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Hydrogeologic Assessment
Proposed Payne Pit
Part Lots 16 and 17, Concession 1 NTR, Municipality of Thames Centre County of Middlesex

Prepared For:

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1.0 INTRODUCTION

This report presents the results of a hydrogeologic assessment completed for the AAROC Aggregates Limited proposed Payne Pit. The proposed licence is located within Part Lots 16 and 17, Concession 1 NTR, Municipality of Thames Centre (formerly Township of North Dorchester), County of Middlesex.

According to the Aggregate Resource Act (ARA) standards, the proposal is classified as a Category 1, Class A Licence for below water extraction. However, no actual below water table extraction is proposed. The proposed extraction would remove aggregate to approximately 0.5 m (or more) above of the high water table. Rehabilitation would replace the subsoil and topsoil layer such that the final ground surface would remain 1.0 m (or more) above the water table and the lands would return back to agricultural use.

This hydrogeological assessment addresses the requirements of the recently updated *Aggregate resources of Ontario standards: A compilation of the four standards adopted by Ontario Regulation 244/97 under the Aggregate Resources Act* (MNRF, August 2020). This report was completed in support of the application on behalf of the applicant, AAROC Aggregates Limited.

1.1 BACKGROUND

The proposed pit location is shown on **Figure 1**. The site consists of two "parcels" (south and north). The southern parcel is located at 6508 Trafalgar Street, and consists of original agricultural fields. Most of the extraction would occur within the southern parcel. The northern parcel, located at 6367 Dundas Street, consists of farm fields, a portion of which was previously extracted and rehabilitated back to agricultural use. Some limited extraction would occur within the northern parcel, however this land would also be used for a haul road for access to Dundas Street.

Surrounding land use is primarily a combination of agricultural and other licenced gravel pits. Some rural residences are also located along Dundas Street and Trafalgar Street. A large woodlot is located along the northeast portion of the southern parcel, and a smaller woodlot is located near the southwest corner of the parcel. The Humphrey (agricultural) Drain is located generally east and north of the site.

1.2 SCOPE

1.2.1 Summary of Provincial Standards

This study utilizes the current ARA related groundwater reporting standards (*Aggregate Resources of Ontario: Technical reports and information standards*, MNRF, August 2020) for a Class A Pit proposing to excavate below the maximum predicted water table.

The standards include the following water table assessment:

> *2.1 Maximum predicted water table report*
>
> *A report must be prepared that details how the maximum predicted water table is identified in metres above sea level, relative to the proposed depth of excavation at the site.*

The maximum predicted water table shall be determined by monitoring the ground water table at the site for a minimum of one (1) year to account for seasonal variations and influences due to precipitation, unless alternative information already exists (e.g. previous hydrogeological study, existing well data) to support a determination of the maximum predicted water table by a qualified person.

An alternative method may be used for sites determining the maximum water table in Precambrian rocks of the Canadian Shield where it is difficult to determine the elevation of the water table. In such cases, the maximum predicted water table may be assumed at an elevation (metres above sea level) that is a minimum of 2.5 metres below the deepest sump or pond on the site, provided a qualified person develops and oversees a drilling and monitoring program to determine if the ground water table would be intercepted at the assumed maximum predicted water table.

The number of drill holes and seasonal monitoring frequency shall be determined by a qualified person based on site conditions.

The standards also include the following site groundwater characterization and impact assessments:

2.5. Water report

Excavation at a pit proposed above the water table may not occur within 1.5 metres above the maximum predicted water table. Excavation at a quarry proposed above the water table may not occur within 2 metres above the maximum predicted water table.

Applications proposing to excavate below the maximum predicted water table must complete the following:

Water report level 1:

Determine the potential for impacts to ground water and surface water resources and their uses (e.g. water wells, ground water aquifers, surface water courses and bodies, springs, discharge areas) and identify if the proposed site is in a Wellhead Protection Area for Quantity (WHPA-Q) set out in an applicable source water protection plan under the Clean Water Act. If so, identify applicable source water protection policies and mitigation measures that will be implemented at the site.

Water report level 2:

Where the results of Level 1 have identified a potential for impacts from the aggregate site on ground water and/or surface water resources and their uses, an impact assessment is required. The assessment is to determine the significance of the effect and the potential for mitigation.

The assessment must address the potential effects of the operation on any ground water and surface water features located within the zone of influence, including but not limited to:

a) water wells (includes all types e.g. municipal, private, industrial, commercial, geothermal and agricultural)

b) springs (e.g., place where ground water flows out of the ground)

c) ground water aquifers;

d) surface water courses and bodies (e.g., lakes, rivers, brooks)

e) wetlands

The assessment must include but not be limited to the following:

f) a description of the physical setting including local geology, hydrogeology, and surface water systems;

g) proposed water diversion, discharge, storage and drainage facilities;

h) water budget (e.g. how water is managed on-site);

i) the possible positive or negative impacts that the proposed site may have on the water regime;

The Level 2 water report must also contain:

j) monitoring plan(s); and

k) technical support data in the form of tables, graphs and figures, usually appended to the report.

The "maximum predicted water table report" provides an assessment of the water table elevation at the site relative to the proposed extraction. The Level 1 report examines the site relative to identified Source Protection Study groundwater quantity protection areas (WHPA-Q) to address quantity protection policies. In addition, the Level 1 report examines the extraction plan relative to the identified water table conditions and provides a general discussion of potential for impact in order to determine the need for a Level 2 report and "scope" the issues to be examined.

The Level 2 report provides a detailed groundwater characterization, examines the type and scale of any potential extraction related impacts, and, based on that assessment identifies any potential for adverse effects on groundwater and surface water resources (and their uses). The need for monitoring and/or mitigation is also assessed. If necessary, the Level 2 report also provides recommendations regarding monitoring and/or mitigation.

The Level 1 and Level 2 hydrogeological reports are typically referenced by the Natural Environment Report (NER), which is also required as part of the ARA application.

1.2.2 Impact Assessment Approach

As part of the licensing process for the site some Municipalilty of Thames Centre or County of Middlesex planning applications are also expected.

A Hydrogeological Study (HS) and/or Environmental Impact Study (EIS) related to groundwater and natural environment feature protection can be required as part of the

planning application process. The municipal EIS study requirements are typically addressed by the NER prepared as part of the ARA application.

