

MEMORANDUM

To: Sanath Bandara, P.Eng.
District of Sechelt

Date: July 11, 2017

From: Caleb Scott, E.I.T.
(Reviewed by David Tara, P.Eng.)

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GROUNDWATER MANAGEMENT ISSUES THE SHORES - PHASE 1 DEVELOPMENT, SECHULT, B.C.

This memorandum provides an assessment of current groundwater management issues at The Shores Phase 1 Development (the site) and recommendations for proactive groundwater management measures to mitigate the ongoing formation of sinkholes at the site.

It is a condition of this memorandum that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

1. BACKGROUND

Thurber Engineering Ltd. (Thurber) prepared a report titled "The Shores – Phase 1 Subdivision: Sinkhole Investigation and Geotechnical Assessment" dated July 16, 2015 (2015 Report). Since that time, Thurber has completed a limited number of site reviews and has reviewed a limited number of site inspection reports completed by District of Sechelt (District) personnel.

At the request of the District, Thurber Engineering Ltd. (Thurber) recently inspected the site and completed a targeted drilling investigation following the discovery of a new sinkhole on Gale Avenue North at approximately Sta. 2+60. The results and our recommendations addressing the zone of immediate concern were provided in our June 30, 2017 report.

This memorandum provides additional comments and recommendations to those provided in our previous memoranda, letters and reports regarding groundwater management.

2. IMPORTANCE OF GROUNDWATER MANAGEMENT

Our understanding is that the sinkholes, which continue to develop at site, are related to the flow of groundwater in the presence of pathways for subsurface erosion (refer to 2015 Report, Section 9). Groundwater must be proactively managed to limit the potential for development of sinkholes. In contrast, poor management of groundwater will exacerbate and accelerate the development of sinkholes.

3. ENGINEERING ASSESSMENT OF CURRENT GROUNDWATER MANAGEMENT

3.1 General

Sinkholes continue to develop at the site and the results of our recent site inspections and investigation at Gale Avenue North indicate that subsurface erosion continues to occur. As such, we conclude that the current passive groundwater management strategy employed by the District and others is inadequate.

3.2 Crowston Road Ditch Lining

The surface drainage ditch on the west side of Crowston Road was partially lined in late 2015. Prior to lining the ditch, surface water flow was observed to infiltrate into the ground before reaching the storm sewer inlet near Seawatch Lane. The purpose of the ditch lining was to reduce the infiltration of surface water in that area.

Our understanding is that the lining appears to be functioning as intended. However, based on limited available data, the effect of the lining on the groundwater levels at the site appears to have been minimal (refer to Figures 8 to 20 of our June 30 report). The beneficial reduction in infiltration due to the ditch lining may have been effectively negated by the recent clearing of vegetation on several lots on the east side of Crowston Road which likely increased the infiltration of precipitation and surface water.

3.3 Lot 3 Seepage Mitigation Measures

In May 2012, a relatively large groundwater spring developed on Lot 3 which eroded significant quantities of sand and silt and was associated with the sinkhole which developed at Seawatch Lane about 100 m to the south. In August 2013, Seepage Mitigation Measures were constructed at the location of the spring on Lot 3 under the supervision of Golder Associates (Golder). As Engineer of Record (EOR) for the seepage mitigation measures, Golder later provided As-Built record drawings for the work which were dated June 11, 2015.

There is a gap in the groundwater monitoring data set between May 2013 and February 2015. However, from the available data (refer to June 30, 2017 report, Figures 7 to 20) it is evident that groundwater levels rose significantly across the site following completion of the Lot 3 Seepage Mitigation Measures. The relatively unmitigated flow of the Lot 3 spring in 2012 and 2013 likely had a dewatering effect on the site. However, due to a lack of groundwater monitoring data, it is unclear if the Lot 3 Seepage Mitigation Measures resulted in groundwater levels above pre-development conditions.

In a June 23, 2015 report to the District of Sechelt, Golder strongly recommended several maintenance measures for the Lot 3 Seepage Mitigation Measures which were to be implemented 'as soon as reasonably possible and before the onset of wet weather conditions'. It is Thurber's understanding that the recommended maintenance has not yet been completed.

During our recent site visits in June 2017, we observed ongoing seepage and lush hydrophilic vegetation surrounding the spring which has formed immediately northwest of the Lot 3 Seepage Mitigation Measures. This spring has been observed since 2015 and continues to flow unabated, though without visible active erosion or transport of suspended sediment.

Thurber has concerns that, in a wet year or otherwise, this unmanaged spring could develop into a large seepage blow out which could result in accelerated subsurface erosion and sinkholes.

4. RECOMMENDATIONS FOR GROUNDWATER MANAGEMENT

4.1 Proactive Groundwater Management

Proactive groundwater management (detailed as follows) is strongly recommended to mitigate the ongoing erosion of subsurface soils which has resulted in sinkholes at the site. If measures are not taken soon to control the ongoing erosion of subsurface soils, new sinkholes will likely develop in the near term. Further, the piping erosion may expand south and southeast beyond the site boundary, affecting neighbouring roads and properties (if they are not already affected).

4.2 Site Dewatering

Site dewatering has the most potential for effective mitigation of the sinkhole development process (2015 Report, Section 11.2). Detailed design is required to provide a system to mitigate subsurface erosion. A pilot program, comprised of temporarily pumped wells and monitoring wells, is required to assess the effectiveness of dewatering measures and to provide data to guide the design of the larger system. We strongly recommend that the District and other stakeholders move forward with a pilot dewatering program.

