6702512	311.55	314.76	SP18-04	301.43	301.26
6714930	325.52	323.41	SP18-03	302.03	301.57
6709237	301.43	304.11	SP18-01	302.61	302.60
6714931	326.03	323.91	SP18-02	303.03	302.85
6702505	331.29	326.66	MW18-02	302.63	301.96
6703150	329.25	327.94	MW18-06	302.92	302.42
6704098	312.99	314.35	MW18-03	303.18	302.56
6702351	313.18	316.53	MW18-04	303.53	302.85
6703315	313.34	315.87	MW18-05	303.69	302.53
6713646	308.19	314.37			

The final calibration statistics and a comparison of simulated vs observed groundwater elevations (i.e., 45-degree plot) are shown on Figure 10. The calibration error is generally distributed both above and below the 45-degree line with no strong bias towards over- or under-estimation of water levels. A mean residual error of -0.38 m and a normalized root mean square error of 7.8% suggest that the model is able to simulate the observed conditions within a reasonable margin of error.

Across the property, simulated groundwater elevations are generally lower than observed while baseflow shows a reasonable agreement with observed target values. Table 4 presents the calibrated baseflows against annual averages of observed baseflows at the four surface water stations SW-1 to SW-4. Simulated rates are reasonably close to those observed on the property. The baseflow at Tributary 3 is under-simulated by roughly 25%, with simulated rates at SW1 207 m^3/d lower than observed and SW4 305 m^3/d lower than observed. Baseflow at Mill Creek over-simulates by roughly 20%. At SW2 and SW3, respectively, the modeled rates are 1,543 m3/d and 1,386 m^3/d higher than observed. The observed baseflows at Mill Creek have been scaled to consider the baseflow contributions from the Mill Creek catchment that is included in the regional model footprint. The simulated rates at the lower end of the creek/tributary are in closer agreement than those higher up the reach. The observed changes in baseflow to Mill Creek and Tributary 3 within the property boundary suggest baseflow increases of 286 m^3/day and 559 m^3/day, respectively. Simulated baseflow contributions from the property to Mill Creek are 129 m^3/day and to Tributary 3 are 461 m^3/day. The simulated baseflow at each of the stations and the simulated gains along the on-property reaches of Tributary 3 and Mill Creek are all within an order-of-magnitude of the observed rates and provide a reasonable representation of flows to and from these surface water features.

Table 4: Calibration to Baseflow

Surface Water Station	Observed (m^3/d) [1]	Simulated (m^3/d)	% Difference
SW1 (Upper Tributary)	818	611	-25%
SW4 (Lower Tributary)	1,377	1,072	-22%
SW2 (Upper Mill Creek)	8,198	9,741	+19%
SW3 (Lower Mill Creek)	8,484	9,870	+16%
Tributary 3 Gains	559	461	-18%
Mill Creek Gains	286	129	-55%

[1] Observed baseflow represents contributions from the catchment area that is included in the regional model footprint.

The simulated hydraulic heads presented on Figure 10 illustrate a general flow direction from northwest to southeast, with groundwater near the property flowing from the north to the southwest. The simulated groundwater head directions are consistent with observed groundwater elevations on the property, the Site geology and hydrostratigraphy, and the results of the Tier Three study.

The overall model calibration results suggest that the model parameterization is reasonable and can be used as a predictive modelling tool. The numerical models that simulate the operational and final rehabilitation phases of the proposed aggregate operation are discussed in Section 4 (Groundwater Flow and Heat Transport Scenarios).

4.0 GROUNDWATER FLOW AND HEAT TRANSPORT SCENARIOS

The calibrated numerical model described in Section 3.5 was used as the starting model to construct the predictive scenario models. These models were simulated to better understand potential changes to the local aquifer system and nearby groundwater receptors. The operational phase model examines the short-term effects resulting from below-water extraction over the operational life of the pit (Section 4.1) and the final rehabilitation model examines the potential long-term changes to the groundwater system following operational activities and property rehabilitation (Section 4.2).

4.1 Simulated Potential Effects During Operations

The below-water aggregate extraction during the operation of the pit will induce a short-term and localized drawdown in the water table. This occurs as groundwater within the aquifer moves from storage within the sand and gravel deposits to fill the pit pond. Conversely, as the pit pond increases in size, it becomes a source of water to buffer the change in groundwater elevations resulting from future aggregate removal and helps to mitigate the extent of groundwater drawdown in the surrounding aquifer.

The transient operational model was constructed to simulate the drawdown resulting from the creation of the pit pond and to understand potential effects the below-water extraction may have on Mill Creek and nearby surface water and groundwater receptors. This model will also inform how groundwater elevations will be affected during periods of active extraction and when extraction operations are paused over the winter months.

4.1.1 Transient Modelling Approach

The calibrated steady-state “Pre-Pit” model was used as the starting point of the Operations model. Initial operational model groundwater elevations reflect those from the Pre-Pit model.

As noted in Section 3.5.3, the pit pond was simulated as a zone of increased hydraulic conductivity and high unsaturated flow porosity, allowing the model to simulate the pond as an open body of water. Adaptive time-stepping was used, with an initial time step of 1E-3 days, up to a maximum of 30 days. Applied recharge remains at the calibrated annual average used in the Pre-Pit model. The following assumptions were considered in simulating the pond development:

- The rate of aggregate extraction was set to 1,000,000 tons per year.
- Extraction occurs from April 15 to December 15 and is paused between December 16 and April 14.

The transient model increases the volume of the pond annually by a total of ~560,000 m^3 for six consecutive years (based on a total estimated extraction of ~3.3 million m^3). Within each new stage of annual pond development, the material properties (hydraulic conductivity and unsaturated flow porosity) of the converted pond volume were transitioned from those representing sand and gravel to those representing the pit pond. This transition occurs over the eight-month extraction period. At the end of the eight-month operational phase, a four-month inactive (or “rest”) period is simulated before extraction resumes. This annual cycle is repeated until the final pond footprint is reached in simulation year 6 (Figure 11). The model is run for a further ten years to allow for the equilibration of any transient processes in the final pond configuration.

4.1.2 Potential Groundwater Level Changes

Figure 12a presents the simulated water table at various stages of pond development (Pre-pit, End of Years 2, 4, and 6). The initial pre-pit condition shows a general flow pattern of groundwater moving from the northwest towards Tributary 3, and groundwater from the northeast entering the site and flowing west towards the lower reaches of Tributary 3 and Mill Creek.

At the end of operations year two, the nascent pond has established a water table at approximately 299.5 masl, steepening the groundwater gradients on-site. The general flow direction of groundwater through the site is now towards the pond.

At the end of operations year four, the gradient on-site remains similar to that at the end of year two, but the steeper groundwater gradients extend north of the site. Groundwater flow upstream of the pond continues towards the pond and groundwater gradients on-site have flattened.

The end of operations year 6, groundwater heads show horizontal gradients north of the pit pond steeper than baseline pre-pit conditions while the pit pond has reached an elevation of approximately 300.5 masl, with flatter groundwater gradients generally between the pit pond and Mill Creek.

Figure 12b presents the simulated drawdown relative to the pre-pit condition. At the end of operations in year two, groundwater drawdown around the pond is simulated to be approximately 2 m at Tributary 3. The maximum drawdown simulated within the pond is approximately 2.9 m.

By the end of operations year four, the area of extraction has migrated to the center of the property. The maximum drawdown is less than in the early stages of the operations, reaching a maximum of 2.8 m in the pit pond while the 0.1 m drawdown now extends further from the pit pond, extending roughly 690 m north of the property.

At the end of operations (year 6), the active extraction area has reached the northern edge of the property and the pond has achieved its final footprint. The drawdown at the northern edge of the pond is ~2.7 m, with the 0.5 and 0.1 m drawdown contours approximately 420 m and 720 m north of the pond.

4.1.3 Potential Baseflow Changes

The cyclical nature of below-water extraction and recovery are noted in the transient changes to baseflow at two on-property surface water stations, SW3 along Mill Creek, and SW4 along Tributary 3 (Figure 13). The presented rates represent a net flow balance, accounting for gains and losses to surface water features within the catchment area. The pre-pit condition represents baseflow simulated in the calibrated pre-pit model.

At Tributary 3, the early stages of the below-water extraction influence groundwater elevations near the Tributary, resulting in simulated baseflow reduction of 400 m^3/d at surface water station SW4 (Table 5). This represents a baseflow decrease of 29% relative to observed pre-pit baseflow rates. As aggregate extraction progresses east, the successive periods of drawdown are somewhat mitigated by the reservoir of water held in the growing pond with a simulated reduction in baseflow of 359 m^3/d at the end of extraction in year six (a 26% reduction relative to observed pre-pit conditions).

Table 5: Changes to Baseflow During Operations

Surface Water Station	Observed (m^3/d) [1]	End of Year 2		End of Year 4		End of Year 6	
		Reduction [2] (m^3/d)	%	Reduction (m^3/d)	%	Reduction (m^3/d)	%
SW4 (Lower Tributary)	1,377	400	29%	397	29%	359	26%
SW3 (Lower Mill Creek)	34,768	275	0.8%	454	1.3%	582	1.7%

[1] Observed baseflow represents contributions from the entire catchment area up-stream of the station.

[2] Reduction is relative to Pre-Pit baseline.

At Mill Creek station SW3, the simulated reductions in baseflow at early times are smaller than at the end of the extraction period, as the pond growth and groundwater drawdown approach Mill Creek at the northeast corner of the property. At the end of extraction in year two, simulated baseflow is reduced by 275 m^3/d, a reduction of 0.8% relative to the observed baseflow at station SW3. By the end of extraction in year six, the maximum simulated baseflow loss becomes 582 m^3/d, or a 1.7% reduction in total baseflow.

4.1.4 Summary

The transient groundwater flow model predicts that during active operation there will be a change in local groundwater elevations up to a maximum of ~4 m on-Site. Drawdown of 0.1 m may temporarily extend off the property up to a distance of roughly 720 m north of the pit pond during operations. The modelling suggests that during periods of active extraction, reductions in simulated baseflow rates at Tributary 3 could approach 30% with Mill Creek baseflow reductions approaching 1.7% at SW3.

4.2 Simulated Potential Effects of the Proposed Final Rehabilitation Pond Condition

The rehabilitation model was constructed to estimate the potential effects of the final rehabilitated condition on local groundwater levels and groundwater baseflow to nearby water bodies. The long-term changes are simulated with a steady-state model evaluating the final pond configuration in an equilibrated hydrogeological system.

4.2.1 Modelling Approach

The pre-pit baseline condition for this scenario is the final calibrated model, which includes the current steady-state groundwater levels and flows. The final pond was added to the model as a zone of high hydraulic conductivity and high unsaturated flow porosity (see additional discussion in Section 3.5.3) and comparisons of the water levels and flow output between the two models allows for the evaluation of potential changes resulting from the final rehabilitated condition.

4.2.2 Potential Groundwater Level Changes

The simulated heads from the rehabilitated condition are presented on Figure 14a. When compared to the pre-pond condition (Figure 10), the final pond configuration flattens the water table over the majority of the property with a pond elevation of approximately 302 masl. Groundwater gradients towards and downstream of the pit pond are steeper than those simulated for Pre-pit conditions and inferred directions of groundwater flow under rehabilitated conditions are consistent with those without the pit pond. Groundwater flows from the northwest towards Tributary 3, from the north onto the Site, and from the Site to the southwest towards Tributary 3 and Mill Creek, while small changes in groundwater flow direction can be seen downstream of the pond with groundwater flow deflecting south and southwest towards Mill Creek and west towards Tributary 3.

The groundwater drawdown for the rehabilitated condition (relative to the calibrated current condition) is shown on Figure 14b. The presence of the pit pond creates an area of drawdown to the north and an area of draw up (an increase in groundwater elevation) to the south. A maximum drawdown of approximately 1 m is located near the northeastern edge of the pond, with 0.5 m drawdown extending approximately 150 m off-property. A maximum draw up of approximately 1 m occurs at the southwestern edge of the pond, with a draw up of 0.5 m extending roughly 40 m off-property.

The resulting change in groundwater flow patterns is illustrated with particle pathlines on Figure 15. Under pre-pit (current) conditions, groundwater flows from the northern boundary of the Site towards the south and west. Under rehabilitated conditions, groundwater flow moves through the northern half of the pond, ultimately flowing through the southwestern half of the pond to the south (to Mill Creek) and the west (to Tributary 3).

4.2.3 Potential Baseflow Changes

The changes in baseflow due to the rehabilitated pond are shown in Table 6. Along Tributary 3, baseflow is reduced; at monitoring station SW1, the final pond configuration results in a baseflow reduction of 8.1% while at station SW4, the baseflow has decreased by 3.6% relative to Pre-pit conditions. At Mill Creek, simulated baseflow reductions of 0.6% and 1.5% were calculated at gauging stations SW2 and SW3, respectively.

Table 6: Baseflow Changes Under Rehabilitated Conditions

Surface Water Station	Simulated Pre-Pit Baseflow (m^3/d)	Simulated Rehabilitated Baseflow (m^3/d)	Change in Baseflow (m^3/d)	Percent Change from Pre-Pit Condition
SW1 (Upper Tributary)	611	561	-50	-8.1%
SW4 (Lower Tributary)	1,072	1,033	-39	-3.6%
SW2 (Upper Mill Creek)	9,741	9,686	-55	-0.6%
SW3 (Lower Mill Creek)	9,870	9,725	-145	-1.5%

Simulated discharge to local wetlands in the pre-pit and rehabilitated scenarios are shown in Table 7. The discharge represents groundwater reporting to the area identified as a PSW (PSW zones shown on Figure 16). Reductions in discharge are simulated in zones 1, 2, and 5. These are areas where groundwater drawdown has been simulated as a result of the formation of the rehabilitated pond (Figure 14b). Zone 5 is located north of and immediately upgradient of the pond and sees the largest reduction in the rate of wetland discharge (-174 mm/yr). Zones 3, 4, 6 and 7 are within areas of increased groundwater elevation (i.e., draw up) and show increased rates of discharge in the rehabilitation scenario, up to an increase of +511 mm/yr in zone 7.

Table 7: Local Discharge to Wetlands

Zone	Local Wetland Discharge (mm/yr)			Area (hectares)
	Pre-Pit	Rehabilitated	Difference	
Zone 1	164	65	-99	11.2
Zone 2	266	155	-111	14.1
Zone 3	142	311	168	16.2
Zone 4	413	671	258	6.7
Zone 5	174	0	-174	23.3
Zone 6	768	885	1116	6.1
Zone 7	816	1,326	511	4.8

Table 8 presents the simulated discharge to creeks as a rate of groundwater inflow per unit length of creek. Zones 1, 2, and 5 show reductions in creek discharge, with zone 1 showing the largest difference (117 L/d/m). Increases in creek discharge are simulated along the creeks in zones 3, 4, 6, and 7 with a maximum increase of 156 L/d/m in zone 6. Across the property, Mill Creek simulates a reduction in creek discharge of 144 L/d/m, while Tributary 3 simulates an increase in creek discharge of 149 L/d/m.

Table 8: Local Discharge to Creeks

Zone	Local Creek Discharge (L/d/m)			Creek Length (m)
	Pre-Pit	Rehabilitated	Difference	
Zone 1	22	-94	-117	515
Zone 2	81	6	-75	1,082
Zone 3	121	152	31	714
Zone 4	79	96	17	793
Zone 5	36	17	-19	754
Zone 6	53	209	156	729
Zone 7	47	58	11	871

4.2.4 Potential Groundwater Temperature Changes

Surface water temperatures generally vary more throughout the year than groundwater temperatures in shallow aquifers. The potential influence on groundwater discharging to surface water receptors from the development of a pit pond were evaluated as outlined below.

A conservative approach was taken to quantify potential thermal impacts on groundwater for the rehabilitated pit pond scenario. Prior studies in Ontario have indicated that the thermal influence from below-water pits typically do not migrate further than 120 to 250 m downstream of the pit pond before their effect becomes negligible (Yang 1995, and Markle and Schincariol 2007). For all surface water receptors within 250 m of the pit pond, the following evaluation was completed:

- Baseflow contributions from the pit pond to Mill Creek and Tributary 3 (within 250 m of the pit pond) were estimated for pre-pit and rehabilitated conditions using particle tracking and simulated water balance data.
- The baseflow contributions from the pit pond to the surface water receptors were expressed as a percentage of the total simulated baseflow reporting to Mill Creek and Tributary 3 upstream of and including the property (at gauging stations SW3 and SW4, respectively).
- Maximum observed groundwater temperatures during the summer months were estimated at a depth of approximately 5 m for monitoring wells across the property. This depth approximates the mid-point of the proposed pit extraction and results in an average maximum groundwater temperature of 11 °C.
- The following conservative pit pond temperature assumptions were applied for this evaluation:
  - The pit pond is completely mixed (i.e., no thermal stratification is considered)
  - The maximum (summer) pit pond temperature was set equal to the maximum mean daily air temperature. For this assessment, 25 °C was selected.
- No thermal attenuation was considered for pit pond-affected groundwater flowing downstream (i.e., pit pond temperatures were taken to arrive at their ultimate discharge location at the maximum mean daily air temperature).

This approach considers the percentage of total baseflow originating from the rehabilitated pit pond that reports to SW3 and SW4 and applies an increase in temperature from existing groundwater (11 °C) to pit pond (25 °C) to that percentage of total baseflow. The potential changes to the temperature of groundwater discharging to surface water features are summarized in Table 9.

Table 9: Groundwater Temperature Changes under Rehabilitated Conditions

Surface Water Station	Baseflow from Rehabilitated Pond Upstream of SW Station (m^3/day)	Percentage of Total Baseflow Originating From Rehabilitated Pond	Temperature Difference between Groundwater and Pit Pond (°C)	Potential Change in Baseflow Temperature[1] (°C)
SW3 (Lower Mill Creek)	110	0.3% [2]	14	0.04
SW4 (Lower Tributary)	67	6.4%	14	0.9

[1] Temperature change reported for SW3/SW4 includes baseflow downstream of SW3/SW4 reporting within 250 m from the rehabilitated pond.
[2] Simulated Baseflow value at SW3 was scaled to reflect the total catchment area upstream of SW3.

All baseflow originating from the Pit Pond and reporting to Mill Creek does so downstream of surface water monitoring station SW3, ~60% of which travels less than 250 m before discharging to surface water. The assessment suggests the potential change in baseflow temperature along this reach of Mill Creek from the presence of the final rehabilitated pond is expected to be < 0.1 °C.

Baseflow reporting from the pit pond to Tributary 3 approaches 7% of the total baseflow arriving upstream of surface water station SW4. Included in this baseflow estimate are flows from the pit pond discharging downstream of SW4 but within 250 m of the pit pond. The potential change in baseflow temperature reporting to Tributary 3 was estimated at < 1 °C.

The estimates of potential thermal influence on groundwater from the pit ponds were completed in a conservative manner. In practice, pit pond temperatures are not expected to reach the maximum mean daily air temperatures, pit ponds are not completely mixed and are expected to stratify, and studies have shown that thermal attenuation occurs as groundwater flows from a pit pond towards its ultimate discharge location. The conservative approach considered for this assessment results in increases to baseflow temperatures for both Mill Creek and Tributary 3 that are expected to be < 1 °C .

5.0 SUMMARY

A three-dimensional numerical groundwater flow model was constructed in FEFLOW. Once the model was calibrated to current conditions using Site and regional hydrogeologic data, the model was used to simulate the transient effects of aggregate extraction and the long-term changes to the groundwater flow system from the rehabilitated pit pond. These groundwater modelling results are summarized below.

- During site operations, aggregate extraction will result in the gradual formation of a pit pond, which is predicted cause a temporary localized reduction in the groundwater table elevation due to the removal of aggregate material, the volume of which will be replaced by groundwater seeping into the pond. The effects on groundwater will be largely confined to the licence area (Site) and surrounding CBM owned property.

- There will be a small area immediately northeast of the proposed licence area (see Figure 12b) west of Mill Creek, where the temporary groundwater table reduction is predicted to be up to approximately 2.5 m (see Figure 12b - Year 6 of extraction operations).
- Temporary reductions to baseflow contributions in the area immediately surrounding the pit pond during operations are predicted to reach a maximum of 29% at SW4 (Tributary 3) and 1.7% at SW3 (Mill Creek).
- Upon rehabilitation, creation of a permanent pond will result in localized water table “flattening”, which is predicted to decrease the local groundwater elevation approximately 1.0 m at the northern end of the pond and increase the local groundwater elevation approximately 0.9 m at the southern end of the pond.
- Post rehabilitation, the maximum groundwater table reduction immediately adjacent to the proposed licence area northeast of the property is predicted to be approximately 0.9 m (see Figure 14b).
- Post-rehabilitation, baseflow contributions along Tributary #3 are expected to change by -7.5% at SW1 and +0.8% at SW4, while Mill Creek is expected to experience a baseflow reduction of roughly 2% along this reach, as a result of the long-term changes in the water table around the final pit pond.
- The PSW areas located upgradient of the rehabilitated pond (Areas 1, 5 and 6 – Figure 16) may show decreases in groundwater discharge of up to 173 mm/yr, while PSWs downgradient of the pond (Areas 2, 3, 4 and 7 – Figure 16) may show gains in groundwater discharge of up to 489 mm/yr, mainly as a result of localized water table flattening.

Additionally, a groundwater temperature mixing-model employed to assess potential changes to temperature at nearby receptors using very conservative (worst case) assumptions. The temperature modelling exercise suggests that the thermal influence of the rehabilitated pond on nearby surface water features is expected to be very slight, with a predicted temperature increase of <1°C at both Mill Creek and Tributary 3.

