Technical Memorandum

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22 February 2016

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From: Bill Banks, P.Eng., Principal Hydrogeologist

Re: Preliminary Hydrogeological Assessment
Proposed Residential Development - Bonarrow Meadows
Rockwood, Township of Guelph-Eramosa

1 Introduction

This Technical Memorandum presents a preliminary hydrogeological assessment completed for a proposed residential development site located in Part of Lots 6 and 7, Concession 4, Township of Guelph-Eramosa, Rockwood. This assessment was conducted to characterize hydrogeological conditions on-site in relation to the local conditions (i.e. a radius of about 2 km around the site). The results of the assessment will also support the evaluation of stormwater management options and pre- and post-development water budget calculations, by providing estimates of current on-site infiltration of precipitation and assessing groundwater flow directions. The interpretation of hydrogeological conditions is also provided in support of an Environmental Impact Study for this proposed development.

The hydrogeological assessment included a review of available information, such as geology maps and reports, aerial photography, groundwater study reports, and source water protection reports. A site reconnaissance was conducted with other project team members, followed by a review of site plans and reports completed for this project. Based on the results of these tasks, the local hydrogeological conditions have been characterized.

2 Background Information Review

The characterization of hydrogeological conditions across the local area where the site is located was completed following a review of relevant reports and other information, including for example:

- Paleozoic and Quaternary Geology Mapping, Ontario Geological Survey (various years).
- Regional Groundwater Characterization and Wellhead Protection Study, Guelph-Eramosa Township, Gartner Lee Limited, April 2004.
- Grand River Source Protection Area, Approved Assessment Report, Chapter 7 (Rockwood), Lake Erie Region Source Protection Committee, August 2012.
- Geotechnical Investigation, Proposed Residential Subdivision, Bonner Property, Township of Guelph-Eramosa, Ontario, Chung & Vander Doelen Engineering Ltd., December 2015.
- Functional Servicing Report, Bonner Property, Braun Consulting Engineers Ltd., February 2016.

- Draft Plan of Subdivision, Bonner Property, Astrid J. Clos Planning Consultants, February 2016.

Presented below is a description of the geology and hydrogeology of the area in which the site is located.

3 Overview of Local Geology and Hydrogeology

3.1 Geology

3.1.1 Bedrock Geology

The County of Wellington is located on the eastern rim of the Michigan Basin. The Paleozoic sedimentary bedrock dips gently to the southwest towards the centre of this basin. The Paleozoic rocks overlie Precambrian rocks that are generally located at a depth of about 850 m.

The sedimentary strata which overlie the Precambrian rocks in Southern Ontario were uplifted and tilted to the southwest towards the centre of the Michigan basin. Glacial erosion exposed (in subcrop) the south-westerly dipping bedrock in roughly northwest-southeast trending bands, with progressively younger sedimentary formations representing the bedrock surface towards the southwest.

The bedrock surface over most of the local area is at an elevation ranging from about 320 to 370 m above mean sea level (amsl). Within this range there are local rises and hollows in the bedrock surface, and an interpreted bedrock valley located just north of the site oriented in an east-west direction. Surface exposures (outcroppings) of the bedrock occur locally and most notably in the valley of the Eramosa River south of the site (i.e. Rockwood).

The depth to bedrock onsite varies from less than 0.1 m to more than 5.0 m, based on the results of the onsite geotechnical investigation (Chung & Vander Doelen, 2015). This variability is attributed to both the thickness of overburden deposits and the undulating bedrock surface.

The Ontario Geological Survey (OGS) has recently revised the nomenclature and interpretation of some Silurian dolostones in Southern Ontario. The uppermost local bedrock stratigraphy, beginning with the youngest bedrock formation, is summarized below.

The Guelph Formation typically consists of brown to grey dolostone interbedded with grey shale and is characterized by medium to thick bedding and medium to fine crystalline texture (Telford, 1976, 1979). The Guelph Formation is the youngest and uppermost bedrock in the local area, with the easterly extent occurring less than 300 m west of the subject site. It is relatively thin in the local area, but ranges in thickness up to about 30 m to the south and west. The Guelph Formation is generally recognized as a moderately-permeable, water-bearing bedrock aquifer.