This report follows a typical HS and EIS approach, which is identified as follows:

- an outline of the study methodology
- a description of the topographic setting, local surface water drainage and natural environment features (including springs, wetlands, etc.);
- a description of reported local water well locations;
- a description of the geologic and hydrogeologic setting (including aquifers, groundwater/surface water interaction, water budget, etc.);
- a description of the proposed extraction;
- an examination of the potential impact of the proposed extraction (impact assessment);
- an assessment of measures that may be needed to mitigate impacts and ensure environmental feature protection; and,
- conclusions and recommendations.

This study provides the planning related HS, and will be referenced by the associated NER prepared for the proposed Payne Pit.

2.0 METHODOLOGY

This assessment included a background information review to characterize the site setting, detailed site-specific fieldwork to characterize local conditions and the use of specific analysis methods for the water budget and impact assessment.

Standard hydrogeologic field and analysis methods are used for this study. The specific methodologies used for each step of the characterization and analysis are outlined in the respective Sections of this report.

2.1 INFORMATION REVIEW

As part of this study the following information sources were used:

1) Harrington McAvan Ltd.; *AAROC Aggregates Payne Pit, Site Plans.*
2) MTE Consultants Inc, January 2021; *Payne Pit Aggregate Extraction – Natural Environment Report (NER) Level 1 and 2.*
3) Englobe Corp, February 2019; *AAROC Aggregates Ltd., Aggregate Assessment, Payne Pit, 6508 Trafalgar Street, Municipality of Thames Centre*, and, additional May 2020 borehole drilling results, summary provided September 2020.
4) Thames-Sydenham and Region Source Protection Committee: *Upper Thames River Source Protection Area Assessment Report Approved* (and associated background documents), September 16, 2015.
5) Thames - Sydenham & Region Drinking Water Source Protection online Interactive Mapping: http://www.sourcewaterprotection.on.ca/approved-source-protection-plan/interactive-mapping/.
6) Ministry of the Environment Conservation and Parks (MECP) published *Water Well Records*, available at: *https://www.ontario.ca/environment-and-energy/map-well-records*.
7) Ministry of Natural Resources and Forestry (MNRF) *Make A Map: Natural Heritage Areas*, available at: *https://www.ontario.ca/page/make-natural-heritage-area-map*.
8) Ontario Geological Survey OGSEarth published geological mapping (KML files viewed on Google Earth); available online at: *http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth*
9) Ontario Base Map (OBM) 1:10,000 series topographic mapping.
10) Upper Thames River Conservation Authority; 2012: *Dorchester Watershed Report Card*.

Additional general references used are noted in the text of this report.

3.0 BACKGROUND REVIEW

The local site setting is shown in **Figure 2**.

3.1 SITE TOPOGRAPHY AND DRAINAGE

Please refer to the Site Plan for specific topographic information at the property. Local topography is shown on **Figure 2**. Topographic information provided below is based on the Site Plan elevation survey.

Within the southern parcel the topographic high point occurs near the southeast corner (at Trafalgar Street), at an elevation of approximately 287 metres above sea level (mASL). A second high point occurs within a low ridge at the northwest corner of the parcel, at an elevation of approximately 286 mASL. The remainder of the site is relatively flat-lying to gently sloped, with low points along the perimeter varying from approximately 282 to 283 mASL along the remainder of Trafalger Street and adjacent lands to the west, and, 280 mASL at the northeast corner.

Within the norther parcel the topographic high point occurs within a low ridge, just south of the farm buildings, at an elevation of approximately 286 mASL. From that point the topography slopes either northeast, to a low point of approximately 280 mASL near the northeast corner, or, south to a low point within the rehabilitated (former) pit at an elevation of approximately 281 mASL.

Overall slopes are relatively gentle and some enclosed drainage areas are present (e.g. low areas in the southern parcel and former pit in the norther parcel) which would capture and infiltrate runoff. Existing surface drainage divides are shown on **Figure 3**.

The Payne Pit property is located within the Dorchester Watershed, as identified by the UTRCA (see Dorchester Watershed Report Card). As noted in **Section 3.2**, the Humphrey Drain flows from southeast to northwest adjacent to the site, and intersects the northeast corner of the southern parcel. This drain is a continuation of the Day-McLeod Drain which crosses Hunt Road east (upstream) of the site, then Dundas Street north (downstream) of the site, Cherry Hill Road and Dundas Street again west of the site; and then flows generally south into the Caddy Creek system.

3.2 NATURAL ENVIRONMENT FEATURES

As noted in the NER, *There are no provincially significant wetlands within the proposed Licence Boundary or within the 120m Adjacent Lands*. A review of MNRF mapping indicates no other wetlands are identified at, or, near the site. In a broader context, some wetland areas (e.g. North Dorchester Swamp) are identified further from the site, generally 400 m or more south and west of the site. A small wetland area occurs approximately 125 m south of the proposed Payne Pit, within adjacent licenced lands.

A small section of the Humphrey Drain (municipal drain) occurs within 120 m of the site. As noted by the NER, at the northeast corner of the site, and within the prosed Licence, there is an un-named tributary of the Humphrey Drain. Field inspection indicates that the unnamed section of drain on the site has a straight man-made channel and begins at an agricultural tile outlet. The Humphrey Drain and the unnamed tributary are both classified as Class D drains (cold water, permanent), however field observations indicate that the unnamed tributary is intermittent (dry in the summer).

3.3 PRIVATE WATER WELLS AND LOCAL GROUNDWATER USE

MECP well records with reported locations within 500 m of the site were examined as an initial assessment of local water supply. The reported water well locations, based on the well records, are shown on **Figure A1** and summarized in **Table A1** in **Appendix A**.

A total of 10 private water supply wells are reported within the review area, the remaining well records represent monitoring wells (installed for this assessment and studies completed for adjacent properties), or well abandonment.

Two overburden water supply wells, one bored and one drilled, to depths between 7.6 and 10.1 m (below ground surface), are reported. The remaining reported private wells are deep drilled bedrock wells, completed to depths between 28 and 59 m. Based on the records, depth to bedrock varies in this area from 24 to 32 m. All the wells reviewed are reported to be used for either domestic or domestic/stock (farm) water supply.

The well record information at and near the site generally confirms the geologic setting discussed in **Sections 3.4** and **3.5**, consisting of surficial sand and gravel, overlying a till sequence that extends to bedrock.

As part of previous work we have completed in the area a private well survey was undertaken for most residences located within 500 m of the Payne Pit site along Trafalgar Street. The survey area represents the closest private wells near the main extraction area at the Payne Pit. Limited extraction is proposed within the parcel that extends north to Dundas Street.