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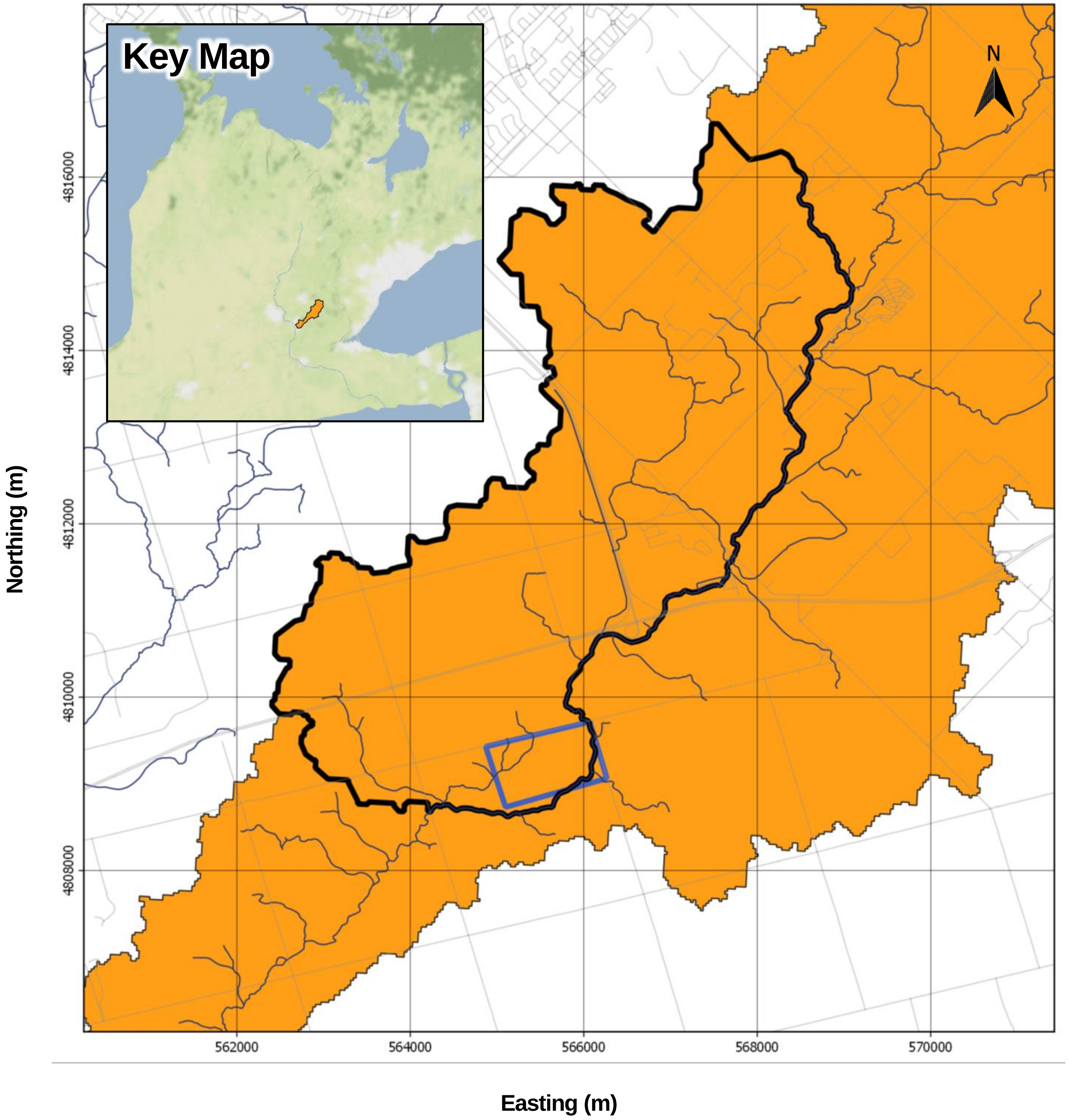
Figures



LEGEND

—	Rivers / Streams	▭	Property Boundary
—	Roads	🟧	Mill Creek Catchment
▭	Model Boundary		

NOTE

1. Key map inset taken from QGIS 3.10.

CLIENT
CBM Aggregates, a division of St. Marys Cement Inc. (Canada)

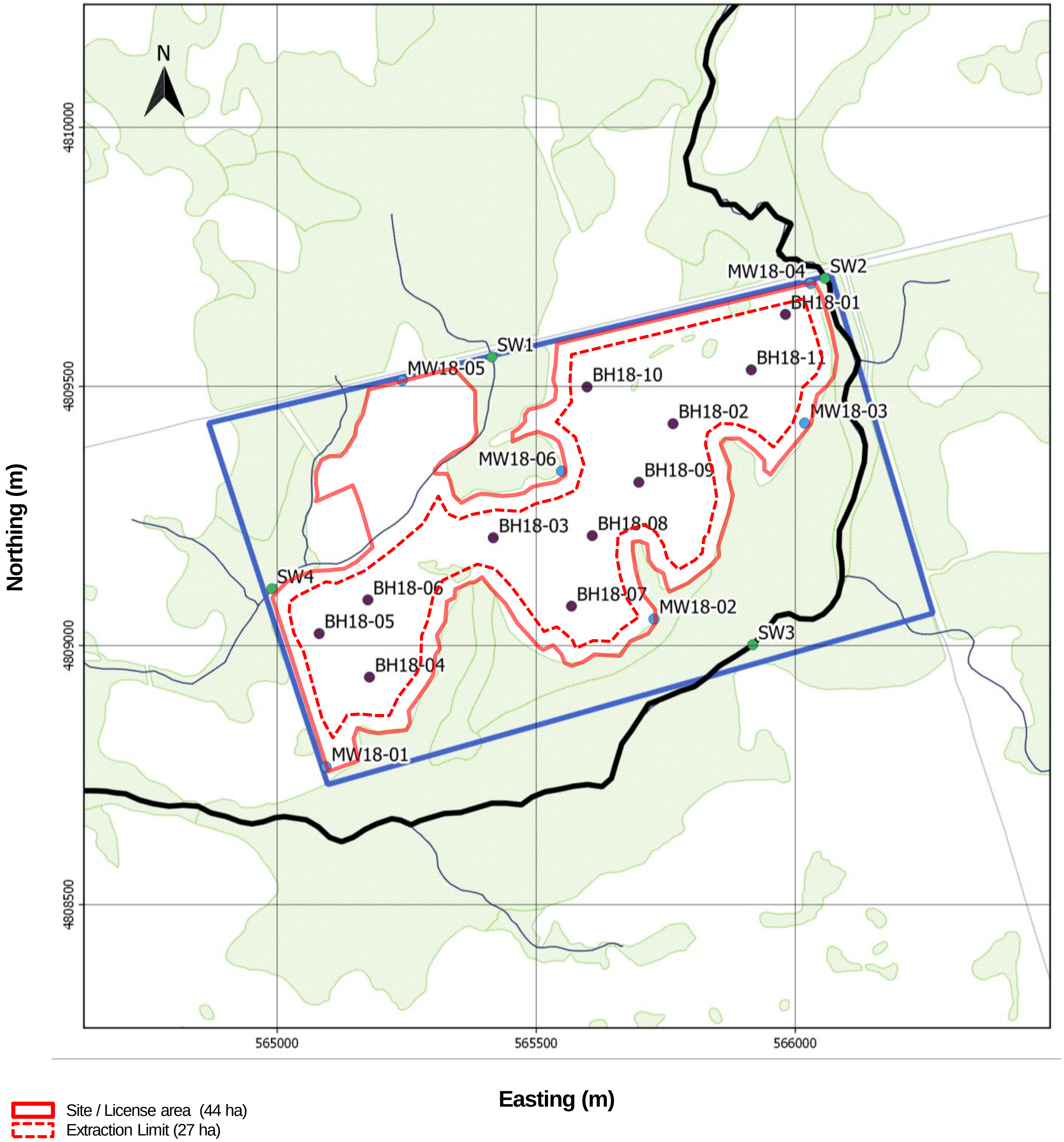
PROJECT
Aberfoyle South Pit Expansion
Water Report Level 1/2

CONSULTANT

YYYY-MM-DD	2021-11-09
PREPARED	SK
DESIGN	SK
REVIEW	GS
APPROVED	GS

TITLE
Groundwater Model Study Area

PROJECT No.	Rev.	FIG.
1791470	**A**	**1**



LEGEND

—	Rivers / Streams	▨	Wetlands
—	Roads	●	Surface Water Station
▭	Model Boundary	●	Monitoring Well
▭	Property Boundary	●	Borehole

NOTE

1. The eastern and southern model bounds (black line) directly overlie Mill Creek.

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PROJECT

Aberfoyle South Pit Expansion

Water Report Level 1/2

CONSULTANT

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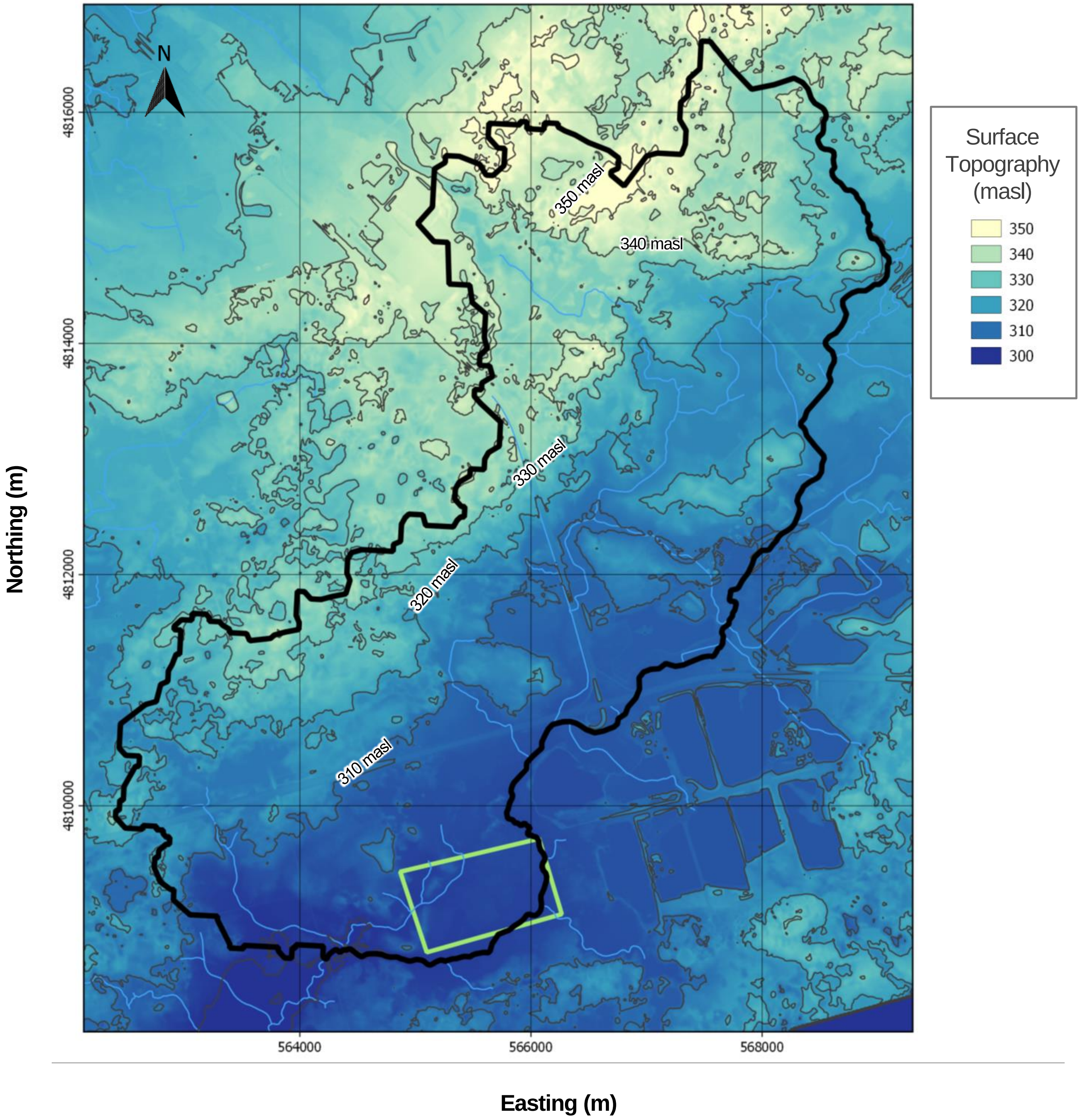
PREPARED	SK
DESIGN	SK
REVIEW	GS
APPROVED	GS

TITLE

Monitoring Network and Resource Borehole Location Plan

PROJECT No.	Rev.	FIG.
1791470	**A**	**2**



LEGEND

▬ Rivers / Streams	─ Elevation Contour
▭ Model Boundary	▭ Property Boundary

NOTE

1. Surface topography based on Ontario Digital Terrain Model (Lidar-Derived) from Land Information Ontario (2019).
2. Surface topography elevation displayed in 10 metre contours.

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Aberfoyle South Pit Expansion
Water Report Level 1/2

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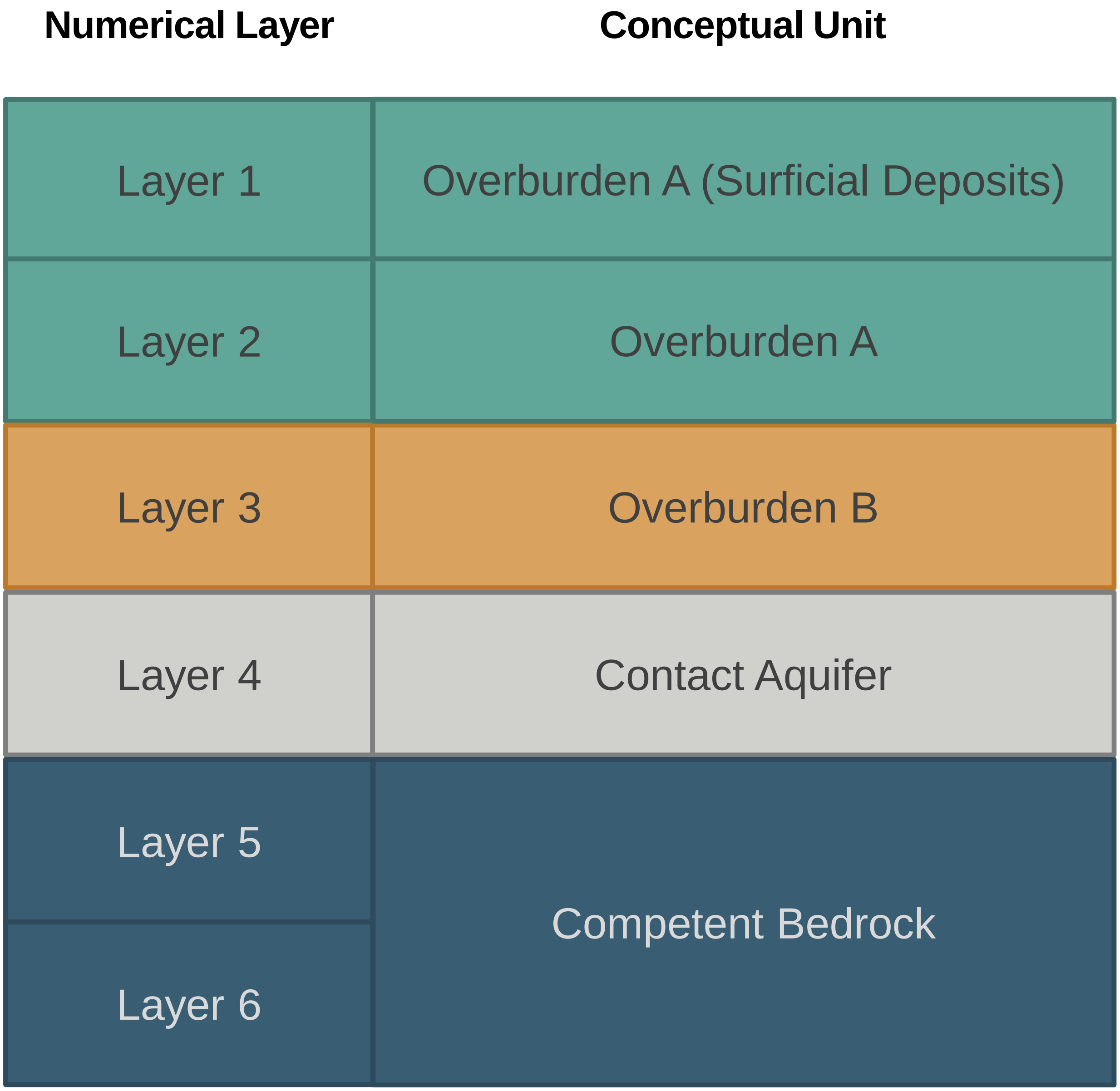
DESIGN	SK
REVIEW	GS
APPROVED	GS

TITLE
Surface Topography

PROJECT No.	Rev.	FIG.
1791470	**A**	**3**



Numerical Layer	Conceptual Unit
Layer 1	Overburden A (Surficial Deposits)
Layer 2	Overburden A
Layer 3	Overburden B
Layer 4	Contact Aquifer
Layer 5	Competent Bedrock
Layer 6	

LEGEND

NOTE

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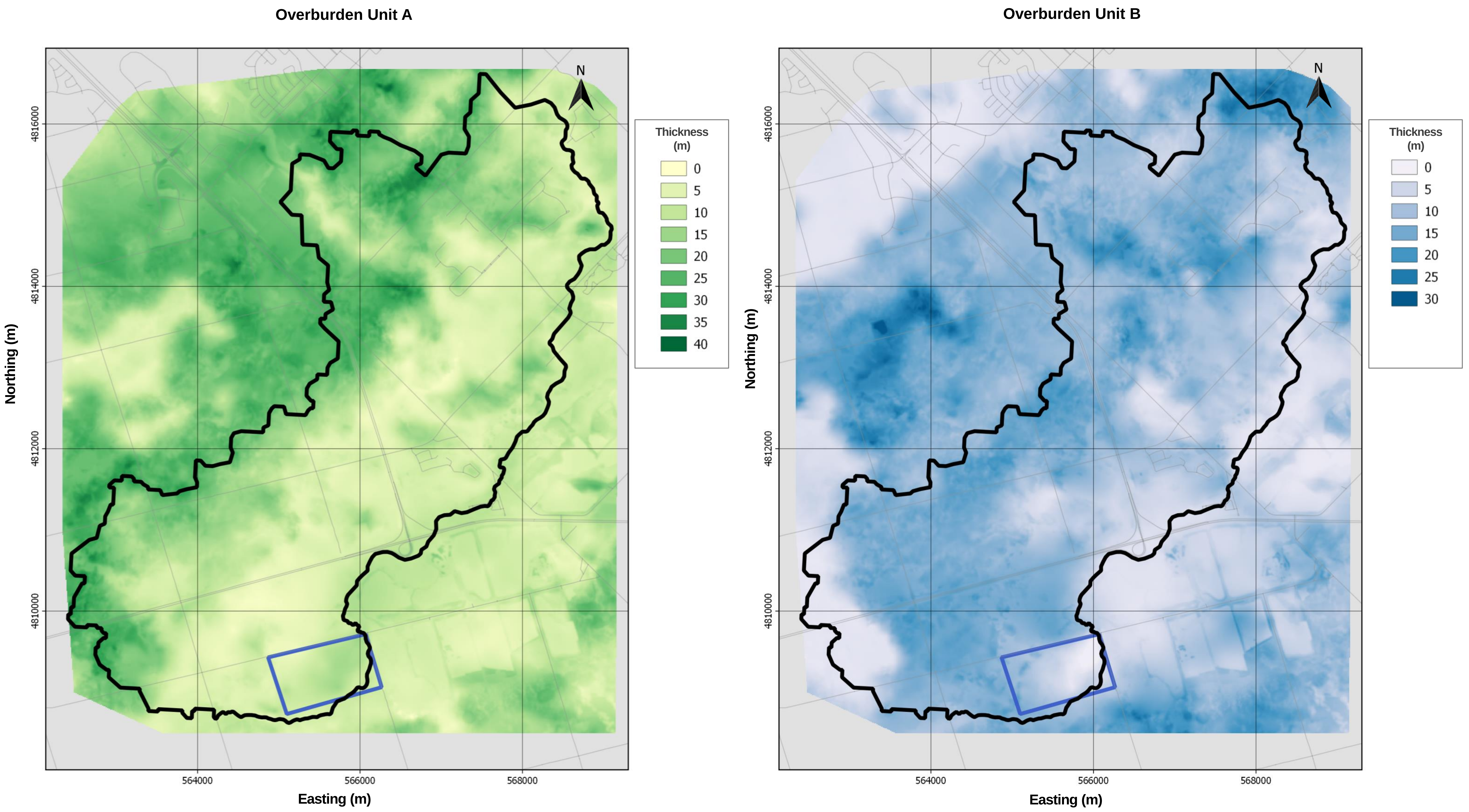
TITLE
Conceptual and Numerical Model Layering

PROJECT No.	Rev.	FIG.
1791470	**A**	**4**



LEGEND

▭	Property Boundary
▭	Model Boundary
—	Roads

NOTES

1. Overburden A thickness is reflective of the combined thickness of numerical model layers 1 and 2.
2. Overburden B thickness is reflective of numerical model layer 3 thickness.

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DESIGN	SK
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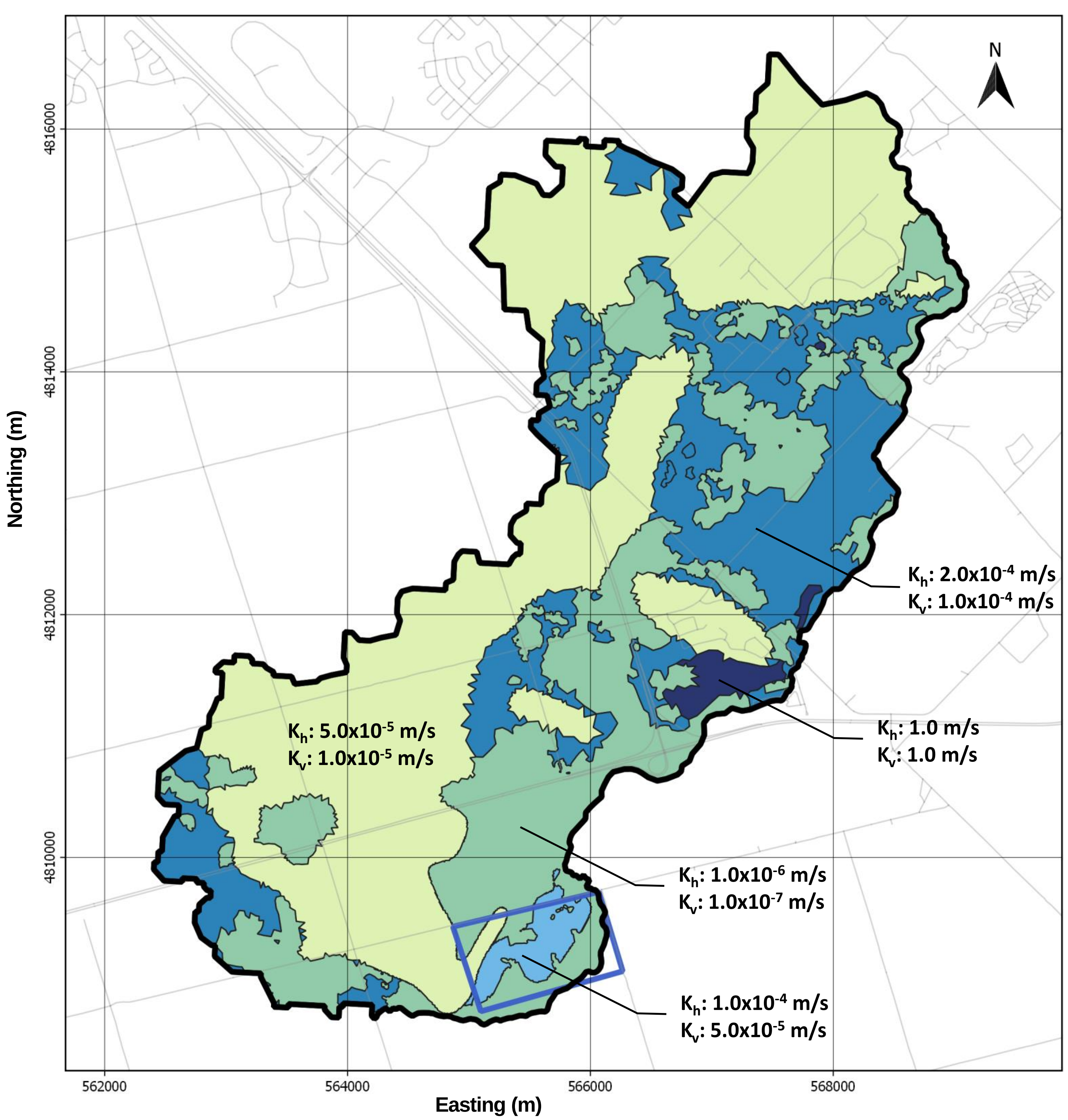
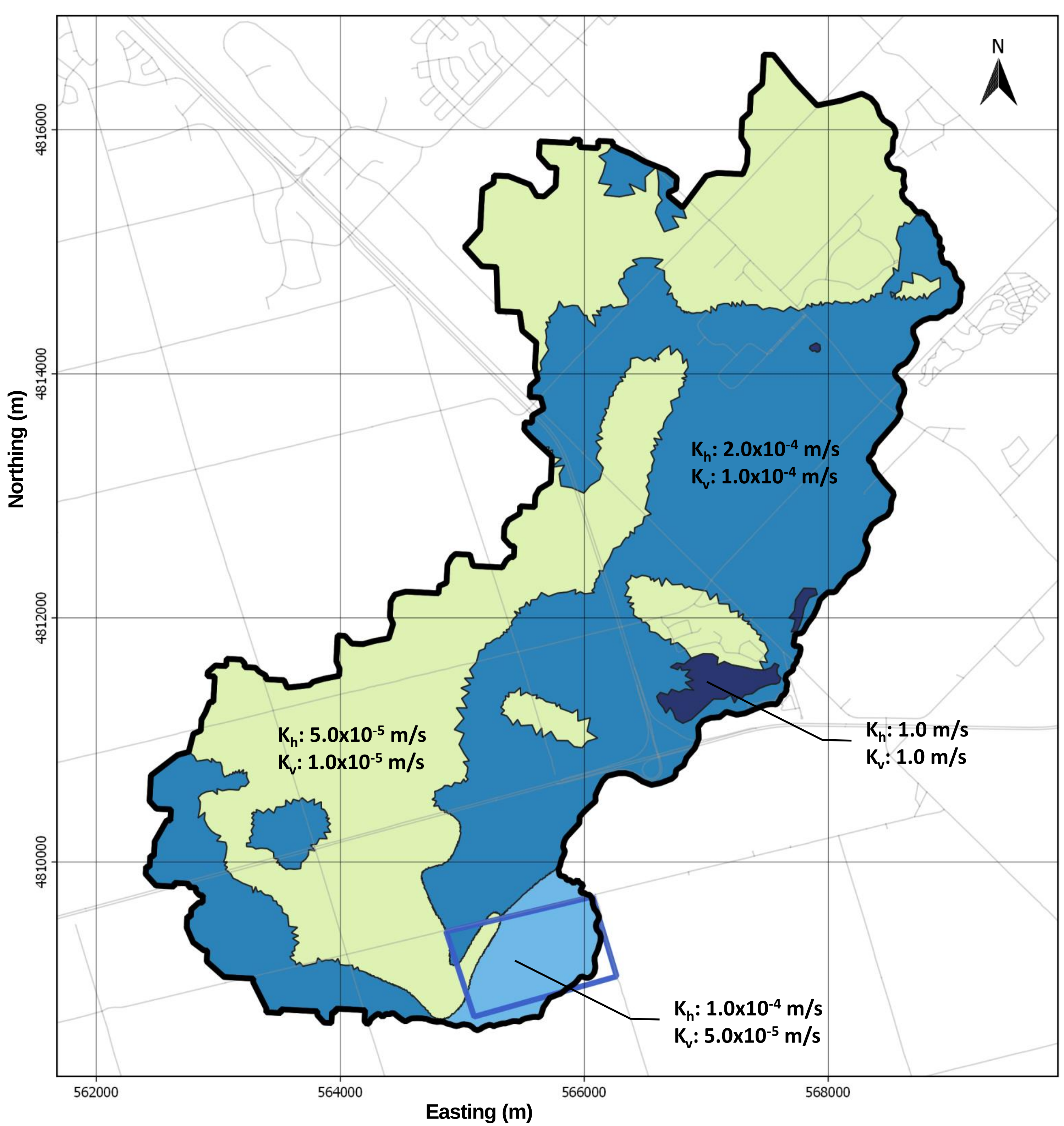
TITLE
Overburden Thickness

PROJECT No.	Rev.	FIG.
1791470	A	5


Surficial Deposits


Overburden A

LEGEND

□ Model Boundary
— Roads
□ Property Boundary
■ Organic Deposits
■ Sand and Gravel Outwash
■ Local Sand and Gravel
■ Weathered Wentworth Till
■ Flooded Pits

NOTES

1. The Surficial Deposits and Overburden A units make up numerical model layers 1 and 2 and represent the shallow aquifer system.
2. In the Surficial Deposits layer, where Sand and Gravel is overlain by wetlands Organic Deposit values were applied.

