GEOTECHNICAL REPORT

Walsh Hills
1711 Terrace Avenue
Snohomish, Washington

Project No. T-8204

Terra Associates, Inc.

Prepared for:

D.R. Horton
Kirkland, Washington

May 19, 2020
Revised July 17, 2020

TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

May 19, 2020
Revised July 17, 2020
Project No. T-8204

Ms. Raelyn Hulquist
D.R. Horton
11241 Slater Avenue NE, Suite 200
Kirkland, Washington 98033

Subject: Geotechnical Report
Walsh Hills
1711 Terrace Avenue
Snohomish, Washington

Dear Ms. Hulquist:

As requested, we conducted a geotechnical engineering study for the subject project. The attached report presents our findings and recommendations for the geotechnical aspects of project design and construction.

The site soils generally consist of approximately six to eight inches of organic topsoil overlying medium dense to very dense silty sand with varying amounts of gravel (weathered and unweathered glacial till). The test borings showed the glacial till soils to the termination of the test borings. We did not observe groundwater seepage in the test pits although light to moderate groundwater seepage was observed in the test borings.

In our opinion, the native and existing inorganic fill soils on the site will be suitable for support of the proposed construction, provided the recommendations presented in this report are incorporated into project design and construction.

We trust the information presented in this report is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Michael Xenos, E.I.T.
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TABLE OF CONTENTS

Geotechnical Report
Walsh Hills
1711 Terrace Avenue
Snohomish, Washington

1.0 PROJECT DESCRIPTION

The project consists of redeveloping the site with 113 single-family residential building lots along with 2 stormwater detention vaults, associated utilities, landscaping, and access. The eastern steep slope would remain undeveloped. Based on the grading plan prepared by CPH Consultants, dated May 12, 2020 grading to achieve building lot and roadway elevations will consist of cuts and fills from 1 to 20 feet. Part of the grading consists of constructing a maximum 18-foot retaining wall near the top of the steep slope. Other vertical grade transitions will be supported with retaining walls as well.

Site stormwater will be collected and directed to one of two stormwater detention vaults located in the southeast and southwest corners of the site. The discharge pipe for the southeast vault will extend to the east down the steep slope and connect to the existing stormwater system.

We expect that the single-family residences will be two-story, wood-frame buildings with the main floors framed over a crawlspace with an attached garage constructed at grade. The structural loading carried by building foundations for the single-family residences are expected to be relatively light, in the range of 2 to 6 kips per foot for bearing walls and 30 to 60 kips for isolated columns.

The recommendations contained in the following sections of this report are based on our understanding of the above design features. We should review design drawings as they become available to verify that our recommendations have been properly interpreted and incorporated into project design and to amend or supplement our recommendations, if required.

2.0 SCOPE OF WORK

On August 29, 2019, we observed the soil and groundwater conditions in 8 test pits excavated with a track-mounted mini-excavator to depths of approximately three to ten feet below existing surface grades. On September 17, 2019 and September 18, 2019, we supplemented this data by drilling 2 borings to depths of 100 feet below existing surface grades. Using the results of our field study and laboratory testing, analyses were undertaken to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions.
- Geologic Hazards per the City of Snohomish Municipal Code.
- Seismic Design Parameters per the current International Building Code (IBC).
- Site preparation and grading.
- Relative slope stability.
- Excavations

- Foundations
- Floor slabs.
- Stormwater facilities.
- Infiltration feasibility.
- Drainage
- Utilities
- Pavements

It should be noted that recommendations outlined in this report regarding drainage are associated with soil strength, design earth pressures, erosion, and stability. Design and performance issues with respect to moisture as it relates to the structure environment are beyond Terra Associates' purview. A building envelope specialist or contactor should be consulted to address these issues, as needed.

3.0 SITE CONDITIONS

3.1 Surface

The site is an approximately 19.3-acre parcel located at 1711 Terrace Avenue in Snohomish, Washington. The approximate site location is shown on Figure 1.

The majority of the site is currently developed with a single-family residential structure, an office building, eight warehouse buildings, and associated access and landscaping. The eastern portion of the site is undeveloped and covered with a moderate forest and associated understory. Site topography is generally flat with a slight slope from west to east that transitions to a steep slope in the eastern, undeveloped portion of the site. The relatively flat portion of the site has an overall relief of approximately 30 feet. The eastern steep slopes have an overall relief of approximately 210 feet.

3.2 Soils

In general, the soil conditions observed consist of approximately six to eight inches of organic topsoil overlying medium dense to very dense silty sand with varying amounts of gravel (weathered and unweathered glacial till) to the termination of the test pits. The exception to this general condition was observed in Test Pit TP-3 where we observed approximately nine feet of medium dense till-like and organic fills overlying the unweathered glacial till deposits.

The test borings showed the glacial till soils are present to the termination of the test borings. We observed an approximately 4- to 8-foot thick layer of hard silt with sandy interbeds at approximately 45 to 55 feet below current site grades.

The *Geologic Map of the Snohomish Quadrangle, Snohomish County, Washington* by J.P. Minard (1985) maps the site as Till (Qvt). The native soils observed in the test pits and test borings are generally consistent with this mapped geology.

The preceding is intended to be a general review of the soil conditions encountered. For more detailed descriptions, please refer to the Test Pit and Test Boring Logs in Appendix A.

3.3 Groundwater

No groundwater seepage was observed in the test pits. We observed light to moderate groundwater seepage in Test Boring B-1 at depths of 23 feet and 50 feet, and in Test Boring B-2 at depths of 6 and 56 feet. The shallow seepage at Test Boring B-2 was observed at the contact between the upper weathered till and underlying unweathered till. Additionally, we did observe mottled soils, which is typically an indication that shallow, perched, groundwater seepage develops during the wet winter months. We expect that perched groundwater levels and flow rates at the site will fluctuate seasonally with the highest levels occurring during and shortly following the winter months (November through May).

The deeper points of seepage observed in the test borings were observed within coarsely-grained zones at the interface between the unweathered till and hard silts as well as atop silt interbeds. This groundwater seepage would not be significantly affected by seasonal weather variations and will be present during the drier summer and fall months.

3.4 Geologic Hazards

We evaluated site conditions for the presence of geologic hazards including erosion hazard areas, landslide hazard areas, and seismic hazard areas in accordance with the City of Snohomish Municipal Code, specifically Section 14.275.

3.4.1 Erosion Hazard Areas

Section 14.275.010.B.1 of the City of Snohomish Municipal Code (SMC) defines erosion hazard areas as "areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a moderate-to-severe, severe, or very severe rill and inter-rill (sheet wash) erosion hazard."

The soils observed in the western and central portions of the site are classified as Tokul gravelly medial loam, zero to eight percent slopes by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). Over these portions of the site with the existing slope gradients, these soils will have a slight potential for erosion when exposed. The soils observed in the eastern, steep slope portion of the site are classified as Tokul-Winston gravelly loams, 25 to 65 percent slopes by the NRCS. Over this portion of the site with the existing slope gradients, these soils will have a severe potential for erosion when exposed and; therefore, meet the above criteria for an erosion hazard area per the SMC.

However, as only the western and central portions of the site are to be developed, it is our opinion that provided the eastern portion of the site remains in its current condition, the site is not an erosion hazard area per the SMC.

Regardless, erosion protection measures as required by the City of Snohomish will need to be in place prior to the start of construction activities.

3.4.2 Landslide Hazard Areas

Section 14.275.010.B.2 of the SMC defines landslide hazard areas as "areas subject to landslides based on geology, soils, topography, and hydrology, including:

> a. Areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a severe limitation for building site development.
>
> b. Areas mapped by the Washington Department of Ecology (Coastal Zone Atlas) or the Washington State Department of Natural Resources (slope stability mapping) as unstable (U or Class 3), unstable old slides (UOS or Class 4), or unstable recent slides (URS or Class 5).
>
> c. Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Washington State Department of Natural Resources.
>
> d. Areas where the following coincide: slopes steeper than fifteen percent, relatively permeable sediment overlying a relatively impermeable sediment or bedrock, and groundwater seepage.
>
> e. Areas that have shown movement in the past 10,000 years or that are underlain or covered by mass wastage debris of that time frame.
>
> f. Slopes that are parallel or sub-parallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials.
>
> g. Slopes steeper than 80 percent subject to rock fall during seismic shaking.
>
> h. Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action.
>
> i. Areas at risk from snow avalanches.
>
> j. Canyons or active alluvial fans subject to debris flows or catastrophic flooding.
>
> k. Slopes of 40 percent or steeper with a vertical relief of 10 or more feet except areas composed of consolidated rock."

Existing site topography in the western and central portions of the site consists of a slight slope with little to no risk of mass movement due to geologic, topography, or hydrologic factors. The steep slope located in the eastern portion of the site has an overall relief of approximately 210 feet with grades of up to 85 percent, meeting condition 'k' listed above. Therefore, the eastern portion of the site would be considered a landslide hazard area per the SMC. As such, the code-required setbacks and buffers will need to be included in the drawings. Section 4.3 below details our analysis of the slope's stability and includes a determination of the appropriate setbacks and buffers.

3.4.3 Seismic Hazard Areas

Section 14.275.010.B.3 of the SMC defines seismic hazard areas as “areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface faulting. One indicator of potential earthquake damage is a record of past earthquake damage. Settlement and soil liquefaction occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow groundwater table.”

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations. Liquefaction mainly affects geologically recent deposits of fine-grained sands underlying the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction; thus, eliminating the soil’s strength.

Based on the soil and groundwater conditions observed, it is our opinion that the risk of liquefaction-related impacts to the proposed structures would be negligible. It is also our opinion that there is little to no risk for severe damage resulting from seismically induced settlement. Therefore, in our opinion, the site does not contain seismic hazard areas as defined by the SMC.

3.5 Seismic Design Parameters

Based on the site soil conditions and our knowledge of the area geology, per the current International Building Code (IBC), Site Class C should be used in structural design.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, there are no geotechnical conditions that would preclude development of the site, as currently planned. The residential structures can be supported on conventional spread footings bearing on competent native soils, competent existing fill, or on structural fill placed on the competent soils underlying the organic topsoil. Floor slabs and pavements can be similarly supported.

The native and existing fill soils encountered at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use these soils from site excavations as structural fill will depend on their moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during winter, the owner should be prepared to import clean granular material for use as structural fill and backfill.

Any development in the vicinity of Test Pit TP-3 should take into account the presence of the organic fill material below the till-like fills. Any organic fill material would not present a suitable bearing surface due to the potential for settlement following the decay of organic material over time. As site grading progresses, it may be necessary to improve the upper ground conditions by excavation and re-compaction where organic soils are encountered to achieve a suitable bearing surface. The need for overexcavation and replacement should be determined by observations in the field during grading.

Detailed recommendations regarding these issues and other geotechnical design considerations are provided in the following sections of this report. These recommendations should be incorporated into the final design drawings and construction specifications.

4.2 Site Preparation and Grading

To prepare the site for construction, all vegetation, organic surface soils, and other deleterious materials should be stripped and removed from the site. We expect surface stripping depths of about six to eight inches will be required to remove the organic surficial soils. Organic soils will not be suitable for use as structural fill but may be used for limited depths in nonstructural areas or for landscaping purposes. Demolition of existing structures should include removal of existing foundations and abandonment of underground septic systems and other buried utilities. Abandoned utility pipes that fall outside of new building areas can be left in place provided they are sealed to prevent intrusion of groundwater seepage and soil.

As noted above, the existing organic fill material observed in Test Pit TP-3 would not be suitable for support of building elements. The need for and lateral extent of overexcavation and replacement should be determined in the field during grading.

Once clearing and grubbing operations are complete, cut and fill operations to establish desired building grades can be initiated. A representative of Terra Associates, Inc. should examine all bearing surfaces to verify that conditions encountered are as anticipated and are suitable for placement of structural fill or direct support of building and pavement elements. Our representative may request proofrolling exposed surfaces with a heavy rubber-tired vehicle to determine if any isolated soft and yielding areas are present. If unstable yielding areas are observed, they should be cut to firm bearing soil and filled to grade with structural fill. If the depth of excavation to remove unstable soils is excessive, use of geotextile fabric such as Mirafi 500X or equivalent in conjunction with structural fill can be considered in order to limit the depth of removal. In general, our experience has shown that a minimum of 18 inches of clean, granular structural fill over the geotextile fabric should establish a stable bearing surface.

The native soils observed at the site contain a sufficient amount of fines (silt and clay size particles) that will make them difficult to compact as structural fill if they are too wet or too dry. Accordingly, the ability to use these soils from site excavations as structural fill will depend on their moisture content and the prevailing weather conditions when site grading activities take place. Soils that are too wet to properly compact could be dried by aeration during dry weather conditions or mixed with an additive such as cement or lime to stabilize the soil and facilitate compaction. If an additive is used, additional Best Management Practices (BMPs) for its use will need to be incorporated into the Temporary Erosion and Sedimentation Control (TESC) plan for the project. Soils that are dry of optimum should be moisture conditioned by controlled addition of water and blending prior to material placement.

If grading activities are planned during the wet winter months, or if they are initiated during the summer and extend into fall and winter, the owner should be prepared to import wet weather structural fill. For this purpose, we recommend importing a granular soil that meets the following grading requirements:

U.S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

*Based on the 3/4-inch fraction.

Prior to use, Terra Associates, Inc. should examine and test all materials imported to the site for use as structural fill.

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-1557 (Modified Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas, the degree of compaction can be reduced to 90 percent.

4.3 Relative slope stability

Part of our investigation was to determine the appropriate buffers and setbacks for the proposed development from the eastern steep slope. In order to determine the buffers and setbacks, we have completed three slope stability analyses. The analyses were performed at locations designated as Cross Sections A-A', B-B', and C-C' using the computer program Slide 2018. The approximate cross section location is shown on Figure 2.

Our analysis considered both static and pseudostatic (seismic) conditions. A horizontal acceleration of 0.15g was used in the pseudostatic analysis to simulate slope performance under earthquake loading. This value is based on the maximum considered earthquake (MCE) peak ground acceleration (PGA) adjusted for pseudostatic analysis following procedures outlined in Section 6.2.2 of the FHWA-NHI-11-032 Seismic Design – Geotechnical Features Manual.

Based on our field exploration, laboratory testing, and previous experience with similar soil types, we chose the following parameters for our analysis:

Table 1 – Slope Stability Analysis Soil Parameters

Soil Type	Unit Weight (pcf)	Friction Angle (Degrees)	Cohesion (psf)
Dense to very dense silty SAND with gravel (unweathered till)	125	40	500

The results of our slope stability analysis, as shown by the lowest safety factors for each condition, are presented in the following table:

Table 2 – Slope Stability Analysis Results

Cross Section	**Minimum Safety Factors**	
	Existing Conditions	***Post Construction***
A-A’	1.88 (Seismic FS = 1.37)	1.88 (Seismic FS = 1.37)
B-B’	1.57 (Seismic FS = 1.20)	1.57 (Seismic FS = 1.20)
C-C’	2.15 (Seismic FS = 1.54)	1.91 (Seismic FS = 1.38)

Based on our analysis, the proposed construction must maintain a 10-foot buffer with a 15-foot building setback from the crest of the steep slope. No clearing should occur on the slope areas that are steeper than 40 percent or within their respective 10-foot buffer areas. In our opinion, a slope monitoring and inspection program would not be necessary as construction activities are not planned to take place on the steep slopes. The results of our analysis are attached in Appendix B.

