

February 6, 2019

File: 11680

The District of Sechelt
Box 129, 2nd Floor, 5797 Cowrie Street
Sechelt, BC
V0N 3A0

Attention: Sanath Bandara, P.Eng.

**THE SHORES PHASE 1 DEVELOPMENT, SECHELT, B.C.
GEOTECHNICAL COMMENTS ON SINKHOLE RISK MANAGEMENT**

Dear Sanath:

A sinkhole collapsed to the south of Seawatch Lane on December 25, 2018. Thurber Engineering Ltd. (Thurber) completed a limited scope drilling investigation and geotechnical assessment of the portion of the District's Seawatch Lane right of way adjacent to the new sinkhole as described in our report dated January 25, 2019.

This report provides our comments on the implications of the recent sinkhole and investigation results for the overall Phase 1 development site and neighbouring sites, discussion of potential temporary access routes, and recommendations for risk mitigation.

Thurber recommended on February 1, 2019 that the District no longer permit occupancy of the public and private properties and buildings in the Phase 1 development.

The temporary access route likely will not be ready for at least several weeks. In the interim to mitigate the risk to the public, on February 1, 2019 Thurber also recommended the installation of barriers on Gale Avenue North and Crowston Road at the entrances to the site, adjacent to the recently installed warning signs.

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

1. BACKGROUND

1.1 General

The Shores Phase 1 Development (the site) has a history of geotechnical issues including sinkholes and groundwater seepage erosion dating back to 2004. The locations of the recorded sinkholes and other site features are shown in Figure 1 (attached). The site includes 14 houses, 2 of which are currently unoccupied (Lot 9 and Lot 21). Partially completed foundations are present on Lot 11 and Lot 15. The SCR map of the site is shown in Figure 2 which shows the lot and street numbers and the locations of the houses.

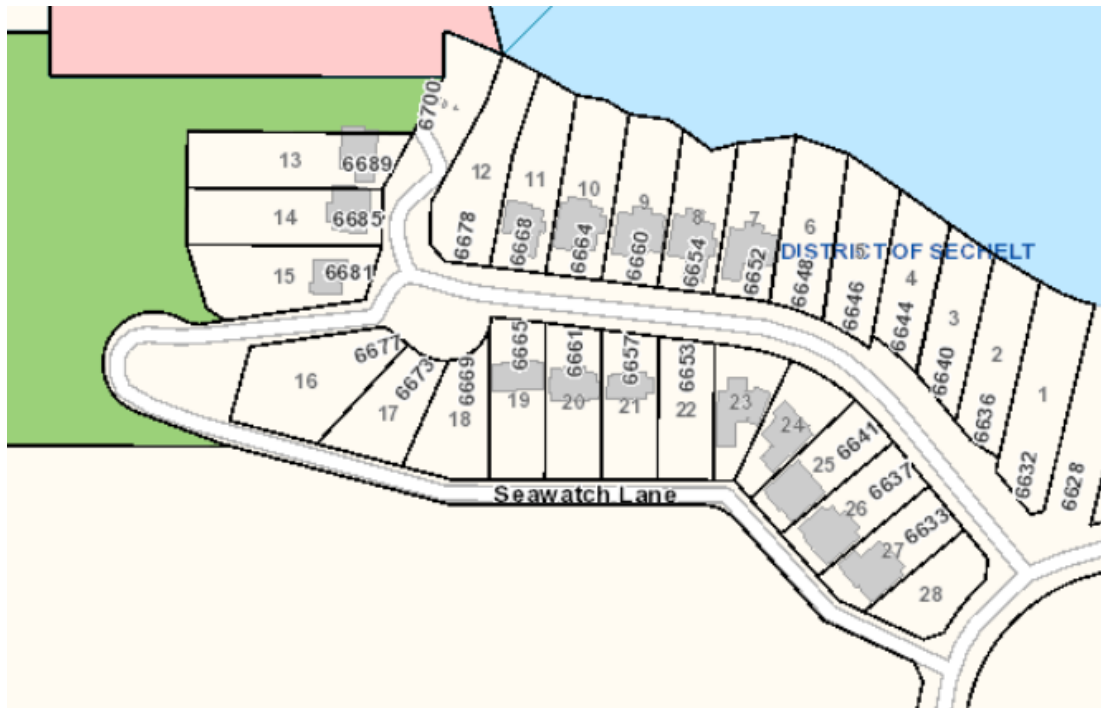


Figure 2. SCRD Map of Phase 1 Site

In 2015, Thurber completed a limited scope investigation following the collapse of sinkholes on Lot 21 and on Gale Avenue North adjacent to Lot 9 as described in our report dated July 16, 2015 (2015 Report). The 2015 Report described our assessment of the sinkhole development process and concluded that additional sinkholes could develop at the site if this process is not disrupted.

In 2017 Thurber completed a limited scope drilling investigation following the discovery of a sinkhole on Gale Avenue North at approximately Sta. 2+60 (adjacent to Lot 7 and Lot 23). The results and our recommendations addressing the zone of immediate concern were provided in our June 30, 2017 report. This investigation also identified a potential future sinkhole on Gale Avenue North at Sta. 2+80 (adjacent to Lot 8 and Lot 22). Temporary traffic detours and heavy vehicle restrictions were implemented around the most severely affected areas.

