GREER GALLOWAY
CONSULTING ENGINEERS

Phase 1 Assessment of Potential Karst

Proposed 1919 Estates Subdivision, Phase 1
Bobcaygeon, Ontario

Prepared for:

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Project 21- 1-6814

December 3,2021

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Jeffery Homes
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Re: **An Assessment of Potential Karst**
Proposed Residential Subdivision, 1919 Estates, Phase 1
Location: Bobcaygeon, Ontario

This report is a follow-up report to an earlier report dated August 23, 2019 in reference to this same property, and a proposed 19 lot residential subdivision registered as the Anderson Subdivision proposed by Andrew Anderson, who was the former owner of the property. The property has undergone a change of ownership, effective April 2021, from Andrew Anderson to Jefferey Homes.

The Andrew Anderson Ownership had envisioned a 19-lot residential development on the south half of the property whereas the Jefferey Homes ownership proposes a 48-lot subdivision on the total property, i.e. – 22 lots on the south part of the property referenced hereafter as 1919 Estates, Phase 1, and an additional 24 lots on the north part of the property at some future date to be referenced as 1919 Estates, Phase 2.

My assessment of the newly proposed 1919 Estates Phase 1 development proposal has followed the methodology outlined in “Karst and hazards Lands Mitigation”, some of the guidelines for geological geotechnical investigations in Ontario Investigations in Ontario, Karst Terrain (Brunton 2013), and inclusive of a desktop study and a site and surrounding area visitation.

I have found no evidence of Karst development on the property, either from published information sources or my visit to the site and surrounding area. Based on these sources and my site visit, I have concluded there is a low risk that karst features might pose a hazard or constraint to the planned development on this property.

I trust this report is complete and sufficient for your requirements. Please contact me if you require any additional information or clarification.

GREER GALLOWAY,
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Yours very truly,

Charles Mitz, M.Eng., Ph.D., P.Geo.
Senior Project Manager

Table of Contents

Figures

1. Introduction

Greer Galloway was retained by Jeffery Homes to update an investigation of karst potential for a planned 22-lot residential development referenced as 1919 Estates, Phase 1, at 168 County Road 49 Lots 18 & 19, Concession 19. Geographic Township of Harvey. The study was commissioned to satisfy the comments made by Mr. Kent Stainton of Kawartha Region Conservation Authority with respect to a Large Fill Procedural Guideline, and a requirement that the property be evaluated for potential karst.

Karst is a landform typically found in areas underlain by carbonate rocks such as limestone or dolostone which are soluble in waters derived from rainfall or snowmelt. Karst features include caves, sinkholes and solution-enlarged fractures. These features can present geologic hazards by increasing vulnerability to groundwater contamination, or through the risk of sinkhole formation affecting buildings and other structures.

My assessment followed the methodology outlined in *Karst and Hazards Lands Mitigation: Some Guidelines for Geological and Geotechnical Investigations in Ontario Karst Terrains, (*Brunton 2013) and included a desktop study and site visit of site and surrounding area. Information reviewed included:

- Maps and reports pertaining to karst, ground and bedrock topography, physiography, hydrology, Quaternary and Paleozoic bedrock geology.
- Existing engineering reports including geotechnical, ecological, archaeological, and hydrogeological assessments.
- MECP water well records
- Historic and recent air photos

The site visit component of the assessment was completed on July 7, 2019 at which time a representative of Greer Galloway (Mitz) walked the property to assess the topography, drainage, and vegetation and to examine bedrock and soil exposures. A windshield survey of the surrounding lands was also carried out following the site visit. Key features were photographed and georeferenced for comparison to features visible in the aerial photography.