In addition to the slope stability analysis, we completed a reconnaissance of the steep slope. During our reconnaissance, we did not observe any evidence of deep-seated landslides. No tension cracks, leaning, or pistoled butted trees and no head scarps associated with a deep-seated failure were observed. What we did observe was evidence of several skin slides or erosion areas throughout the slope. These are common on steep slopes because during heavy precipitation events the upper loose soils become saturated and slide along the more competent material. This can manifest as mud flowing down the slope and becoming deposited in a less steep area or on the lower roadway. The skin slides or erosion are typically not an indication of slope instability but simple erosion that can occur. Contributing to the precipitation that falls directly on this slope, there is also the overland flows from the adjacent flat parcel area that currently flow unmitigated toward the slope. This precipitation combines with the precipitation that falls directly on the slope and can contribute to the skin slides or erosion. Once the project is completed, the flows from the project area will be captured and directed to the sites stormwater system preventing some precipitation from reaching the slopes. The post construction drainage should assist in preventing some skin slides or erosion from occurring.

<u>4.4 Excavations</u>

All excavations at the site associated with confined spaces, such as utility trenches, must be completed in accordance with local, state, and federal requirements. Based on regulations outlined in the Washington Industrial Safety and Health Act (WISHA), the upper medium dense soils would be classified as Type C soil. The dense silty sand and silty sand with gravel soils would be classified as Type A soil.

Accordingly, temporary excavations in Type C soils should have their slopes laid back at an inclination of 1.5:1 (Horizontal:Vertical) or flatter, from the toe to the crest of the slope. Side slopes in Type A soils can be laid back at a slope inclination of 0.75:1 or flatter. For temporary excavation slopes less than 8 feet in height in Type A soils, the lower 3.5 feet can be cut to a vertical condition, with a 0.75:1 slope graded above. For temporary excavation slopes greater than 8 feet in height up to a maximum height of 12 feet, the slope above the 3.5-foot vertical portion will need to be laid back at a minimum slope inclination of 1:1. No vertical cut with a backslope immediately above is allowed for excavation depths that exceed 12 feet. In this case, a four-foot vertical cut with an equivalent horizontal bench to the cut slope toe is required. All exposed temporary slope faces that will remain open for an extended period of time should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Perched groundwater seepage may be observed within excavations extending to the dense till deposits during the winter months. In our opinion, the volume of water and rate of flow into the excavation should be relatively minor and would not be expected to impact the stability of the excavations when completed, as described above. Conventional sump pumping procedures along with a system of collection trenches should be capable of maintaining a relatively dry excavation for construction purposes in these soils, if necessary.

The above information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Terra Associates, Inc. assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

4.5 Foundations

The residential structures may be supported on conventional spread footing foundations bearing on competent native soils, competent existing fill, or on structural fill placed above the competent soils. Foundation subgrades should be prepared, as recommended in Section 4.2 of this report.

Perimeter foundations exposed to the weather should bear at a minimum depth of 1.5 feet below final exterior grades for frost protection. Interior foundations can be constructed at any convenient depth below the floor slab.

We recommend designing foundations bearing on competent material for a net allowable bearing capacity of 2,500 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used in design. With the anticipated loads and this bearing stress applied, building settlements should be less than one-half inch total and one-fourth inch differential.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressure acting on the sides of the footings may also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 350 pounds per cubic foot (pcf). We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundations will be constructed neat against competent native soil or the excavations are backfilled with structural fill, as described in Section 4.2 of this report. The recommended passive and friction values include a safety factor of 1.5.

4.6 Floor Slabs

Slab-on-grade floors may be supported on a subgrade prepared as recommended in Section 4.2 of this report. Immediately below the floor slab, we recommend placing a four-inch thick capillary break layer composed of clean, coarse sand or fine gravel that has less than three percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction, and aid in uniform curing of the concrete slab. It should be noted that if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will be ineffective in assisting uniform curing of the slab and can actually serve as a water supply for moisture seeping through the slab and affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained.

4.7 Stormwater Facilities

As noted above, site stormwater will be collected and directed to one of two stormwater detention vaults located in the southeast or southwest corners of the site. The southeast vault is near the top of the steep slope. Stormwater plans were not available at the time of this report.

Detention Vault

We expect that the bottom of the excavations for the detention vaults will expose native, dense to very dense silty sand with gravel soils. Vault foundations supported by these native soils may be designed for an allowable bearing capacity of 6,000 psf provided that the foundation subgrade is at least 6 feet below current site grades. For short-term loads, such as seismic, a one-third increase in this allowable capacity can be used.

Vault walls should be designed as below-grade retaining walls. The magnitude of earth pressure development on engineered retaining walls will partly depend on the quality of the wall backfill. We recommend placing and compacting wall backfill as structural fill as described in Section 4.2 of this report. To prevent overstressing the walls during backfilling, heavy construction machinery should not be operated within five feet of the wall. Wall backfill in this zone should be compacted with hand-operated equipment. To prevent hydrostatic pressure development, wall drainage must also be installed. A typical wall drainage detail is shown on Figure 3.

With wall backfill placed and compacted as recommended and drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 pounds per square foot (psf) should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge). For evaluation of below-grade walls under seismic loading, an additional uniform lateral pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall in feet, can be used. These values assume a horizontal backfill condition and that no other surcharge loading such as traffic, sloping embankments, or adjacent buildings will act on the wall. If such conditions will exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are given in Section 4.5 of this report.

If it is not possible to discharge collected water at the footing invert elevation, the invert elevation of the wall drainpipe could be set equivalent to the outfall invert. For any portion of the wall that falls below the invert elevation of the wall drain, an earth pressure equivalent to a fluid weighing 85 pcf should be used.

Pipe Anchors

The discharge pipe for the southeast detention vault will extend down the eastern steep slope and connect to the existing storm system at the base of the slope.

As we understand, the pipe that will be used for the outfall will consist of an 18-inch diameter HDPE pipe. The pipe would be anchored or secured at the top and would then be placed on the slope surface. HDPE pipe will move on the slope due to thermal expansion and contraction. To limit movement, hillside anchors or guides need to be installed at set intervals on the installation alignment. Based on a preliminary analysis using a relatively straight alignment, we expect the hillside anchors will need to be placed approximately every 15 feet. We should re-evaluate this spacing based on the actual pipe alignment when it is finalized. This installation is similar to stormwater outfalls installed on steep slopes throughout the Puget Sound area.

Analysis indicates the 18-inch diameter HDPE pipe can be secured at the top using a cast-in-place concrete block or anchor. For the estimated 400 feet of pipe a concrete block with a weight equal to 233 cubic feet of unreinforced concrete will be needed. A typical concrete anchor design detail is shown on Figure 4.

The HDPE alignment down the slope must limit impact to the existing vegetation and trees. We recommend all trees that are currently on the slope remain and the HDPE pipe bend around the trunks of the trees, if necessary. To limit vegetation removal and maintain low vegetation surface cover, we recommend suspending the HDPE pipe a minimum distance of six inches (plus or minus two inches) above the slope surface using pipe anchor guides as shown on Figure 5. Removal of existing vegetation should be limited with vegetation only removed as needed to install the guide anchors. Areas disturbed by construction must be restored by planting or reseeding and covering with long-term erosion control matting.

4.8 Infiltration Feasibility

The native glacial till soils composed of silty sand characteristically exhibit low permeability and would not be a suitable receptor soil for discharge of development stormwater using infiltration/retention facilities. Conventional stormwater detention with controlled release to the drainage basin should be used to manage development stormwater.

4.9 Drainage

Surface

Final exterior grades should promote free and positive drainage away from the building areas. We recommend providing a positive drainage gradient away from the building perimeter. If a positive gradient cannot be provided, provisions for collection and disposal of surface water adjacent to the structure should be provided.

Subsurface

We recommend installing a continuous drain along the outside lower edge of the perimeter building foundations. The drains can be laid to grade at an invert elevation equivalent to the bottom of footing grade. The drains can consist of four-inch diameter perforated PVC pipe that is enveloped in washed ½- to ¾-inch gravel-sized drainage aggregate. The aggregate should extend six inches above and to the sides of the pipe. The foundation drains and roof downspouts should be tightlined separately to an approved point of controlled discharge. All drains should be provided with cleanouts at easily accessible locations. These cleanouts should be serviced at least once each year.

4.10 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) or local jurisdictional requirements. At minimum, trench backfill should be placed and compacted as structural fill as described in Section 4.2 of this report. As noted, soils excavated on-site should generally be suitable for use as backfill material. However, the site soils are fine grained and moisture sensitive; therefore, moisture conditioning may be necessary to facilitate proper compaction. If utility construction takes place during the winter, it may be necessary to import suitable wet weather fill for utility trench backfilling.

4.11 Pavements

Pavements should be constructed on subgrades prepared as recommended in Section 4.2 of this report. Regardless of the degree of relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. Proofrolling the subgrade with heavy construction equipment should be completed to verify this condition.

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. As we understand, traffic will mainly consist of light passenger and commercial vehicles with only occasional heavy traffic in the form of moving trucks and trash removal vehicles. Based on this information, with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of hot mix asphalt (HMA) over four inches of crushed rock base (CRB)
- Three and one-half inches full depth HMA

All paving materials should conform to Washington State Department of Transportation (WSDOT) specifications for HMA and CRB.

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

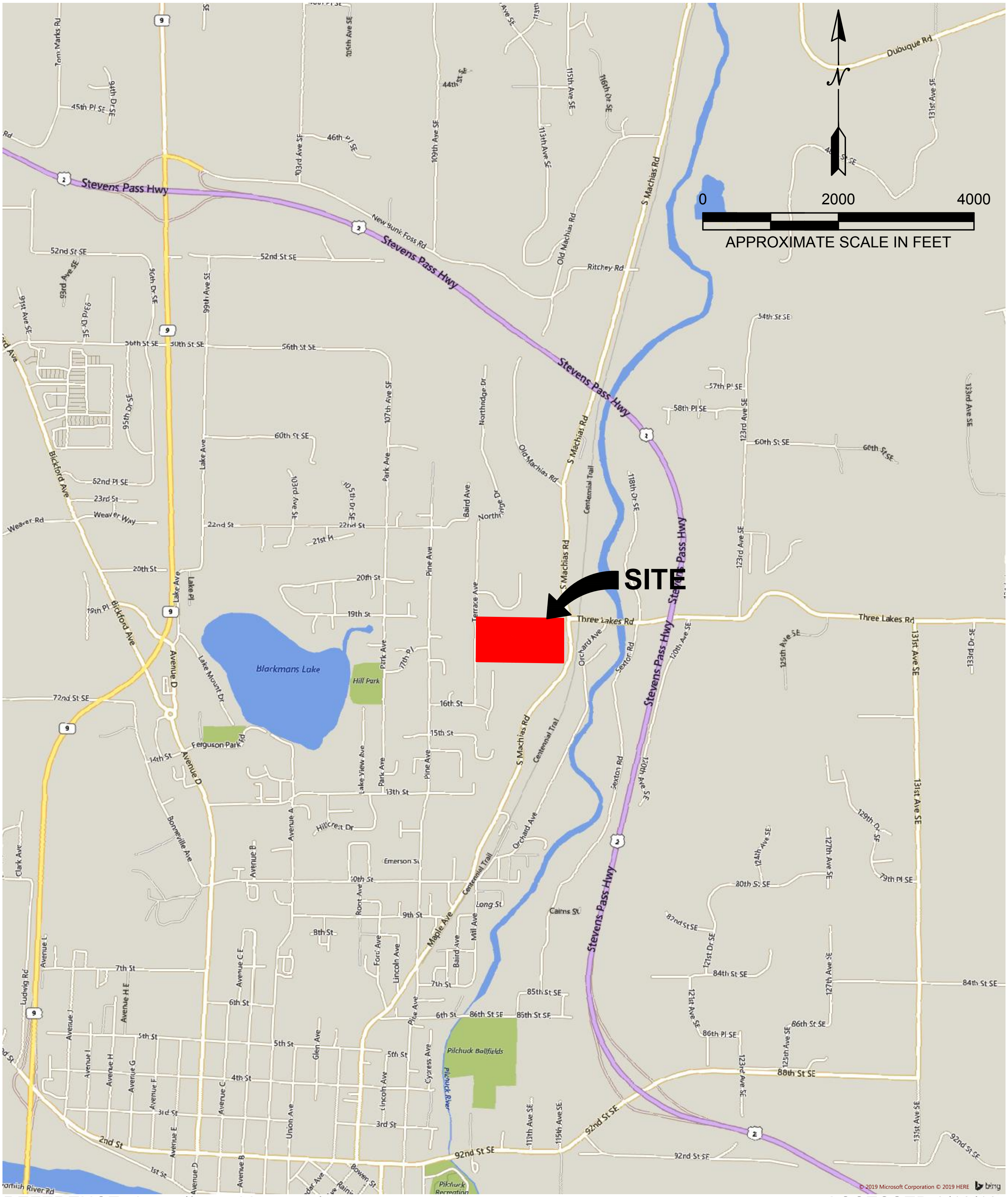
5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final designs and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical services during construction in order to observe compliance with our design concepts, specifications, and recommendations. This will allow for design changes if subsurface conditions differ from those anticipated prior to the start of construction.

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Walsh Hills project in Snohomish, Washington. This report is for the exclusive use of D.R. Horton and their authorized representatives. No other warranty, expressed or implied, is made.

The analyses and recommendations presented in this report are based on data obtained from the subsurface explorations completed on-site. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, Terra Associates, Inc. should be requested to reevaluate the recommendations in this report prior to proceeding with construction.