On May 25, 2018 District Staff observed new settlement and cracking in the patched asphalt within the temporary traffic detour on Gale Avenue North. Remaining geotechnical investigation options within the temporary detour were assessed to be impractical due to the presence of buried utilities and the potential for continually changing ground conditions. In the absence of groundwater management to mitigate the ongoing sinkhole development process and pending sinkhole repairs, Thurber recommended full closure of Gale Avenue North to traffic to the west of Lot 6 in our memorandum dated June 15, 2018.



On September 19, 2018, residents of the development discovered a new sinkhole on Lot 6 which is private property with no structures. The surface expression of the sinkhole was approximately 1.5 m wide and 0.5 m deep and has since expanded nominally to 2 m wide and 0.75 m deep. Plastic snow fencing has been installed around the perimeter of the Lot 6 sinkhole. The District installed yellow caution flagging along the edge of the Gale Avenue North right of way adjacent to Lot 6 and relocated the road closure traffic barriers approximately 20 m east (towards Crowston Road). Gale Avenue North is currently closed to traffic between approximately the west edge of Lot 5 and the west edge of Lot 9.

Since the 2015 Report, the District has continued groundwater monitoring and site inspections. However, our recommendations for groundwater management, proactive investigation of sinkhole hazards and sinkhole repairs have not been implemented. Thurber has completed a limited number of site reviews and has reviewed site inspection reports completed by District personnel. Prior to January 10, 2019, our most recent site review was completed on September 24, 2018.

1.2 Recent Events

Based on our interviews of District staff and residents, we understand that the new sinkhole collapsed on or around December 25, 2018. The sinkhole is located on private property centred approximately 3 m south of Seawatch Lane at approximately Sta. 4+60 and south of Lot 21 and Lot 22 as shown on Figure 1.

The District was informed on December 26, 2018 and notified the owner of the affected property who is reported to have backfilled the void with approximately 400 m³ of fill on December 27, 2018 as an emergency repair (see attached photographs). According to District staff, the sinkhole void appeared to be in the order of 12 m deep and 3.7 m wide at the ground surface. The void appeared to become significantly wider with depth, particularly in the upslope direction (south) and was estimated to be in the order of 12 m wide at the base.

We understand that on January 9, 2019 the District temporarily closed this portion of Seawatch Lane pending geotechnical assessment in accordance with the recommendations in our January 2, 2019 memorandum and subsequent correspondence. Thurber conducted a reconnaissance of the site on January 10, 2019 and provided interim recommendations as documented in our Field Review Report No. 18.

Thurber completed a limited scope drilling investigation of the closed portion of Seawatch Lane. The results of the investigation and our assessment of the cause of the sinkhole and the roadway integrity were provided in our January 25, 2019 report. The investigation confirmed that Seawatch Lane has been undermined and the thickness of the remaining soil crust may not be sufficient to support its ongoing use as the current conditions are anticipated to change and deteriorate with time. We recommended that this section of Seawatch Lane be permanently closed to vehicle traffic.



2. GEOTECHNICAL COMMENTS

2.1 Implications for Phase 1 Site

In our opinion, the December 2018 sinkhole adjacent to Seawatch Lane and the 2017/2018 sinkhole activity on Gale Avenue North and Lot 6 are symptomatic of the ongoing deterioration of subsurface conditions at the Phase 1 site. They further demonstrate that the sinkhole hazard is increasing with time and is not confined to locations where sinkholes have occurred previously. There is a very high probability of at least one sinkhole collapse each year based on the recent history of the site.

The 2015 Report provides a detailed discussion of the sinkhole development process. The December 2018 sinkhole and the results of the recent sinkhole investigation on Seawatch Lane are consistent with this process.

South of Gale Avenue North, the pattern of sinkholes, springs and loosened ground conditions indicates that the 'Lower Sand' stratigraphic unit (see Figures 9 to 14 in our 2015 Report), typically located between about El. 20 m and El. 25 m, is particularly susceptible to seepage erosion. Further they suggest that this unit has been extensively eroded as a result of seepage erosion initiated in approximately 2004 and continuing to present. As this sand is eroded, the overlying soils above the groundwater table are undermined and progressively collapse. In some cases, the undermining results in a sinkhole collapse at ground surface. The undisturbed natural ground conditions in this portion of the site are relatively strong resulting in relatively sudden collapses when sinkholes daylight.

At Gale Avenue North and to the north of the road, the pattern of sinkholes, springs and loosened ground conditions indicates that the underlying 'Lower Silty Sand' stratigraphic unit (see Figures 9 to 14 in our 2015 Report) is being eroded which is undermining the overlying engineered fills. The surface expressions of sinkhole collapses in this area have so far been shallower and often the surface deformation has been episodic over a period of years. We interpret this difference in behaviour to be a result of the lower strength of the fills compared with the undisturbed natural ground. The lower strength fills have a reduced ability to form large unstable 'crusts' over developing voids. However, sudden collapses are still possible.