The Eramosa Formation consists of three members including, from youngest to oldest , the Stone Road Member, the Reformatory Quarry Member and the Vinemount Member. This bedrock formation is generally recognized as cream coloured, coarsely crystalline dolostone. It often contains mud-rich and microbial mat-bearing lithofacies that may act as aquitard materials, resulting in a low vertical permeability (Brunton, 2008).

The Gasport Formation is a bluish-grey to white cross-bedded crinoidal grainstone-packstone with sequences of reef mound and coquina (shell bed) lithofacies (Brunton, 2008). This unit has been referred to as the Amabel Formation in previous hydrogeological investigations. This is the uppermost bedrock formation beneath the site. Biohermal and/or reefal structures, as well as associated fossiliferous beds, are relatively common. The total thickness of the formation is reported to be approximately 30 to 35 m in the area. The Gasport Formation is generally recognized as a highly permeable, water bearing aquifer. This formation represents the groundwater supply source for many communities in southern Ontario, including Rockwood.

3.1.2 Physiography

The physiography in the area where the site is located is varied and contains a number of landforms and soil types. The local area is situated within two physiographic regions: the Horseshoe Moraines and the Guelph Drumlin Fields as defined by Chapman and Putnam (1984). The Horseshoe Moraines are a series of broad, horseshoe-shaped glacial moraines, which flank the uplands that lie to the west of the Niagara Escarpment in Southern Ontario.

The eastern limb of the Horseshoe Moraines passes through the southern edge of Wellington County and is characterized by northeast-southwest trending bands of hummocky terrain containing three distinct moraines: the Paris, Galt, and Moffat moraines (Karrow, 1987). The topographically elevated lands of the Paris Moraine form a drainage divide southeast of Rockwood, between the Eramosa River and Blue Springs Creek. In some areas the moraines are hummocky with local relief of 30 m or more, steep irregular slopes, and basins of closed drainage, as characterized by frequent small ponds and marshy areas.

The Guelph Drumlin Field consists of a series of northwest-southeast trending drumlins that are situated to the northwest of the Paris Moraine. Numerous drumlins are located within 2.0 km northwest of the site.

A gentle ridge that crosses the site from west to east is the easterly extent of a feature that is referred to as the Eramosa Esker. Eskers comprise varying amounts of sand and gravel, as they originated as the beds of meltwater streams that flowed beneath stagnating glacial ice.

The topography of the local area ranges from hummocky in the upland areas to the southeast, to flat to gently rolling through much of the area northwest of the moraine. The lower lying areas between the Paris Moraine and the Guelph Drumlin Field, and interspersed between the drumlins, contain a series of terraced deposits of glaciofluvial outwash (sand and gravel) and lacustrine (sand) materials. The surficial deposits across the southern third of the site have been mapped as glaciofluvial gravelly deposits, which are bounded on the north by the esker. The remaining northern part of the site is mapped as silty to sandy till.

3.1.3 Overburden Geology

Overburden deposits in the local area were formed by numerous glacial events during the Wisconsinan ice age. Glacial ice advanced and retreated in the area on several occasions, leaving a complex assortment of deposits, ranging from about 10,000 to 30,000 years in age. Surficial deposits of this region were mapped by Karrow (1968, 1987). As described above, the most prominent surface features in the area of the site are the Paris Moraine, the outwash sand and gravel deposits, the Eramosa Esker, and the Guelph Drumlin Field. These features are shown on the OGS map of local surficial geology in Figure 1. The Paris Moraine typically consists of relatively thick accumulations of glacial till, which may be locally intermixed with sand and/or sand and gravel deposits. The occurrence of the till and kame deposits correspond with areas of hummocky topography.

As indicated above, the thickness of the overburden over bedrock within the vicinity of the site varies considerably, with onsite ranging from less than 0.1 m to more than 5.0 m. The overburden is very thin within the Eramosa River valley, with numerous bedrock outcrops. The overburden ranges upwards to about 45 m at the highest elevations of the Paris Moraine to the southeast. The surficial deposits are often underlain by one or more different deposits and as a result, the overburden geology must also be considered from a vertical profile perspective. The general textural characteristics and stratigraphic relationships of the overburden deposits are described below.

