THURBER ENGINEERING LTD.

celebrating 60 YEARS

December 13, 2017 File: 14463

Brad Geary
1649 Columbia Valley Road
Lindell Beach, BC
V2R 4X2

45900 SLEEPY HOLLOW ROAD, CULTUS LAKE
GEOTECHNICAL RECOMMENDATIONS FOR SITE DEVELOPMENT
REVISION 1

Dear Brad:

As requested, Thurber Engineering Ltd. has completed a supplementary site reconnaissance for the proposed subdivision at 45900 Sleepy Hollow Road. Further details regarding our previous work and investigation are provided in our two letters that were addressed to Pan-Canadian Mortgage Group (PCMG) dated July 8, 2015 and December 2, 2016.

This report was prepared for the exclusive use of Brad Geary. Additionally, Thurber grants permission for the Fraser Valley Regional District (FVRD) to use this report for the proposed development project for which it was prepared. Any use which a third part makes of this report, or any reliance on decisions based on it are the responsibility of such third parties.

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

The site has been historically divided into two areas, the "Lower" area along Sleepy Hollow Road and the "Upper" area that is accessed by a gravel road. Previously, Thurber has completed a preliminary geotechnical assessment and has provided recommendations for development to PCMG. The geotechnical assessment and recommendations focused on the Lower Area. A total of four test pits and one test hole were completed in the Lower Area and three test pits and one test hole were completed in the Upper Area. One test hole was completed approximately half way up the gravel access road to the Upper Area.

We understand that you have been given authorization by PCMG to proceed with re-zoning if the property. Further, we understand that you would like a to develop the Upper Area and then proceed with development of the Lower Area. We understand that you currently do not have a civil engineer for this project but are considering hiring Creus Engineering Ltd. (Creus).

This letter supplements our previous letters and provides specific comments relating to the development of the Upper Area. This letter also includes recommendations that were made in our previous letters and revisits our previous recommendations regarding geotechnical hazard for the Lower Area with consideration for regrading the slope to reduce the geotechnical hazard for the

Lower Area. We are using base plans that were developed by Creus which show preliminary lot layouts that were developed for PCMG.

2. SITE DESCRIPTION AND LOCATION

The property is roughly 7.7 hectares and is located to the south of Sleepy Hollow Road and east of Vance Road. The Lower Area is sparsely covered with vegetation within the extents of the former gravel pit and moderately treed outside of the former gravel pit. Above (south of) the Lower Area is moderately steep to steep terrain that is moderately to densely treed. The steepest terrain is aligned northeast-southwest through the centre of the site, between the Lower Area and the access road to the Upper Area. The Upper Area is dissected by several ATV trails.

2.1 Previous Lot Layout

Creus' original lot layout, prior to geotechnical input, included 13 lots in the Lower Area and 17 lots within the Upper Area. This layout was revised after our first letter to include 13 lots in the Lower Area and 11 lots in the Upper Area. The number of lots was reduced to 10 in the Lower Area following input from our December 2016 letter. We had only provided Creus very preliminary guidance for the Upper Area as the focus was on the Lower lots at that time and thus their lot layout focuses on the Lower Area.

Thurber has used Creus' original lot layout, excluding their Upper Area lots, for our test hole location plan (Dwg. 14463-1) and our Preliminary Geotechnical Assessment Site Plan (Dwg. 14463-2) which we reference throughout this letter.

3. DEFINITIONS

3.1 Landslide

The APEGBC 2010 Guidelines for Legislated Landslide Assessments for Proposed Residential Developments (Landslide Guidelines) define a landslide to be: A movement of rock, debris [wood] or earth down a slope. Landslides can be a result of a natural sequence of events and/or human activities.

Hungr et al (2014) builds on the common definition of landslides and describes landslides as physical system that develops through time. In essence, a landslide can start as a slow creep, progress to failure, runout along a path and finally be deposited.

For the purposes of this report we will use the term landslides to mean a mixture of soil, rock, debris, and water moving downhill along the ground surface.

3.2 Rockfall

Rockfall would generally be included with the broad definition of landslide as described in the 2010 Guidelines. For the purposes of this report we will use the term rockfall to refer to rock fragments detaching from soil or bedrock and falling, rolling, bouncing and finally deposition.

4. BACKGROUND INFORMATION

4.1 Previous Geotechnical Investigation

Thurber completed seven test pits to approximately 2.5 m depth in 2015 and three test holes to depths between 4.5 m and 24.4 m in 2016. The soil conditions encountered in the test pits and test holes generally comprised sand and gravel. Some test pits encountered silt in the top 1 m to 2.5 m of the test pit. This is consistent with visual observations of exposed soil cuts on site. Detailed logs of the test pits and test holes from our previous reports are attached. The location of the test pits and test holes are shown on Dwg. 14463-1.

4.2 Surficial Geology

The Geological Survey of Canada Map 1487A for Chilliwack (West Half, 1980), shows the lower site area is underlain by Pleistocene Age Sumas Drift comprising till, glaciofluvial and ice-contact deposits consisting of outwash gravels and sands more than 10 m thick. At the northeast corner, the Sumas Drift is in contact with Quaternary Postglacial Salish Sediments comprising mountain stream channel, floodplain and overbank sediments of gravel and sand more than 10 m thick.

The upper sloped property area is underlain by Pre-Tertiary Age bedrock metamorphic siltstone and sandstone overlain by typically less than 2 m of glacial, eolian and colluvial deposits, i.e. mixed cohesive and granular soils.

The soil conditions observed visually at surface and in the test holes and pits confirmed the mapped deposits.

4.3 Aerial Photograph Interpretation (API)

The key observations from the API are discussed below and annotated on Dwg. 14463-2, as appropriate. Further discussion and detail is provided in Thurber's 2015 report.

The earliest available photograph from 1940 shows a landslide scar in the steep slope area near the northeast corner of the site. The landslide transported material north-westwards towards Gurney Road, as shown on Dwg. 14463-2. The landslide scar is visible in the 1946 and 1954 aerial photographs, but is masked by vegetation and indistinct in photographs later than 1954.

All the aerial photographs show steep gullies/watercourses in the northeast corner of the site. However, these gulley features are not observed in the steep slopes above Lots 1 to 10.

The 1973 aerial photograph indicates a possible fill area at the northwest end of the easement between the existing properties on Gurney Road and the northeast edge of the lower lot area.

The approximate extent of the gravel pit activity observed in the 1973 aerial photograph is shown on Dwg. 14463-2. The 1983 aerial photograph shows that about 60 to 70% of the 1973 gravel pit extent is tree covered. The 1993 aerial photograph shows the gravel pit extending marginally to the southeast and southwest of the 1973 aerial photograph extents. Photographs after 1993 show the gravel pit to be inactive and the gravel pit extent is partially masked by vegetation.

5. SITE RECONNAISSANCE

Christopher Clarke, P.Eng., of Thurber completed a site reconnaissance of the property on October 20, 2017. The purpose of the reconnaissance was to review the current conditions of the property, note any observed changes from our previous reconnaissance, and to focus on the Upper Area with emphasis on the road alignment and geotechnical setbacks from toe and crest of slopes.

Select site reconnaissance observations are annotated on Dwg. 14463-2. Vegetation obscured much of the terrain and restricted access to some areas in the northeast portion of the property.

5.1 Lower Area

The site reconnaissance of the Lower Area and the slopes above it to the south served to confirm our previous observations. The slopes above the western portion of the Lower Area (Lots 1 to 9 on Dwg. 14463-2) are steep and comprise colluvium and talus. There is minor bedrock outcrop at the top of the slopes, immediately below the access road to the Upper Area. There is also steep, near vertical, sand and gravel slopes below the access road that are typically 1 m to 2 m high. These near vertical slopes are likely scarps of previous shallow, planar failure and erosion. However, no evidence of previous significant instability was noted within this area.

The slopes above the eastern portion of the Lower Area do not appear to be bedrock controlled and thus are not as steep as the slopes above the western portion. However, these slopes show signs of old landslide features. In addition to the old landslide features, there are other signs of potential and visible slope instability including natural water springs that flow from the slopes, gullying, oversteepened slopes, bowled features / shallow instability and overturned trees. It was previously noted that the lot at the east end of Gurney Road was raised approximately 2 m to 3 m above Gurney Road on coarse granular material indicative of slope deposits and possibly landslide debris.

5.2 Access Road

The western portion of the access road to the Upper Area appears to have followed a bedrock controlled bench that appears to have been cut and locally blasted. The access road grade steepens up to 20° to 25° (36% to 47%) at the end to access the Upper Area. The road appears to have been constructed entirely in cut. Exposures of metasedimentary bedrock were noted along the access road driving surface and along cuts on the uphill side of the road.

5.3 Upper Area

The Upper Area above the access road is moderately to steeply sloped and is dissected by ATV trails. There are occasional rock outcrops along some of the trails and along the Powerline Right-of-Way (RoW). There is a knoll along the southern property line that showed signs of shallow (<1 m deep) slope instability.

Based on our site reconnaissance, we have developed a geotechnical crest and toe of slope for the Upper Area, shown on Dwg. 14463-2.

6. ANALYSIS

Our stability and rockfall analyses have been group into two areas; generally bedrock controlled slopes and generally soil controlled slopes. Generally, the slopes on the western part of the property are bedrock controlled whereas the slopes on the eastern part of the property are soil controlled. Dwg. 14463-2 includes an approximate divide between the two areas.

6.1 Static Slope Stability Analysis

We have completed limit equilibrium analysis using the software program Slope/W. Three typical cross sections were used and their locations are shown on Dwg. 14463-1 and -2. The cross sections were developed from LiDAR information provided by Creus. The soil stratigraphy was developed based on our test holes, test pits, soil exposures, and bedrock outcrops that were observed during the site reconnaissance.

The required building envelope setback from the geotechnical crest of slope is 20 m for the bedrock controlled slopes and 40 for the soil controlled slopes for a static Factor of Safety (FS) of 1.5. The results of the analysis show that the FS is quite sensitive to the depth of bedrock. If bedrock is in fact closer to the ground surface then it may be possible to reduce this setback, however, the depth to bedrock would need to be confirmed with drilling.