Landslides are also possible as the ongoing subsurface erosion undermines and destabilizes the natural slope, engineered fills and retaining walls. Two landslides were recorded in 2005 which were attributed to seepage erosion (see our 2015 Report).

Future sinkholes or landslides could damage existing infrastructure such as underground utilities, roads or sidewalks, or private property including buildings and retaining walls. Injury or even death are possible consequences.



2.2 Implications for Neighbouring Sites

The December 2018 sinkhole occurred on the privately-owned property 'REM Block A, Exp. Plan 9589' (Phase 2 property) located immediately to the south of the Phase 1 site. This is the second recorded sinkhole to collapse beyond the limits of the Phase 1 site; the first occurred in 2007 south of Seawatch Lane and Lot 28. In both of these cases, it is our understanding that the Lower Sand stratigraphic unit had been eroded and undermined the overlying soils resulting in a sinkhole collapse.

There were also 2 other sinkholes reported on the south shoulder of Seawatch Lane during early construction around 2004 to 2006 (see Figure 1). We infer that these sinkholes also occurred due to the subsurface erosion of the Lower Sand.

The extent to which the Lower Sand has been eroded is not known but it is very unlikely that the limit coincides with the Phase 1 site boundary.

Thurber was provided with a copy of Golder Associates' July 13, 2017 report on the geotechnical investigation and assessment of the Phase 2 property for residential development. In 2017, 5 sonic test holes were drilled on the Phase 2 property. It appears that these test holes did not encounter signs of the sinkhole formation process.

The observed pattern of piping erosion of the Lower Sand appears to extend relatively horizontally upslope between El. 20 m and El. 25 m. As the 2017 Golder test holes did not extend to this elevation interval, it is possible that the subsurface erosion process was present at greater depth but not detected. Further it is possible that the sinkhole formation process is active at locations between the test holes, which were spaced more than 100 m apart.

Based on our understanding of the sinkhole development process on the Phase 1 site and on the occurrence of the December 2018 sinkhole, we interpret that the process is also active on at least some portions of the Phase 2 property.

So far, there are no observable signs that the sinkhole development process is expanding east or west beyond the Phase 1 site boundaries. However, the potential for east-west spread exists and increases south of Gale Avenue North due to the groundwater gradient between these locations and the groundwater discharge areas near Gale Avenue North.