Wentworth Till

The Wentworth Till is the surface till which forms the Paris Moraine (Karrow, 1968). The Wentworth Till may be locally associated with deposits of kame sand and gravel and may overlie older deposits of glacial outwash and/or glacial till in some areas. The older Port Stanley Till has been mapped to the northwest of the Paris Moraine and may underlie the Wentworth Till in some areas. The Wentworth Till is also likely present beneath surficial sand and gravel deposits in areas northwest of the Paris Moraine, such as the northern part of the site.

The Wentworth Till is described as a buff-coloured, stony, sandy to silty sand till (Karrow, 1968). It is reported to typically contain an average of 49 percent sand, 33 percent silt and 18 percent clay. The texture of the till is typically coarser in end moraines than elsewhere and, as in the Paris Moraine, often grades into poorly sorted kame gravel.

Outwash Sand and Gravel Deposits

Outwash sand and gravel deposits are a dominant feature found within the broad plain northwest of the Paris Moraine. These materials were likely deposited within an ancient glacial meltwater channel, which at one time flowed to the northwest of the Paris Moraine, along what is now the drainage channel of the Eramosa River. The surficial deposits across the southern third of the site consist of these coarse-grained deposits.

The outwash deposits are characterized by level to undulating surfaces that may contain stream channels and sometimes kettle holes. Kettles are typically formed by melting of ice blocks that became trapped and partially or completely buried in the deposits. Deposits of peat and muck are also frequently found associated with the outwash sand and gravel deposits, such as those located northwest of the site.

Ice Contact Sand and Gravel Deposits

Ice contact sand and gravel (kame and esker) deposits are typically found associated with the outwash sand and gravel deposits and also in somewhat isolated pockets within the Paris Moraine. The Eramosa Esker crosses the middle of the site, observed as a west-to-east ridge.

Port Stanley Till

The drumlins to the northwest of the Paris Moraine in the Guelph Drumlin Field are comprised of a sandy facies (up to 40 percent sand) of the Port Stanley Till, which is typically a silt to sandy silt till. The till may extend to bedrock in the drumlins and may underlie surficial sand and gravel deposits in many areas.

3.2 Hydrogeology

3.2.1 Hydrogeologic Units

Groundwater occurs within both the bedrock formations and overburden deposits throughout the local area. Groundwater is a renewable resource and is recharged by rainfall and snow-melt events. Groundwater flows horizontally and vertically through the overburden and bedrock formations under hydraulic gradients. The rate of groundwater flow is dependent on the hydraulic conductivity of the deposits and formations, as well as the magnitude of the local and regional hydraulic gradients. The rate of groundwater flow is typically very slow relative to the flow of surface water in creeks, streams, and rivers.

Geologic deposits and formations with similar hydraulic characteristics are commonly grouped into hydrogeologic units. Three main hydrogeologic units were identified in the vicinity of the site based on a review of available hydrogeological reports. Each unit is described below.

Bedrock Aquifers

Bedrock aquifers are a major source of municipal and domestic water supply in the area. The bedrock is part of a major regional aquifer. Locally, the Guelph Formation and the Gasport Formation have historically been considered to represent one hydrogeologic unit due to their similar hydraulic characteristics. It is noted however that the Eramosa Formation, the unit that overlies the Gasport, is considered to be an aquitard, limiting the hydraulic connection between the Guelph and Gasport Formations. As a result, the Guelph and Gasport Formations have more recently been considered as individual aquifers.

Currently, the closest Rockwood municipal supply wells, referred to as Wells 1 and 2, are located about 250 m southeast of the site. It is understood these wells derives their supply from the Gasport Formation. Other municipal wells servicing Rockwood are located further to the southeast of the proposed development site. Most of the private water supply wells in the area of the site have been reported to be completed in the bedrock, likely deriving a supply from the uppermost Guelph Formation aquifer to the west and the Gasport Formation aquifer to the east.