The surveyed residences are shown on **Figure A2** and the survey results are summarized in **Table A2** (**Appendix A**). As shown by the survey results, no additional new information was collected for water wells at the site by the door to door survey. One shallow bored well is known to occur adjacent to the southwest corner of the proposed Payne Pit, and is reported as water well record (WWR) #4104875.

Based on the fact that actual extraction will remain above water table, no significant impacts are expected to the local groundwater system. As described in **Section 3.6** of this report, a monitoring well (MW5) has been installed at the site near the adjacent residence. Ongoing water level monitoring is proposed.

3.4 QUATERNARY GEOLOGY

According to Physiographic mapping available for the area the site straddles Spillway (northeast corner) and Till Plain (remainder of site) features. Surficial geology mapping indicates that the majority of the site is classified as a stone-poor sandy silt to silty sand textured till on Paleozoic terrain. Surrounding deposits are mapped as ice-contact stratified deposits of sand and gravel with minor silt, clay and till.

As noted in **Section 3.6**, the geotechnical resource assessment completed at the site indicates the surficial materials are primarily sand and gravel, which is underlain by a clayey to silty till unit.

3.5 BEDROCK GEOLOGY

The underlying bedrock at the site is the limestone of the Dundee Formation. Bedrock elevation is reported to be approximately 250 mASL, with a general southward slope.

3.6 GEOTECHNICAL ASSESSMENT

A geotechnical resource assessment was completed within the southern parcel by Englobe Corp (2019). As part of the assessment a total of 12 test pits and 5 boreholes were completed. A water table monitoring well was installed in each of the borehole locations. After the norther parcel was acquired, Englobe Corp completed an addition 10 test pits and 4 boreholes within that area in May 2020. Water table monitoring wells were installed in 2 of the northern parcel boreholes.

The monitoring well locations are shown on **Figure 4**. The borehole drilling results at monitoring well locations are summarized in **Table 1**. Please refer to the geotechnical report for detailed logs and additional details.

Location	Depth of Topsoil (m)	Sand/Gravel Thickness (m)	Depth to Till (m)	Total Depth (m)	Elevations (mASL)			
					Top of Well	Ground Surface	Top of Screen	Screen Bottom
MW1	0.25	3.55*	3.80	5.00	286.54	287.51	283.49	281.99
MW2	0.28	2.33	2.60	3.50	280.92	281.90	279.42	277.92
MW3	0.30	3.50	3.80	5.00	285.40	286.32	282.32	280.82
MW4	0.33	2.28	2.60	3.50	283.27	284.24	281.88	280.38
MW5	0.25	5.35	5.60	7.30	283.95	285.03	280.27	277.27
MW6	0.38	2.12	2.50	3.50	280.51	281.32	278.92	277.42
MW7	0.38	2.92	3.30	4.30	284.11	284.84	281.84	280.34
* described as: *silty sand, some gravel and clay*								

Table 1: Monitoring Well Log Summary

In summary, most of the site has a surface layer of topsoil overlying a sand and gravel deposit of varying thickness, underlain by a clayey to silty till unit. The sand and gravel layer may be absent, or have significant silt content, within the southeastern corner of the southern parcel. As noted previously, the southern portion of the northern parcel was previously extracted and rehabilitated. Within this area most of the sand/gravel layer has been removed.

3.7 SOURCE PROTECTION CONSIDERATIONS

Relevant Source Protection mapping was reviewed. The proposed Payne Pit is not within any identified Well Head Protection Area (WHPA) or Intake Protection Zone (IPZ). In addition, no WHPA-Q zone has been identified in this area. Source Protection considerations are also summarized in **Section 8**.

4.0 FIELD WORK

The on-site fieldwork completed for this assessment included site inspections; installation of a gauge point within the on-site agricultural ditch (tile outlet); and, water level monitoring.

4.1 WATER LEVEL MONITORING

Routine monthly water level monitoring began in December 2018, after the southern parcel monitors were installed. Northern parcel monitors were included in the program in July/August 2020. Water level measurements for the site are summarized in table and hydrograph format in **Appendix B**. In early 2019 a t-bar (SG1) monitoring gauge was also installed at the tile drain outlet in in order to provide surface water elevation measurements at that location. Monitoring SG1 illustrates the seasonal nature of discharge from the tile drain outlet and flow within the ditch. When water is present at SG1 the water level is interpreted to represent the water table at that location.

Measurements were obtained by Groundwater Science Corp. as depth to water below top of well casing or reference point using a Heron Instruments® electronic water level tape and recorded in the field. Measurements are currently ongoing.

The water table has fluctuated to date by varying amounts across the site, from approximately 0.4 m at MW2 and MW6, to 1.5 m at MW1. The seasonal water table fluctuation is shown on the site hydrograph (**Appendix B**).

Based on the monitoring results, high water table conditions at the site are represented by the April 2019 water levels (prior to the installation of MW6 and MW7). Based on the pattern of water level variation at all locations since July 2020, the water levels at MW6 and MW7 appear to be consistent with other monitors at the site.

High table elevations at the site are summarized in **Table 2**. The elevations listed for MW6 and MW7 are based on projections using other on-site monitors.

Location	Water Table Elevations (mASL)	
	January 2021	High Water Table April 2019
MW1	286.16	286.39
MW2	279.13	279.13
MW3	282.11	282.44
MW4	280.71	281.15
MW5	278.91	279.78
MW6	279.43	279.97
MW7	282.19	282.44
SG1	279.60	279.61

Table 2: High Water Table Elevations

As noted later in this report, we recommend continued seasonal monitoring to confirm high water table conditions at the site and ensure extraction remains 0.5 m (or more) above high water table conditions.

High water table contours for the site, based on the elevations shown in **Table 2**, are provided in **Figure 5**. Additional discussion regarding water levels at the site is provided in **Section 5.0**.

5.0 HYDROGEOLOGIC SETTING

The hydrogeologic setting of the site is discussed in context of the known regional setting, information review undertaken for this site, and, monitoring and assessment completed as part of this study.

In order to illustrate the specific conditions in this area of the site 2 schematic cross-sections were developed based on site topographic mapping, water well record database, borehole logs and water level monitoring results. The cross-section locations are shown on **Figure 6**. The sections are provided as **Figure 7** and **Figure 8**.