3. RECOMMENDATIONS FOR SINKHOLE RISK MITIGATION

3.1 Precautionary Closure of Phase 1 Site

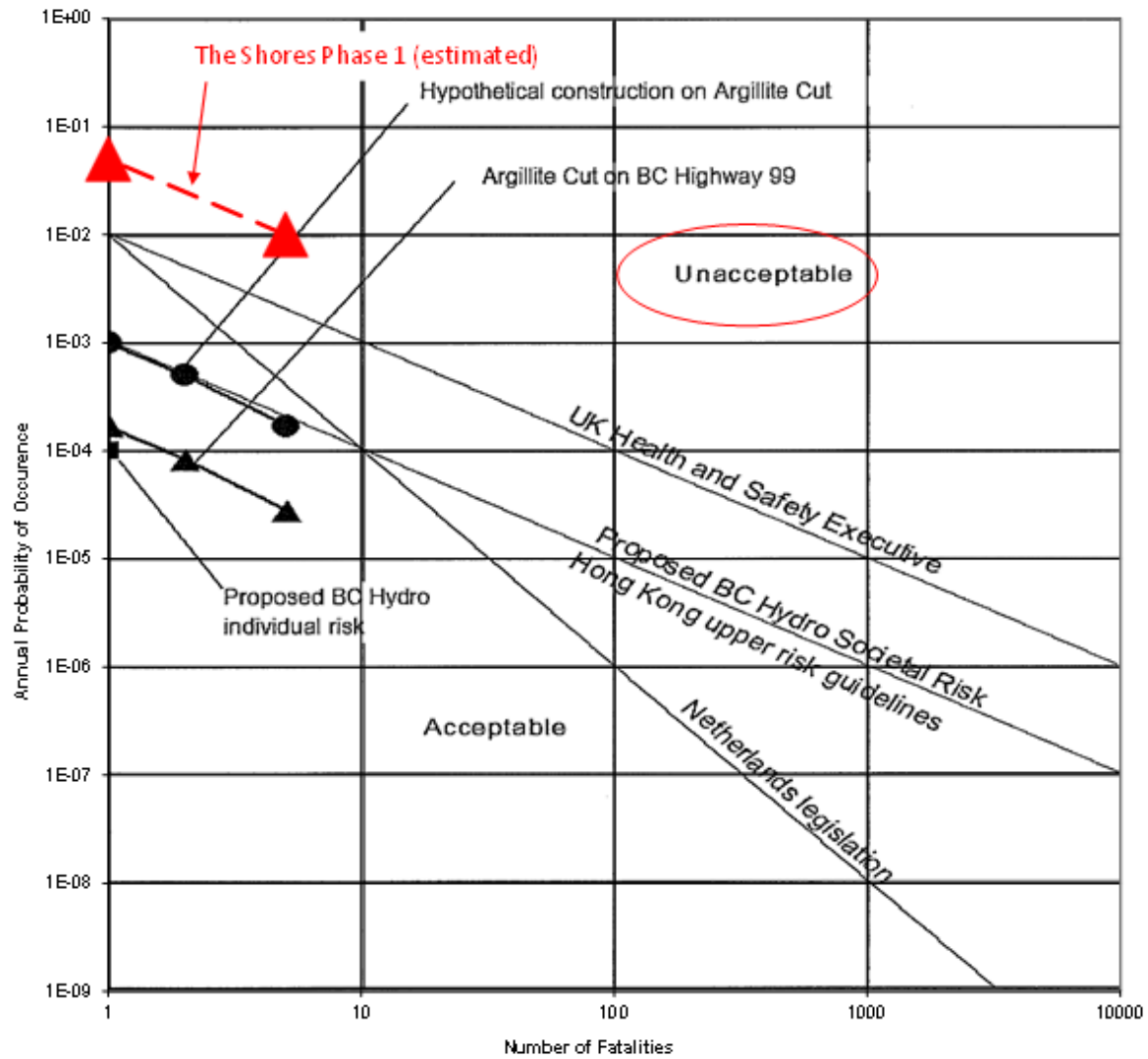
Site Occupancy

The probability of sinkhole collapse is evidently high and is anticipated to increase with time. Further, our recommendations for sinkhole risk management have not been implemented, including proactive groundwater management, comprehensive investigation of sinkhole hazards, and repair of sinkholes.

It appears that the maintenance of the Lot 3 seepage control measures recommended by Golder in 2015 have not been completed and we have observed evidence of seepage erosion within the control structure (see our January 10, 2019 Field Review Report). Further, the current stability of the 2013 sinkhole repair on Seawatch Lane is unknown and difficult to assess without drilling which could damage the geogrids used in the repair.

In consideration of the above, we recommend that the District no longer allow occupancy of the public and private properties and buildings within the Phase 1 site. The high hazard of sinkhole collapse in combination with the consequences of potential injury or death result in a high, and in our opinion, unacceptable level of risk to the public. We confirm we provided this recommendation to the District on February 1, 2019.

This recommendation is supported by a comparison of the estimated risk with criteria for acceptable societal risk in various jurisdictions including public entities in BC. We estimate that the annual probability of sinkhole collapse is 1 which is supported by the recent history of the site. The probability of a fatality associated with a sinkhole collapse is difficult to quantify. Assuming an annual probability of a fatality associated with a collapse is between 1 in 20 and 1 in 100, this results in an estimated annual probability of a sinkhole collapse resulting in a fatality of between 1 in 20 (5 E-2 per annum) and 1 in 100 (1 E-2 per annum). For discussion purposes, the number of fatalities resulting from a single sinkhole collapse could be assumed to be between 1 and 5 (e.g. a full vehicle); however other scenarios are possible. These values are plotted in Figure 3 and fall within the Unacceptable Risk zone.



Underlay from Figure 14, Hoek (2007) Practical Rock Engineering, Analysis of Rockfall Hazards Chapter

Figure 3. Societal Acceptance of Risk Comparison



Road Closure

Further we recommend proactive closure of the remaining open sections of public roadway within the Phase 1 site. Thurber provided this recommendation in an email to the District on February 1, 2019. These road closures should be considered permanent, unless proactive groundwater management and sinkhole repairs are completed, after which an assessment regarding reopening the roads could be undertaken.

Based on the recorded locations of past sinkholes and to provide a geotechnical setback, we recommend the road closures be installed on Gale Avenue North and Crowston Road at the entrances to the site, adjacent to the recently installed warning signs. This would cut-off through traffic between Gale Avenue North and Crowston Road.

A sinkhole was recorded on this section of Crowston Road around 2005 during initial site grading (see Figure 1). Crowston Road also has a limited setback from the 2007 and 2012 sinkholes at Seawatch Lane and the east-west extents of the affected ground have not been confirmed. As such, this section of Crowston Road should be closed. If the permanent loss of the through route is not acceptable, we recommend a detailed geotechnical investigation of Crowston Road to assess its integrity.

The closure of road access will also prevent or challenge the maintenance and emergency repair of utilities. Utilities may be undermined and damaged by the collapse of sinkholes or landslides which could result in additional safety hazards and could further exacerbate the sinkhole development process.

Warning Signs

The warning signs recently installed at the site entrances on Gale Avenue North and Crowston Road should be maintained and additional signage installed if the existing signs do not appear to be effectively deterring public access.

Site Monitoring

As the closed roadways and utility infrastructure will still be District property, we recommend that regular visual and groundwater monitoring of the site continue.

If new sinkholes are discovered, caution tape should be installed approximately 10 m from the edge to warn pedestrians.