6.2 Seismic Slope Stability Analysis

We have updated our limit equilibrium pseudo-static analysis using Slope/W to analyse slope stability during the design 1:2475 seismic event using the same cross sections and stratigraphy described above. Seismic loads are represented as a pseudo-static force, typically equal to 0.5 times peak ground acceleration (PGA). The 2015 National Building Code Seismic Hazard Calculator (NHCSHC) estimates the PGA is 0.275g for a 1 in 2475 year return-period earthquake (probability of exceedance is 2% in 50 years) at this site. The results from the NBCSHC for the site are attached.

When the FS is less than 1 with the pseudo-static force, APEGBC's Landslide Guidelines recommend completing an additional pseudo-static analysis using a tolerable displacement of 15 cm as outlined in Appendix E.

One of two methods can be used by estimating the seismic yield coefficient that would result in 15 cm of displacement. We completed our analysis using Method 2 which estimates the seismic yield coefficient that is comparable to 15 cm of slope displacement as:

$$k_{15} = (0.006 + 0.038M)*S(0.5) – 0.026$$

M = Moment Magnitude of the Design Earthquake

S(0.5) = Spectral Response Acceleration at a period of 0.5 seconds.

For our analysis, we assumed a moment magnitude of 7.5 and the NBCSHC estimates S(0.5) = 0.496. The resultant k_{15} acceleration is 0.12g.

The results of the analysis indicate that the required building envelope setback from the geotechnical crest of slope for seismic conditions for the Upper Area is 15 m for bedrock controlled slopes and 40 m for soil controlled slopes. If bedrock is in fact closer to the ground surface then it may be possible to reduce this setback, however, the depth to bedrock would need to be confirmed with drilling.

6.3 Rockfall Analysis

Rockfall analyses were previously completed for the Lower Area and were not updated as our observations regarding rockfall for the Lower Area are unchanged.

Results of the rock fall analysis are attached and show rock runout approximately 20 m north of the Geotechnical Toe of Slope as discussed below.

7. GEOTECHNICAL HAZARD AND RISK

The terms hazard and risk are related yet different. The hazard can be described broadly as what is the probability or likelihood of an event occurring that causes harm to people, property or the environment. Risk is the combination of the hazard and consequence should that hazard occur.

Within Canada there is no commonly defined range of acceptable risk/safety. The APEGBC 2010 Guidelines state that “it is not the role of a Professional Engineer or Professional Geoscientist to define such levels of safety; they must be established and adopted by the local government or the provincial government after considering a range of societal values”. Within B.C. acceptable risk is provided by local governments (e.g. FVRD) and/or Ministry of Transportation and Infrastructure (MoTI) who has jurisdiction over subdivision development outside of areas of local government control. The FVRD has adopted the report by Cave (1993) titled Hazard Acceptability Thresholds for Development Approvals by Local Governments and the APEGBC 2010 Landslide Guidelines in their Geo-Hazard Assurance Statement for Development Approvals.

7.1 Geotechnical Hazards on Lower Area

As discussed in our December 2016 report, the Lower Area has been, and will be, subject to small-scale localized landslides and rockfall with a return period of 1:50 to 1:100. Under the acceptance criteria by Cave it would not be permissible for subdivision (infill/extend) on the majority of the Lower Area. Thus, mitigation measures are required for subdivision approval on the site.

Based on the Cave report, the acceptable return period for hazards must be 1:500 to 1:10,000 for approval of a new subdivision. For the purposes of our assessment and this report we have considered a 2,475 year return period hazard as recommended in the APEGBC 2010 Guidelines. For potential larger return period hazards we have considered “what if” scenarios that are possible and have designed and recommended mitigation measures for these longer return period hazards. It is our opinion that this approach satisfies the guidance provided by Cave: **Approval, but with siting requirement to avoid the hazard or with requirements for protective works to mitigate the hazard and with a covenant including “save harmless” conditions as well as siting conditions, protective works or both.**

7.2 Geotechnical Hazards on Upper Area

The steeper slopes within the Upper Area, below the geotechnical crest of slope, could be subject to small-scale localized landslides and rockfall with a return period of 1:50 to 1:100. These areas are not permissible for development.

There is a knoll that is situated along the south property line that is subject to small-scale localized landslides with a return period of 1:50 to 1:100. Regrading of the knoll to decrease the return period may be difficult as it is on the property boundary.

Areas that are setback from the geotechnical crest of slope as outlined in Section 6.1 and are setback 6 m from the geotechnical toe of knoll slope are currently subject to small-scale localized landslip with a return period of 1:500 to 1:10,000. Cave provides the following guidance: **Approval, but with siting requirement to avoid the hazard or with requirements for protective works to mitigate the hazard and with a covenant including "save harmless" conditions as well as siting conditions, protective works or both.**

Regrading of the Upper Area is likely to require cuts and fill slopes. It may be necessary to use reinforcement such as geogrid or shotcrete and anchors to safely construct cuts and fills.

Table 1
Estimated Annual Return Frequencies for Geotechnical Hazards

Geotechnical Hazard	Estimated Annual Return Frequency		
	Lower Area	Lower Area after Mitigation	Upper Area Outside Setback Areas
Small-Scale Localized Landslip	1:50-1:200	1:500-1:10,000	1:500-1:10,000
Rockfall Small Scale Detachment	1:100	1:1000-1:10,000	N/A

The estimated annual return frequencies in Table 1 are qualitative, rather than quantitative, and were established primarily using engineering judgement based on the information available at this time. The annual return frequencies are subject to change due to construction activities such as regrading, logging and water diversion.

8. DISCUSSION AND RECOMMENDATIONS

The following discussion and recommendations are written in the context of and to address the FVRD Geo-Hazard Assurance Statement requirements and the previous work complete by Thurber with Creus for PCMG.

8.1 General

General site grading and design should avoid concentration of water near a slope crest. Clearing of existing vegetation should be limited to what is required for site access and building sites and all existing vegetation should be retained on steeply sloping areas of the site.

Precautionary scaling of loose rock blocks from the existing soil and rock slopes above the lots should be completed prior to construction. Boulders that may be supported by vegetation on the hillside should be removed.

No retaining walls or other permanent fills should be placed near the crests of slopes. Grading along crests of slopes may be permissible only if it results in reducing the existing grade.

In general, it should be anticipated that the near-surface silty soil will be removed to expose the gravelly soil or bedrock below. Subsurface drainage measures may also be required in areas of groundwater seepage in the soil and/or bedrock.

Sections 8.2 to 8.4 below provide site specific recommendations for building setbacks, hazard mitigation and drainage. We have used previous drawings prepared by Thurber for our slope gradient maps to convey our required setbacks, location of hazard mitigation requirements and areas where structures are not permitted. Thurber must be given the opportunity to review the site grading plan, lot layout, and housing footprints proposed by your civil engineer to confirm the intent of our geotechnical hazard assessment recommendations are met.

8.2 Lower Area

Geotechnical mitigation measures for the Lower Area are discussed in our December 2016 report. Our mitigation measures for lot development are unchanged and are summarized below.

Small surficial landslides and rockfall is expected to occur from the slopes to the south of the proposed lots. To provide storage for the small frequent events, we recommend a flat (maximum 6H:1V) bench at base of slope before the berm. This area should be allowed to vegetate naturally with no structures or gardens.

To retain smaller landslides and rockfall we recommend a berm be constructed. The berm should have 1.7H:1V or flatter side slopes with a minimum 2 m wide bench on top.

For all lots, the house should be setback from the berm with a minimum 15 m flat (maximum 6H:1V) back yard. No permanent or habitable structures should be located within this area. Small garden features and sheds are acceptable provided they do not interfere with the berm.

Localized landslides and rock fall will require peridodic maintenance of the berm and flat areas so they remain at the as-designed geometry. This will most likely consist of periodically removing material that has accumulated behind the berm.

We recommend that all houses be constructed with concrete walls above ground level. The concrete wall should be a minimum of 1.5 m high above ground on the back of the house and 1 m high above ground on the sides. These above grade concrete walls will provide an additional level of protection from upslope hazards.

We had noted that Lots 9 to 11 may be filled to “effectively move the Geotechnical Toe of Slope towards the south”.

Historic landslides were observed on the eastern slopes above the Lower Area in the vicinity of Lots 12 and 13. Within Lots 12 and 13 the proposed house location is likely to be at the south side of the lot near the steep slopes. It is our professional opinion that development of these lots is not feasible due to existing sloping ground and not enough space to setback house sites from the toe of slope. Therefore, we do not recommend house construction on Lots 12 and 13.

Lot specific geotechnical hazard mitigation is provided in Table 2 and shown on Dwg. 14463-3.

Table 2
Lower Area Mitigation Measures

Lot	Berm Setback from Geotechnical Toe of Slope (m)	Berm Height (m)	House Setback from Berm Toe (m)	Raised Concrete Foundation Wall
1 to 8	5	2	15	Yes
9 to 11	15	3	15	Yes
12 to 13	House Construction Not Recommended			

You have inquired about regrading / scaling the slopes south of the Lower Area lots to reduce the hazard level or to move the hazard level boundary further to the south. It is our opinion that it is best to leave the slope as is and to construct mitigation measures at the toe of the slope. However, if you elect to regrade the slope it is likely that you will need to excavate to bedrock at the top of the slope to flatten the colluvium soil slope. This would reduce both the risk of rockfall and small-scale landslip but will likely require rock support in the form of rock bolts or wire mesh. Rock outcrops were noted at the top of the slope, immediately below the access road and near the toe of the slope at about the midway point in the property (above Lots 8-10). The depth to bedrock is unknown throughout the rest of the slope.

8.3 Access Road

We understand that the FVRD ideally requires that the road be graded no steeper than 11% (6.3°). The existing road is steeper and thus will require regrading and realignment of the eastern portion to reduce the road grade to 11%. We recommend that the road is aligned so that it is entirely in cut. Filling on the already steep, locally unstable slopes between the access road and the Lower Area should be avoided. This is particularly important where the road will need to traverse along the slopes above the eastern portion of the Lower Area where there are numerous steep gullies, drainage paths, and historic landslides. Drainage will need to be constructed under the road where it crosses gullies.

Fill must not be placed on the eastern slopes as it will increase the risk of landslides that may affect the eastern portion of the Lower Area as well as neighbouring properties on Gurney Road. The road alignment should be expected to be within cut that will encounter both bedrock and sand and gravel. Cuts in rock will require blasting, scaling, and rock stabilization such as rock bolts, mesh, and shotcrete. Cuts in sand and gravel may require stabilization with permanent shotcrete and anchors. Detailed design recommendations for this work should be provided by Thurber once site grading plans have been completed.