Cross-section A (**Figure 7**) runs west to east through the south edge of the site. The section illustrates the local topography, generalized geologic sequence and depth to bedrock. The majority of the overburden sequence consists of a till assemblage, overlain by a surficial sand and gravel layer. The surficial unit forms a local unconfined aquifer where saturated. The till sequence forms a regional aquitard and the bedrock forms a regional confined aquifer system.

Cross-section B (**Figure 8**) runs through the site from north of Dundas Street to south of Trafalgar Street. A similar hydrogeologic setting is shown. As illustrated, the composition of the sand and gravel unit and presence of the till unit controls water table elevation and flow.

As illustrated by the cross-sections, the Payne Pit site consists of a sand and gravel deposit that “sits” on the underlying till sequence. The water table at the site occurs within the sand and gravel deposit, which forms an unconfined aquifer where saturated. The underlying till sequence limits vertical flow and promotes horizontal flow, thereby controlling both the elevation and slope of the water table.

The primary groundwater function of the proposed extraction area is recharge. This recharge supports the groundwater flow off-site to the northeast and southwest. As shown on **Figure 5**, a groundwater flow divide occurs at the site extending from MW1 to MW7. Shallow groundwater flows either northeast (toward the municipal drain system) or southwest (toward the North Dorchester Swamp system) from the divide.

6.0 PROPOSED EXTRACTION

The following general description of the proposed Payne Pit extraction is provided as a framework for the impact analysis. For specific details regarding existing site conditions or the extraction plan please refer to the Site Plan(s).

The proposed licenced area is approximately 66 hectares (ha) in size. The proposed extraction area is 60 ha, consisting of the existing farm fields. The proposed operations would remove the existing topsoil and subsoil layer (typically stored in perimeter berms) and extract sand and gravel to within (but not below) 0.5 m of the water table. Rehabilitation would replace the subsoil and topsoil layer, such that the final ground surface is 1 m (or more) above the water table. No extraction ponds are proposed.

As shown on **Figure 9**, post extraction drainage within the rehabilitated area would be similar to existing drainage patterns. Based on the proposed final rehabilitation contours, runoff within much of the west portion of the southern parcel would be retained and infiltrated on-site. Runoff within the east portion of the southern parcel would continue to move toward the on-site agricultural drain. Within the norther parcel the former pit area would continue to infiltrate runoff from the immediate area. Runoff within the norther portion of the northern parcel would continue to move northeastward, toward the municipal drain.

There are no other proposed water use, diversion, storage or drainage facilities on-site. As shown on the Site Plan, a spills response program will be in place at the site.

7.0 MAXIMUM PREDICTED WATER TABLE REPORT

The proposed extraction would occur within unconsolidated surficial sand and gravel deposits. Therefore the following definitions are used:

> *"ground water table" means*
>
> *a) for unconsolidated surficial deposits, the ground water table is the surface of an unconfined water-bearing zone at which the fluid pressure in the unconsolidated medium is atmospheric. Generally, the ground water table is the top of the saturated zone.*
>
> *"maximum predicted water table" means the maximum ground water elevation (metres above sea level) predicted by a qualified person who has considered conditions at the site and mean annual precipitation levels.*

The water table at the site was measured and determined by the installation of 7 water table wells and 1 surface water gauge. The measured water table at the site corresponds to the top of the saturated zone within the unconfined surficial sand and gravel aquifer.

At the Payne Pit site the maximum predicted water table elevation is shown on **Figure 5**. The maximum predicted water table elevation varies across the proposed extraction area from approximately 285.5 mASL (at MW1) to 280 mASL (at MW5 and MW6).

Site extraction is to remain above the predicted maximum water table.

8.0 WATER REPORT LEVEL 1

The purposed of the Water Report Level 1 is to identify if the site is within a WHPA-Q area (and identify if related Source Protection Policies should be implemented), and, to determine the potential for adverse effects to groundwater and surface water resources and their uses (e.g. water wells, ground water aquifers, surface water courses and bodies, springs, discharge areas).

The site is not located within an identified WHPA-Q area as set out in an applicable source water protection plan under the Clean Water Act.

Based on the extraction plan, no direct impact on the groundwater table, and/or groundwater conditions in the area (on and off-site) are expected. Given that existing on-site drainage patterns will be largely maintained, potential changes to site runoff contribution to local drainage systems and groundwater recharge rates will be relatively minor. Therefore no significant change in groundwater quantity, quality or flow direction is anticipated. As a result, no significant off-site impacts to water wells or natural environment features are expected.

To confirm the scale of potential change to site runoff and recharge rates, a water balance assessment is recommended as part of a Water Report Level 2 evaluation. The Level 2 evaluation is included as **Section 9** of this report.

9.0 WATER REPORT LEVEL 2

The Level 2 evaluation is completed to examine issues related to the potential for the proposal to affect the local water balance at the site.

9.1 POTENTIAL IMPACT

9.1.1 Site Water Balance

A water balance analysis was completed for existing and proposed final site conditions in order to examine the potential changes in runoff and recharge associated with the proposed extraction. The assessments examine average annual conditions and are developed according to standard water input/output methodology. The water balance calculations are included in **Appendix C**.

"Average" climate data for the area is based on monthly precipitation and temperature climate normals (1981 to 2010) as reported by Environment Canada for the London Airport Weather Station. Evapotranspiration, runoff and infiltration rates are estimated in accordance with MECP development application guidelines (*Hydrogeological Technical Information Requirements for Land Development Applications*, April 1995) and stormwater management guidelines (*Stormwater Management Planning and Design Manual*, March 2003).

Based on the climate data monthly actual evapotranspiration (AET) estimates were calculated for differing soil and vegetation conditions relevant to the site and proposal using the *Computer Program for Estimating Evapotranspiration Using the Thornthwaite Method*, United States Department of Commerce, National Oceanic and Atmosphere Administration (NOAA) Technical Memorandum ERL GLERL-101 (November 1996). The AET estimates for agricultural areas of the site are developed according to Soil Moisture Retention value of 75 mm (moderately deep rooted crops on fine sand soil), and reflect the fact that a soil moisture deficit, which limits the amount of water available for evapotranspiration, typically occurs during summer months.

A climate and Thornthwaite analysis summary for "average" monthly and annual conditions is provided in **Appendix C**. Annual average precipitation is estimated to be 1011.5 mm/yr, and AET within the cultivated area is estimated to be 571.5 mm/yr.