3.2 Sinkhole Management Area

We recommend that land use and development be restricted on properties neighbouring the Phase 1 site because these properties may also be affected by the sinkhole hazard as the subsurface erosion spreads. Further, the potential mismanagement of surface water and rainwater infiltration in this area has significant potential to exacerbate the sinkhole hazards at the Phase 1 site and on neighbouring sites.

Figure 4 presents our recommendations for the boundary of the Sinkhole Management Area based on the currently available information and understanding of the sinkhole hazards. This boundary includes a precautionary geotechnical setback from known sinkhole areas because the extents of the subsurface erosion have not been confirmed on the neighbouring properties.

It is possible that this boundary does not include the full area currently affected by the sinkhole development process or that the subsurface erosion could spread beyond this boundary in the future. The limits of the boundary may need to be extended in the future. The low-density zoning of the existing rural developments south of the Sinkhole Management Area boundary should be maintained to avoid increasing risk exposure.

Reduce Infiltration and Surface Water Management

Further to the recommendations of our July 11, 2017 memorandum, land use and water management restrictions should be implemented within the Sinkhole Management Area to reduce the infiltration of stormwater into the ground to pre-development levels. We suggest that the restrictions include:

- Deforestation and clearing of vegetation should be prohibited. Revegetation of areas already cleared should be implemented to the extent possible.
- All existing and proposed ponds and stormwater ditches including the east Crowston Road ditch should be lined at the base and sidewalls. Ponds should be decanted into the stormwater system to reduce their storage volume and to mitigate overtopping potential.
- Rock pits or other measures intended to promote the infiltration of stormwater should not be used.
- Discharge of water onto the ground surface including irrigation should be prohibited.

Potential Subsurface Erosion and Sinkhole Hazards

The properties within the Sinkhole Management Area should not be developed with occupied structures without a detailed investigation and assessment of the potential for subsurface erosion and sinkholes at those sites. The assessment must determine how far the subsurface erosion



process has migrated beyond the Phase 1 site boundaries and to what extent. The investigation should consider the observation that the subsurface erosion process has been observed to expand relatively horizontally upslope at approximately El. 20 m.

The assessment must also consider the potential for the subsurface erosion problem to expand with time and provide effective measures to mitigate this potential. Development applications in this area should be subjected to geotechnical peer review.

3.3 Proactive Groundwater Management

We encourage in the strongest possible terms that all stakeholders proactively address the problems at the site. Proactive groundwater management is recommended to mitigate the expansion of the affected area. Without effective groundwater management it is likely that the area affected by sinkholes will expand with time, creating new hazardous areas, requiring additional road closures and the extension of the Sinkhole Management Area boundary.

Further to the comments in our July 19, 2017 memorandum, the objective of site dewatering is to slow or halt the ongoing subsurface erosion process in order to mitigate the formation of additional sinkholes and exacerbation of existing sinkholes. In our opinion, an effective site dewatering system would practically halt the subsurface erosion process which would put the site in a state of relative equilibrium. This would provide the opportunity to identify and repair the existing damage to the subsurface or to confirm the locations of geotechnical setbacks so that neighbouring developments can proceed.

The difficulty and cost of installing an effective groundwater management system increases rapidly as the size of the affected area expands and because the depth of erosion below the ground surface increases as it moves upslope.

Our 2015 Report generally recommended consideration of a dewatering system which included dewatering wells on Seawatch Lane. To avoid exacerbating the subsurface erosion issue, it is critical that the dewatering wells be located upgradient (approximately upslope) of the current limits of erosion. These limits have not been defined but are interpreted to be south of Seawatch Lane. Thus, the dewatering well configuration discussed in 2015 is no longer an option.

We recommend consideration of an array of vertical dewatering wells installed on the neighbouring private properties to the south and southeast of the Phase 1 site. These wells could be permanently pumped or temporarily pumped to facilitate the installation of a passive horizontal drain system. Siting the wells would first require confirming the current extents of subsurface erosion with detailed geotechnical investigation. The dewatering system would need to be permanently monitored with piezometers to confirm it remains effective.

Our July 11 and July 19, 2017 memoranda recommended a pilot dewatering study as proof of concept. We continue to recommend a pilot study. However, the details and costs of this proposal



would need to be updated. The pilot program would provide an improved understanding of the required scale of an effective site dewatering system and an opportunity to update our 2015 cost estimates for the detailed feasibility study and the permanent site dewatering system.

4. CONCEPTUAL OPTIONS FOR SHORT TERM TEMPORARY ACCESS

4.1 Objectives and Limitations

We recognize that the road closures already in effect were installed on relatively short notice and this caused hardship for the affected residents. Further, we recognize that the recommended precautionary closures described in this report will cause additional hardship for affected residents.

We understand that the District would like options to provide short term temporary use of the currently closed portions of Seawatch Lane and Gale Avenue North so that residents may move items and vehicles in or out of the affected area as they choose.

To facilitate the road use, temporary structures will be required to bridge the areas where sinkhole activity is known. This approach is similar to wearing skis when crossing a frozen lake to distribute your weight to avoid falling through a weak spot in the ice. Of course, if the ice breaks around the outside of your skis, the skis provide little to no benefit. Similarly, it is possible that unknown developing sinkholes could be present in addition to the known areas of concern.