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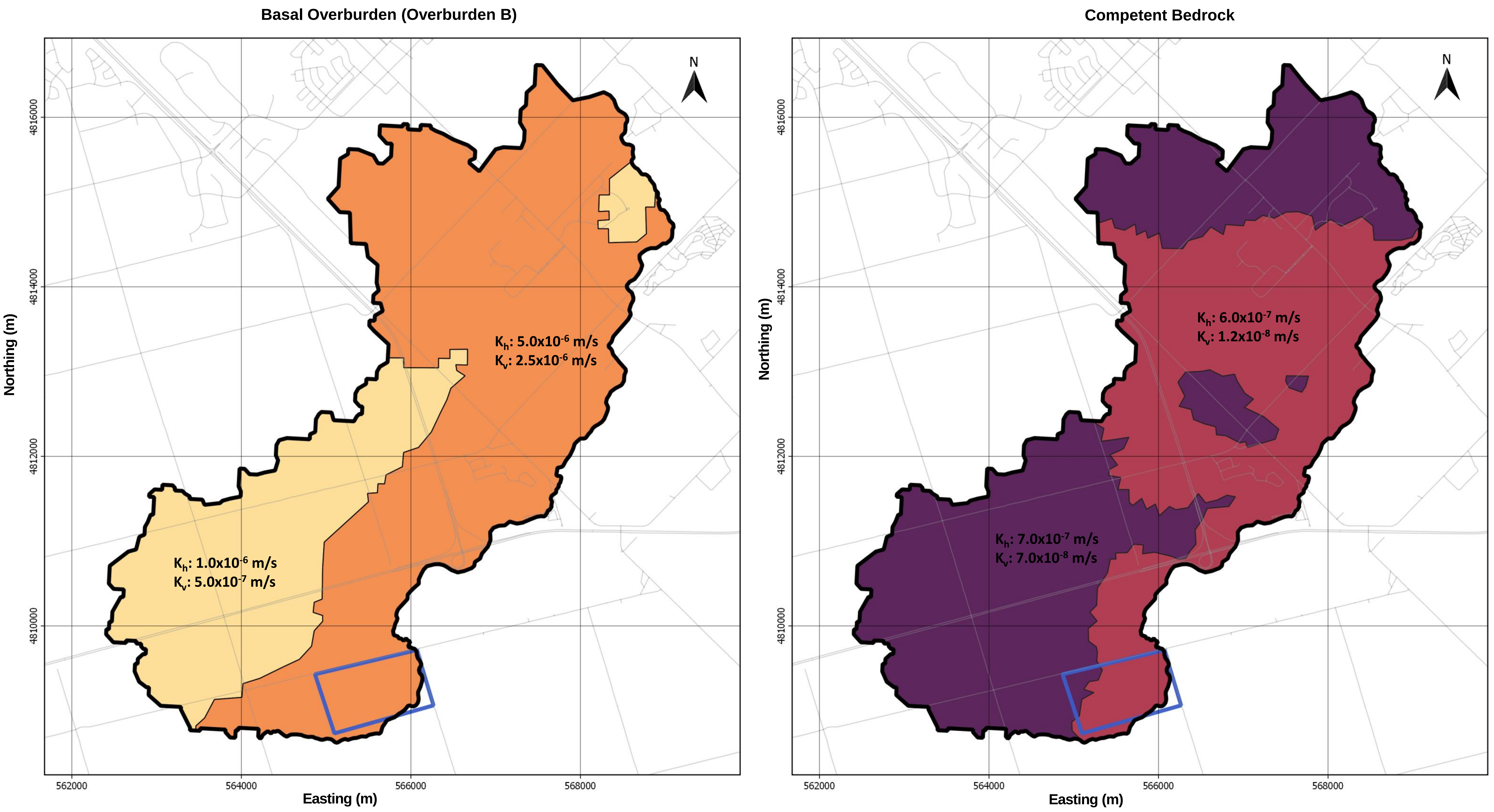
PROJECT
Aberfoyle South Pit Expansion
Water Report Level 1/2

TITLE
Modelled Hydraulic Conductivity
Upper Overburden

PROJECT No. 1791470
Rev. A
FIG. 6a



LEGEND

▭ Model Boundary
— Roads
▭ Property Boundary
🟨 Port Stanley Till
🟧 Wentworth Till
🟪 Guelph Formation
🟥 Reformatory Quarry Member

NOTES

1. Overburden B (numerical model layer 3) acts as an aquitard between the shallow aquifer system and the Contact Aquifer.
2. The weathered Contact Aquifer layer (not pictured) has a constant isotropic hydraulic conductivity of 1x10^{-5} m/s (numerical model layer 4).
3. The Competent Bedrock is assigned in numerical model layers 5 and 6.

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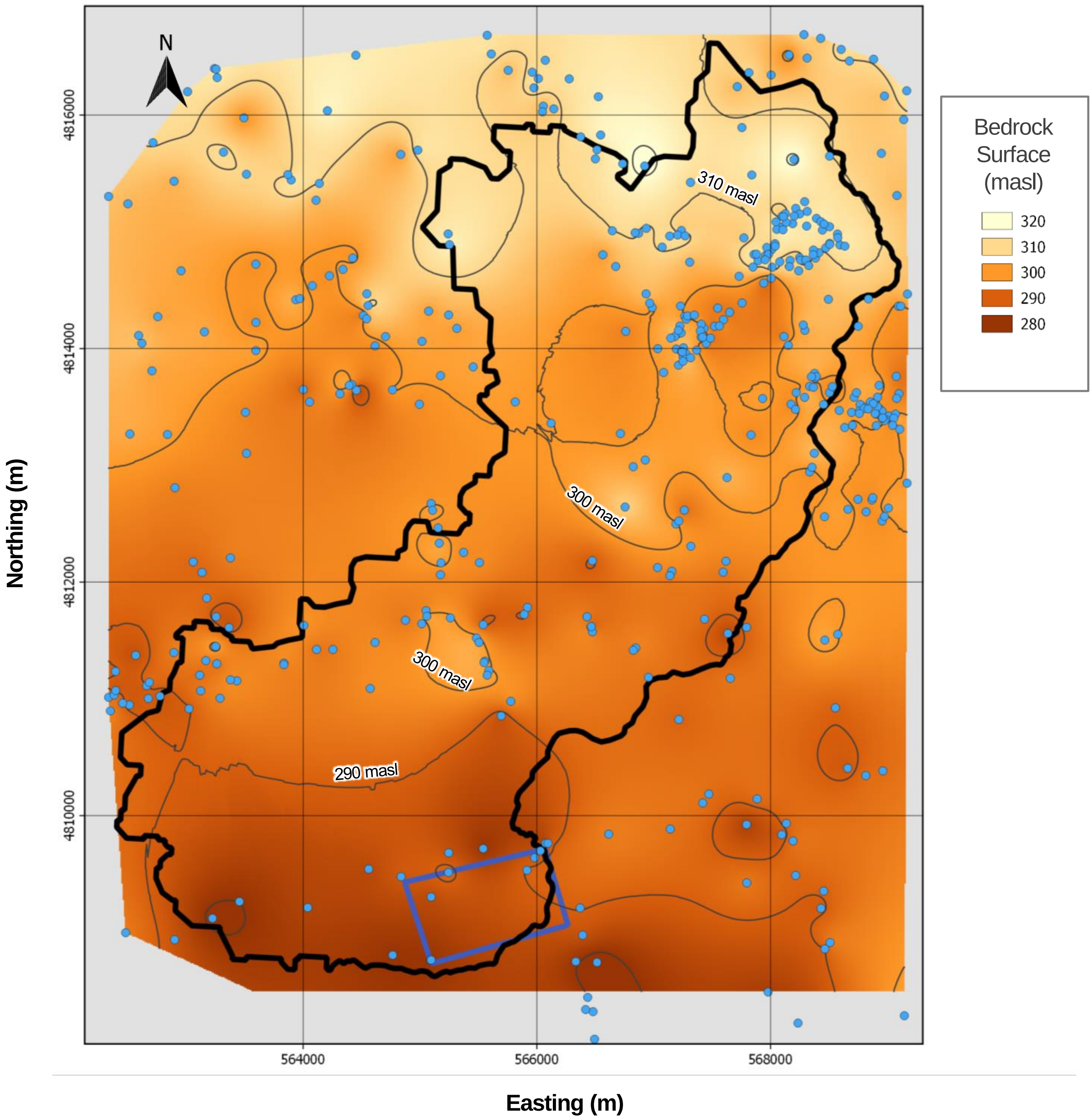
PROJECT
Aberfoyle South Pit Expansion
Water Report Level 1/2

TITLE
Modelled Hydraulic Conductivity
Basal Overburden and Bedrock

PROJECT No.	Rev.	FIG.
1791470	A	6b



LEGEND

▭ Property Boundary
▭ Model Boundary
— Elevation Contour
● Control Point

NOTE

1. Bedrock surface data points are from MECP well record database and on-site borehole data.
2. Elevation displayed in 10 metre contours.

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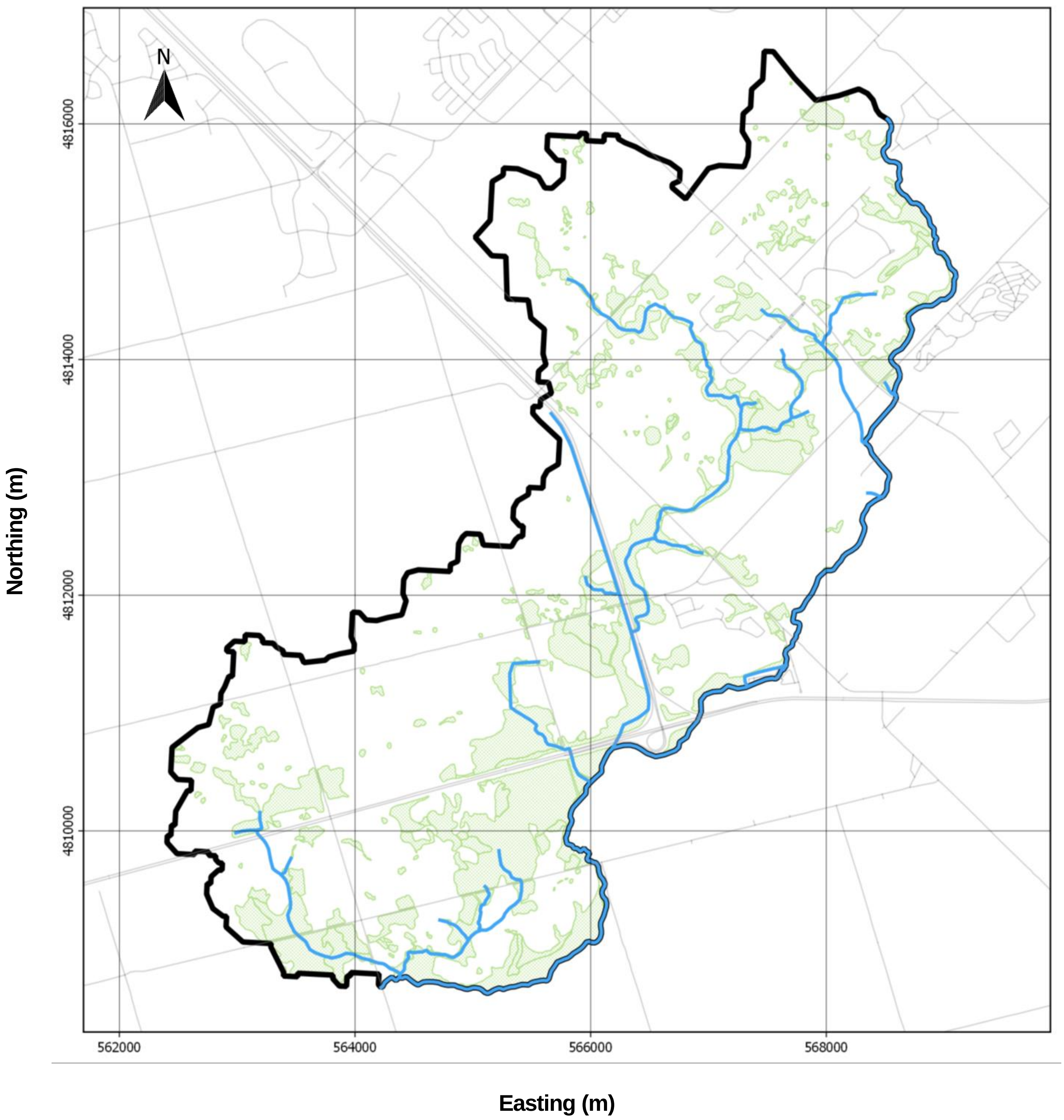
TITLE
Bedrock Surface

PROJECT No. **1791470**
Rev. **A**
FIG. **7**



LEGEND

━ Rivers / Streams	▨ Wetlands
─ Roads	
▭ Model Boundary	

NOTE

1. Rivers, streams, and wetlands are modelled as type 1 flow boundary conditions.
2. No-flow boundary conditions are assigned to all other outer model boundary nodes.

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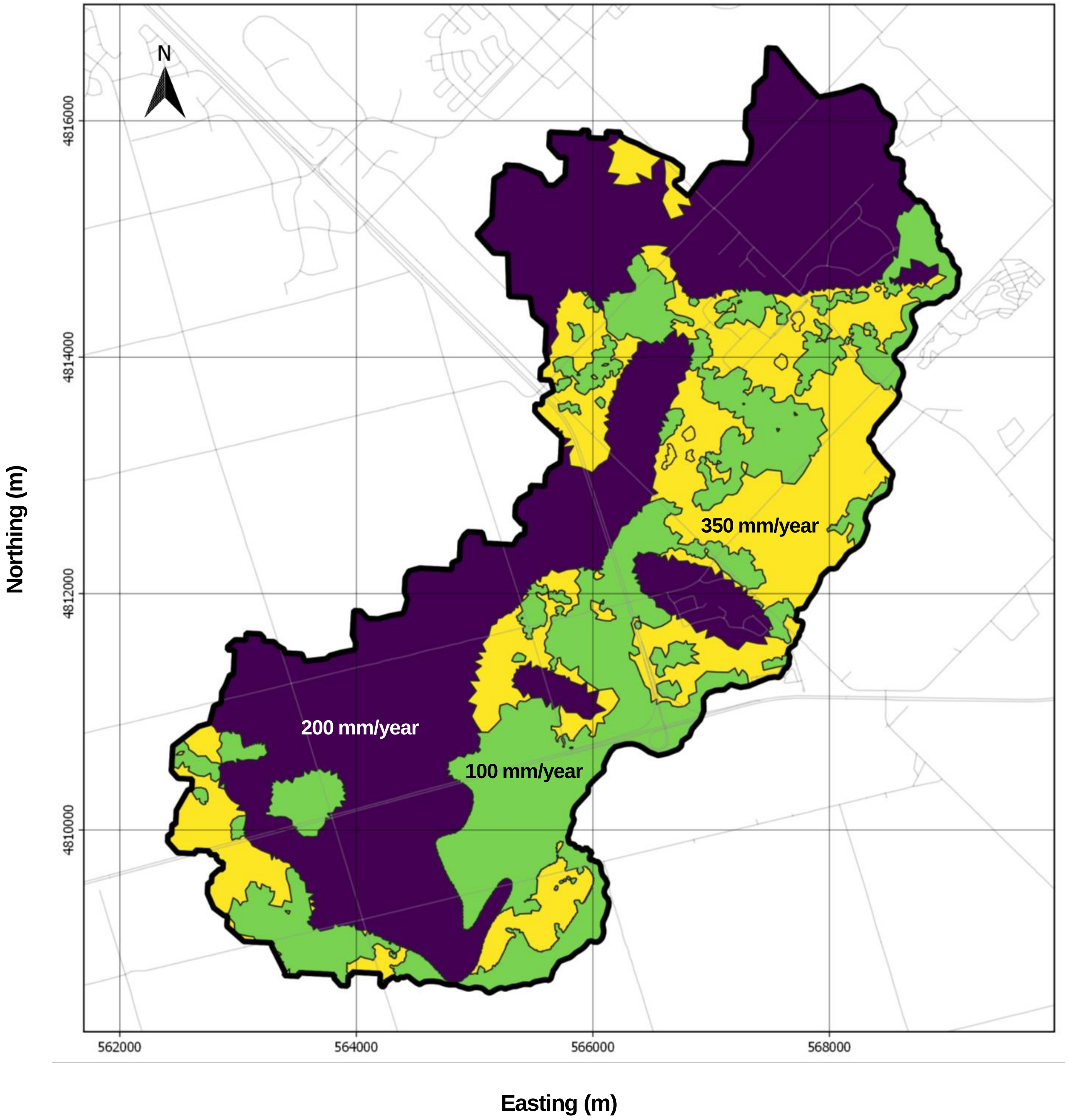
TITLE
Numerical Model Boundary Conditions

PROJECT No.	Rev.	FIG.
1791470	**A**	**8**



LEGEND

— Roads
▭ Model Boundary
🟩 Organic Deposits
🟪 Till
🟨 Sand and Gravel

NOTE

1. Initial recharge assignment is based on Quaternary material distribution. Where Sand and Gravel is overlain by wetlands, Organic Deposit rates are applied.

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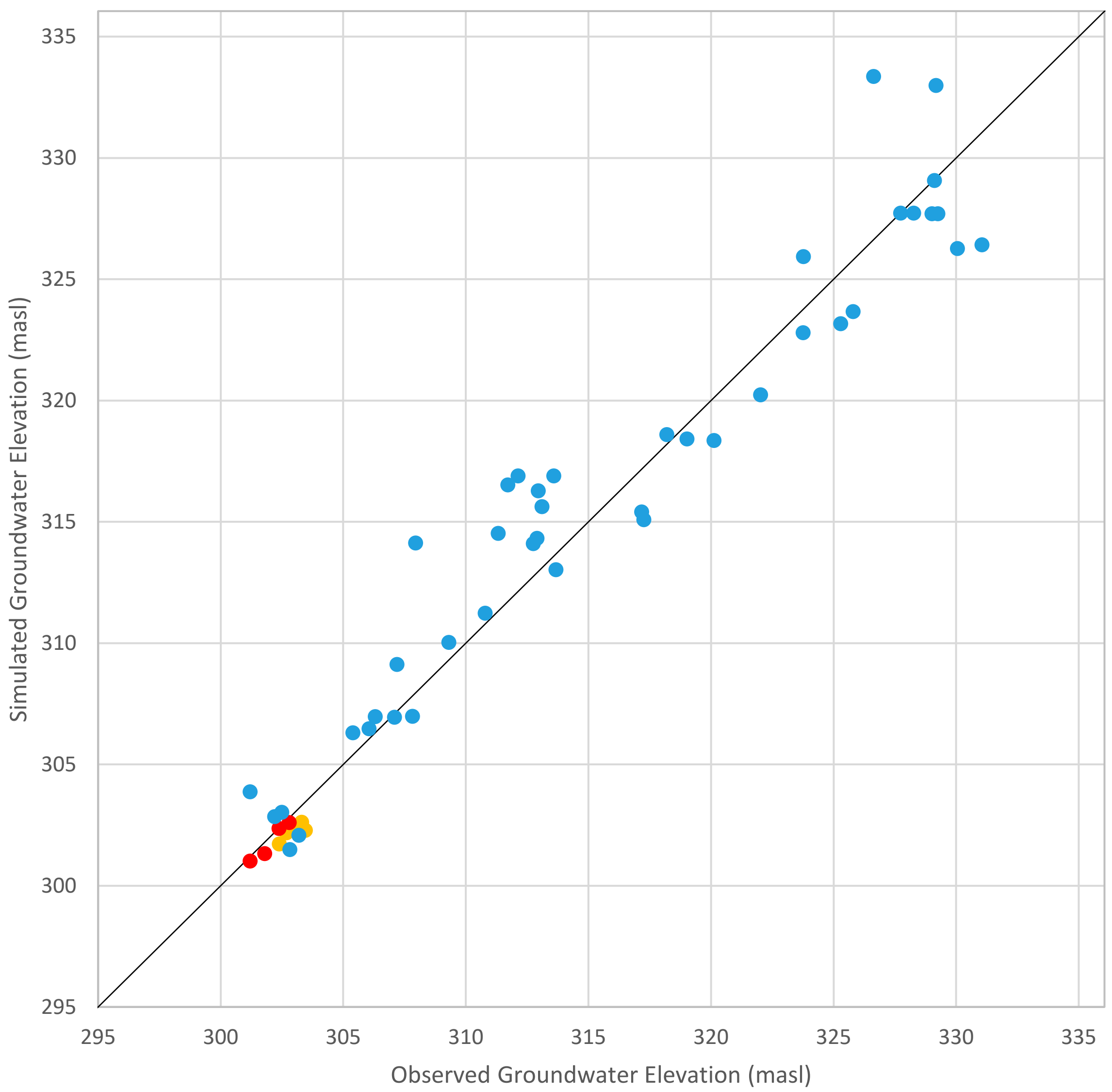
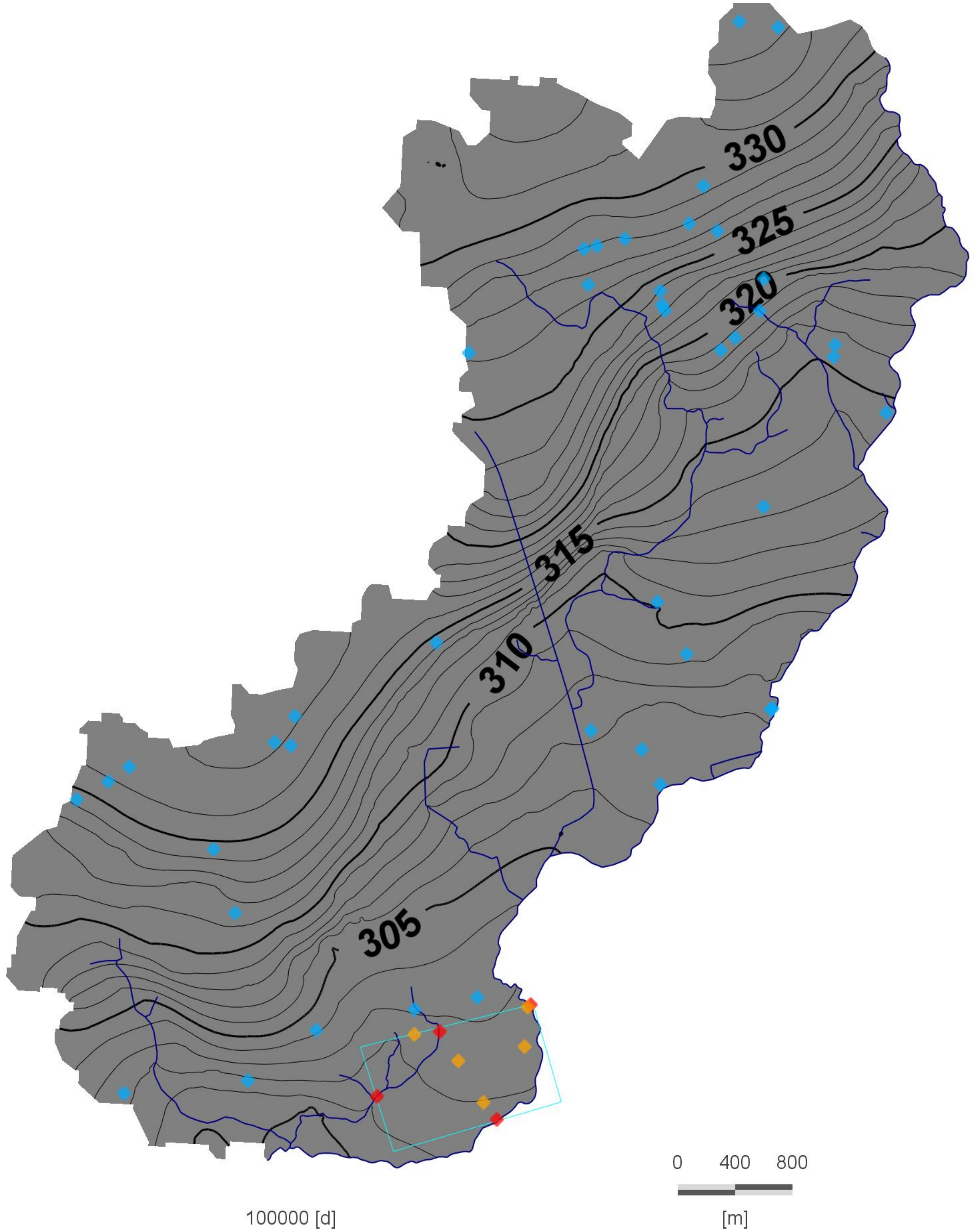
TITLE
Model Recharge