REFERENCE: https://www.bing.com/maps

ACCESSED 9/10/19

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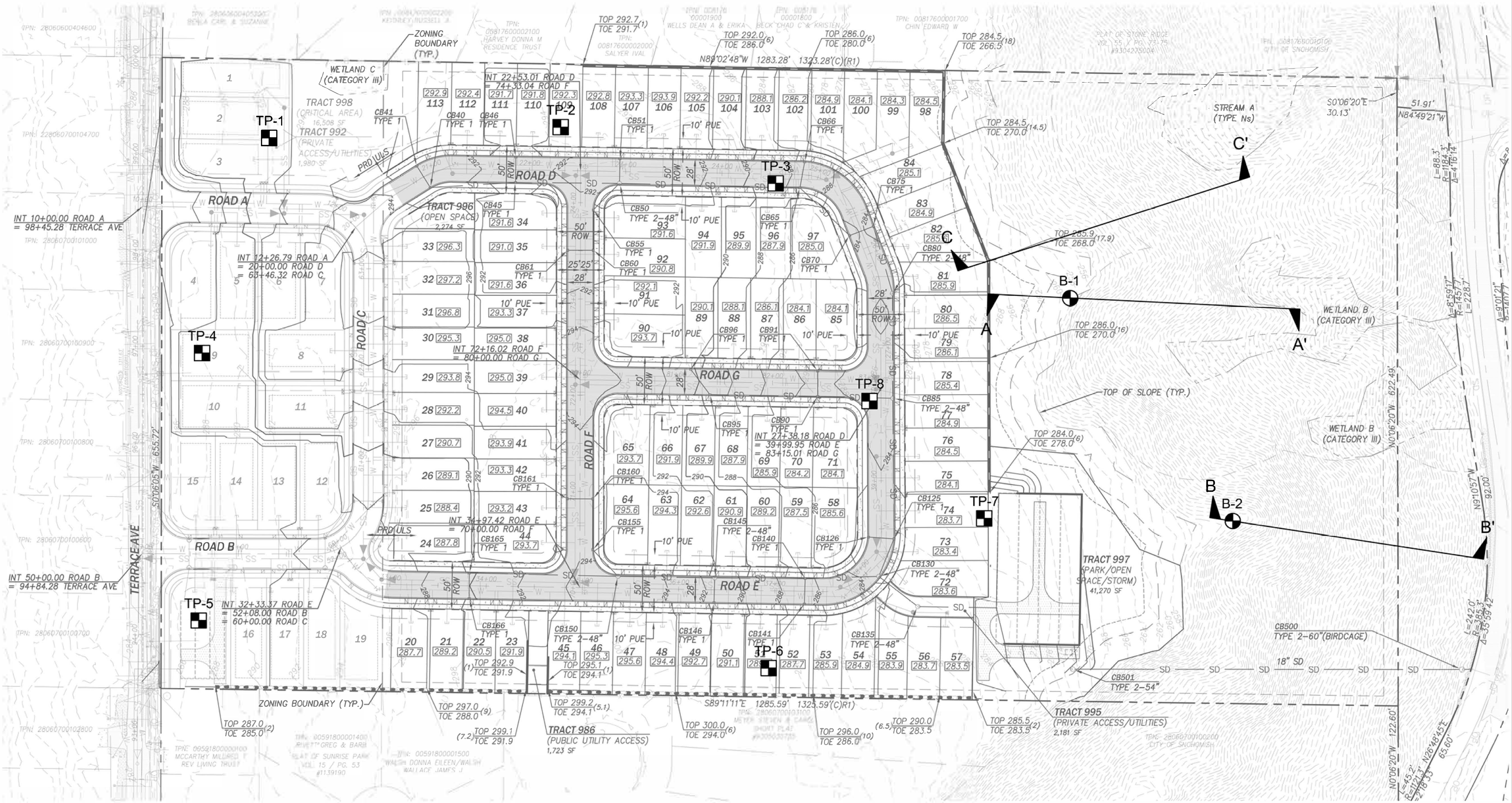
VICINITY MAP WALSH HILLS SNOHOMISH , WASHINGTON		
Proj.No. T-8204	Date:JULY 2020	Figure 1



NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

REFERENCE: SITE PLAN PROVIDED BY CPH CONSULTANTS.

LEGEND:

- APPROXIMATE TEST PIT LOCATION
- APPROXIMATE BORING LOCATION
- APPROXIMATE CROSS SECTION LOCATION

0 100 200

APPROXIMATE SCALE IN FEET

N

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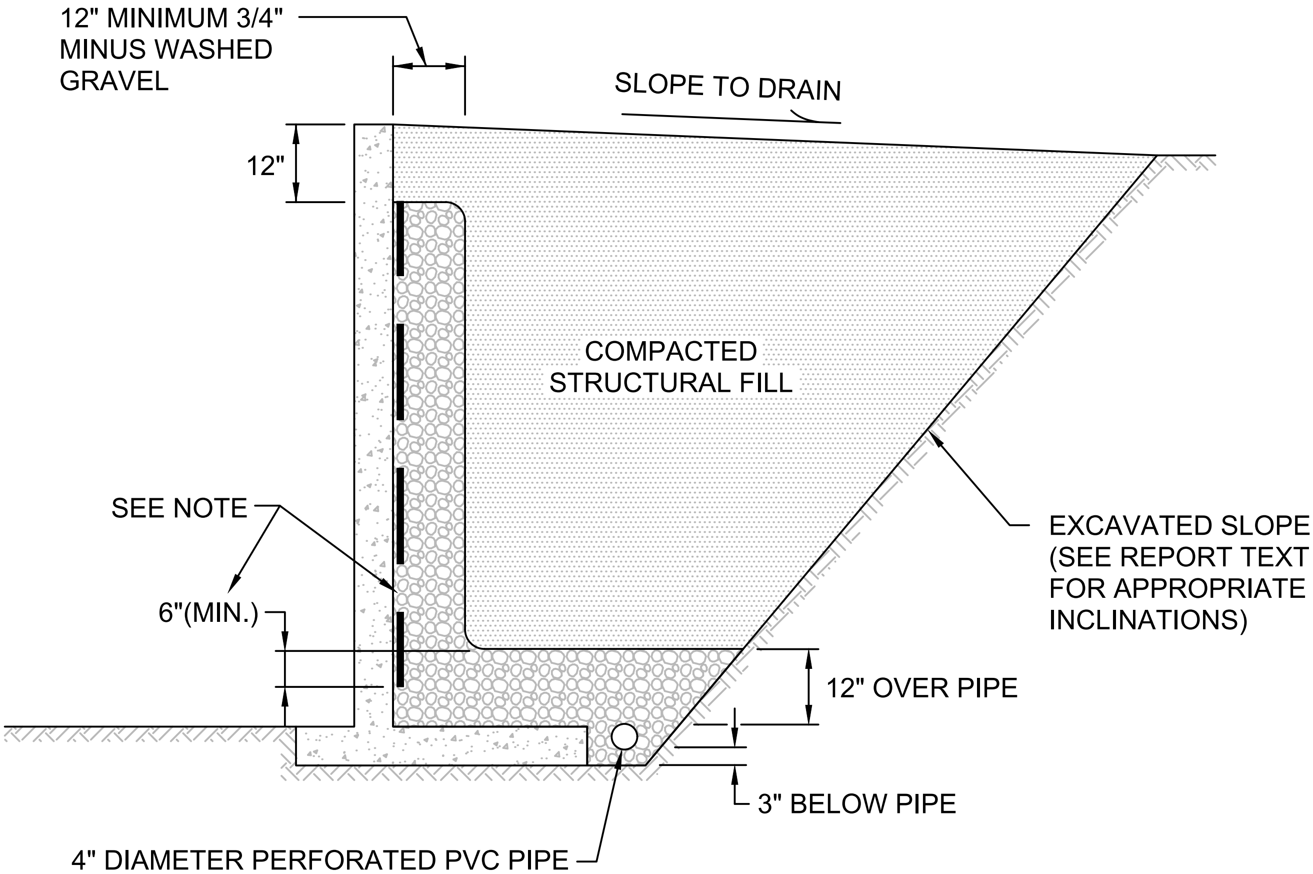
EXPLORATION LOCATION PLAN
WALSH HILLS
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date:JULY 2020	Figure 2

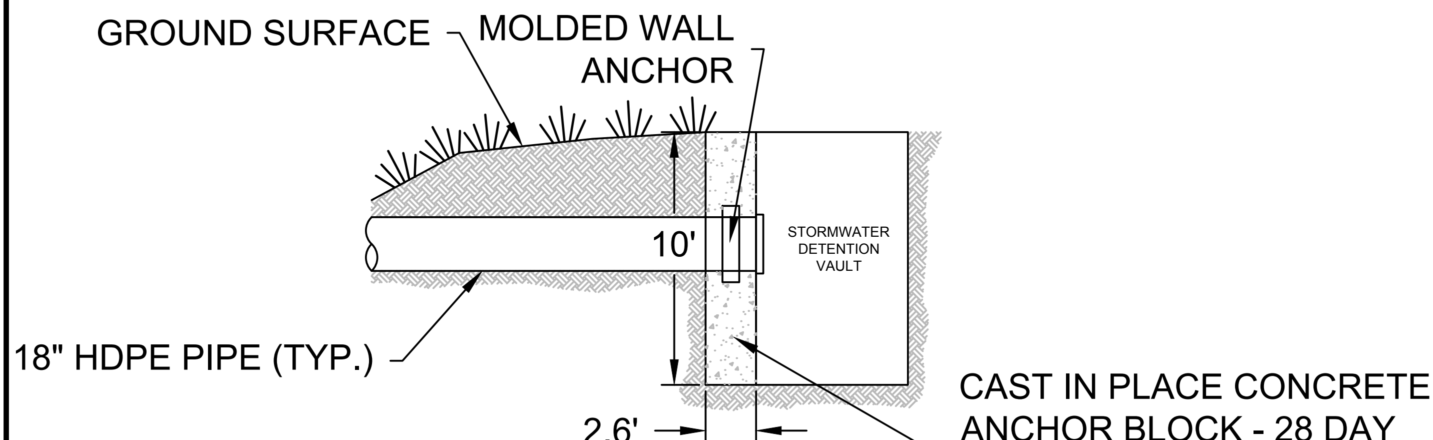


NOT TO SCALE

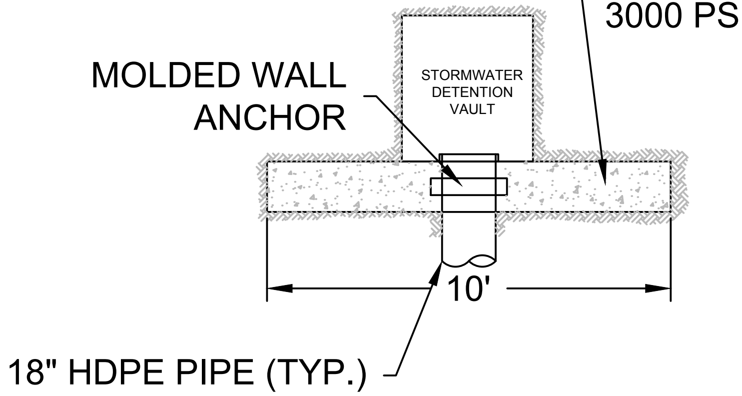
NOTE:

MIRADRAIN G100N PREFABRICATED DRAINAGE PANELS OR SIMILAR PRODUCT CAN BE SUBSTITUTED FOR THE 12-INCH WIDE GRAVEL DRAIN BEHIND WALL. DRAINAGE PANELS SHOULD EXTEND A MINIMUM OF SIX INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

Terra Associates, Inc. Consultants in Geotechnical Engineering Geology and Environmental Earth Sciences	TYPICAL WALL DRAINAGE DETAIL WALSH HILLS SNOHOMISH , WASHINGTON	
	Proj.No. T-8204	Date:JULY 2020	Figure 3



1 CONCRETE ANCHOR DETAIL PROFILE
NOT TO SCALE



2 CONCRETE ANCHOR DETAIL PLAN
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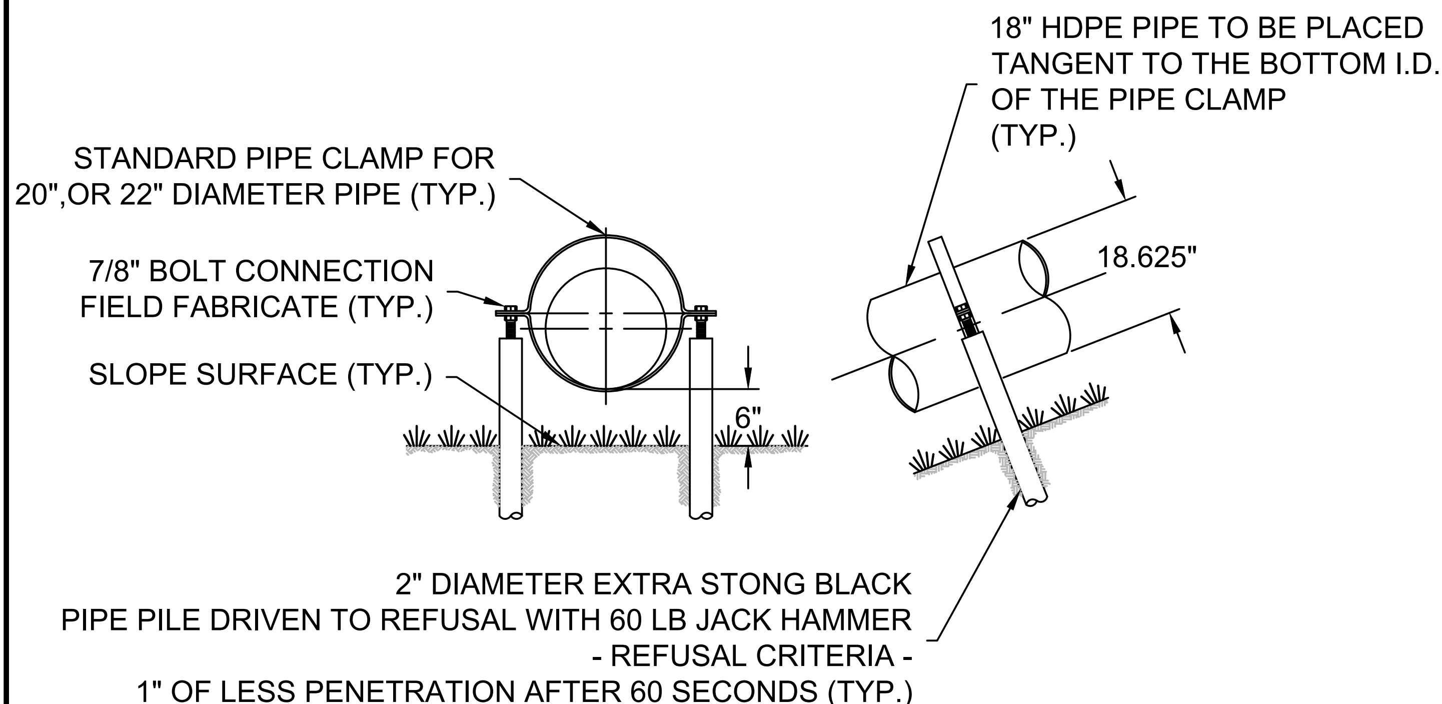
CONCRETE ANCHOR DETAIL
WALSH HILLS
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date:JULY 2020	Figure 4



1 HILLSIDE ANCHOR DETAIL
NOT TO SCALE

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HILLSIDE ANCHOR DETAIL
WALSH HILLS
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date:JULY 2020	Figure 5

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Walsh Hills
Snohomish, Washington

On August 29, 2019, we investigated subsurface conditions at the site by excavating 8 test pits with a track-mounted mini-excavator to depths of about 3 to 10 feet below existing grades. On September 17, 2019 and September 18, 2019, we supplemented this data by observing soil conditions at 2 borings drilled to depths of about 100 feet below existing surface grades. The test pit and boring locations were approximately determined in the field by sighting and pacing from existing surface features. The approximate test pit and test boring locations are shown on Figure 2. The Test Pit and Test Boring Logs are presented as Figures A-2 through A-11.