To manage the uncertainty and risk associated with the changing conditions and limited subsurface information, we recommend that the temporary structures extend as far as practical beyond the known affected areas. The size of past sinkholes at ground surface has varied significantly from 2 m diameter to 12 m diameter, but more commonly they have been in the 3 m to 6 m diameter range.

At a minimum, we recommend that temporary structures be installed at the 2012 sinkhole on Seawatch Lane and on Gale Avenue North including adjacent to Lot 6 through Lot 10 (approximately 100 m length). Based on the observed sinkhole behaviour described herein, the Gale Avenue North route is interpreted to be less hazardous than a longer route along Seawatch Lane. Gale Avenue North is also wider and flatter which is beneficial for large equipment movements. The extents of the temporary structures need to be confirmed following risk management discussions with the District.

We assume that the design criteria for these temporary structures will be 'Life Safety', such that some permanent damage to the structure would be tolerable in the event that a sinkhole collapse occurred. These road openings would be restricted to authorized users including the affected residents and property owners. Those assisting the residents, including family, friends, neighbours, and contractors should be informed of the hazards which they may be exposed to while using these temporary access structures.



To reduce uncertainty due to changing conditions, these temporary structures should be installed as soon as the details have been confirmed and adequate notice to residents has been provided. The structure should be in service for as short a window as practical to mitigate the hazard exposure (e.g. 1 to 2 weeks). Implementation of our site occupancy recommendations should not be delayed until temporary access has been provided.

It may be possible to use a similar approach to respond to future geotechnical emergencies within the closed areas. This will require engineering review on a case by case basis.

4.2 Temporary Bridge Decks

One potential option to bridge the affected areas is to install temporary steel bridge decks, sitting directly on the pavement. Temporary bridges could be sized to span the largest past sinkhole at the site (12 m diameter). Transition ramps would be required at the start and end of bridge decks.

The challenge is that temporary bridges are typically unloaded and installed with portable cranes. Cranes are very heavy and would require the construction of temporary crane pads and access routes to mitigate the potential for sinkhole collapse below the crane.

Temporary bridge decks can be rented from suppliers in the Lower Mainland. Depending on the selected spans and quantities, it may be necessary to barge the bridges to the Sunshine Coast.

4.3 Temporary Timber Mats

Another option to consider is the use of heavy equipment 0.3 m square (12"x12") timber swamp mats. Each swamp mat is typically 1.2 m wide and typically come in 6 m and 9 m lengths. We propose a 2-layer system, similar to a railway or corduroy road. Layer 1 would be rows of swamp mats oriented perpendicular to the road (acting as cross ties). Layer 2 would be 2 rows of mats oriented parallel to the road to provide a driving surface and to bridge between the cross ties (acting like rails). The abutting joints between 'rail' mats would be staggered. The maximum size of sinkhole this system could span needs further consideration but is likely less than a temporary bridge structure.

Using this approach, the configuration of the mats could be adapted to the road curvature and additional mats could be installed to access driveways and to facilitate vehicle turning. Transition mats or other means would be required to ramp up and down from the temporary timber structure.

The swamp mats could be unloaded and stockpiled on Crowston Road south of the site entrance and warning sign. The mats could be installed one by one using a tracked excavator in a progressive pattern with the machine sitting on the mats for the safety of the equipment and operator. Swamp mats can also be rented from local suppliers. It may be possible to transport the mats using BC Ferries routes or a barge.



4.4 Alternative Access Routes

In the development of the proposed conceptual access options described above, we also considered several alternative short-term access routes. Most of these potential alternative routes would require construction on private property.

There is an existing deactivated industrial road that connects Crowston Road with Seawatch Lane from the south near TH13-1 (see Figure 1). The road would require clearing and grading to reactivate it. This route bypasses the recent December 2018 sinkhole. However, this route may be exposed to unidentified sinkhole hazards (see Sinkhole Management Area). Further this route would not provide temporary access to Lot 7 and Lot 8 on Gale Avenue North. As such, this option was discounted.

A variation of the first alternative would include constructing a new road to connect the west end of Seawatch Lane to existing industrial roads which connect to Mason Road. This route would enter the site near the west boundary of the proposed Sinkhole Management Area. However, it would require substantial effort to construct a stable ramp down the sandy cut slopes at the west end of Seawatch Lane. Further this route also would not provide temporary access to Lot 7 and Lot 8 on Gale Avenue North. As such, this option was discounted.

Another option considered was to construct a temporary access ramp from Gale Avenue North down across Lot 1 and Lot 2 to the existing Statutory Right of Way access road on the lower slope to the north of the houses. This existing access road is located downslope of the recorded sinkholes and is interpreted to be a lower hazard area. However, the ramp down from Gale Avenue North would likely have to be very steep to avoid crossing upslope of the Lot 3 spring mitigation works. The lower slope is generally wet year-round due to groundwater discharge which contributes to the challenge of building a stable ramp. Slope instability on the lower slope has the potential to exacerbate groundwater seepage issues and the sinkhole development process. Further this route would not provide meaningful access to Lot 7 and 8 (it would provide access to the north end of their sloping backyards). As such, this option was discounted.