PROJECT No.	Rev.	FIG.
1791470	**A**	**9**



Mean Residual Error	-0.38	[m]
Mean Absolute Error	1.70	[m]
Median Residual	-0.13	[m]
Minimum Residual	-4.63	[m]
Maximum Residual	6.73	[m]
Root Mean Square Error	2.33	
Normalized RMS	7.8%	



LEGEND

● Golder MWs ● Golder SPs ● MECP

▭ Property Boundary
Rivers / Streams
Inferred Direction of Groundwater Flow

NOTES

1. Groundwater elevation contours are presented at a 1 metre contour interval.
2. The groundwater elevations are taken from model layer 2 (Overburden A hydrostratigraphic unit) with a constrained Mill Creek boundary condition.
3. RMS = Root Mean Square Error

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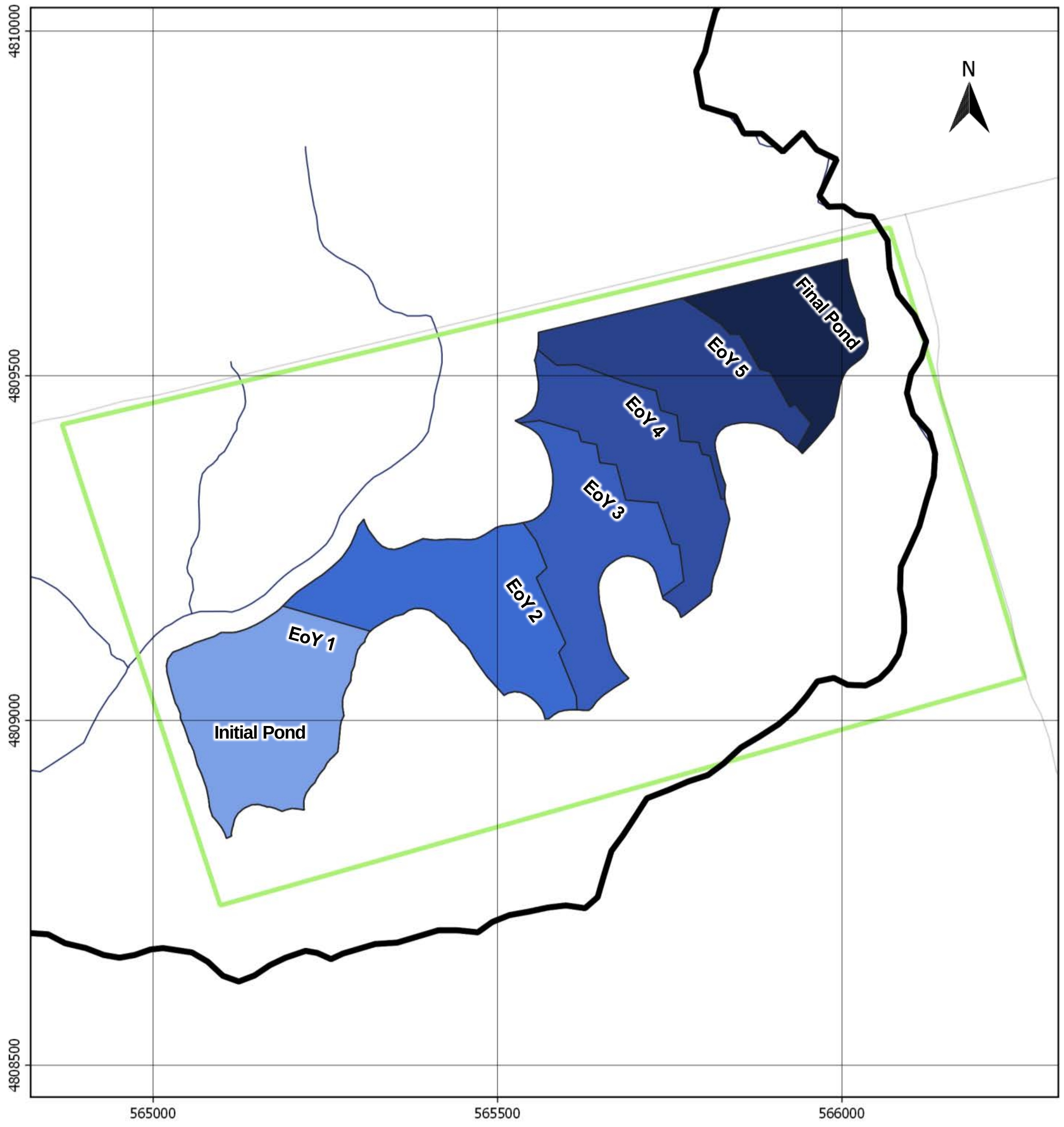
APPROVED GS

PROJECT
Aberfoyle South Pit Expansion
Water Report Level 1/2

TITLE
Calibration Results
Statistics and Water Table Elevation

PROJECT No. 1791470
Rev. A
FIG. 10



LEGEND

— Roads
▭ Model Boundary
▭ Property Boundary
— Rivers / Creeks
▬ Pond Extent

NOTE

1. EoY = End of Year.
2. Assumed extraction rate of 1,000,000 tons per year and an extraction period of 8 months per year.

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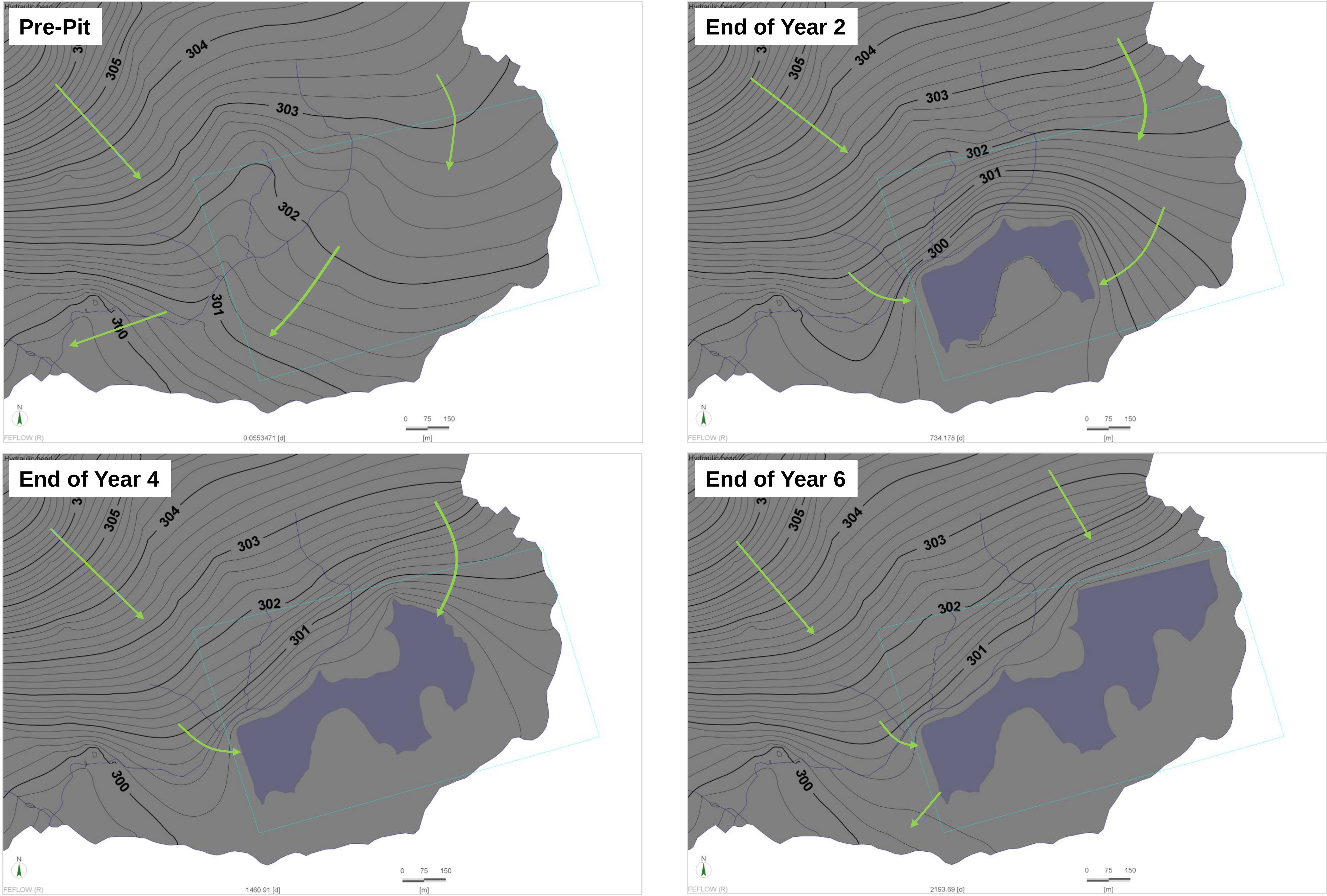
APPROVED	GS

TITLE
Pond Progression
Progression of Below Water Table Extraction

PROJECT No.	Rev.	FIG.
1791470	**A**	**11**



LEGEND

■ Pit Pond Extent
▭ Property Boundary
— Rivers / Streams
→ Inferred Direction of Groundwater Flow
— Water Table Elevations

NOTES

1. End of Year 2 = End of operations in year two.
2. Hydraulic head contours are taken from model layer 2 (Overburden A) and are shown in 0.2 m intervals.
3. End of operations is reached in year 6, assuming an extraction rate of 1,000,000 tons per year.

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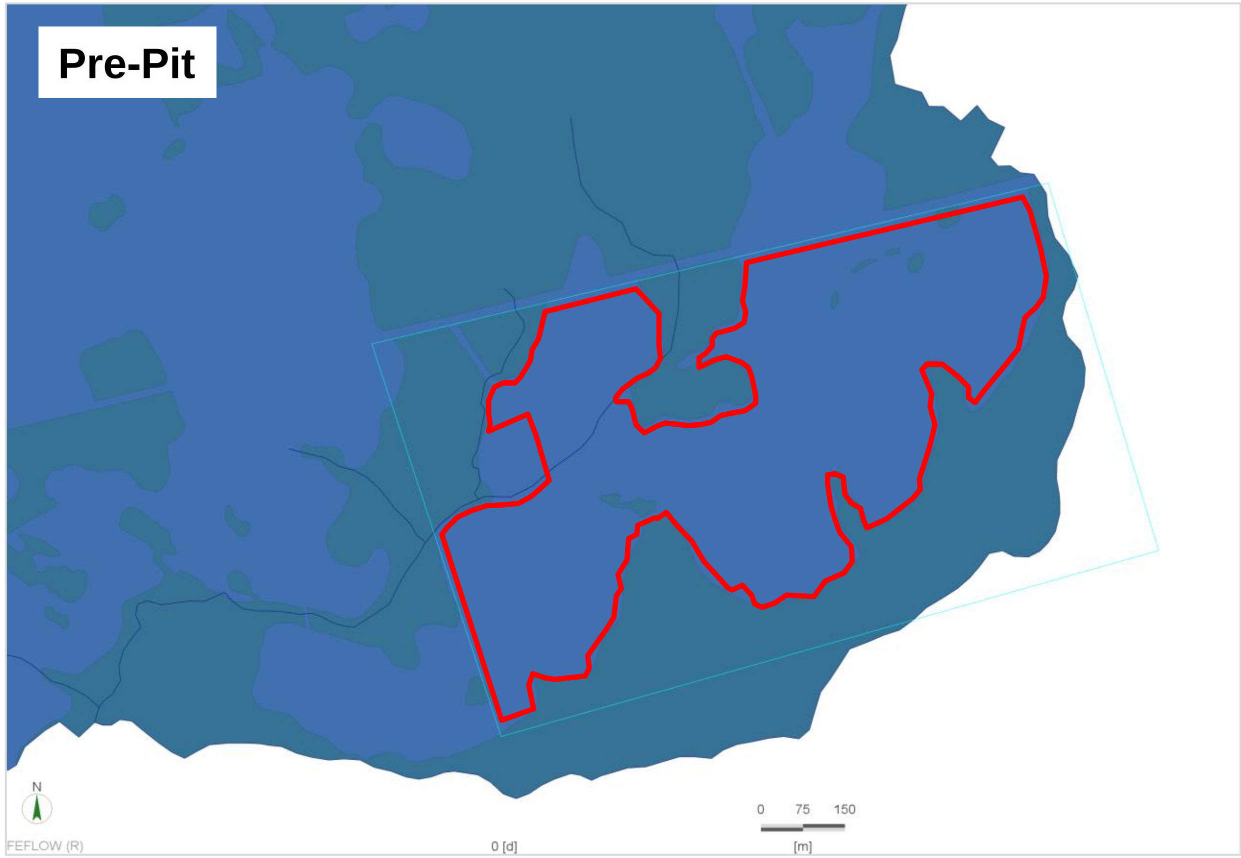
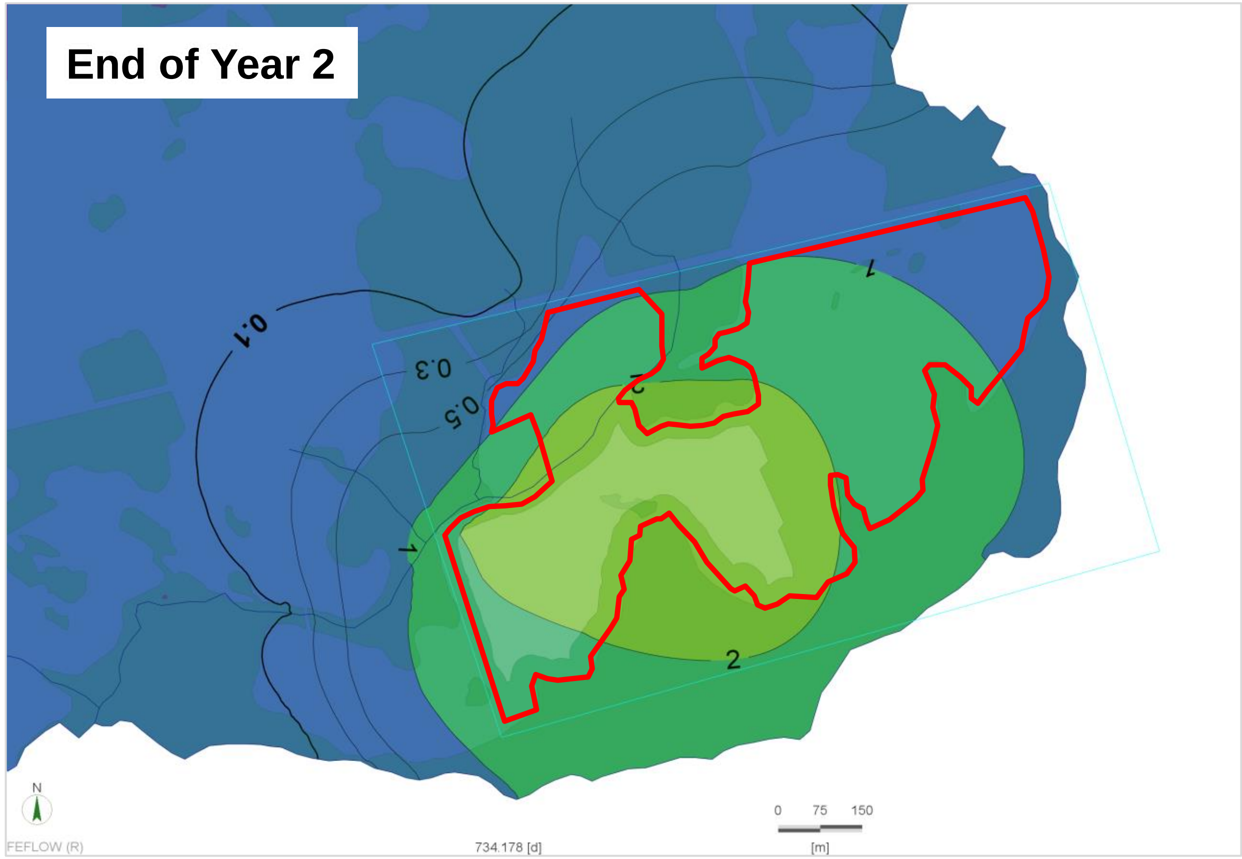
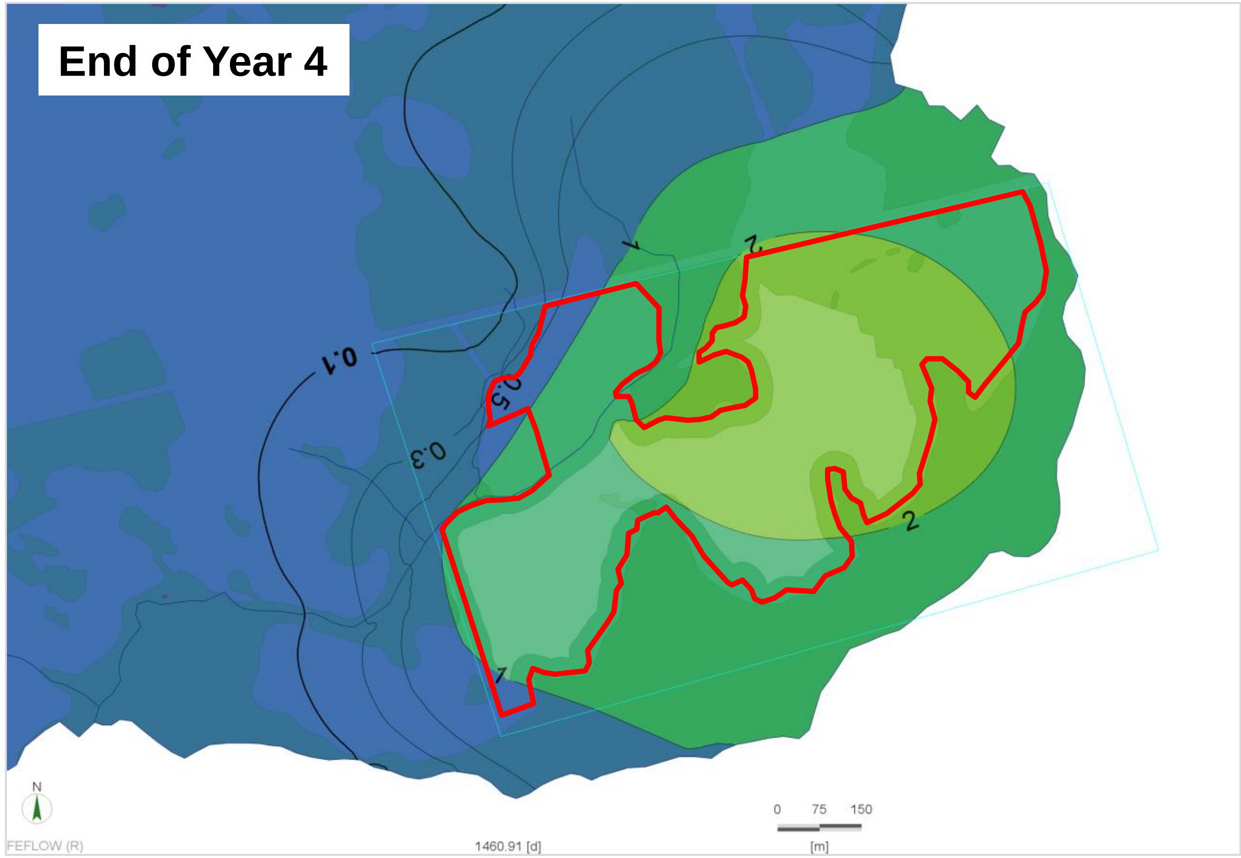
PROJECT
Aberfoyle South Pit Expansion
Water Report Level 1/2

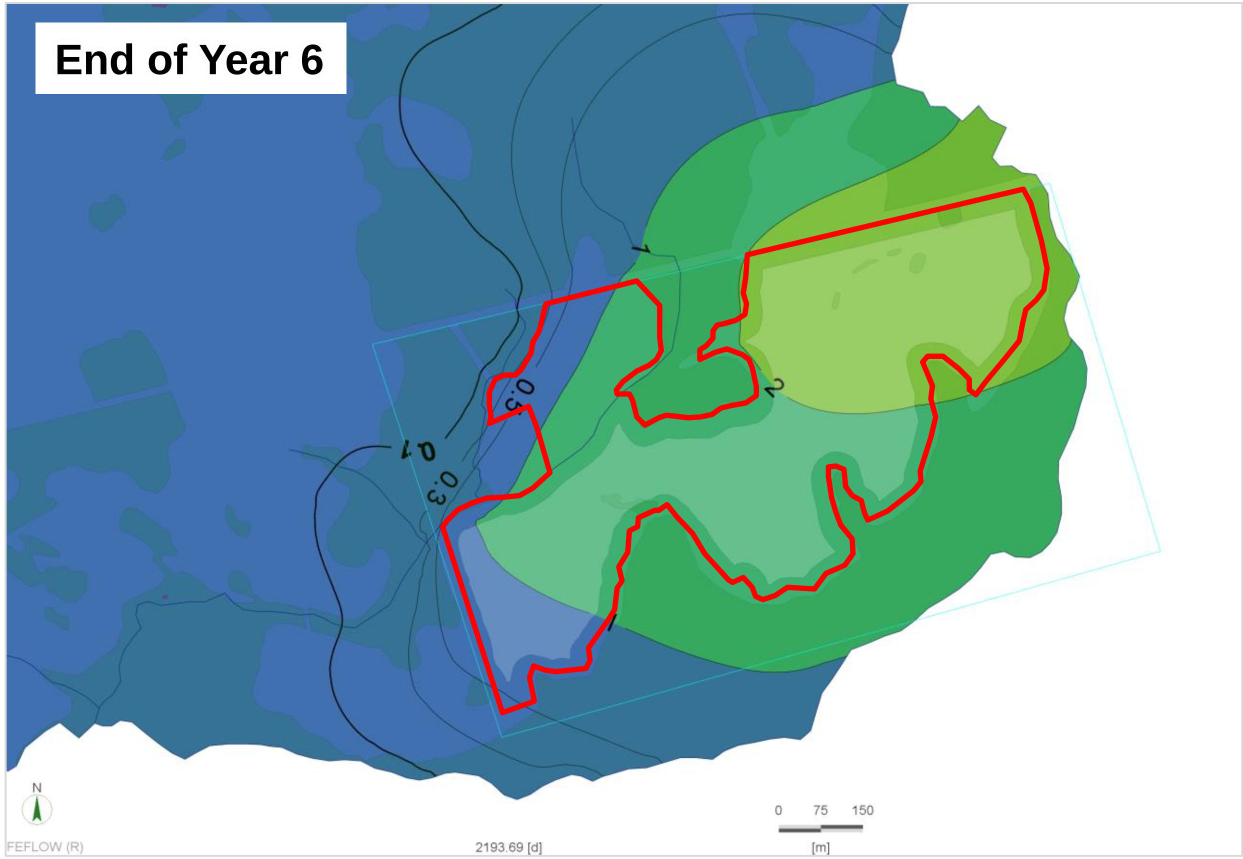
TITLE
Operational Model
Modelled Heads

PROJECT No. 1791470
Rev. A
FIG. 12a









LEGEND

Drawdown (m)

- 🟥 4
- 🟧 3.5
- 🟨 3
- 🟩 2.5
- 🟩 2
- 🟩 1.5
- 🟦 1
- 🟦 0.5
- 🟦 0
- 🟪 -0.5
- 🟪 -1

- ▬ Wetlands
- ☐ Pit Pond Extent
- ☐ Property Boundary
- — Rivers / Streams
- 🟥 Site / License Area

NOTES

1. End of Year 2 = End of operations in year two.
2. End of operations is reached in year 6, assuming an extraction rate of 1,000,000 tons per year.