8.4 Upper Area

Depending on grading and the access road footprint, we believe that lot development is feasible between setbacks. However, we consider it unlikely that lots can be developed east of the existing access road as regrading for the new road in addition to the required building setback will not leave much buildable space. It may be possible to regrade the knoll to obtain more buildable lot space however grading may be difficult to complete along the south property line without impacting the powerlines RoW.

Table 3
Summary of Geotechnical Setbacks for Upper Area

Area	Setback (m)
Bedrock Controlled Slopes	20
Soil Controlled Slopes	40

The gravelly sand encountered beneath the silt crust in the Upper Area is generally considered to be adequate as foundation soil for conventional residential units. Removal of the silt crust below buildings and road footprints will be required.

8.5 Rock Cut Slopes

We recommend that an allowance is made for a 3 m wide zone of cleaned bedrock above all rock cuts and at soil/rock interface in mixed soil and rock cuts. For preliminary design purposes, all permanent and temporary rock cut slopes should be designed at 1H:4V.

Depending on the actual rock conditions encountered and the effectiveness of the controlled blasting, rock cut slope stabilization may include rock bolting, shotcrete, dental concrete and slope mesh. Rock slopes should be excavated with smooth faces to limit potential for bouncing of rockfall. Fencing between drilled rock anchors along the crest of permanent rock cuts may be required in steeper areas to limit potential for colluvial material and rockfall from the slope above impacting the lots.

8.6 Soil Slopes

For preliminary design and grading, permanent, unsupported soil cuts in overburden and permanent fill slopes should be cut steeper than 2H:1V. Less dense soil and areas where groundwater seepage is encountered may require cutting at shallower slope angles and should be reviewed by Thurber. It may also be possible to locally steepen cut and fill slopes depending on their height. We recommend that these slopes be vegetated with a variety of species, including deep rooting species, as soon as possible following completion of excavation. Vegetation will limit the potential for surficial sloughing due to long term weathering of the near surface soils.

9. FUTURE WORK

The next steps to assess the development of the lots should be as follows:

1. Determine if it is feasible to develop in the Upper Area depending on the minimum lot sizing required by FVRD. If feasible, your civil engineer should develop grading and lot layout drawings and cross sections for the Upper Area based on the input provided by Thurber in this report.

2. Develop a lot layout for the Lower Area based on minimum lot sizing required by FVRD that include our hazard mitigation measures. If you elect to regrade the slope above the Lower Area then further investigation may be required to determine the depth to bedrock along the slope.

3. Thurber to review grading and lot layout plans. Additional input will be needed for soil and rock stabilization depending on the requirements for grading.

4. The building setback lines should be surveyed and staked in the field. Allowance should be made to allow Thurber to review the staked setback lines in the field to review that our recommendations were conveyed appropriately.

10. CONCLUSION

The lots should generally be graded flat or gently sloping and mitigation features as described above should be implemented so that small-scale landslicdx and rockfall can deposit before reaching the houses. The Geotechnical Toe of Slope and berm should be marked out by survey in the field and Thurber should review the location on site to confirm that it is consistent with our recommendations.

It is a condition of the above recommendations that Thurber will be retained to review grading plans and to complete inspections during construction to confirm that construction is in accordance with our recommendations. For the Cave conditions to be satisfied a covenant including “save harmless” conditions will be required. Provided that the above recommendations are followed we estimate that the risk of a small-scale landslip and rockfall reaching the house and causing injury will be between 1:500 and 1:10,000 and 1:1,000 and 1:10,000, respectively. Thus, it is our professional opinion that the Upper Area and the area within Lots 1 to 11 in the Lower Area as shown on Dwg. 14463-2 can be developed such that the site will be safe for the intended use.

We trust that this information is sufficient for your needs. Should you require clarification of any item or additional information, please contact us at your convenience.

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60 YEARS

Yours truly,
Thurber Engineering Ltd.
David Regehr, P.Eng
Review Principal

Christopher Clarke, P.Eng.
Project Engineer

Attachments:
Statement of Limitations and Conditions
Test Hole Location Plan (Dwg. 14463-1)
Preliminary Geotechnical Assessment Site Plan (Dwg. 14463-2)
Geotechnical Hazard Mitigation Detail (Dwg. 14463-3)
Property Location Map (Dwg. 14463-4)
Test Hole and Test Pit Logs
Slope Stability Analysis Results
Rock Fall Analysis Results
1940 Aerial Photograph Showing Landslide Scar

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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.

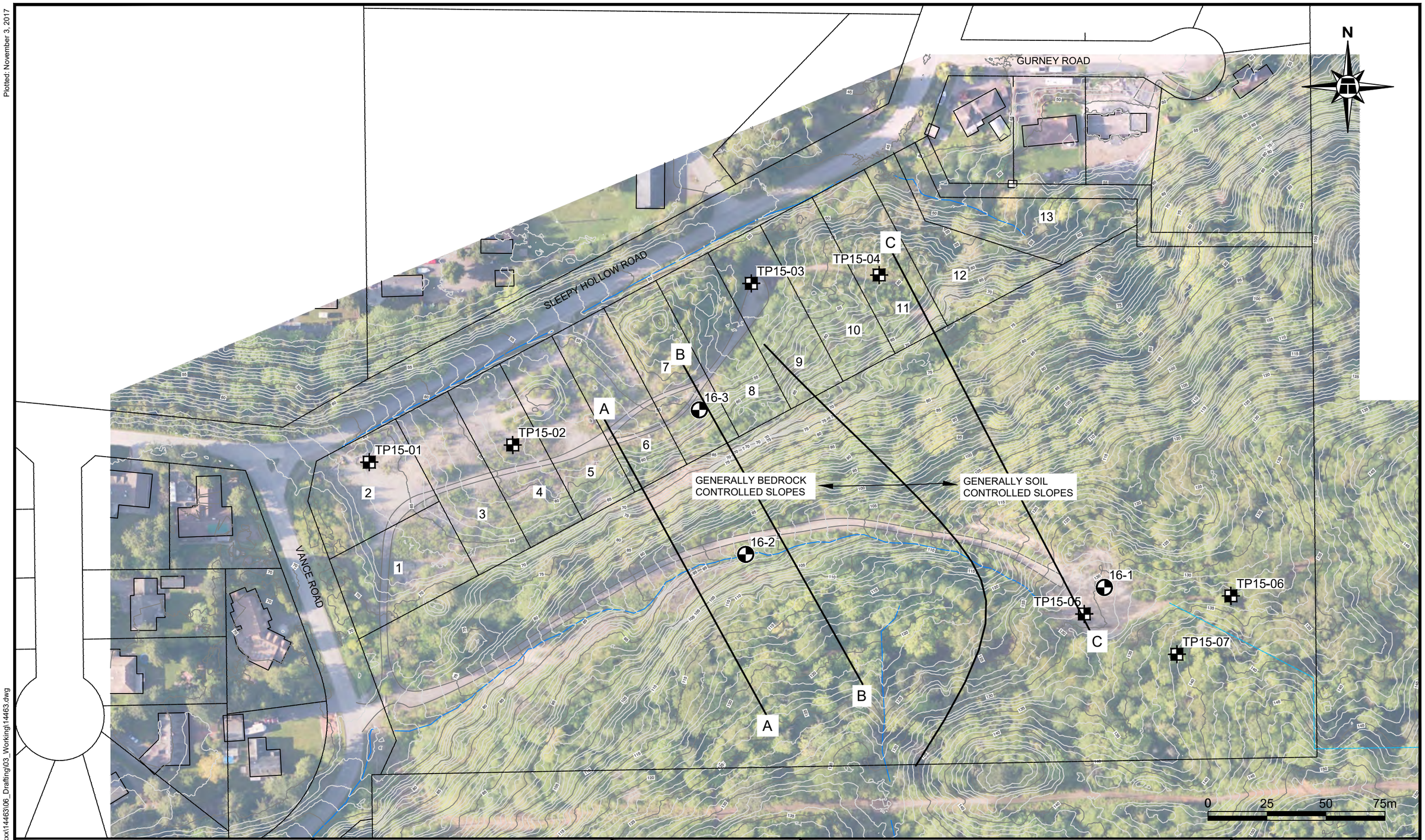
6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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.

Plotted: November 3, 2017



LEGEND:

- TEST HOLE
- TEST PIT (2015 INVESTIGATION)

NOTES:

1. BASE PLAN PROVIDED BY CREUS ENGINEERING LTD. ON OCTOBER 17, 2016.
2. TEST HOLE LOCATIONS ARE APPROXIMATE.

THURBER ENGINEERING LTD.