A geotechnical engineer from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test pit and test boring, obtained representative soil samples, and recorded water levels observed during excavation. During drilling, soil samples were obtained in general accordance with ASTM Test Designation D-1586. Using this procedure, a 2-inch (outside diameter) split barrel sampler is driven into the ground 18 inches using a 140-pound hammer free falling a height of 30 inches. The number of blows required to drive the sampler 12 inches after an initial 6-inch set is referred to as the Standard Penetration Resistance value or N value. This is an index related to the consistency of cohesive soils and relative density of cohesionless materials. N values obtained for each sampling interval are recorded on the Test Boring Logs, Figures A-10 and A-11. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test pits and test borings were placed in sealed plastic bags and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the Test Pit and Test Boring Logs. Grain size analyses were performed on select soil samples. The results are shown on Figures A-12 through A-14.

MAJOR DIVISIONS				LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	More than 50% material larger than No. 200 sieve size	**GRAVELS** More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
			Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
				GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
		SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, sands with gravel, little or no fines.
				SP	Poorly-graded sands, sands with gravel, little or no fines.
			Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
				SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS	More than 50% material smaller than No. 200 sieve size	**SILTS AND CLAYS** Liquid Limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity. (Lean clay)
				OL	Organic silts and organic clays of low plasticity.
		SILTS AND CLAYS Liquid Limit is greater than 50%		MH	Inorganic silts, elastic.
				CH	Inorganic clays of high plasticity. (Fat clay)
				OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS				PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

Density	Standard Penetration Resistance in Blows/Foot
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

COHESIVE

Consistancy	Standard Penetration Resistance in Blows/Foot
Very Soft	0-2
Soft	2-4
Medium Stiff	4-8
Stiff	8-16
Very Stiff	16-32
Hard	>32

	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
	2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER
▼	WATER LEVEL (Date)
Tr	TORVANE READINGS, tsf
Pp	PENETROMETER READING, tsf
DD	DRY DENSITY, pounds per cubic foot
LL	LIQUID LIMIT, percent
PI	PLASTIC INDEX
N	STANDARD PENETRATION, blows per foot

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UNIFIED SOIL CLASSIFICATION SYSTEM
WALSH HILLS
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date:JULY 2020	Figure A-1

LOG OF TEST PIT NO. TP-1

FIGURE A-2

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(7-inches organic TOPSOIL) Light brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, trace cobbles, occasional boulder. (SM)		
1				
	1		Medium dense	12.5
2				
3	2			9.5
		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, mottled, trace cobbles, occasional boulder, light cementation. (SM)		
4			Dense	
5	3			11.6
		Test Pit terminated at approximately 5 feet. No groundwater seepage observed. No caving observed.		
6				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-2

FIGURE A-3

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Brush & mulch **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(8-inches organic TOPSOIL) Light brown transitioning to reddish-brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, occasional cobble, occasional boulder. (SM)		
1				
	1		Medium dense	15.5
2				
3	2	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, trace cobbles, light cementation. (SM)		12.6
4			Dense	
5	3	Test Pit terminated at approximately 5 feet. No groundwater seepage observed. No caving observed.		11.4
6				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-3

FIGURE A-4

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Blackberry bushes **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(8-inches organic TOPSOIL)		
1	1	FILL: Grayish-brown to gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, some mottling, trace organics, trace cobbles, occasional asphalt debris, occasional glass fragments, occasional plastic waste. (SM)	Medium dense	9.6
2				
3				
4	2			12.0
5	3			18.2
6	4		Medium dense to dense	16.9
7	5	FILL: Black silty SAND, fine sand, moist, scattered organics, trace glass fragments. (SM)		42.8
8	6			38.1
9		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, mottled. (SM)	Dense	
10	7			19.2
11		Test Pit terminated at approximately 10 feet. No groundwater seepage observed. No caving observed.		
12				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-4

FIGURE A-5

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(7-inches organic TOPSOIL) Light brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, trace cobbles, occasional boulder. (SM)		
1				
	1		Medium dense	12.9
2				
3	2	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, dry to moist, mottled, trace cobbles, light cementation. (SM)	Dense	8.3
4	3	Test Pit terminated at approximately 4 feet. No groundwater seepage observed. No caving observed.		11.5
5				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-5

FIGURE A-6

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(6-inches organic TOPSOIL) Light brown silty SAND with gravel, fine sand, fine to coarse gravel, dry to moist, scattered rootlets. (SM)		
1				
	1		Medium dense	11.8
2				
3	2	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, dry to moist, mottled, scattered cobbles, light cementation. (SM)	Dense	9.8
4	3	Test Pit terminated at approximately 4 feet. No groundwater seepage observed. No caving observed.		13.5
5				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-6

FIGURE A-7

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(8-inches organic TOPSOIL) Light brown silty SAND, fine sand, dry to moist, scattered rootlets, trace gravel. (SM)		
1	1		Medium dense	12.3
2		Light gray silty SAND with gravel, fine sand, fine to coarse gravel, dry, light cementation. (SM)	Dense	
3	2			6.7
		Test Pit terminated at approximately 3 feet. No groundwater seepage observed. No caving observed.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-7

FIGURE A-8

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass & brush **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(7-inches organic TOPSOIL) Brown transitioning to gray silty SAND, fine sand, moist, scattered rootlets, trace gravel. (SM)		
1				
	1			26.2
2				
	2			15.0
3			Medium dense	
4	3			10.9
		Mottling observed below approximately 4.5 feet		
5				
6	4			12.9
		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, trace cobbles, light cementation. (SM)	Dense	
7	5			11.4
		Test Pit terminated at approximately 7 feet. No groundwater seepage observed. No caving observed.		
8				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-8

FIGURE A-9

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(8-inches organic TOPSOIL)		
		Brown to reddish-brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, trace cobbles. (SM)		
1				
	1			18.8
2				
3			Medium dense	
	2			16.0
		Brownish-gray silty SAND, fine to medium sand, moist, trace gravel. (SM)		
4				
5				
	3			11.9
6	4			15.0
		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, mottled, trace cobbles, occasional boulder. (SM)	Dense	
7	5			13.7
		Test Pit terminated at approximately 7 feet. No groundwater seepage observed. No caving observed.		
8				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF BORING NO. B-1

Figure No. A-10

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** Septermber 18, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 23 Feet, 50 Feet **Approx. Elev:** ~255 Feet

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0–3	Black silty SAND, fine sand, moist, scattered organics. (SM) (Organic TOPSOIL)	Dense	31	30.9 4.7
3–5.3	Brown SAND with silt, fine to medium sand, moist, trace organics. (SP-SM)	Medium Dense	28	6.5 10.2
5.3–14	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, occasional sand with silt layer. (SM) *Mottling observed in 5-foot sample*	Very Dense	50/6"	9.8
		Very Dense	76	5.7
		Dense	46	10.4
14–23	Brownish-gray sandy SILT to SILT with sand, fine sand, moist, scattered gravel. (ML)	Hard	32	15.8
		Very Stiff	26	8.8
23–35	Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist to wet, slightly mottled. (SM)	Dense	46	12.5
		Very Dense	50/6"	15.3
		Very Dense	50/6"	11.1

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-1

Figure No. A-10

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** Septermber 18, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 23 Feet, 50 Feet **Approx. Elev:** ~255 Feet

Depth (ft)	Soil Description	Consistency/ Relative Density
35 – ~53	Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist to wet, slightly mottled. (SM)	Very Dense
~53 – ~57	Gray SILT, moist, occasional sand with silt seam. (ML)	Hard
~57 – ~66	Gray silty SAND, fine to medium sand, moist to wet. (SM)	Very Dense
~66 – ~68	Gray SILT, moist. (ML)	Hard
~68 – 70	Brown silty SAND, fine to medium sand, moist, occasional silt inclusions. (SM)	Very Dense

Depth (ft)	SPT (N) Blows/foot	Moisture Content (%)
40	50/5"	10.7
45	50/4"	11.0
50	50/6"	16.4
55	50/6"	20.0
60	92	14.8
65	93/6"	17.2
		28.1
70	50/4"	14.3

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-1

Figure No. A-10

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** Septermber 18, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 23 Feet, 50 Feet **Approx. Elev:** ~255 Feet

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
70	Brown silty SAND, fine to medium sand, moist, occasional silt inclusions. (SM)	Very Dense		
75			50/4"	16.7
80			50/6"	15.5
85			50/4"	19.6
90			50/6"	17.5
95			50/6"	20.3
100	*Material becomes dark gray.		50/6"	21.5
	Test boring terminated at approximately 100 feet. Light to moderate perched groundwater seepage observed at approximately 23 feet and 50 feet.			
105				

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-11

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** September 17, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 6 Feet, 56 Feet **Approx. Elev:** ~240 Feet

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0	Black silty SAND, fine sand, moist, scattered organics. (SM) (Organic TOPSOIL)	Dense	42	27.4
	Light brown silty SAND with gravel, fine sand, fine to coarse gravel, dry. (SM)			5.5
5		Very Dense	51	7.8
	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist. (SM)		50/6"	9.8
10			71	10.4
		Dense	42	13.1
15			41	10.9
20		Very Dense	91	6.9
25			50/5"	9.1
30			50/6"	7.1
35			50/4"	9.9

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-11

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** September 17, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 6 Feet, 56 Feet **Approx. Elev:** ~240 Feet

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
35	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist. (SM)	Very Dense		
40			50/4"	7.7
45			50/6"	8.4
	Gray SILT, moist to wet, occasional sand with silt interbeds. (ML)	Hard		
50			77	23.1
55			78	22.6
	Gray silty SAND, fine to medium sand, moist, occasional interbedded silt layer. (SM)	Very Dense		19.2
60	*Occasional organic in 60-foot sample*		50/5"	10.9
65			50/5"	7.5
70			50/5"	7.1

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-11

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** September 17, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

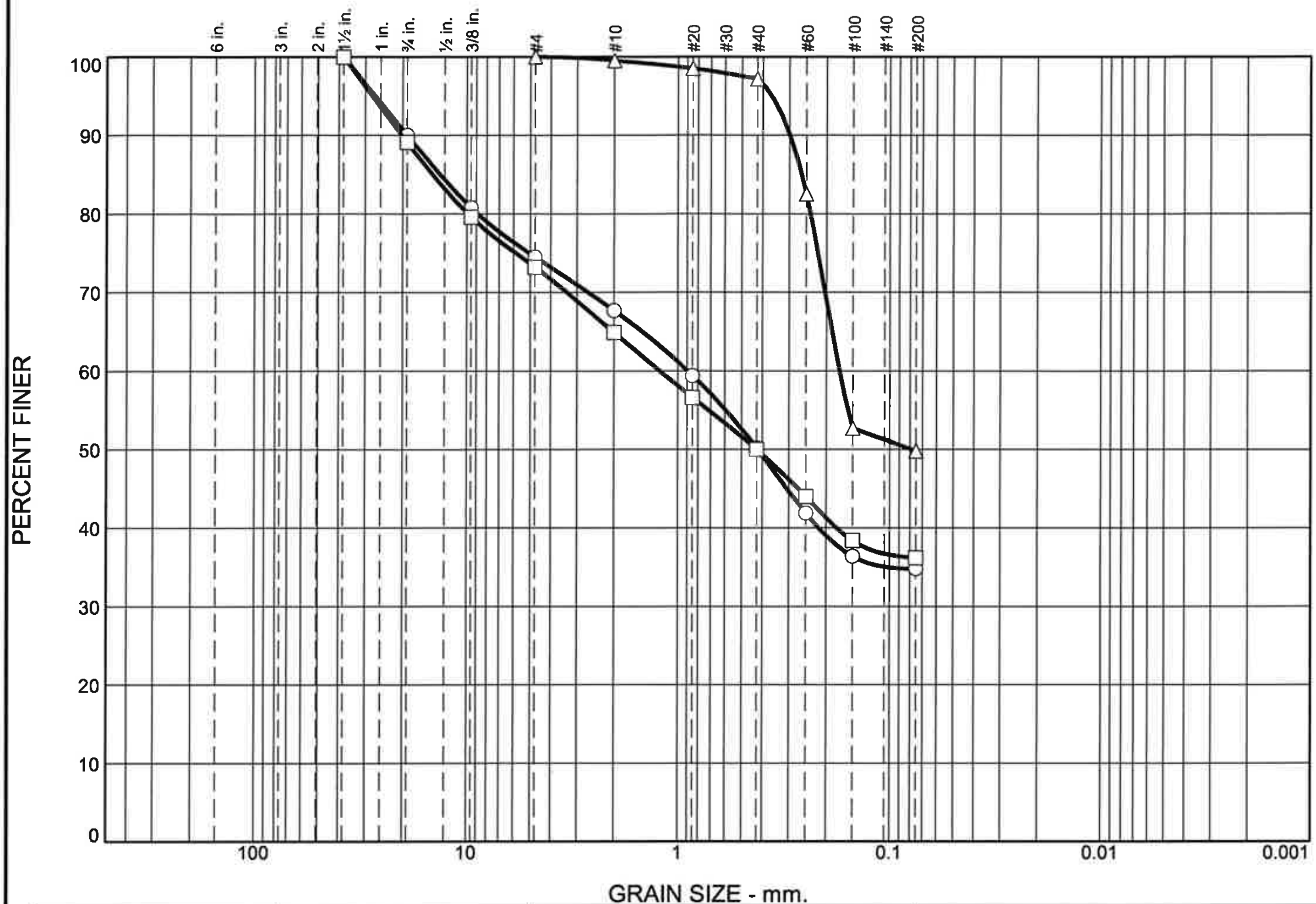
Location: Snohomish, Washington **Depth to Groundwater:** 6 Feet, 56 Feet **Approx. Elev:** ~240 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot (10, 30, 50)	Moisture Content (%)
70	I	Grayish-brown silty SAND, fine to medium sand, moist, scattered silt inclusions. (SM)			
75	I			50/6"	8.0
80	I			83	9.0
85	I		Very Dense	50/5"	8.9
90	I			93/6"	7.9
95	I			50/4"	7.1
100	I	Test boring terminated at approximately 100 feet. Light perched groundwater seepage observed at approximately 6 feet and 56 feet.		50/6"	6.1
105					