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Aberfoyle South Pit Expansion
Water Report Level 1/2

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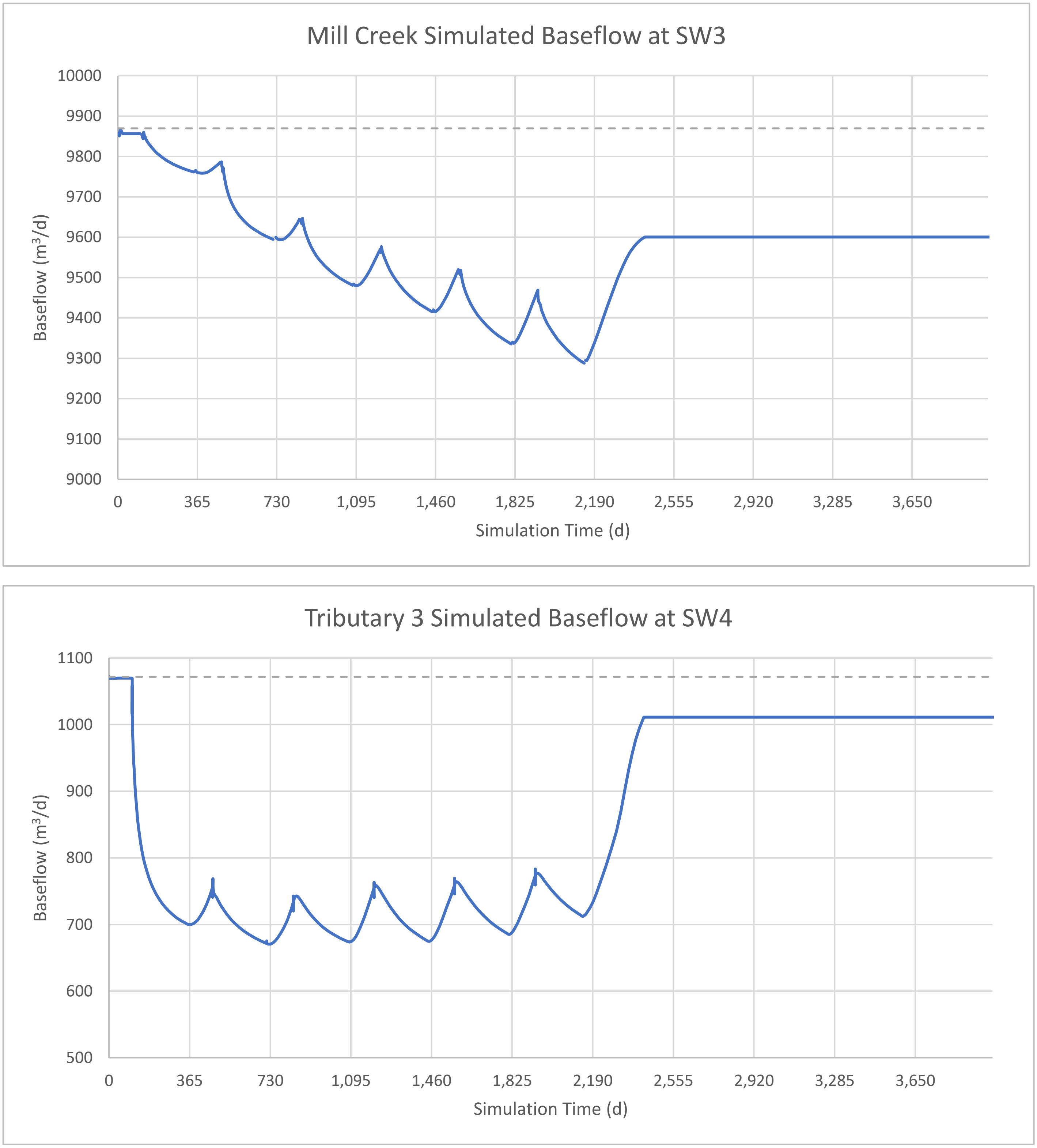
REVIEW	JR
APPROVED	GS

TITLE
Operational Model
Modelled Groundwater Drawdown

PROJECT No.	Rev.	FIG.
1791470	A	12b



LEGEND

—	Simulated Operations Baseflow
- - -	Simulated Pre-pit Baseflow

NOTE

1. Simulated pre-pit base flow is taken from the calibrated current conditions model and is 9870 m³/d at SW3 and 1072 m³/d at SW4.
2. The simulated catchment upstream of SW3 only represents 27% of the actual Mill Creek catchment upstream of SW3.

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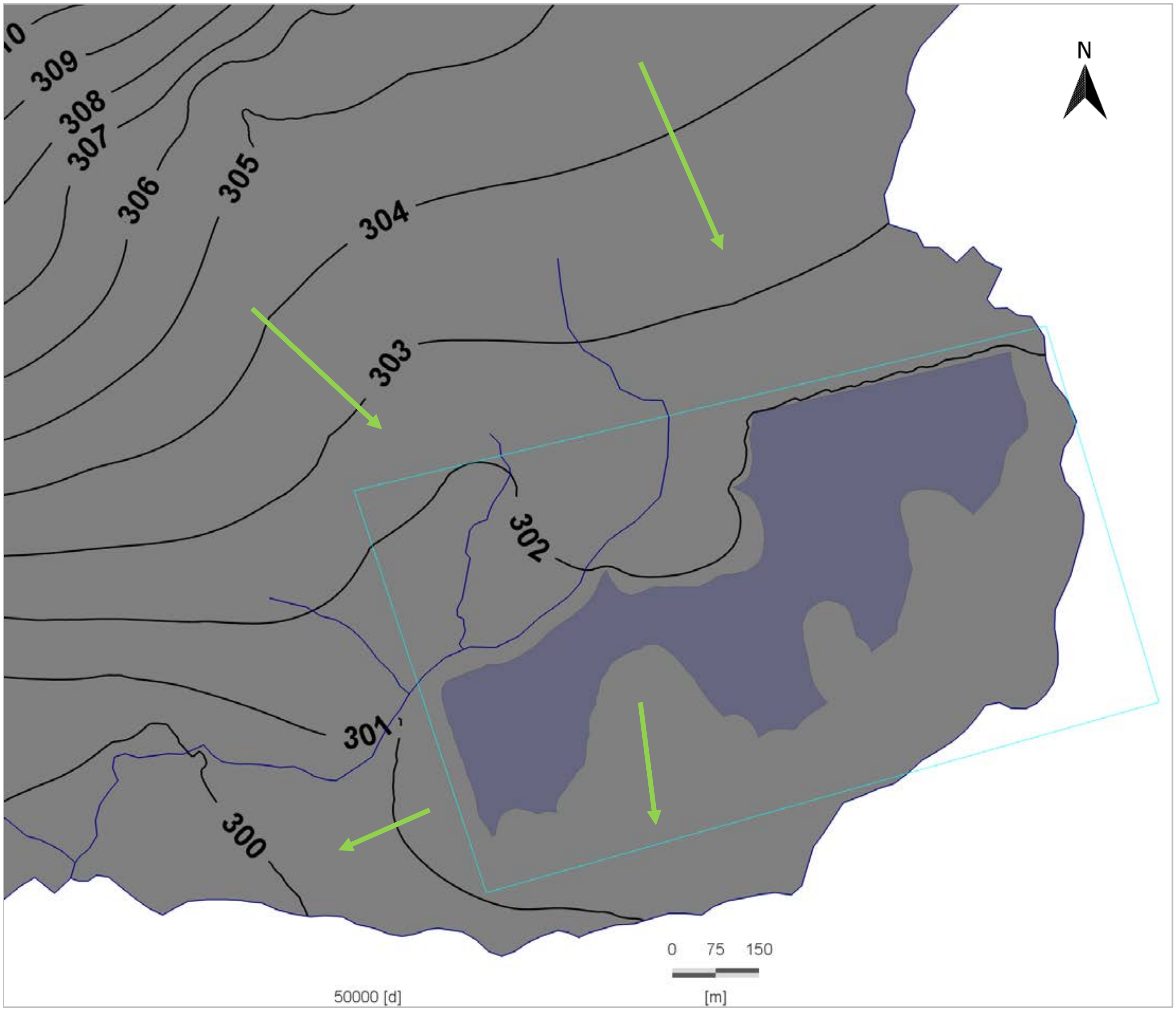
TITLE
Transient Changes in Baseflow
SW3 and SW4

PROJECT No.	Rev.	FIG.
1791470	**A**	**13**



LEGEND

▬	Pit Pond Extent
▭	Property Boundary
—	Rivers / Streams
→	Inferred Direction of Groundwater Flow
—	Water Table Elevation (masl)

NOTE

1. Simulated groundwater elevation contours are taken from model layer 2 (Overburden A) and are shown at 0.2 metre intervals.

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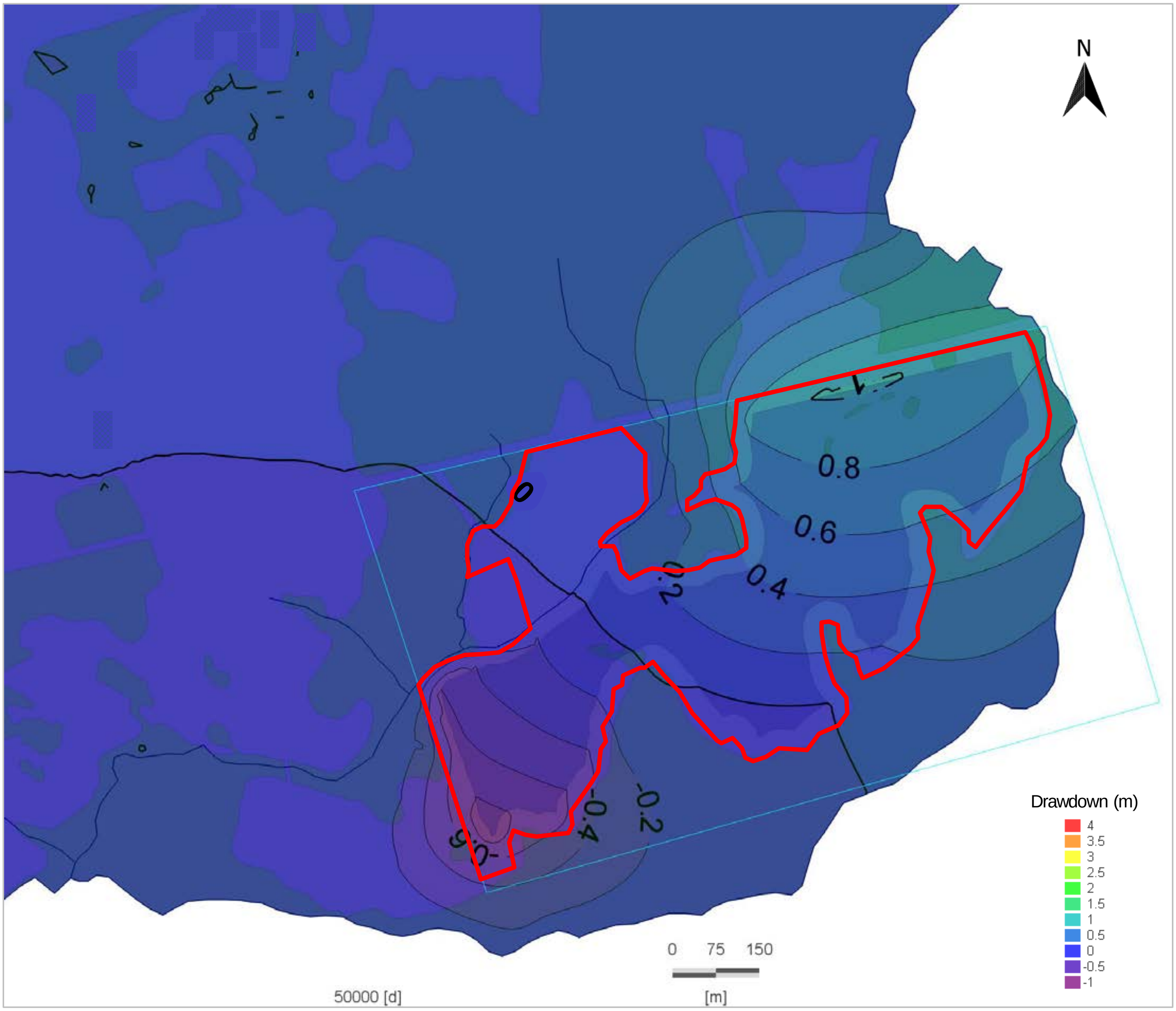
REVIEW	JR
APPROVED	GS

TITLE
Final Rehabilitated Condition
Modelled Heads

PROJECT No.	Rev.	FIG.
1791470	**A**	**14a**



LEGEND

- ▨ Pit Pond Extent
- ▨ Wetlands
- ▭ Property Boundary
- — Rivers / Streams
- — Drawdown Contour
- ▭ Site / License area

NOTE

1. Drawdown is calculated relative to the pre-pit calibrated model.
2. Drawdown contours are taken from model layer 2 (Overburden A) and are shown at 0.2 m intervals.
3. Drawdown (a decrease in groundwater elevation) is presented with the red to green colour scale, while draw up (an increase in groundwater elevation) is presented with the blue to purple colour scale.

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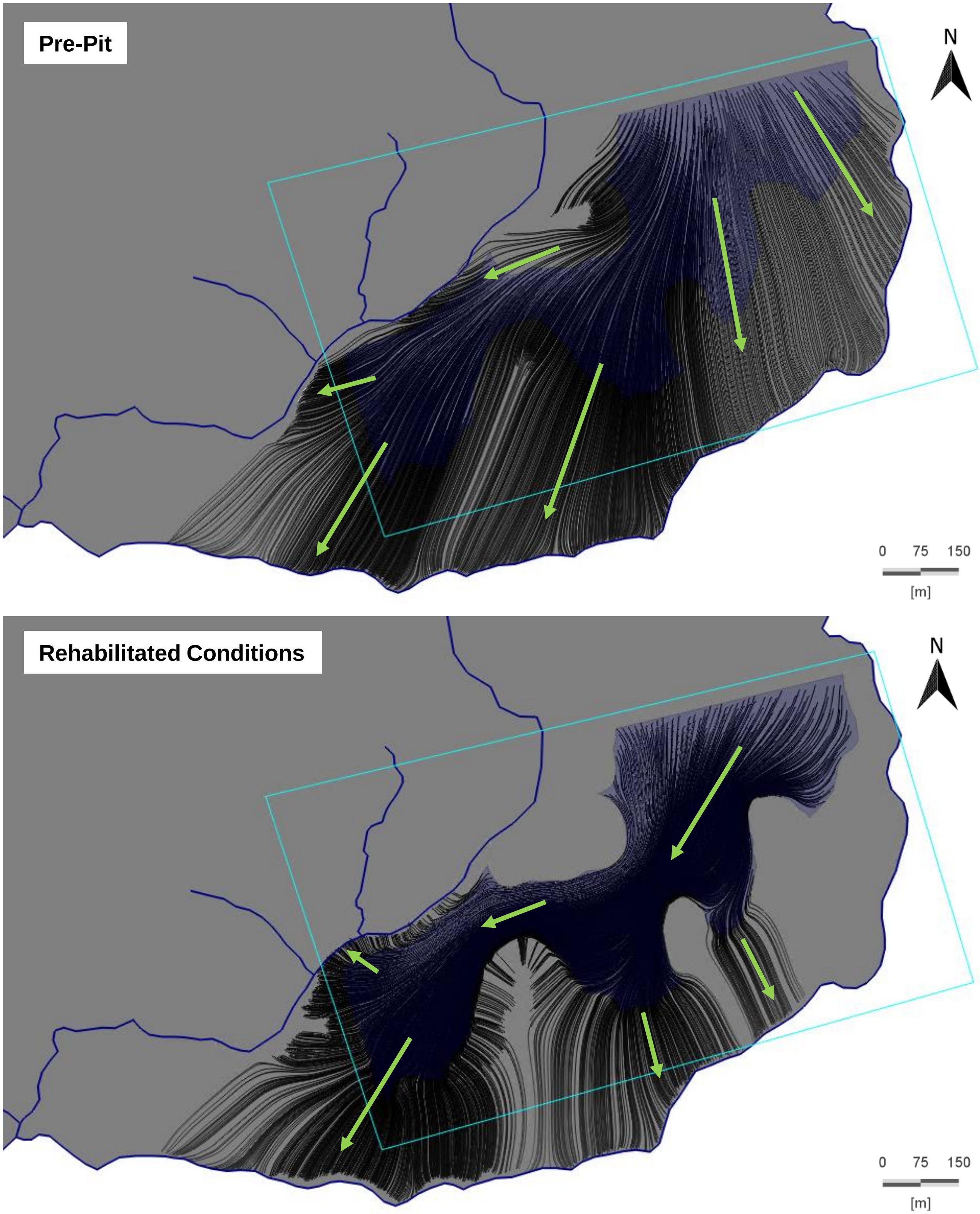
REVIEW	JR
APPROVED	GS

TITLE
Final Rehabilitated Condition
Modelled Groundwater Drawdown

PROJECT No.	Rev.	FIG.
1791470	**A**	**14b**



LEGEND

▬ Pit Pond Extent
☐ Property Boundary
— Rivers / Streams
— Particle Pathlines
→ Inferred Direction of Groundwater Flow

NOTE

1. Particles are released from the footprint of the rehabilitated pond at the top and bottom of model layers 1 and 2 (Surficial Deposits and Overburden A) and forward tracked to their ultimate discharge location.

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Aberfoyle South Pit Expansion
Water Report Level 1/2

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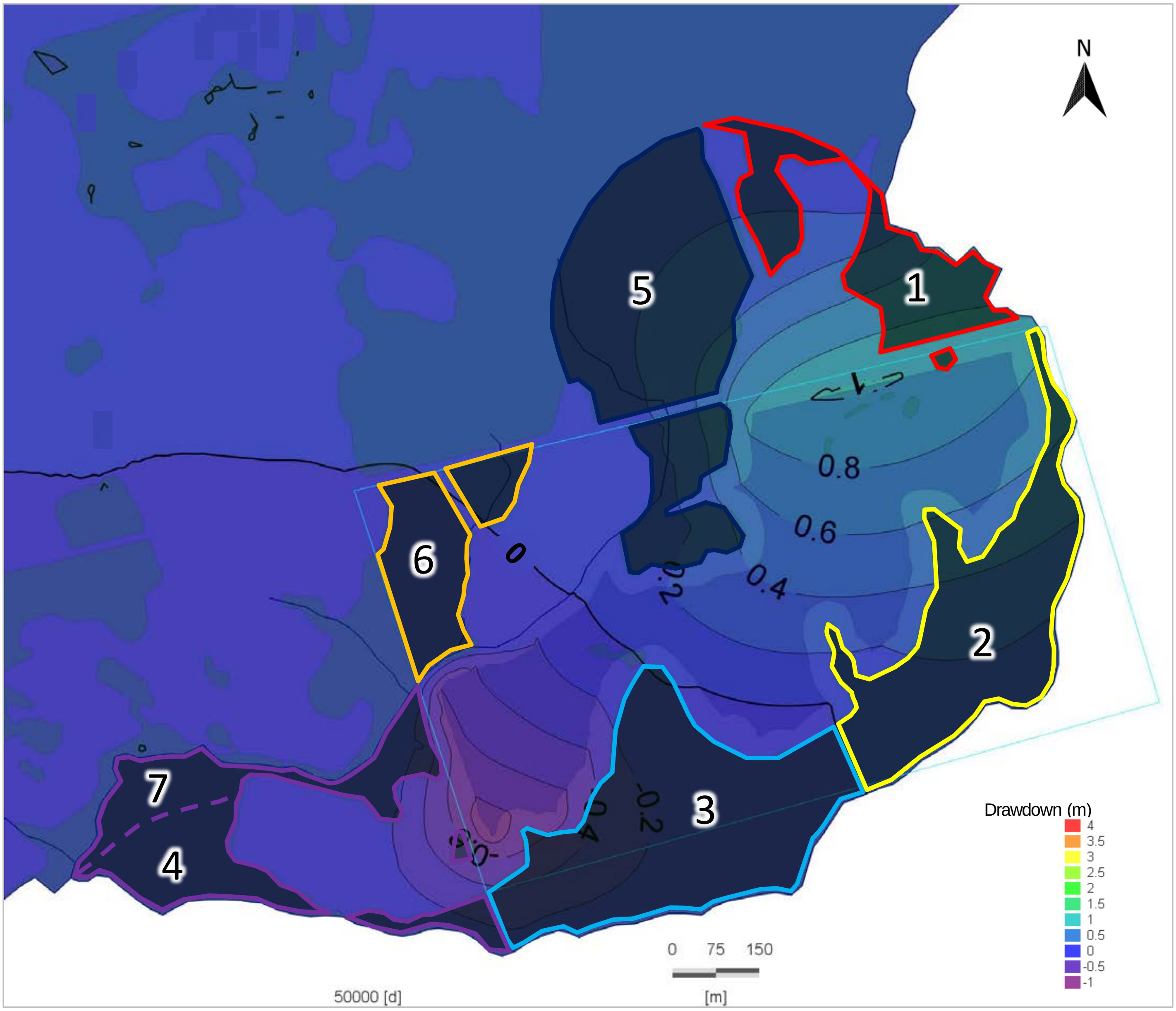
DESIGN	SK
REVIEW	JR
APPROVED	GS

TITLE
Final Rehabilitated Conditions
Groundwater Flow Pathlines

PROJECT No.
1791470

Rev.
A

FIG.
15



LEGEND

- ▨ Pit Pond Extent
- ▨ Wetlands
- ▭ PSW Zones
- ▭ Property Boundary
- — Rivers / Streams
- — Drawdown Contour

NOTE

1. See Figure 14b for further details on drawdown.
2. Creek zone 5 extends from the 0 m drawdown contour upstream through PSW zone 5 to the start of the tributary.
3. Creek zone 6 extends from within PSW zone 6 upstream to the 0 m drawdown contour.
4. The division between zones 4 and 7 is based on particle pathlines and groundwater head contours.