CLIENT: BRAD GEARY

TEST HOLE LOCATION PLAN

SLEEPY HOLLOW ROAD SUBDIVISION — CULTUS LAKE, BC

DESIGNED	DRAWN	APPROVED
CJC	NAK/MOM	

DATE	SCALE	
03/11/17	1:1500	
PROJECT No.	DWG. No.	REV.
14463	1	1

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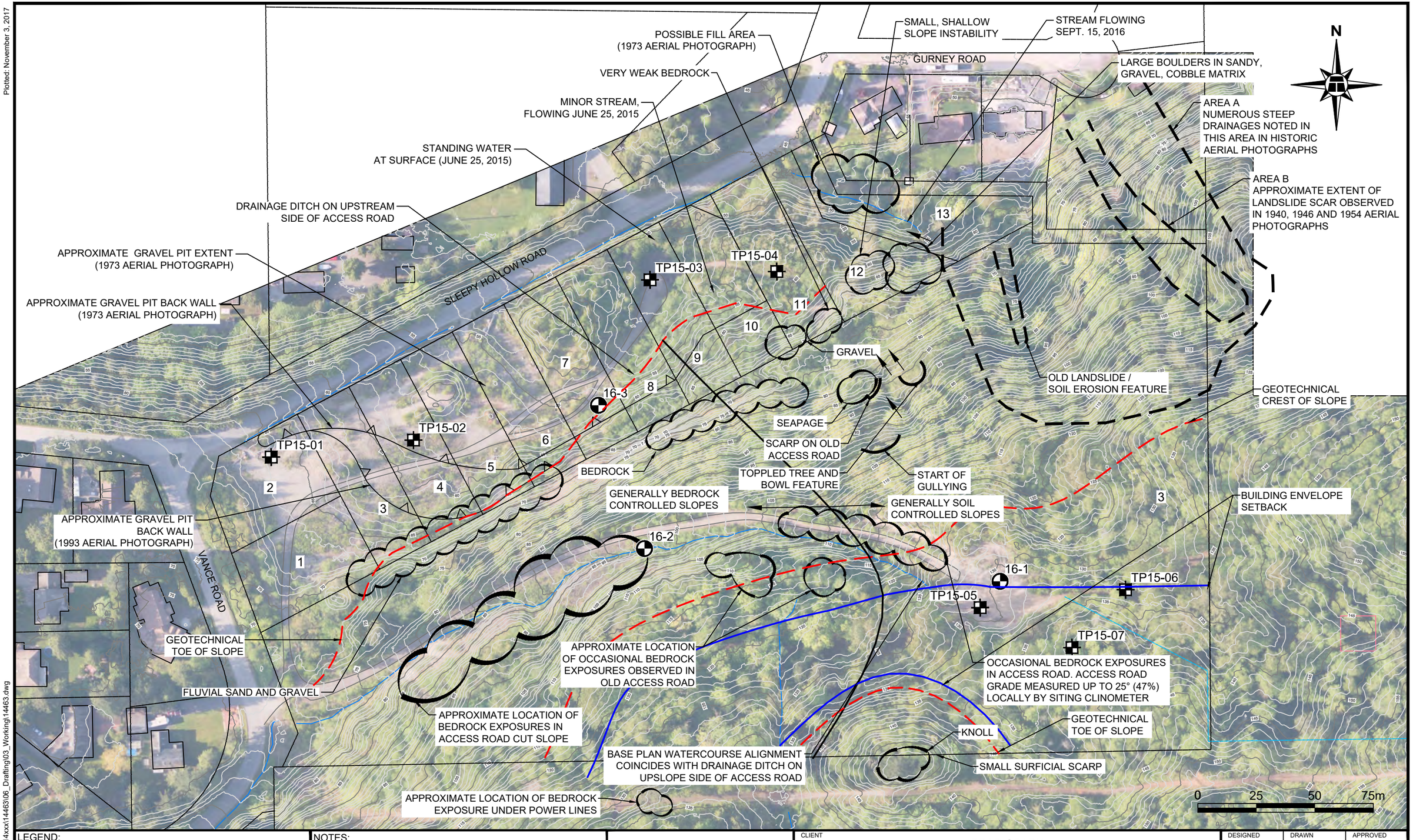
CANCEL PRINTS BEARING EARLIER NUMBER

Plotted: November 3, 2017



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LEGEND:

- TEST HOLE
- TEST PIT (2015 INVESTIGATION)
- WATER SEEPAGE OBSERVED ON SLOPE
- GEOTECHNICAL TOE OF SLOPE

NOTES:

1. BASE PLAN PROVIDED BY CREUS ENGINEERING LTD. ON OCTOBER 17, 2016.
2. AERIAL IMAGE BY TERRA REMOTE SENSING INC. DATED MAY 21, 2015.
3. TEST HOLE LOCATIONS ARE APPROXIMATE.

THURBER ENGINEERING LTD.

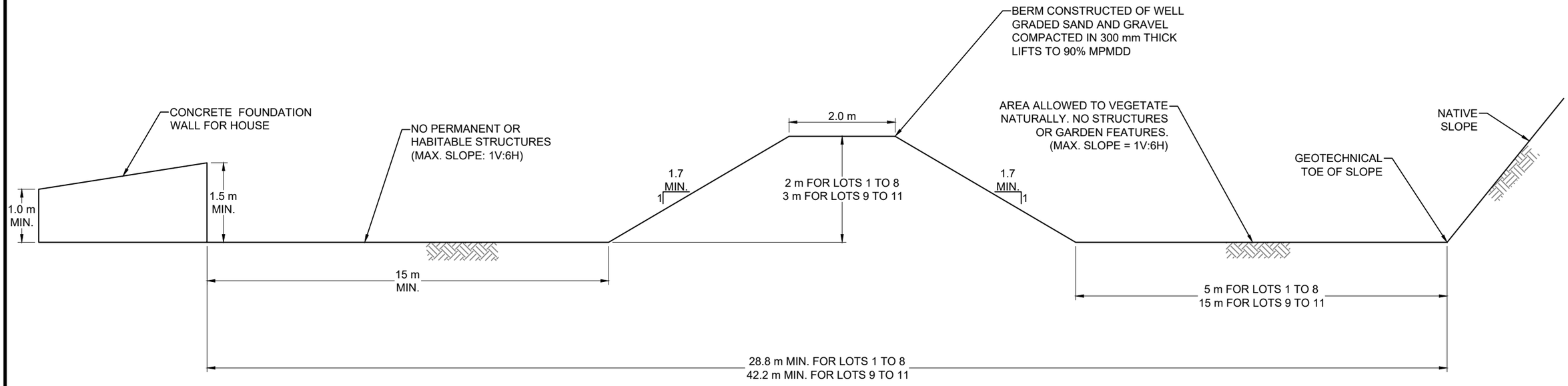
CLIENT: BRAD GEARY

PRELIMINARY GEOTECHNICAL ASSESSMENT
SITE PLAN

SLEEPY HOLLOW ROAD SUBDIVISION — CULTUS LAKE, BC

DESIGNED	DRAWN	APPROVED
CJC	NAK/MOM	
DATE: 03/11/17	SCALE: 1:1500	
PROJECT No.: 14463	DWG. No.: 2	REV.: 1

CANCEL PRINTS BEARING EARLIER NUMBER



LEGEND:

NOTES:

THURBER ENGINEERING LTD.

CLIENT: PAN CANADIAN MORTGAGE GROUP

GEOTECHNICAL HAZARD MITIGATION DETAIL

SLEEPY HOLLOW ROAD SUBDIVISION — CULTUS LAKE, BC

DESIGNED	DRAWN	APPROVED
BSP	NAK	DNR

DATE	SCALE
01/12/16	N.T.S.

PROJECT No.	DWG. No.	REV.
14463	3	-

THURBER ENGINEERING LTD.

CLIENT: BRAD GEARY

GENERAL SITE LOCATION

SLEEPY HOLOW ROAD SUBDIVISION CALTUS LAKE B.C.

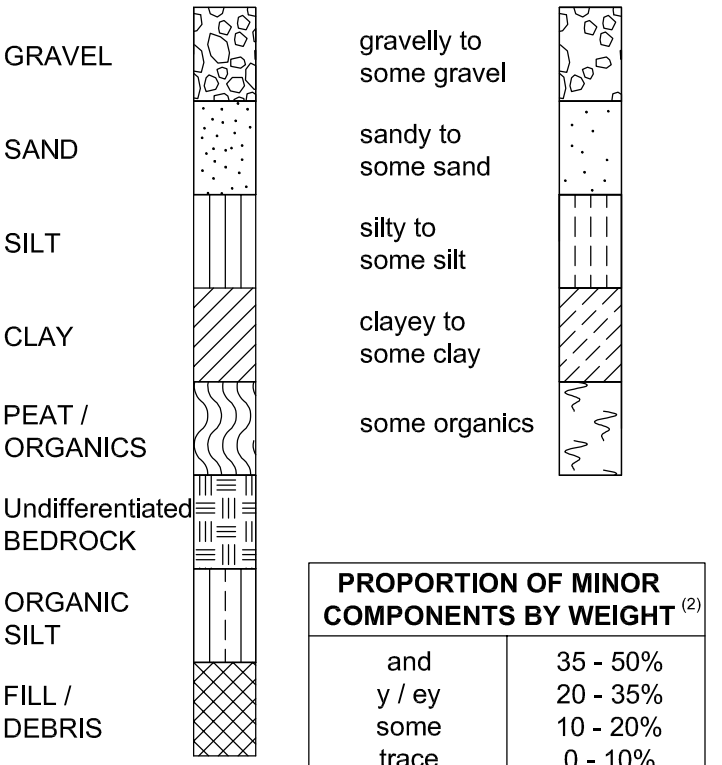
DESIGNED	DRAWN	APPROVED
CJC	MOM	

DATE	SCALE
03/11/17	1:7500

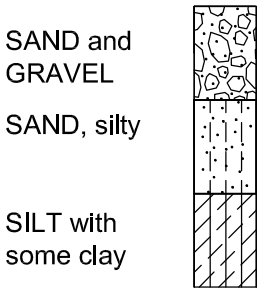
PROJECT No.	DWG. No.	REV.
14463	4	0

SYMBOLS AND TERMS
FOR SOIL DESCRIPTION AND TEST HOLE LOGS

BASIC SOIL SYMBOLS



SYMBOL VARIATIONS - EXAMPLES (1)



DENSITY OF GRANULAR SOILS	
Description	SPT N (5) (6)
Very Loose	0 - 4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very Dense	> 50

PROPORTION OF MINOR COMPONENTS BY WEIGHT (2)	
and	35 - 50%
y / ey	20 - 35%
some	10 - 20%
trace	0 - 10%

CONSISTENCY OF COHESIVE SOILS	
Description	Undrained Shear Strength (kPa) (6)
Very Soft	< 12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	> 200

PENETRATION TESTS	
Dynamic Cone Penetration	
Standard Penetration	
Becker Closed Casing	
Becker Open Casing	
Bounce Chamber Pressure	

CLASSIFICATION BY PARTICLE SIZE				
		Size Range (6)		
			U.S. Standard Sieve Size	
Name		(mm) (3)	Retained	Passing
Boulders		> 200	8 inch	-
Cobbles		75 - 200	3 inch	8 inch
Gravel:	coarse	19 - 75	0.75 inch	3 inch
	fine	5 - 19	No. 4	0.75 inch
Sand:	coarse	2 - 5	No. 10	No. 4
	medium	0.4 - 2	No. 40	No. 10
	fine	0.075 - 0.4	No. 200	No. 40
Fines (Silt or Clay) (4)		< 0.075	-	No. 200

(1) Only selected examples of the possible variations or combinations of the basic symbols are illustrated.
(2) Example: SAND, silty, trace of gravel = sand with 20 to 35% silt and up to 10% gravel, by dry weight. Percentages of secondary materials are estimates based on visual and tactile assessment of samples.
(3) Approximate metric conversion.
(4) Fines are classified as silt or clay on the basis of Atterberg limits.
(5) SPT N values on test hole logs are uncorrected field values.
(6) Reference Canadian Foundation Engineering Manual 4th Edition, 2006.