Other emergency alternatives exist such as helicopter transport and marine transport. Helicopter access was assumed to be prohibitively expensive for the transportation of household items. Marine transportation to the beach may be feasible and cost effective, but items would first need to be moved from the houses to the beach which would likely be less practical than using the existing roads.

After consideration of these options, the most direct routes using the existing roads were considered the most practical option, provided that known hazard areas are bridged and the limitations of, and risks associated with, this as described above are accepted.



4.5 Detailed Design

The selected concept will require detailed engineering design. A structural engineering review will be required to confirm a load rating for the temporary structures, in the event that a sinkhole of an assumed diameter collapses below the structure while it is in service.

The details of the transitions onto and off the temporary structures will require further consideration with support from the supplier and the District. Civil road design support may also be required.

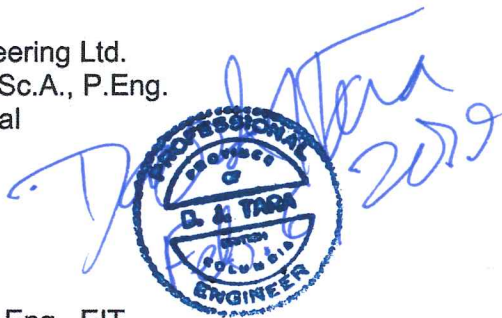
The proposed configuration should be reviewed by Thurber prior to procurement. Geotechnical field review will be required during installation of the structures prior to their use.

5. CLOSURE

We trust that this letter is sufficient for your needs. We recommend that the District of Sechelt immediately provide this report to the residents of the Phase 1 site and to those affected by the proposed Sinkhole Management Area. Should you have any questions or require clarification, please contact us at your convenience.

Yours truly,
Thurber Engineering Ltd.
David Tara, M.Sc.A., P.Eng.
Review Principal

Caleb Scott, M.Eng., EIT
Project Engineer



Attachments:

Statement of Limitations and Conditions

Figures

Figure 1. Site Plan

Figure 4. Sinkhole Land Use Management Area

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

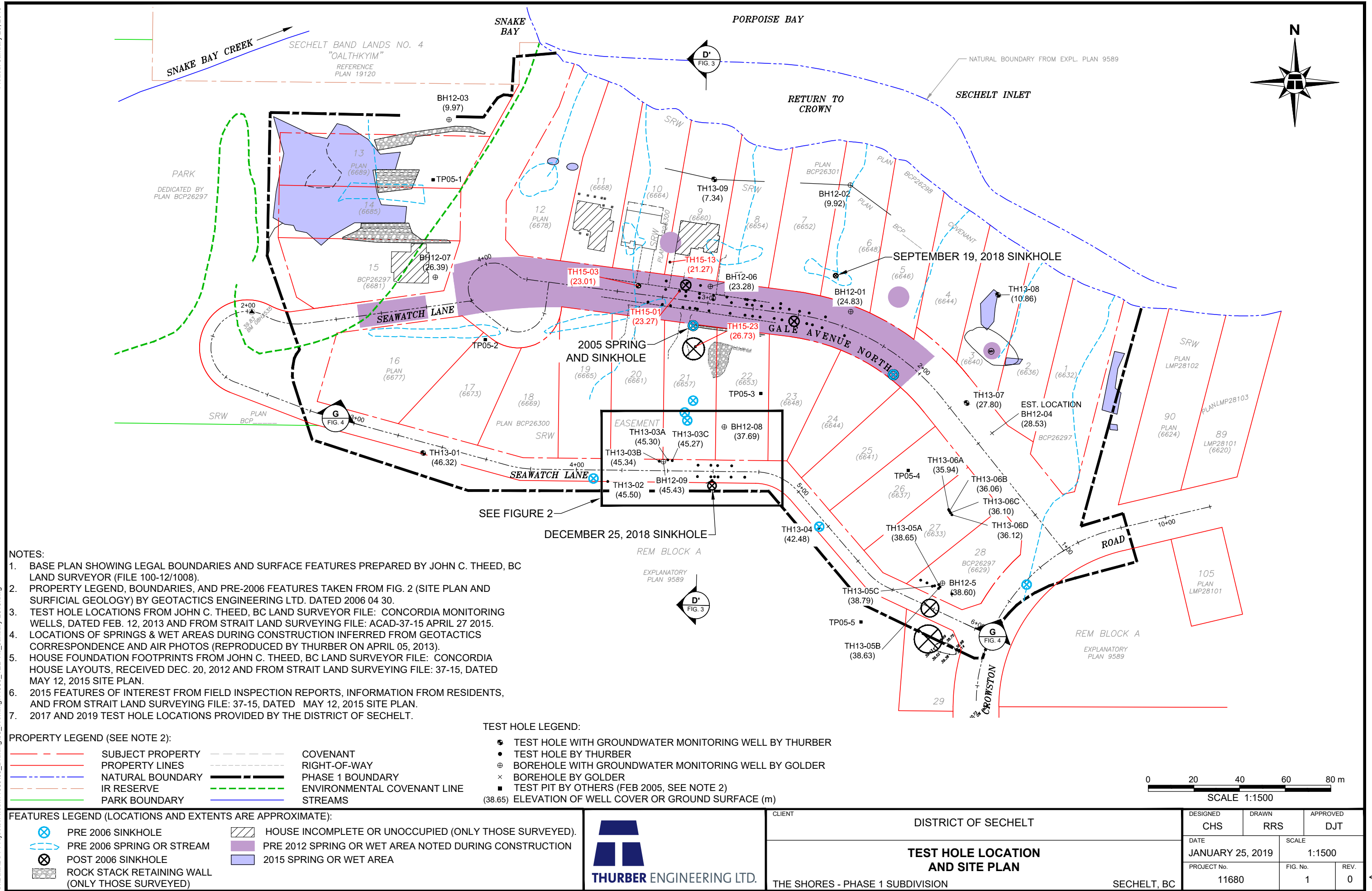
- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification 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.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