Inappropriately positioned dewatering measures could promote rather than mitigate subsurface erosion. To appropriately position site dewatering measures, an investigation of current ground conditions is first required along the south perimeter of the site to assess whether subsurface erosion has extended beyond the site boundaries. This investigation would also provide the District with information to guide its consideration of applications to develop the neighbouring properties. In our opinion, the neighbouring lands to the south and southeast of the site should not be developed without detailed investigation and assessment of the potential that the sinkhole issue has expanded beyond the site. Further details can be provided, if required.

4.3 Lot 3 Seepage Mitigation Works

The maintenance recommended by the EOR (Golder) for the Lot 3 Seepage Mitigation Measures should be completed without delay (i.e. this summer) and under the direction of the EOR.

The EOR should be requested to provide an updated assessment of the performance of the Lot 3 Seepage Mitigation Measures in consideration of the ongoing seepage zone immediately to the northwest.

The Lot 3 Seepage Mitigation Measures have resulted in increased site groundwater levels and, in our opinion, may be partly responsible for re-initiating the sinkholes at Lots 9 and 21 and more recently at Sta. 2+60 on Gale Avenue North. As such, all stakeholders must be mindful of the effects of actions on groundwater levels at the overall site.

4.4 Inspect and Maintain Buried Utilities

We suggest that camera inspections of buried utilities at the site be completed annually during a window of dry weather and between February and May when groundwater levels are higher. This will increase the potential for identifying locations where groundwater may be infiltrating into buried pipes and damaged locations which may indicate active sinkhole formation.

Damaged pipes should be repaired to mitigate the potential for contribution to the subsurface erosion problem, and to mitigate the potential for pipe failure.

4.5 Reduce Infiltration of Precipitation and Surface Water

It may be possible to mitigate seasonal highs in groundwater levels and thereby reduce subsurface erosion by reducing the infiltration of precipitation and surface water at the site and at nearby sites to the south and southeast.

4.5.1 Irrigation Restrictions

We recommend that irrigation and water discharge restrictions be implemented across the upper slope area of the site including Lots 16 to 28. Similar restrictions should also be implemented at neighbouring properties to the south and southeast, if they are developed (see our comments in Section 4.2).

4.5.2 Borrow Area Pond

Consideration should be given to draining the seasonal pond which forms in the borrow area (south of site, accessed from Crowston Road), by connecting it to the lined ditch at Crowston Road. Detailed analysis would be required to confirm that ditch and storm sewer capacities are adequate for this increased catchment area.

4.6 Groundwater Monitoring

We recommend that groundwater levels be monitored and the site-wide surface monitoring checklist be completed on a weekly basis. If, for some reason, a complete inspection of the site cannot be completed, monitoring of the groundwater levels should take priority. Regular

groundwater level monitoring and surface inspection are critical as they provide context in the event of future sinkhole activity due to the ongoing subsurface erosion process. Groundwater monitoring also provides a means to assess the effectiveness of groundwater management measures.

Consideration should be given to the installation of groundwater dataloggers in select monitoring wells to reduce personnel commitments and to provide consistent data collection. Additional details can be provided if required.

4.7 Comprehensive Site Wide Sinkhole Investigation

We continue to recommend that a comprehensive site-wide investigation be completed to identify areas where sinkholes may be developing. If this investigation is not completed, developing sinkholes may only be discovered when they collapse without warning which could result in harm to persons or property.

4.8 Neighbouring Developments

4.8.1 Reduce Infiltration & Surface Water Management

Consistent with the recommendations of our January 20, 2017 memorandum, for the new development east of Crowston Road, the District should require that design measures and construction management practices be implemented to mitigate the potential for the new development to exacerbate the ongoing groundwater-related subsurface erosion and sinkhole issues at The Shores site. The objective of these measures would be to reduce the infiltration of stormwater into the ground to below pre-development levels.

While details should be provided by the developer's geotechnical consultant after its own assessment, at a minimum consideration should be given during construction to installing impervious liners at the base and sidewalls of all existing and proposed stormwater sedimentation ponds. These ponds could be decanted into the stormwater system to mitigate overtopping potential. In addition, the development design should not include the use of rock pits or other measures intended to promote the infiltration of stormwater. Further, the east ditch of Crowston Road may need to be lined (similar to the west ditch) if stormwater flows increase as a result of the new development. The developer's geotechnical consultant should provide a detailed plan to address the potential impacts of the development on the Shores and adjacent sites.

4.8.2 Potential Subsurface Erosion & Sinkhole Hazard Assessment

Prior to permitting development of the adjacent lands to the south and southeast of the site, we recommend that the District require a detailed assessment of the potential for subsurface erosion and sinkholes at those sites. The assessment must determine whether the subsurface erosion process, which resulted in several sinkholes along Seawatch Lane (in 2012 and during early construction) and at Lot 29 in 2007, has migrated beyond the site boundaries and to what extent. Development applications in this area should be subjected to geotechnical peer review.

5. CLOSURE

The risk of sinkhole collapse is difficult to predict. Without addressing the concerns outlined in this memorandum and our previous correspondence, the site will likely experience another sinkhole collapse in the near term. Future sinkholes could affect existing infrastructure such as underground utilities, roads or sidewalks, or private property including buildings and retaining walls. Injury or even death is a possible consequence. If conditions continue to deteriorate, lack of action will likely result in access to Lots 7 and 8 being cut off in the relatively near future. As such, we strongly encourage all stakeholders to proactively address the problems at the site.

We trust that this is sufficient for your present needs. Please contact us if you have any questions.



STATEMENT OF LIMITATIONS AND CONDITIONS

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- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

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