THURBER

Sheet 1 of 3

LOG OF TEST HOLE

TEST HOLE NO. 16-1

LOCATION: See Dwg. 14463-1
N 5435991, E 576489

TOP OF HOLE ELEV: 130.0 m (est.)
METHOD: Auguer/Odex
DRILLING CO.: VanMars Drilling Ltd.
INSPECTOR: SMP

THURBER

CLIENT: Pan-Canadian Mortgage Group
PROJECT: Sleepy Hollow Road Subdivision

DATE: September 27, 2016
FILE NO.: 14463

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: Disturbed, Undisturbed, No Recovery | UNDRAINED SHEAR STRENGTH (kPa): Peak, Residual, Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m)	COMMENTS		SOILS DESCRIPTION	ELEVATION (m)
0	Solid stem auger from 0 to 1.5 m depth. Odex from 1.5 to 24.4 m depth.	SP-SM	Compact, brown, moist, gravelly SAND with traces of silt and organics.	
1		SP/GP		129
		GP	Dense, brown to grey, moist, sandy GRAVEL with a trace of silt.	
2				128
3		GP/SP	Dense, brown to grey, moist, gravelly SAND with a trace of silt.	127
4				126
		CL/CH	- 75 mm thick layer of stiff, brown, moist SILT and CLAY with some sand at 4.6 m depth	
5		SP/GP		125
			- 300 mm boulder at 5.5 m depth	
6				124
		SP/GP		
		SP	Dense, brown to grey, moist SAND with a trace of silt.	
7				123
		SP		
8		SP-SM/GP-GM	Brown, moist SAND and GRAVEL with a trace of silt.	122
			Compact, grey to brown, moist SAND with a trace of silt.	
9				121
		SP		
10				

LOG OF TEST HOLE 14463.GPJ THURBER BC.GDT 29-11-16- THURBER BC NEW.GLB

Sheet 2 of 3

LOG OF TEST HOLE

TEST HOLE NO. 16-1

LOCATION: See Dwg. 14463-1
N 5435991, E 576489

TOP OF HOLE ELEV: 130.0 m (est.)
METHOD: Auguer/Odex
DRILLING CO.: VanMars Drilling Ltd.
INSPECTOR: SMP

THURBER

CLIENT: Pan-Canadian Mortgage Group
PROJECT: Sleepy Hollow Road Subdivision

DATE: September 27, 2016
FILE NO.: 14463

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ● GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS		SOILS DESCRIPTION	ELEVATION (m)
10			Compact, grey to brown, moist SAND with a trace of silt.	
11	Drillers note ground water at 10.7 m depth. Odex hammer coming up wet between 10.7 and 15.2 m depth.	SP		119
12		SP		118
		SW-SM	Dense to very dense, brown to grey, moist to wet, gravelly SAND with a trace of silt.	
13				117
		SW/GW		
14				116
15			- 75 mm lens of stiff, brown, moist, clayey SILT, and gravelly SAND and SILT at 15.2 m depth	115
		CL & ML/SM		
		SM	Dense, brown to grey, moist SAND with some silt and a trace of gravel. - 100 mm thick wet zone with orange staining at 15.5 m depth	
16				114
17			Very dense, brown, moist SAND and GRAVEL with some silt.	113
		SP-SM/GP-GM		
18				112
		SM/ML	Very dense, grey, moist, gravelly SAND and SILT.	
19			Brown, moist SAND with some silt.	111
20		SM/GM		

LOG OF TEST HOLE 14463.GPJ THURBER BC.GDT 29-11-16- THURBER BC NEW.GLB

Sheet 3 of 3

LOG OF TEST HOLE

TEST HOLE NO. 16-1

LOCATION: See Dwg. 14463-1
N 5435991, E 576489

TOP OF HOLE ELEV: 130.0 m (est.)
METHOD: Auguer/Odex
DRILLING CO.: VanMars Drilling Ltd.
INSPECTOR: SMP

THURBER

CLIENT: Pan-Canadian Mortgage Group
PROJECT: Sleepy Hollow Road Subdivision

DATE: September 27, 2016
FILE NO.: 14463

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ■ GASTECH reading ⊠ PID reading

DEPTH (m)	10 20 30 40 50 60 70 80 90 100	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
20	○	SM/GM	Grey to brown, moist SAND and GRAVEL with some silt.	
21	▼		Hard, grey METAMORPHOSED SILTSTONE.	109
22				108
23		METAMORPHOSED SILTSTONE		107
24	○			106
			End of test hole at required depth. Hole open to 23 m depth and on completion of drilling, groundwater observed at 21 m depth.	
25				105
26				104
27				103
28				102
29				101
30				

LOG OF TEST HOLE 14463.GPJ THURBER BC.GDT 29-11-16- THURBER BC NEW.GLB

Sheet 1 of 1

LOG OF TEST HOLE

TEST HOLE NO. 16-2

LOCATION: See Dwg. 14463-1
N 5436005, E 576337

TOP OF HOLE ELEV: 100.0 m (est.)

METHOD: Odex

DRILLING CO.: VanMars Drilling Ltd.

INSPECTOR: SMP

THURBER

CLIENT: Pan-Canadian Mortgage Group

PROJECT: Sleepy Hollow Road Subdivision

DATE: September 28, 2016

FILE NO.: 14463

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ● GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0		Very dense, brown to grey, moist GRAVEL and SAND with a trace of silt.	
1	GP/SP		99
	SP-SM/GP-GM		
2	METAMORPHOSED SILTSTONE	Dark brown to grey, moist GRAVEL and SAND with some silt and trace zones of clayey silt.	98
		Hard, grey METAMORPHOSED SILTSTONE.	
3			97
4			96
5		End of test hole in confirmed bedrock. Hole open to 4.4 m depth and no ground water observed upon completion of drilling.	95
6			94
7			93
8			92
9			91
10			

Sheet 1 of 2

LOG OF TEST HOLE

TEST HOLE NO. 16-3

LOCATION: See Dwg. 14463-1
N 5436098, E 576318

TOP OF HOLE ELEV: 55.0 m (est.)

METHOD: Odex

DRILLING CO.: VanMars Drilling Ltd.

INSPECTOR: SMP

THURBER

CLIENT: Pan-Canadian Mortgage Group

PROJECT: Sleepy Hollow Road Subdivision

DATE: September 28, 2016

FILE NO.: 14463

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ✱ GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0	GP-GM/SP-SM	Very dense, grey to brown, moist GRAVEL and SAND with traces of silt and organics. Occasional cobbles/boulders.	
1			54
		- 300 mm diameter boulder at 1.5 m depth	
2	SP/GP		53
		- 300 mm diameter boulder at 2.1 m depth	
3			52
	GP/SP		
4			51
	GP/SP	- bouldery below 4.6 m depth	
5			50
6			49
		- 450 mm diameter boulder at 6 m depth	
		- 300 mm diameter boulder at 6.7 m depth	
7	SP/SW		48
		- 300 mm diameter boulder at 7.6 m depth	
8			47
		- 300 mm diameter boulder at 8.2 m depth	
	SW/SP		
9		- 250 mm diameter boulder at 8.8 m depth	46
	GP/SP		
10			

LOG OF TEST HOLE 14463.GPJ THURBER BC.GDT 29-11-16- THURBER BC NEW.GLB

Sheet 2 of 2

LOG OF TEST HOLE

TEST HOLE NO. 16-3

LOCATION: See Dwg. 14463-1
N 5436098, E 576318

TOP OF HOLE ELEV: 55.0 m (est.)

METHOD: Odex

DRILLING CO.: VanMars Drilling Ltd.

INSPECTOR: SMP

THURBER

CLIENT: Pan-Canadian Mortgage Group

PROJECT: Sleepy Hollow Road Subdivision

DATE: September 28, 2016

FILE NO.: 14463

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ● GASTECH reading ⊠ PID reading

DEPTH (m)	10 20 30 40 50 60 70 80 90 100	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
10			Very dense, grey to brown, moist GRAVEL and SAND with traces of silt and organics. Occasional cobbles/boulders.	
	○	GW		
11			End of test hole at required depth. Hole open to 10.8 m depth and no groundwater observed upon completion of drilling.	44
12				43
13				42
14				41
15				40
16				39
17				38
18				37
19				36
20				

LOG OF TEST HOLE 14463.GPJ THURBER BC.GDT 29-11-16- THURBER BC NEW.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-01**

LOCATION: See Dwg. 19-5849-1-1
N 576179,
E 5436039

TOP OF HOLE ELEV: 65.8 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ■ GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0		Inferred compact to dense, brown fine to coarse SAND and subrounded to rounded GRAVEL and COBBLES, with some subrounded to rounded 600 mm minus boulders. (Probably Reworked Sand and Gravel).	
1	Percolation test adjacent to test pit at 1.2 m depth.	GP/SP Inferred compact to dense, light brown, fine to coarse SAND and subrounded to rounded GRAVEL, and traces of subrounded cobbles and subrounded minus 600 mm boulders. (Probably Reworked Sand and Gravel).	65
2		SW/GW	64
		End of hole at required depth. No groundwater observed.	
3			63
4			62
5			61
6			60
7			59
8			58
9			57
10			56

LOG OF TEST PIT 19-5849-1.GPJ THURBER BC.GDT 7/6/15- THURBER BC.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-02**

LOCATION: See Dwg. 19-5849-1-1
N 576236,
E 5436060

TOP OF HOLE ELEV: 59.0 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ■ GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0		Inferred loose to compact, brown fine to coarse SAND, subrounded to subangular to tabular GRAVEL with traces of minus 125 mm cobbles and organics to 0.3 m depth (Probably Reworked Sand and Gravel).	
1	SW-SM/GW-GM		58
	Percolation test adjacent to test pit at 1.2 m depth.	Inferred dense, brown fine to coarse SAND and subangular GRAVEL with traces to some subrounded to rounded minus 150 cobbles (Probably Native Sand and Gravel).	
2	GW-GM	End of hole at required depth. No groundwater observed.	57
3			56
4			55
5			54
6			53
7			52
8			51
9			50
10			

LOG OF TEST PIT 19-5849-1.GPJ THURBER BC.GDT 7/6/15- THURBER BC.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-03**