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	10.0	15.5	6.8	17.5	15.4	34.8	
□	0.0	10.9	15.9	8.3	14.9	13.8	36.2	
△	0.0	0.0	0.0	0.5	2.3	47.4	49.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			13.3443	0.8966	0.4195					
□			14.4649	1.2153	0.4250					
△			0.2631	0.1732	0.0787					

Material Description	USCS	AASHTO
○ silty SAND with gravel	SM	
□ silty SAND with gravel	SM	
△ silty SAND	SM	

Project No. T-8204 **Client:** D.R. Horton

Project: Terrace Avenue Development

○ **Location:** Test Pit TP-3 **Depth:** -4 feet **Sample Number:** 2

□ **Location:** Test Pit TP-4 **Depth:** -1.5 feet **Sample Number:** 1

△ **Location:** Test Pit TP-7 **Depth:** -4 feet **Sample Number:** 3

Remarks:

○ Tested on September 10, 2019

□ Tested on September 10, 2019

△ Tested on September 10, 2019

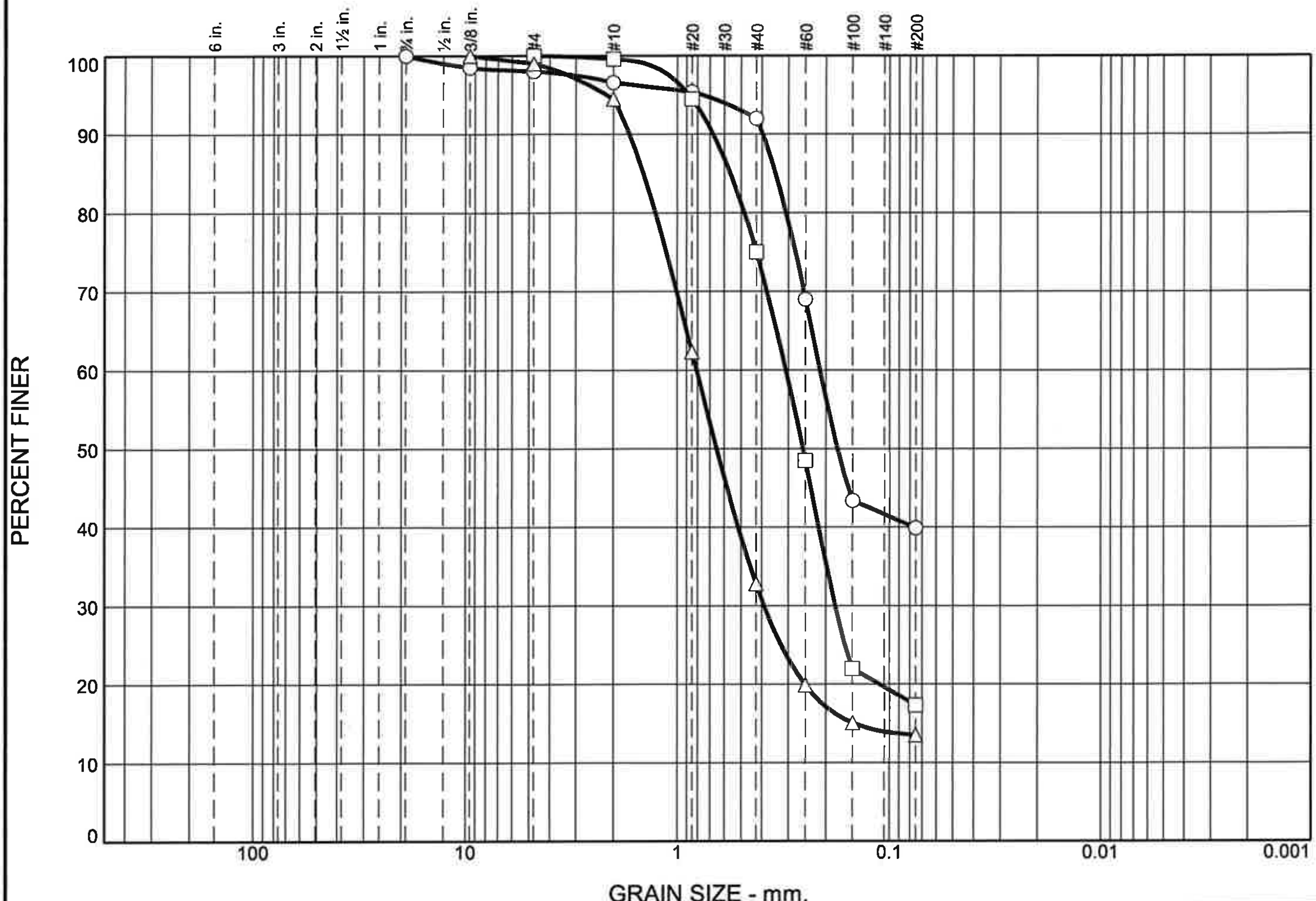
Terra Associates, Inc.

Kirkland, WA

Figure A-12

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.0	1.4	4.6	52.1	39.9	
□	0.0	0.0	0.0	0.4	24.6	57.7	17.3	
△	0.0	0.0	1.0	4.5	61.7	19.3	13.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.3448	0.2133	0.1765					
□			0.5627	0.3082	0.2566	0.1805				
△			1.4424	0.8090	0.6511	0.3896	0.1469			

Material Description	USCS	AASHTO
○ silty SAND	SM	
□ Silty SAND	SM	
△ Silty SAND	SM	

Project No. T-8204 **Client:** D.R. Horton

Project: Terrace Avenue Development

○ **Location:** Test Pit TP-8 **Depth:** -3.5 feet **Sample Number:** 2

□ **Location:** Test Boring B-1 **Depth:** -3 feet **Sample Number:** 2

△ **Location:** Test Boring B-1 **Depth:** -60 feet **Sample Number:** 18

Remarks:

○ Tested on September 10, 2019

□ Tested on October 1, 2019

△ Tested October 1, 2019

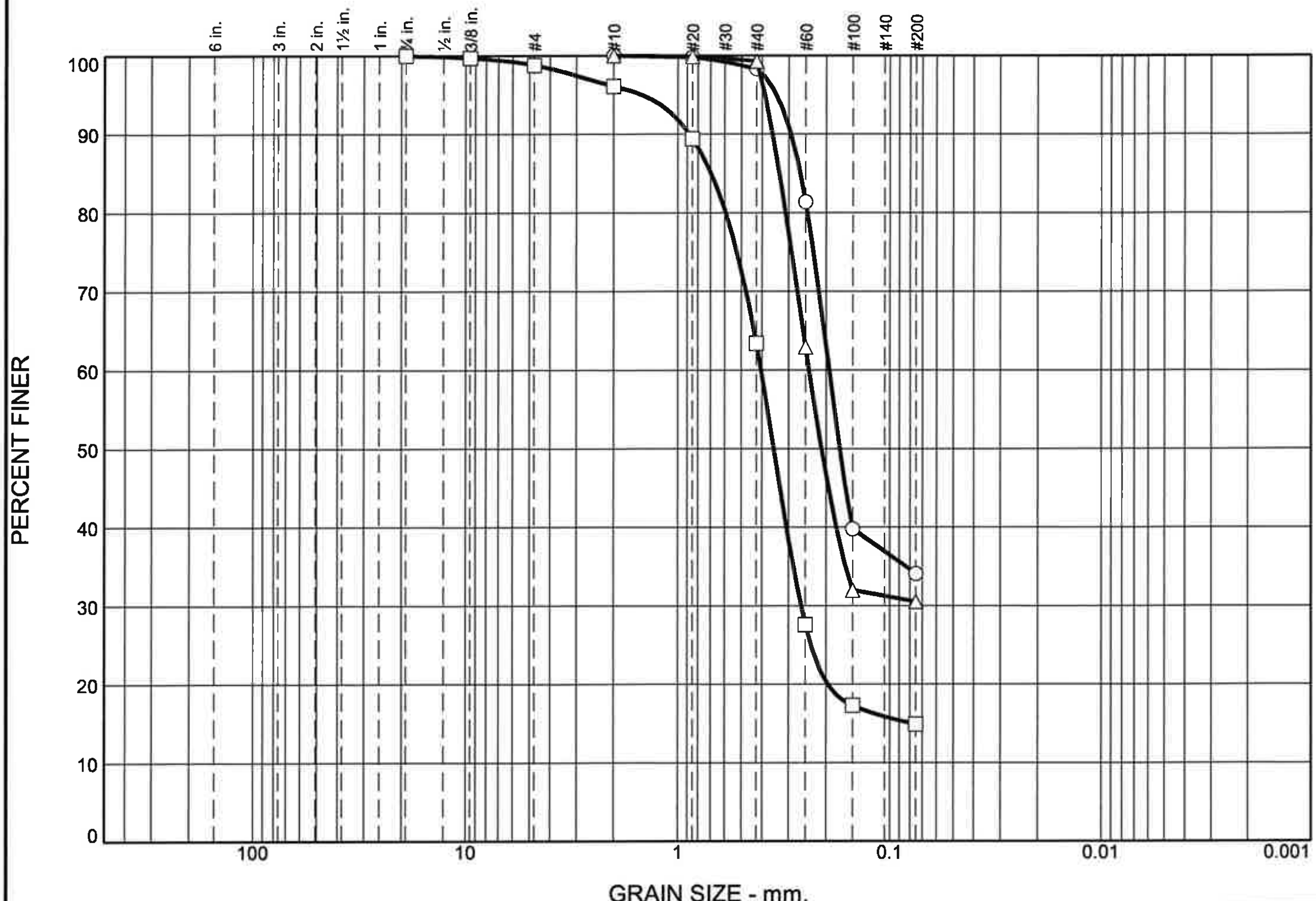
Terra Associates, Inc.

Kirkland, WA

Figure A-13

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	1.7	64.2	34.1	
□	0.0	0.0	1.2	2.7	32.7	48.5	14.9	
△	0.0	0.0	0.0	0.0	0.7	68.8	30.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2647	0.1935	0.1726					
□			0.6963	0.4038	0.3516	0.2619	0.0780			
△			0.3318	0.2408	0.2101					

Material Description	USCS	AASHTO
○ Silty SAND	SM	
□ Silty SAND		
△ Silty SAND	SM	

Project No. T-8204 **Client:** D.R. Horton

Project: Terrace Avenue Development

○ **Location:** Test Boring B-1 **Depth:** -100 feet **Sample Number:** 27

□ **Location:** Test Boring B-2 **Depth:** -70 feet **Sample Number:** 20

△ **Location:** Test Boring B-2 **Depth:** -80 feet **Sample Number:** 22

Remarks:

○ Tested on October 1, 2019

□ Tested on October 1, 2019

△ Tested on October 1, 2019

Terra Associates, Inc.