The difference between precipitation falling on the assessment area (direct input) and evaporation/evapotranspiration (direct initial output) is termed the water "surplus". Surplus water within an assessment area can either infiltrate to recharge the groundwater system or form surface water runoff. Land surface runoff rates at the site are calculated according to the MECP development application guidelines methodology, which assigns an infiltration factor (IF) to apply to the water "surplus" in order to calculate recharge. The IF depends on individual factors related to topography, soil type and vegetation/cover.

Based on a characterization of the current site topography as flat land, with open sandy loam and being primarily under cultivation, an IF of 0.8 (80%) is estimated. The remainder of the surplus (20%) becomes runoff. The analysis indicates that naturally drained areas of the site would have recharge and runoff unit rates of 0.352 mm/yr and 0.088 mm/yr respectively.

The total site area is 66.0 ha. As shown on **Figure 3**, existing runoff within approximately 18.93 ha of the southern parcel has the potential to reach the on-site agricultural drainage ditch. Runoff within approximately 2.09 ha of the northern parcel has the potential to reach the off-site municipal drain. The remaining area (44.98 ha) is internally drained and results in some enhanced on-site recharge.

Therefore under existing conditions the annual runoff volume toward the on-site ditch is estimated to be 16,658 m^3/yr (0.53 L/s on average). Similarly, annual runoff toward the off-site municipal drain is estimated to be 1,839 m^3/yr (0.06 L/s on average). Due to retained runoff the on-site annual recharge rate is estimated to be 271,902 m^3/yr (8.62 L/s on average), and the unit rate equates to 0.412 mm/yr.

As shown on **Figure 9**, after rehabilitation the agricultural ditch runoff area is approximately 21.15 ha and the northern municipal drain runoff area is approximately 3.22 ha. The retained runoff area of the site is approximately 41.63 ha.

Therefore under proposed future conditions the annual runoff volume toward the on-site ditch is estimated to be 18,612 m^3/yr (0.59 L/s on average). The future annual runoff toward the off-site municipal drain is estimated to be 2,834 m^3/yr (0.09 L/s on average). The future on-site annual recharge rate is estimated to be 268,954 m^3/yr (8.53 L/s on average), and the unit rate equates to 0.408 mm/yr.

The reconfiguration of the site results in a slight increase in runoff flow leaving the site, and contributing to local stream systems. An associated slight (1%) decrease in on-site recharge is predicted.

The overall change in annual runoff and recharge is very small in scale. The calculation indicates that no significant negative effect on water availability can be expected within the groundwater system due to the proposed extraction.

9.1.2 Potential For Impact To Water Wells

Based on the setting and water balance analysis, no significant change in groundwater volume or flow direction would be expected. After rehabilitation agricultural activities will resume at the site, essentially the same as existing land use. Therefore no long-term change in groundwater quality would be expected. In the short-term over the life of the pit standard operating controls, including fuel handling and spills response, will minimize the potential for other water quality impacts.

One reported water supply at the adjacent property west of the site relies on a shallow bored well. Shallow bored or dug wells rely on the immediate surrounding area for recharge, and do not typically source water from distance. The overall maintenance of groundwater recharge at the site will ensure the water table will remain within current seasonal ranges, both on-site and in the adjacent area. This will also ensure ongoing water availability at any local shallow wells.

We recommend ongoing water level at the site and quality monitoring at the closest monitoring well (MW5) to ensure no impacts occur. We also note that a standard water well interference protocol exists between MNRF and MECP to ensure that local water supplies are protected. The protocol should be referenced on the Site Plan.

9.1.3 Potential For Impact to Natural Environment Features

The proposed above water table extraction will maintain both on-site groundwater recharge volumes and off-site runoff contributions to agricultural/municipal drains in the area. Therefore overall water inputs to these features will be maintained. Based on this assessment, there are no significant potential impacts to local natural environment features anticipated with the proposed extraction.

9.2 MONITORING, MITIGATION AND CONTINGENCY PLAN

The following general private water supply protection recommendation should be listed on the Site Plan:

> *Where the Ministry of Natural Resources and Forestry with the assistance of the Ministry of the Environment Conservation and Parks, according to existing water well interference complaint protocols, has determined that the operation of the pit has caused any well water to be adversely affected, the licensee shall, at the licensee's expense, either deepen the well or replace the well to ensure that historic water production quality standards are maintained for that well. If this pit operation has caused a water supply problem, the licensee shall, at their expense, ensure a continuous supply of potable water to the affected landowner.*

In order to confirm water table elevations at the site, the following monitoring program is recommended:

1. *During operational years water level measurements shall be obtained on a quarterly (seasonal) basis at MW1, MW2, MW3, MW4, MW5, MW6 and MW7, as accessible.*
2. *During operational years annual water quality samples for general parameters (anions and metals) and petroleum hydrocarbons shall be obtained at MW5 (as accessible).*
3. *During operational years the monitoring results will be summarized and submitted in an annual report to the Ministry of Natural Resources and Forestry. The water level monitoring results will be reviewed to determine if adjustments are needed to extraction depths as operations proceed in order to ensure rehabilitation plans can be achieved as proposed.*