LOCATION: See Dwg. 19-5849-1-1
N 576342,
E 5436113

TOP OF HOLE ELEV: 51.0 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: Disturbed, Undisturbed, No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m)	10 20 30 40 50 60 70 80 90 100	COMMENTS		SOILS DESCRIPTION	ELEVATION (m)
0				Inferred dense, brown fine to coarse, SAND with some subrounded to subanglar gravel, subrounded to rounded cobbles and minus 250 mm boulders (Gravel Pit Road).	
1	○	Percolation test adjacent to test pit at 1.2 m depth.	SP	Inferred compact, brown fine to medium SAND with some subrounded to subangular gravel and traces of minus 100 mm cobbles.	50
2		Damp below 1.7 m depth.			49
				End of hole at required depth. No groundwater observed. Standing water at surface within 10 m of test pit.	
3					48
4					47
5					46
6					45
7					44
8					43
9					42
10					

LOG OF TEST PIT 19-5849-1.GPJ THURBER BC.GDT 7/6/15- THURBER BC.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-04**

LOCATION: See Dwg. 19-5849-1-1
N 576378,
E 5436096

TOP OF HOLE ELEV: 61.3 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

PENETRATION (blows/300 mm) | WATER CONTENT (%) ○ Disturbed ● Undisturbed | WATER LEVEL Plastic Limit — Liquid Limit | SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm) ■ GASTECH reading ⊠ PID reading

DEPTH (m)	10 20 30 40 50 60 70 80 90 100	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0			Topsoil over firm to soft, brown sandy SILT/inferred loose to compact silty fine to coarse SAND with some fine to coarse, subangular to subrounded gravel and minus 100 mm cobbles (Fill).	61
1			Firm to soft, black to brown SILT with some fine sand, traces to some angular to subangular gravel and traces of minus 175 mm cobbles with wood fragments (Fill).	60
2				59
3			End of hole at required depth. No groundwater observed.	58
4				57
5				56
6				55
7				54
8				53
9				52
10				

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-05**

LOCATION: See Dwg. 19-5849-1-1
N 576471,
E 5435979

TOP OF HOLE ELEV: 128.8 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

PENETRATION (blows/300 mm) | WATER CONTENT (%) ○ Disturbed ● Undisturbed | WATER LEVEL Plastic Limit — Liquid Limit | SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm) ■ GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS		SOILS DESCRIPTION	ELEVATION (m)
0	Sidewall spalling below 0.5 m depth.		Inferred compact to loose fine to medium SAND with traces subrounded to subangular gravel (Probably Reworked Sand).	
1	Percolation test adjacent to test pit at 1.2m depth.	SP	Inferred compact to loose fine SAND with traces to some subrounded gravel.	128
2				127
		SP/GP		
3			End of hole at required depht. No groundwater observed.	126
4				125
5				124
6				123
7				122
8				121
9				120
10				119

LOG OF TEST PIT 19-5849-1.GPJ THURBER BC.GDT 7/6/15- THURBER BC.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-06**

LOCATION: See Dwg. 19-5849-1-1
N 576533,
E 5436973

TOP OF HOLE ELEV: 138.4 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

PENETRATION (blows/300 mm) | WATER CONTENT (%) ○ Disturbed ● Undisturbed | WATER LEVEL Plastic Limit — Liquid Limit | SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm) ■ GASTECH reading ⊠ PID reading

DEPTH (m)	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0		Firm, brown SILT with traces of fine sand with frequent organics, wood debris and rootlets (Forest Root Mat).	138
		Firm, brown SILT with traces sand.	
1	Percolation test completed in test pit at 1.2 m depth.	SM/ML	137
2		SM Inferred compact to loose, brown to grey fine SAND.	136
		End of hole at required depth. No groundwater observed.	
3			135
4			134
5			133
6			132
7			131
8			130
9			129
10			

10 20 30 40 50 60 70 80 90 100

LOG OF TEST PIT 19-5849-1.GPJ THURBER BC.GDT 7/6/15- THURBER BC.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP15-07**

LOCATION: See Dwg. 19-5849-1-1
N 576537,
E 5436002

TOP OF HOLE ELEV: 129.8 m (est.)

METHOD: Case 580 Super N Backhoe

EXCAVATOR: Ponte Brothers Contracting Ltd

INSPECTOR: AGB

THURBER

CLIENT: Creus Engineering Ltd.

PROJECT: Sleepy Hollow Road Subdivision, Cultus Lake

DATE: June 25, 2015

FILE NO.: 19-5849-1

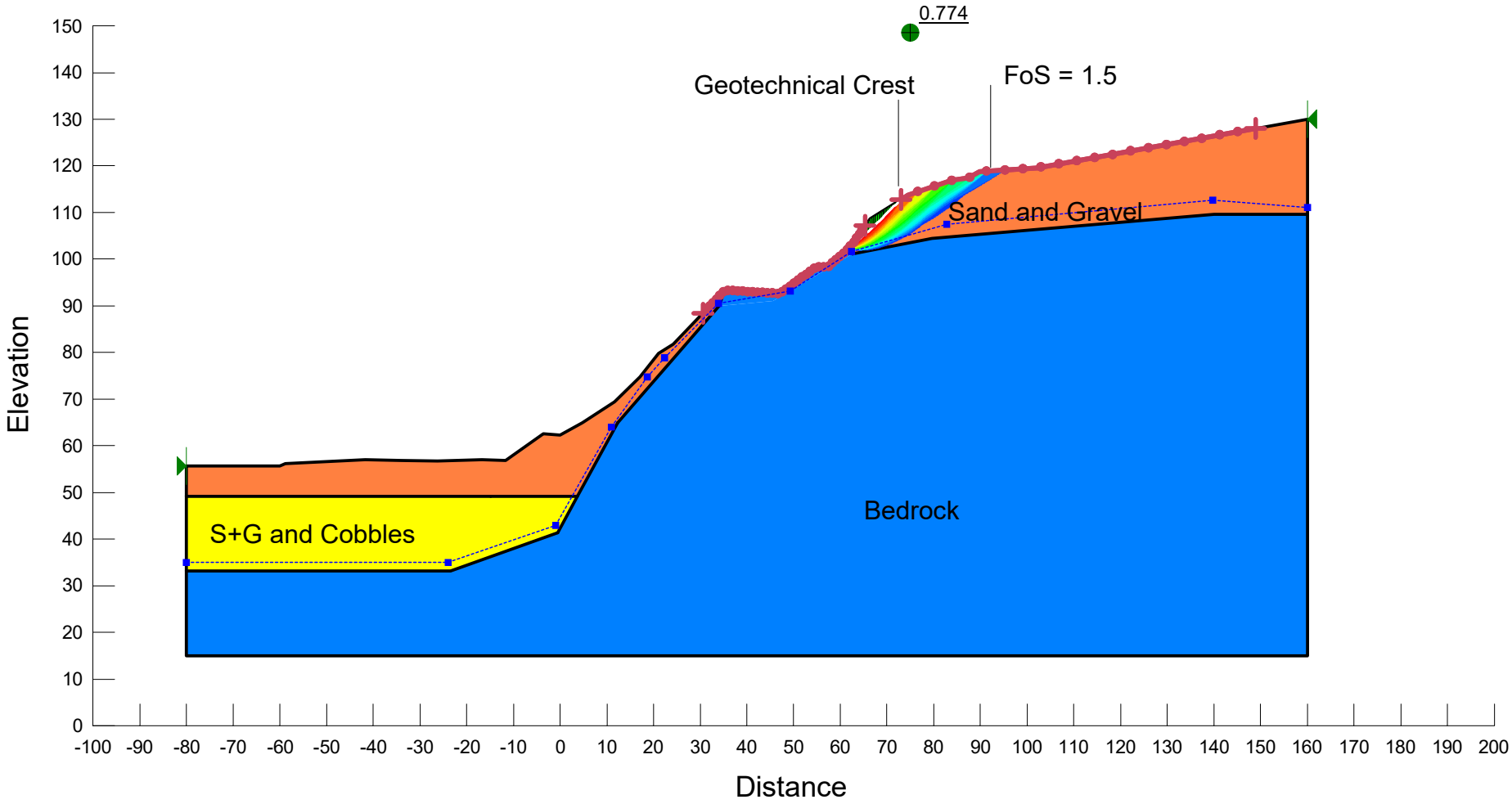
PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ■ GASTECH reading ⊠ PID reading

DEPTH (m)	10 20 30 40 50 60 70 80 90 100	COMMENTS	SOILS DESCRIPTION	ELEVATION (m)
0			Firm, brown SILT with traces of fine sand with frequent organics, wood debris and rootlets (Forest Root Mat).	
			Firm, brown SILT with traces sand.	129
1		Percolation test completed in test pit at 1.2 m depth.	Inferred loose to compact, brown to grey fine SAND.	
				128
2			End of hole at required depth. No groundwater observed.	
3				127
4				126
5				125
6				124
7				123
8				122
9				121
10				120