2. Site Description

2.1 General

The site is located off Highway 49 about 2.5 km north of Bobcaygeon. The description is 168 County Road 49, Part of Lot 19, Concession 19, in Geographic Township of Harvey, now in the Municipality of Trent Lakes, Ontario. The proposed development consists of 19 residential lots that are to be serviced by individual wells and septic systems. The total area of the proposed development is approximately 21.27 hectares that includes the residential lots, a wetland area that bisects the property and proposed road allowances. Proposed lot sizes vary between 0.5 and 1.42 ha with an average lot size of 0.71 ha (jp2g, 2019). The lots will be accessed by one of two streets which will be constructed on the west and east halves of the subdivision lands respectively, leaving the wetland area unaltered. The street to be constructed on the west half of the property will connect to County Road 49 while the street to be constructed on the east half of the property will connect to Moon Line North. Apart from the Village of Bobcaygeon, land use in the area is primarily agricultural.

2.2 Physical Setting

The subject lands are located in an area of rolling topography with elevations exceeding 295 metres above mean sea level (mASL) in the western portion of the site and falling away to a local low of

approximately 290 mASL in an approximately 2.9 ha wooded wetland area that bisects the centre of the site. East of the wetland the topography remains rolling with an overall eastward slope to a low of approximately 282 mASL along Moon Line Road. The overall topography is distinctly rolling with irregular hummocks up to 5 m in height and numerous pockets of closed drainage. Drainage on the property is generally to the central wetland or a small creek running east towards Moon Line Road.

Vegetation consists of woodlands, wetland, and fields. Jp2g (2018) describe the vegetation assemblage as fields and cleared areas. Vegetation noted within the open field (cultural meadow) portions of the site consists primarily of various grasses and herbaceous vegetation interspersed with juniper shrubs and occasional red cedar. Vegetation on the forested portion consists of a mixed forest with trees of various ages, a white cedar coniferous forest, and a common buckthorn thicket as well as a mature sugar maple dominated deciduous forest.

Photos showing the general topography and vegetation cover are shown in Figures 1 to 3, below:

Figure 1 – Site Photos **Left panel:** Looking to the west toward Highway 49 and the access to the property; **Right panel**: a view of the wetland area in the central portion of the site (looking to the south).

Figure 2 – Site Photos **Left panel:** Looking to the south along a north-south oriented fence line in the eastern portion of the property. Fencerows were typically piled with grey-weathering angular to subangular limestone clasts removed from the fields during more than a century of farming activity at the site; **Right panel**: a view of a typical area of closed drainage characterized by lush vegetation but no indications of standing water accumulation.

Figure 3 – Panoramic photo of the central portion of the site showing typical hummocky topography.

2.3 Bedrock Geology

The subject property is within a physiographic region known as the Carden Plain – an irregular area of limestone alvar and thin drift some 20 - 40 km wide and extending along the southern edge of the Canadian Shield from Georgian Bay to the Frontenac Axis. The bedrock geology in the vicinity of the site consists of shales and limestones of the middle Ordovician age Shadow Lake, Gull River, Bobcaygeon, and Verulam Formations. The western half of the property is underlain by the limestones and shales of the middle Ordovician Verulam Formation while the eastern half of the property is underlain by the upper member of the Bobcaygeon Formation. The upper member of the Bobcaygeon Formation outcrops at the base of a small scarp located immediately to the north of the northeast corner of the subject lands.

The Shadow Lake Formation is a discontinuous, time-transgressive unit that unconformably overlies the older Precambrian basement. The unit consists of non-fossiliferous, red, maroon and green, poorly sorted, argillaceous, arkosic sandstones and conglomerates, arenaceous (sandy) siliciclastic shales and siltstones (Armstrong, 2000). The nearest mapped exposure of the Shadow Lake Formation occurs along the shore of Pigeon Lake some 1.7 km northeast of the site although the unit likely extends beneath the site at depth.

The Gull River Formation overlies the Shadow Lake Formation and outcrops along much of the northern Pigeon Lake shoreline. It consists of light grey to brown, variably fossiliferous, very fine-grained pale to medium grey-weathering limestone. Armstrong and Rhéaume (1994) subdivide the Formation into an upper and lower member with the lower Gull River member typically containing a greater proportion of argillaceous to silty dolostone beds. The Gull River strata are regionally extensive and continuous. The nearest mapped exposure of this unit occurs approximately 1.3 km to the east of the site.