10.0 CONCLUSIONS

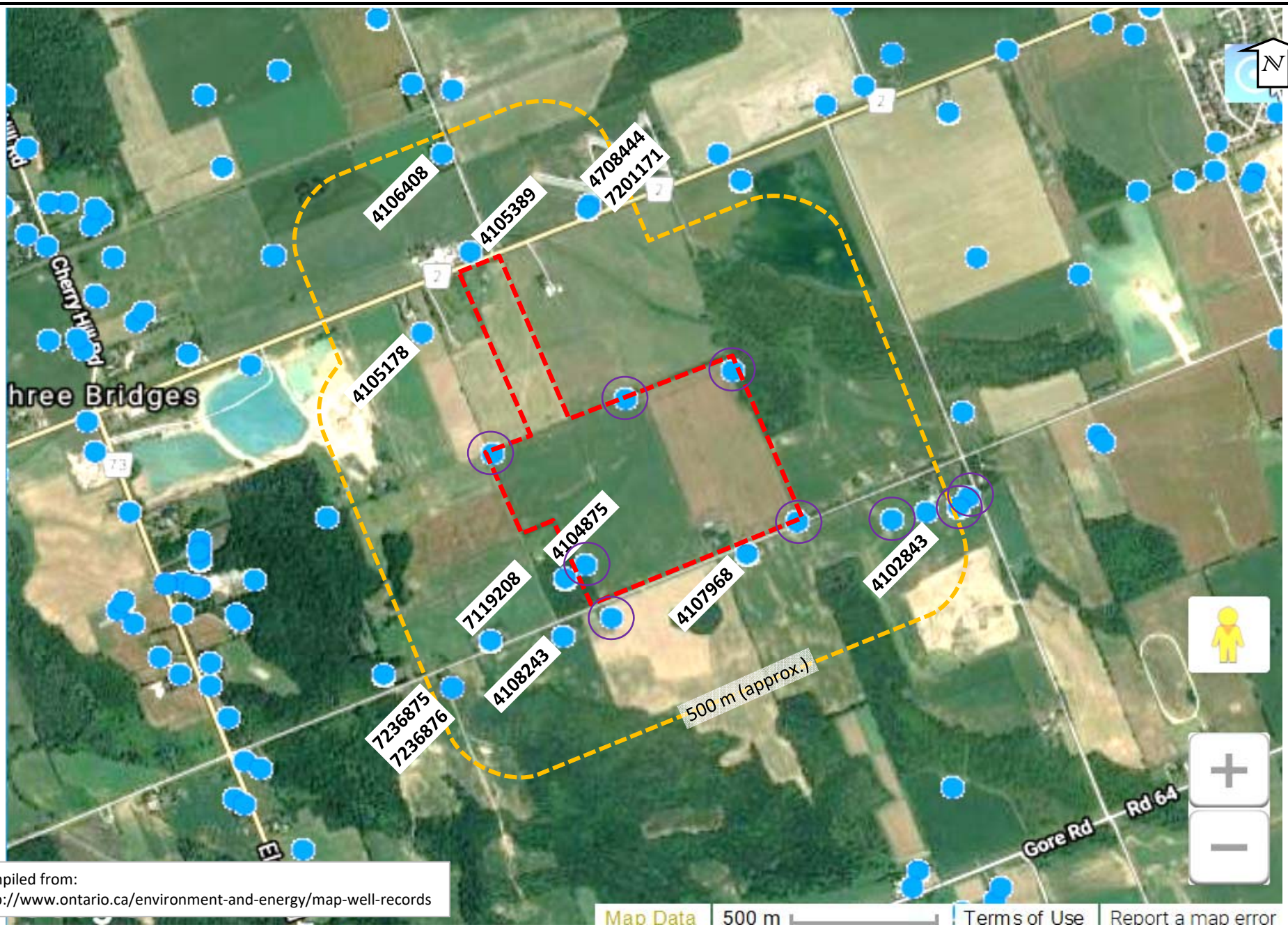
Based on the results of the impact assessment, and, proposed monitoring and mitigation plan, there are no potential for significant adverse effects to groundwater and surface water resources and their uses; and, there is no potential for significant impacts to local groundwater aquifers, natural environment features or water supply associated with the proposed Payne Pit.

All of which is respectfully submitted,

Andrew Pentney, P.Geo.
Senior Hydrogeologist
Groundwater Science Corp.

Figures

Appendix A
Private Water Supply Review



compiled from:
http://www.ontario.ca/environment-and-energy/map-well-records

study site (approximate)

water well locations and reference numbers
as shown, circled locations = monitoring wells

Date: January 2021
scale: approx., as shown

Groundwater Science Corp.

Reported Water Well Locations

AAROC Aggregates Ltd. Proposed Payne Pit
Hydrogeologic Assessment

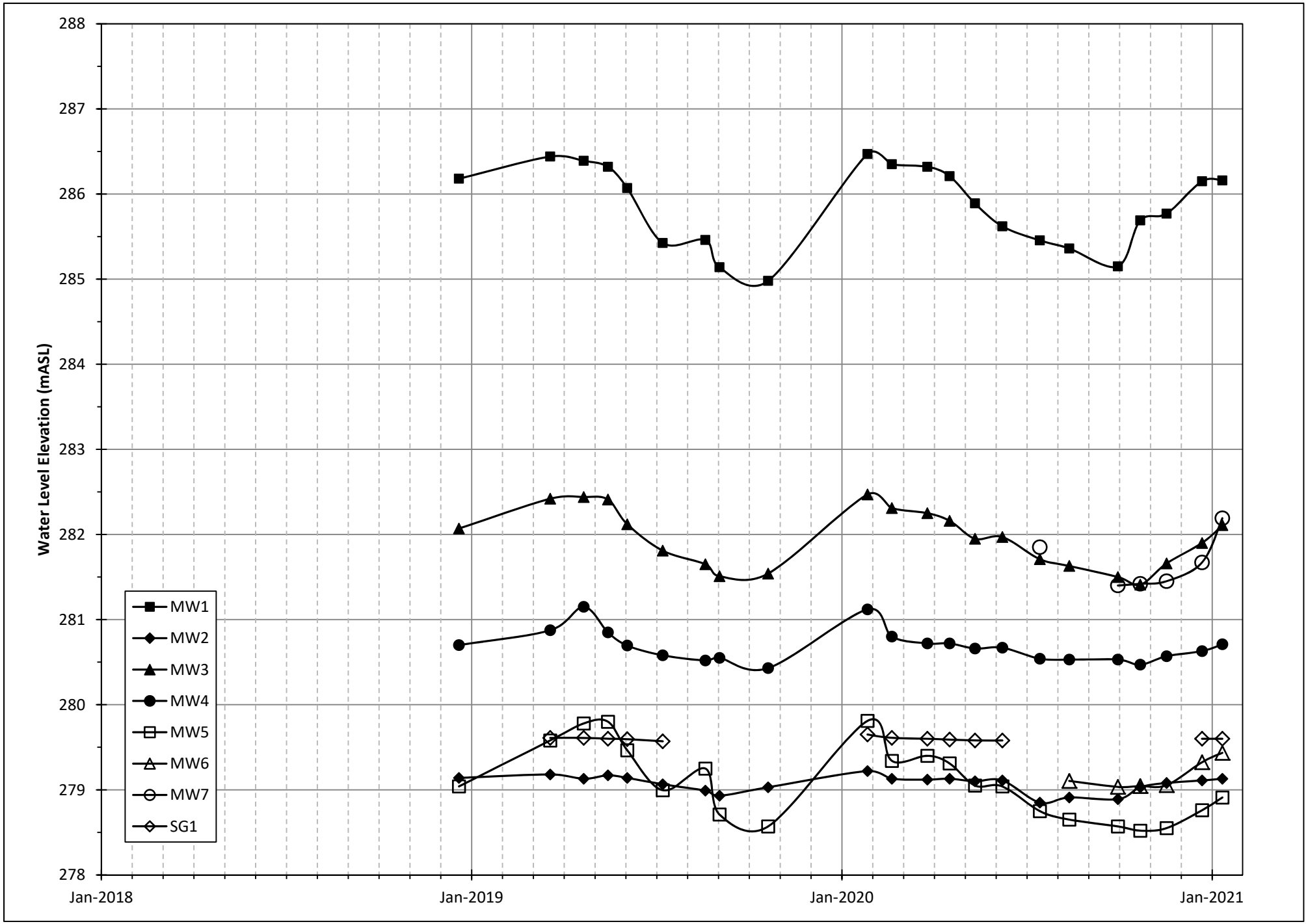
Record No.	Total Depth (m)	Type		Use	Static Level (m)	Bedrock Depth (m)	Source Classification
		constr.	unit				
4102843	41.1	drilled	bedrock	stock and domestic	11.0	31.7	confined bedrock aquifer
4104875	7.6	bored	sand/gravel	domestic	5.5	-	unconfined surficial aquifer
4105178	55.5	drilled	bedrock	stock and domestic	12.2	32.3	confined bedrock aquifer
4105389	34.7	drilled	bedrock	domestic	19.5	23.8	confined bedrock aquifer
4106408	58.8	drilled	bedrock	domestic	15.2	26.2	confined bedrock aquifer
4107968	41.5	drilled	bedrock	domestic	11.3	32.3	confined bedrock aquifer
4108243	28.3	drilled	bedrock	domestic	6.1	27.7	confined bedrock aquifer
4708444	39.6	drilled	bedrock	stock	12.2	23.5	confined bedrock aquifer
7119208	29.0	drilled	bedrock	domestic	3.4	26.5	confined bedrock aquifer
7201171	dug well abandonment record				0.0		
7236875	dug well abandonment record						
7236876	10.1	drilled	sand	domestic	4.6	-	confined overburden aquifer