LOG OF TEST PIT 19-5849-1.GPJ THURBER BC.GDT 7/6/15- THURBER BC.GLB

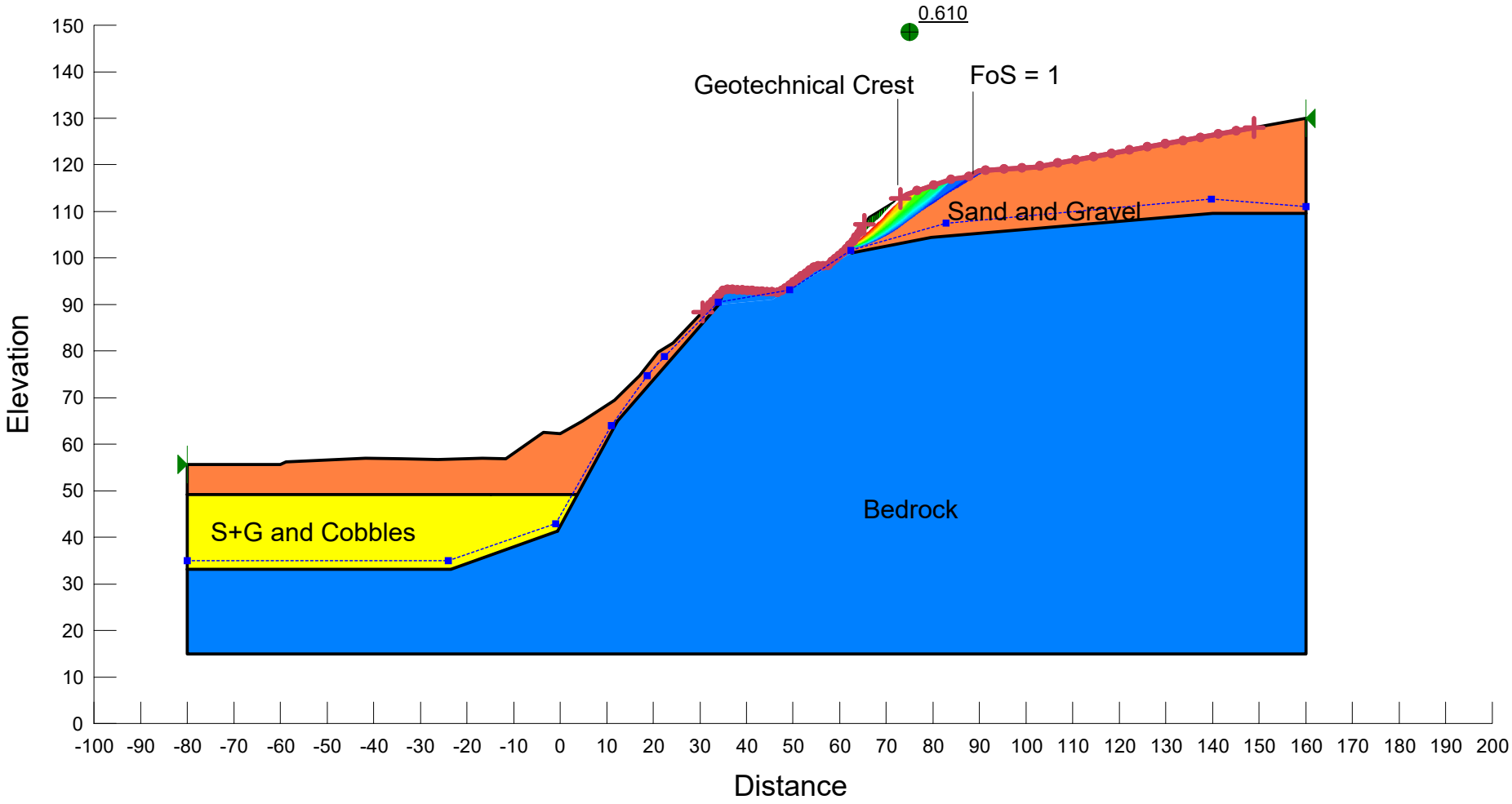
Slope Stability
Morgenstern-Price
11/1/2017
Section A-A

Name: Sand and Gravel Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: S+G and Cobbles Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: Bedrock Unit Weight: 24 kN/m³ Cohesion: 1e+006 kPa Phi: 1e+006 °



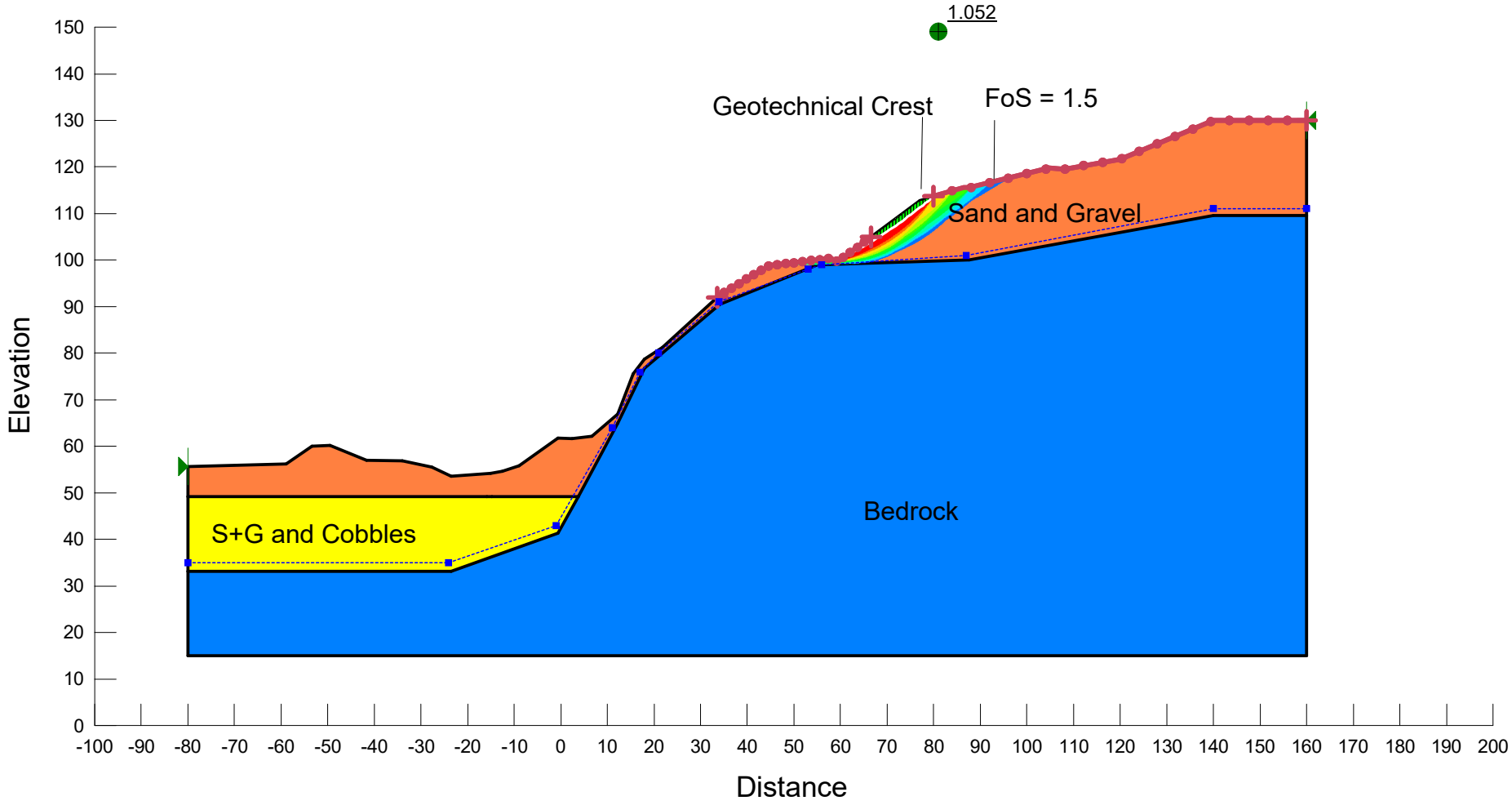
Slope Stability (Seismic - k=0.12)
Morgenstern-Price
11/1/2017
Section A-A

Name: Sand and Gravel Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: S+G and Cobbles Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: Bedrock Unit Weight: 24 kN/m³ Cohesion: 1e+006 kPa Phi: 1e+006 °



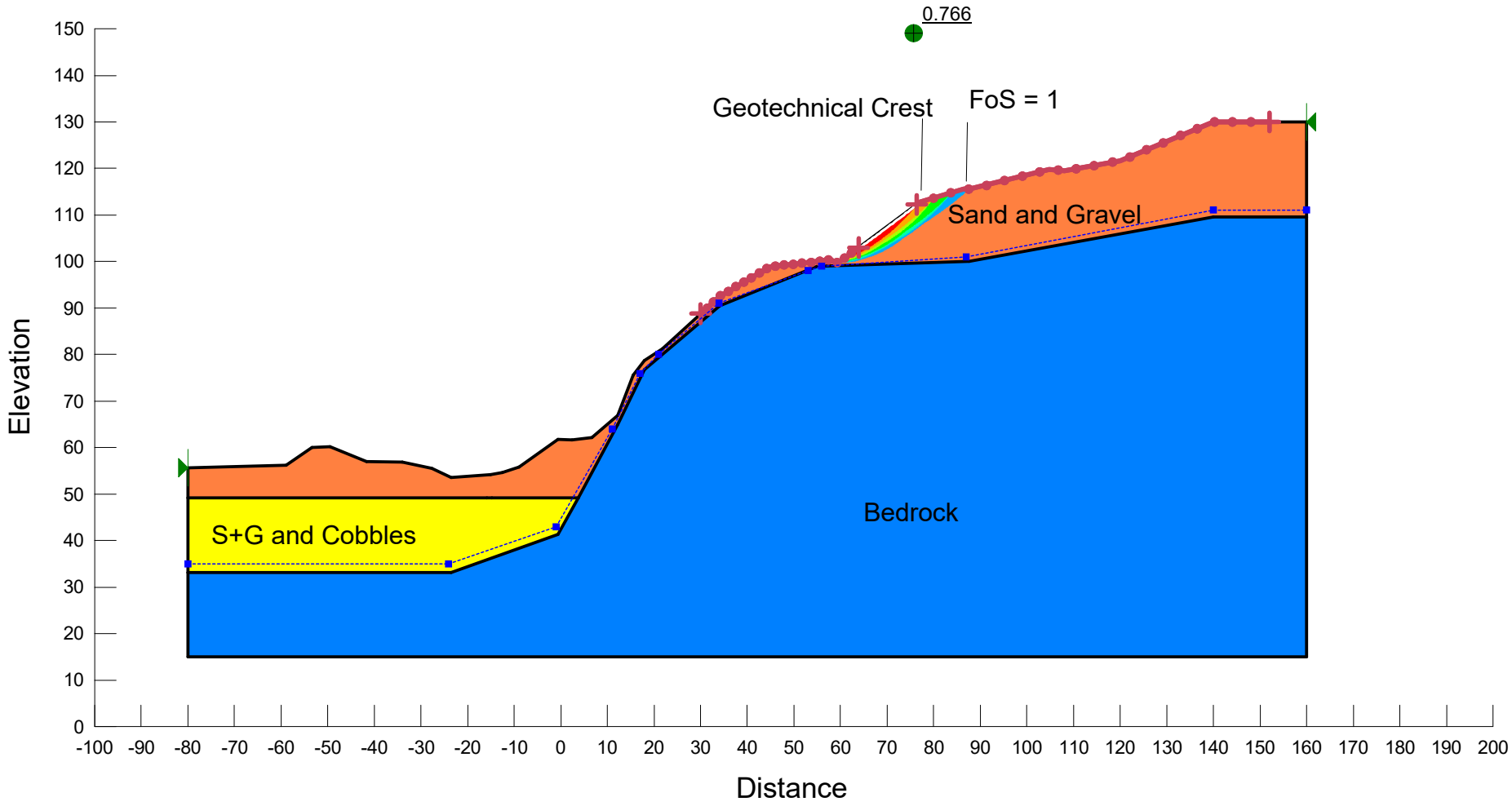
Slope Stability
Morgenstern-Price
11/3/2017
Section B-B