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REVIEW	JR
APPROVED	GS

TITLE
PSW And Creek Zonation

PROJECT No.
1791470

Rev.
A

FIG.
16

APPENDIX H

Project Team CVs

Education

MSc. Earth Sciences, University of Waterloo, 1995

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

Professional Affiliations

Practising Member, Association of Professional Geoscientists of Ontario

Active Member, Society of Exploration Geophysicists

Member, Canadian Nuclear Society

Professional Summary

George Schneider is a Senior Geoscientist and Principal Fellow at WSP, formerly Golder Associates, with over 30 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 Fellow / Senior Geoscientist, WSP, formerly Golder Associates (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 since 1995 and is currently a Principal 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 the Waterloo-Wellington-Brant Regional Committee of the Ontario Stone Sand and Gravel Association (OSSGA).

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

Mississauga, Cambridge and Whitby, Ontario

Project director responsible for a range of multi-disciplinary projects including: environmental investigations at explosive contaminated sites and mine sites, aggregate resource studies, groundwater supply and management studies and nuclear waste management. Managed the Environmental Services Division in the GTA including: Geosciences, Geophysics, Site Characterization and Restoration, Environmental Due Diligence, Hydrogeology and Waste Management and Field Technician Groups.

Associate / Senior Project Manager, Golder Associates (2002 to 2005)

Mississauga, Ontario

Senior geoscientist responsible for the management of a diverse range of projects including: environmental investigations at explosive contaminated sites, aggregate resource studies, hydrogeological studies and geophysical investigations in support of hydrogeological studies, environmental site assessments, mine site developments, aggregate resource studies and geotechnical investigations.

Intermediate, then Senior Geoscientist, Golder Associates (1995 to 2002)

Waterloo, then Mississauga, Ontario

Responsible for project management, performing geophysical, geological and hydrogeological field investigations, numerical data analysis, data assessment, and reporting for: aggregate resource studies, groundwater resource studies, permits to take water, assessment of contaminated sites, geotechnical investigations and hydrogeologic characterization of mine tailings disposal and open pit mine sites.

Collected, processed and interpreted data for a variety of land and marine geophysical techniques including: time and frequency domain electromagnetics, magnetics, gravity, ground penetrating radar (GPR), seismic reflection and refraction, acoustic tomography, pulse velocity testing of man-made structures, cross-hole seismic testing, leak detection, vertical seismic profiling (VSP), electrical resistivity imaging (ERI), borehole camera logging and geophysical well logging including: natural gamma, gamma-gamma, neutron, temperature, deviation, inductive conductivity, magnetic, caliper, resistivity, heat-pulse flowmeter and optical televiewer.

Geophysicist, Waterloo Centre for Groundwater Research (1987 to 1995)

University of Waterloo, Waterloo, Ontario

Conducted geophysical field investigations and drilling programmes under the direction of Dr. J.P. Greenhouse and Dr. P.F. Karrow in the Waterloo Region related to the quaternary geology and the assessment of water resources in the Region including: seismic surveys, borehole geophysical surveys and two Rotasonic drilling programmes. Compiled three editions of a catalogue of geophysical logs for the Waterloo Region from 1988 to 1993. Co-authored more than 20 research papers, reports and posters, including 13 publications on the quaternary geology and/or water resources of the Waterloo Region.

Designed and constructed borehole and resistivity geophysical instruments, digital data acquisitions systems and developed innovative computer software for geophysical and hydrogeological applications. Carried out surface, borehole and laboratory geophysical investigations in support of more than 85 groundwater-related research projects including: geophysical investigations of DNAPL/LNAPL contamination, delineation of aquifers, groundwater contaminant plumes and karst features.

Other duties included: teaching assistance for University of Waterloo Earth Sciences and Geophysics courses and organization of technical conferences, short courses and field demonstrations.

PROJECT EXPERIENCE – WATER RESOURCES AND SOURCE WATER PROTECTION

Hydrogeological Assessment – Cambridge Zone 3 Class EA – Region of Waterloo (2016-2019) Cambridge, Ontario	As a subcontractor to GM BluePlan, completed a hydrogeological assessment for the Region of Waterloo of the Cambridge Zone 3 Well Field, as part of a class EA, to examine options to increase the sustainable water supply capacity of the well field. Project Director and Senior Technical Reviewer.
Hydrogeological Assessment – Harrington McAvan (2015 – 2019) Puslinch, Ontario	Carried out a hydrogeological and geotechnical assessment to support the re-zoning and future redevelopment of a property near Puslinch, Ontario for Farhi Holdings, including a preliminary assessment of potential water resources and septic capacity. Project Manager and Senior Technical Reviewer.
Municipal Well Construction and Testing (2015-2019) 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 and Maryhill. Designed, constructed and permitted 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 (2014-2018) 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 (2013-2018) 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.
GPR, Seismic Refraction and Borehole	Acquired, processed, interpreted and reported on GPR, seismic refraction and geophysical logging surveys at Municipal well fields in the Town of Walkerton, Ontario in the hydrogeological investigation following the E. coli

Geophysical Logging - Walkerton (2000) Walkerton, Ontario	tragedy in the summer of 2000. These surveys were used to help develop a conceptual geologic and hydrogeologic model for the site, and to identify fractured rock zones in the wells and assess the integrity of the well casing seal to the formation.
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.

PROJECT EXPERIENCE – AGGREGATES

Aggregate Licence Investigations (2019-present) Caledon, Ontario	Project Director and Senior Technical Reviewer for resource and hydrogeological technical studies at the Caledon properties for CBM Aggregates for a future below water table quarry licence application near Caledon, Ontario.
Aggregate Licence Investigations (2018-present) Peterborough, Ontario	Project Director and Senior Technical Reviewer for hydrogeological, natural environment and cultural heritage technical studies at the Blezard property for CBM Aggregates near Peterborough, Ontario.
Resource Evaluation – CBM (2018) Ayr, Ontario	Project Manager and Senior Technical Reviewer for an aggregate resource assessment at the Bromberg Pit for CBM Aggregates near Ayr Ontario.

Resource and Hydrogeological Investigation – CBM (2018) Dorchester, Ontario	Project Director and Senior Technical Reviewer for aggregate resource and hydrogeological studies at the Dorchester Pit for CBM Aggregates to support a Site Plan Amendment.
Resource and Hydrogeological Investigation – CBM (2018) Thamesford, Ontario	Project Director and Senior Technical Reviewer for aggregate resource and hydrogeological studies at the Thamesford Pit for CBM Aggregates to support a Site Plan Amendment.
Aggregate Licence Investigations – CBM (2018-present) Puslinch, Ontario	Project Director and Senior Technical Reviewer for hydrogeological, natural environment and cultural heritage studies at the Lake property for CBM Aggregates in Puslinch, Ontario.
Resource and Hydrogeological Investigation – CBM (2017) Puslinch, Ontario	Project Director and Senior Technical Reviewer for aggregate resource and hydrogeological studies at the Lanci Pit for CBM Aggregates to support a Site Plan Amendment.
Resource Evaluation – CBM (2017) North Dumfries, Ontario	Project Manager and Senior Technical Reviewer for an aggregate resource assessment at the Dabrowski Pit for CBM Aggregates.
Resource Evaluation – CBM (2017) Puslinch, Ontario	Project Manager and Senior Technical Reviewer for an aggregate resource assessment at the McNally Pit in support the expropriation of land for highway development at the McNally Pit for CBM Aggregates.
Resource and Hydrogeological Investigation – CBM (2016) North Dumfries, Ontario	Project Director and Senior Technical Reviewer for an aggregate resource evaluation and Level 1&2 Hydrogeological Assessment at the Dance Pit for CBM Aggregates in North Dumfries, Ontario.
Imported Fill Investigation – CBM (2016) Limehouse, Ontario	Project Manager for a soil sampling investigation to confirm imported soil quality at the CBM Pit near Limehouse, Ontario.
Resource Evaluation – CBM (2016) Orangeville, Ontario	Project Director and Senior Technical Reviewer for an aggregate resource evaluation at the Gray Pit for CBM Aggregates near Orangeville, Ontario.
Resource and Hydrogeological Investigation – CBM (2016) North Dumfries, Ontario	Project Director and Senior Technical Reviewer for an aggregate resource evaluation and Level 1&2 Hydrogeological Assessment at the Dance Pit for CBM Aggregates in North Dumfries, Ontario.
Aggregate Investigations - MTO Northeast (2015) North Bay, Ontario	Project Manager for aggregate investigations on numerous Crown land sites for MTO Northeast. Work included resource assessments, Level 1 / 2 Hydrogeological, Natural Heritage and Cultural Heritage Assessments, in support of Pit and Quarry Permits.
Resource Evaluation and Expert Testimony- Ministry	Provided specialized forensic engineering / geological advice and services related to aggregate resources on a property in northern Ontario. Work

of Transportation Ontario (2013-2014) Ontario	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.

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KEVIN M. MACKENZIE, MSc, PEng

Senior Business Practice Leader & Water Resources Engineer

Areas of practice

Hydrology, Hydraulics

Water Resources Engineering

Languages

English - Fluent

PROFILE

Mr. MacKenzie joined Golder Associates in 1997. Principal responsibilities include hydrologic and hydraulic modelling, design of hydraulic structures and erosion control measures and providing technical water resources support for a wide variety of environmental studies. Project experience includes unsteady hydraulic modelling of mixed sub and supercritical flood waves, prediction of flood flows from extreme design storms, flow monitoring and rating curve development, regional hydrological analyses, water budgets and balances, water management planning and consideration of fluvial geomorphology and ecological principles in design.

Water resources work has been completed for clients in the Power Generation, Power Transmission, Aggregate and Mining Sectors as well as Regional Government Agencies and Environment Canada.

Prior to joining Golder Associates, Mr. MacKenzie was involved in water resources research for four years, as part of his graduate studies, then as a research associate at the University of Guelph. Mr. MacKenzie has an excellent understanding of a wide variety of hydrology, hydraulics, soil erosion and fluvial geomorphology disciplines.

EDUCATION

PhD Candidate Water Resource Engineering, University of Guelph,	In Progress
MSc (Eng.) Water Resource Engineering, University of Guelph	1995
BSc (Eng.) Water Resource Engineering, University of Guelph Minor: Environmental Engineering	1993

PROFESSIONAL ASSOCIATIONS

Professional Engineers Ontario, since 1999	PEO
Engineers Nova Scotia, since 2018	Engineers NS

CAREER

Senior Principal, Water Resources Engineer, WSP Cambridge, ON	2022 -Present
Principal, Water Resources Engineer, Golder Associates Ltd., Cambridge, ON	1997 – 2021
Research Associate, University of Guelph Guelph, Ontario	1995 - 1996

PROFESSIONAL EXPERIENCE

HYDROLOGY/HYDRAULICS

- Moira River Flood Mitigation Alternatives Assessment, Foxboro, Ontario: Reviewed and updated floodplain mapping for the Foxboro area, identified several alternative flood mitigation alternatives ranging from floodways and hydraulic controls to lot level flood proofing. Alternatives were assessed and compared based on triple bottom line scores. Triple bottom line analysis considered detailed economic analysis using regions specific flood damage curves developed by Golder’s project partner.
- Atlantic Gold Hydraulic and Geomorphic Channel Assessments, Central Nova Scotia: Senior reviewer and technical advisor for hydraulic and fluvial geomorphic characterization and baseline studies for a mine development northeast of Halifax, Nova Scotia. Tributaries of 15 Mile Stream were inventoried and used as analogues to design channel diversions around proposed open pit mine excavations.
- Low Impact Development Treatment Train Tool (LID-TTT),GTA, Ontario: Team lead and hydrology advisor for development of a software tool for modelling and evaluating water balance and nutrient budgets for development sites. Worked with three large conservation authorities in the GTA, through several phases implementation of the LID-TTT, to progressively add model capability for assessing the benefits of various LIDs to support planning and early stage engineering of urban development sites.
- Garson Mine Water Management and Inundation Study, Sudbury, Ontario: Senior review and technical advice for flood inundation study downstream of the Vale Garson Mine near Sudbury Ontario. The study included an options assessment, development of improved water management operating practices and conceptual design of reservoir retrofits.
- International Falls Dam Rule Curve Cultural Study, Rainy River, Ontario: The effects of a recently updated operating rule curve at the International Falls Dam on water levels in Rainy River and the potential for changed water levels to affect locations of cultural significance are being investigated on behalf of the International Joint Commission on the Great Lakes.
- Credit River Floodline Mapping, Mississauga, Ontario: Golder completed the most recent comprehensive update of the flood risk investigation and floodline mapping for the Credit River between Old Derry Road and Lake Ontario. This reach alternately flows through an entrenched bedrock valley and remnant beach plains adjacent to Lake Ontario in the most urbanised part of Mississauga. Mr. MacKenzie served as project staff on this project.
- Water Quality Forecasting and Infrastructure, Annapolis Basin, Nova Scotia: Golder was part of a project team working with the Atlantic Innovation Fund / Applied Geomatics Research Group to develop a complex water quality forecasting tool for use by the shell fishing industry in the Digby Gut area. Real time weather forecasts were used to drive real time hydrology and database scenario models of runoff, water quality (bacteriological) and Bay of Fundy tidal fluctuations and their effects on contaminant movement in the Digby Gut. Hydrodynamic modelling was used to estimate contaminant movement and exposure of shell fishing areas to contamination. This information was packaged for use by shell fishers in order to minimize harvests of contaminated shellfish, thereby protecting the resource and minimizing post-harvest dupurification costs. Mr. MacKenzie was the hydrology and hydrometry technical lead for Golder on this project.

- Brookfield Homes – Channel Rehabilitation, Brantford, Ontario: Assisted a channel rehabilitation/stabilization assessment and associated 'field fit' design for Brookfield at a tributary of Fairchild Creek to address debris removal and channel instability - responsible for field investigations and construction supervision/inspections.
- River Diversion Design, Northern Ontario: Technical advisor for baseline channel hydraulics and fluvial geomorphic studies in support of a major mine development project in Northern Ontario to characterize baseline conditions at several stream channels, as well as to advance a conceptual design for a proposed diversion channel.
- Borer's Creek Modelling and Restoration Design, Dundas, Ontario: HEC-RAS modelling and assessment of a failing reach of Borer's Creek that threatened to expose a high-pressure natural gas pipeline. Design of remedial measures for failing banks and restoration of the affected reach. Coordinated regulatory approvals. The project was successfully implemented before the spring freshet and significantly reduced the risk of damage to the pipeline.
- Voisey's Bay Nickel Mine, Voisey's Bay, Labrador: A theoretical tailings dam breach was investigated using DAMBREAK to quantify potential impacts on an environmentally sensitive creek. Flood passage downstream of the breach was complicated by several small ponds and alternating sub and supercritical river reaches. Proposed mining operations at the Voisey's Bay nickel deposit require extensive management of surface waters. Five small dams were considered to safely convey clean water around the proposed tailings facility and to contain and treat tailings water. Modelling and design of the reservoirs and outflow structures was completed using GAWSER.
- Plains Midstream – Dechlorination and Approval, Sarnia, Ontario: Technical advisor for the design and permitting of a dechlorination system for the Plains Midstream fractionation plant in Sarnia, Ontario. The system is being designed to reduce the free chlorine concentration in the wastewater discharge. Golder is also preparing the ECA (Industrial Sewage Works) amendment package for the facility, to include additional Limited Operational Flexibility (LOF) for the facility for the additional of the dechlorination system, and future sewage work modifications. LOF for the facility will grant future modifications to the works through the appropriate MOE reporting progress, if a professional engineer can demonstrate the modifications will not alter the process discharge quantity and quality limits established for the facility.
- Channel Restoration Design, Algonquin Park, Ontario: Technical advisor for the hydraulic design of a stream re-alignment with associated grade controls at an historic train derailment site. Contaminated materials will be removed from the stream bed and banks and adjacent railway embankment. Removal of the contaminated materials will result in a net loss of stream substrate and a change to the fluvial geomorphology of the reach. Grade and stream bank controls were designed to minimize the risks of mobilizing residual contaminants and of significant channel migration.
- Omya – Stormwater Management Design and Approvals, Perth, Ontario: A review of existing stormwater management infrastructure was completed for an industrial mineral processing site near Perth Ontario. As a result of incremental development of the site, parts of the stormwater management infrastructure were found to be inadequate. Additional stormwater management works were conceptualized and submitted to MOE for approval. Following approval, Golder provided liaison with the local Conservation Authority, completed basic design drawings suitable for design-build and applied for permitting under the Conservation Authorities Act.

- OSSGA Carden Plain Cumulative Impact Assessment, Carden, Ontario: Due to the increased level of aggregate extraction activity in the Carden Plain area, the Ontario Ministry of the Environment (MOE) requested a multidisciplinary study and impact assessment to evaluate the potential cumulative impacts of quarry dewatering at multiple sites on groundwater, surface water and ecological receptors. Golder was retained by the Ontario Stone, Sand & Gravel Association to complete the required study. The project included extensive interaction with the MOE and the Ministry of Natural Resources (MNR). The objectives of the study were to screen out areas where cumulative impacts are unlikely, identify areas where cumulative impacts are likely, and to provide a preliminary assessment of the potential magnitude of predicted cumulative impacts. For the purpose of this study, a cumulative impact was defined as the additive effect of multiple quarry dewatering operations on groundwater, surface water and/or natural environment features. Golder was responsible for all aspects of this project including the development of the final field programs in consultation with personnel from the MOE. Mr. MacKenzie was the surface water lead for the project and participated in the public consultation aspects of the project.
- Technical Reviewer Contaminated Site Channel Design, Mississauga, Ontario: Golder was retained to review an options analysis and remedial channel design for a PCB contaminated channel in Mississauga. The remedial design included removal of the most contaminated material and design of a hardened channel lining to secure residual contaminants in-situ. Mr. MacKenzie reviewed the hydraulic channel analysis and design and provided a technical review report for consideration by the municipality and the channel designer.
- Contaminated Site Channel Stability Analysis, Welland, Ontario: Golder recently completed Phase IV of an assessment of 12 sites in the Niagara River Area of Concern that were identified in the RAP Stage 1 Update as requiring further assessment. The Phase IV study is a detailed assessment of remedial alternatives for the site including passive and intervention options. In support of the passive treatment options, Golder completed a detailed investigation of the complicated stream and wetland hydraulics of one of the sites on Lyon’s Creek. In the intervening years since the historic contamination, the site had developed into a wetland, which provided habitat for threatened plant and animal species. The hydraulic conditions were evaluated using one- and two-dimensional hydraulic models (HEC-RAS and RIVER-2D) to identify areas that are at risk for re-suspension of contaminated sediments and areas that are likely to accumulate new un-contaminated sediment with time. The results supported the passive treatment alternative. Mr. MacKenzie led the hydraulic investigation component of the Lyon’s Creek study.
- Confidential Mine Site Closure, Eastern Ontario: Technical advisor for comprehensive surface water investigations in support of a risk assessment at two former uranium mines near Bancroft, Ontario. The studies included meteorology and flow monitoring, water column profiling with a particular focus on lake stratification and turnover, and water quality sampling.
- Confidential Mine Site Closure, Northern Ontario: Technical advisor for surface water investigations, including streamflow studies, lake column profiling and water quality sampling, at a former nickel mine near Kenora, Ontario.
- OPG Atikokan – Environmental Compliance Approval, Northern Ontario: Technical advisor for the Environmental Compliance Approval ('ECA') Sewage (including Stormwater) amendment application for the Atikokan GS Biomass Conversion project. The study included a review of existing sewage works and associated ECA

and MISA conditions. Implications from the proposed site changes to the sewage works, consisting of process streams (Furnace Ash Treatment Plant, Condenser Cooling Water), sanitary sewage system/lagoons and the coal pile runoff pond, along with their associated ECA conditions.

- Confidential Manufacturing Client, Norval, Ontario: Baseline characterisation and impact assessment modelling of a proposed shale quarry in order to quantify and where necessary mitigate potential flow, water quality and thermal effects of the quarry on nearby watercourse and wetlands. Included conceptual design of mitigation measures and preparation of application materials for re-zoning and license under the Ontario Aggregate Resources Act.
- Big Bay Point Water Balance, Barrie, Ontario: Monthly and annual water budgets were prepared using the Thornthwaite Water Budget method. This water budget assessment was performed to determine the rate of marina water pumping required from the proposed development area at Big Bay Point, to the golf course and Environmental Protection Area in support of detailed design of stormwater management facilities to meet post-development peak flow targets. Mr. MacKenzie provided technical advice and senior review for this project.
- Baseline Hydrology Study for Proposed Mine, Ring of Fire, Northern Ontario: Technical advisor for baseline hydrology studies and effects evaluations in support of a major mine development project in Northern Ontario. Assessments were prepared as part of a multi-disciplinary Environmental Impact Statement (EIS) and Environmental Assessment (EA) under the Canadian Environmental Assessment Act (CEAA).
- Quarry License Expansion, Flamborough, Ontario: A level II hydrogeology study was completed in support of a rock quarry license expansion application. The surface water component of the study included establishment of eight continuous stream flow gauges and associated baseflow separation analysis. The baseflow separations were used to estimate mean annual recharge to groundwater. This information was provided to Golder hydrogeologists for use in estimating boundary conditions for the FEFLOW groundwater model. In addition, monthly and annual surface water balances were modelled using the Thornthwaite Water Budget method coupled to a GIS procedure. The fraction of surplus water that infiltrates was estimated using GIS and the method outlined in MOE 2003. The infiltration estimates were initially assumed to equal recharge. The resulting modelled groundwater levels were reviewed to identify areas of upward gradient or minimal downward gradient. This information was used in subsequent iterations to adjust the recharge estimates.
- Aggregate Site Water Use Study, Southern Ontario: Participated in a “typical water use” study for the aggregate industry. The study was initiated by the Aggregate Producers Association of Ontario (now the Ontario Stone Sand and Gravel Association) in preparation for planned changes, by the MOE, to the Permit to Take Water application process. Changes to the process were anticipated to include charges for water taking or use. The MOE was simultaneously working on new Source Water Protection legislation. As a result, the APAO felt it would be prudent to quantify actual water use versus maximum permitted water taking rate and to illustrate typical water use at aggregate sites.
- Aggregate Site Permitting and Approvals, Southern Ontario: Application packages including MNRF and MECP applications and supporting studies and reports have been prepared for numerous aggregate sites across Southern Ontario. Applications have been completed for aggregate pit and quarry licenses under the Aggregate Resources Act, Permits to Take Water (PTTW) to allow quarry dewatering and for

Environmental Compliance Approvals (ECA) under Section 53 of the Ontario Water Resources Act to allow offsite discharge of quarry and storm water.