The Bobcaygeon Formation overlies the Gull River and forms the upper bedrock over the eastern half of the property. It is a light grey-brown to blue-grey to grey-brown, fine- to coarse-textured fossiliferous limestone. Thin shale interbeds and partings are encountered within the limestone and these increase in abundance upward while crinoidal grainstones and nodular textures are more common in the lower part of the Formation. Armstrong and Rhéaume (1994) subdivide the Bobcaygeon Formation into an upper, middle and lower member with the upper member forming the uppermost bedrock beneath the eastern half of the property. Several outcrops of this formation were identified in the northeast corner of the property. In this area, limestone of the upper Bobcaygeon forms a flat, sparsely jointed pavement with a “step” upward in elevation to the south.

Bedrock exposed in the “step” is a highly fractured and weathered grey-brown, fine-textured limestone with individual limestone layers typically thinner than 150 mm and separated by numerous shaley layers. Minimal solution widening (circa 1 to 2 mm) was noted in the bedrock joints and no cavities/voids were noted in the limited extent of the vertical exposure. Photos of the Bobcaygeon Formation outcrop are shown in Figure 4.

The Verulam Formation overlies the Bobcaygeon Formation and forms the uppermost bedrock over the western half of the property. It consists of grey, interbedded, bioclastic to very fine-grained limestone and grey-green calcareous shale. No outcrops of Verulam Formation were observed on the property.

Figure 4 – Bedrock outcrop in the northeastern corner of the property. **Left Panel**: an exposure on the face of a low step or scarp **Right Panel**: jointed limestone pavement

2.4 Quaternary Geology

The landscape of the area has been shaped by glacial processes over the past 2 million years of the Pleistocene Epoch. During this time, multiple glaciations occurred separated by relatively warmer interglacial periods. While some of the bedrock topography may reflect the effects of the earlier glaciations, the majority of the topographic features and all of the overburden materials date from the latter part of the most recent glacial period known as the Wisconsinan glaciation. The maximum ice extent occurred approximately 23,000 years ago when glacial ice covered all of Ontario and extended as far as Ohio in what is now the United States. The melting of the ice sheet in the Bobcaygeon area laid down glacial till - poorly sorted materials that had been entrained within the ice and created the rolling hummocky topography of the subject area. The till material is typically coarse-textured and contains a high percentage of angular limestone clasts. Post-glacial soils consist of recent alluvial deposits and organic soils occur within low-lying or poorly drained areas. Quaternary geological mapping by Finamore and Bajc (1983) shows very stony silty sand with numerous large boulders over the majority of the property with thin overburden or exposed bedrock in the north-easterly corner of the site. Test pitting by Terraspec (2017) found similar soil conditions to those mapped by Finamore and Bajc with the typical soil layers including silty topsoil, minor silty sands, and silty sand and gravel/cobble till. Bedrock was encountered at approximately 2.5 m depth in the west portion of the site and at greater than 3 m over the eastern half of the property.

2.5 Hydrogeology

The fractured limestones of the Verulam and Bobcaygeon Formations form the primary source of exploitable groundwater in the area, while coarse till and alluvial sands form a marginal discontinuous aquifer locally exploited by shallow dug wells. The well records in the vicinity of the site care predominantly drilled wells sourcing the bedrock with reported yields typically in the range of 9 to 45 L/min. Within the property, the groundwater table is encountered within bedrock at depths between 6 and 10 m (Jp2g, 2019). Well capacities ranged from 26 – 75 liters per minute for the four test wells drilled on the property. The water bearing zone was found at depths ranging from 27 m to 55 m. Transmissivities were estimated (Jp2g, 2019) to range from 44 to 143 m^2/day.