- NOTES:
1. BASE PLAN SHOWING LEGAL BOUNDARIES AND SURFACE FEATURES PREPARED BY JOHN C. THEED, BC LAND SURVEYOR (FILE 100-12/1008).
 2. PROPERTY LEGEND, BOUNDARIES, AND PRE-2006 FEATURES TAKEN FROM FIG. 2 (SITE PLAN AND SURFICIAL GEOLOGY) BY GEOTACTICS ENGINEERING LTD. DATED 2006 04 30.
 3. TEST HOLE LOCATIONS FROM JOHN C. THEED, BC LAND SURVEYOR FILE: CONCORDIA MONITORING WELLS, DATED FEB. 12, 2013 AND FROM STRAIT LAND SURVEYING FILE: ACAD-37-15 APRIL 27 2015.
 4. LOCATIONS OF SPRINGS & WET AREAS DURING CONSTRUCTION INFERRED FROM GEOTACTICS CORRESPONDENCE AND AIR PHOTOS (REPRODUCED BY THURBER ON APRIL 05, 2013).
 5. HOUSE FOUNDATION FOOTPRINTS FROM JOHN C. THEED, BC LAND SURVEYOR FILE: CONCORDIA HOUSE LAYOUTS, RECEIVED DEC. 20, 2012 AND FROM STRAIT LAND SURVEYING FILE: 37-15, DATED MAY 12, 2015 SITE PLAN.
 6. 2015 FEATURES OF INTEREST FROM FIELD INSPECTION REPORTS, INFORMATION FROM RESIDENTS, AND FROM STRAIT LAND SURVEYING FILE: 37-15, DATED MAY 12, 2015 SITE PLAN.
 7. 2017 AND 2019 TEST HOLE LOCATIONS PROVIDED BY THE DISTRICT OF SECHLT.

PROPERTY LEGEND (SEE NOTE 2):

	SUBJECT PROPERTY		COVENANT
	PROPERTY LINES		RIGHT-OF-WAY
	NATURAL BOUNDARY		PHASE 1 BOUNDARY
	IR RESERVE		ENVIRONMENTAL COVENANT LINE
	PARK BOUNDARY		STREAMS

TEST HOLE LEGEND:

- TEST HOLE WITH GROUNDWATER MONITORING WELL BY THURBER
- TEST HOLE BY THURBER
- ⊕ BOREHOLE WITH GROUNDWATER MONITORING WELL BY GOLDER
- × BOREHOLE BY GOLDER
- TEST PIT BY OTHERS (FEB 2005, SEE NOTE 2)
- (38.65) ELEVATION OF WELL COVER OR GROUND SURFACE (m)

FEATURES LEGEND (LOCATIONS AND EXTENTS ARE APPROXIMATE):

	PRE 2006 SINKHOLE		HOUSE INCOMPLETE OR UNOCCUPIED (ONLY THOSE SURVEYED).
	PRE 2006 SPRING OR STREAM		PRE 2012 SPRING OR WET AREA NOTED DURING CONSTRUCTION
	POST 2006 SINKHOLE		2015 SPRING OR WET AREA
	ROCK STACK RETAINING WALL (ONLY THOSE SURVEYED)		



CLIENT	DISTRICT OF SECHLT		
THE SHORES - PHASE 1 SUBDIVISION	TEST HOLE LOCATION AND SITE PLAN		
	DESIGNED	DRAWN	APPROVED
	CHS	RRS	DJT
	DATE	SCALE	
	JANUARY 25, 2019	1:1500	
	PROJECT No.	FIG. No.	REV.
	11680	1	0

Figure 4. Sinkhole Management Area
Thurber File: 11680

Date: February 6, 2019



Legend

- Parcel Boundaries
- Crown Provincial

382.2 0 191.09 382.2Meters

This information has been compiled by the Sunshine Coast Regional District (SCRD) using data derived from a number of sources with varying levels of accuracy. The SCRD disclaims all responsibility for the accuracy or completeness of this information.



1/28/2019
1: 7,523