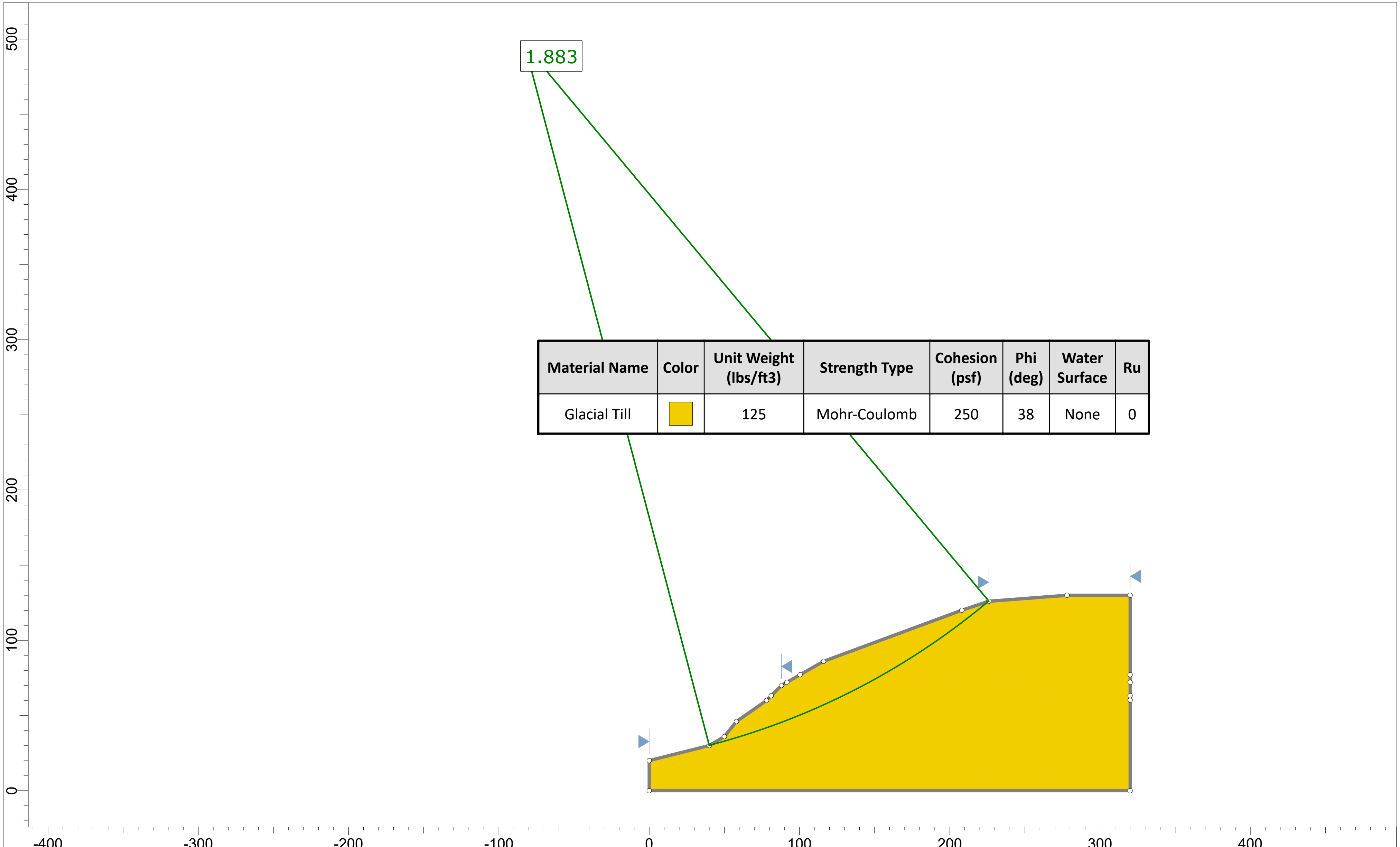
Kirkland, WA

Figure A-14

Tested By: FQ

APPENDIX B

SLIDE OUTPUT

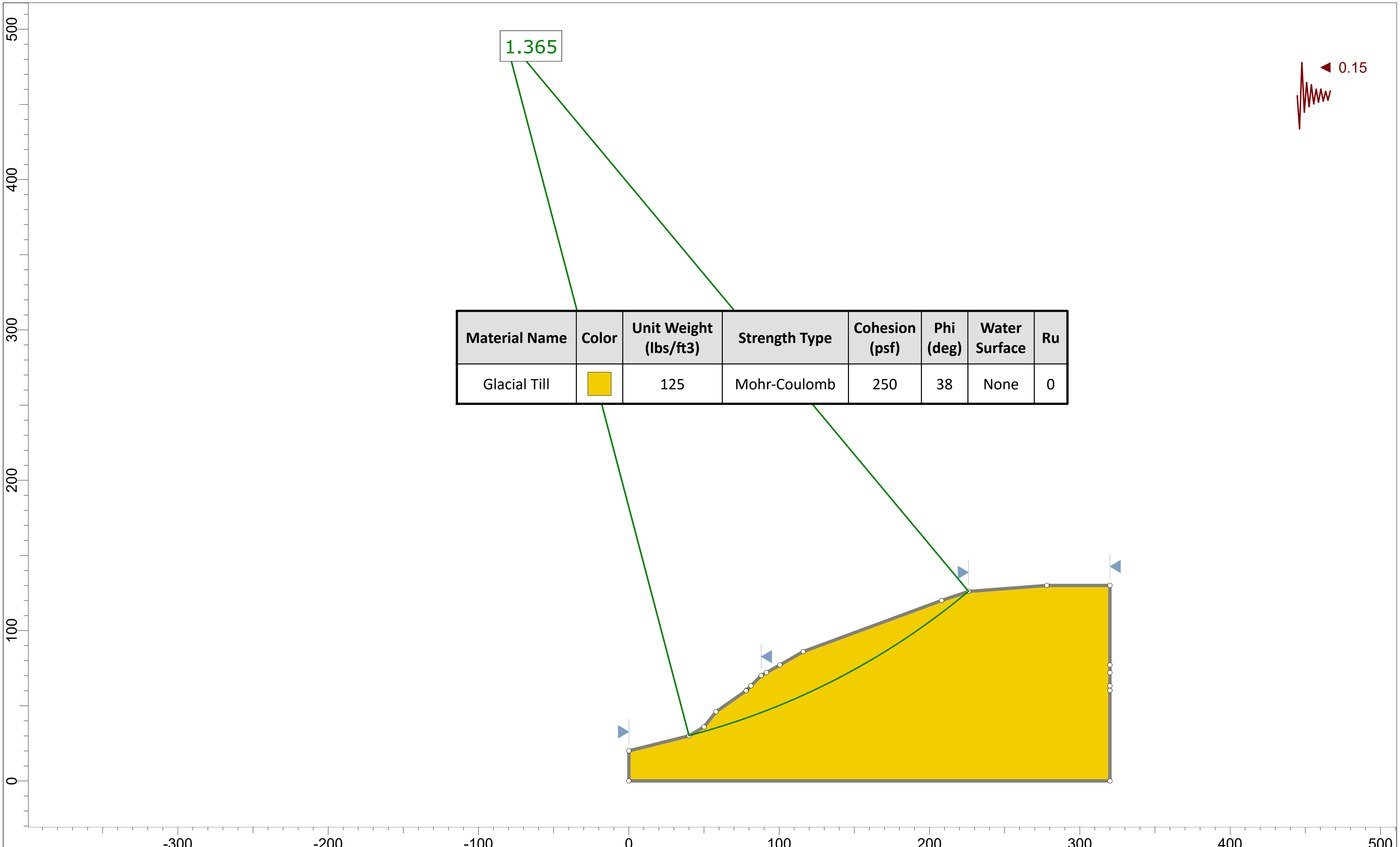


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**
Analysis Description	Cross Section A-A' - Existing Conditions
Drawn By	C. Decker
Scale	1:1060
Company	Terra Associates, Inc.
Date	October 2, 2019
File Name	Cross-section A-A'.slmd

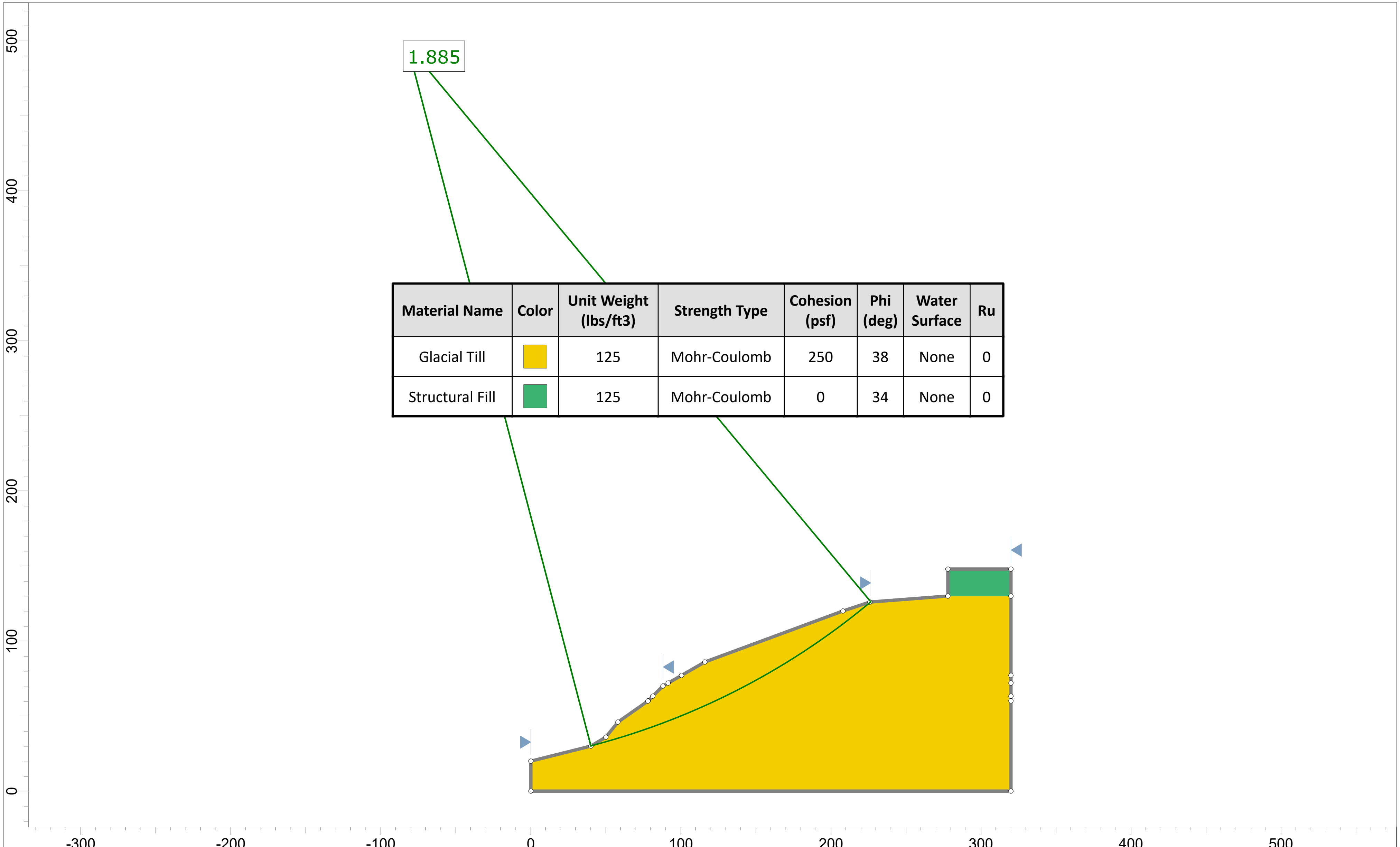


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section A-A' - Existing Conditions - Seismic		
Drawn By	C. Decker	*Scale* 1:1060	*Company* Terra Associates, Inc.
Date	October 2, 2019	*File Name*	Cross-section A-A'.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

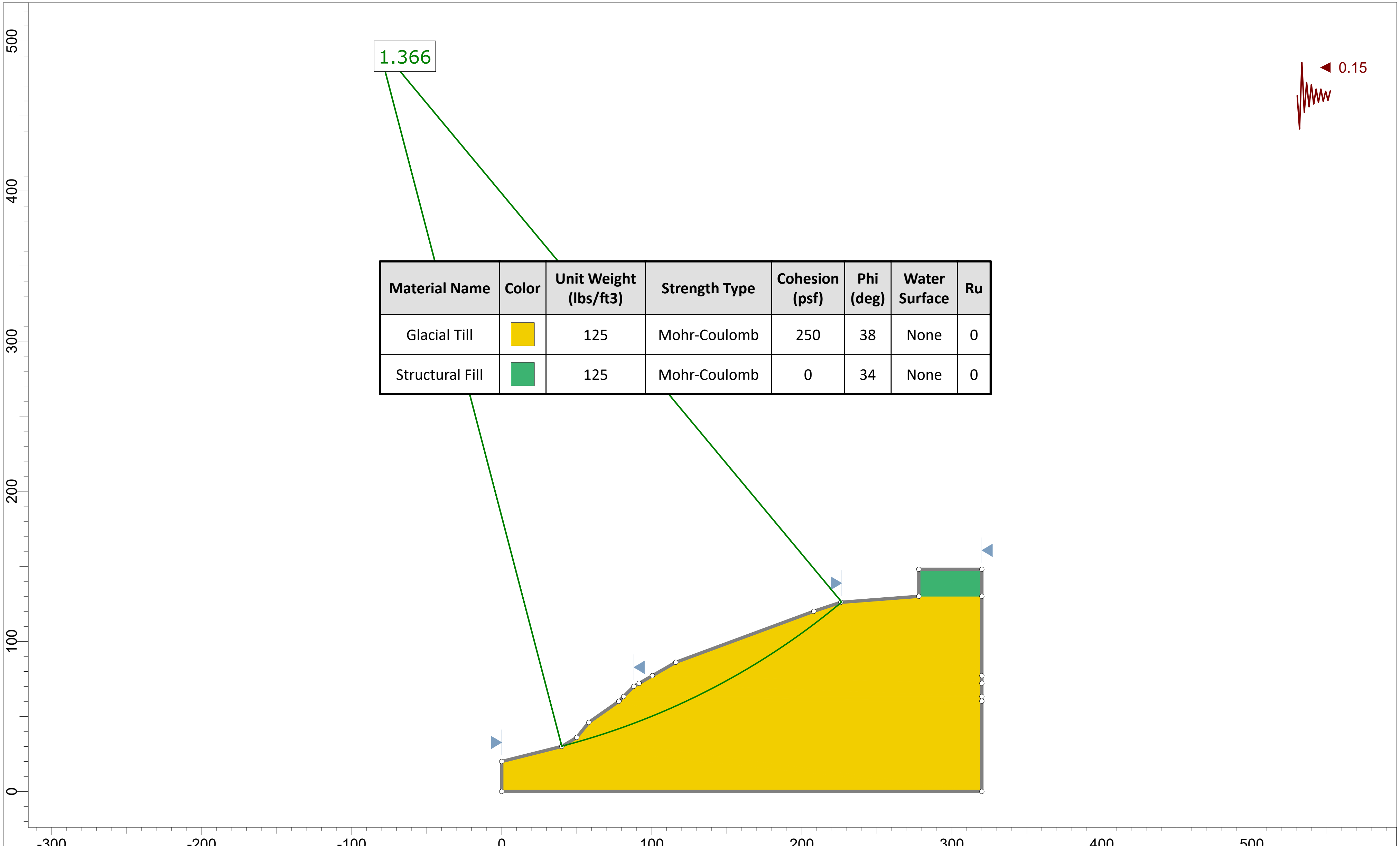
Project

Terrace Ave Development

Analysis Description

Cross Section A-A' - Post Construction

Drawn By	C. Decker	*Scale*	1:1062	*Company*	Terra Associates, Inc.
Date	May 15, 2020			*File Name*	Cross-section A-A'.slmd

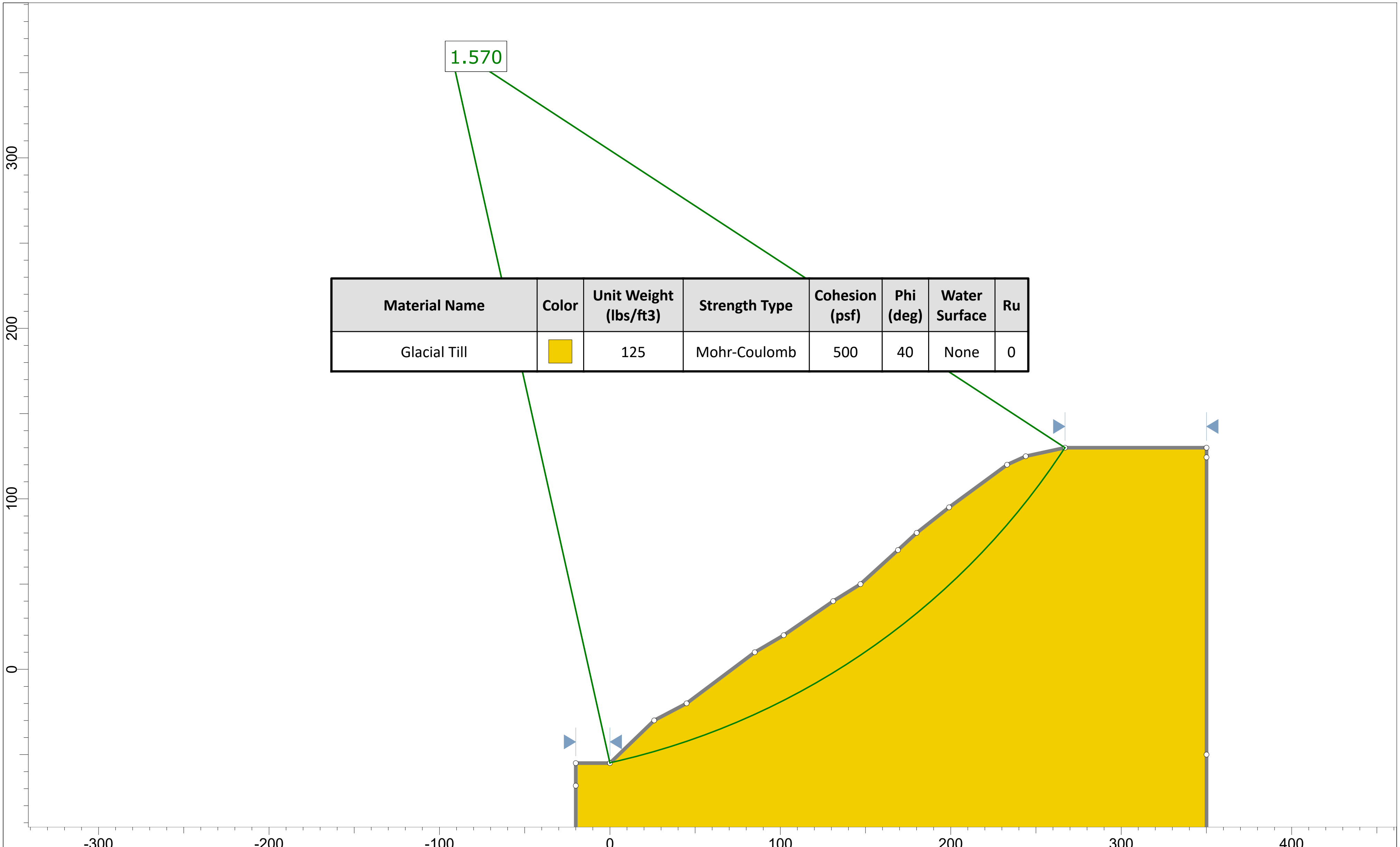


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section A-A' - Post Construction - Seismic		
Drawn By C. Decker	*Scale* 1:1062	*Company*	Terra Associates, Inc.
Date	May 15, 2020	*File Name*	Cross-section A-A'.slmd