Sand and Gravel Aquifer

The outwash and kame/esker sand and gravel deposits may be considered as a hydrogeologic unit where they are sufficiently thick. Due to their permeable nature, infiltration of precipitation, groundwater recharge and the rate of groundwater flow will be relatively high in these deposits.

Silty Sand and Gravel Till

Glacial tills typically contain a variable mixture of material types and significant amounts of fine-grained material such as silt and clay. The presence of these fine-grained materials significantly reduces the intergranular porosity and hydraulic conductivity of the till unit. Since the till unit will not transmit water readily and will likely limit the flow of groundwater, it is not considered to be an aquifer and it is not a source of water supply locally.

3.2.2 Groundwater Occurrence and Flow

The depth to groundwater onsite is variable, as observed during the drilling and test pit excavating for the geotechnical investigation (Chung & Vander Doelen Engineering Ltd., 2015). Borehole and test pit logs indicate the depth to groundwater varied from 0.74 to 2.29 m below current grade, where observed at 10 of 26 locations.

Evaluations of groundwater flow patterns in the bedrock aquifer during the Regional Groundwater Characterization and Wellhead Protection Study of Guelph-Eramosa Township (Gartner Lee, 2004) indicated that groundwater flow in the area of the subject site is south-easterly towards the Eramosa River.

The horizontal direction of groundwater flow in the overburden is interpreted to generally follow the surface water drainage pattern (i.e. topography) of the local area. Based on this, it is further interpreted that groundwater flows southerly towards the site from an elevated area to the north, with a component of flow discharging to the Grey Municipal Drain located along the northern edge of the site (refer to Figure 2). Based on the local topography, it is also interpreted that shallow groundwater flow from the northern part of the site discharges to the Drain.

Groundwater also flows under a downward vertical hydraulic gradient over most of the local area. Upward hydraulic gradients may exist in the vicinity of the Eramosa River and nearby wetlands, resulting in groundwater discharge to surface water, particularly in areas where the bedrock is exposed at surface, or where the bedrock aquifer is hydraulically connected to overlying saturated sand and gravel. Further analysis of groundwater recharge on the subject site is presented in Section 4 below.

3.2.3 Hydrology

The Grey Municipal Drain crosses the northern corner of the site, originating in the elevated area to the north. This surface water feature then flows northwesterly into a wetland as shown on Figure 2 (source GRCA website 2016). Based on observations made during a site reconnaissance on 25 November 2015, it is apparent that groundwater discharges to this drain in the vicinity of the site. Watercress was observed at several locations in the Drain.

Wetlands are often found associated with the glacial outwash deposits within the lower lying areas to the northwest of the site.

4 Estimated Groundwater Recharge

Based on an averaging of precipitation normals from meteorological stations in Guelph and the surrounding area, for the period 1981 to 2010, the average annual precipitation, for the area in which the study site is located, is estimated to be about 925 mm. It has been estimated that the average annual evapotranspiration for this area is about 555 mm. This estimate of evapotranspiration is based on conditions that include: the depth to water table is greater than 1.0 m, the soil texture is granular, level to gently sloping topography, and land cover predominantly comprises vegetation. These conditions currently apply to the subject site, and as such, there remains about 370 mm on an average annual basis as surplus for recharge and runoff. Runoff from this site under existing conditions is estimated to be about 190 mm. Therefore, the pre-development total annual average groundwater recharge on this site is therefore conservatively estimated to be about 180 mm.

It is recommended that stormwater management techniques be designed to maintain, or possibly enhance, the estimated average annual rate of groundwater recharge for the site. This will support maintenance of local groundwater levels. Stormwater management systems should also be designed to protect groundwater quality. Reference should be made to the comparison of pre- and post-development rates of recharge and runoff, provided in a water budget in support of proposed stormwater management for the site in the Functional Servicing Report (Braun Consulting Engineers, February 2016).