- Simcoe County Groundwater Studies, Simcoe County, Ontario: A base flow survey was conducted to quantify groundwater discharge in a series of watershed in Simcoe County. The project was conducted in two phases, one for North Simcoe and one for South Simcoe. Water budget and average annual infiltration calculations were completed in support of groundwater modelling. Surface-groundwater interactions were estimated throughout the region to provide a water balance Hydrology Studies for Quarry Developments
- Ottawa Region, Ontario: A series of water resources investigations were completed for aggregate producing clients in the Ottawa area. The studies were completed in support of Certificate of Approval applications made under Section 53 of the Water Resources Act. Each study included a water balance analysis for the quarry and an estimate of future quarry discharge rates. These data were used to estimate the effects of quarry development on downstream water resources.
- Water Supply Studies, Sudbury, Ontario: Two municipal water supplies were investigated as Groundwater Under Direct Influence of surface water (GUDI). Surficial water resources were investigated, and a water balance was prepared in support of groundwater modelling studies.
- Hydrological Effects Assessment, Hagersville, Ontario: A long-term field monitoring programme was designed and implemented to track changes in flow regime resulting from closure of an underground Gypsum mine. Part of the mine was closed and allowed to flood. Three flow monitoring stations were established in Boston Creek, which flows over the mine. The stations were selected to represent background conditions upstream of the mines influence, conditions above the mine and downstream of the mine influence. Data loggers and transducers were installed to continuously (hourly) record water levels and flows in the creek.
- GORO Nickel Mine, New Caledonia: The GORO Nickel mine is located in an area of extreme precipitation. Hydrological and preliminary erosion assessments were completed in support of mine development planning and design. These data were used, by the multi-disciplinary project team, to design tailing basin capacities, diversion ditches and dams.
- Round Lake Water Level Control Study, Engelhart, Ontario: Flow exiting Round Lake flows down several kilometres of a very mild sloped reach of the Blanche River before cascading down a set of rapids at a rock outcrop. The rock outcrop was historically blasted to facilitate log driving practices. This modification has caused large fluctuations in water levels in Round Lake and the Blanche River. A hydrological and hydraulic study of the river and lake were completed and a fish-friendly rock-fill weir was designed to stabilise water levels.
- Bruce Nuclear Generating Station, Bruce County, Ontario: Participated in background water quality assessments in the surrounding environment. This work included water quality sampling in Baie du D’Or and Lake Huron. The data were used to assess potential effects of the generating station on the quality of surrounding water resources.
- Pickering-A Nuclear Generating Station, Pickering, Ontario: A multi-disciplinary environmental assessment was completed for the re-start of four CANDU reactors at the Pickering A generating station. A comprehensive review of existing water quantity and quality data was completed. Potential effects, of operating the station, on surrounding water resources were identified and evaluated.

- Falconbridge Smelter Area Closure, Falconbridge, Ontario: Performing a detailed analysis of water quantity and quality to address potential long-term impacts of the closure on the watersheds of Coniston and Emery Creeks. A daily water budget and reservoir routing model was implemented on a spreadsheet to investigate the efficiency of a variety of different closure scenarios. Also involved in hydrometry, automated water level monitoring, water quality sampling, hydrologic modelling.
- Fire Water Intake, Blind River, Ontario: Alternative designs for a fire water intake structure modification were assessed to minimise maintenance and sediment deposition and increase safety. Two-dimensional finite element flow modelling of the intake environment and one dimensional, coupled, unsteady, sediment and hydraulic modelling of the river reach was completed. Modelling results indicated that relocating the intake structure would reduce the risk of failure resulting from sediment accumulation.
- Asacha Gold Mine, Russia: The Asacha gold mine lies close to the divide between a pristine watershed and a partially developed watershed. Hydrologically modelled areas potentially affected by mining operations to aid in developing a safe and detailed water management plan.

LINEAR INFRASTRUCTURE

- Trans Canada Pipelines Vaughan Mainline Expansion, Vaughan, Ontario: Senior technical advisor for baseline hydrology studies, effects assessments and permitting, in support of the environmental and socio-economic assessment (ESA) under the National Energy Board (NEB) filing process and construction planning and design for a ~12 km pipeline expansion in the Greater Toronto Area.
- Trans Canada Pipelines Eastern Mainline Expansion, Vaughan, Ontario: Senior technical advisor for baseline hydrology studies, effects assessments and permitting in support of the environmental and socio-economic assessment (ESA) under the National Energy Board (NEB) filing for the Eastern Mainline Expansion in Ontario (~260 km long gas pipeline through central and eastern Ontario).
- Trans Canada Pipelines Parkway West Connection, Vaughan, Ontario: Senior technical advisor for baseline hydrology studies, effects assessments and permitting, in support of the environmental and socio-economic assessment (ESA) under the National Energy Board (NEB) filing process for a local service connection in the Greater Toronto Area.
- Trans Canada Pipelines Kings North Connection, Ontario: Surface water discipline lead for the Kings North Connection Project, including baseline hydrology studies and effects assessments in support of the environmental and socio-economic assessment (ESA) under the National Energy Board (NEB) process. Scour assessments, sag-bend setback recommendations and permitting were also completed to support construction activities.
- Pipeline Corridor Investigations, Timmins, Ontario: A pipeline was proposed to slurry tailing from the Kidd Metallurgical Site to the Kidd Mine, approximately 35 km away. The tailings are to be used for paste back-filling of depleted areas of the underground mine. An environmental review of water resources along the proposed pipeline corridor was completed. Larger watercourse crossings were mapped, and directional drilling was proposed to mitigate environmental effects.
- Trans Canada Pipelines Borer’s Creek Modelling and Restoration Design, Dundas, Ontario: HEC-RAS modelling and assessment of a failing reach of Borer’s Creek that threatened to expose a high pressure natural gas pipeline. Design of remedial measures for failing banks and restoration of the affected reach. Coordinated regulatory approvals. The project was successfully implemented before the spring freshet and significantly reduced the risk of damage to the pipeline.

CLIMATE *CHANGE*

- Senior review and technical advisor for an assessment of potential climate change effects and vulnerabilities on a multi-site water management system including eight reservoirs, flooded underground mine works, an active smelter complex, a water treatment plant and associated dams and infrastructure. A Goldsim model of the water management system was constructed and validated. Ensemble Global Circulation Model (GCM) results, from approximately ninety model runs, were obtained for the 2050 horizon. Monte Carlo simulations were used to simulate daily weather patterns constrained by the GCM results and the same daily weather patterns were used to model a potential future range of water management scenarios using the Goldsim water management model.
- Goldcorp Sudbury Integrated Nickel Operations – East End Infrastructure Assessment, Sudbury, Ontario: Evaluated climate change risks to several small flow conveyance structures including culverts, pipes and flow measurement structures. Peak flows from small sub-catchments are typically sensitive to short duration intense precipitation events. A trend analysis and curve fitting exercise was completed on observed maximum annual events, over recent site history, for a range of event durations ranging up to 24 hours. The trend analysis was used to estimate potential changes to Intensity-Duration-Frequency statistics at the 2050 horizon. This information was used to assess the capacity of existing flow conveyance infrastructure in small sub-catchments.
- Meteorological Service of Canada – Environment Canada, Ottawa and across Canada: Participated on a national research team studying the effects of climate change on hydrological variables. Contribution to the study was to complete a regionalization study based on measured hydrologic variables from the Reference Hydrometric Basin Network (RHBN) including mean annual flow, lowest annual daily flow and peak annual daily flow. The data series were grouped according to their similarity using a cluster analysis routine. The homogeneous hydrologic regions identified by this method were compared to hydrologic regions identified in previous studies using meteorological and physiographic variables. Cluster analysis results consistently identified three homogeneous regions in the British Columbia mountains as well as several regions in Ontario, the Maritimes and along the St. Lawrence. The study demonstrated a significant lack of RHBN coverage in the northern part of the Prairie Provinces and the North West Territories, such that homogenous regions, if they exist in these areas, could not be identified by cluster analysis.
- Infrastructure Ontario (Ontario Realty Corp.) – Infrastructure Climate Risk Assessment, Ontario: Completed the water resources and drainage components of a climate risk assessment on three typical buildings owned by Infrastructure Ontario. Risk was assessed using guidance provided in Engineers Canada’s PIEVC protocol. Co-led focus group workshops with building operators and subject matter experts to assess potential future risk.
- Iqaluit Water Supply, Nunavut: Senior technical reviewer for a climate risk investigation of the Town of Iqaluit’s water supply. A Goldsim model was developed for the lake-based water supply. Various scenarios were investigated to assess the vulnerability of the supply to climate change.
- BHP Billiton, Elliot Lake, Ontario: Technical advisor for applying climate change projections to extreme precipitation events used to assess potential climate change implications for tailings storage facilities and water management ponds. This work was completed as a part of the Dam Safety Surveillance and Management program at BHP Billiton’s closed Canadian and U.S. sites.

SOURCE WATER PROTECTION

- Ontario Clean Water Agency, Lake Ontario, Canada: Hydrology and river boundary conditions lead for the Ontario Clean Water Agency (OCWA) Lake Ontario Decision Support System (DSS). OCWA, in partnership with GTA municipalities, is developing a DSS for managing Lake Ontario based drinking water intakes. Golder teamed with DHI to develop a hydrodynamic, thermodynamic and water quality model to integrate into a web-based forecasting platform for Lake Ontario. The system is expected to go live in 2021 to provide municipalities with the advance information to anticipate and mitigate the effects of accidental spills on water supply infrastructure.
- Source Water Protection: Midland and Penetanguishene Tier 3, Midland, Ontario: Surface water lead for the Midland and Penetanguishene Tier 3 water budget and water quantity risk level assessment. This study involved implementation of a combined surface and groundwater model using MIKE-SHE. The modelled recharge distribution was applied to a groundwater model developed by Golder using FEFLOW in order to further refine drawdown effects in close proximity to wells and surface water features. The study area included the whole of the Midland Peninsula and areas of provincially significant wetlands in close proximity to municipal wells with GUDI designation. Groundwater and surface water interactions, both recharge and discharge areas were significant in spatial scale and an important part of this project.
- Source Water Protection: Peer Reviewer York Region Tier 3, York Region, Ontario: Peer reviewer for the surface water components of the ongoing York Region Tier 3 water budget and water quantity risk level assessment for the area between and surrounding Aurora and Stouffville. The project team is proposing to use GSFLOW to model both the surface and groundwater systems. GSFLOW is an integrated surface and groundwater hydrology model developed by the US Geological Survey, based on MODFLOW and PRMS components. The study area is complex as it includes the southern flank of the Oak Ridges Moraine and straddles the divide between Lake Ontario and Lake Simcoe. Stouffville is in the headwaters of the Rouge River watershed.
- Source Water Protection: Peer Reviewer Halton Hills Tier 3, Halton, Ontario: Peer reviewer for the surface water components of the ongoing Halton Region Tier 3 water budget and water quantity risk level assessment for the Georgetown and Acton areas. The project team used MIKE-SHE to model surface and groundwater hydrology and applied the modelled recharge distribution to FEFLOW to provide further discretization around key areas of interest including wells and surface water features. The study area is complex as it includes the Niagara Escarpment, the Acton re-entrant valley and several buried bedrock valleys which are believed to play and important role in delivering groundwater to the area. The study area also straddles the divide between the Grand River and Credit River watersheds.
- Source Water Protection: Peer Reviewer Orangeville Tier 3, Orangeville, Ontario: Peer reviewer for the surface water components of the ongoing Orangeville, Mono and Amaranth Pilot Tier 3 water budget and water quantity risk level assessment. The project team is using HSPF and MODFLOW to model surface and groundwater hydrology respectively. The study area is complex as it includes the Niagara Escarpment and the Oak Ridges Moraine. The study area also straddles the divides between the Grand River, Credit River and Nottawasaga River watersheds.
- Source Water Protection: Peer Reviewer CTC Tier 1 and Tier 2, Southern Ontario: Peer reviewer for the surface water components of the Tier 1 and Tier 2 water

quantity stress assessments for the CTC Source Protection Region, which includes the Credit River (CVC), Toronto Region (TRCA) and Central Lake Ontario (CLOCA) watersheds. Data availability and modelling approaches used by the different conservation authorities and their consultants varied across the CTC region.

- Source Water Protection: Lower Speed River (Guelph) Tier 3, Guelph, Ontario: Golder Associates teamed with AquaResource to complete a Tier 3 water budget and water quantity risk level assessment for the Lower Speed River watershed. The study area includes the City of Guelph, part of Cambridge and contributing drainage and recharge areas located north and east of Guelph. An extensive baseflow survey was conducted across the study. Baseflow was measured at thirty-two locations during the spring, summer and autumn of 2008. This information was used to estimate varying groundwater discharge and recharge rates to support definition of boundary conditions for the groundwater model.

- Source Water Protection: Nickel District CA Valley East Tier 3, Sudbury, Ontario: Senior technical advisor for the Valley East Tier 2 and Tier 3 water quantity stress assessment. The City of Sudbury draws drinking water from several wells located in the Valley East area. Worked with project team to identify a modelling approach that would make the best use of, sometimes limited, existing data. The Tier 2 results led to the initiation of the Tier 3 Local Area Water Budget for the groundwater supply in Valley East.

- Source Water Protection: Ramsay Lake Tier 1 and Tier 2, Sudbury, Ontario: Senior technical advisor for the Ramsay Lake Tier 3 water budget and water quantity risk level assessment. The City of Sudbury draws water directly from Ramsay Lake for part of its drinking water supply. Ramsay Lake and its contributing drainage areas are being modelled using HEC-HMS (Hydraulic Engineering Corps - Hydrological Modelling System). Based on existing information, it appears that the hydrology of Ramsay Lake is dominated by surface water inputs and as such, there is no plan to include groundwater modelling at this time. HEC-HMS will be used to complete the risk level assessments. Additional field data collection has been initiated to fill existing data gaps regarding key inflows to the lake and the outflow adjacent to Science North.

- Source Water Protection: Bronte Creek, Halton, Ontario: Golder Associates were commissioned to undertake a Threats Assessment of a potential intake at Bronte Creek. Mr. MacKenzie directed the project for Golder. The intake, intended to deliver surface water to a small water treatment plant, was identified as one potential alternative for providing a drinking water supply to nearby residential properties possibly affected through the construction of an adjacent quarry. The Threats Assessment identified eleven water quality issues at the potential intake location, attributing causes to a number of likely contaminant sources throughout the watershed. In accordance with MOE Draft Guidance Modules, the work undertaken as part of this assessment included stakeholder liaison, hydraulic modelling, IPZ delineation, vulnerability analysis, the compilation of issues and threats inventories and a description of data knowledge gaps. Should surface water abstraction from Bronte Creek be identified as the preferred alternative for providing long-term drinking water supply, this Threats Assessment report will provide the basis for the Tier 2 assessment.

- Source Water Protection: Timmins IPZ Study, Timmins, Ontario: An Intake Protection Zone (IPZ) and the vulnerability scores for the City of Timmins drinking water treatment plant on the Mattagami River were assessed. The delineation of the IPZ included the consideration of river flow conditions, influences of dam operation, location of significant potential upstream sources of contamination, local transportation routes, storm sewer drainage patterns and the behaviour of spills in the river. The project also included the collection of site-specific data through a field program. The field program used non-conventional methods to measure travel time due to restrictions on the use of dye tracers in the river because of the presence of private drinking water intakes. The field program collected detailed velocity data that was used to estimate dispersion and to calibrate a HEC-RAS model that was used to predict the travel time under various flow conditions.

WASTE MANAGEMENT

- Barrie Landfill Reclamation, Barrie, Ontario: Technical advisor for stormwater management modelling and conceptual stormwater infrastructure design. The project included a significant removal and replacement of historic municipal waste. Daily and permanent cover design required new stormwater management strategies and facility design. Interacted with groundwater modellers to develop representative and conservative boundary conditions for modelling.
- Nexcycle, Southern Ontario: Technical advisor in support of the ECA (Sewage) application package for a glass recycling facility. The project included conceptual design of Best Management Practices and source controls to improve stormwater quality.
- Eagleson Landfill Brookside Creek Channel Design, Northumberland, Ontario: Ongoing support regarding a channel remediation design/assessment for the County of Northumberland 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.
- Edgewood Landfill Monitoring, Flamborough, Ontario: Designed and implemented a flow and water quality monitoring programme to assess potential historic effects of watercourses surrounding the closed Edgewood Landfill site in Flamborough Ontario. This work was completed as part of an inventory and assessment of historic landfill operations in the City of Hamilton.
- Bath CKD Landfill Design and Monitoring, Kingston, Ontario: Monitored existing water quality and flows associated with an existing Cement Kiln Dust landfill. Designed stormwater control measures for design of a new landfill cover for the existing landfill as well as four new cells to increase the capacity of the landfill.
- Brow Landfill Storm-water Management Plan, Flamborough, Ontario: Developed a storm-water management plan to address drainage requirements for the site and mitigation measures required to control potential impacts as part of the closure process. Designed drainage channels, a stormwater management pond, hydraulic flow control structures and a drop structure to safely convey stormwater over the edge of the Niagara Escarpment into a purpose designed plunge pool.
- Adams Mine Landfill, Kirkland Lake, Ontario: Completed a baseline hydrology assessment including flow and water quality monitoring as part of an investigation into the feasibility of a proposed land-filling operation at Adams Mine. Monitoring included flow measurements from boats in medium to large rivers.

PUBLICATIONS AND PRESENTATIONS

Publications

MacKenzie, K.M., Singh, K., Binns, A.D., Whiteley, H.R. and Gharabaghi, B., 2022. Effects of urbanization on stream flow, sediment, and phosphorous regime. Journal of Hydrology, 612, p.128283.

MacKenzie, K.M., Gharabaghi, B., Binns, A.D. and Whiteley, H.R., 2022. Early detection model for the urban stream syndrome using specific stream power and regime theory. Journal of Hydrology, 604, p.127167.

Rose, G. T and MacKenzie, K. M. (2013). Water Quality Forecasting and Infrastructure Optimization System. Meeting #68 of the Atlantic Coastal Zone Information Steering Committee (ACZISC). Bedford Institute of Oceanography, Halifax, Nova Scotia, January 16-17, 2013.

S. I. Ahmed, K. MacKenzie, B. Gharabaghi, R.P. Rudra, W.T. Dickinson. (2011). Within-storm rainfall distribution effect on soil erosion rate. ISELE Paper Number 11000. International Symposium on Erosion and Landscape Evolution. Anchorage, Alaska September 18-21, 2011.

Bell, J., K. MacKenzie and J. Southwood. (2011). Down Under Up North - Could an Australian water- sensitive urban design project work in the Canadian context? Water Canada July/August 2011.

DeVito, C. and MacKenzie K. (2011). Critical Shear Velocity Estimates Improved with In-Situ Flume. 20th Canadian Hydrotechnical Conference, Ottawa Ontario June 14th to 17th 2011.

Davidson C. and MacKenzie K. (2011). Golder Daily Climate Record Generator. 20th Canadian Hydrotechnical Conference, Ottawa Ontario June 14th to 17th 2011.

Mackenzie, K.M., R.P. Rudra and W.T. Dickinson. (1996). Modelling the inter-rill detachment process: Some considerations for improving model results. ASAE Paper No. NABEC96-94, Amer. Soc. Agr. Engr., St. Joseph, MI.

MacKenzie, K.M., R.P. Rudra and W.T. Dickinson. (1995). The effect of temporal distribution of rainfall on inter-rill detachment. ASAE Paper No. 95-2378, Amer Soc. Agr. Engr., St. Joseph, MI.

Presentations

MacKenzie, Kevin. (2009). Industrial Wastewater Approvals. Canadian Environmental Compliance Conference and Trade Show (CANECT). Metro Toronto Convention Centre, April 2009.

MacKenzie, Kevin. (2007). Industrial Wastewater Approvals. Canadian Environmental Compliance Conference and Trade Show (CANECT). Metro Toronto Convention Centre, April 2007.

CRAIG M. J. DE VITO, PEng

Water Resources Specialist

Areas of practice

Water Resources Engineering

Languages

English – Fluent

PROFILE

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 and sediment control inspection.

EDUCATION

BSc Engineering (Co-op), University of Guelph, Guelph, Ontario	2007

CAREER

Water Resources Specialist, WSP, Mississauga, ON	2007 – Present
Co-Op , Water Resources, Golder Associates Ld. (WSP Acquisition), Mississauga, ON	May 2006 – Dec 2006
Co-Op Student, University of Guelph, Environmental Biology, Guelph, ON	May 2005 – Aug 2005
Co-Op, Water Resources, Ontario Clean Water Agency – Toronto, ON	Jan 2005 – Apr 2005
Co-Op Student, Hydromantis Inc., Consulting Engineers – Toronto, ON	Jun 2004 – Sept 2004

PROFESSIONAL EXPERIENCE

Water Supply Forecasting

- City of Iqaluit, Nunavut, Canada (2012 to 2013): Developed a water balance model (using GoldSim) to quantify water deficit risks under future population growth and climate change scenarios. Analytical output and recommendations were subsequently provided in order to assist the City in water license application process for a supplementary source and provide a risk matrix of long-term probabilistic water supply deficits.
- City of Rankin Inlet, Rankin Inlet, Nunavut, Canada (2015): Water supply deficits were evaluated using a water balance model (using GoldSim) under future growth and climate change scenarios. The model evaluated water taking from the supply reservoir and an adjacent river while maintain use for aquatic live and social activities.

Channel / Crossing Design

- County of Northhumberland, Cobourg, Canada (2009 to 2015): 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, Whitby, Canada (2014 to 2016): 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.
- Confidential Client, Timmins, Canada (2015): Ongoing support of a natural channel diversion design/assessment for a proposed pit mine. The channel design incorporates fluvial geomorphic processes to accommodate fish passage and habitat. Hydraulic modelling was conducted to limit erosion and maintain stability of the channel banks and crossings.
- Canadian National Railway, Southern Ontario, Canada (2016 to 2020): 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.
- Trans Canada Pipelines Channel Rehabilitation, Dryden, Ontario, Canada (2017): Designed a stream channel rehabilitation to remediate TransCanada Line 100-1 exposure caused by erosion and beaver activity near Dryden, Ontario. The project progressed from conceptual design through to construction monitoring. The final design was focused on improving channel stability over the pipelines to reduce meander and erosion.
- Trans Canada Pipelines Channel Rehabilitation, Barrie, Ontario, Canada (2016 to 2017): Developed the design and supported construction of channel rehabilitation works at a tributary of Bear Creek that is crossed by TransCanada pipelines Line 100-1 and Line 100-2 near Barrie, Ontario. The goal of the rehabilitation is to improve long term channel stability at the watercourse crossing. The work includes the completion of field studies and hydraulic modelling, development of conceptual designs, and the preparation of environmental permitting.

Erosion and Sediment Control

- Prodigy Gold Inc., Wawa, Ontario, Canada (2021 to 2022): Completed Erosion and Sediment Control Plans for a variety of earth work projects at the Magino Mine Project. These plans for stream diversions, embankments and shorelines were completed as part of a LRIA permitting package.
- Prodigy Gold Inc., Wawa, Ontario, Canada (2021): Managed the monitoring and inspection of erosion and sediment control measures site-wide that included various earth work projects. The continuous monitoring was responsible for identifying erosion and sedimentation issues and recommend corrective actions.

Environmental Compliance Approvals, Water Discharges

- Canadian National Railway, Algonquin Park, Ontario, Canada (2015 to 2017): 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 nearby lake within the Park.

- Essroc Aggregates, Cambridge, Ontario, Canada (2016 to 2017): Managed and completed an Environmental Compliance Approval for Industrial Sewage Works for an aggregate pit and wash plant in Cambridge, Ontario. The application included supporting documentation of the wash ponds which only discharged to the environment through the groundwater.
- Fish and Bird Emporium, Innisfil, Ontario, Canada (2016): 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.
- Lafarge Canada Inc. – Soares, Dundas, Ontario, Canada (2007 to 2009): Carried out field investigations, water budget analysis and coordinated various project tasks related to the proposed Lafarge Soares License Application.
- Amherst Quarries Ltd., Windsor, Ontario, Canada (2008): Performed reconnaissance of the local watersheds and hydrologic features of the quarry sumps. Carrying out quarterly volumetric flow monitoring and water quality sampling. Local drainage channels were evaluated using computer models including HEC-RAS. Developed a water balance to model drainage from the site and the adjacent Canard River.
- O'Shanter Development Company – Arbour Farms Dufferin, Ontario, Canada (2007 to 2021): Conducting annual dry weather volumetric flow monitoring and groundwater well monitoring related to the Arbour Farms assessment of the proposed quarry.
- Brampton Brick – Norval, Norval, Ontario, Canada (2007 to 2008): Performed field investigations and coordinated various project tasks related to the proposed Brampton Brick Norval quarry development.
- Lafarge Canada Inc. West Paris, Ontario, Canada (2016 to 2022): Completed baseline monitoring, including flow and water level monitoring, water quality monitoring. Supported license applications for extension properties and Permit to Take Water applications and continued site plan monitoring.
- Lafarge Canada Inc. Wellington, Ontario, Canada (2015-2022): Conducted baseline investigations of site drainage, local watercourses, including the Speed River. Potential impact on the water resources as a result of below water extraction was evaluated to support Permit to Take Water Applications and Environmental Compliance Approvals.
- Lafarge Canada Inc., Woodstock, Ontario, Canada (2015-2022): Completed water quality, water level and flow monitoring at local water features. Developed potential effects assessment of quarry extraction and drain realignments in support of a Major Site Plan Amendment.
- Nelson Aggregate Company, Burlington, Ontario, Canada (2006 to 2007): Carried out volumetric flow monitoring throughout neighbouring watersheds for the proposed Lafarge Nelson License Application. Performed wetland mapping on the proposed quarry site.
- CBM Aggregates, Various Sites in Southern Ontario (2007 to 2022): 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.