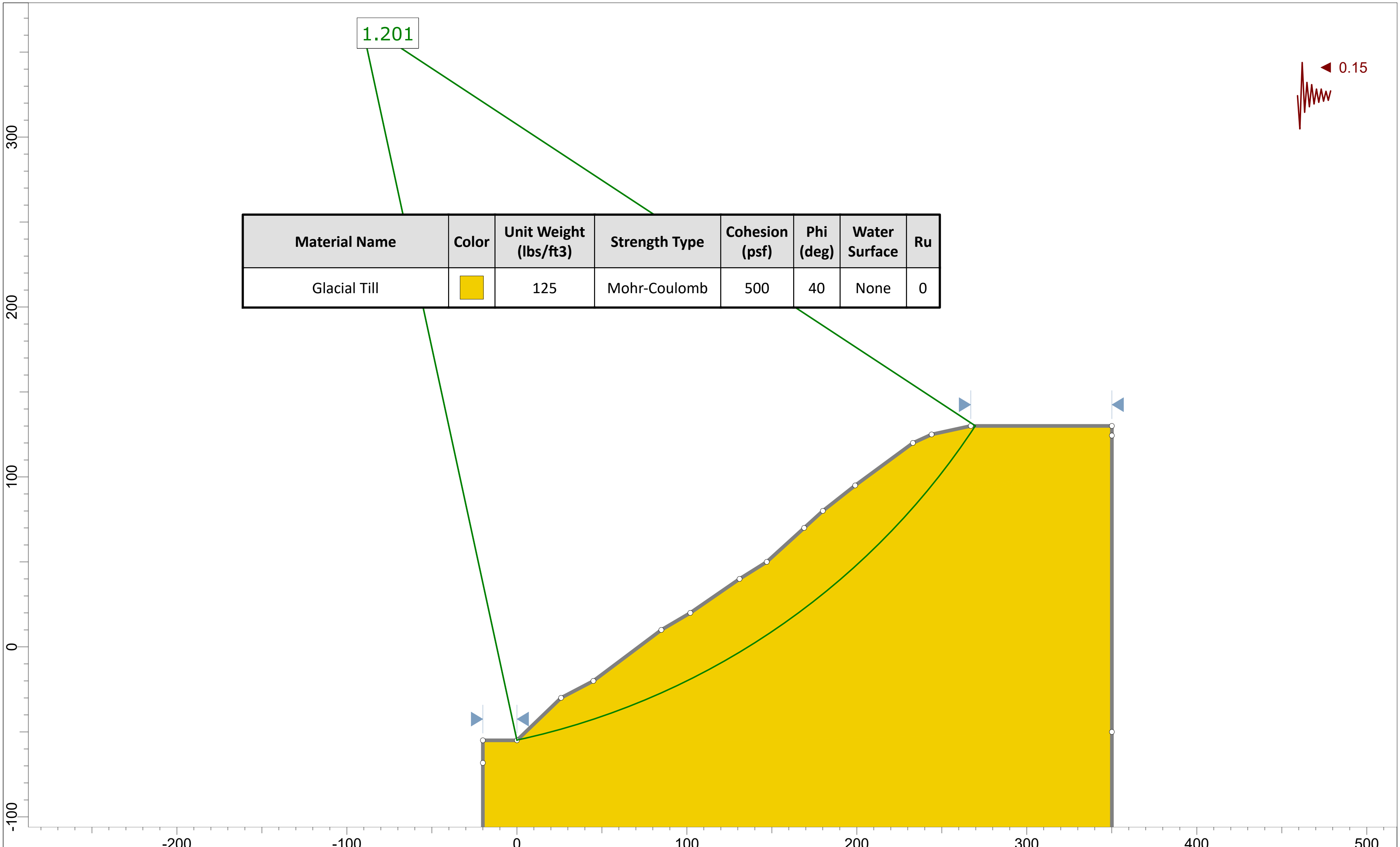


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section B-B' - Existing Conditions		
Drawn By C. Decker	*Scale* 1:934	*Company*	Terra Associates, Inc.
Date May 15, 2020		*File Name*	Cross Section B-B Detention Vault.slmd

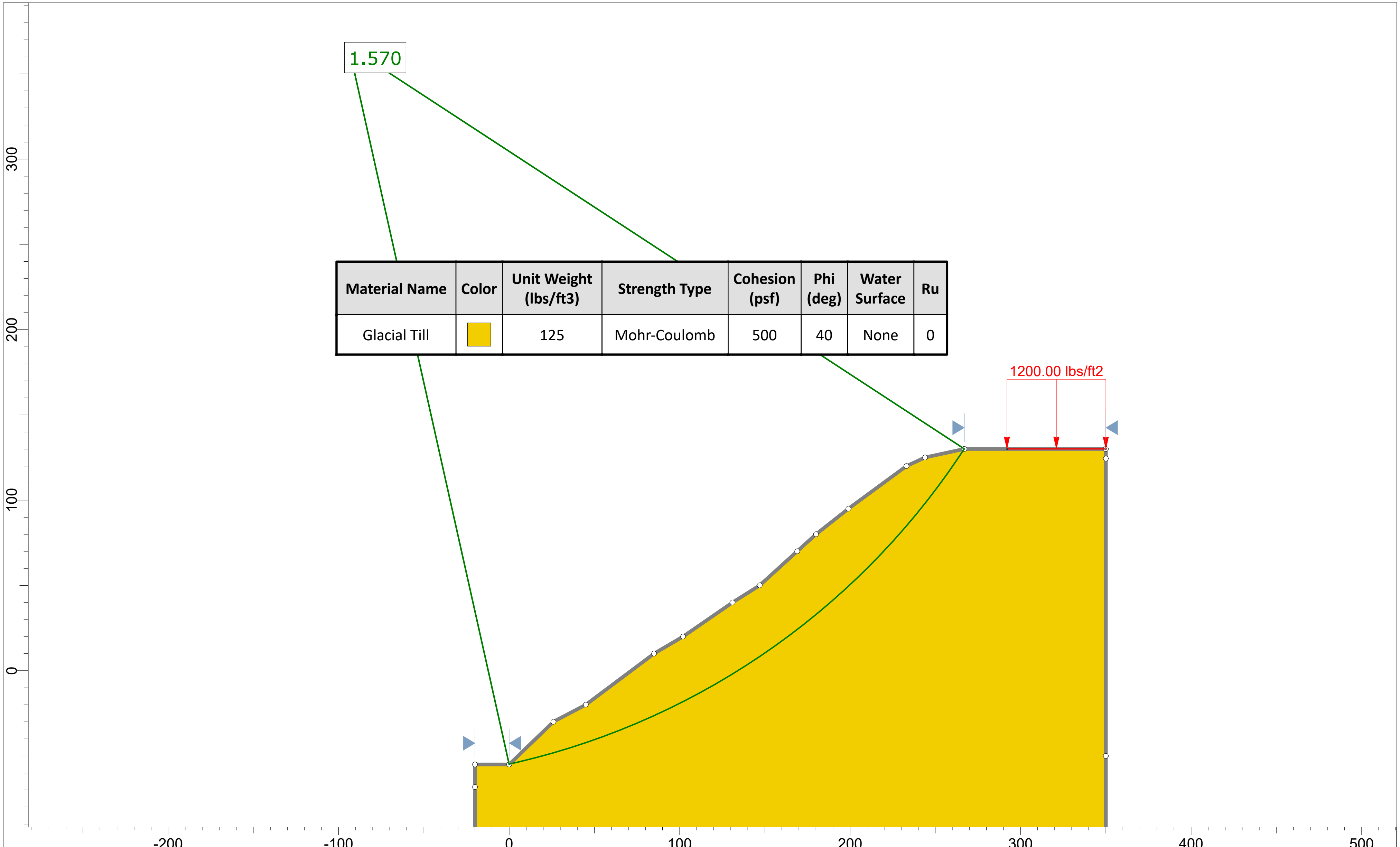


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**
Analysis Description	Cross Section B-B' - Existing Conditions - Seismic
Drawn By	C. Decker
Scale	1:937
Company	Terra Associates, Inc.
Date	May 15, 2020
File Name	Cross Section B-B Detention Vault.slmd

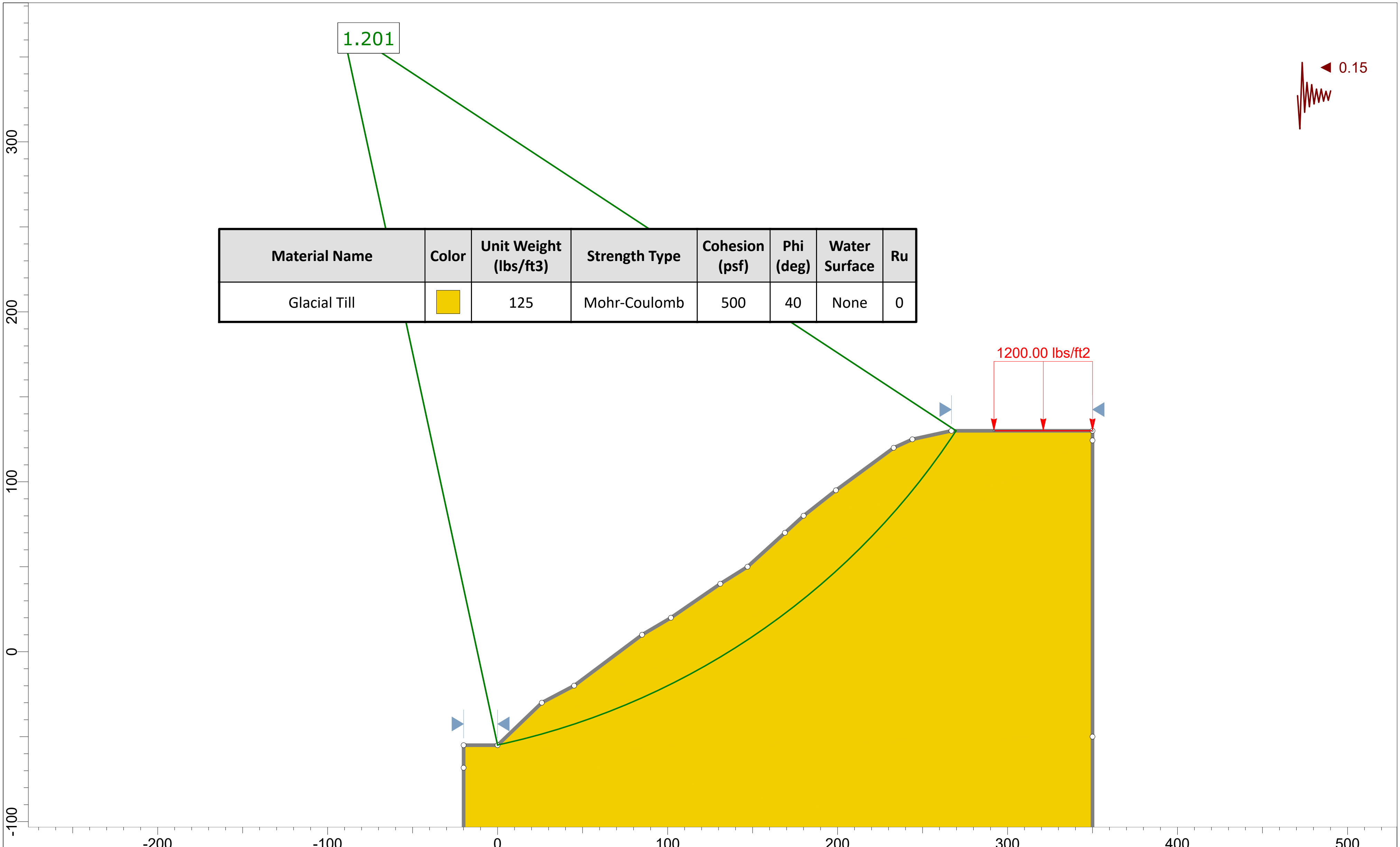


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**
Analysis Description	Cross Section B-B' - Post Construction
Drawn By	C. Decker
Scale	1:934
Company	Terra Associates, Inc.
Date	May 15, 2020
File Name	Cross Section B-B Detention Vault.slmd