Precipitation falling on the property contributes to recharge of the bedrock aquifer. There is little evidence of surface water runoff over much of the property reflecting the coarse permeable character of the predominant glacial till and the areas of closed drainage across the site. Groundwater was generally not encountered in overburden during a geotechnical investigation of the property (Terraspec, 2017) except for perched groundwater at depths between 1 and 2 m in two of the 10 test holes. Piezometric elevations in bedrock indicate an overall southeasterly groundwater flow direction.

3. Karst and Risk Factors

Karst features such as caves, sinkholes and solution-enlarged fractures are caused mainly by chemical dissolution of soluble carbonate bedrock by acidic groundwater over a lengthy period of many thousands of years. While the potential for a sudden collapse of an underground cave or the development of a sinkhole are obvious hazards (especially in areas of the world such as Florida, Mexico, Spain etc.) this kind of hazard is rare in Ontario. More common is the potential for karst features to cause zones of abnormal permeability that render groundwater more susceptible to biological and chemical contamination.

Brunton and Dodge (2008) published a karst map for southern Ontario and Manitoulin Island that breaks down karst potential into four categories:

- areas of known karst (red);
- areas of inferred karst that are a natural extrapolation of the known karst areas (orange);
- areas of potential karst (yellow);
- areas of unknown or no observed karst.

No areas of known karst are mapped as occurring within the property. Inferred karst is mapped as occurring within a small area (approximately 0.5 ha) in the extreme northeast of the property in the area coinciding with the exposed bedrock encountered in our site reconnaissance and described previously. The east half of the property (essentially all lands to the east of the central wetland area) is mapped as an area of potential karst. Potential karst regions possess predominantly carbonates or mixed carbonate/evaporite successions that are susceptible to karstification but which are either far removed from present- and paleo-drainage river systems, and/or covered by overburden or younger stratigraphic units. These regions also lack direct observation of karst features by OGS staff and/or do not have any reported karst features.

A number of Ontario-specific karst risk factors have been identified (Brunton and Dodge, 2008; Brunton, 2013). These are:

- karst-susceptible geology consisting of carbonate rocks or evaporites
- thin or absent soil cover
- proximity to the Paleozoic–Precambrian unconformity
- proximity to major river systems and adjacent swampy areas

- proximity to significant sequence stratigraphic boundaries
- proximity to margins of escarpments near major rivers, particularly at bends in major rivers

Particular stratigraphic intervals such as the upper Gull River–lower Bobcaygeon formational contact have been identified as being prone to the development of karst (Brunton and Dodge, 2008). The Verulam Formation and upper member of the Bobcaygeon are not known to be especially susceptible to karstification.

4. Summary

I found no evidence of karst development on the property either in published information sources or in my visit to the property. Based on the results of my karst assessment I conclude that there is a low risk that karstic features would pose a hazard and constraint to the planned development of the property. Specific observations/conclusions are presented below:

- Half of the property is underlain by limestones of the Verulam Formation and is mapped as having little potential for the development of karst while the remainder is mapped as potential karst (except for a small area in the northeast corner of the property which is mapped as inferred karst.
- The small area of inferred karst occurs is underlain by exposed bedrock with no visible karst features such as sinkholes, excessive joint dissolution etc.
- The eastern half of the property (mapped as potential karst) has a soil cover generally exceeding 3 m
- Well yields and associated drawdowns in the 4 test wells drilled on the property are suggestive of a fractured bedrock environment but inconsistent with the intersection of voids such as caves
- Moderate to high total dissolved solids in groundwater are consistent with a lengthy residence time not with rapid recharge conditions

While I did not find evidence of hazardous karst conditions at the site, I note that all limestone dominated terrains such as the Carden plain have the potential for bacterial contamination owing to the presence of solution widened joints/fractures and the generally thin and discontinuous soil cover. For this reason, the proposed development characteristics, (i.e., large lots spaced in a linear property perpendicular to the groundwater flow direction) are considered appropriate for the geological setting.

I trust that this report is complete and sufficient for your present requirements. Please call me if you have any questions about the report.

Respectfully Submitted,

Charles Mitz, M.Eng., Ph.D., P.Geo.
Senior Project Manager

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