5 Source Water Protection

The Grand River Source Protection Area Approved Assessment Report (Lake Erie Region Source Protection Committee, 2012) includes mapping of Wellhead Protection Areas (WHPA) and Groundwater Vulnerability for the Rockwood Municipal Well System. There are two municipal wells located southeast of the site, referred to as Wells 1 and 2. Two other municipal wells are located in the southeast part of Rockwood, referenced as TW2/02 and TW3/02. The WHPA mapping (refer to Appended Map 7-48 from Approved Assessment Report) indicates the proposed development site is located outside of any of the protection areas for these municipal wells. Therefore, it is not expected that Source Protection Policies for municipal water supply sources will be directly applicable to this site.

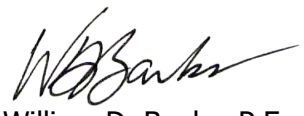
6 Summary

The following summarizes the characterization of the hydrogeological conditions of this proposed development site.

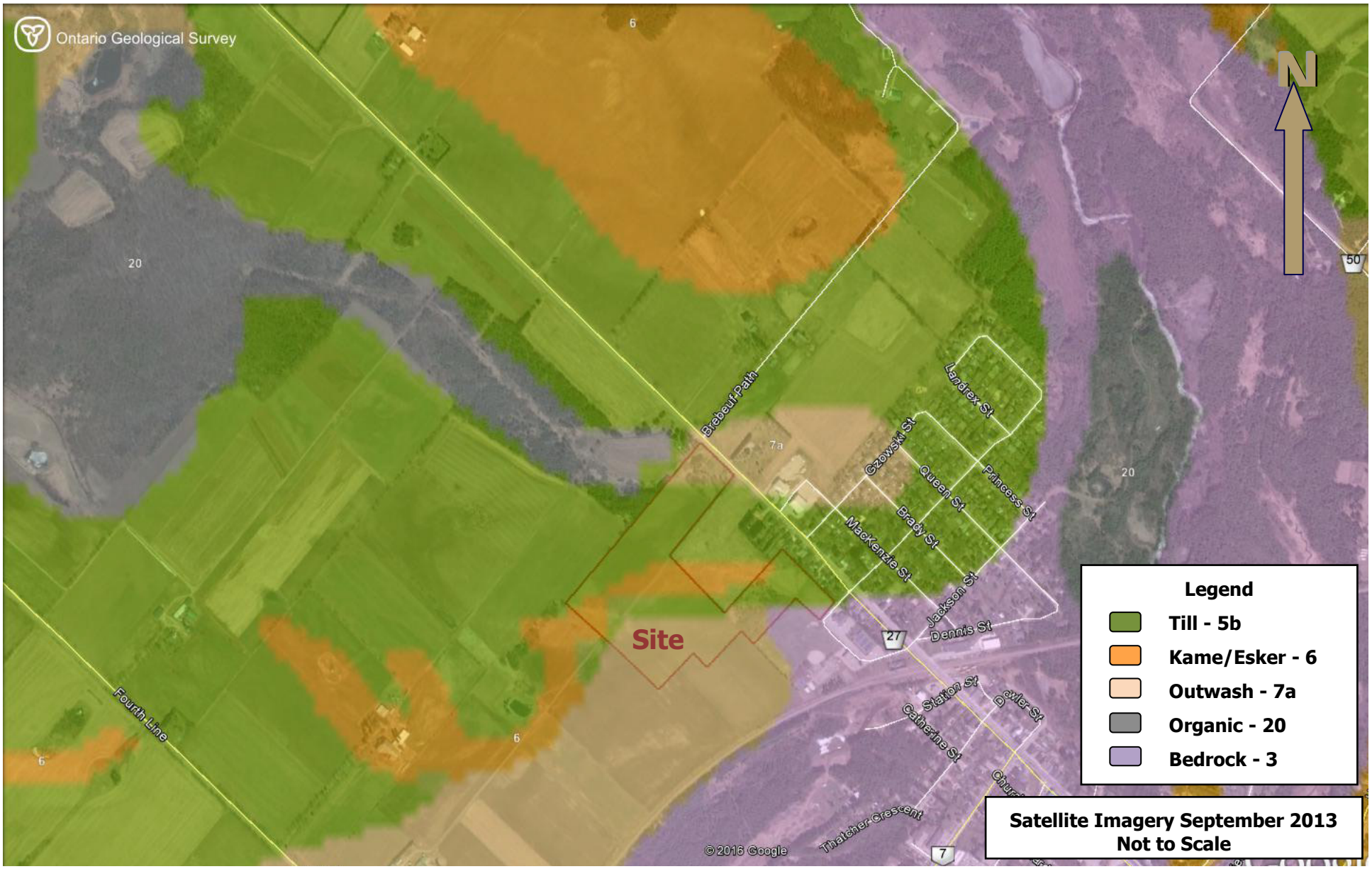
1. The depth to groundwater (i.e. uppermost water-bearing zone, or water table) varies across the site as observed during the drilling and test pit excavating for the geotechnical investigation (Chung & Vander Doelen Engineering Ltd., 2015). Borehole and test pit logs indicate the depth to groundwater varied from 0.74 to 2.29 m below current grade, where observed at 10 of 26 locations.