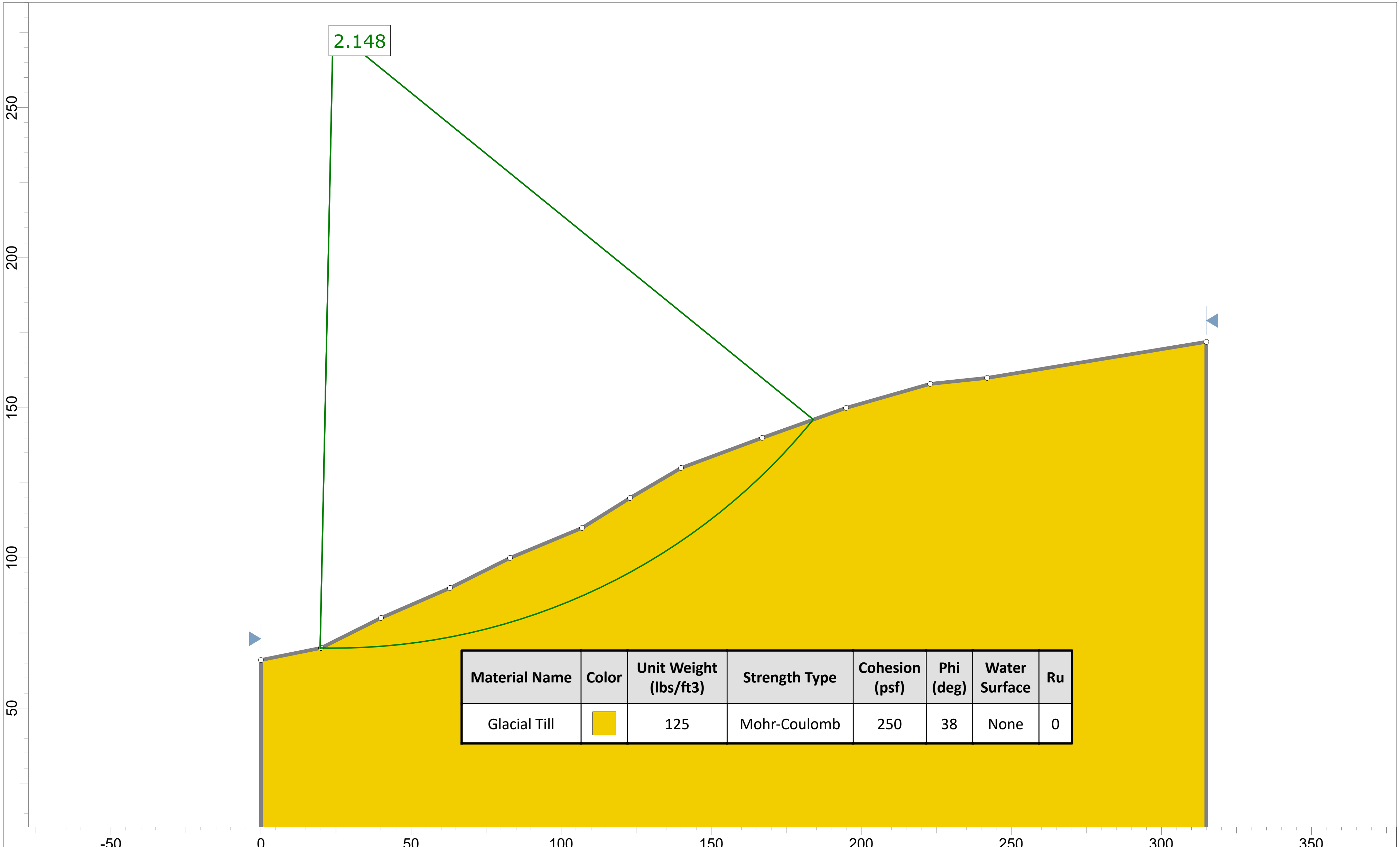


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**
Analysis Description	Cross Section B-B' - Post Construction - Seismic
Drawn By	C. Decker
Scale	1:937
Company	Terra Associates, Inc.
Date	May 15, 2020
File Name	Cross Section B-B Detention Vault.slmd

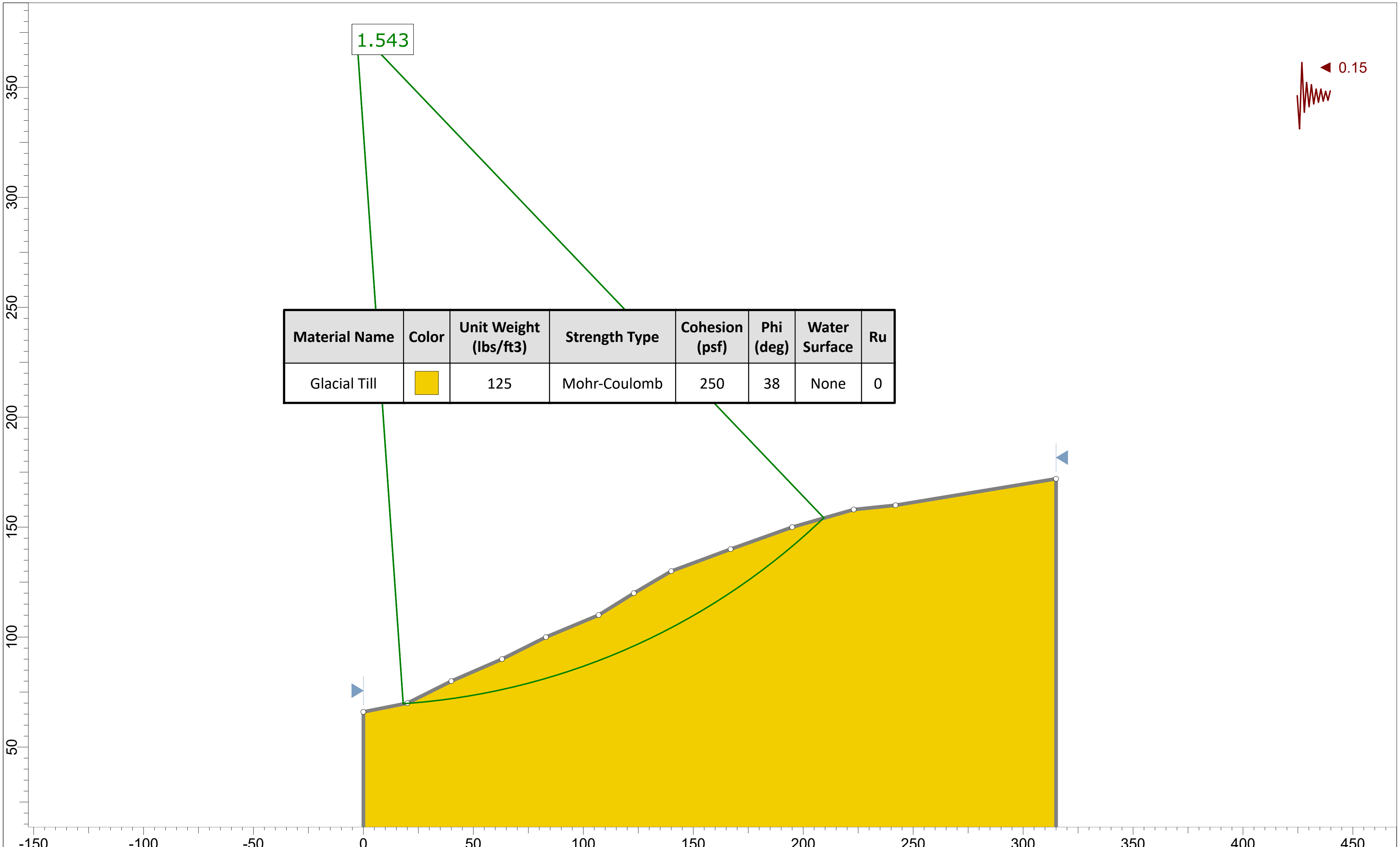


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**
Analysis Description	Cross Section C-C' - Existing Conditions
Drawn By	C. Decker
Scale	1:531
Company	Terra Associates, Inc.
Date	5/6/2020, 2:14:41 PM
File Name	Cross Section C-C'.slmd

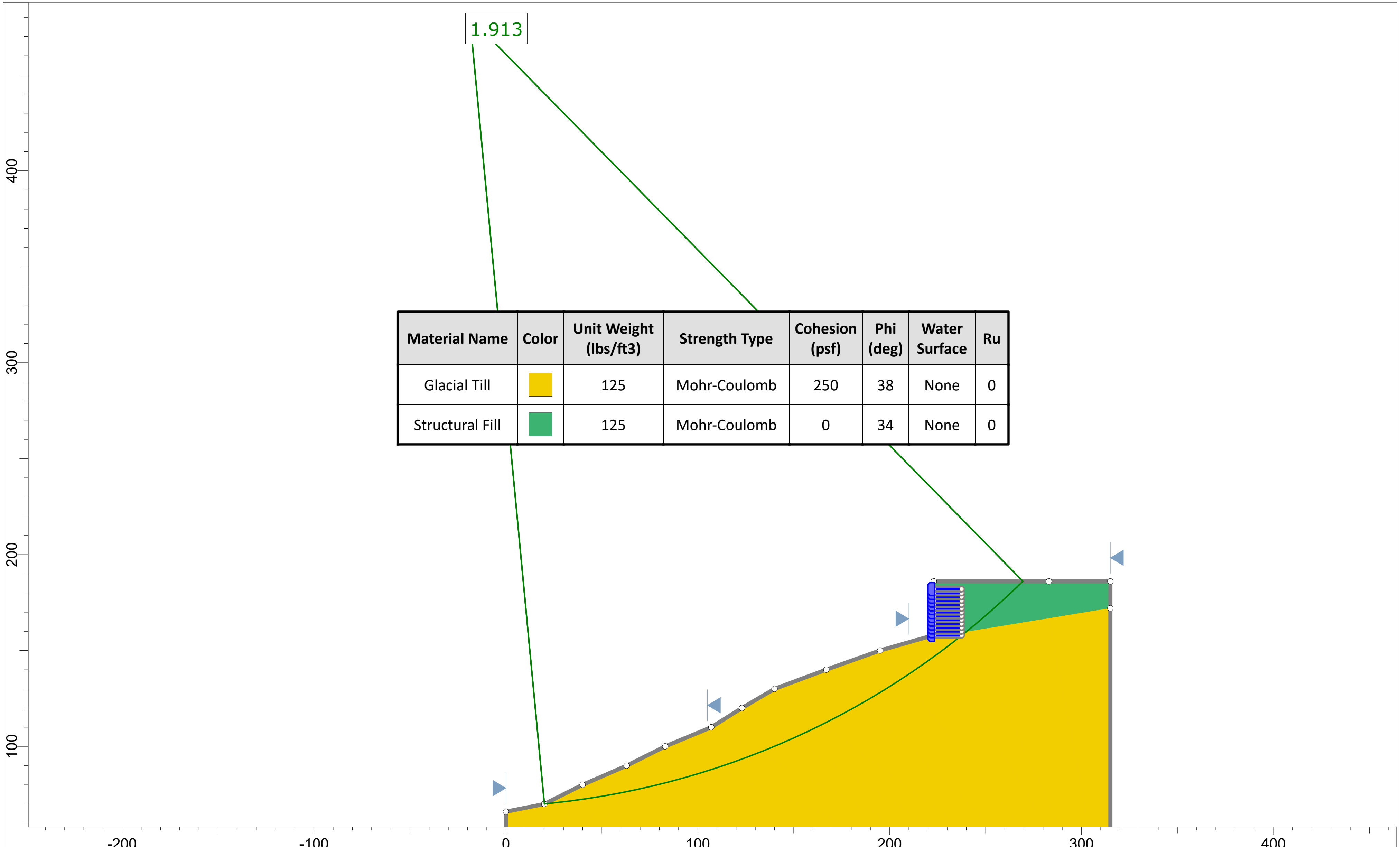


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**
Analysis Description	Cross Section C-C' - Existing Conditions - Seismic
Drawn By	C. Decker
Scale	1:724
Company	Terra Associates, Inc.
Date	5/6/2020, 2:14:41 PM
File Name	Cross Section C-C'.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project

Terrace Avenue

Analysis Description Cross Section C-C' - Post Construction Conditions

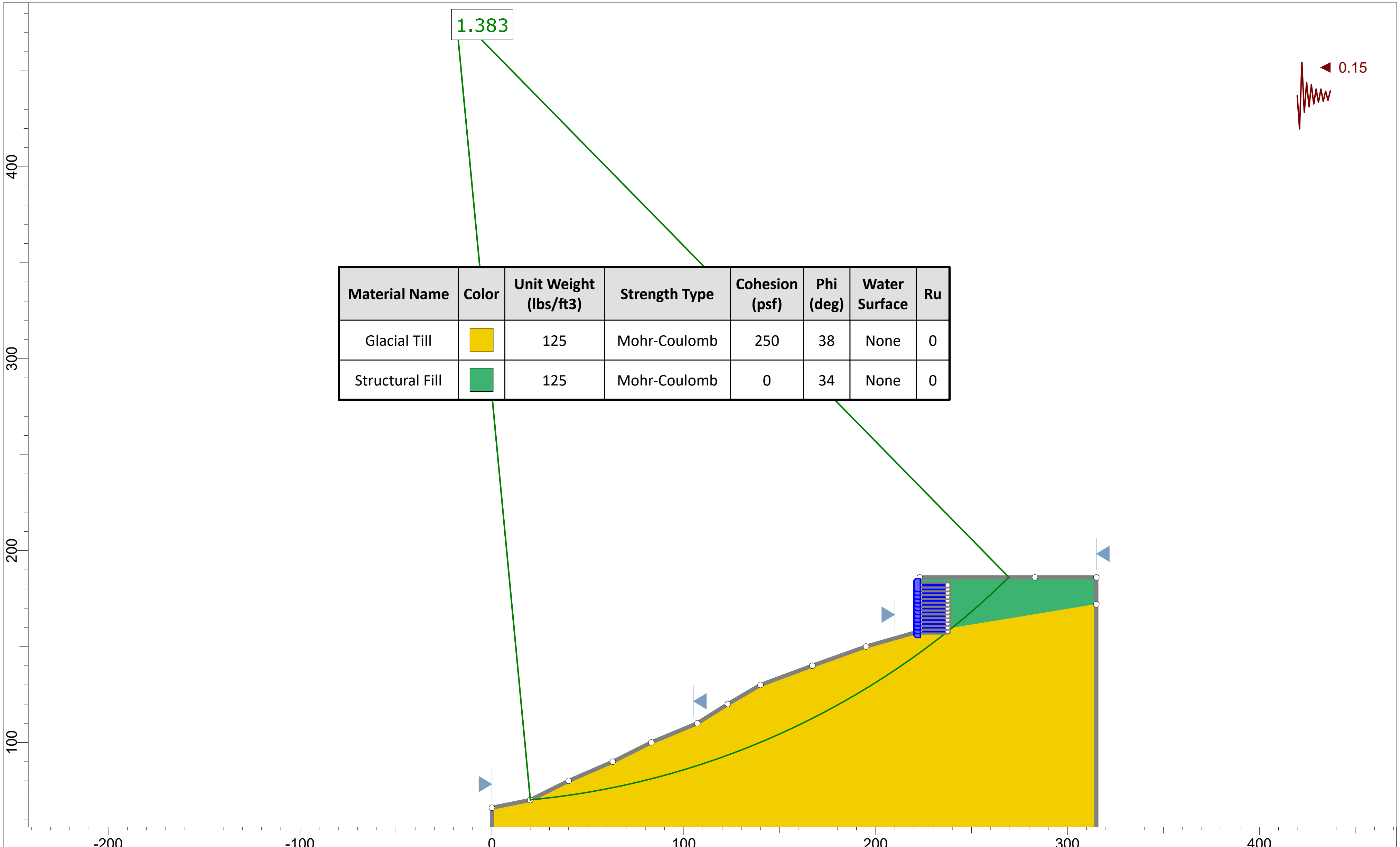
Drawn By C. Decker

Scale 1:830

Company Terra Associates, Inc.

Date 5/6/2020, 2:14:41 PM

File Name Cross Section C-C'.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**		
Analysis Description	Cross Section C-C' - Post Construction Conditions - Seismic		
Drawn By	C. Decker	*Scale*	1:830
Company	Terra Associates, Inc.		
Date	5/6/2020, 2:14:41 PM	*File Name*	Cross Section C-C'.slmd