Address	Survey Response	Survey Reported		Commentary
		Well Type	Well Depth	
6545 Trafalgar St	16-Jul-17	drilled	41.1 m	WWR#4107968 based on location, age, driller, diameter, depth
6508 Trafalgar St	none	n/a	n/a	
6338 Trafalgar St	13-Jul-17	drilled	7.6 m	WWR#4104875 based on location, age, depth, diameter (bored, galvanized casing), usage includes barn (horses)
6351 Trafalgar St	none	n/a	n/a	
6307 Trafalgar St	11-Jul-17	drilled	25.0 m	WWR#4108243 based on location, age, driller
6242 Trafalgar St	none	n/a	n/a	
6208 Trafalgar St	12-Jul-17	drilled	30.0 m	WWR#7119208, copy provided by respondent

Appendix B
Water Level Monitoring Results

Date	Water Level Elevation (mASL)							
	MW1	MW2	MW3	MW4	MW5	MW6	MW7	SG1
20-Dec-18	286.18	279.14	282.07	280.70	279.04	-	-	#N/A
20-Mar-19	286.44	279.18	282.42	280.88	279.58	-	-	279.61
22-Apr-19	286.39	279.13	282.44	281.15	279.78	-	-	279.61
16-May-19	286.32	279.17	282.41	280.85	279.80	-	-	279.60
4-Jun-19	286.07	279.14	282.12	280.70	279.47	-	-	279.60
9-Jul-19	285.43	279.07	281.81	280.58	279.00	-	-	279.57
20-Aug-19	285.46	278.99	281.65	280.52	279.25	-	-	dry
3-Sep-19	285.14	278.93	281.51	280.55	278.71	-	-	dry
21-Oct-19	284.98	279.03	281.54	280.43	278.57	-	-	dry
27-Jan-20	286.47	279.22	282.47	281.12	279.81	-	-	279.65
20-Feb-20	286.35	279.13	282.31	280.80	279.34	-	-	279.61
26-Mar-20	286.32	279.12	282.25	280.72	279.40	-	-	279.60
17-Apr-20	286.21	279.13	282.16	280.72	279.31	-	-	279.59
12-May-20	285.89	279.10	281.95	280.66	279.05	-	-	279.58
8-Jun-20	285.62	279.11	281.97	280.67	279.04	-	-	279.58
15-Jul-20	285.46	278.85	281.71	280.54	278.75	-	281.85	dry
13-Aug-20	285.36	278.91	281.63	280.53	278.65	279.10	-	dry
30-Sep-20	285.15	278.89	281.50	280.53	278.57	279.03	281.40	dry
22-Oct-20	285.69	279.03	281.41	280.47	278.52	279.04	281.42	dry
17-Nov-20	285.77	279.08	281.66	280.57	278.55	279.05	281.45	dry
22-Dec-20	286.15	279.11	281.90	280.63	278.76	279.32	281.67	279.60
11-Jan-21	286.16	279.13	282.11	280.71	278.91	279.43	282.19	279.60

notes:
mASL = metres above mean sea level



AAROC Aggregates
Proposed Payne Pit

Water Level Hydrograph

Groundwater Science Corp.
Hydrogeologic Assessment

Appendix C
Water Balance Calculations

Proposed Payne Pit - Site Scale Recharge Water Balance

Purpose:

To assess present and future recharge contributions to the local groundwater system within the site (defined by the proposed Licence boundary).

Assumptions:

- climate conditions at the site are represented by 1981 to 2010 climate normals as reported by Environment Canada for the London Airport weather station
- Agricultural area actual evapotranspiration rate calculated (as AET) using the Thornthwaite method assuming 75 mm Soil Moisture Retention (moderately deep rooted crops on fine sand soil) for both existing and future conditions.
- existing runoff rates estimated using MECP Infiltration Factors (*MOEE Hydrogeological Technical Information Requirements For Land Development Applications* , April 1995) for flat lying topography, sandy soils, cultivated land.