2. Evaluations of groundwater flow patterns in the bedrock aquifer during the Regional Groundwater Characterization and Wellhead Protection Study of Guelph-Eramosa Township (Gartner Lee, 2004) indicated that groundwater flow in the area of the subject site is south-easterly towards the Eramosa River.
3. The horizontal direction of groundwater flow in the overburden is interpreted to generally follow the surface water drainage pattern (i.e. topography) of the local area. Based on this, it is also interpreted that groundwater flows southerly towards the site from an elevated area to the north, with a component of flow discharging to the Grey Municipal Drain located along the northern edge of the site. Based on the local topography, it is also interpreted that shallow groundwater flow from the northern part of the site discharges to the Drain.
4. The Grey Municipal Drain crosses the northern corner of the site, originating in the elevated area to the north. This surface water feature then flows northwesterly into a wetland. Based on observations made during a site reconnaissance on 25 November 2015, it is apparent that groundwater discharges to this Drain in the vicinity of the site. Watercress was observed at several locations in the Drain.
5. The estimated average annual precipitation for the local area is 925 mm and the average annual evapotranspiration for this area is about 555 mm. Therefore, there remains about 370 mm on an average annual basis as surplus for recharge and runoff. Runoff from this site under existing conditions is estimated to be about 190 mm and the resulting pre-development total annual average groundwater recharge on this site is conservatively estimated to be about 180 mm.
6. It is recommended that stormwater management techniques be designed to maintain, or possibly enhance, the estimated average annual rate of groundwater recharge for the site. This will support maintenance of local groundwater levels. Stormwater management systems should also be designed to protect groundwater quality.
7. Based on Source Water Protection mapping for the Rockwood municipal well system, the subject site is not located within the Wellhead Protection Areas. Therefore, it is not expected that Source Protection Policies for municipal water supply sources will be directly applicable to this site.

Respectfully submitted,
Banks Groundwater Engineering Limited



William D. Banks, P.Eng.
Principal Hydrogeologist



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Hydrogeological Assessment
Proposed Residential Development - Bonarrow Meadows
Rockwood, Township of Guelph-Eramosa

Surficial Geology

Figure 1

THIS MAP IS NOT TO BE USED FOR NAVIGATION

Grand River Conservation Authority

Map created: February 19, 2016

Figure 2 - Hydrology

LEGEND

- WATERSHED MASK
- BUILDING - SYMBOLIZED (GRCA)
- BUILDING - TO SCALE (GRCA)
- WATERSHED BOUNDARY (GRCA)
- UTILITY LINE (NRVIS)
- ROADS-ADDRESSED (MNR)
- RAILWAY (NRVIS)
- DRAINAGE-NETWORK (GRCA)
- WETLAND (GRCA)
- DRAINAGE-POLY (NRVIS)
- 2010 ORTHO (ONT)

GRCA Disclaimer

This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.

The source for each data layer is shown in parentheses in the map legend. For a complete listing of sources and citations go to:

http://grims.grandriver.ca/docs/SourcesCitations2.htm

0 115 230 345 460 m.

NAD 1983, UTM Zone 17 Scale 1:10,000

N

Map 7-48: Rockwood Water Supply Wellhead Protection Area Initial Vulnerability (Insert)