Site Rehabilitation

- Client Confidential, Bancroft, Ontario, Canada (2010 to 2022): 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, Near Kenora, Ontario, Canada (2009 to 2018): 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.
- Niagara Peninsula Conservation Authority, Welland, Ontario, Canada (2009 to 2010): Completed stream sediment investigations on Lyon's Creek, downstream of the Welland Canal, including a stream survey, sediment sampling, loading, scour and re-suspension analysis. Reported investigation results as part of the Niagara River remedial options.
- Lafarge Canada Inc., Bath, Ontario, Canada (2006 to 2008): Reporting annually on volumetric flow monitoring and water quality data collected monthly on and adjacent to the Lafarge Bath cement kiln dust landfill and rehabilitation. Engineering drainage features on site was also completed.
- Canadian Gypsum Company Ltd. Haggersville, Ontario, Canada (2006 to 2015): Performing volumetric flow monitoring, water quality and continuous water level monitoring on Boston Creek adjacent to the mine site. Annual reporting was also conducted until rehabilitation completion.

Threats Assessment

- Hanson Brick Ltd. – Tremaine Bronte Creek, Burlington, Ontario, Canada (2008): Evaluated the risks of a potential drinking water intake on Bronte Creek. Risks in the watershed were evaluated and analysed using plume dispersion algorithms to estimate contaminate impacts on the potential intake. Evaluation was completed using computer models including HEC-RAS.
- Teck Resources, Elk Valley, British Columbia, Canada (2013 to 2015): Conducted water quality modelling to support mine site investigations for a mining project in British Columbia. Water quality parameters were modelled 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.

Urban Water Management

- Metrolinx, Toronto, Ontario, Canada (2017 to 2018): 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.
- Toronto Transit Commission, Vaughan, Ontario, Canada (2018 to 2019): Task Manager of the stormwater monitoring and reporting as part of the ECA requirements at the 407 subways station. The monitoring involved storm event water quality monitoring to evaluate Stormwater Management Pond performance, erosion and sediment control inspections, annual reporting and recommendations for performance improvements.

- Town of Oakville, Oakville, Ontario, Canada (2008 to 2012): 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).
- City of Barrie, Barrie, Ontario, Canada (2008): Performing volumetric flow monitoring under flash flooding or melting conditions in areas of low permeability in the City of Barrie.
- Black and McDonald Ltd. – Castrol, Toronto, Ontario, Canada (2007): Conducted reconnaissance and water quality sampling regarding the Castrol Oil storm water discharge to the city storm sewer. Testing performance of the on-site water treatment equipment and evaluating replacements.

Mining Operations and Exploration

- Adrianna Resources, Lac Otelnuk, Quebec, Canada (2010): Conducted transducer installations and collected cross sectional geometry information at surface water points of interest influencing site drainage and watersheds adjacent to Lac Otelnuk.
- Xstrata, Copper, Las Bambas, Peru (2008): Conducted transducer installations at surface water points of interests influencing the site drainage and watersheds located on and adjacent to site Las Bambas.
- Xstrata, Copper, Antapaccay, Peru (2008): Conducted transducer installations at surface water points of interests influencing the site drainage and watersheds located on and adjacent to site Antapaccay.
- Xstrata, Nickel, Loma Miranda, Dominican Republic (2007 to 2010): Managed and carried out quarterly field campaigns for Loma Miranda and Energy Conversion Project, which involved installation and monitoring of river hydrology, water quality sampling and rain data collection. Quarterly reporting was conducted, summarizing campaigns.

Pipeline Work

- Trans Canada Pipelines, New Gas Line, Vaughan, Ontario, Canada (2017 to 2018): 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.
- Trans Canada Pipelines, New Gas Line, South Eastern, Ontario, Canada (2015 to 2016): Completed watercourse baseline investigations for Eastern Mainline Expansion in Ontario (260 km long new gas pipeline spanning central and eastern Ontario). Responsible for field data collection of baseline conditions at major watercourse crossings and evaluating the hydrotechnical characteristics of each potential crossing.
- Trans Canada Pipelines Gas Line Construction, Brampton, Ontario, Canada (2018-2020): Designed drainage improvements at a gas pipeline valve station to control flooding in the area to allow maintenance staff to work safely. The work involved conservation authority permitting and negotiation with landowners and other stakeholders.

Environmental Assessment and Permitting

- Walker Environmental Group Inc. Ingersol, Ontario, Canada (2018-2019): Completed baseline evaluation and impact assessment for the proposed landfill in the Town of Ingersol. This included the flow and water quality monitoring of the Thames River and local tributaries. Desktop analysis of the potential impacts utilized hydrologic models, climate change predictions, water quality models and stormwater design.
- Marten Falls First Nation, Marten Falls, Ontario, Canada (2019-2020): Drafted existing surface water conditions report and impact assessment to support the proposed all season road from Marten Falls to Nakina Ontario. This work involved watercourse crossing surveys utilizing helicopter transportation. The field studies visited a subset of the crossings to evaluate the impacts of the road alignment.
- NextBridge, Northern Ontario, Canada (2018): Completed water quality and hydrotechnical analysis to support the NextBridge Infrastructure East-West Tie Transmission Line Project in Northern Ontario (430 km long new transmission line). Conducted baseline studies, effects evaluations, permitting support through hydrotechnical analysis and preliminary design criteria.
- Hydro One, Northern Ontario, Canada (2019-2022): Completing baseline evaluation and impact assessment for the proposed power transmission corridor from Thunder Bay to Dryden. This work involved watercourse crossing surveys in remote areas of a subset of the crossings to evaluate impacts of the proposed transmission line corridor.

JEFF RANDALL, MASc, PEng

Lead Geological Engineer

Areas of practice

Hydrogeology, Groundwater Modelling

Languages

English - Fluent

PROFILE

Mr. Randall is a geological engineer in Golder's Cambridge office, specializing in numerical groundwater modelling and data management, analysis, and visualization. Mr. Randall has experience with database applications and tools such as MS Access and Visual Basic for Applications, and conceptual model development and data visualization software such as ArcGIS, Surfer, and Tecplot. Mr. Randall has numerical modelling experience with software including FEFLOW, Visual MODFLOW, MODFLOW-Surfact, Groundwater Vistas, and HydroGeoSphere.

Recently, Mr. Randall has been responsible for the construction and calibration of regional and local scale groundwater flow and transport models in support of environmental impact assessments in Canada and internationally.

EDUCATION

MASc, Civil Engineering, University of Waterloo	2005
BASc, Geological Engineering, University of Waterloo	2003

PROFESSIONAL ASSOCIATIONS

Professional Engineers Ontario, since 2013	PEO

CAREER

Lead Geological Engineer, Mine Water, WSP	2022 – Present
Geological Engineer, Mine Water, Golder Associates Ltd., Cambridge, ON	2008 – 2021
Associate Engineer, HydroGeoLogic, Inc., Kitchener, ON	2005 – 2008
Research Assistant, Civil Engineering, University of Waterloo, Waterloo, ON	2003 – 2005

PROFESSIONAL EXPERIENCE

Numerical Modelling

York Region Ontario, Canada - Lead modeller for an update and re-calibration of the York Tier 3 regional groundwater model to reflect a new conceptual hydrogeological model. The updated model was used to develop new WHPA and Vulnerability Scoring assessments for new and existing regional pumping wells.

Confidential Client, USA - Lead modeller for construction and calibration of 2D / quasi-3D cross-sectional FEFLOW models in support of Life-of-Mine stability assessment for an open-pit mining operation. Simulations to match historical pit conditions and future mine plans were completed. Predictive simulations of dewatering plan designs were completed to support geotechnical slope stability assessments.

Teck Frontier Project, Alberta, Canada - Responsible for the compilation and analysis of hydrogeological data as well as the construction and calibration of regional groundwater flow models. Predictive numerical models were constructed and simulated in support of the impact assessment to estimate seepage from tailings storage areas.

Brukunga, South Australia, Australia - Constructed a local-scale 3D groundwater flow model (FEFLOW - converted toHydroGeoSphere) to support on-going rehabilitation efforts at the site. The model was used in the evaluation of proposed co-disposed tailings impoundment designs.

Eastbank Aquifer, System - Public Utility District 1 of Chelan County, Washington State, USA - Modelling lead for construction and calibration of a local-scale 3D groundwater flow and heat transport model (FEFLOW) to support operational planning at the Public Utility District. Model calibration was completed using parameter estimation software (PEST) and focused on transient groundwater temperature and hydraulic head data. The model was used to simulate the hydraulic and thermal aquifer responses to possible future external stresses.

PCS - Patience Lake, Saskatchewan, Canada - Constructed and calibrated regional- and local-scale 3D groundwater flow and transport simulation models (FEFLOW) to support on-going groundwater management operations at the Patience Lake Site. These models were used to evaluate potential brine migration pathways / mechanisms and help in the development of groundwater containment strategies.

Key Lake Tailings Management Facility, Saskatchewan, Canada - Developed and calibrated multiple regional-scale 3D groundwater flow simulation models (MODFLOW) to support the preparation of an Environmental Impact Assessment. These models were constructed to include updated site hydrogeological data and were used to evaluate the groundwater system response (groundwater quantity and quality) to numerous possible future operational conditions.

Vale – Saskatchewan Potash Project, Saskatchewan, Canada - Constructed a regional-scale numerical groundwater flow model (MODFLOW) for a proposed potash mine site in Saskatchewan. This model was used to help guide additional hydrogeologic drilling programs and to identify potential seepage pathways from proposed salt storage facilities at the mine site.

Western Potash - Milestone Project, Saskatchewan, Canada - Developed a regional-scale 3D numerical MODFLOW model to assess possible hydrogeologic impacts and to determine potential seepage pathways from a proposed potash mine in Saskatchewan.

Potash One – Legacy Mine, Saskatchewan, Canada - Developed regional- and local-scale 3D numerical MODFLOW models in support of an Environmental Assessment for a proposed potash mine in Saskatchewan. The purpose of the model was to determine potential transport pathways from proposed on-site salt storage facilities.

Agrium - Triton Mine, Saskatchewan, Canada - Constructed and calibrated regional- and local-scale 3D numerical MODFLOW models in support of an Environmental Assessment for a proposed potash mine in Saskatchewan. The modelling was completed to assess any potential impacts of groundwater pumping withdrawals and to evaluate potential transport pathways from the proposed mine site.

Key Lake Tailings Management Facility, Key Lake, Saskatchewan, Canada - Responsible for the completion of a regional-scale 3-D groundwater flow model (MODFLOW). This model was used to gain a better understanding of the groundwater flow system and evaluate groundwater responses to several potential pump-and-treat operations at the Key Lake Mine.

Kabanga, Tanzania - Lead modeller responsible for the development and calibration of a regional scale 3D numerical MODFLOW model to evaluate regional groundwater flows in support of the Kabanga EA for a potential mining operation in Tanzania. The impact of mine dewatering was evaluated for various mine development scenarios and schedules to identify potential impacts on groundwater resources in neighbouring communities.

Confidential Client, Southern Ontario, Canada - Responsible for the construction of a local-scale groundwater flow model for the subject property. The groundwater model was used to refine the understanding of the groundwater flow patterns beneath the site and to provide an assessment of the potential impact on groundwater conditions due to the construction of permeable reactive barrier and bentonite slurry barrier walls.

U.S. Bureau of Reclamation, San Joaquin Valley, California, USA - Lead modeller for an integrated surface water-groundwater model of the San Joaquin Valley, CA. This project includes data compilation and development of a three-dimensional HydroGeoSphere model to simulate integrated surface and subsurface flow regimes within the San Joaquin Valley. Model construction and data processing were completed using ArcGIS, Microsoft Access, VBA, GridBuilder, Tecplot and HydroGeoSphere.

Southwest Florida Water Management District Florida, USA - Lead modeller for the Northern District Water Resources Assessment Project. This project includes the development of a regional-scale groundwater flow model for Pasco, Sumter, Citrus, Hillsborough, Hernando, Marion, Lake, Polk, Levy, Alachua and Putnam counties, Florida. The MODFLOW-based finite difference groundwater flow code, MODHMS, was used to simulate and calibrate a regional-scale model to pre-development and post-development conditions. The calibrated model was used to establish parameter sensitivities, evaluate long-term regional impacts of groundwater withdrawals and provide boundary and initial conditions for density dependent saltwater transport models. The density dependent transport models can be used to assess potential saltwater intrusion along coastal boundaries, as well as to assess the long-term impacts of groundwater withdrawals on inland saltwater migration. Groundwater Vistas, VBA, ArcGIS, PEST, ViewHMS and MS Access were used throughout model construction.

PUBLICATIONS AND PRESENTATIONS

Publications

Randall, J. E. 2005. “The Analysis of Seasonally Varying Flow in a Crystalline Rock Watershed and Calibration of an Integrated Groundwater and Surface Water Model” M.A.Sc. Thesis, Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, Ontario.

Conference Proceedings

- Lawrence, Karl P., Jefferey E. Randall, Ashley Mathai, Rob McLaren and Willy Zawadzki. 2013. Simulation of Horizontal Well Depressurization in Groundwater Flow Models. MODFLOW and More 2013, June. Golden, United States.
- Sykes, J.F., S.D. Normani, M.H. Brouwers and J.E. Randall. 2006. The analysis of the impact of aquatic fauna on a watershed in a crystalline rock setting using an integrated surface water and groundwater model. HydroEco'2006International Conference on Hydrology and Ecology: The Groundwater / Ecology Connection, September. Karlovy Vary, Czech Republic.
- Sykes, J.F., J.E. Randall and S.D. Normani. 2006. The analysis of seasonally varying flow in a crystalline rock watershed using an integrated surface water and groundwater model. XVIth International Conference on Computational Methods in Water Resources, June. Copenhagen, Denmark.

Education

Master of Science Earth Sciences, Hydrogeology, Collaborative Water Program, University of Waterloo, Waterloo, 2019

Bachelor of Applied Science Geological Engineering (Water Resources Option, Honours), University of Waterloo, Waterloo, 2014

Golder Associates Ltd. – Cambridge

Paul Menkveld, M.Sc., E.I.T., Environmental Scientist

Mr. Menkveld is an Environmental Scientist in the Geoscience Group at WSP Golder's Cambridge office, with more than 8 years experience in engineering consulting and hydrogeology. He is a graduate of the Geological Engineering (B.A.Sc.) and Master of Science (M.Sc.) programs at the University of Waterloo. During Mr. Menkveld's 6 years at WSP Golder, he has built meaningful experience practicing physical hydrogeology for aggregate, water supply, linear infrastructure, nuclear waste storage, contaminated sites, and mining applications. He is a skilled hydraulic and aquifer test analyst and has extensive field experience to support a range of hydrogeological investigations.

Employment History

WSP Golder – Cambridge, Ontario

Environmental Scientist (2016 to Present)

Responsible for the coordination, implementation, analysis, and reporting of hydrogeology projects for a range of applications. Developed project management skills to collect comprehensive environmental data on interdisciplinary teams for permit applications, amendments, and compliance monitoring. Mr. Menkveld has consistently managed projects with attention to detail to implement best practices and meet client expectations.

Mr. Menkveld has coordinated, supervised, and conducted field work including: borehole drilling, soil sampling (including brown field sampling), monitoring well installations, aquifer testing, groundwater sampling, and surface water sampling.

WSP Global Inc. (formerly GENIVAR and Jagger Hims Ltd.) – St. Catharine's, Ontario

Environmental Engineering Intern (2012 to 2012)

Performed data analysis, figure preparation, and technical report writing to support landfill monitoring, aggregate extraction, environmental assessments, and groundwater monitoring. Mr. Menkveld conducted a wide variety of field work including ground water monitoring and sampling, supervising drilling and logging in overburden and bed rock, stream gauging, and surface water sampling.

GeoSolv Design/Build Inc. – Aurora, Ontario

Engineering Intern (2012 to 2012)

Supervised sites of multi-million dollar projects during the geotechnical soil improvement stage and coordinated projects with contractors, clients, drillers, and suppliers to maximize project efficiency. Mr. Menkveld supervised the successful application of specialized geotechnical techniques including helical screw piles and rammed aggregate piers.

PROJECT EXPERIENCE

Maryhill Supply Well Replacement Maryhill, Ontario, Canada	Supervised drilling, including wireline PQ coring and tricone mud rotary methods, of a replacement for a municipal supply well. Supervised hydraulic testing the well, including a large scale aquifer test with the observation of private wells. Performed analysis and reporting for PTTW amendment.
Hydrogeologic Investigation and Closure Application of Closed Landfill Parry Sound, Ontario, Canada	This multi-year project included the evaluation, sale, and development of a brownfield and closed landfill site. The scope included hydrogeologic investigations to identify contaminants of concern, map their transport, assess risk, the development of reasonable use criteria, closure application to the regulator, and subsequent monitoring. Significant project coordination was required to mobilize and support a field team in a remote area to perform a range of tasks.
Mine Site Exploration Drilling and Hydraulic Testing Rankin Inlet, Nunavut, Canada	Coordinated a complex field program and supervised work site in a remote area. Responsible for core logging, fluid management, preparation of drill fluid with a tracer, packer testing, and coordination of personnel and materials via helicopter. Addressed dynamic health and safety risks in a remote location.
KW Habilitation Services Brownfield Redevelopment Kitchener, Ontario, Canada	Supported the completion of an EA Ph1 and 2 and supplemental monitoring during and following construction on a brownfield site to a higher use. Coordinated with construction subcontractors to ensure protection of and access to monitoring network.
Colour Paradise Greenhouses Research Site, Mannheim, Ontario Ontario, Canada	Conducted an extensive field program to assess the vulnerability of a shallow screened well to transient surface water features. During the course of this research program the field work included: well installation, time domain reflectometry, stream gauging, meteorology station deployment, geophysical soil moisture measurements, optical surface water tracking, groundwater sampling, resistivity measurements, and Guelph Permeameter operation. Lab work included, sieve analysis, permeameter, moisture content analysis, and the construction of a high accuracy Buchner Funnel apparatus.
NWMO Ignace Geoscientific Field Investigations Ignace, Ontario	Supervised drilling operations and fluid management of a deep borehole for preliminary deep geologic repository studies for the Nuclear Waste Management Organization. Responsibilities included managing fluid quantities, specifics of drill operation, preparation of tracer tagged drill water, preliminary borehole geophysics, and site supervision.
Metrolinx Subway Hydrogeology Scarborough, Ontario	Supported the hydrogeology and dewatering scope of the project, which included development, single well response testing, groundwater, and headspace sampling, to support design and dewatering calculations.
Free Phase PHC Site Monitoring and Remediation, Hamilton, Ontario	Supported ECA compliance groundwater and surface water monitoring on a long term industrial site with significant free phase hydrocarbon contamination in the shallow bedrock. The project required careful coordination with the requirements of the ECA and on site industrial HSSE procedures.

Cambridge Zone 3 Cambridge, Ontario	Supervised the drilling of boreholes through the Gasport Formation, including complex karst. Supervised characterization, testing, and construction of multilevel monitoring wells. Supported monitoring and analysis of large scale operational testing, including instrumentation and analysis of groundwater surface water interaction.
Hamilton Area Greenhouse Hamilton, Ontario, Canada	Managed long term Permit to Take Water compliance monitoring, amendment and renewal applications, for greenhouse site with nitrate contamination, including water level monitoring, nitrate species analysis, and spill response. Pioneered the use of no purge hydrasleeve sampling techniques to improve efficiency and technical quality. Improved client relationship and delivered economical and consistent results.
Aggregate Extraction Site Baseline Monitoring Brantford, Ontario, Canada	Project manager of a multi-year baseline surface water and groundwater data collection, permit to take water application, and revision of threshold triggers for extraction. Monitoring was conducted to characterize the groundwater flow system and surface water features on the site to support dynamic management of operations and mitigate environmental impacts.
Deep Geologic Repository Borehole Sealing Tiverton, Ontario, Canada	Conducted project coordination multiple subcontractors to achieve complex project objectives and optimize progress. The scope focused on the removal and sealing of >800m boreholes instrumented with Westbay groundwater monitoring systems, across multiple aquifer systems. Successful removal required conceptual model development, creative downhole problem solving, and implementation of specialized and oil field tools.

PROFESSIONAL AFFILIATIONS

Professional Engineers of Ontario

International Association of Hydrogeologists

PUBLICATIONS

Journal Articles

Menkveld, Paul and David Rudolph. A field study of event based, seasonally affected, depression focused recharge in glaciated terrain. *University of Waterloo, Department of Earth and Environmental Sciences* (2019)

Wiebe, Andrew, Paul Menkveld, Ehsan Pasha, Jacqueline Brook, Mike Christie and David Rudolph. Impacts of Event-based Recharge on the Vulnerability of Public Supply. *Sustainability*, 13(14) (2021), 7695.

Wiebe, Andrew, Paul Menkveld, Cailin Hillier, Emilie Mesec and David Rudolph. Meteorological and hydrological data from the Alder Creek watershed. *Federated Research Data Repository*, https://doi.org/10.20383/101.0178 (2019)

SIMON KRAUSE

M.Sc., Groundwater Modeller

Areas of practice

Groundwater Modelling

Hydrogeology

Languages

English

German

PROFILE

Simon is a junior environmental professional in Golder's Cambridge office with five years of experience specializing in numerical modelling. His primary role is to develop and construct groundwater flow models for source water protection and other hydrogeological investigations. This role includes 3D data management, visualization and analysis to provide engineering design recommendations and conclusions. He is a skilled processor and integrator of large datasets in the development of conceptual hydrogeological models, with experience in the construction, calibration, and interpretation of numerical groundwater models. QA/QC has been a strong focus throughout his time at Golder/WSP.

His software capabilities include: FEFLOW, MODFLOW, Visual MODFLOW, Groundwater Vistas, HydroGeoSphere, Surfer, Grapher, Leapfrog, and QGIS. He is proficient in the programming language Python.

EDUCATION

B.Sc, Environmental Geoscience, University of Toronto	2007-2012
M.Sc, Hydrogeology & Environmental Modelling, University of Tübingen	2014-2017

CAREER

Groundwater Modeller, Mine Water East, WSP (Formerly Golder)	2018 – Present

PROFESSIONAL EXPERIENCE

Quarry

Aecon C&M, Canada

Use of a 3D MODFLOW model (Visual MODFLOW) to predict pit inflows. Various forecast models were constructed to help the client maximize resource extraction and mitigate adverse impacts on sensitive habitats.

Landfill Sites

Walker Ingersol, Canada

Use of a MODFLOW model (Visual MODFLOW) to calculate inflows through a liner system and quantify seepage to nearby receptors for various scenarios. Particle tracking was employed to augment mass balance analyses.

Mining

AngloGold, Colombia

Developed cross-sectional numerical models in FEFLOW/HydroGeoSphere to estimate the impact (inflows and drawdown) of a series of 6km long tunnels to a gold mine in Colombia. Work included compilation of hydraulic conductivity test data to conceptualize the hydrostratigraphic model prior to running the forecast simulations.

IAMGOLD, Canada

Built and calibrated model in MODFLOW (GW Vistas) to estimate tailings seepage rates to nearby receivers and to improve tailings facility design. Quantified open-pit inflows to the mine, along with the impact on nearby lakes.

Geothermal

Sidewalk Labs, Canada

Developed thermal transport models in FEFLOW to estimate the energy capture and efficiency of closed-loop heat exchangers under varying conditions.

Hydrogeology

Region of York, Canada

Used forward and reverse particle tracking using MODFLOW to delineate well-head protection areas. Work included modelling in Visual MODFLOW and post-processing in GIS.

SKILLS

Numerical Modeling

Conceptual hydrogeological model development.

2D and 3D numerical modelling with the following software:

- MODFLOW (Visual Modflow, Groundwater Vistas, FloPy)
- FEFLOW
- HydroGeoSphere

Data Management

Handling large datasets, auto generation of charts/maps using the following tools:

- QGIS/ArcGIS
- Surfer
- Python
- Tecplot
- Leapfrog
- Paraview
- Excel/MS Access

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