1) Water Balance Components

Infiltration Factor for land surface

Flat Land	0.3	
Open Sandy Loam	0.4	
Cultivated Lands	0.1	
Factor:	0.8	80% of surplus becomes infiltration recharge
	0.2	20% of surplus becomes runoff

General Site Recharge Calculation (includes pond areas)

surplus = precipitation - evapotranspiration
site recharge = precipitation - evapotranspiration - runoff - pond evaporation

2) Estimate of Existing Rainfall Recharge

Precipitation Rate =	1.0115	m/yr
AET =	0.5715	m/yr
Water Surplus =	0.4400	m/yr
Recharge Rate =	0.352	m/yr
Runoff Rate =	0.088	m/yr
"Site" =	66.0	ha
=	660,000	m^2
Runoff Area to Ditch =	18.93	ha
	189,300	m^2
Runoff Area to NE =	2.09	ha
	20,900	m^2
Retained Runoff Area =	44.98	ha
	449,800	m^2
Precip. "Input" =	667,590	m^3/yr
Crop Evapotrans. =	377,190	m^3/yr
Runoff to Ditch =	16,658	m^3/yr
=	0.53	L/s
Runoff to NE =	1,839	m^3/yr
=	0.06	L/s
Existing Recharge =	271,902	m^3/yr
Annual Recharge Rate =	0.412	m/yr
=	8.62	L/s

3) Estimate of Post-Rehabilitation Recharge

Precipitation Rate =	1.0115	m/yr
AET =	0.5715	m/yr
Water Surplus =	0.4400	m/yr
Recharge Rate =	0.3520	m/yr
Runoff Rate =	0.0880	m/yr
"Site" =	66.0	ha
=	660,000	m^2
Runoff Area to Ditch =	21.15	ha
	211,500	m^2
Runoff Area to NE =	3.22	ha
	32,200	m^2
Retained Runoff Area =	41.63	ha
	416,300	m^2
Precip. "Input" =	667,590	m^3/yr
Crop Evapotrans. =	377,190	m^3/yr
Runoff to Ditch =	18,612	m^3/yr
=	0.59	L/s
Runoff to NE =	2,834	m^3/yr
=	0.09	L/s
Future Recharge =	268,954	m^3/yr
Annual Recharge Rate =	0.408	m/yr
=	8.53	L/s

SMR = Soil Moisture Retention (mm)					
Soil Type	Vegetation Type				
	Shallow Rooted Crops (e.g. beans)	Moderately Deep Rooted Crops (e.g. corn)	Deep Rooted Crops (e.g. pasture)	Orchards	Closed Mature Forest
Fine Sand	50	**75**	100	150	250
Fine Sandy Loam	75	150	150	250	300
Silt Loam	125	200	250	300	400
Clay Loam	100	200	250	250	400
Clay	75	50	200	200	350

Source: *Instructions and Tables For Computing Potential Evapotranspiration And The Water Balance,* C.W. Thornthwaite and J.R. Mather, 1957

Estimated Evapotranspiration Values (mm) using Environment Canada London Airport Weater Station 1981 to 2010 Climate Normals

Month	Daily Average Temperature (C.)	Average Monthly Precipitaiton (mm)	PET	AET (75 mm SMR)	Surplus
January	-5.6	74.2	0	0	74.2
February	-4.5	65.5	0	0	65.5
March	-0.1	71.5	0	0	71.5
April	6.8	83.4	33.6	33.6	49.8
May	13.1	89.8	79.4	79.4	10.4
June	18.3	91.7	115.2	112.7	-21.0
July	20.8	82.7	135.5	115.7	-33.0
August	19.7	82.9	118.8	96.9	-14.0
September	15.5	103.0	81.1	81.1	21.9
October	9.2	81.3	39.9	39.9	41.4
November	3.4	98.0	12.2	12.2	85.9
December	-2.6	87.5	0	0	87.5
Annual Total (mm):		1011.5	615.6	571.5	440.1

Source: *Computer Program for Estimating Evapotranspiration Using the Thornthwaite Method* , United States Department of Commerce, National Oceanic and Atmosphere Administration (NOAA) Technical Memorandum ERL GLERL-101 (November 1996)

MOE Infiltration Factors

Topography Factor							
Classification	Criteria					Slope (%)	Value of Infiltration Factor
Flat land	Average Slope Not Exceeding:	0.6	m per	1	km	0.06	0.3
Rolling land	Average slope of:	2.8	m per	1	km	0.28	0.2
	to:	3.8	m per	1	km	0.38	
Hilly land	Average slope of:	28	m per	1	km	2.8	0.1
	to:	47	m per	1	km	4.7	

Soil Factor	
Soil Type	Value of Infiltration Factor
Tight impervious clay	0.1
Medium combinations of clay and loam	0.2
Open sandy loam	0.4

Cover Factor	
Classification	Value of Infiltration Factor
Cultivated lands	0.1
Woodland	0.2

Source:
MOEE Hydrogeological Technical Information Requirements for Land Development Applications,
Ontario Ministry of the Environment and Energy, April 1995

Appendix D
Qualifications

Groundwater Science Corp.

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QUALIFICATIONS

February 2020

Andrew Pentney, B.Sc., P.Geo.

Current Position

Principal, Senior Hydrogeologist

Groundwater Science Corp., Waterloo, ON

Providing hydrogeological consulting expertise to regulatory agencies, environmental consultants and industry. Services ranging from individual consulting and assessments to project support for larger study teams, including testimony at OMB hearings.

Over 30 years of hydrogeologic consulting experience.

Education

B.Sc. (1987) : University of Waterloo, Waterloo, ON

General Science, including Geology courses (stratigraphy, quaternary geology and hydrogeology).

Professional memberships

Registered Professional Geoscientist in Ontario

Licenced MOE Well Technician and Contractor

Range of Experience

- Technical consultation for 8 Subwatershed Scale characterization studies (GRCA, CVC). Focus on assessing groundwater – surface water interaction (at rivers, streams, wetlands, ponds).
- Planning approval and environmental peer review, watershed planning support to Credit Valley Conservation on an as-needed basis from 2001 to 2014. Focus on protecting stream and wetland systems.
- Community Scale Septic System Impact studies for Alton, Cheltenham and Erin as part of Village Planning Assessments.
- Water supply development, testing and impact assessment, Permit To Take Water consulting, Source Water Protection characterization and water balance studies for municipal water supplies, golf courses, industrial supply (over 20 assessments).
- Aggregate Resource Act Level 1 and Level 2 Assessments, and associated Zoning and Official Plan amendment impact assessments, at over 30 above water and 28 below water extraction sites. Extensive assessment and analysis of groundwater-surface water interactions (most studies assessed rivers, streams, wetlands and/or ponds).
- Aggregate Resource Act compliance monitoring at over 30 above water or below water extraction sites. Includes measurement and analysis of water level, water quality, thermal impact and groundwater-surface interaction at streams, wetland and ponds.