Name: Sand and Gravel Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: S+G and Cobbles Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: Bedrock Unit Weight: 24 kN/m³ Cohesion: 1e+006 kPa Phi: 1e+006 °

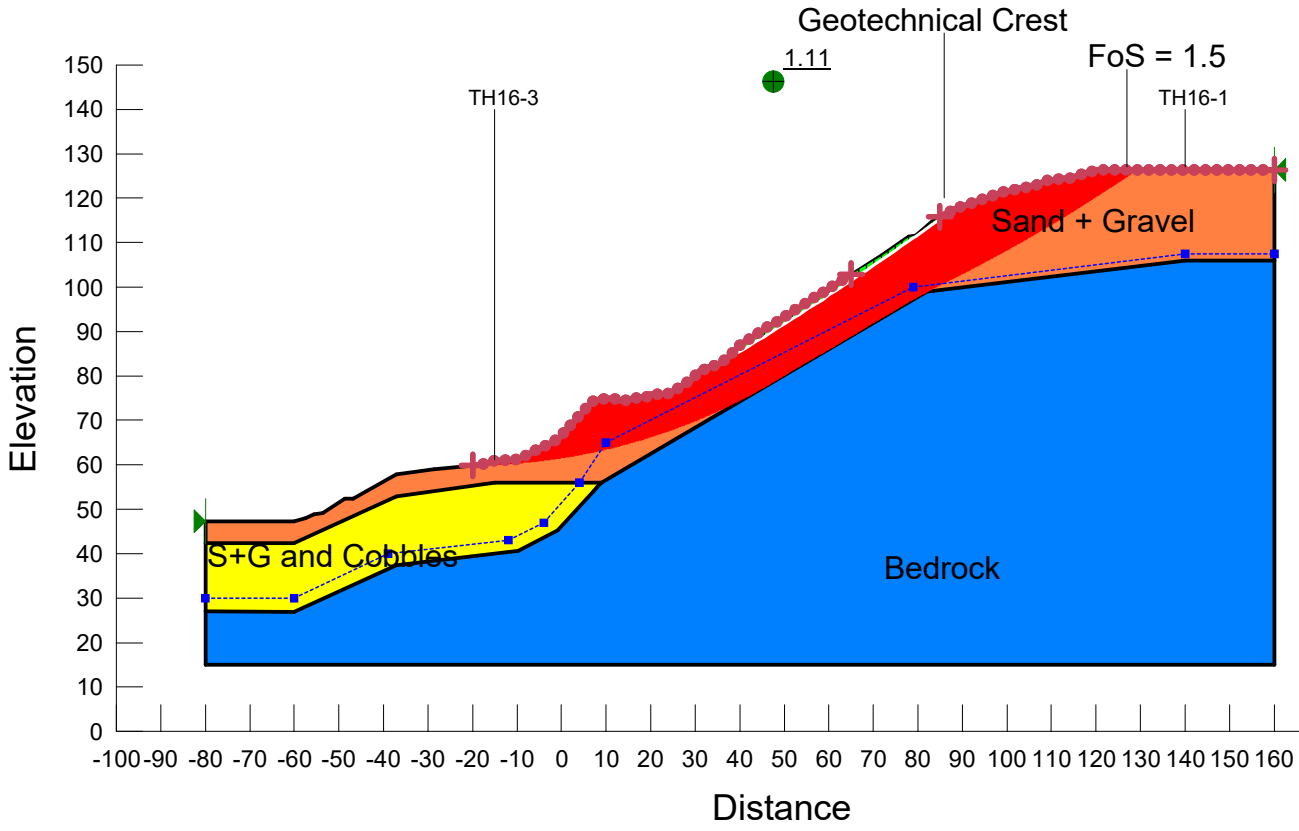


Slope Stability (Seismic - k=0.12)
Morgenstern-Price
11/3/2017
Section B-B

Name: Sand and Gravel Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: S+G and Cobbles Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 36 °
Name: Bedrock Unit Weight: 24 kN/m³ Cohesion: 1e+006 kPa Phi: 1e+006 °



SLOPE/W Analysis
Morgenstern-Price
11/3/2017
Section C-C

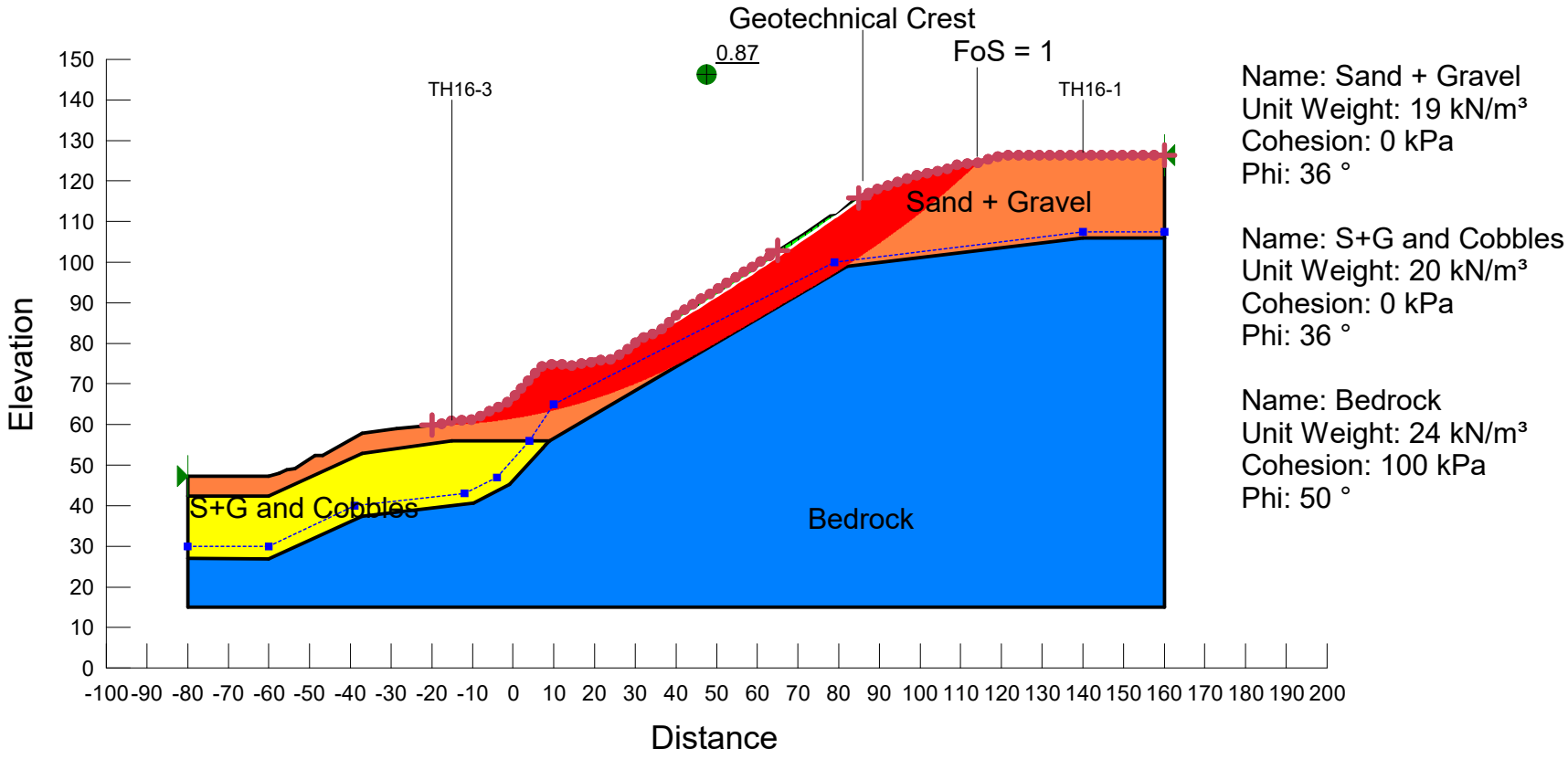


Name: Sand + Gravel
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 36 °

Name: S+G and Cobbles
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 36 °

Name: Bedrock
Unit Weight: 24 kN/m³
Cohesion: 100 kPa
Phi: 50 °

SLOPE/W Analysis - seismic (k=0.12) higher water table
Morgenstern-Price
11/3/2017
Section C-C



Name: Sand + Gravel
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 36 °

Name: S+G and Cobbles
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 36 °

Name: Bedrock
Unit Weight: 24 kN/m³
Cohesion: 100 kPa
Phi: 50 °

0+200 RockFall
Friction angle: Use friction fngle specified in material editor
Minimum Velocity=0.1
Angular Velocity of the rocks CONSIDERED
Standard Deviations NOT USED when generating slope vertices
Random-number generation: Random
Material name: Talus Cover [default]
Coefficient of Normal Restitution (RN): mean=0.32 std dev=0.04
Coefficient of Tangential Restitution (RT): mean=0.82 std dev=0.04
Friction Angle: mean=30 std dev=2
Roughness: std dev=0

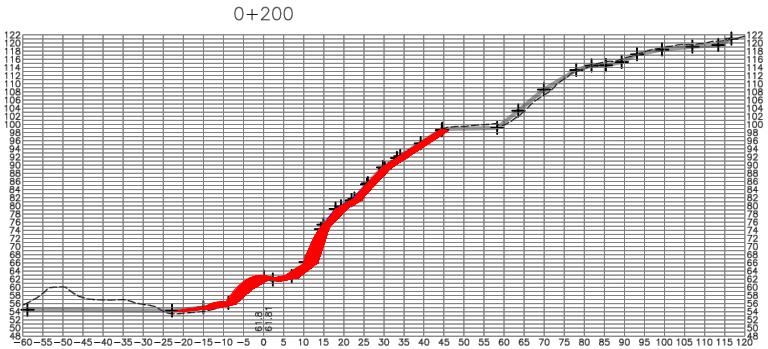


Figure 3. Extract from 1940 aerial photograph BC20740.